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Quantitatively exploring the future of renewable portfolio standard in the Korean electricity sector via a bottom-up energy model

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ABSTRACT

The Republic of Korea started to apply a new renewable energy policy, renewable portfolio standard (RPS) in 2012, but the policy has failed to obtain positive evaluation and some problems have arisen during the first two years. In this study, we have tried to investigate the current design (operational mechanism) of the policy, to examine the reasons for its problems, and to quantitatively predict future outlook. For the examination and prediction, we use the bottom-up model approach, which has not been commonly used for the RPS policy but is usually utilized for evaluating specific policy options in an energy system. Therefore, the main purpose of this study is not only to introduce a new approach for the exploration of the RPS policy, a scenario-based quantitative analysis based on a bottom-up energy system model, but also to apply the approach into the policy in Korea. We develop a multi-regional bottom-up energy model and explicitly implement the mechanism of the policy in the model, such as the transfer of tradable attribute – Renewable Energy Certificates (RECs). The results of the model predict a serious disharmony of the current design of the policy under the national basic plan; the optimistic fulfillment rate of RECs in the entire mechanism will be around 66% in 2022, so the most regulated generators will suffer from the large shortfalls of RECs and the total penalty for all regulated generators will be expected up to 1350 billion KRW in 2022. We also diagnose the reasons of the disharmony as well as address some suggestions for its continued application. As the Korean case study, we believe that the approach in this study can be utilized when policy makers design or amend the mechanism of RPS with RECs to help the policy operate efficiently and to prevent potential undesirable consequences.

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1. Introduction

The renewable portfolio standard (RPS) policy idea was firstly described in California in 1995 and has been propagated quickly across states and countries [1]. Even though the design of the policy may vary, at its heart the policy requires electricity suppliers (or, alternatively, electricity generators or consumers) to source the minimum amount of energy from renewable energy. The compliance of most such policies is implemented by a tradable attribute of electricity generated from renewable resources – Renewable Energy Certificates (RECs) – to increase the flexibility and reduce social costs. The discussion of the detailed design of the policy began in the late 1990s from both the United States and Europe simultaneously [2]. On one hand, after the first mention of the concept of RECs came in 1995 when a California RPS was designed, a market for green power opened in 1998. The Texas public utility commission (PUC) was first to adopt rules for a renewable energy credit trading system. On the other hand, a voluntary certificate trading program for the Netherlands was developed in 1997 and was operated during the following three years. After some efforts, in 2001, the EU started the Directive on Electricity Production from Renewable Energy Sources (RES Directive). Nowadays, RECs are quickly becoming the currency of renewable energy markets all over the world.

In the United States, fourteen of eighteen states with RPS used RECs in 2005 [2]. As of 2011, 29 states plus Washington, D.C. have adopted RPS policies and most states allow or require the use of RECs to demonstrate compliance with RPS targets [3]. In most RPS policies, retail electricity providers are required to obtain a certain fraction of their electricity from renewable energy sources. The REC compliance rule with regard to geographic eligibility, delivery requirements, and eligible technologies varies among states. Basically, many of the state RPS policies define regionally delivered RECs as eligible to meet state requirements, so regional REC markets exist in some parts of the country. The two primary regional markets for REC are operated by wholesale electricity markets: (1) Independent System Operator New England (ISO New England) for New England states with RPS, (2) PJM-Interconnection for most states with RPS in the wholesale market. In addition to regional compliance markets, a small national voluntary market for RECs exists. Sixteen states plus D.C. are incorporating a solar carve-out into their RPS, stipulating that a portion of the RPS be derived from solar resources and trading solar renewable energy certificates (SRECs) [4].

In Europe, the RES Directive is now covering fifteen countries. The Directive laid out an EU-wide tracking certificate system in 2009 [5]. With its evolution, a non-profit organization, the Association of Issuing Bodies (AIB) has established a voluntary market, the European Energy Certificate System (EECS system), covering eighteen European countries [6]. The growth of this market has averaged 35% a year since 2001 [7]. Aside from this market, some countries have their national level compliance markets within legislative RPS policies. Representatively, the United Kingdom started a policy encouraging renewable sources, the Renewables Obligation (RO) with a tradable attribute (ROCs), similar to the RPS with RECs [8]. In the Asia-Pacific region, Australia and Japan adopted the RPS policy with RECs in the late 1990s or early 2000s. Recently, India launched a REC trading mechanism in 2011 [9], and China is currently considering the implementation of RPS with RECs [10].

In this context, a crucial change in Korean renewable energy policy in the electricity sector was introduced in 2012. From 2001 to 2011, the government compensated for differences between the cost of electricity generation from new and renewable energy resources and the cost from fossil fuel, in order to accelerate investment in new and renewable energy. This compensation was referred to as the feed-in-tariff (FIT) policy. However, the FIT did not promote the distribution of new and renewable energy as expected. As of 2011, new and renewable energy resources comprised only 3.0% of primary energy sources produced [11]. This rate is the lowest among the 34 OECD member countries. In 2008, the Korean government announced a challenging target of increasing the rate of renewable energy resources to 11% by the year 2030. As one of ways to reach the target, the government phased the FIT policy out, and started to apply a RPS policy with RECs to major power generators in 2012. However, the new policy has failed to change the situation during last two years. As a result, we would like to examine explicitly whether the current design of RPS policy with RECs is appropriate or not and to suggest how to revise.

Therefore, the main purpose of this study is not only to introduce a new approach for the examination and the suggestion for the policy, a scenario-based quantitative analysis based on a bottom-up energy system model, but also to apply the approach into the policy in the Republic of Korea. We expect that the introduced approach can be used for the policies in other countries in similar way. In Section 2, we first review previous studies which tried to explore the future of RPS policy, and we compare with our approach in this study. In Section 3, we describe the design of RPS policy in the Korean electricity sector and its problems from the initial experience. Section 4 introduces how to develop a bottom-up energy model, The Integrated MARKAL-EFOM System (TIMES) model – created by the International Energy Agency (IEA) Energy Technology Systems Analysis Program (ETSAP) [12], for the national electricity sector and how to implement the RPS policy with RECs into the model. After then, in Section 5, a scenario-based analysis using the model predicts the possible future results of the policy with explicit numbers, particularly for economic perspective, and we address some important issues on the current design of the policy and provide our suggestion on potential government amendments for its continued application. In the last section, we summarize the contributions and conclusions of this study.

2. Literature review

When the RPS policies have been introduced in early 2000s, some studies concerned about how to design the policies. Morthorst analyzed possible ways to set up a green certificate market during the process of RPS legislation in Denmark as treating some of consequences in comparison with a voluntary green certificate market in Holland [13]. Langniss and Wiser pointed out seven positive design and implementation features of the Texas RPS with RECs by reviewing the early experience of the policy [14]. Kent and Mercer presented an overview of the evolution and initial operation of Australia's mandatory renewable energy target (MRET) [15]. Shrimali and Tirumalachetty critically examined the early results of the mechanism [9]. These studies