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When outcomes are the reflection of the analysis criteria: A review of the tradable green certificate assessments

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ABSTRACT

The tradable green certificates (TGC) framework is a prevalent policy support scheme enacted to stimulate investments in electricity from renewable energy sources (RES-E). In several countries, including Sweden and Norway, the TGC framework is currently under reevaluation. In this process, academic literature plays a crucial role in reflecting the outcomes of this policy framework. The outcomes, however, are often limited by the analysis criteria, which reflect what has been accounted for or disregarded when assessing the performance of the TGC framework. The analysis criteria also stress what is considered as a successful outcome. Given the importance of such criteria, this paper presents an extensive and systemic literature review of academic publications assessing the performance of the TGC framework. The findings are to provide an overview of the publications' analysis criteria and outline their outcomes. We also provide descriptive statistics for the publications and examine the average citation record of the publications that use various analysis criteria in order to explore their relative impact on later studies. These findings can help policymakers put the assessments into perspective when reevaluating a country's TGC system. They also suggest several intriguing directions for future studies in this field.

Contents

1. Introduction

The policy support scheme dubbed tradable green certificates (TGCs) is a framework enacted to stimulate investments in electricity from renewable energy sources (RES-E). TGC schemes are

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market-based, cost-efficient, and technology-neutral policy frameworks [1,2]. The specific design of TGC systems mandates that a certain quota of the electricity consumed should be from RES-E. Certificates are allocated to electricity producers for every megawatt hour (MWh) of their RES-E production. Producers can then sell the certificates on a market where the price is determined based on supply and demand, thereby gaining additional revenue.

TGC systems pursue various objectives in different countries, though in general they aim to increase the share of renewable sources in electricity production, drive investment in RES-E in a cost-efficient manner, and induce innovation and technical changes [see, 2,3,4]. However, outcomes of TGC systems suggest that not all of these objectives are satisfied [2,5,6]. In practice, the systems are coupled with unbalanced competition among renewable energy technology subsectors [1], high investment risks due to uncertainty surrounding certificate and electricity prices [7], and a lack of equity (i.e., "*lack of fairness in the distribution of costs and benefits between actor groups*") [2: p. 1257]. These outcomes have been assessed in academic research seeking to enhance the designs of the TGC framework by providing policy implications and recommendations.

Currently, TGC support schemes are under reevaluation in several countries. For example, after more than a decade of experience with TGC systems Sweden and Norway are now reevaluating their systems (see, [8,9]). In such policy development, academic literature plays a pivotal role. Indeed, policymakers and other related authorities often review and refer to academic research and consult scientific advisers when evaluating the policy options (e.g., [10,11]).

The outcomes and challenges reported in academic research are, however, limited by the analysis criteria that the researchers in each study have used to assess TGC systems' performances. The criteria chosen elucidate what scholars account for—or disregard—when assessing the TGC systems' outcomes. The criteria make assumptions about what renders a policy framework successful, or, to phrase it differently, the criteria stress desirable outcomes. The analysis criteria also can impact prospective studies inasmuch as they form a literature background for those studies.

To fully understand the underlying assumptions and basis on which policymakers build their reevaluations and potential redesigns, this paper aims to answer: *By what analysis criteria are TGC schemes assessed, and can these criteria be categorized into groups? And what is the relative impact of publications that use each of these criteria*? The answers to these questions will help policymakers understand how to put such assessments into perspective when using them to reengineer national TGC systems.

This paper addresses these questions by conducting an extensive and systematic literature review based on the Web of Science database, and contributes to the literature in three ways. First, our study sheds light on the main analysis criteria used in the publications to assess TGC systems' performance, and it outlines their outcomes. Second, this study examines the relative impact of the publications that apply different analysis criteria by evaluating their citation records. This is to measure the relative impact of the publications' influence on later studies and possibly on policymakers' evaluations of a country's TGC system. Moreover and in third, we provide descriptive statistics—authorship characteristics, publishers, citation records, methodological preferences and country of empirical setting—in order to present an overview of selected academic publications in this research area.

The remainder of the paper is structured as follows. Section 2 provides an overview of the TGC framework. Section 3 describes the methodology of this study and presents the descriptive statistics of selected publications. Section 4 summarizes and discusses the findings of the literature review and presents the analysis criteria. Section 5 presents concluding remarks and suggests several intriguing directions for future studies.

2. Overview of the TGC framework

Policy schemes supporting renewable electricity in general are categorized into two groups: price-based and quantity-based [1,12,13]. Remarkably, while a combination of these two policy groups is also applicable, it can increase the chance of complexity [14]. In the price-based policy support schemes, a fixed price is determined for each RES-E type (e.g., wind, solar, biomass, etc.) and additional policies (e.g., subsidies) are often enacted to pay the cost-based purchase price for RES-E producers. A known type of the price based policy support scheme is feed-in tariff (FIT) which is enforced in countries such as Spain or Germany [15,16].

On the other hand, in the quantity-based policy support scheme, governments mandate a certain amount of the produced electricity (i.e., quantity) to be from RES-E. The TGC framework, on which this study focuses, is a known example of this policy scheme group.

In markets with enforced TGC systems electricity producers receive a certificate for every MWh of RES-E production. The producers can sell the certificates in a market that functions based on supply and demand, and therefore acquire additional revenue. In a market with TGCs, various parties (e.g., supplier, distributors, or consumers) may have a certificate quota obligation. The parties with an obligation need to show that a quota of their electricity comes from renewable energy sources. In doing so, those parties have two options: to build eligible RES-E power plants and generate certificates themselves, or to purchase certificates from existing RES-E producers. Just like electricity from conventional power sources, electricity from RES-E is sold at official market prices [17]. Owing to the TGC framework's technology-neutral design, all renewable energy technologies pursuant to the renewable directive are eligible for the same level of subsidies [2,17–19].[1]

The TGC framework is currently enforced in many countries including Australia [20], 29 states in the United States as of 2012 [21], several European countries (e.g., Sweden, the UK, Belgium) [22], and recently in India [23] (see Table 1 for an overview).

3. Methodology

3.1. Data collection

The systematic literature review presented in this paper was conducted using a four-step procedure (see Fig. 1). First, we identified the main keywords. Given our objective of delineating how academic researchers assess the performance of TGC systems in the electricity industry, the following combination of keywords was selected: (*electricit* OR power*) *AND* (*certificate**).[2] Note that TGC systems have different labels in different countries—*renewable-electricity standards* or *renewable portfolio standards* in the United States and Australia, *renewable energy certificates* in India, *renewable obligations* in the United Kingdom (UK), and *tradable green certificates* in several European countries, including the Nordic countries. In all the academic publications examined here, however, the term *certificate* has been used to refer to the tradable commodity; therefore, this is a representative term for the keyword search conducted for this paper.

[1] Note that in the UK the design of TGC system has been reviewed. In the current design some types of renewable energy technology receive more certificates for every MWh produced RES-E. For example, offshore wind power is eligible for 2 certificates, when onshore wind power is not. However, in our review study there was no research examining how and if this specific design lead to more investments in renewable electricity.

[2] The word *power* refers to *electric power*, which is used as an alternative for *electricity*.