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Small systems, big targets: Power sector reforms and renewable energy in small systems☆

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ABSTRACT

There is some consensus that the traditional energy-only electricity markets, where prices are based on system marginal cost, cannot function efficiently with both fossil fuels and renewables, resulting in market disruptions and price volatility. Consequently, much effort has been focused on how to integrate these different resources in larger and mature electricity systems such as the use of capacity markets in addition to energy-only markets. This paper argues that the effectiveness of competition is limited by the size of an electricity system and there is a threshold size (and associated characteristics such as tropical locations, lack of access, and the prevalence of remote communities of consumers) below which competition will not produce the expected outcomes. This paper contributes to the policy discourse by discussing the reform of small electricity systems to integrate renewable energy via the means of three case studies: Nicaragua, El Salvador, and Australia's Northern Territory. The paper concludes that electricity reforms and renewables can be complementary in small systems when supported by appropriate instruments and incentives. We draw policy lessons for other small systems that are pursuing a triad of objectives including electricity reform, large-scale renewables development and improving energy access.

1. Introduction

The global energy landscape and operating environment of the electricity supply industry (ESI) are undergoing a slow but certain transformation. The electricity sector is waking up to new disruptions occurring at the grid edge (Arriaga et al., 2017). Distributed energy, clean energy demand and technological progress are reshaping the traditional, centralized fossil fuel-based electricity systems, to accommodate variable renewables and other network-related loads (Sioshansi, 2017). The number of consumers becoming 'prosumers',[1] either through improvements in energy efficiency, or through distributed energy resources, is also on the rise. These changes will become more pronounced as energy storage advances into a viable grid-based resource.

Falling wholesale energy prices at a time of rising generation costs, stagnant energy demand growth and growing penetration of renewable energy and other distributed energy resources are part of the transformation (Sioshansi, 2015). These transformations were not anticipated by policy-makers advocating market-based reforms in the early 1990s. The latter were largely motivated by the breakdown of the traditional economies of scale argument associated with vertical integration of the electricity supply industry, and the potential for competition to lower prices, encouraging innovation in generation and retail supply. "*Competition where feasible, regulation where not*" was the overriding principle of market-based reforms (Newbery, 2002). Electricity sector restructuring, when coupled with effective regulation and competition, was expected to deliver significant consumer benefits when designed and implemented well (Joskow, 2003).

Policy attention of late has also focused on the suitability of electricity market reform carried under the 'standard' or prescriptive approach – the end result of which is market liberalization – for the integration of intermittent renewables. There is a growing concern that traditional energy-only electricity markets where price and investment signals are based on system marginal cost cannot function efficiently with both fossil fuels and renewables. The former have high marginal costs and the latter have zero marginal costs, potentially resulting in market disruptions and price volatility. Consequently, policy has focused on finding new ways to integrate renewables and fossil fuels

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[1] A 'prosumer' is an economic agent such as a household that supplies excess energy produced to the grid (producer) but also consumes electricity from the grid (consumer).

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through adopting competitive solutions (such as the use of capacity markets in addition to energy-only markets) (Sen et al., 2016).

A generic high-level reform of the ESI (the "standard approach" involves steps such as: corporatisation, vertical unbundling (separation)) and restructuring of the sector, introducing competition in the wholesale generation, horizontal separation of incumbents to create competition, establishing an independent regulatory authority, and privatisation of competitive segments of the ESI (Jamasb et al., 2017). The extent of vertical separation has varied across functional, accounting, legal, or ownership separation. Vertical separation was also expected to prevent cross-subsidization between competitive segments and regulated network businesses, and discriminatory behaviour such as denial of access to networks (Joskow, 1998). However, policymakers and scholars have not adequately addressed the central question of "what are the implications of a small electricity system on the effectiveness of market-oriented reforms?"

This paper argues that the effectiveness of reform and competition is limited by the size of an electricity system – in other words, there is a threshold size (and associated characteristics) under which competition by itself will not produce the expected outcomes, and for which distinct policy solutions are required to resolve the problems of scaling up and integrating renewables. Small and isolated systems have characteristics which imply that the economic rationale underpinning the reform of large electricity systems is not readily applicable to them, as the benefits from increased competition are limited. Yet, this has not deterred policymakers from attempting the "standard approach" to reforms in small systems, recently including, for instance, Australia's Northern Territory electricity market (Nepal and Menezes, 2017). Simultaneously, many countries (or territories) with small systems have ambitious renewable energy targets, and in principle face similar policy problems as "larger" or more conventional electricity systems, although the drivers behind these targets are related to electricity access for remote communities rather than decarbonisation per se.

The absence of prior literature on electricity reforms which accounts for the issues of small systems implies limited scope for learning from previous experience from such systems. Yet they account for a small but important number of countries in the Asia Pacific, South East Asia and the Caribbean. These countries are particularly vulnerable to climate change, and their reform objectives have included market restructuring alongside improving access and scaling up renewables (Nepal and Jamasb, 2012a; Nepal and Menezes, 2017).

This study attempts to fill the gap in literature by reviewing policy experience in three small electricity systems: two of these – Nicaragua and El Salvador - have successfully integrated renewables to over 50% of generation within a few years. Based on these countries' experience, we identify a number of practical policy solutions. We propose that a third, Australia's Northern Territory, closely fits the generic case for the adoption of a similar approach, as the Territory has adopted an ambitious renewable energy target in the midst of ongoing power sector reforms. We conclude with policy options for countries or territories which face the problem of reforming electricity markets to integrate renewables, and which fit the characteristics of small electricity systems.

We suggest that electricity sector reforms and renewables can be complementary when supported by appropriate instruments and incentives in small systems. A sophisticated regulatory institutional framework is desirable, but is neither a necessary condition nor a guarantee for successful renewable energy development. Private sector investments can (but not necessarily always) correlate with a high share of renewables.

The remainder of the paper is as follows. Section 2 outlines the characteristics of small electricity systems and sets out the preliminary arguments on why these could adopt renewables integration alongside the 'standard' electricity reform model. Section 3 presents case studies on Nicaragua and El Salvador – two successful cases of electricity market reform and renewables integration in small systems - and Australia's Northern Territory. It documents existing policies and arrangements for renewable energy development in these markets. Section 4 synthesises policy lessons drawn from the case studies, applicable to other small electricity systems globally. Section 5 concludes.

2. The characteristics of small electricity systems

Several small systems have undertaken the process of restructuring their sectors to introduce greater competition riding on the 'wave' of popularity of electricity market reforms that were initiated and spread worldwide in the 1990s. Examples include countries in Africa, and small economies and territories in the Caribbean and the Pacific (Weisser, 2004). In this section, we discuss the features of small electricity systems and summarise the literature addressing the unsuitability of electricity reforms in the scaling and integration of renewables.

"Small" electricity systems can be defined by a set of distinct characteristics. In absolute terms, the literature defines a small electricity system as one that has an installed electricity capacity of below 1000 MW (MW) (Besant-Jones, 2006). This is, however, not the sole characteristic. An electricity system can also be considered "smaller" relative to a wider electricity market. This could include a system situated within a country (such as the provincial markets in Australia), or within a wider region (such as individual systems within a transnational network – for instance the countries within Latin America's SIEPAC network) which accounts for a small proportion of that overall system. The Single Electricity Market (SEM) in Ireland is an example of a smaller and isolated market in the European context (Nepal and Jamasb, 2012b). An important trend including some small power systems globally is the formation of power trade areas with neighbouring countries and are summarised in USAID (2016).

In many small systems, energy demand is often too low (and the demand base is too small) to allow the benefits of greater competition to manifest – for instance, through the lowering of electricity prices. Small electricity systems are also sensitive to the impact of large foreign investors and developers in electricity generation and distribution (Besant-Jones, 2006). The benefits of greater competition in small electricity systems may be lower than the transaction costs involved in fostering competition. Alternatively, the benefits of greater competition in small systems may be lower than the benefits obtained from economies of coordination and scope under vertical integration. The costs of vertical separation may be so large to offset the gains from competition even when it is possible to introduce limited competition in generation and achieve some benefits (Bacon, 1994). Hence, countries with small systems can have intermediate reform options although some degree of vertical separation is likely to improve quality of services and lower costs.

Many small systems are geographically distinctive, and prevalent largely among countries in the tropics with higher energy demand (Central America, the Asia- Pacific and the Caribbean). Given their often maritime locations and vulnerability to the impacts of climate change and oil market volatility, many small systems have adopted ambitious renewable targets. Small systems in the tropics often host remote communities with relatively poor electricity access. Finally, small systems in the tropics generally have other reliable resources of renewables to draw on, such as continuous/more predictable solar, and often hydro, rather than solely relying on imported fossil fuels. As of 2014, there were around 88 small electricity systems in the world measured in terms of installed generation capacities (see Table A1). These small systems are predominantly located in Africa, the Caribbean and the Pacific.[2] An earlier study by Bacon and Besant-Jones (2001)

[2] Some small island economies also have small electricity systems. However, the implications of reforms in island economies is a body of literature in itself and hence is not the focus of this paper. See, e.g., Niles and Lloyd (2014), Dornan (2015) and Timilsina and Shah (2016).