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Business potential of sustainable energy in Korea: Hybrid method of various feasibility studies from path dependence and path evolution perspective

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ABSTRACT

It is a common practice, in Korea as well as other countries, to use economic feasibility study for policy-maker or business communities before deciding substantial investments on sustainable energy projects especially photovoltaic industry in 2008.

Many feasibility studies provided the basis for worldwide investments in the photovoltaic industry in 2008 by many Korean firms. In 2011, however, many firms have decided to withdraw from the photovoltaic industry and retract investments. This research analyzes the gap between the results of the conventional feasibility study and the reality in the perspective of path dependence and path evolution, and proposes a hybrid market feasibility study model to account for the gap. In other words, conducting conventional feasibility studies do not incorporate changes in economic feasibility due to changes in society and are thus not precise in predicting market feasibility when the business environment has changed.

In addition, this study shows how policy support can create a bubble in the sustainable energy industry and distort the market value. Policy support is necessary, but must be implemented with right timing, contents and delivery system.

1. Introduction

Ever increasing concerns about climate change have led to extensive research on various alternative sources of energy other than conventional carbon-based energy. Although the novelty and potential contribution to only one earth environmental protection, new and sustainable energy [1] are still relatively underdeveloped in the market. For example, its investment and maintenance costs are high when compared to conventional energies, including nuclear energy. From the consumers' point of view, the switch to alternative sources of energy requires suitable and stable arrangement of infrastructure. Therefore, the quest for a balance between the environmental value and economic value should focus on when and on what conditions the new and sustainable energy would reach grid-parity.

Reflecting this trend, institutes and firms in many countries have conducted studies on the market feasibility of sustainable energy industry. These feasibility studies showed that photovoltaic and wind power have prospects, and that other new and sustainable energy, such as bio-energy, fuel cell, and ocean power were attractive. The Korea Advanced Institute of Science and Technology (KAIST) also conducted research on the market feasibility of sustainable energy. The results of KAIST's research were similar to other analyses.

In 2011, however, the index (Fig. 1 and Appendix A), which represents the world green market (energy efficiency, renewable–solar, renewable–wind, renewable–other, renewable-bio fuels and biomass, power storage, energy conversion) dropped by 36% in Jan. 2006 and by 132% in Jan. 2008.

Meanwhile, leading companies, such as Solyndra Ltd. invested by USA [2], Spectrawatt Solar invested by Intel and Goldman Sachs [3] and Evergreen Solar [4] filed for bankruptcy. Meanwhile, the EU overhauled the Sustainable Energy subsidy scheme by over 50% [5]. The Operating Income of Q-Cell, which was a leader in the photovoltaic industry in 2010, recorded a loss of $439 Million 2Q and was placed on the Merger and Acquisition (M&A) market [6].

On the other hand, the Korean sustainable energy industry is experiencing a radical paradigm shift. State-owned energy companies have become privatized. The industry is in transition

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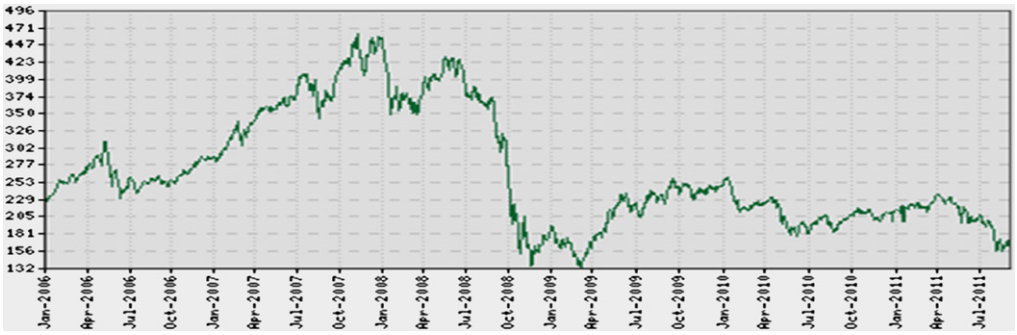

Fig. 1. New energy global index.

from extensive government control to a more flexible and market-oriented operation. Korea is now faced with challenges of addressing energy security with a decentralized supply system [7]. Currently, Korea is facing challenges in allocating its budget to diverse sustainable energy sources, such as photovoltaic, wind, bio (ethanol, bio-diesel), fuel cells and secondary batteries.

Although many innovative technologies have been introduced, there may not be suitable methods for evaluating the industry because the criteria and methods are stale and highly dependent on the past.

This paper intends to answer the following questions:

- Are conventional path-dependent feasibility studies significantly different from path-evolving feasibility studies?
- If there is a significant difference, what factors make the gap significant?
- Considering the alternative criteria for evaluation, does the green industry have bright prospects in the future?
- How should the government and business sector react to changes in the green industry?

To answer these questions, it is necessary to conduct a comparative study that compares conventional path-dependent methods with path-evolving methods.

Thus, the purpose of this paper is: 1) to study why these radical changes have emerged and what factors cause these radical changes; 2) to present path-evolving methods in order to explain the gap between theory and practice by reinterpreting conventional evaluation factors and methods from the prospective of path evolution. By doing so, this study will be able to suggest a new method suitable for evaluating innovative technologies.

2. Path change theory and feasibility studies

The concept of path change consists of path dependence, path evolution and path creation, which are interconnected [8] (see Table 1).

Path dependence explains the evolution of technology adoption processes and industry evolution [14]. It is also used to explain why and how to make a decision at "*the critical juncture or the point of selection*" [15] and retain the decision in the future, even though the initial conditions or environmental factors, which were considered in the past, are no longer relevant. If this dependence becomes consistently strong, the result follows that of positive feedbacks and will be locked-in the past. This is why reversing the path is difficult. Paul David [16] pointed out that an inferior "*standard*" first introduced to the market can maintain its positions continuously because of "*the legacy they have built up*". The case of QWERTY vs. Dvorak [16] is a perfect example.

David [16] and Arthur [9] developed the concept of path dependence in the way of technology-adoption and technology-competition. Adding on the research of David [16], Arthur (1989) [9] described the terms of "*lock-in effects*" in the historical development of technology-competition in which path dependency might lead to suboptimal results. He defined the prerequisite for such path development as "*increasing returns*", meaning that some kind of self-reinforcing advantage has to exist.

Path evolution is an extension of path dependence and is designed to explain incremental changes. This concept shows that small and partial changes that are accumulated gradually can create a new path. In the concept of path evolution, there is no "critical juncture" and intentional behavior for path breaking. Instead, path-evolution needs multiple decision-points and complicated decision process. It is a process that combines diffusion, layering, and conversion.

The major characteristic of new technologies has uncertain economic perspectives [14]. In the perspective of path dependent economic assessment, new technologies cannot be valued accurately because the new technologies are evaluated not by creative or innovative criteria, but by conventional or standardized criteria that were verified in the past by other researchers.

These extended models are useful for understanding market growth or decline, business opportunity, industry potential and direction for industry, when conducting a strategic analysis or doing market research. Many researchers, however, have some difficulties in using these creative approaches for evaluation because of the switching cost from an existing path to a new path. Since the size of switching cost depends on the width of radical new path, it is relatively easier to be locked in the existing path (see Table 2).

3. Conceptual framework and method

To answer the research question, it is necessary to compare the different results drawn from conventional evaluation methods and path-evolving evaluation methods. This model explains other factors that may affect the market value, and conducts sensitivity analysis in order to check the volatility of the results for changes in a certain factor (see Fig. 2).

Table 1
Summary of path dependence, path evolution and path creation.

Path dependence	Self-reinforcing sequence	Increasing returns Arthur [9,10], Cowan [11], Mahoney [8]	A→A→A→A→A
		Negative feedback Bennett et al. [12]	A→B→A→D→A
		Cyclical processes Bennett et al. [12]	A→B→A→B→A
Path evolution Djelic et al. [13]	A(a)→A(ab)→A(abb)→A(abbb)→B(bbba)		
Path creation Mahoney [8]	A→(characteristics of entrepreneur & intentional deviation on existing path)→B		