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Liquidity in green power markets – An international review

Fanny Frei, Allister Loder, Catharina R. Bening*

ETH Zurich, Department of Management, Technology, and Economics, Chair of Sustainability and Technology, Weinbergstrasse 56/58, CH-8092 Zurich, Switzerland

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ABSTRACT

The success of green electricity promotion hinges, among other things, on the liquidity in green power markets, i.e. how easy it is for market participants to trade green power in the market. This study reviews archetypes of green power markets worldwide with regard to market liquidity. Additionally, it identifies mechanisms through which trading characteristics, namely the dominant trading channel and the dominantly traded product, can influence liquidity in green power markets. The study finds that trading on an exchange platform or via brokers can foster liquidity better than bilateral trading. Also, trading spot or forward products can better support liquidity in green power markets than trading long-term contracts.

1. Introduction

In the pursuit of climate change mitigation, energy supply is seen as an important field of action, as it accounts for roughly 35% of global anthropogenic greenhouse gas emissions [1]. A particularly high mitigation potential is ascribed to renewable and CO_2-neutral (green) power generation [2]. As a result, green power generation has gained importance on state and international-level political agendas, and awareness among power consumers has been raised. Political support, along with an enhanced voluntary demand for green power, has led to rapid growth in green power generation worldwide [3]. However, once it is injected into the grid, green power can no longer be physically distinguished from conventional electric power [4]. Therefore, *Certificates of Origin* have been introduced *(CO)*.

Usually, COs are traded in the form of *Tradable Green Certificates (TGC)* on a green power market that is separate from the conventional power market [5,6]. The sale of TGCs is meant to complement electricity sales and takes place either in compliance green power markets, where TGC demand stems from quota obligations by the regulator, or voluntary green power markets, where demand arises from customers by choice [6–8]. The guiding theoretical thought behind TGCs is the idea of internalizing environmental externalities that arise when power is produced conventionally [9]. Through the use of TGCs, compliance with regulatory demands, such as renewable portfolio standards (RPS), can be retraced. Also, the TGC system guarantees that voluntary green power consumers know the origins of their electricity.

The success of green power promotion, i.e. whether political goals with regard to green power generation are met by a market mechanism, hinges inter alia on how *liquid* green power markets are [10,11]. Market liquidity, is a term coined by Keynes, to describe the price deviation effect from the consensus value, i.e. the equilibrium price, when immediately executing an order in the market [12]. Reasons for these deviations are implicit and explicit transaction costs [13] – in short, how easy it is to trade [14]. Liquid green power markets should ensure market price transparency as well as low transactions costs when it comes to finding trade partners. As a result, liquid green power markets allow market participants to evaluate the value of their green power assets and liabilities, as well as the associated risks, and only a confident evaluation of these values and risks can encourage investment in green power generation [15]. The Northwest Hydroelectric Association, for example, reports that market liquidity in the USA Oregon green power market is so low that banks consider it as too risky a market to invest in, and therefore assess renewable energy projects that rely on income from TGCs as non-financeable [16]. This example shows that market liquidity in green power markets can influence whether the political goals related to green power generation are met.

The concept of market liquidity is derived from financial markets, but applies to all markets [17]. While no studies exist on liquidity in green power markets specifically, the necessity of sufficient liquidity in electricity markets has been analyzed before [18,19]. Measuring market liquidity is a challenging task, since liquidity is not directly observable. Different indicators are applied of which trading volume is one of the most frequently used [13,20,21]. A literature review on comparative studies that assess the performance of green power markets revealed two main bodies of literature.[1] On the one hand, there is the literature on *compliance* green power markets. That stream of literature mainly identifies success

* Corresponding author.
E-mail address: cbening@ethz.ch (C.R. Bening).
[1] A detailed overview of the literature review is given in Appendix A.

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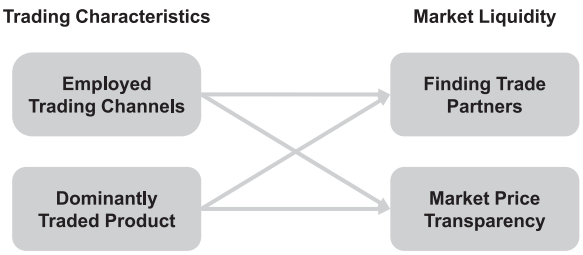

Fig. 1. Influence of trading characteristics on market liquidity in green power markets.

factors for green power markets in the policy dimension and derives implications for policy makers (e.g. [22,23]). On the other hand, there is the literature on *voluntary* green power markets. That body of literature focuses on success factors for green power markets mainly in the retail and marketing dimension, and infers implications for retailers (e.g. [24,25]). This study, however, adapts a *wholesale* perspective, in contrast to the policy or retail perspectives that are more common in previous studies. It does so because the liquidity of a green power market becomes most manifest in the wholesale market, where traded quantities and product standardization are higher than in the retail market. It is assumed that market liquidity, i.e. finding trade partners and market price transparency, in a green power market is determined by the wholesale market's architecture, i.e. the employed trading channels and the dominantly traded products (see Fig. 1) [26].

This article therefore addresses the following research question:

How can different trading characteristics influence market liquidity in green power markets?

To answer this question this study identifies the trading characteristics of nine existing green power markets that cover the existing range of green power markets in terms of regulatory obligations, size, and geographical location. The nine markets are mapped according to their trading characteristics. From there, the mechanisms through which the trading characteristics can influence market liquidity are analyzed by means of three illustrative examples.

The remainder of this article is structured as follows: In Section 2, the key elements of a green power market are briefly described. Section 3 introduces the methodology used for the sampling, mapping, and review of green power markets. The obtained results and illustrative cases are presented in Section 4. Section 5 discusses the results and their limitations and derives implications for market participants and policy makers before stating possible avenues for future research.

2. Key elements of green power markets

In green power markets, the CO of green power is traded. This CO is usually embodied by a TGC,[2] which represents the actual asset in green power markets. TGCs are intangible, virtual assets in an electronic TGC register, which is operated by an issuing body [10]. A TGC market consists of an issuing body, primary sellers, potential intermediaries, and final buyers of TGCs [8]. The issuing body assigns TGCs to the generators of green power, according to the amount of MWh of green electricity produced. The generator of green power acts as the primary seller on the TGC market. The final buyers of TGCs are electrical load consumers, i.e. end users. They either purchase TGCs on a voluntary basis or acquire TGCs due to an RPS set by the regulator [8]. In between, TGCs can be bought and sold on the wholesale market several times, either on exchange platforms[3] or *over-the-counter* (OTC), i.e. via brokers[4] or bilaterally.

Common TGC products include *spot* products, where the TGC is delivered immediately, *derivate* products (such as *futures* and *forwards*), where delivery occurs at an agreed point in time in the future, and *long-term contracts*, where trade parties agree upon the continuous delivery of generated TGCs for a predefined period of time. Fig. 2 summarizes the key elements of a typical green power market.

TGCs in different green power markets are not necessarily exactly equivalent commodities. The main differences include the eligibility of a power plant for TGCs, which depends on the regulatory framework of the TGC-issuing body. In general, all power plants that run on renewable sources, like biomass, hydro, solar, or wind, are eligible [7,27]. Also, in some markets the amount of TGCs issued per MWh depends on the renewable energy source, the generation technology, or the size of the plant. This regulation is called *banding* [28] and refers to the distinction between different technology bands. It is an alternative to creating separate TGC markets for different renewable energy sources. Finally, depending on the market design, the validity of TGCs can either be limited or so-called *infinite banking* of TGCs is admissible, which leads to differences in the admissible maturity of TGCs [8].

3. Methodology

To answer the research question and review liquidity in green power markets worldwide, this study proceeds in three steps. First, compliance green power markets and voluntary green power markets worldwide were identified, and a sample set of nine markets that cover the existing range of green power markets in terms of regulatory obligations, size, and geographical location was chosen. Second, these markets were mapped according to their wholesale trading characteristics, and third, three liquidity indicators were quantitatively assessed for all nine markets and the mechanisms through which wholesale trading characteristics can influence market liquidity were identified by means of three qualitative illustrative examples.

The following section introduces the methodology used for the sampling, mapping, and review of green power markets.

3.1. Sampling

Drawing from compilations by the Renewable Energy Policy Network for the 21st Century [3], North Carolina State University [29], Price Waterhouse Coopers [30], and the US National Renewable Energy Laboratory [31], the compliance green power markets – as well as the voluntary green power markets worldwide – were identified. This resulted in a total of 59 green power markets, which are all listed in Appendix B. For this study, nine markets were sampled. In order to establish an international review of different types of green power markets, it was essential that the sample cover a wide range of existing green power markets. This study, therefore, focuses on diverse cases [32] with regards to three criteria. First, the sample contains markets that are governed by different regulatory settings, i.e. compliance as well as voluntary markets. This sampling criteria is specifically relevant to the study of market liquidity, as the regulatory setting of a green power market determines how (and in the case of compliance markets even how much) demand arises. Since demand is – along with supply – the most important constituent of a market and, hence, its liquidity, it is particularly important that this study's sample cover both compliance and voluntary green power markets. Second, markets that differ notably in size were included in the study's sample. The number of TGCs issued annually is nearly 100 times greater in the largest market than in the smallest market in the sample. The rationale behind the study's sampling strategy was to obtain a sample that ultimately shows variance in market liquidity. As market size can be considered a very loose proxy for market liquidity [13,20,21], it is particularly relevant that our sample covers markets of very different sizes. Third, the sample accounts for green power markets in different geographical regions, i.e. Europe, North America, and Asia. Green power markets are usually rather regional markets because of two main reasons: In compliance markets, on the one hand, the regulatory settings are mostly relevant to either an individual

[2] One TGC often equals the CO of 1 MWh of green electricity [31].

[3] Central exchange platforms are either organized as central dealer markets or central auction markets [11].

[4] Brokers merge, buy, and sell offers and charge a commission in return for this service.