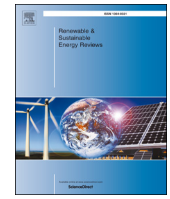
Renewable and Sustainable Energy Reviews 90 (2018) 937–944

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser



Financing for renewable energy projects: A decision guide by developmental stages with case studies

Patrick T.I. Lam*, Angel O.K. Law

Dept of Building & Real Estate, The Hong Kong Polytechnic University, Hong Kong

ARTICLE INFO

Keywords:
Renewable projects
Financing sources
Developmental stages
Stakeholders
Case studies

ABSTRACT

In terms of development cycle, renewable energy (RE) projects entail funding supports from the technological innovation stage onwards. Due to uncertainties in resource availability and technical risk, only a limited variety of funding sources are available for startups. As the RE development project passes through this early stage into technical maturity, more funding sources may be attracted to bring it to commercial fruition. When the technology is eventually deployable to mass applications, even more funding venues exist, sometimes enabling exit of the original innovators via transfer of ownership, or fostering asset growth with investor participation in built facilities. Due to the environmental benefits to be harvested, governments have a pivotal role to play in relation to funding, either directly or indirectly at all stages.

This research is aimed at identifying the developmental stages of RE projects and studying the inter-relationships with stakeholders, under the influence of technology push and market pull. Discussions are focused on different types of RE projects and modes of financing, culminating in a diagrammatic model depicting the various decision factors to assist funding-raising activities at different RE developmental stages. Illustrations are provided through a series of carefully selected case studies in western countries. This is followed by a discussion on RE development financing in the Asian context, with conclusions drawn in the light of recent emergence of new business models and a smart era. Decision makers in RE projects may regard this article as a guide for their fund raising activities.

1. Introduction

Renewable energy (RE) projects may involve a variety of technologies at different stages of technical maturity, ranging from innovative technologies at trial phase to proven know-how deployed at the operational and commercial phases. Funding of such projects entails the use of different types of financial instruments. In many occasions, various government policies are being used to support the commercialization of new startup technologies and to enhance the competitiveness of renewable energy in the market in order to reduce the traditional reliance on fossil fuel-based energy production.

When making decisions on the funding approach for RE projects at different developmental stages, the interactions of project developers with other stakeholders, including the government, should be considered. Whilst well established RE developers may be experienced with the financial market from which they tap on funding resources regularly, startups are usually inventors who lack financial backgrounds. They may benefit from the findings of this research in their attempt to unravel their developmental path amidst a myriad of financing means, including the state-of-art practices. The appropriateness of each type of funding means vis-à-vis the nature and stages of RE projects is demonstrated through eight operational case studies conducted from a comprehensive desk-top search from literature in the recent 5 years. A diagrammatic model is drawn up to summarize the issues and their inter-relationship for decision making. Developers of RE projects (especially startups undertaking new ventures in the emerging market in Asia) may refer to it as a roadmap for raising funds at different stages. Hence, this research is aimed at identifying suitable financing modes for RE projects at different developmental stages from the perspective of RE developers, with the specific objective of providing guidance on funding decisions.

2. Literature review

The financing structures for renewable energy projects depend on natural resources availability, technical maturity (hence the stage of development), and financial viability of renewable energy technologies, as well as support via government policies and the regulatory

* Corresponding author.
E-mail address: bsplam@polyu.edu.hk (P.T.I. Lam).

https://doi.org/10.1016/j.rser.2018.03.083
Received 30 April 2017; Received in revised form 24 March 2018; Accepted 26 March 2018

environment. For example, pre-investment financing is necessary for hydro-electric project development due to land resumption and their impacts on downstream communities [1], hence necessitating resettlement of residents by the project promoters. Biomass projects are more dependent on carbon financing to cover their cost since the enduring availability of adequate and affordable resources is a key risk [1]. Solar projects require large amounts of investment subsidies to cover up-front payments and entail the provision of tax incentives, but they are less reliant on debt [2]. Wind farm projects are mainly financed through debt due to lower debt service costs compared with equity dividend payouts [3]. This broad distinction into debt, equity and policy instruments is further expounded as follows:-

2.1. Types and sources of finance for renewable energy projects

Generally speaking, three types of finance can be used for RE projects: debt, equity. as well as grants and subsidies. Debt may be raised in the form of loans from banks, or by issuing bonds through the capital market. Being a commonly adopted financing source for up-front and on-going project costs, much depends on relative costs and tenures [4]. Concessional finance is a low-cost debt at below-market interest rates with long repayment periods raised directly through sovereign banks or indirectly through subsidies afforded to commercial banks [2,4]. Loan guarantees and credit guarantees are often used in RE projects as credit enhancement measures provided by government agencies or development finance institutions (DFIs) [4]. DFIs underwrite loans and provide liquidity facilities at concessional rates [4]. The provision of credit lines extended through commercial financing institutions (CFIs) to RE projects allows blending of commercial and concessionary loans to reduce overall costs [1]. Bond finance for RE projects can be a cheaper means than commercial loans, and affords a recycling opportunity to limited amounts of construction capital through refinancing initial project expenditures [4]. For example, the Japan Bank for International Cooperation (JBIC) provided loan guarantees for four renewable energy projects in Asia and South America to local development banks [4,5]. Project bonds are used to fund undertakings, with the debt commitment being paid back from the cash flow generated by the projects [6]. Green bonds are issued by governments, banks, multilateral development agencies (MDAs), corporations and project companies to raise fund for an asset contributing to a low carbon and climate resilient (LCR) economy [6]. For example, Climate Awareness Bonds are issued by the European Investment Bank (EIB) for lending to renewables and energy efficiency projects in the European Union [7]. Asset-backed securities are bonds which are backed by the cash flows generated from operating RE projects, and are generally used for refinancing purpose [1]. As in January of 2018, the total estimated issue volume of climate-aligned (or "green") bonds has reached US$895 billion (increased by US$201 billion from last year), and room for a much larger market is predicted [28]. The insurance sector is less likely to issue policies to clients or assets not meeting the resilience standards against climate change and green bonds are perceived as investment conducive to meeting this changed requirement. Previously, the green label was said to mislead investors in that transparency was inadequate to monitor the use of bond proceeds, but with increasing standardization and certifications of "green" use due to emerging market regulatory forces, the concern of investors against "green-washing" is diminishing [29].

Equity is a fund raised from shareholders in different domains, including venture capital, private equity funds, and public share capital markets. Different types of equity investors will be engaged depending on the stage of technology development, rates of return, and the degree of associated risk [8]. Venture capital investors provide early stage capital, and take significant risk but expect higher returns [9]. Private equity investors concentrate in later stages and more mature technology or projects, with the intention to find an "exit" for their investment and reap their returns within a 3–5-year period [8].

Grants and subsidies are typically provided by governments and public agencies to projects that are commercially marginal [2]. Capital grants generally represent an effort of local authorities to reduce the ultimate financial cost of RE technology projects to increase their competitiveness [1].

In general, larger RE projects need to have access to long-term funding acquired on a project finance basis, while smaller RE projects typically rely on corporate finance [1]. Project financing is focused on a special-purpose vehicle company, which raises loan capital, the repayment of which relies on project cash flows with limited recourse to assets of the parent company [10]. Large amounts of debt can be obtained to pursue RE projects with negligible impact on the balance sheet or creditworthiness of the company [11]. In the case of corporate finance, the lenders' decisions are based on the overall creditworthiness and risk profile of the borrowers. Corporate loan is used to achieve quicker financing execution and lower costs of legal and arrangement fees for small RE projects [10]. Large corporations such as utilities and multinational companies operating in the RE market can use their access to cheap capital for raising funds [2]. They can expand their balance sheets to fund the long-term development of RE technologies by issuing new bonds and equity. Since the later part of this decade, the major consumers of electricity amidst the advent of social media, such as Google and Facebook, have been purchasing RE for their data centers under long-term agreements at fixed prices, which removed the volume and price risks from equity and loan financings, leaving only the inherent instability risk of RE for consideration. This risk is being mitigated by technological advances in energy storage (such as batteries), which have seen cost reductions and storage capacities. The International Renewable Energy Agency predicts that energy storage cost will reduce by 48–64 per cent between 2016 and 2030, and storage volume will grow from approximately 4.67 TWh to around 7 TWh from 2017 to 2030, representing an increase of around 50% from 2017 [30].

3. The technical maturity and developmental stages of renewable energy technologies

The costs of RE technologies depend on the maturity of technology, economies of scale of the systems, and natural resource availability [12]. For example, geothermal and wind projects are well-developed on an industrial scale compared to solar thermal and photovoltaic technologies [4]. The photovoltaic systems are highly tied to the position of the sun, whereas solar thermal systems can generate electricity after getting dark. However, the cost of solar thermal plants is higher due to complexity of the systems. The installation and maintenance of offshore wind turbines incur much higher cost than that of onshore wind systems because of the marine installation conditions and transportation. The cost of biomass plants heavily depends on the installation types and biomass feedstocks, such as organic wastes from agriculture, households or industry. Pre-investment financing is necessary for hydro-electric project development due to the impacts on land use and resettlement of downstream communities [1].

There are three main stages for energy-related technological innovation in a market economy [13]: (1) New technology R&D and demonstration, which involve basic research, technology-specific research, development and demonstration; (2) Marketization, which involves demonstration of technology to a potential market; (3) Market penetration, which involves market accumulation and product diffusion. Each stage embraces technology improvement and cost reduction, and is driven by two main forces: Technology-push and Market-pull [13]. "Technology-push" elements dominate early stage R&D, whilst "market-pull" becomes increasingly important in the subsequent stages of innovative technology development. Private investment in RE technologies is scarce in the early stages and increases when the technology is closer to market [14]. The "technology-push" situation is primarily manifested in the development of low green-house gas (GHG) technologies, usually through public funds and R&D programs, instead of through regulatory constraints on emissions. On the other hand,