



Commercialization of renewable energy technologies: A ladder building approach



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ABSTRACT

The objective of this study is to investigate how different renewable energy technologies (RETs) can be effectively commercialized in Finland. The country, not being endowed with natural reserves of hydrocarbons, is striving to increase the share of renewable energy generation in its primary energy supplies. Finland has long been involved in the development and innovation of technologically advanced products and services. The recent economic meltdown and decline in the information and communication technology (ICT) sector have triggered the inevitability of developing a sector that can serve as the backbone of the economy in the years to come. Clean technologies offer an excellent opportunity for a technologically advanced country like Finland to become a key player in the emerging market. The country has excellent standing when it comes to innovation input, innovation culture and public R&D in clean technologies; however, it lags behind when it comes to the commercialization of these novel technologies.

This study aims to address the problem by investigating questions such as: What are the key factors that influence the commercialization of RETs in Finland? How do technological, regulatory and market-related factors affect the widespread adoption of RETs in Finland? The study also highlights the significance of support mechanisms and suggests the improvements required, at the micro-level (firms) and macro-level (policies, regulation and infrastructure), to develop a successful RET market in Finland. The findings of the study are presented against the backdrop of existing literature, energy policies, and the data collected from the energy experts in academia, technology firms, utility companies, investment firms, and regulatory bodies. The study has thus identified the factors that are central to the acceleration of RETs commercialization in Finland. Based on the findings, the study presents a comprehensive framework for the commercialization of RETs in Finland.

1. Introduction

Commercialization is considered to be the most important [1–3], and at the same time, least developed part of innovation management [4,5]. The literature is full of evidence indicating the significance of commercialization in the technology's success or failure [6–9]. The successful conversion of an idea into a product or technology is extremely challenging [10]. A staggering number of inventions have failed to become successful products due to a weak commercialization strategy [11,12]. A study conducted by Cierpicki et al. estimated the failure rate of commercialized products to be over one-third of all those introduced in the western economies [13]. Similarly, Stevens and Burley have demonstrated that out of a hundred small R&D projects, only one or two reach the market-launch stage and become successful [14].

Research, development and the introduction of new technology in the market are a costly business, consuming a significant proportion of a firm's

resources. The process becomes even riskier if the technology in question is high-tech and the company has invested a significant amount of time and resources in the development process. Chakravorti [15], Chesbrough and Rosenbloom [16] have explained that the resources commitment and the stakes involved make the process pivotal for companies, as it is the stage where the product is launched into the market, exposed to the customers, and is expected to generate revenues. A product's penetration into the market and its success or failure is heavily dependent upon how efficiently the whole process has been carried out. Perez-Bustamante affirms that mastering commercialization is of utmost importance, as it is the last stage of the product innovation chain, through which an innovation is transformed into the final product and becomes a part of mainstream economic activity [17]. According to Aalam et al. commercialization guarantees that the product not only fulfils performance and reliability requirements, but also meets consumer demand and is available at reasonable prices [18]. It is further argued that the successful commercialization process can be a key

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for companies to maximize return on inventions, gain competitive advantage and explore opportunities for trade and market expansion [19].

A significant number of market failures are attributed to the lack of a strategically devised commercialization process, and its significance highlighted by the practitioners are no secret [20]. However, a number of companies, one way or another, tend to find themselves trapped in this phase. This leads us to ask if companies and executives underestimate the importance of commercialization during the technology development phase. The answer to this question in most cases will probably be in the negative. An online survey of over 2000 executives from around the world, working in a wide range of industries, regions, areas of expertise, tasks and responsibilities, found that a significant portion of the professionals considered the step crucial for a company's success and growth [21]. However, more often than not, companies leave a loophole in the process, which can then lead to the failure of the technology in the market. Acknowledging the importance of the process yet failing to deliver has raised researchers' interest in the topic and has prompted them to investigate the reasons behind such failures.

Commercialization, by its very nature, is a complex and multifaceted phenomenon, requiring extensive research and understanding of the business environment before it can yield the required results. Due to its overlapping nature and the interaction of various actors, players and stakeholders in the process, the phenomenon has been studied through the lens of economics, entrepreneurship, innovation, marketing, transition management, strategic management and international business. This multidisciplinary nature has encouraged researchers of diverse backgrounds to study the process from different perspectives, such as technology development, sociological aspects, socio-technical systems, marketing, consumer behaviour and finance.

Rogers [22] defines commercialization as the conversion of an idea to the product or services for sale in the marketplace. Siegel et al. [23] describe commercialization as the process of converting a new product, processes, and related know-how into a profit-generating venture. According to Aarikka-Stenroos and Lehtimäki [24], commercialization can be seen as the marketing of the innovation with the objective of converting it into a profit-making proposition. Balachandra et al. explain commercialization as a process of bringing technology from the laboratory to market acceptance and use. Furthermore, the notion is unfolded as the formation of a market that can sustain and thrive on its own, without backing and support, on a level playing field with competing technologies, thus helping technologies to avoid being trapped in the 'valley of death'¹ [25]. Cooper has introduced a seven-stage model, asserting that the process starts with the generation of the idea followed by preliminary assessment, concept and product development, trial production and lastly the commercialization phase where the product is launched in the market [1]. Vijay elaborates that commercialization is an arrangement between the key process (imaging, incubating, demonstrating, promoting and sustaining) necessary to develop and sustain the product in the market, combined with sub-processes, facilitating the transition by mobilizing essentials to ensure success at each phase [2].

Contrary to the belief that commercialization is an integrated aspect in each stage of new product development – from idea generation to the product launch and the subsequent sustaining of the market, scholars such as Koen et al. [26], O'Conner et al. [27], and Booz, Alan and Hamilton [28] have considered commercialization as the final stage of product development, predominantly dealing with measures such as marketing strategies and their implementation, introduction of the product to market and the launch of the technology. However, findings of recent research have highlighted that many decisions and activities seemingly performed in the earlier phases of the development process do have an impact on the overall commercialization and

success of a technology [29], strengthening the argument that the process evolves simultaneously and commercialization and product development are interlinked [3,24]. In the light of the above-mentioned definitions, irrespective of the orientation towards the phenomenon-stage based approach or the process-driven approach, it is obvious that a scientific discovery or an invention does not become an innovation until it has been successfully commercialized [19,30], diffused [22,31] and sustained in the market [2].

The process of commercialization can be tiresome and lengthy, as can be observed in the cases of the jet engine, television and fluorescent lamps, where it took a number of years² before these technologies were actually commercialized [32]. These cases reveal that it is not just the scientific discovery or the benefit a technology offers that will ensure its success or rapid adoption [33]. There are a number of forces at play that determine the future of a technology [34]. There have been cases where technologically advanced products were overshadowed by inventions that were considered inferior in terms of technological capabilities and benefits, but had benefited from a better commercialization process [9,35]. This leads us to the discussion of what companies should do to avoid failures and achieve success. According to Zahra and Nielsen [36], the commercialization of a technology can be improved by developing efficiencies in the technology development process. Overall success lies in the sum total of successes achieved at each stage of the new product's development [2].

Ettlie [37] emphasized that an organization should be strong when it comes to core knowledge and organizational capabilities [38]. Many authors have embraced the issue and have studied the ways through which competencies can be developed at the firm level [39,40]. According to Teece et al. [39], capabilities can be enhanced by developing the skills and knowledge of the personnel involved, bringing improvements in the overall processes, systems and equipment. Smith et al. [41] have emphasized that the knowledge and expertise of the individuals can lead firms to gain competitive advantage. Menon et al. elaborate that developing the culture of innovation [42] and engaging creative individuals who have diversified knowledge and skills can enhance overall efficiency [23]. In addition to developing internal capabilities, it may also be a good idea to involve external partners in order to augment the skills-base, bridge any gaps, and gain complementarities. A study conducted by Manoukian et al. [43] highlights that the engagement of an external partner can help in developing the process and improving the overall performance of the organization. Chen [44] and Snow et al. [45] have shown in their studies that the organization attained success by integrating an external partner in the development process. Being part of ecosystems [46] and obtaining the services of business incubators [47], an accelerator programme [48] and facility parks [49] can also help companies develop the product further and ensure the efficient use of the resources. Universities and research centres are home of innovative ideas and creative minds. Collaboration with academic institutions and research centres can be very useful in the development and successful commercialization of technology [50]. Similarly, the involvement of venture capital organizations can also be useful in improving the overall process of commercialization [46]. Small- and medium-sized companies often find themselves in a situation where they are lacking the financial resources to perform necessary product development features and launch the technology in the marketplace [51]. Cooperation with such organizations will not only help address the financial issues, but can also complement the firm with the skills and knowledge necessary to commercialize the technology successfully.

It is equally important to have the right dissemination scheme in place. This aspect of a commercialization strategy is more concerned with how the technology should be launched in the marketplace. The literature

¹ In transition from the demonstration to the commercialization phase where the cost of production is higher and the market penetration is low.

² 79 years for the fluorescent lamp, 22 years for the television and 14 years for the jet engine

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