

**Crowdfunding for renewable and sustainable energy projects: an
exploratory case study approach**

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Abstract

Global warming has become one of the major challenges faced by the world today. Use of renewable energy can help mitigate the adverse effects of climate change and environmental pollution. However, owing to high up-front costs and the risk of commercializing renewable energy initiatives compared with conventional technology, a barrier exists in securing financing of renewable energy projects. This article aims to explore the knowledge of the emerging crowdfunding in general and more specifically, to focus on how best to employ this new funding source for renewable and sustainable energy projects. Firstly, incorporation of literature findings is undertaken from two fields: crowdfunding and renewable energy development. A case study approach is employed to demonstrate how crowdfunding has been applied in renewable projects. Eight international cases were chosen to represent various crowdfunding models that differ in terms of reward and returns associated with the investment. Crowdfunding can play a significant role at the start of a renewable and sustainable energy project's life-cycle. A variety of crowdfunding approaches may be used to finance the early stages of renewable energy development, particularly when stakeholders are the beneficiaries, or the concerned groups related to environmental protection and sustainability. Crowdfunding is also suitable for supporting research and development efforts of innovative green technology start-ups. This article introduces crowdfunding as a new source of green financing and gives evidences for using crowdfunding in renewable and sustainable energy development, in comparison with other funding sources

Keywords- Renewable energy development; crowdfunding; sustainability; green financing

1. Introduction

Global warming has become one of the major challenges faced by the world today. Human activities, such as burning fossil fuels and deforestation, intensify climate change due to greenhouse gas (GHG) emissions. Use of renewable energy can help mitigate the adverse effects of climate change and environmental pollution. Since renewable technologies are still relatively new, the research and development efforts aimed at their further exploitation require significant investments. However, due to high up-front costs and the risk of commercializing renewable energy initiatives compared with conventional technology, a barrier exists in securing early financing of renewable energy projects in the built environment [1].

In principle, there is a variety of financing sources to raise fund at early stages of renewable startups, such as business angels (individual rich persons aiming at high returns from early-stage ventures), venture capital and private equity (usually firms comprising of fund managers investing in startups in growth stage on behalf of their limited partners). However, owing to the risky nature of renewable energy (RE) projects and a lack of collateral at the early stage, RE start-up entrepreneurs cannot assemble debt finance from banks or venture capitalists easily. Although renewable projects may exhibit the potential to attract business angel investors, they require additional capital and time to develop new technologies compared to conventional fuel projects. In addition, it takes time and efforts for entrepreneurs to identify and locate appropriate business angels for investment since they are unlikely to disclose themselves [2]. In the past few years, crowdfunding has been increasingly used as an alternative means of financing to the traditional funding tools in the renewable energy arena, enabling entrepreneurs to develop renewable projects with a degree of independence that is not commonly considered for bank financing or investment by large financial institutions. Crowdfunding enables entrepreneurs to develop their businesses gradually, or else scale up their operations quickly through share placement in order to attract venture capital funds at the early-stage. Crowdfunding not only bridges the gap for innovative early-stage businesses but also offers opportunities for further venture capital investment [3]. The extensive application of world-wide web, coupled with growth in the use of social media, has made crowdfunding a promising and effective way to raise donations and more recently as a source of finance for clean energy and sustainable development projects.

The current paper aims to explore the fundamentals of the emerging crowdfunding phenomenon in general and more specifically, to focus on how best to employ this new funding source for renewable and sustainable energy projects. Its objectives include: (a) introducing crowdfunding as a prelude in a finance supply chain for start-up and innovative businesses in the RE sector; and (b) comparing crowdfunding with other means of financing RE startups. In the following sections, relevant literature will be reviewed to discuss the key issues in crowdfunding. Case studies will be employed to demonstrate how crowdfunding

may be applied in renewable energy projects. Subsequently, the research findings will be analyzed and conclusions will be drawn.

2. Literature Review

2.1 Definitions of Crowdfunding

Crowdfunding is “a collective effort by consumers who network and pool their money together, usually via the internet, in order to invest in and support efforts initiated by other people or organizations” [4]. Powers [5] describes crowdfunding as “a financial mechanism that allows startup companies to solicit funds from the general public through website intermediaries”. It is “an open call, essentially through the Internet, for the provision of financial resources either in the form of donation or in exchange for some forms of reward and/or voting rights in order to support initiatives for specific purposes” [6]. Projects and businesses are funded by collection of contributions from a multitude of individuals, enabling innovators, entrepreneurs and business startups to make use of their social networks to raise capital [7]. Valanciene and Jegeleviciute [8] describe crowdfunding as “a method to establish the connection between entrepreneurs, who aim to raise capital, and novel investors, who form an emerging source of capital and are willing to invest small amounts, through internet-based intermediaries”. In an entrepreneurial context, Mollick [9] refers crowdfunding as a funding approach by entrepreneurial individuals and groups for their ventures by tapping on relatively small contributions from a large number of individuals using the internet, without the assistance of financial intermediaries. The last point about the absence of financial institutions as intermediaries distinguishes crowdfunding from capital or loan market activities. Golic [10] concluded that crowdfunding is an outgrowth of social media, and is a system that requires close cooperation between three participating parties – *entrepreneurs*, investors (crowdfunders) and intermediaries (crowdfunding platforms). Each party has a mission that brings them together to achieve a commonly desired goal. Individuals, SMEs, non-governmental organizations (NGOs) usually play the role of the entrepreneur. Through crowdfunding, entrepreneurs not only raise funds for their projects/businesses from a large group of individuals but also test their business ideas. Crowdfunding allows entrepreneurs to gain feedback on some critical attributes of their new product before releasing them into the public marketplace [7]. Investors, the so called “crowdfunders”, converge as *a large pool of members of the general public* [2]. They may be ordinary people who do not possess the competence of professional investors [10]. Crowdfunders recognize the potential of a project or consider certain ideas promising and thus they invest a small financial resource each. Crowdfunders receive either non-financial benefits or financial compensation in return for their contributions. The rewards for the investors in crowdfunding can be social return, products or services, financial return or refund [7]. A crowdfunding platform is a virtual electronic intermediary between the entrepreneurs and investors, through which all communications and fundraising take place [10]. According to Valanciene and Jegeleviciute [8], there are two types of crowdfunding platforms depending on the way of money collection.

One type of crowdfunding platform keeps the funds in a special escrow account and if the target amount of funds has not been collected, the money is paid back to investors, whereas in another type of crowdfunding platform, entrepreneurs retain all the proceeds.

2.2 Comparison of Crowdfunding with other financing means

As mentioned above, a variety of financing sources exist for the development of RE projects. Table 1 shows the different sources of finance which may be accessible to RE entrepreneurs in an innovative project cycle, starting from the nascent stages. The major benefits and limitations from the entrepreneurs' perspective are summarized with relative applicability shown for different stages of business development. Initial funding for the concept design and R & D works usually comes from personal sources, i.e., a combination of founders, family and friends, or government grants [11,12]. Seed funding is drawn from business angels for prototyping and commercialization [13]. Once the project has been proven feasible with sufficient market growth, venture capitalists and private equity investors are engaged [14]. These investors may exit once the conditions for bank loans are ripe (assets being available as collaterals), for which interest payments need to be expended on a contractual basis, with maturity periods being extendable upon renewals. The entrepreneurs may use some equipment on lease terms by paying rent. When profits are stable for meeting the requirements of stock exchanges, initial public offers may attract public subscription of shares, which is the most expensive form of finance in the long run. Finance stemming from carbon-trading may come in for projects proven to reduce emissions (feasibility subject to prevailing carbon credit prices), but transaction cost is always high [15]. Feed-in tariff or government subsidies may be available when the RE technology matures and the resulting power can be put on grid. Whilst these alternative ways of finance provide commercial benefits (which may dwindle in financial crises as seen in 1997-2003 in Asia and then from 2007-2010 worldwide) for the participants, crowdfunding fills in the gap and add legitimacy and public support to sustainable development projects such as RE, especially in the early stages [16]. Given their reliance on technology and the absence of physical infrastructure, crowdfunding platforms have an advantage over financial institutions in that they have low fixed and transaction costs, the saving of which may be passed on to entrepreneurs and investors.

(Insert Table 1 here)

Literature has it that traditional financing models such as the Pecking Order Theory still holds largely true for established firms [17], in that owners prefer the use of internal funds first, followed by external debt and lastly external equity due to the avoidance of loss of control. Yet, from a sample of 5,000 startup firms, it was found that heavy reliance was put on external debt rather than friends and family-based sources [18]. Another interview-based regression study of 1,214 entrepreneurs yields the conclusion that novice owners may prefer equity to debt, which they feel a personal burden, hence setting a limit to offering collaterals even if available [19]. Hence, crowdfunding suits these alternative situations since different models may be adopted before the company is fully established.

2.3 Crowdfunding Models

Crowdfunding can be categorized as either donation-based, reward-based, equity-based, or lending-based depending on the funding purpose and investment method [3]. Donation-based crowdfunding is used by non-governmental organizations (NGOs) for funding project and core costs [7]. It can also be used to finance social gain activities and innovative projects. NGOs have used the donation-based crowdfunding to attract donations for their missions or projects for more than a decade. Funders donate without expecting monetary compensation. The difference between traditional fundraising and donation-based crowdfunding is that unlike the former focusing on organizations, donations are called for in the name of a specific project in crowdfunding [7]. Reward-based crowdfunding is commonly used by entrepreneurs who need to raise funds for a campaign and has been increasingly used in the pre-sale of customer-oriented products and services [20]. Crowdfunders may receive a token gift of appreciation for backing a project or pre-ordering a product or service. In pre-ordering crowdfunding, a funder pays an entrepreneur in advance, who uses the money as working capital to make the products or provide the services. Lending-based crowdfunding uses an online platform that matches lenders with borrowers in order to provide unsecured loans [21]. The borrower can either be an individual or a business requiring a loan. Lenders obtain a fixed-interest debt, providing for repayment of principal according to an agreed schedule [3]. A crowdfunding platform sets the interest rate, which is usually higher than the saving rates available to the lenders and lower than a traditional loan available to the borrowers. Equity-based crowdfunding is defined as an offer of securities for sale by a private business to the general public, often through an online platform [22]. Investors may subscribe for shares in private businesses not yet listed on a stock exchange, thereby acquiring small parts of the equity stake through the crowdfunding platform. In addition, a crowdfunding platform offers a direct interaction opportunity with both the potential investees and like-minded investors. There are some differences between equity-based crowdfunding and investment into public companies on stock markets. Private companies raising funds via equity-based crowdfunding do not have to comply with stringent reporting standards, while share acquisition through the stock exchange entails full compliance by publicly listed firms. Furthermore, there is no direct interaction in stock market and access is granted only to authorize brokers and listed companies complying with formal requirements.

According to Kirby and Worner [21], reward-based and donation-based crowdfunding may be collectively referred to as “community crowdfunding”. These two models of crowdfunding represent ways of fundraising for charitable causes or creative projects, or pre-paying for an innovative product being developed by a business. They do not provide any financial return through a yield or return on investment [23]. Equity-based crowdfunding and lending-based crowdfunding may be referred collectively as financial return crowdfunding [21] or investment crowdfunding [3]. Investment crowdfunding involves funding through debt securities, selling the intellectual property rights of firms as well as shares of ownership [3]. Fig. 1 briefly describes different types of crowdfunding models and further elaborations follow.

(insert Fig.1 here)

2.4 Motivation of Crowdfunders

The heterogeneity in crowdfunding models is related to the motivation of crowdfunders. Crowdfunding involves conventional investment decision-making and a host of psychological factors affecting charity-giving decisions [24]. Traditional investors are extrinsically motivated by the prospect of future financial returns, while charitable donors are intrinsically motivated due to psychological gains. Iyer and Kashyap [25] explored the influence of materialism, social investment efficacy, risk tolerance, environmental attitude, collectivism, and religiosity on non-economic objectives of the investors. They concluded that investors would mix financial gains with their non-economic objectives, and sometimes investors are willing to forgo financial returns to achieve social benefits. More specifically, according to DeBuysere [7], there are three kinds of motivation for individuals involved in crowdfunding: social return, material gain and monetary reward. The social return usually occurs in donation-based crowdfunding widely used by not-for-profit organizations [7]. Crowdfunders make only donation and feel satisfied without any kind of returns. The motivation of this type of crowdfunders is intrinsic. The donors are motivated by public recognition, self-esteem and satisfaction for one's own wellbeing [4]. In respect of material return, crowdfunders receive a non-financial benefit in return for their financial contribution. They are rewarded with a product or service in return in reward-based crowdfunding. The crowdfunder is bestowed with a reward having a higher perceived value than the actual economic value. On the other hand, in lending-based or equity-based crowdfunding, investors like the crowdfunding idea and invest to receive some financial return for interest or dividend pay-outs. Some funders are primarily motivated by the projects that manifest their common values, such as local community engagement. Other investors may have expert knowledge on certain products and want to deploy their funds and knowhow for enhancing the project's chance of success. Sometimes, in lending-based or equity-based crowdfunding, the investors are contented to receive service or products from the entrepreneurs, in lieu of a dividend or interest disbursement. To summarize, crowdfunders participate in donation-based or reward-based crowdfunding out of altruistic or normative motives, arising from their sense of belonging to a community [26] or the outcomes of the project [9]. On the other hand, crowdfunders in lending-based or equity-based models are mainly motivated by a prospect of financial returns.

3. Case Studies

This research employs a case study approach [27,28]. The case-study approach is suitable for investigating why or how phenomena occurred and the relationships among these phenomena [28]. Through case studies, one may better understand a novel phenomenon

and concept [27]. Given the complexity of crowdfunding alternatives, multiple cases were studied to demonstrate adequate robustness to depict the variety and distinct features of different crowdfunding models and the motivation of the crowdfunders [29]. The case studies were retrieved through desk research and selection was based on the ground that they were renewable energy projects. The selected cases depict the common features of crowdfunding and also include adequate contextual and structure diversity [21]. The use of multiple cases is based on the “theoretical replication logic” for producing contrasts in a cross-case way [28].

Driven by the above rationale, eight case studies were carried out to obtain a better understanding of crowdfunding within the context of renewable projects. They demonstrate the use of different types of crowdfunding models (as bracketed in the respective sub-headings) for financing climate mitigation actions across the globe:

3.1 Case A: Efficient Stoves to Protect Pandas by WWF, China (Reward-based)[31]

The WWF-China Giant Panda Program (GPP) Team targeted to raise USD 50,000 via a crowdfunding platform to build 100 highly energy efficient cook stoves for local households in a village nearby Giant Panda habitat in Sichuan Province of China. The project aimed to reduce the non-renewable biomass consumption by local households, by improving the efficiency of the cook stoves, saving surrounding forest areas and reducing CO₂ emissions. A conventional cook stove used approximately 30 tons of firewood every year per household. The deforestation and forest degradation caused by massive firewood harvesting have destroyed panda habitats, leading to the ecological biodiversity loss of the Giant Panda nature conservation areas. Being replaced with efficient stoves, wood consumption could be halved and air quality in homes was improved. This project also got Golden Standard credit in a Voluntary Emission Reduction scheme to offset carbon from the stoves. By the end of the campaign, the GPP team had raised USD 2,439 from 91 funders who were offered rewards such as Panda e-cards, Panda drawing, or Panda album etc. Since this was a scalable project, the building stoves were proportional to the fund that was raised from crowdfunding.

3.2 Case B: “A Flame Called Hope” by WWF Nepal (Donation-based)[32]

The Gold Standard Biogas Voluntary Emission Reduction (VER) Scheme dubbed as ‘A Flame Called Hope’ by WWF Nepal was aimed at raising USD 100,000 to provide access to clean and alternate biogas energy for 150 households in a village in Nepal’s Terai. Deforestation in the Terai Arc Landscape has become worse due to the rising demand for timber for daily use as fuel. The affordable and highly effective technology turned animal and human waste into biogas (a clean cooking gas) as a better alternative to wood. One biogas unit saves approximately 4 tons of CO₂ equivalent emissions. The Gold Standard Biogas VER Project was also a carbon-financing project that contributes to emissions reductions, bringing financial benefits to local communities. The carbon credit sale further sustained the implementation of the biogas project. By the end of the campaign, the WWF Nepal had raised USD 2,626 from 66 funders who received social recognition and thank-you cards as rewards.

3.3 Case C: Pay-As-You-Go Solar Energy, Tanzania (Lending-based)[33]

Via a crowdfunding platform with 91 investors USD\$15,000 loan has been raised to enable the production and sale of 1,000 Solar Home Systems to small-scale businesses and their families in Mwanza, Tanzania. More than 1/3 of the production costs were covered by raised loan. The target customers were small stall or shop owners who cannot afford connection to the electric grid. The “Pay-As-You-Go” photovoltaic technology enables users to pay cash-in-hand for the use of clean energy in an affordable manner. The investors received quarterly payment in fixed annual interest rate of 3.5% over a 12-month term. It is expected to improve the living of 4,000 people benefiting from solar energy annually. The household energy savings is estimated at USD\$5,000 for the first year and USD\$75,000 the second to the fifth year. The project would displace kerosene as the main lighting fuel and is slated to achieve an emission reduction of 100,000 kg of CO₂ annually.

3.4 Case D: SunnyMoney, Zambia (Lending-based)[34]

SunnyMoney is a UK-based subsidiary on charity which aims at replacing kerosene lamps with affordable solar energy products in Africa. The USD\$20,000 loan via a crowdfunding platform with 146 investors was used to supply 1,232 solar-powered lights. Through SunnyMoney’s solar school campaign, solar-powered lights were sold to students and families in the Copperbelt region of Zambia. The lenders received quarterly payment in fixed annual interest rate of 3.5% over a 12-month term. It is expected to improve the living of 6,776 people benefiting from solar energy annually. This would save an estimated USD\$149,072 in total energy cost and increase 12% of net income.

3.5 Case E: Brighter Schools, United Kingdom (Debenture)[35]

Brighter Schools plc has been set up via a crowdfunding platform to fund and own the installation of photovoltaic systems in schools of the United Kingdom. The installation is aimed at reducing the schools’ expenditure on energy and impact on the environment. The £216,000 raised was funded by 158 participants within two weeks, who paid for the initial solar power installations. Investors received an estimate return rate of 7.2 to 8.3% over an investment period of 20 years. The Feed-in Tariff and school payments for electricity generated were used to repay investors and provide the investment return. Furthermore, the project provides the learning opportunity for students being involved in renewable energy and sustainability project.

3.6 Case F: Resilient Energy Great Dunkilns, United Kingdom (Debenture)[36]

The Resilient Energy Great Dunkilns is a community wind energy project in the United Kingdom using debenture (a long-term loan) which is repaid the installments over a number of years. The project is the first Community Scale wind turbine to get permission in the Forest of Dean in Gloucestershire, England. The total investment crowdfunding was £1,400,000, provided by 425 investors within approximately four months. The turbine has been fully operated and generated electricity since October 2012. The amount of electricity generated by the wind turbine is 1,315 MWh for 317 households per year and saved 565 tons of CO₂

emission per year. The rate of return to the buyers of debentures is approximately 6.75% to 8.0% across the 20-year life of the project.

3.7 Case G: Caballero Fabriek by Solar Green Point, Netherland (Equity-based)[37]

Solar Green Point as a co-operative in the Netherland has installed 1,000 solar panels on the roof of the Caballero Fabriek (an old filter cigarette factory) in The Hague for a new form of solar panel owner collective. The total investment amount was about €500,000. The project was fully funded by 186 participants within 4 months. The participants are members of a co-operative, which will automatically be liquidated after 25 years. All the power generated by the solar panels is purchased by Eneco and feeds into the electricity grid. The generated electricity is sufficient for 80 households and leads to an annual reduction of CO₂ emissions by 133 tons. Each year Eneco pays the revenues from the solar panels to members of the cooperative. Participants who are Eneco's power customer are given the same amount per unit of electricity as what they pay for Eneco power they consume. Participants who are not Eneco's customers get the settlement based on an average market rate.

3.8 Case H: Wind Eeklo by Ecopower, Belgium (Equity-based)[38]

Ecopower cvba is a financing co-operative for renewable energy in Belgium. The Eeklo project by Ecopower involves financing of three wind turbines located in Eeklo, Belgium. The total investment was €4,090,000 and was raised by 1,825 members of Ecopower in approximately 5 years. Investors are only allowed to buy a maximum of 50 shares and given the right to one vote in the co-operative's General Assembly, irrespective of the amount of shares which they have. The price of a share in the co-operative is €250 and yields on shareholders' investments are capped at a maximum of 6%. Participants received a dividend on their investment or/and electricity from Ecopower.

4. Cross-case analysis

Table 2 summarizes the case findings, showing different types of crowdfunding reward and returns associated with the investment over a wide geographical spread at an ascending scale of total funds raised for each type.

(Insert Table 2 here)

Owing to the above-mentioned investment behavior and motivation for crowdfunders, the selected cases are categorized in accordance with the format suggested by Ordanini et al [4]:

- (1) Low risk model for investors expecting solely non-material return, and these are similar to charitable undertakings;
- (2) Low-to-medium risk models with a broad range of material return possibilities rewarding investors; and
- (3) High risk models with mainly financial returns for investors participating as if they were venture capitalists.

Fig. 2 shows the crowdfunding models of renewable and sustainable energy projects based on the risk and return intensity spectrum and the type of return.

(Insert Fig.2 here)

The decision for adopting the most suitable crowdfunding model for a renewable energy project revolves on several factors emphasizing on access to funding, cultural dimensions, and cash flow [3]. The nature and level of community benefits affect the choice of crowdfunding mechanism by the fund raiser [9]. Funders participating in the crowdfunding cases in this study were motivated in different ways when they contributed and invested. In *Case A* (Reward-based) and *Case B* (Donation-based), funders' desire to participate in the projects are motivated primarily by helping people in need of money for energy efficient technology and household appliances. The encouragement, support and financial assistance that an individual renders on a collective basis upon a needy entity are key purposes of the crowdfunding participation [4]. On the other hand, investors in *Cases C, D, E* and *F* (either lending-based or debenture-based crowdfunding) participated out of their wish to reap a financial return from their contributions, hence they made a non-trivial investment in renewable energy and sustainability projects. In *Cases G* and *H* (equity-based crowdfunding), the participants are attracted not only by the financial return for their investment but also the desire to be involved as shareholders of the companies. Looking at the total amounts of funding raised for the renewable and sustainable energy projects, differences in the level of financial efforts required for crowdfunding participation across the eight cases are highlighted. The initial capital requirements using donation-based and reward-based crowdfunding are relatively small, while the use of lending-based and equity-based crowdfunding requires larger amounts of up-front disbursement.

4.1 Donation-based and reward-based crowdfunding models

Donation-based and reward-based crowdfunding models seem to be suitable for small-scale renewable energy projects in remote areas and green innovation projects since they have a short time frame for delivery and small-to-moderate capital needs for initial development, whilst the technology is generally comprehensible to the average investor. Since providing

electricity to remote areas from centralized energy supply is expensive, most people living in rural areas, particularly in developing countries, have no access to reliable and affordable energy services [39,40,41]. Small-scale renewable energy generation and installation of dispersed renewable energy technology are more cost effective to provide electricity in remote areas [39]. However, the governments of developing countries are budget-constrained and most funds from international support are allocated to large-scale energy projects [40]. On the other hand, small-scale and community-based renewable energy projects are important to support the development for reaching the poor [41]. Based on these characteristics, donation-based crowdfunding may be used for supporting this type of sustainable energy projects in developing countries. Small amount donations are usually made because people feel compelled to support the projects. Startups using donation-based crowdfunding cultivate a suitable emotional relationship with their potential donors. As a matter of caution, there must be transparency and accountability on the usage of donated funds, which will otherwise discredit the charity missions which they purport to support. For example, investors are kept updated on their projects using crowdfunding platforms. Lehner [42] claims that crowdfunding creates a “buzz in the social media” to attract empathy from potential investors on the projects. Reward-based funding may supplement seed funding for projects utilizing green innovative products which have low capital intensity and have potential in solving economic, social, and geographical problems. Energy and climate technology should operate in the intended market, region and, in more abstract term, the ecosystem. In cases of lacking resources or insufficient media attention, crowdfunding platforms may help to raise funds from the “crowd” beyond the projects’ geographical boundaries. They can target small scale renewable energy projects in need of finance which may not be attained by traditional development agencies. Furthermore, they can channel small sums to otherwise unbankable projects in an incremental manner. This not only provides funding for social good but also builds support and engagement for green initiatives and innovations. It also encourages young people to take part in proactive engagement with the society. It is relatively hard to obtain funds from venture capitalists until the products have been fairly well proven. Entrepreneurs fund the seed capital through crowdfunding to create innovative green product and test market appetite. Despite the primary goal in raising funds, reward-based crowdfunding can also help companies market and promote their products; understand better the tastes of their consumers; or generate new ideas for products or services. As such, crowdfunding may be used for supporting user innovation or mass customization campaigns, or for gaining better intelligence of consumers’ preferences. Original ideas may also be validated by targeting at a specific audience.

4.2 Lending-based and equity-based crowdfunding models

Projects suitable for lending-based and equity-based crowdfunding include large-scale renewable and sustainable energy projects or those highly dependent on infrastructure provision with either substantial up-front expenditure and/or completion time. Crowdfunding for renewable energy has distinct advantages. Despite crowdfunding not being

ground breaking new, the increased usage of modern social media has given crowdfunding an enormous boost [12]. In crowdfunding, a large dispersed “audience” (the dedicated crowd) provides small sums of money large enough to fund a project or a venture [39]. Crowdfunders can fill a funding gap left by large financial institutions. In addition, it allows those otherwise excluded to be engaged in renewable energy projects using a simple investment approach. Individuals may invest into communities of their own and thus help to create sustainable economic health [55]. Community engagement with renewable energy development can build up community capacity, empower community and enrich social capital [43]. The participation of funds from the recipients and their involvement in the initial stages of energy supply projects enable the development of productive alternatives with a higher resource generating potential [44]. Such loans are backed by a revenue-producing asset, and lenders contribute financially for a service (electricity) they already pay for. Renewable energy is sold at competitive rates to inhabitants, while a proportion of the revenue is used to support local sustainability projects. A right balance needs to be maintained between specialist input and community involvement in the projects. This means that the more risky development and planning stage is led and financed by specialists with the right experience and knowledge, while the project would be opened up for community investment in the lower-risk construction and operational phases by the sale of ‘debentures’. Investors buy the debentures that give the owners the right to a proportion of the profits from the sale of electricity over 20-25 years. When residents own their energy assets, money can flow back into their own community, not to foreign investors. This not only do economy and technology matter, but gaining buy-in from the public is important too. Climate change problems may be tackled with a proactive stance. Money may be saved on energy bills, and economic and social benefits may be engendered [45]. The wind and solar energy projects in the UK, as presented in this study, are backed by debenture-based crowdfunding, which allows people to make relatively small investments in projects that give them access to a share of the profits. Another advantage of financing the renewable energy project through crowdfunding is the independence from larger international energy companies. Because of renewable technological innovations, small-scale decentralized production for renewable energy is available. The development of decentralized renewable energy production can be fostered by local community energy initiatives and establishment of energy cooperatives [46]. This will mitigate against problems of demand changes and over-reliance on too few energy sources, or investing large amounts in unwarranted capacities. Energy cooperatives are associations of local actors who work together to develop renewable energy projects. The objective of these cooperatives is to promote the use of renewable energy sources by local communities. Joint ventures reduce the risk of investment and ensure that profits are shared among members of the cooperative and that some parts of the returns are invested in community development. Community energy not only incorporates residents’ opinions and ideas but also involves them as active stakeholders in the energy supply and demand processes [47]. The principles of openness, transparency, democracy and solidarity are conducive to the cooperative business model. A community-based equity approach creates

significant resources to allow the pursuit of sustainable development by local community operation through community enterprises [43]. Thus, equity-based crowdfunding can be used as a financial tool for renewable energy cooperatives. This enables local community organizations to finance and build local renewable energy infrastructure through contributions by a local community of interest or geography, which sees a long-term impact from adoption of certain technology. Community members share their ideas to work on solutions to a problem or provide favorable business conditions for own benefit of the community [4].

4.3 Governance and ownership considerations

Depending on how they are structured, the governance and ownership of new ventures may be affected to a limited extent by crowdfunding. Donation-based and reward-based crowdfunding do not include funders in the governance and ownership of the companies. Startups prefer those financing sources which do not deprive control from the owners and entail lower transaction costs [48]. Lending-based funding offers mainly short-term debts, which are often subordinated to more senior debts from banks. Hence, it has only limited effect on governance. Voting rights in equity-based crowdfunding may be limited as well. Furthermore, equity crowdfunding is often subject to capital market rules, hence it is limited in terms of funding level, geographical scope and promotion possibilities [49]. Renewable energy generation provides opportunities for the local governance of energy generation, in contrast to the more centralized traditional energy generation [46]. The joint ownership between a cooperative and a developer using equity-based crowdfunding allows local communities a financial stake in local renewable energy projects. Energy cooperatives promote a democratic way of decision-making on energy issues. Energy security can be maintained by giving communities control of the energy they use. Cooperative members can share the dividends in proportion to their investments and democratic management is exercised with each member having one vote.

5. Possible Limitations of Crowdfunding

Since crowdfunding is new, potential problems exist [50]. The unproven technology being promoted by startups may fail, as frequently do new businesses. Unlike instruments such as listed stock or bonds, a secondary market does not exist for investors to carry out transactions. Hence, there is a lack of liquidity for the investment. Legislators are also concerned with the likelihood of fraud for transactions carried out online, which makes due diligence difficult. Information asymmetry therefore exists to an extent worse than listed financial instruments which carry transparent financial reports and sometimes credit ratings. Whilst angel investors and venture capitalists are experienced in new ventures, online investors may not be as sophisticated [23]. Coupled with the risk of cyber insecurity, participants of this mode of financing needs extra caution and platform operators have to make necessary improvements and give substantiated assurance for it to flourish with larger funding requirements to be met.

For the fund raisers themselves, they may worry about their new entrepreneurial ideas being stolen by more resourceful organizations once they make them public [51,52,53]. Even if funding is successful, startups have to take care of laborious accounting and administer the numerous subscribers, large and small [54,55]. Furthermore, there is never certainty in the active participation of the crowdfunders over time, especially with donation or reward-based scenarios due to their altruistic motivation or sense of belonging which may weaken over time [16].

6. Conclusion

Crowdfunding may be used for raising capital for renewable energy development in their start-up and early stages, supplementing public funds, business angels and bank borrowings. Donation-based and reward-based crowdfunding are suitable for small-scale renewable and sustainable energy and green innovation projects during their inception and prototype stages. The limited scale of funds raised through these crowdfunding approaches are more suitable for supporting small and remotely located projects, mostly relying on contributions by concerned parties, or investors who are mindful of environmental protection. With crowdfunding, investors may decide which projects are worth funding not only from the economic standpoint but the community benefits accruing from them. This provides additional capital for early growth and a channel for expressing the non-financial interest of funders. Although crowdfunding is probably not the substitute of traditional financing methods such as business angels, venture capital or bank loans, crowdfunding plays an important and increasingly widespread role at the start of a renewable energy project's life-cycle. Once projects have been tested by the investors as to their bottom lines, lending or equity-based crowdfunding may be used. As crowdfunding matures in volume and gains investors' acceptance, larger and more traditional financing from business angels and venture capitalists may be arranged. Having proved sufficient market growth, more intensive capital may be sought from investment banks for business expansion [3]. Crowdfunding appears a broader concept that not only aimed at raising funds, but also represents a way to develop corporate activities for the society. A community that uses renewable energy not only helps reduce carbon emissions but also increases a greater awareness of energy issues. This leads to increased energy efficiency across the community and a reduction in energy costs. Through a number of case studies, this research shows the diversity of crowdfunding arrangements for renewable and sustainable energy development. Crowdfunding is also suitable for supporting research and development efforts of innovative green technology start-ups. Once the number of participants and the amount of funding involved pass the thresholds of institutional regulations, this method of fund raising will be subject to the usual monitoring and procedural hurdles meant to protect investors. The convenience of carrying out transactions via the world-wide web has its strength, but a weakness exists in terms of the low verifiability of project details. Hence, crowdfunding will find its best use when

complemented with other financing methods in the whole life-cycle of renewable projects. Fig.3 shows the ball-park monetary values as demarcation points of the crowdfunding models.

(Insert Fig.3 here)

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Table 1: Comparison of Different Financing Sources including applicability at various RE Technology Development Stages

Host's View/ Stage of Business	Internal Fund/ Grant	Angel Investor	Crowd-funding	Venture Capital/ Private Equity	Loans/ Debt	Listed Equity	Carbon Finance	Feed-in Tariff
Pros	Maintain privacy; No dilution of control	Direct interaction with angel investors for sharing experience	Initial cost low; Build public image; Versatile	Suit any new proven technology	Maintain privacy; No dilution of control; Interest deductible for tax	Large amount possible	Encourage Emission reduction	Promote RE growth
Cons	Limited Amount	Not suitable for scaling up scope	Info disclosure; Uncertain response	Need mature capital market for exit	Lenders' conditions imposed; Collateral required	Info disclosure; Dilution of control	Uncertain delivery of carbon credits	Subject to regulatory controls
Inception	**	***	***					
Seed		**	***					
Startup			**	**				
Early Growth			**	***	**			
Expansion			*		***	***	*	*

(Legend: the no. of * indicates relative applicability; empty cells indicate rare applications)

Table 2: Summary of Cases

	Project	Product	Project Location	Type of Crowdfunding	Total Investment (USD)	No. of funders/ Investors	Rewards/ Return on Investment
A.	Efficient Stoves to Protect Pandas	Highly energy efficient cook stoves	China	Reward	\$2,500	91	Panda e-cards, drawing, /album
B.	“A Flame Called Hope”	Biogas energy	Nepal	Donation	\$2,700	66	Social recognition, thank-you cards
C.	Pay-As-You-Go Solar Energy	Home Solar Systems	Tanzania	Lending	\$15,000	91	Money
D.	SunnyMoney	Solar-powered lights	Zambia	Lending	\$20,000	146	Money
E.	Brighter Schools	Solar PV systems	United Kingdom	Debenture	\$327,600	158	Money
F.	Resilient Energy Great Dunkilns	Wind turbine	United Kingdom	Debenture	\$2,123,400	425	Money
G.	Caballero Fabriek	Solar panels	Netherland	Equity	\$592,800	186	Electricity/ Money
H.	Wind Eeklo	Wind turbines	Belgium	Equity	\$4,848,700	1,825	Electricity/ Money

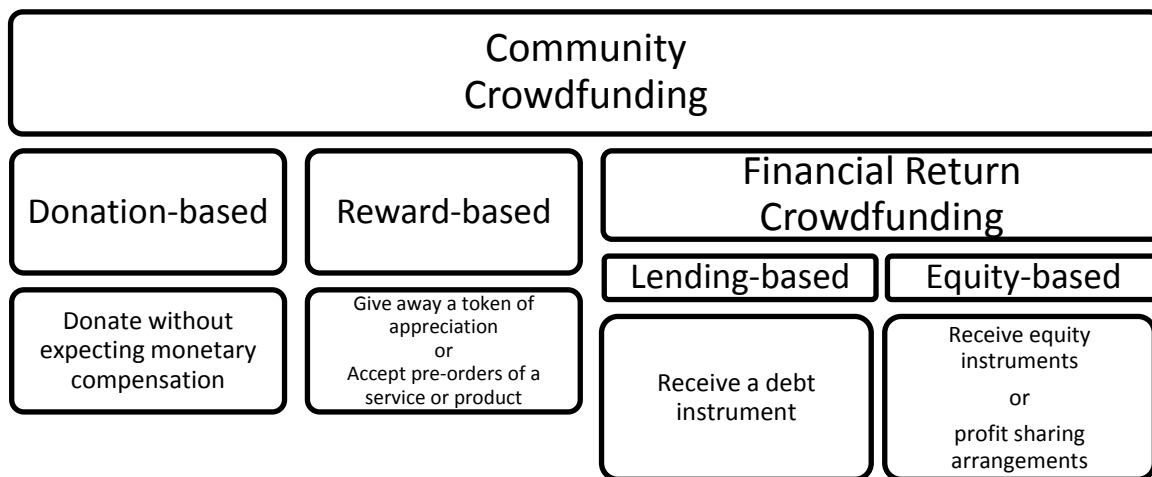
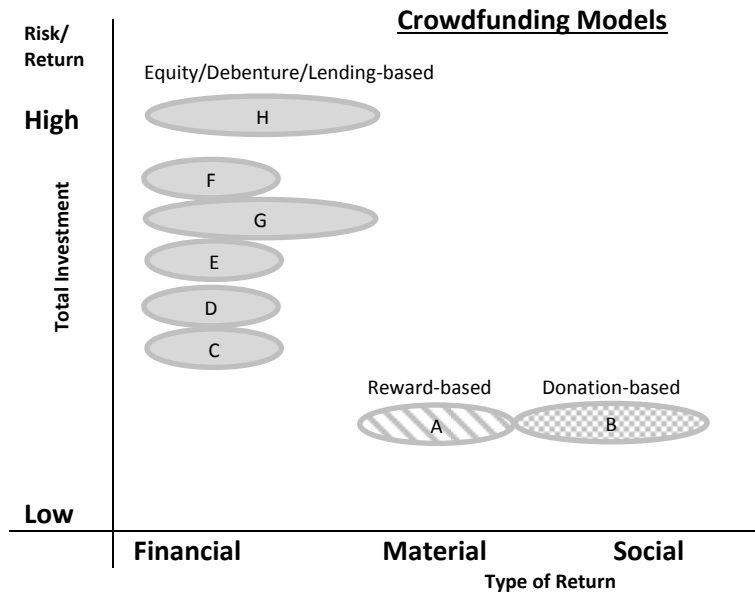


Fig 1. Various Models of Crowdfunding

(Source: Adapted from the World Bank [3]; Kirby and Worner [21])



Case	Crowdfunding Model	Product	Return(s)
A	Reward	Biogas energy	Material
B	Donation	Energy efficient cook stoves	Social/Material
C	Lending	Solar home systems	Financial
D	Lending	Solar-powered lights	Financial
E	Debenture	Solar PV systems	Financial
F	Debenture	Wind turbine	Financial
G	Equity	Solar panels	Material/Financial
H	Equity	Wind turbines	Material/Financial

Fig.2. Crowdfunding models of renewable and sustainable energy projects based on their risk/return intensity spectrum and types of return.

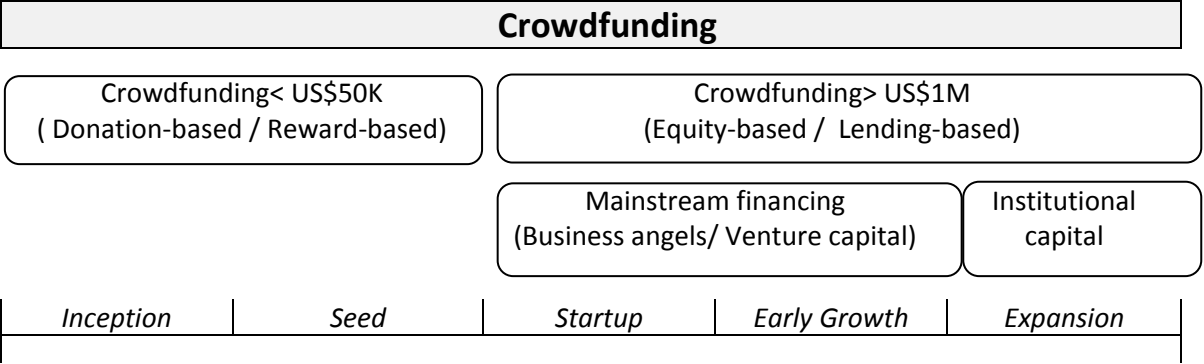


Fig.3. Financial Spectrum of Renewable Energy Projects