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A real option-based model to valuate CDM projects under uncertain energy policies for emission trading

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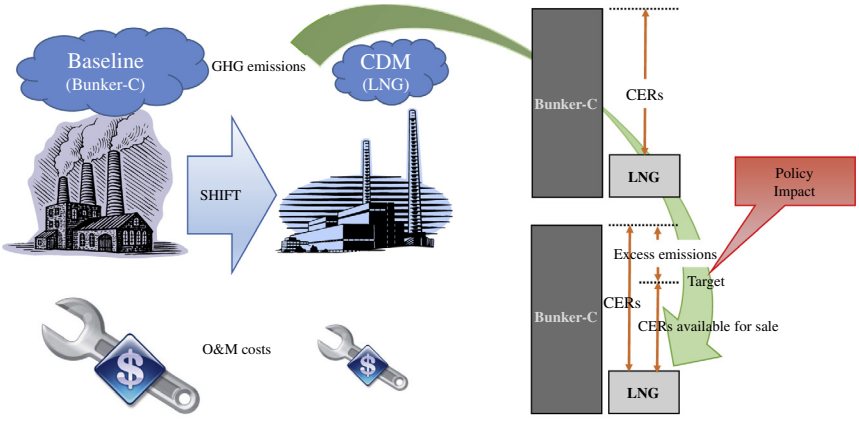
HIGHLIGHTS

- A real option-based model for the valuation of CDM projects is proposed.
- This study investigates the impact of energy policies on the value of CDM projects.
- Level of target emission and its schedule should be carefully designed.
- Government subsidy facilitates the implementation of CDM projects.
- Period for free emission allowance prevents promoting CDM projects.

GRAPHICAL ABSTRACT

Energy policy impact on CDM project



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ABSTRACT

Emission trading has been considered a primary policy tool for emission reduction. Governments establish national targets for emission reduction and assign emission reduction goals to private entities to accomplish the targets. To attain the goal, private entities should perform offset projects that can produce emission credits or buy emission credits from the market. However, it is not easy for private entities to decide to implement the projects because energy policies associated with emission trading keep changing; thus, the future benefits of the offset projects are quite uncertain. This study presents a real option-based model to investigate how uncertain energy policies affect the financial viability of an offset project. A case study showed that the establishment of a target emission was attractive to the government because it could make the CDM project financially viable with a small amount of government subsidy. In addition, the level of the government subsidy could determine the investment timing for the CDM project. In this context, governments should be cautious in designing energy policies, because even the same energy policies could have different impacts on private entities. Overall, this study is expected to assist private entities in establishing proper investment strategies for CDM projects under uncertain energy policies.

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1. Introduction

Emission trading has been widely utilized as a tool to meet national targets for emission reduction. After the emission trading market was first established by the European Union (EU) [1], many countries, including China, Australia, the United States and Korea, are on their way to developing similar markets. In the United States, 10 eastern state governments established the Regional Greenhouse Gas Initiative for emission trading [2]. Australia implemented a carbon pricing mechanism in 2012 [3]. China launched regional emission trading pilot projects to establish a national emission trading scheme in 2015 [4,5], and Korea approved a bill for a national emission trading system starting in 2015 [6]. In general, emission trading works on the cap and trade program. The program imposes a cap on the emissions (target emissions) of private entities; if private entities cannot meet the target amounts, they should buy emission credits in the market to avoid penalties [7]. Emission trading also includes the offset mechanism, which enables private entities to use the emission reductions obtained by joint implementation and/or clean development mechanism projects to comply with the targets [8].

The energy policies regarding emission trading include target emissions, offset mechanism and periods for free emission allowances [9]. The change of theses policy directly affects the price of the emission units and the financial viability of the sustainable development investment [10]. For this reason, it is essential for policy makers and investors to understand the impact of the policy change on the investment. This study proposed a real option-based model to reasonably consider the uncertain energy policies in the valuation of a CDM project. For the generality of the model, we focused on a CDM project that can be implemented by all countries (developing and developed countries). A case study of the CDM project, which switched from bunker-C oil to liquefied natural gas (LNG), was conducted to verify the proposed model. In the given case, the proper level of governmental subsidies, which could trigger the immediate implementation of the CDM project, was determined using sensitivity analyses. The contribution of the study to the body of knowledge for CDM project and energy policy is twofold. First, this study provided a systematic framework to properly incorporate the various uncertainties in the valuation of sustainable development investment. By adopting the real option analysis, the reasonable estimation of the opportunity value for deferring a CDM project was obtained. Second, this study analyzed the impact of energy policies on the decision making process for sustainable development. Consequently, the proposed framework enables decision-makers to have early recognition of the various risks associated with different energy policies for CDM projects.

2. Theoretical backgrounds

2.1. Clean development mechanism

In 2005, the Kyoto Protocol introduced three market-based mechanisms (Kyoto Mechanism), including emission trading (ET), joint implementation (JI), and clean development mechanism (CDM), in order to provide methodologies to trade the right to emit the greenhouse gases (GHGs) between countries [11–13]. Here, the CDM projects represent investments for sustainable development to obtain certified emission credits (CERs) in developing countries [14]. The CERs can be used to offset the domestic target amounts along with emission reduction units of JI [15,16]; EU's emission trading system [15], US state GHG programme [15], and Korea's target management scheme [16] allow private sectors to utilize these units as an offset for the excessive emission.

Based on the implementation architecture, there are three approaches for CDM projects: bilateral, multilateral, and unilateral [17]. While bilateral and multilateral CDM projects imply a joint venture project between an industrialized and a developing country, a unilateral CDM project indicates that the activities are developed, implemented, and financed solely by a host country that does not belong to the Annex I group [18]. The CDM project used in our case study falls into the category of a unilateral project.

2.2. Real option analysis

Real option analysis (ROA) has proven its usefulness in assessing projects under uncertain future conditions in various areas. Recently, the application of ROA to green and sustainable development projects has increased due to the growth of attention to global warming and climate change effects. ROA was used to determine the investment strategies for promoting mitigation technologies under various uncertainties such as energy policy change, prices (CO_2, fuel) and technology cost. For example, Zhou et al. [19] adopted a real option analysis to estimate the value of the carbon capture and storage (CCS) technology application to three kinds of power plants based on two scenarios of climate policy. Zhu and Fan [20] evaluated the value of CCS technology deployment for thermal power generation sector using real option. Zhang et al. [21] developed a real option based model to analyze the investment of CCS technology, considering multiple uncertainties such as carbon price and government incentives. The common claims of these studies were that the carbon price was the most critical factor for the success of renewable technology deployment and renewable energy would be profitable in the long term. ROA was also utilized to estimate the value of the climate or energy policies. Lee and Shih [22] presented a model to investigate the policy impact on the renewable energy investment by comparing CO_2 emission cost and feed-in tariff. Lee and Shih [23] also developed a model to evaluate the strategic options for the implementation of the renewable energy development policies. Reuter et al. [24] proposed a model to examine policy impacts on the two energy generation plants (coal-fired power plant and wind farm). These studies revealed that private investors were not willing to invest in sustainable development project without governmental subsidy (feed-in tariff and subsidies for construction costs). The previous studies have greatly advanced the state of the art in the valuation of mitigation technologies, and design and planning flexibility. However, so far, it has not yet been clearly addressed how the various emission trading mechanisms affected the value of a CDM project. In addition, few studies have examined the regulatory aspect of climate and energy polices. This study demonstrated adverse and beneficial aspects of governmental emission trading policies in implementing sustainable development project, by investigating their impacts on the CDM project. Overall, the study provided guidelines for private entities to establish an appropriate investment strategy under uncertain energy policies.

3. Investment decision for CDM projects under uncertain energy policies

3.1. Framework for the valuation of a CDM project under uncertain energy policies

The enactment of new energy policies typically affects the financial viability of a CDM project in two ways. It can change market conditions regarding fuel and CERs prices, which are the primary cost items of the CDM project, and it can also directly affect project feasibility by authorizing government subsidy or imposing penalty or restriction for CO_2 emissions. Thus, it is