

Review

# Renewable Energy Entrepreneurs: A Conceptual Framework

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**Abstract:** The adoption of renewable energies contributes to sustainable development worldwide. Entrepreneurs are key agents in facilitating their promotion, as they improve the mix of the means of production and thus transform renewable energy technologies into viable energy systems. Nonetheless, the literature tends to treat entrepreneurs as a homogeneous group, thus preventing comprehensive understanding of their motivations, behaviors, capabilities, and effects. This study addresses this research gap by identifying and categorizing the various characteristics of these entrepreneurs and developing an integrated classification method. Four examples of renewable energy entrepreneurs, in China, Denmark, Germany, and India, are analyzed according to the proposed classification method, while demonstrating their differences. Thus, through proposing a new analytical typology, this study improves our understanding of renewable energy entrepreneurs and their significant role in the promotion of renewable energy worldwide.

**Keywords:** renewable energy; entrepreneurs; energy transition; entrepreneurial heterogeneity

## 1. Introduction

Evidence across the globe indicates that renewable energy (RE) is gradually substituting mature energy systems that are often based on fossil fuels [1]. RE currently accounts for 18.2% of global energy consumption and 26.5% of global electricity production [2,3]. While RE technologies vary, they have several major advantages with sustainability aspects over fossil fuels systems [4–6]. RE relies on non-perishable resources [7], produces very low to zero greenhouse gas emissions [8–10], and reduces emissions of other pollutants that harm the environment [11–13]. Nevertheless, RE technologies also suffer from several drawbacks: most notably, they are often less cost-effective than fossil fuels systems in terms of energy efficiency, financing, economies of scale, and land use [14–16].

Promoting RE technologies therefore requires innovation which enables RE to gradually become more efficient, economically viable, cost-effective, and environmentally sustainable than their fossil rivals [17,18]. While state regulations often play an important role in the promotion of RE technologies, entrepreneurs are key agents for their advancement [19]. RE entrepreneurs improve the mix of the means of production and thus constitute a significant link in facilitating the transformation of innovation-based RE technologies and their transition into viable energy systems [20].

Despite the importance of entrepreneurs for promoting RE, the academic literature has tended to address them as a single homogeneous group of profit-seeking and business-oriented actors, paying insufficient attention to differences in entrepreneurial agency and its implications for RE

advancement [21,22]. This knowledge gap has resulted in a lack of understanding of the different motivations, behaviors, capabilities, and effects that form RE entrepreneurship. Due to the centrality of entrepreneurs in promoting RE, an exploration of their heterogeneity is essential for better understanding RE diffusion.

Based on a systematic review of academic literature, this study addresses this gap by identifying the characteristics of various RE entrepreneurs and proposing a classification method that illustrates their different profiles. This classification method demonstrates that RE entrepreneurs are, in fact, heterogeneous actors marked by different characteristics, motivated by diverse incentives, exposed to different risks, and making use of a range of innovations to promote RE. The classification is based on analytical analysis, intentionally broad enough to include and represent various types of entrepreneurs even if they work in different countries, under different regulation systems, and in varying circumstances. It therefore avoids definitional constraints such as existing legal definitions of RE entrepreneurs. The novelty of the study, therefore, lies in the introduction of a comprehensive and integrated framework for RE entrepreneurs' analysis. Since the diffusion process of RE depends heavily on entrepreneurs, the proposed typology examines and sheds light on another angle of this process and thus contributes to its better understanding. By so doing, the study also strengthens policymakers' capabilities of shaping appropriate regulations to promote RE, based on different entrepreneurs' characteristics.

The study starts by introducing the concept of RE entrepreneurs and examining their characteristics: their motivations, sectors, structures, scopes, capabilities, risks, and innovations. This is followed by a section proposing a classification method illustrating the entrepreneurs' different characteristics, which constitutes their unique profiles. The next section presents the examples of several RE entrepreneurs in four different countries and demonstrates their classification according to the proposed method. The paper ends by highlighting the contribution of this study to academic literature and suggesting directions for future research.

## 2. RE Entrepreneurs

Entrepreneurs are essential economic agents, responsible for providing different goods or services by combining various means of productions, usually through innovative mechanisms [23,24]. RE entrepreneurs are, therefore, the agents that promote and establish RE facilities in practice [19,20]; it is they who carry the various risks associated with the process while also being its main beneficiaries [25–27]. They do this by optimizing the mix of the means of production (e.g., capital, natural resources, labor force, and capabilities) and thus promoting viable RE systems while harnessing varied innovations [21,22,28].

Unlike many other entrepreneurs in various fields (e.g., finance, real-estate development, etc.), the uniqueness of RE entrepreneurs lies in the broad heterogeneity of their characteristics, as discussed in the following section. For example, RE entrepreneurs are not motivated just by financial incentives but possibly also by energy-utilization, environmental, and social incentives [29]. Another example relates to the fact that RE entrepreneurs are not an exclusively private sector phenomenon, as public sector and third sector entrepreneurs, such as state-owned enterprises and cooperatives, can also be important RE entrepreneurs [30]. Hence, despite commonalities in their promotion of RE, RE entrepreneurs should not be regarded as a homogenous group. Rather, they are defined by the characteristics that distinguish them from one another, classified as external influential factors, motivations, functional features, risks, and innovations. These various characteristics of RE entrepreneurs have been separately discussed in several studies (e.g., [20–22]), but for the first time, they have been systematically synchronized into one coherent and unified conceptual framework, which is based on an extensive literature review.

### 2.1. External Influential Factors

There are a several external factors that influence RE entrepreneurs while also distinguishing them from one another. RE entrepreneurs operate in different countries and regions under a range of

regulatory, political, economic, and physical systems that affect their promotion of RE facilities. First, regulation is a significant factor that determines “the rules of the game”; in other words, it dictates the entrepreneurs’ degree of freedom and limitations to act [31–33]. Regulation systems vary between countries and regions and may also differ in the way they are applied to different types of entrepreneurs in the same region, thus raising entrepreneurs’ adaptation costs [14–36]. Belarus is an example of the constraining effect of regulation on RE entrepreneurs, as the entrepreneurs are not free to choose RE customers, and therefore their capacity to operate is limited [37].

Political and economic environments can also significantly impact RE entrepreneurs. This may include the level of democracy and economic liberalism as well as other factors such as economic growth rates, the prices of fossil fuels, solar panels, or wind turbines, and more [31,38,39]. For example, countries with liberal market economies, such as Germany, the United Kingdom, and the United States, tend to show a greater range of RE entrepreneur types with greater degrees of freedom than countries with more centralized and regulated economies, such as China or Russia. Liberal economies usually have a wide range of actors in finance, consultancy, construction, among others, while in non-liberal or developing economies, entrepreneurs tend to be more homogeneous and less enterprising [40–42].

Finally, physical conditions, such as access to natural resources, considerably affect the activities of RE entrepreneurs and the promotion of RE across regions. The ability of any entrepreneur to promote RE facilities depends on the existence of suitable physical conditions, as RE projects require optimizing the use of natural resources. Without suitable sun, wind, or water sources, most entrepreneurs will be unable to promote relevant RE facilities [3,6]. For example, RE entrepreneurs in Norway have traditionally avoided promoting solar facilities due, primarily, to the insufficient solar radiation [43].

## 2.2. Motivations

A main inherent distinction between different entrepreneurs relates to their motivations, i.e., the incentives encouraging their involvement in RE projects, which relate to financial, energy-utilization, environmental, and social aspects. RE entrepreneurs are usually driven by more than one type of motivation and differ in the way they prioritize the various motivations [17,20,44]. The complexity of the incentives and their different relative weights in driving RE entrepreneurs can be analytically represented in the following prototypes.

### 2.2.1. Financially-Oriented Entrepreneurs

Financially-oriented entrepreneurs are motivated by financial incentives for promoting RE facilities. These incentives refer to profit-seeking through the sale of energy or other means such as cost savings originating in self-consumption, land lease payments for establishing RE projects, and thermal energy use for industry purposes (i.e., cogeneration) [45–48]. For example, Danish financially-oriented entrepreneurs have made the local wind energy industry a world leader, with the support of suitable government regulation [49,50]. Although financial incentives primarily characterize private sector entrepreneurs, many other RE entrepreneurs also strive to generate financial profits and might cancel RE projects in their absence. For example, in Ontario, Canada, a public entrepreneur, aiming to establishing a 100-million-dollar wind farm, canceled the project despite its energy and environmental advantages as it was not financially profitable [51].

### 2.2.2. Energy-Oriented Entrepreneurs

Energy-oriented entrepreneurs are motivated by energy-utilization incentives, namely, their desire or need to use the produced energy. Ultimately, this motivation characterizes all types of RE entrepreneurs as it represents the baseline rationale for all RE projects [52,53]. However, different entrepreneurs might prioritize this motivation differently; self-consuming RE entrepreneurs, for example, often prioritize this motivation over others [46,54,55]. One example of this can be found in Spain, where many communities have begun, with the support of a new designated government regulation, to promote RE facilities for purposes of self-consumption [56].

### 2.2.3. Environmental-and Sustainability-Oriented Entrepreneurs

Environmental- and sustainability-oriented entrepreneurs seek to be involved in RE projects in order to produce clean energy, reduce pollutant emissions, and advance climate change adaptation and mitigation efforts. For example, the government of India has established several wind farms in an attempt to reduce pollutant emissions and the ecological footprint of the Indian subcontinent [57]. When considering their environmental externalities, some entrepreneurs are aware that RE facilities can be more cost-effective than conventional electricity means [58–61]. For example, in Germany, many RE entrepreneurs are driven by environmental awareness rather than pure financial calculations, and this affects their business considerations [62].

### 2.2.4. Socially-Oriented Entrepreneurs

Socially-oriented entrepreneurs are motivated by incentives that relate to aspects such as job creation, socioeconomic improvements, and others [39]. The Maranchón wind farm in Spain is an example of an RE project that has created jobs in a remote and peripheral location with limited employment opportunities, thus benefiting the community partner-entrepreneur [63]. Furthermore, by establishing RE projects with the involvement of different communities, community members can work together toward common goals while strengthening social ties, thus further motivating community entrepreneurs to establish RE projects [64–68]. Nevertheless, in most cases (with international development being an exception), social motivations do not stand alone and are likely to be accompanied by other motivations. In the United Kingdom, for example, thousands of "green" jobs have been created as part of community RE projects, motivating community entrepreneurs to promote more RE projects in order to form new employment opportunities and to enjoy the accompanying financial, energy, and environmental benefits [69,70].

## 2.3. Functional Features

RE entrepreneurs may also vary according to various functional features which ultimately shape their involvement in RE projects. These features include their sector, the organizational structure and scope of their territorial activity, and their capabilities.

### 2.3.1. Sector

Entrepreneurs may be associated with different sectors, each with unique characteristics. Since the public sector is financed by the general public, it is accountable to a wide and diverse target audience and assumed to represent public interests, which may not align with business interests [71–73]. The private sector usually places greater emphasis on profit maximization, has better business capabilities, and is committed to its shareholders and investors [29,31,74]. The third sector is known for its commitment to social and environmental causes which often compete with business interests [75–77]. Some entrepreneurs may be associated with several sectors, including local communities that establish private companies to promote their self-interest in RE projects. For example, the local community of the Isle of Wight, UK, owns the Wight Community Energy Company which has established several solar farms [78]. Similarly, there are entrepreneurship that are based on the collaboration of entrepreneurs from diverse sectors [79]. One example is the town of Yarmouth in Massachusetts, USA, where a private entrepreneur has joined a third sector cooperative called CVEC in order to initiate RE projects [80].

### 2.3.2. Structure and Scope

RE entrepreneurs may differ in their organizational structures: for example, individuals, communities, companies, non-profit associations, government agencies, etc. (e.g., [81–84]). They may also differ in the scope of their territorial activity: for example, local, nationwide, interstate, global, etc. (e.g., [85–88]). In this context, there are many examples of collaborations between local and global entrepreneurs, each with their respective advantage [79]. While small local entrepreneurs are usually

knowledgeable about the environment, the local population, and other conditions relevant for the project, large international entrepreneurs may have more resources, particularly financial resources, as well as extensive knowledge and experience [13,69,89]. For example, in Germany, community entrepreneurs use their local advantage for promoting RE projects, working either separately or jointly with large international companies that exploit their large-scale competitive advantages [62,90,91].

### 2.3.3. Capabilities

Lastly, RE entrepreneurs are also characterized by different capabilities in terms of their fields of specialization (e.g., financial abilities, natural resources accessibility, operation and maintenance, knowledge, regulation familiarity, community relations, business connections, etc.) and experience (e.g., a single project or several projects). These capabilities may relate to specific types of projects or certain RE technologies: for example, an entrepreneur may be an expert in solar panels but have little expertise when dealing with wind turbines [5,39,92]. In some cases, different entrepreneurs, such as local communities and private companies, may collaborate in order to maximize their capabilities and expertise for the establishment of RE projects [79].

### 2.4. Risks

RE entrepreneurs face different risk exposures according to their particular characteristics (e.g., sector, scope, capabilities, etc.), the project's characteristics, and their level of competence in the project [42,93–95]. They also differ in their risk aversion levels, which leads them to take part in projects with varying degrees of risk [74,96,97].

The main risk facing RE entrepreneurs concerns the possible gap between expected and realized energy production [5,42]. For example, several large wind farms in Germany were found to generate less electricity than predicted due to the high density of the wind turbines, and thus alternative solutions needed to be found [98].

Other significant risks relate to financial losses. Possible financial losses or lower than predicted profits might deter any RE entrepreneur [93]. In some cases, profits might only be reduced, but in others, they might cause the entire project to be canceled [94,99,100]. For example, in Saudi Arabia, the largest planned solar project in the world was canceled due to the high financial risks [101]. Entrepreneurs sometimes collaborate in order to share the financial risk [79]. An example of such collaboration is in the community of Feldheim in Germany, which relies entirely on RE for its energy needs. In order to reduce the significant financial risks, the community partnered with several private companies, which serve as co-investors while also sharing the risks [39].

Regulation is another potential source of entrepreneurial risk. RE systems are based on supportive regulation that enables their physical and financial establishment. Regulatory changes may require costly technical adjustments, which can lead to the cancellation of entire projects [34,35,40]. For example, a 2000 MW wind farm planned in Oklahoma, USA, was canceled after the regulator, American Electric Power, changed the initial regulatory requirements [102].

RE projects might also pose several environmental risks for entrepreneurs, especially when they themselves are located in the projects' surrounding environment, as is the case with community entrepreneurs. Although RE facilities tend to be more environmentally friendly than conventional means of production [103,104], they might still be responsible for environmental hazards such as landscape destruction, increased noise, and river flow disturbance. In some cases, the entrepreneurs themselves suffer from these hazards, while in other cases they may be required to compensate those affected [95,105,106]. For example, in Latin America, several hydropower facilities have caused unrepairable environmental damage, placing various communities at risk as they serve as both the projects' entrepreneurs and clients simultaneously [107].

Lastly, RE entrepreneurs might be exposed to social and business-related risks. RE projects can be canceled due to business disputes caused by the respective partners' different goals, unfair profit distributions, exposure to hazards, and others [108–110]. Social issues might pose risks to entrepreneurs when local residents oppose the construction and operation of RE infrastructures in their proximity in order to avoid associated negative effects or externalities [111,112]. For example, the establishment of the Swaffham wind farm in the United Kingdom was nearly canceled due to major disputes between private entrepreneurs and local residents who opposed the project due to hazards associated with the wind turbines [113].

## 2.5. Innovation

Promoting RE technologies requires entrepreneurs to innovate in order to make RE more efficient, economically beneficial, cost-effective, and environmentally sustainable [17,18]. Innovation can be defined as the introduction of something new in the form of devices, methods, or actions [114,115]. Even though RE entrepreneurs are not necessarily the sources of the innovation, they are the main agents who identify and harness various RE innovations—be they financial, energy-utilization, environmental, or social innovations—in order to promote RE systems [18,20,21].

### 2.5.1. Financial Innovations

Different innovations, related to financial issues, enable entrepreneurs to promote RE by influencing RE's cost-effectiveness and prices [116–118]. First, the reduction in the manufacturing costs of RE technologies has enabled entrepreneurs to promote such technologies by offering energy prices that are lower than fossil fuels systems [119,120]. An example of this can be found in the low prices of photovoltaic panels. Many of these panels are mass produced in China due to technological innovations that simplify the production process [121], thus enabling RE entrepreneurs to offer cheaper solar energy prices all over the world [122–125]. Moreover, innovation improves the efficiency of renewable systems, i.e., more energy is produced from the same facilities [126–128]. Wind turbines are one example; their characteristics, for example, aerodynamic capabilities, have improved significantly in recent years, thus enabling RE entrepreneurs to offer more efficient energy production than in the past while also influencing international wind energy prices [129].

### 2.5.2. Energy-Utilization Innovations

Innovation is also associated with significant improvements related to energy utilization. First, innovation enables RE entrepreneurs to produce energy from various previously unexploited sources [130–132]. For example, in recent years, significant progress has been made in energy production from sea waves in Greece, Spain, Italy, China, and elsewhere [133–137]. Second, innovation improves energy usability, influencing the quality and quantity of the energy produced by RE entrepreneurs [138–140]. For example, there have been significant improvements in storage facilities, enabling RE entrepreneurs to control the timing of RE production while limiting the dependency on external factors such as wind speed and solar radiation [105,141]. Third, innovation enables RE entrepreneurs to reach remote areas that have poor or no connectivity to electricity grids [16,142,143]. For example, remote villages in developing countries, such as India, rely on off-grid RE facilities for electricity in a way that was not possible a few years ago [144–146].

### 2.5.3. Environmental Innovations

Innovation also makes RE more environmentally sustainable [147–149]. First and foremost, through innovation, RE entrepreneurs can promote RE facilities with reduced emissions of pollutants and greenhouse gases (GHGs). Because they produce few or no GHG emissions, RE systems have emerged as popular energy alternatives for climate change mitigation [8–10]. One example is the use of landfill biogas for electricity generation, which contributes to the reuse of pollutants such as methane [150–153]. Moreover, innovation also enables RE entrepreneurs to promote decentralized RE infrastructures

that can reduce environmental damage relative to larger centralized facilities [104,154,155]. Since RE systems tend to be more decentralized and diversified than fossil fuels systems, relying on them also reduces the vulnerability to extreme climate change-related events and contributes to climate change adaptation strategies [156–158]. One example is the promotion of multiply mini-hydroelectric facilities which decrease river flow disturbance more than large-scale hydroelectric facilities, thereby reducing the overall environmental damage [159–161]. Innovation also enables the reduction of other negative environmental aspects such as landscape destruction or noise pollution [95,106,111]. For example, the noise of the Gamesa wind turbine in Zaragoza, Spain, was reduced for the sake of local residents and animals [162].

#### 2.5.4. Social Innovations

Finally, RE innovation can enhance social acceptability [108,109]. Despite broad positive societal views on the desirability of RE infrastructure, such projects often face local opposition due, mainly, to the hazards they may cause, which can vary by their scope and level of influence, as well as by other variables, such as the characteristics of the impacted population [111,163]. While some hazards, such as noise disturbance often influence only the adjacent populations [162], other hazards, such as landscape destruction can influence a much larger and distanced populations [112]. Further, while some of these hazards may have a minor influence on various populations, such as in cases of smell disturbance [164], other hazards, such as river flow intervention, may have a wider effect on the local population's quality of life, including with regard to employment and food sources [107]. Thus, by reducing the impact of these hazards, as a function of their influence, RE innovation can help entrepreneurs gain local support, e.g., [104,154,155]). In Pakistan, for example, innovative mini-hydroelectric facilities minimized river flow disturbance and reduced the damage to the local residents, thus mobilizing their support [165]. Moreover, through innovative compensation mechanisms, entrepreneurs can increase the social acceptability of RE facilities by local residents. Such practices are found in various RE projects worldwide, for example, in Columbia, and involve the compensation of local communities in an attempt to increase social acceptability [113].

### 3. Profiles of RE Entrepreneurs

The previous discussion suggests that while entrepreneurs are RE promoters, they also differ in several aspects; they are thus not homogenous and, instead, form a heterogeneous and diverse group of actors. The four main inherent characteristics differentiating between them include their motivations, their functional features (consisting of four sub-characteristics: sector, structure, scope, and capabilities), the risks they face, and the innovation they harness to promote RE. Figure 1 illustrates these various characteristics and their possible components while outlining key external influential factors (regulation, political and economic climate, and physical conditions).

The capital letters in Figure 1 (i.e., A–G) represent the characteristics of RE entrepreneurs, and the numbered, lowercase letters represent the specific components of these characteristics. As discussed earlier, RE entrepreneurship is, in reality, more complex and diversified; here, it has been simplified somewhat for analytical purposes. For example, entrepreneurs may be influenced by several components, such as an entrepreneur who has both financial (a1) and environmental (a3) motivations. They may, however, also be characterized and influenced by a single component: for example, a private entrepreneur (b2) who is unrelated to the public (b1) or the third (b3) sectors. Furthermore, different components may characterize entrepreneurs at a specific point in time and for a specific RE project. For example, entrepreneurs can acquire capabilities over time, such as experience in operation and maintenance of RE facilities (e3). Another example may relate to the risks (F) RE entrepreneurs face and the innovation methods (G) they use, which may also change over time or between projects. Figure 2 represents an illustration of the profile of a random, hypothetical RE entrepreneur according to the above classification.

Figure 2 depicts an example of a hypothetical RE entrepreneur. The different rows in the figure represent the entrepreneur’s characteristics, divided into their various possible components. Different background textures are used to represent the status of the characteristics’ components: if a certain component completely applies to the entrepreneur then it is presented with a smooth grey background; if the component only partly applies, it is presented using a dotted background; and if the component does not apply or rarely applies then it is presented with a white background. As can be seen, this hypothetical profile represents an entrepreneur who is strongly motivated by financial reasons (a1), while its energy (a2), environmental (a3), and social (a4) motivations are of lower prioritization. Being perhaps part of a partnership, this private sector (b2) entrepreneur also has limited connections with the public (b1) and third (b3) sectors. This entrepreneur is organized in a corporate structure (c3) whose activities are mostly in the local regional scope (d1) with some being nationwide (d2). The entrepreneur has an equal mix of the different significant capabilities, including financial (e1), natural resources accessibility (e2), operation and maintenance experience (e3), regulation knowledge (e4), and business skills (e5). In the project illustrated in this example, the entrepreneur faces, primarily, financial risks (f1), followed by energy production risks (f2), and much lower environmental (f3), social (f4), and regulation (f5) risks. Finally, this entrepreneur mobilizes more financial (g1) and energy-utilization (g2) innovations to promote RE facilities but also uses some environmental (g3) and social (g4) innovation mechanisms.

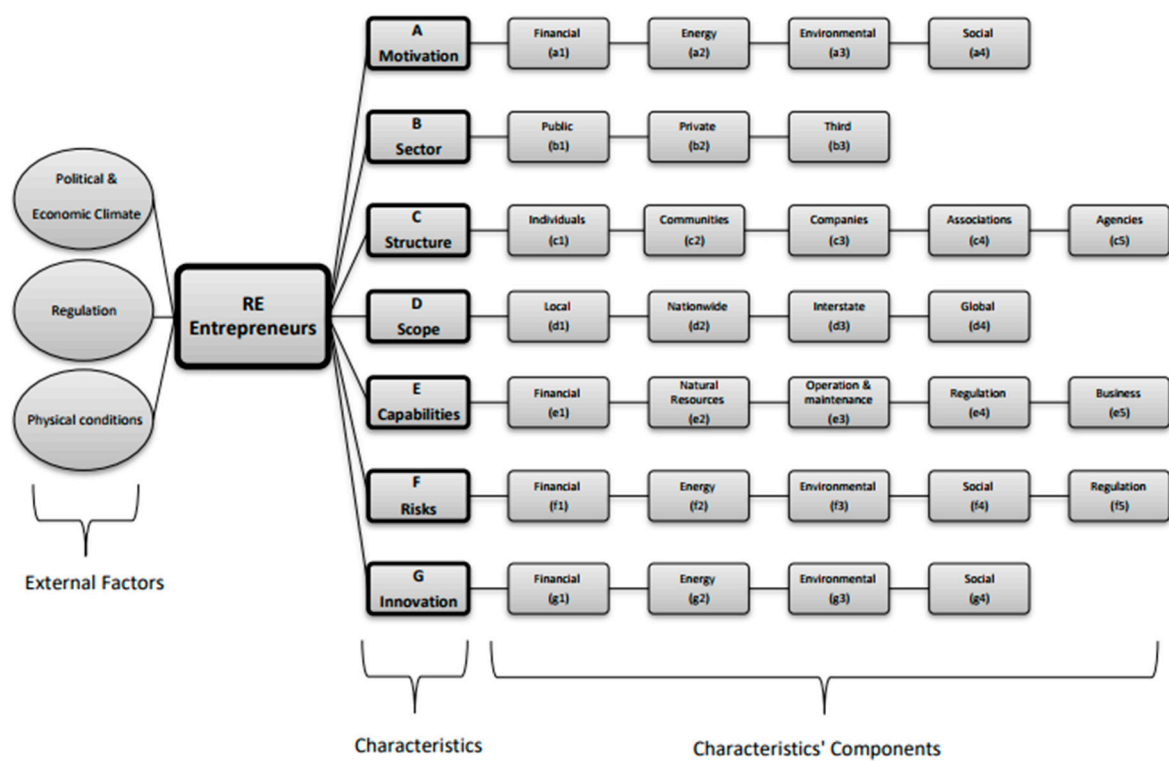


Figure 1. Profile structure of RE entrepreneurs.



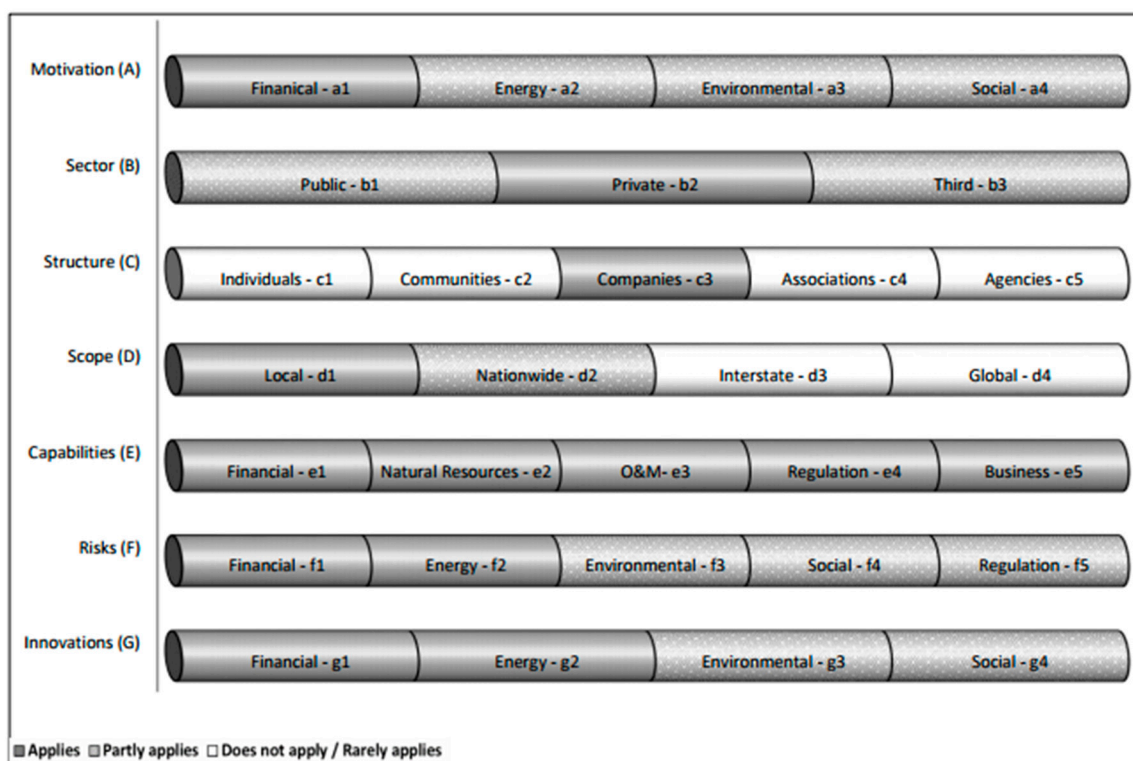


Figure 2. Schematic profile of a hypothetical RE entrepreneur.

#### 4. RE Entrepreneurs: Four Examples

In the following section, four real-world examples of RE entrepreneurs will be presented in order to illustrate the proposed classification method. While these examples do not represent the whole spectrum of RE entrepreneurs, they nevertheless characterize common types of RE entrepreneurs and support diverse illustrations. The information regarding the various RE entrepreneurs is based on their own reports as well as on different external sources, including academic publications and professional and government reports. While each of the four RE entrepreneurs is discussed, examined, and classified according to their own unique characteristics, it should be noted that the graphical figures are schematic in their essence, and are aimed to illustrate the described classifications.

##### 4.1. State Utility Entrepreneurs: The Case of China’s State Grid Corporation

The State Grid Corporation of China is the largest electric utility in the world in terms of workforce, budget, and grid length. Its main responsibilities are to maintain, extend, and operate the national electricity grid. Nevertheless, the state utility also has an important role in implementing Chinese environmental policy through the promotion of RE. In this context, it serves as an entrepreneur promoting RE projects including the establishment of several large-scale hydropower facilities as part of an expensive mega project [166–170].

Despite its name, and as depicted in Figure 3, the Grid Corporation serves more as a state agency (c5) than as a private company (c3), as it is completely owned by the Chinese state (b1). Being a nationwide state utility (d2), the Grid Corporation enjoys many advantages such as regulation adaptation made especially for its operation (e4), significant access to public financial resources (e1), and access to natural resources (e2). Furthermore, thousands of skilled workers provide it with high operation and maintenance capabilities (e3) [166–170].

The main aim of the Grid Corporation’s RE projects is to reduce air pollution in a country where this has been a long-term problem (a3) and to provide electricity to the country’s fast-growing population (a2). In order to do this, this Chinese entrepreneur fosters energy (g2) and environmental

(g3) innovation to produce clean energy using high-end technology, which has become much cheaper in the last few years thanks to recent developments (g1). Nevertheless, the Grid Corporation faces several risks: the risk of failing to improve the environmental situation in China due to the poor air quality (f3) and the risk of sub-supplying electricity to the ever-growing population (f2). Figure 3 schematically illustrates the Grid Corporation’s RE entrepreneur profile [166–170].

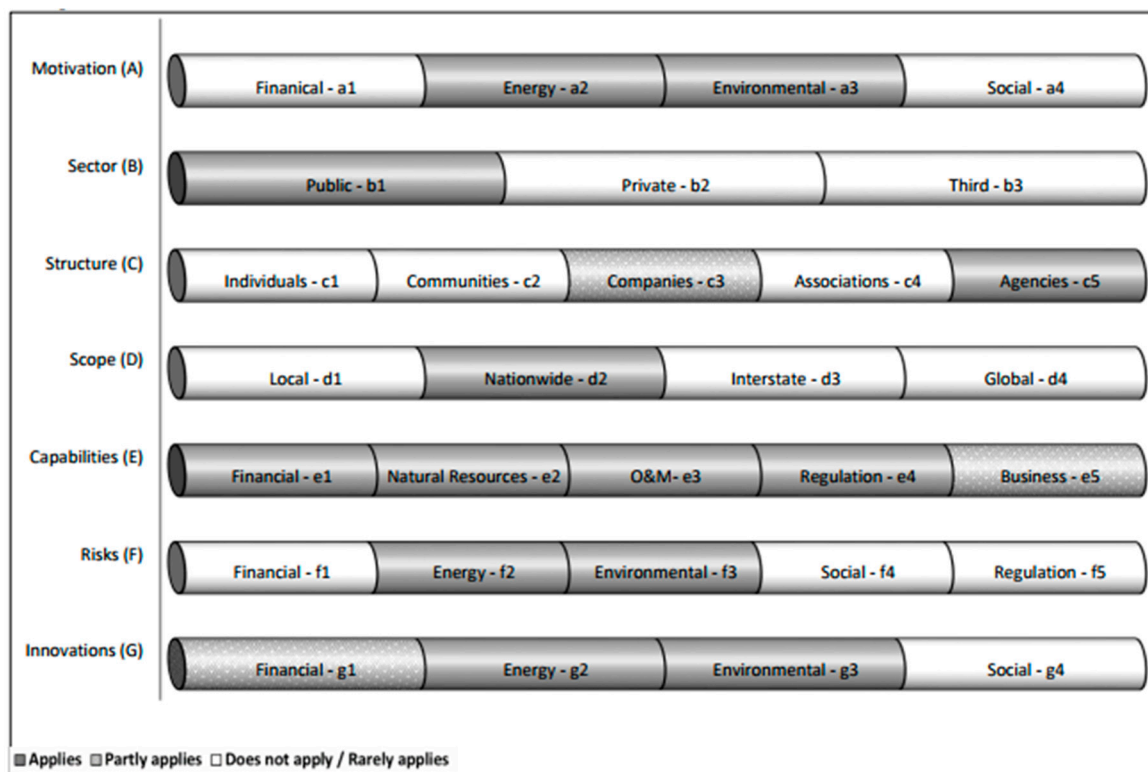


Figure 3. Schematic profile of the State Grid Corporation of China.

#### 4.2. International Entrepreneurs: The Case of Ørsted

One example of an international RE entrepreneur is Ørsted, the largest Danish energy company, which operates in numerous countries and employs thousands of workers. Ørsted has set up hundreds of RE projects with an installed capacity of more than 35,000 MW, using diverse RE technologies, most notably wind power [171–177].

The company’s stocks are divided almost equally between the Danish government (b1) and other private holders (b2), thus allowing the government to keep its interests with regard to environmental and sustainability issues (a3). Nevertheless, similar to other listed energy companies (i.e., companies whose shares are listed on a stock exchange), this company (c3) is obligated, primarily, to provide financial profits for its stockholders (a1) through the sale of clean energy (a2), also allowing it to demonstrate high financial capabilities (e1). As one of the world’s leaders in promoting wind energy, Ørsted is known for using cutting-edge innovative technologies for energy-utilization (g2) and environmental aspects (g3), also enabling it to provide the lowest possible energy prices (g1). The extensive activity of this RE entrepreneur across Denmark (d2) as well as in other European countries (d3) and on other continents (d4) has provided it with notable experience in the operation and maintenance of diverse RE facilities (e3). This has also made the company highly skilled in operating in different business environments (e5) [171–177].

Nevertheless, operating in different countries requires the company to adjust itself to different regulatory environments which pose risks (f5). In addition, due to its multi-country operation, the company has to cope with diverse social risks. These risks (f4) are caused by the potential

environmental hazards of wind turbines (f3). This issue has led the company to adopt several social innovative mechanisms, focusing on compensating local populations as well as increasing local involvement in the projects (g4). Figure 4 schematically illustrates Ørsted’s RE entrepreneur profile [171–177].

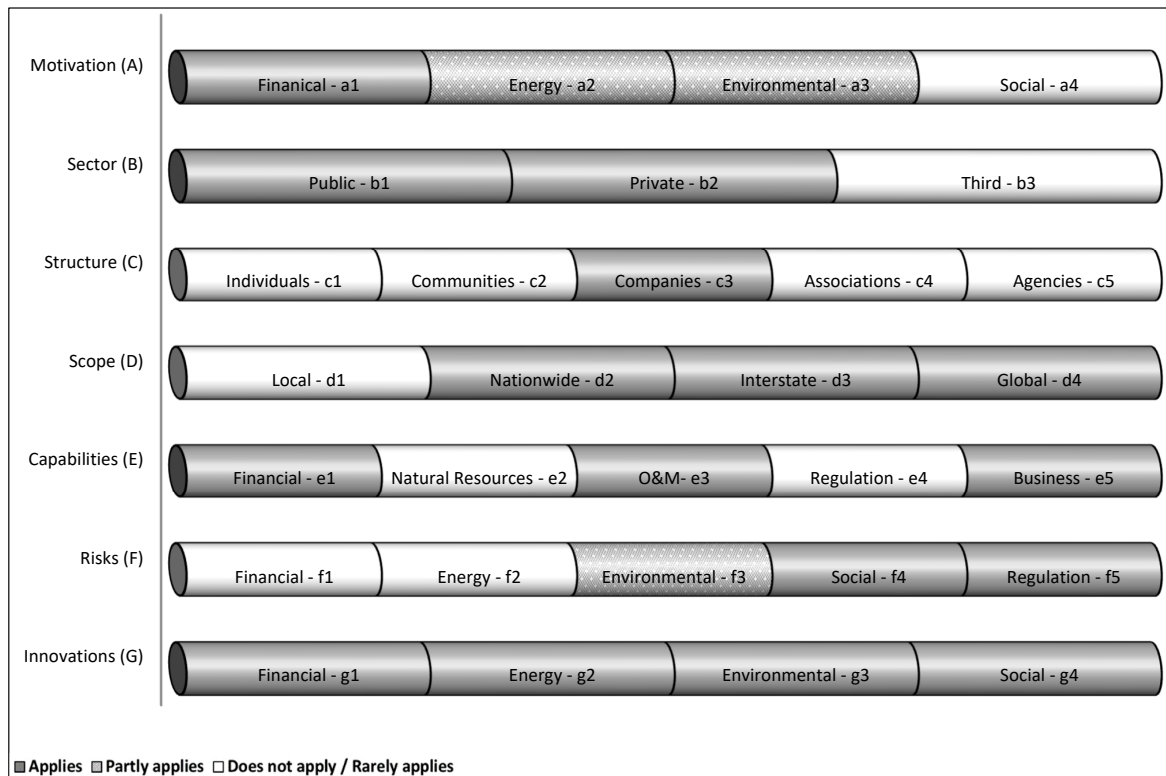


Figure 4. Schematic profile of Ørsted.

### 4.3. Self-Consuming Entrepreneurs: The Case of Germany

Self-consuming RE entrepreneurs are a common phenomenon in Germany [90,178–182]. German individuals (c1), communities (c2), and small companies (c3) promote solar panels or small wind turbines in order to meet their own energy needs (a2) and enjoy some financial benefits (a1). These self-consumption RE facilities also contribute to global efforts that aim to reduce the GHG emissions of the electricity industry (a3) [90,178–182].

These local entrepreneurs (d1) often have direct access to natural resources (e2), which is a necessary condition for the establishment of RE facilities. High accessibility to natural resources alongside with extensive knowledge of the projects’ local environment provide these entrepreneurs with some advantages concerning their business skills in the relevant RE projects (e5). Due to their operation in a well-developed renewable energy market, these entrepreneurs also have access to high-end innovations which facilitate the promotion of their projects in financial (g1), energy (g2), environmental (g3), and social (g4) aspects [90,178–182].

However, due to their limited size, the involved entrepreneurs may face significant financial risks (f1), which could prevent their facilities from producing electricity (f2) or seldom force them to establish facilities that are less environmentally friendly than desired (f3). The lack of relevant resources might also make it hard for these entrepreneurs to adapt to regulation changes (f5). In addition, because of the local nature of the relevant RE projects, their facilities are usually established in proximity to local communities, which might raise risks of social unacceptability (f4). In order to try and overcome some of these issues, these local initiatives are often based on different levels of collaboration between private (b2) and public (b1) actors in an attempt to increase the capabilities and resources of the partners

while also reducing their risks. Community–private sector partnerships are one common example of such collaborations. Figure 5 schematically illustrates the profile of German self-consuming RE entrepreneurs [90,178–182].

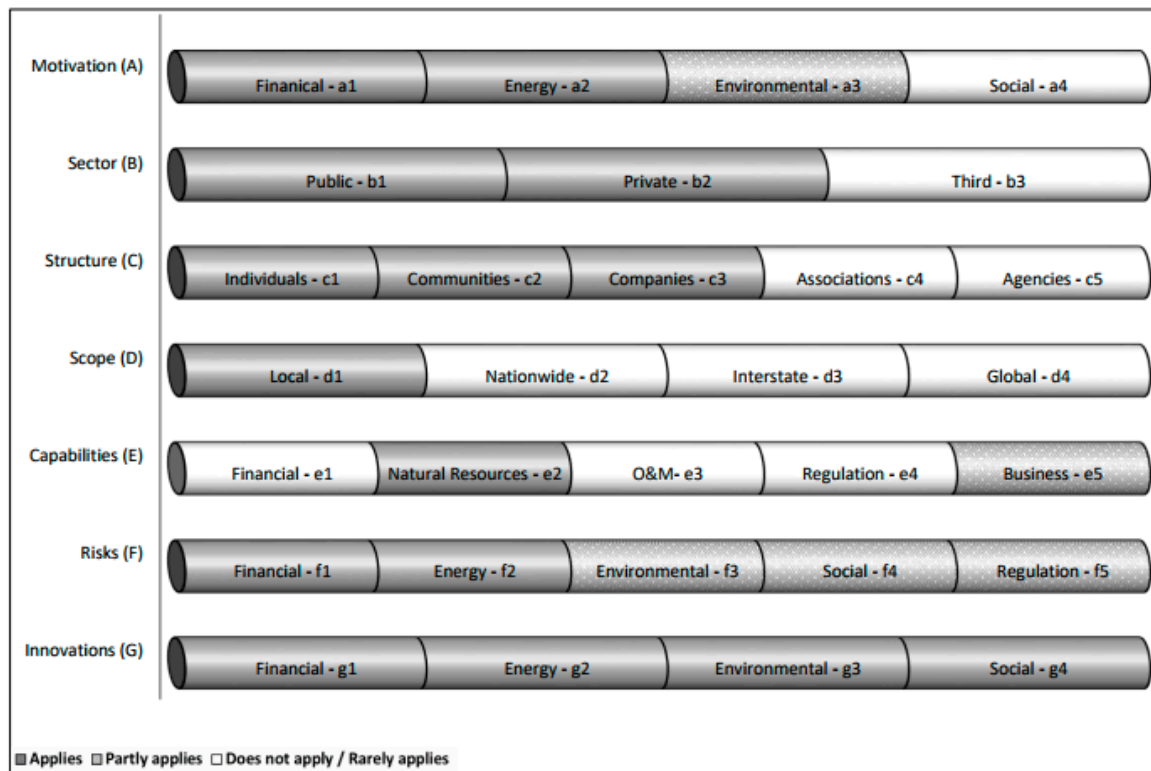


Figure 5. Schematic profile of German self-consuming entrepreneurs.

#### 4.4. Third-Sector Entrepreneurs: The Case of India

Several third-sector RE entrepreneurs (b3) operate in India to assist local women to establish RE facilities (e.g., Barefoot College, Greenpeace, BASIX, SSP), with some support from local governments (b1) and private actors (b2). A significant aim of these entrepreneurs is to strengthen the status of these women (a4) while also providing them with some financial means (a1). These initiatives also help to provide electricity to many of India’s poor rural areas (a2), as most of these entrepreneurs operate in the local scope (d1), while others operate across the entire country (d2) [183–190].

The primary capabilities of these entrepreneurs relate, on the whole, to their experience in doing business across India’s rural regions (e4) and their knowledge of local regulations (e5). These third-sector entrepreneurs try to establish numerous collaborations in order to enhance other relevant capabilities, most notably in finance (e1), engineering (e3), and natural resource accessibility (e2). Such collaborations may include key individuals (c1), local communities (c2), private companies (c3), other third-sector associations (c4), and relevant government agencies (c5) [183–190].

The main risks these entrepreneurs face relate to the failure to produce electricity in remote rural regions (f2), which might pose financial risks (f1) as well as some social risks (g4) caused by the frustration of local residents. In order to avoid these risks, the entrepreneurs use energy-related innovation, which enables them to generate electricity in remote regions (g2), financial innovation (g1), which enables them to establish relatively low-cost facilities, and social innovation (g4), which introduces energy to the local population and enhances the social acceptance of the RE facilities by the population, which is often deterred by external intervention. Figure 6 schematically illustrates the profile of certain third-sector RE entrepreneurs in India [183–190].

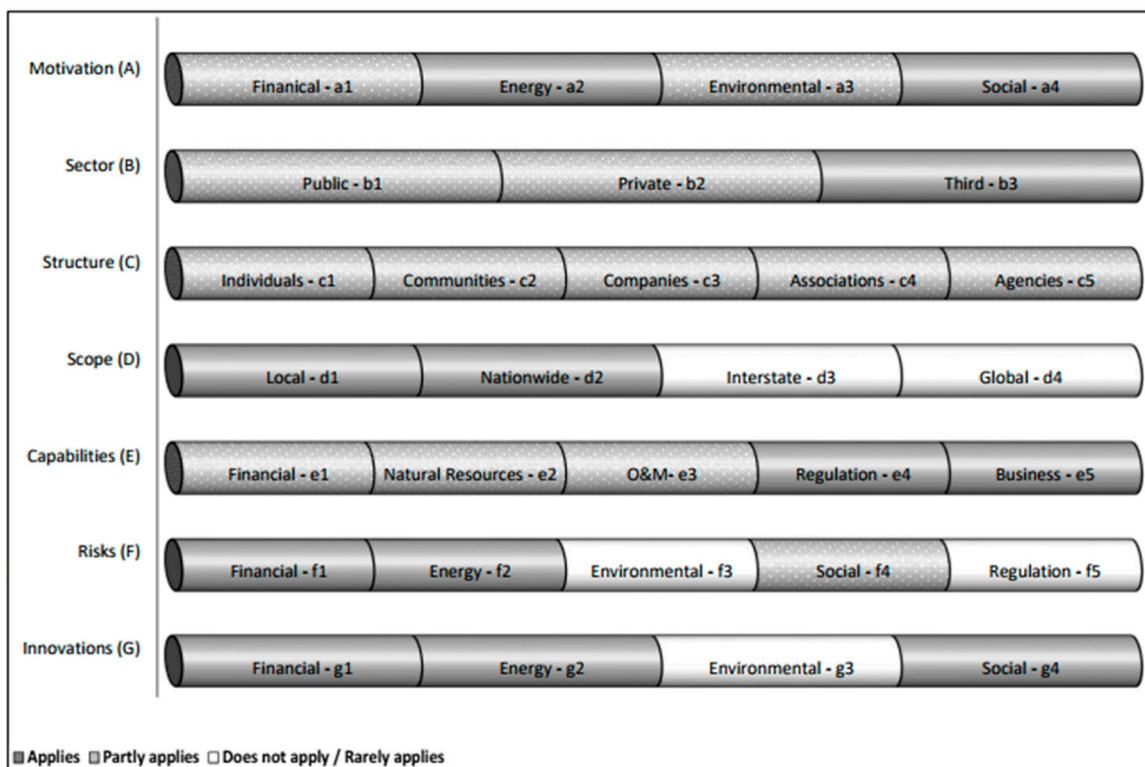


Figure 6. Schematic profile of Indian third-sector entrepreneurs.

### 5. Conclusions

Entrepreneurs are key agents in promoting RE through the harnessing of different innovations. They thus advance RE technologies and have a significant role in broader RE diffusion processes [19–21] in which various technologies (e.g., solar, wind, hydroelectric) are adopted [3,31]. Nevertheless, despite this important role, academic literature has paid these entrepreneurs insufficient attention, thus limiting comprehensive understanding of their different motivations, behaviors, capabilities, and effects by addressing them as a homogeneous group. This study has addressed this gap by identifying the characteristics of various RE entrepreneurs and proposing a classification method that illustrates their different profiles.

Building theory regarding RE entrepreneurs requires the consideration of a wide range of cases and experiences. Although the classification of RE entrepreneurs alone does not constitute theory, it advances the foundation for generating principles for further theoretical development. In examining RE projects and experiences in a wide range of cases, we see that RE entrepreneurs are very diverse. We suggest that efforts to categorize them need to take account of external factors (i.e., regulation, political and economic climate, and physical conditions) and of four main groups of characteristics: motivations, functional features (including four sub-groups: sector, structure, scope, and capabilities), risks, and innovation. Through examining the divergence among RE entrepreneurs, it is clear that this is not a unitary phenomenon. Developing theory to both explain and describe the phenomenon requires considerably more case-study information as well as regional, national, and internationally comparative work in the years to come. This paper contributes to the effort by identifying and discussing some of the key factors that differentiate RE entrepreneurs.

The suggested typology, aimed to classify RE entrepreneurs, has been demonstrated via four distinct examples of RE entrepreneurs: the State Grid Corporation of China, the Danish company Ørsted, self-consuming entrepreneurs in Germany, and third sector entrepreneurs in India. These four examples of RE entrepreneurs highlight several notable findings. First, despite the tendency to link entrepreneurs from different sectors to specific motivations, the reality is often more nuanced. The motivations of

various entrepreneurs do not always correspond with the expectations stemming from their sectorial affiliation. This possible mismatch between sectors and motivations contributes to the heterogeneity of RE entrepreneurs. For instance, it appears that private-sector RE entrepreneurs can also have environmental motivations (e.g., the case of Ørsted), while third-sector RE entrepreneurs can also have financial motivations (e.g., the case of Indian third-sector entrepreneurs). In this regard, an issue for further exploration relates to the question of whether or not a positive relationship exists between the operation scope of RE entrepreneurs and their capabilities. In this study, local entrepreneurs' capabilities have been found to be mostly associated with place-oriented features (e.g., the natural resources accessibility of self-consuming entrepreneurs in Germany); while RE entrepreneurs, with a wider scope of operation, have been found to possess some capabilities, which are less place-dependent in their nature (e.g., the financial capabilities of the State Grid Corporation of China). These various differences between RE entrepreneurs often encourage them to collaborate, as part of various partnerships, in order to harness their varied capabilities, as shown in the case of Indian third-sector entrepreneurs. The formation of different partnerships between various RE entrepreneurs can also be the result of their efforts to share their risks, often stemming from the use of innovative methods, such as in the case of self-consuming entrepreneurs in Germany.

This study, therefore, contributes to the literature in several manners. First and foremost, it provides a comprehensive and integrated classification method, which illustrates RE entrepreneurs' varying profiles, based on the identification of their different characteristics. In so doing, the study also lays the foundation for a research framework regarding entrepreneurs influence on RE diffusion. Since the diffusion process of RE depends also on the role of entrepreneurs [19], their varied characteristics should be taken into account when analyzing this process. This analysis should also take account of other factors shaping RE diffusion, which are often discussed by the literature, such as regional scopes, RE technologies, etc. e.g., [3,91,117,119]. Moreover, the study illuminates how the characteristics of RE entrepreneurs may have a significant influence on the social acceptance of RE projects, in addition to other factors discussed by the literature, such as the type of RE technology or population features e.g., [92,101,102,125]. Since social acceptance of RE projects depends heavily on community trust [191], the characteristics of RE entrepreneurs may play a significant role in this matter (e.g., local entrepreneurs' RE projects may enjoy a higher social acceptance rather than global ones).

This study also contributes to several key players. In this framework, it provides policy-makers with an improved set of tools to make informed decisions regarding the promotion of RE, though the adjustment of their policy to the specific characteristics of the relevant RE entrepreneurs. Further, it provides various RE entrepreneurs with a better understanding of their peer-entrepreneurs and their different behaviors and capabilities in a manner that may serve as a basis for possible collaborations. Finally, the study contributes to the general public, whether as part of its role as the consumer of RE, as the financier of government RE subsidies, or as the landlord or various RE facilities, by improving the comprehension regarding the diversity of RE entrepreneurs and regarding the need to approach each entrepreneur according to his/her own unique characteristics.

Nevertheless, additional attention should be given to several issues. First, as a theoretical study, this study lacks in-depth empirical examination of RE entrepreneurs (e.g., interviews, surveys, large-scale data analyses, etc.). As a result, the classification of the various RE entrepreneurs has to be substantiated and quantified. In this framework, the typological framework suggested in this paper can serve for future empirical testing of the relationship between RE entrepreneurs' characteristics and success and failure to meet the goals of RE projects as viewed from the perspective of various stakeholders. Such an analysis can contribute to better matching decisions in the setup of RE partnerships. Second, since the proposed classification is based on aggregated evidence from many places and cases across the globe, the study avoids thorough discussion of unique or nontraditional cases. Further, the study lacks a temporal dimension regarding the evolution of RE entrepreneurs over time, as well as regarding the interactions occurring between the RE entrepreneurs themselves, or between RE entrepreneurs and other actors (e.g., regulators, commercial banks, etc.). In this respect, it should be examined

whether RE entrepreneurs' profiles, in a particular location, social, economic, cultural, policy context, and time, tend to converge or rather differ one from another, while increasing their entrepreneurial heterogeneity. Finally, future studies should also examine more thoroughly whether and to what extent the characteristics of various RE entrepreneurs influence the actual features of the RE diffusion process around the globe, as well as the social acceptance of RE projects by different communities and regions.

In conclusion, by identifying and classifying the heterogeneity of RE entrepreneurs, this study has turned the spotlight on these important players, while illuminating their great diversity, and has thus paved the way for a better understating of their varied role as part of the global process of RE diffusion.

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