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Financing the decarbonized energy system through green electricity tariffs: A diffusion model of an induced consumer environmental market

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ABSTRACT

This paper explores whether consumer-focused green electricity tariffs can incentivize investment in the transition to a decarbonized energy system. Green electricity tariffs are a means by which 'green consumers' can contribute to investment in renewable energy and energy sector transition. In order to conceptualize factors constraining the adoption of green electricity tariffs this paper develops a model that links the willingness-to-pay (WTP) literature with the established innovation diffusion literature. This concern arises from a need to reconcile the large disparities that have been empirically observed between the proportion of households actually adopting green electricity tariffs and the proportion in WTP surveys that claim they would (stated-willingness-to-adopt or SWA). Using the Bass Model as the point of departure our model depicts how increasing consumer environmental concern, driven by word-of-mouth and mass media communication channels, results in an increasing proportion of households with a SWA. The presence of response bias and the free rider problem result in 'feasible adoption' being below the SWA. Feasible adoption is, in turn, differentiated from actual adoption by the extent of market imperfections, such as the supply side problems and regulatory failures often discussed in the empirical literature.

1. Introduction

Energy sector transition towards a decarbonized 'smart' energy system promises a myriad of potential benefits including reduced environmental impact, greater energy system efficiency, higher system reliability and new business models and business opportunities [1–7]. For these benefits to be reaped fundamental changes on the demand and the supply side of the energy sector are needed so as to enable a "paradigm shift from the present electricity network, based on centralized generation and top-down distribution, to a new digitalized grid, increasingly based on a distributed and networked architecture" [5, p.252]. On the supply side this transition requires investment in, and policies to 'induce the diffusion' [8] of, a range of technologies, including large scale and 'distributed' renewable energy technologies, smart meters, energy storage technologies, as well as ICT technologies and software enabling improved energy measurement, control and management [3,5]. The altered supply side architecture will in turn enable new technological applications, such as Electric Vehicles, which are seen as necessary for the decarbonization of the economy [3,5].

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Although there are contrasting visions of the smart energy systems of the future and the related transition pathways [1,3,4,7], most policymaker-supported visions of the future also see major changes on the demand side of the energy system, with consumers taking an increasingly 'active' role in the system [3,5]. It is envisaged that energy consumers will become increasingly demand responsive and may become "prosumers" (energy producers as well as consumers). Further, Giordano and Fulli [5, p.253] observe that "[s]egmenting consumers according to their energy profile and attaching business value to the "attributes" of electricity (e.g. power quality premiums, green electricity premiums) and to the services it enables rather than simply to its supply is a fundamental change of perspective, which will be an underlying characteristic of the whole Smart Grid system". An important component of the smart grid vision of the 'active' consumer is, therefore, the differentiated selling of green electricity.

Green electricity tariffs are not, however, an abstraction for the future. Energy sector liberalization and the emergence of green consumerisms have meant such tariffs have been available to some consumers for well over a decade [4]. This paper explores whether consumer-focused green electricity tariffs can incentivize investment in the transition to a decarbonized energy system. More superficially, it develops a model that helps explain the large disparities that have been observed between actual adoption of green electricity tariffs and stated intention to do so (as reported in consumer surveys). A better understanding of the gap between stated preference and actual adoption behavior will allow policymakers to gauge what role green energy tariffs can play in incentivizing investment in renewables and in energy sector transition more generally.

1.1. The emergence of contemporary retail green energy tariffs

During the last two decades governments around the world and supranational bodies like the European Union have sought to liberalize the electricity sector so as to ensure more efficient allocation of resources via competitive forces [3,6]. A component of this process has been retail electricity liberalization. In Europe, for instance, Directives 2003/54/EC explicitly mandated that all European retail consumers should have the ability to choose between competing electricity suppliers. The liberalization of the electricity sector has coincided with mounting concerns about global warming which in turn has lead to the establishment of a range of policies including Emissions Trading and Feed-In-Tariffs aimed at accelerating transition towards a decarbonized energy system [7,8].

The fusion of retail energy sector liberalization and mounting concern for the environment have precipitated the emergence of an innovative means of achieving CO_2 reductions by incentivising the deployment of renewables: green electricity tariffs. Accordingly, green electricity tariffs are product innovations whereby the electricity supply company guarantees that the quantity of electricity delivered to the end consumer is match by an equivalent amount of renewable energy generation. The tariffs thus provide additional investment incentives for the deployment of renewable energy sources (RES). A critical component in the development of these markets has been the use of willingness-to-pay (WTP) surveys to measure market potential or latent demand for green tariffs. However, a growing body of empirical and policy-focused research has found that this apparent latent demand has not, on the whole, materialized into households actually adopting these tariffs [9–11].

The reasons originally advanced to explain these divergences relate to the free rider problem and to biases in WTP estimates (in particular upward response bias) [9,11,12]. More recently, additional explanations have been mooted in a policy literature that has identified contextual problems in individual markets or market imperfections common in many markets [9–11,13,14]. In the latter case, an often cited market imperfection is a lack of trust in product offerings due to insufficient transparency, with non-government organizations often stepping in to try to alleviate these problems by providing accreditation and labeling schemes [4,15].

In order to conceptualize the various factors constraining the adoption of green electricity tariffs, this paper develops a model that links the WTP literature with the established innovation diffusion literature. As already intimated, this concern arises from a need to reconcile the large disparities that have been empirically observed between the proportion of households actually adopting green electricity tariffs and the proportion in WTP surveys that claim they would (to avoid confusion we call this proportion of households stated-willingness-to-adopt or SWA).[1] Using an epidemic diffusion framework our model depicts how increasing consumer environmental concern, driven by word-of-mouth and mass media communication channels, results in an increasing proportion of households with a SWA. The presence of response bias and the free rider problem result in 'feasible adoption' being below the SWA. Feasible adoption is, in turn, differentiated from actual adoption by the extent of market imperfections, such as the supply side problems and regulatory failures often discussed in the empirical literature.

The distinctions between SWA, feasible adoption and actual adoption, should help policymakers conceptualize the difficulties experienced in green energy markets, thereby making it easier for them to assess the role that these markets can play in incentivizing RES investments specifically and energy sector transition more generally. The rest of the paper develops the 'Diffusion Model of an Induced Environmental Market' in the following way. Immediately following (Section 2), is a brief introduction to the WTP and innovation diffusion literatures that provide the grounding for the model. Section 3 provides a summary of the empirical research on green energy markets that have explored the divergence between SWA and actual

[1] SWA measures the proportion of consumers that have a WTP > g, where g is the lowest available premium for green electricity, which, for the sake of simplicity, we assume to be zero. The assumption is, therefore, that for now there is a marginal green tariff g which satisfies g = 0 but the model is flexible enough to accommodate for any g (see Footnote 5 for further discussion). Though clearly SWA and WTP are closely related, the dichotomy allows for the possibility that the dollar or price premium estimate of WTP may be correct but market imperfections or free rider concerns are preventing the actual adoption of the tariff (SWA) at the given WTP. Thus, our model is concerned with why WTP estimates do not materialise into equivalent proportions of green tariff adoption, once we take into account the lowest cost tariff. Accordingly we do not necessarily question the accuracy of WTP estimates. The model presented here incorporates a WTP upward bias measure; however, this could be set to zero (See also Section 5.2 and Footnote 8).