Strategic variables of commercialization of renewable energy technologies

Cite as: J. Renewable Sustainable Energy **7**, 023105 (2015); https://doi.org/10.1063/1.4914078
Submitted: 03 November 2014 . Accepted: 20 February 2015 . Published Online: 03 March 2015

Alireza Aslani

Strategic variables of commercialization of renewable energy technologies

Alireza Aslani[a)]
Faculty of New Sciences and Technology, University of Tehran, Tehran, Iran and Industrial Management Department, Faculty of Technology, University of Vaasa, Vaasa, Finland

(Received 3 November 2014; accepted 20 February 2015; published online 3 March 2015)

Utilization of renewable energy sources, as domestic and local natural resources, has important role among the energy policies of the governments. However, diffusion of renewable energy technologies have faced with challenges that slow the development plans and affect security of energy supply. As commercialization is an important contributor to successful diffusion and adaptation of a technology, this research studies the role of commercialization of renewable energy technologies and identifies the key factors of commercialization. A decision matrix is also presented to show the best government strategies for successful commercialization of renewable energy products and services. The contributions help researchers and policy makers to focus more on the strategic variables of commercialization of renewable energy technologies. © *2015 AIP Publishing LLC*. [http://dx.doi.org/10.1063/1.4914078]

I. INTRODUCTION

Renewable energy (RE) industry is one of the fastest growing industries in the past years. Utilization of renewables is one of the main strategies of the governments to increase their security of energy supply, in particular, for dependence countries to imported fossil fuels. According to the IEA world energy investment outlook 2014 factsheet, the global new investment in RE technologies reached to $300 billion, with annual investing increasing from $60 billion in 2000.[1]

According to the last IEA reports in 2014, RE resources (RERs) had a share of 13.5% of the world's total primary energy supply in 2012.[2] However, around 74% of this share is for biofuels that mostly are traditional biofuels like wood, and only 8% is the share of geothermal, solar, and wind resources (18% hydropower).[2] Although the amount of total primary energy supply from the new RERs (solar, wind, and geothermal) had increased more than 21 times in the world in 2012 compared with 1973; however, the share of non- hydro and biofuels RERs still is low compared with other fuels. This shows that the new RERs are at the beginning of commercialization both in utility and home scales. Although governments have tried to increase the share of new RERs in the primary energy supply, statistics show that they have not been successful in their most plans. As the economic utilization of RERs needs new technologies, the commercialization these technologies in the frame of new products or services have faced with challenges. In particular, commercialization of renewable technologies is difficult because of several reasons such as competition difficulties compared with fossil fuels technologies, their entrepreneurial nature, technological investment, and political and market uncertainties.

A successful case for diffusion and adoption of RE technologies is China. According to REN21 statistics (2014), China led the world in RE production and new capacity investment in 2013.[24] There are also other ambitious goals in other countries such as India, Germany,

[a)]Author to whom correspondence should be addressed. Electronic mail: alireza.aslani@ut.ac.ir. Tel./Fax: +358 44 255 0010.

Turkey, Italy, etc. As an example, around 4.2 GW of RE power capacity was added in India in 2012 which was 32% of total energy installed capacity (total 66 GW.43).[28] Therefore, India was ranked as fourth world-wide in terms of RE attractiveness and commercialization. Germany is another country that is another world leader in development and utilization photovoltaic (PV).

Due to the importance of the diffusion of RE technologies, this article is to study the commercialization of RE technologies. The research starts by reviewing the importance and public acceptance of RE commercialization. Then, the pathway to commercialization of those technologies is discussed. After that, key factors of commercialization in the RE industry are identified based on a qualitative and inductive approach. Finally, the suitable government strategies for successful commercialization are introduced in an innovative frame of a decision matrix.

II. LITERATURE REVIEW

Commercialization is the process of introducing or launching a new technology, product, service, or production method in the market. Commercialization is often confused with marketing or sales processes, but it is an important part of innovation diffusion process that includes searching, discovering, developing, improving, accepting, and commercializing of new products, process, methods, or organizational structures.[3,4] In other words, innovation means invention plus commercialization.[6] An innovation, when commercialized, is the important contributor to the economy growth.[5] Therefore, commercialization shows technologies or innovations which are developed in the laboratories make their way to the market.

The history of commercialization in the RE industry involves three main generations depending on the development of related technologies.[7] First generation of commercialization of RERs includes biomass, hydroelectricity, and geothermal power/heat with mature and economically competitive technologies. The second generation is market ready technologies such as solar heating/thermal power, photovoltaic, wind power, and modern form of bioenergy and waste. Finally third generation is the technologies that require continued R&D investment to be ready for utilization in the economic scale such as ocean or wave energy and biomass gasification.[8]

Almost all countries have invested on utilization of RERs; however, China, Germany, India, Spain, and the United States are top countries in terms of RE investment.[9] In the regional level, countries have also especial plans for diffusion of RE technologies. As an example, European Union has ambitious plans for RE development for its members. They should increase the share of RE by 20% by 2020.[10] In particular, Germany, Spain, Italy, Switzerland, Finland, and Sweden have major green power market in Europe. Because of the well-defined government incentives, wind power industry, as an example, has reached to explosive growth in terms of cumulative installed capacity and manufacturing in China from 2005.[25] The total installed wind power capacity was 91 424 MW in China in 2013 with highest number of installed capacity in the world (21% growth compared with 2012).[26] The country had also more than 600-fold growth in the total export of wind turbines in six years (from 2.3 MW in 2007 to 1392.5 MW in 2013).[25] The success in commercialization of RE technologies in Chinese is because of several government incentives such as R&D support, localization policy, feed-in tariff policy, providing credit lines and loans to wind power enterprises and exporters, etc.[27]

Another example is India that the Indian Government has enacted several policies to support the expansion of RE commercialization.[29,30] As an example, the capital subsidy policies are during the initial stages of RE projects. Indeed, tax incentive accelerates the development of RE products and projects. Other policies such as fiscal and financial incentives is also exist to encourage the RE producers and manufacturers to increase their market and profit in the energy industry.

Germany is also a world reference in the development and installation of RE, in particular photovoltaic. The country has established an international commercialization cooperation where manufacturers, businesses, consultants, and R&D organizations share their experience with other countries. In particular, for the case of commercialization in the PV industry, Germany

has supportive mechanisms such as banking and financing supports (even during the economic crisis) in order to speed the new PV products, technologies, and services.[31] More than 25 PV inverter manufacturers, 65 companies with PV productions, 45 PV equipment manufacturers and many manufacturers of materials for PV modules and system components are working in Germany. Just in 2012, around 110 000 workers were employed in the PV industry in Germany.[32]

A. The pathway to commercialization of RE technologies

As Figure 1 illustrates, the commercialization concept refers to process of developing an idea into a marketable product/service.

To have a successful commercializing of RE technologies in the market, and due to the maturity level of each RE technologies and their development generations, studies, and our experiences show that the pathway to commercialization of RE technologies can be defined in three main phases:[11–13]

(1) Pre-commercialization: demonstration and pilot projects for new RE technologies.
(2) Pilot projects transitioning to commercial level.
(3) Commercial level transitioning into home/utility scale level.

The above phases are completed by corporations of different sectors such as universities and research centers, public and private funds and investments, and product/services companies. Despite several policies and plans in order to successful diffusion of RE utilization, achievements have gaps with targets. Our studies show that more than 70% of the patents that are related to RE technologies have not had any place in the market. This means there are barriers for development of RE technologies, products, and service. Table I shows the most important barriers of RE technologies.[23]

Due to the importance of security of energy supply for governments as one of the main factors of robust economic growth, and because of environmental and feasibility limitations of fossil fuels, strong public support exists for replacements strategies such as diffusion of RE technologies utilizations.[14] In fact, public acceptance is one of the key criteria for successful commercialization of RE technologies. For instance, more than 65% of Us people believe that solar technology should play a greater role in the portfolio of energy resources in the U.S.[15] Indeed, 67% are willing to invest in RE and 49% would be willing to pay $5 or more per month if their electricity utility company increase its use of RE technologies.[15] This attention is even more in Europe. Our studies shows that in the Nordic countries, in particular, in Finland, more than 75% of the Nordic people believe that one of the main solution to decrease the dependency on imported energy is utilization of domestic RERs. In reality and as we showed in Secs. I and II, however, it seems commercialization of RE technologies could not be successful in all aspects.

III. RESEARCH METHODOLOGY

The purpose of this research is to provide an overview on important factors of commercialization of RE technologies. The philosophy of current work is based on the pragmatism where

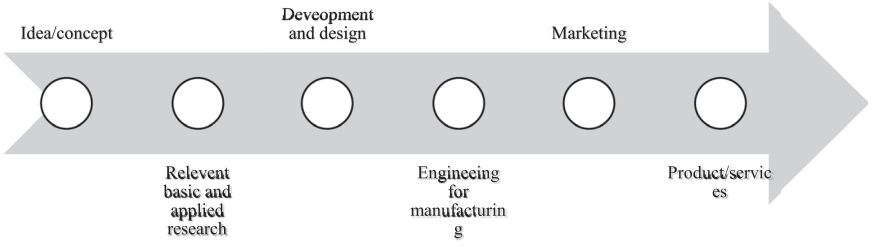

FIG. 1. Process of commercialization of a technology/product/service.

TABLE I. Important barriers to successful RE businesses.

	Barrier or limitation
1	Budgetary limitations
2	Lack of information on RE market, demand, and potential
3	Failure in commercialization plans
4	Ambiguous policies and regulations
5	Cost of RE utilization for end-user
6	Conversion efficiency of RERs
7	Operation and maintenance costs
8	Lack of mechanisms to provide modern and efficient energy services in rural areas
9	Inadequate incentive for RERs utilization compared to fossil fuels(e.g., taxation, tariffs, substitutes, and feed in)
10	Absence of policies related to promotion RE energy
11	Low public awareness of RERs
12	Lack of familiarity with green certificates and standards
13	Lack of robust planning of RE development at the strategic and practical levels
14	Low storage capacity of RE technologies compared to fossil fuels
15	Gaps between research projects and needs of the market
16	Poor quality of some RE technologies and utilization
17	Lack of specialized and skilled manpower in RE industry
18	Dominance of old fossil energy-inefficient technologies
19	Social and environmental barriers via beneficiary groups
20	Location selection
21	Inadequate coordination among the various stakeholders

ideas and practices are assessed in terms of their usefulness, workability, and practicality. The approach is inductive based on the qualitative method. An inductive approach offers a flexible structure for researcher to alter the intended path of the research as new findings. According to Ref. 16, the inductive approach tries to develop a theory in sections that is supported by empirical evidences.[16] The empirical evidence come from the interview with professionals in the field of RE technologies and business. Indeed, direct observation and judgment of the researcher, and analysis of statistics reports are other sources of the research.

To extract key factors to commercialization of RE technologies, as well as, formulation of commercialization strategies, 23 interviews with academic professionals, business man, and policy makers in Finland were done by researcher. The interviews were based on the open response—qualitative questionnaire to identify the factors and strategies. The period of the data collection is April till June 2014 and the focus of companies and professionals were wind, biomass, solar, and geothermal sources. The questions were about the strategic variables such as

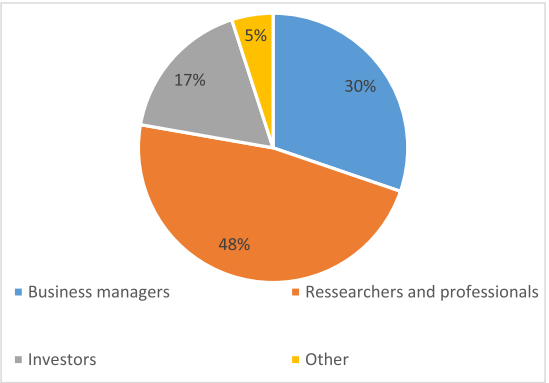

FIG. 2. Segmentation of the responders.

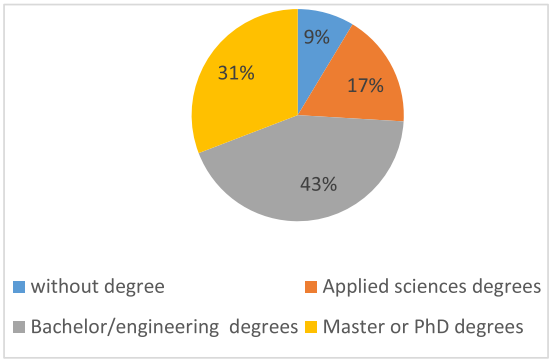

FIG. 3. Level of academic degrees for responders.

economy, government, or regulations that mainly affect commercialization of RE with their positive or negative roles. Figures 2 and 3 illustrate the segmentation and education level of the responders. As Figure 2 illustrates the responders of the questionnaire are categorized in the three main groups: business mangers working in the field of RE products/services, researchers and professionals working at the universities and research institutes (mainly from the technology management, marketing, and energy departments), and investors. The education level of the responders is also mainly bachelor with engineering and marketing background (Figure 3).

To organize and extract qualitative data and create the conceptual frameworks, NVIVO 9 (QSR) software was used. NVIVO is for qualitative research using rich text-based and/or multimedia information. The software helped researcher in three main ways: managing data, managing the ideas, and querying data.[17]

The qualitative framework of the data accumulation and the analysis method is depicted in Figure 4. According to the figure, after collecting data from sources, they were numbered in order of each category and the related question, and then it has been coded. In the next step, the mutual points of each code and memo have been recognized and filtered. Finally, the important polices and schemes have been selected and introduced. Since the review and reprocessing has been strictly performed in each stage, the research validity is ensured.

IV. DATA ANALYSIS AND DISCUSSION

By analysis of responses, the researcher tried to understand the main key factors of commercialization of RE technologies. The factors are categorized in six main groups. Then, each factor was enriched based on the responders' opinion and scientific publications. Analysis

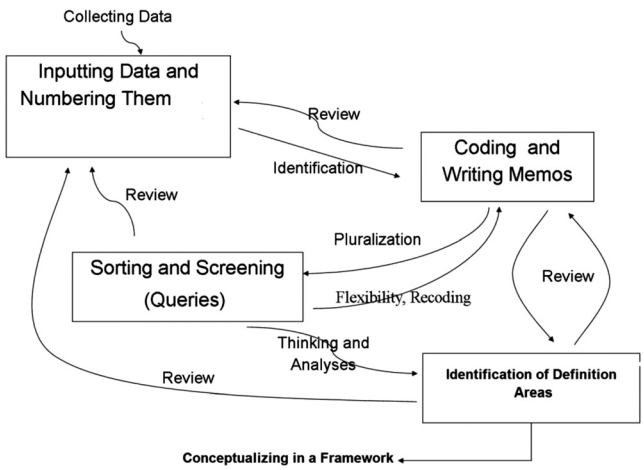

FIG. 4. Research framework of the qualitative part.

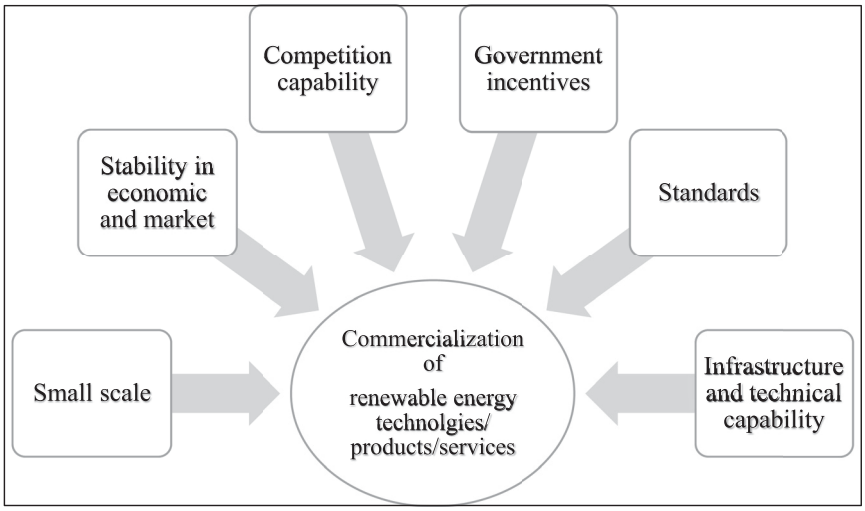

FIG. 5. Key factors of commercialization of RE technologies.

shows that there are six key areas that governments, beneficiaries, and stakeholders must work on to overcome the barriers to commercialization of RE technologies (Figure 5). The factors must be addressed throughout each phase of the commercialization pathway described in Sec. II A. Following each factor is described.

A. Competition capability

Competition is one of the important factors for successful commercialization of a product or service. Energy industry consists of different and mature technologies with core role of fossil fuels as the main sources of those technologies. This causes that the change rate of such industry is very slow. Thereby, it is difficult to familiarize the professionals and customers in such industry with RE technologies at the home and utility scales because of the lack of knowledge and experience. In addition to the familiarity and experience, cost-effectiveness of RE technologies and operation and maintenance of such technologies are the most important issues for successful competition RE technologies with other technologies. In order to overcome the competitions challenges, we must identify the competition forces of energy industry. In other words, the nature of RE competitiveness in energy industry should be viewed as composite forces of consumers, competitors, and substitute products/services. Therefore, to have a successful commercialization of a RE technology, identification of key aspects or elements of each competitive force that impact the RE industry in necessary.

B. Government incentives

Due to the importance of security of energy supply on economic growth and social development, the public policies in energy sector is strategic. On the other hand, to diffusion of a new technology, the supportive polices are very important. These polices can be categorized in five main groups: economic/finance (e.g., tax and loan), commercial (e.g., tariffs and technology/product/service export encouragements), research and development (e.g., founds and science and technology collaborations), ownership (e.g., investments on public private companies), and regulations (e.g., environmental and technical regulations). Table II shows the effective policies and targets for commercialization of RE technologies. The most important RE policies that can help to commercialization of RE technologies are subsides, tax incentives, and governmental found for R&D research are the main sources of government incentives for RE technologies.

TABLE II. Effective policies of commercialization of RE technologies.

Policies	Description/examples
Reduce investment costs	Subsidies, tax, rebates, relief, loan, grants
Public investment	Public funds for direct investment, guarantees, training, etc.
Development of science and technology corporations	International corporations in the science and technology fields of RERs, creating RE science parks
Forcing price or quantity policies	Mandate prices to be paid for RE or indicate a fixed amount of electricity generation from RE
Emission reduction	Allocate a percentage of mandated environmental emissions reductions to be met by RE
Privatization of utilities	Permit to private sector to own the energy unities (new utilities/operated utilities)
Self-generation by end-user	Permit end users to generate their own electricity/heat or even sell to the companies

C. RE standards

One of the effective decisions for commercialization of RE technologies is RE standards. The standards help to encourage or force different sectors (including industries, home, etc.) to produce or consume an indicated amount of their energy needs from RE technologies/products/services. These standards can be categorized in two main groups:

(1) RE portfolio standards (RPSs) that indicate a minimum percentage of generation sold or capacity installed be provided by RE for utilities, industries, etc. Some countries like U.S. or Brazil have successful experience in such policy.[18]
(2) RE certificates (Green certificates) that are a way for utilities or customers to trade RE production or consumption credits to meet obligations of the polices.[19]

D. Infrastructures and technical capability

One of the important strategies to increase the security of energy supply is decentralized forms of utilization. The pre-requirement for this strategy is utilization of RE technologies along with smart utilization and grid. However, the achievement to this strategy needs providing strong policies and building developed infrastructures. As an example, the high efficient utilization of electricity from RERs in smart cities in Finland requires access to transmission and distribution lines.

E. Economic and market stability

The survey shows that stability in new markets is essential to success or failure of a new product/service. In particular, continues changing in policies and stability in some economics factors such as inflation, prices, fluctuating in exchange rates have negative impacts on diffusion of new technologies. On the other hand, the robust profit in new technologies is highly dependent on export in particular, in knowledge based products/services. In addition to encouraging the private sector to invest on RE industry, a stable situation in policy and prices can increase customers' trusts for a product or service. In fact, when a RE technology or product/service has not a robust strategy for market penetration, the situation is completely ready for substitute technologies and products. For example, although most of citizens in Europe have a variety of choices in the electricity market from different sources, customers need to be informed about the advantages and incentives of using RE electricity. In other words, government and RE companies should communicate the benefits of RE to persuade customers to switch from traditional sources. Most of the customers, in particular in developing countries, know little about the RE technologies; therefore, they may, for example, think that solar or wind technologies are unreliable as they are available only when the sun is shining or the wind is blowing.[20] Therefore, they should be aware that the reserving technologies have been

developed or those technologies can be highly reliable when combined with other alternatives. This means, science, engineering, and technician educational programs needed to develop more to support the RE industry.

Overall, developing a policy framework that supports a stable market and informs and educates citizens, industrial men, and policymakers to commercialization of RE are one of the important factors. Indeed, the market needs to develop other terms of RE technologies including jobs, maintenance services, education, and standards for meeting them.

F. Big potential but small size

The survey shows that, despite high potential of RE utilization, RE projects and companies are generally small in Finland and Europe. This causes that they have fewer resources compared with large energy companies. While small companies are less able to communicate strongly with different groups of customers, they have less power with larger players of electricity/heat market.[21] For instance, they cannot participate strongly in regulatory or legislative proceedings to define or enact new market rules. On the other hand, small companies or projects bring more costs for financial institutions to evaluate their creditworthiness compared with large projects. Therefore, it increases different costs such as marketing and negotiating for contracts. To response the above challenges, the roles of public sector in particular science and technology parks and incubator centers are critical. The science and technology parks are one of the best places for creating and growth of RE companies. As some special services such as financing, commercialization, hoteling, incubating, clustering, and venture capitals are offered in such parks, the new ideas and start-up companies can be easily developed. A study by author shows that the rate of failure in companies which are created and worked in the science parks and incubator centers is considerably low (40% compared with 80% in Iran). Therefore, science parks and incubator centers, in particular, those are a part of the research universities, should have special plans to absorb new ideas and companies related to RE technologies and products/services and try to develop them by their supportive commercialization and clustering programs.

G. Strategies for successful commercialization of RE technologies

The second contribution of the research survey is identification of commercialization complexities of RE technologies. During the analysis of commercialization factors of RE technologies, the respondents mainly focused on the important role of the governments when the investment costs and technology levels of RERs are different. According to the number of project failure in commercialization of RE projects/products, as well as role of government and private sector, and diversity of RERs and related technologies, the researcher proposes a decision matrix for selecting a suitable commercialization strategy to clarify how government and public sector can enter into the RE markets in order to reach a successful RE commercialization. Figure 6 illustrate the decision matrix. The commercialization of each source of RE can be analyzed independently based on the bellow decision matrix.

According to the matrix, when the needed investment cost of a RE technology, as well as the complexity level of a RE technology are high, the investment is along with risk. Therefore, the government's investment has a core role in commercialization of a technology. The best strategy in such situation is the commercialization of RE technology with direct government/public investment and engaging in the projects. This means the government should have direct supportive polices and the RE projects must be done under management of the governments with corporation of private companies.

At the high level of investment cost, but lower level of technical complexity, investments of the public sector can have an important role. However, the government polices should be mostly in the frame of R&D funds to help the private sectors in order to develop their commercialization capability.

On the other hand, when the investment costs of a RE technology is low, but the complexity of the RE technology is high, a successful commercialization can be happened via technical,

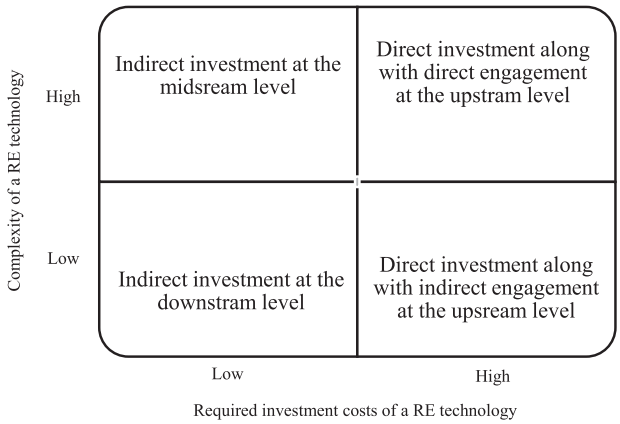

FIG. 6. Decision matrix to show the government strategy for commercialization of RE technologies.

and grants supports of the public/private clusters. This can be occurred at the incubators centers and science and technology parks that governments can offer some indirect investment supports. In such situation, the government supports incubator centers and science parks, and they offer the commercialization service to the RE companies. Indeed, clusters of companies related to the RE technologies can be created and worked.

Finally, when both investment costs and complexity of RE technologies are low, the supportive policies can be occurred via end users and consumers (downstream). This means the government can encourage the end users by offering the loans to renovate their energy systems by using RE technologies, etc.

V. CONCLUSION

Climate change, pollution, and security of energy supply are the main source of challenges for policy makers that addressing them requires major changes in energy infrastructures.[22] In response, RE technologies are the main contributors to reduce dependency on fossil fuels and provide opportunities for mitigating greenhouse gases.

Commercialization of RE technologies in different scales cannot be handled or analyzed in the same manner as fossil fuels technologies. In other words, commercialization efforts to diffuse RE technologies need to be sustainable and should promote the goal of policy development. Limited success on governmental development plans of RE technologies illustrates the necessity for commercial-based approaches in diffusion of RE technologies. However, the government plays an important role in RE commercialization activities by encouraging the RE companies (including start-ups, matures, spin offs) to undertake R&D and create both local and export markets for RE technologies.

This research showed that the essential requirements for successful commercialization of RE technologies are providing a stable market and stable policies in the industry, accurate identification of the potential adopters, designing, developing, and informing a user-friendly RE products/services, and providing post-adoption supports. Therefore, six key factors of RE commercialization were identified based on an inductive-qualitative research. Due to the important role of government supports and polices during diffusion of RE technologies, a decision matrix was also designed to show how and when the public sector should enter to the market and commercialization process in this industry.

As the future research, the importance of each identified factor in each RER or region/country can be separately analyzed. The role of each commercialization strategy such as licensing, joint ventures, etc., should be analyzed for each technology. Indeed, importance of the identified factors can be prioritized based on different decision making methods such as AHP (Analytic Hierarchy Process). Further, the practical aspects of the designed decision matrix can

be reviewed in different countries. A road map for commercialization of the RE technologies based on the decision matrix is another suggestion for future research.

[1]IEA, IEA world energy investment outlook 2014 factsheet, 2014, see http://www.iea.org/media/140603_WEOinvestment_Factsheets.pdf (last accessed January 19, 2015).
[2]Key world Energy statistics for 2014, IEA reports, 2014, see http://www.iea.org/publications/freepublications/publication/KeyWorld2014.pdf (last accessed January 19, 2015).
[3]T. Joe, B. John, and P. Keith, *Managing Innovation*, 3rd ed. (Wiley, UK, 2005).
[4]A. Tekawad, "A literature survey on a managerial perspective on the process of innovation management," M.S. thesis, Faculty of Engineering, University of Southern California, California, 2004.
[5]C. J. Chen, "Technology commercialization, incubator and venture capital, and new venture performance," J. Bus. Res. **62**(1), 93–103 (2009).
[6]R. E. Goldsmith and F. R. Gordon, *The Measurement of Innovativeness* (Elsevier Science Ltd., 2003).
[7]International Energy Agency, Renewables in global energy supply: An IEA facts sheet, 2007, see https://www.iea.org/publications/freepublications/publication/renewable_factsheet.pdf (last accessed January 19, 2015).
[8]P. Balachandra, H. S. K. Nathan, and B. S. Reddy, "Commercialization of sustainable energy technologies," Renewable Energy **35**, 1842–1851 (2010).
[9]Renewables Global Status Report, *REN21* (REN21, France, 2012).
[10]A. Aslani, M. Naaranoja, and K. F. V. Wong, "Strategic analysis of diffusion of renewable energy in the Nordic countries," Renewable Sustainable Energy Rev. **22**, 497–505 (2013).
[11]P. R. Walsh, "Innovation nirvana or innovation wasteland? identifying commercialization strategies for small and medium renewable energy enterprises," Technovation **32**, 32–42 (2012).
[12]A. Aslani, E. Antila, and K. F. V. Wong, "Comparative analysis of energy security in the Nordic countries: The role of renewable energy resources in diversification," J. Renewable Sustainable Energy **4**(6), 062701 (2012).
[13]K. Jagoda, R. Lonseth, A. Lonseth, and T. Jackman, "Development and commercialization of renewable energy technologies in Canada: An innovation system perspective," Renewable Energy **36**, 1266–1271 (2011).
[14]Council on Foreign Relations, *Public Opinion on Global Issues: World Opinion on Energy Security* (Council on Foreign Relations, US, 2012), Chap. 5b.
[15]P. Z. Vera, U.S. Consumers Demand More Solar, Applied material, 2010, see http://blog.appliedmaterials.com/solstice (last accessed January 19, 2015).
[16]Z. Sarmad, *The Research Method in Behavioral Science* (Aghah, Tehran, 2009) (in Persian).
[17]P. Bazeley, *Qualitative Data Analysis with NVIVO/Patricia Bazeley* (SAGE, Los Angeles, 2007).
[18]NREL, Renewable Portfolio Standards in the States: Balancing Goals and Implementation Strategies, National Renewable Energy Laboratory of the US department of Energy, 2014, see http://www.nrel.gov/tech_deployment/state_local_activities/basics_portfolio_standards.html (last accessed January 19, 2015).
[19]F. Beck and E. Martinot, *Renewable Energy Policies and Barriers*, Encyclopedia of Energy Vol. 5 (Elsevier, 2004), pp. 365–383.
[20]A. Aslani, "Private sector investment in renewable energy utilization: Strategic analysis of stakeholder perspectives in developing countries," Int. J. Sustainable Energy **33**, 112 (2013).
[21]A. Aslani and A. Mohaghar, "Business structure in renewable energy industry: Key areas," Renewable Sustainable Energy Rev. **27**, 569–575 (2013).
[22]M. Z. Jacobson and M. A. Delucchi, "Providing all global energy with wind, water, and solar power, Part I: Technologies, energy resources, quantities and areas of infrastructure, and materials," Energy Policy **39**, 1154–1169 (2011).
[23]A. Aslani, M. Naaranoja, and A. Mohaghar, *Renewable Energy Industry: Business Aspects*, Encyclopedia of Energy Engineering and Technology, 2nd ed. (Taylor and Francis, 2015).
[24]Renewables Global Status Report, *REN21* (REN21, France, 2013).
[25]S. Zhang, W. Wang, L. Wang, and X. Zhao, "Review of China's wind power firms internationalization: Status quo, determinants, prospects and policy implications," Renewable Sustainable Energy Rev. **43**, 1333–1342 (2015).
[26]Wind Energy Statistics, Global Wind Energy Council, 2013, pdf available at http://www.gwec.net/wp-content/uploads/2014/02/GWEC-PRstats-2013_EN.pdf.
[27]J. G. Gosens and Y. L. Lu, "Prospects for global market expansion of China's wind turbine manufacturing industry," Energy Policy **67**, 301–318 (2014).
[28]G. Shrimali, D. Nelson, Sh. Goel, Ch. Konda, and R. Kumar, "Renewable deployment in India: Financing costs and implications for policy," Energy Policy **62**, 28–43 (2013).
[29]P. Purohit and T. C. Kandpal, "Solar photovoltaic pumping in India: A financial evaluation," Int. J. Ambient Energy **26**(3), 135–146 (2005).
[30]J. I. Lewis, "Building a national wind turbine industry: Experience from China, India and South Korea," Int. J. Technol. Global. **5**, 281–305 (2011).
[31]J. Mundo-Hernández, B. Alonso, J. Hernández-Álvarez, and B. Celis-Carrillo, "An overview of solar photovoltaic energy in Mexico and Germany," Renewable Sustainable Energy Rev. **31**, 639–649 (2014).
[32]C. Hünnekes and K. Plume, "Photovoltaic business in Germany–status and prospects, IEA," PVPS Annual Report 2013, pp. 55–57, see http://www.iea-pvps.org/index.php?id=6.