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Local factors affecting the spatial diffusion of residential photovoltaic adoption in Sri Lanka

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ABSTRACT

Literature has established many social, economic, residential and environmental factors affecting photovoltaics (PV) adoption in developed countries. However in developing countries, only limited research has been conducted on the viability of micro-generation PV as a main stream clean energy source for greening the electricity grid. This study provides an insight into how residential PV adoption operates in a small developing country.

Using a zero-inflated negative binomial regression model (ZINBM), this study compares the influencing factors of PV adoption in the Colombo district of Sri Lanka, a lower-middle income country, against the well-established factors of PV adoption in developed countries. The results suggest that highly educated middle-aged persons and retirees in the Colombo district are more likely to adopt PV. In addition, early adopters reside in larger houses of average, or above average, housing quality. In the short term, policies focused on expanding the knowledge base on PV technology, as well as incentivising the initial costs of installation, could increase the adoption rate of PV systems in Sri Lanka. In the longer term, increasing opportunities for tertiary education could accelerate the diffusion of innovations, as well as narrow socioeconomic gaps by even distribution of benefits of technological innovations.

1. Introduction

Small developing nations, such as Sri Lanka, do not have mandatory carbon dioxide reduction commitments. Therefore, the need for greening the local electricity supply is not a reaction to outside pressures, but a call from within the country itself. As a country which has prided itself in the past for its clean hydro-electricity, the government and people of Sri Lanka recognise the value of greening the national grid in its path to economic development.

Since the end of the civil war in 2008, Sri Lanka has been on a fast track towards economic prosperity. Sri Lanka was promoted to the lower-middle income country group in 2010 by the International Monetary Fund (IMF). To facilitate economic growth, the demand for electricity in the country increased by 25% between 2010 and 2016, according to the leading electricity provider, the Ceylon Electricity Board (Ceylon Electricity Board (CEB), 2010, 2016a). At present, the power sector in the country is in a transition stage, shifting from hydropower to thermal power to satisfy increasing demand. From 2010 to 2016, thermal electricity generation in the country increased by 90%, while generation from hydropower decreased by 25% (CEB, 2010, 2016a). 67% of Sri Lanka's electricity generation comes from thermal fuel (CEB, 2016a). Electricity generation in Sri Lanka is highly dependent on the 900 MW Norocholai coal power plant which began operations in 2011. Between 2013 and 2016, coal power electricity generation rose by 240% (CEB, 2013, 2016a). As a country which does not have any thermal resources, the rising cost of purchasing coal is also a burden on the economy.

The above trends are likely to continue as hydro-power capacities have been exhausted, while demand for electricity increases in the country. Plans for a second 500 MW coal power plant in Sampur, Trincomalee had to be put on hold due to pressure from local environmentalist groups. The government is now under pressure to find clean energy solutions for its energy supply to partner with economic development in the country. Sri Lanka's national energy policy-2008 declared that, by 2015, the country would endeavor to achieve a 10% contribution to grid electricity from Non-Conventional Renewable Energy (NCRE) sources, excluding conventional hydroelectricity. The contribution of NCRE (excluding mini-hydro) remained at 3%, as of 2015 (CEB, 2015). Therefore, new avenues are currently being explored by the power sector in the country. This study explores the possibility of

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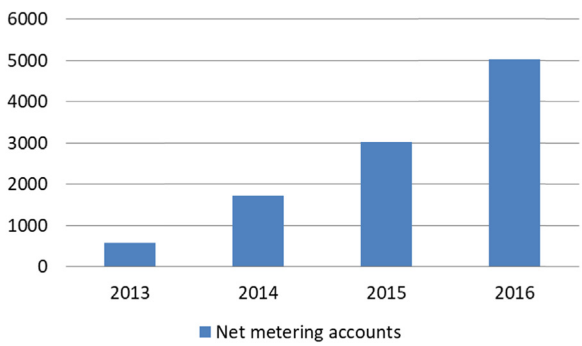

Fig. 1. Net-Metering accounts in Sri Lanka 2013–2016. Source: CEB (2014, 2015, 2016a).

using micro-generation PV to get closer to the NCRE target.

Net-Metering, introduced in 2010, served as the only policy in support of solar micro-generation energy in Sri Lanka until September 2016. The number of Net-Metering users in the country has steadily increased in the period 2013–2016 (Fig. 1). The main driving force behind the increasing number of residential PV adoptions in the country is the local electricity tariff system (Table 1). Households that use more than 91 kWh of electricity see their unit tariff increase from Rs.10.00 to Rs.27.75 (177% increase), resulting in high electricity bills. Therefore, households with higher electricity consumption voluntarily convert to PV systems to save on the electricity bill. In addition, PV is popular among other renewable energy technologies due to its durability, flexible installation, relative simple operation and maintenance, and reduced installation costs (Moosavian et al., 2013; Simpson and Clifton, 2015).

However micro-generation PV is still not a significant contributor to the electricity grid. In 2016, the total capacity of PV installations met 0.01% of net electricity demand (CEB, 2016a). The government of Sri Lanka has taken necessary steps to make micro-generation PV systems a popular and viable source of green energy.

1.1. The Soorya Bala Sangramaya programme

In order to maintain the sustainability and security of micro-generation PV, on the 6th September 2016, the Government of Sri Lanka (GoSL) launched a pioneering programme in PV popularisation known as “Soorya Bala Sangramaya” (A Sinhala term meaning “Battle for solar energy”). The programme introduced two further schemes, in addition to Net-Metering, to promote PV adoption. The first scheme, Net-Accounting, introduces an export tariff: LKR 22.00 per unit is paid to the PV adopter during the first 7 years, and LKR 15.50 per unit from the 8th year to the 20th year. In the second scheme, Net Plus, the PV adopter becomes a micro electricity provider; the total electricity generation from the solar rooftop system would be purchased by the utility at the same rate as for Net- Accounting. It is hoped that, through the programme, 200 MW of solar electricity will be contributed to the national grid by 2020 and 1000 MW by 2025 (Soorya Bala Sangramaya programme, 2016; CEB, 2016b). At the end of 2016, 15% of the 2020 solar electricity generation target had been achieved (CEB, 2016a, 2016b).

Table 1
Tariff for electricity consumption above 60 kWh for a domestic account in Sri Lanka.
Source: Ceylon Electricity Board, Tariff plan-Domestic purpose available at http://www.ceb.lk/for-your-residence-2/.

Tariff block (kWh)	0–60	61–90	91–120	121–180	> 180
Unit rate Rs/kWh	7.85	10	27.75	32	45

The two new schemes are similar to the Feed in Tariff (FiT) policy, which has been implemented by many countries to promote PV adoption (Ahmad et al., 2015; Moosavian et al., 2013; Snape, 2016). The FiT policy guarantees fixed prices and long contractual periods, along with grid access, to any technology using renewable fuel for electricity generation (Ahmad et al., 2015). Until the introduction of Soorya Bala Sangramaya, Sri Lanka did not have exclusive FiT rates for micro-generation of PV. With the introduction of the Soorya Bala Samgramaya Programme, the generation of solar electricity has become more attractive to the public.

Many studies provide evidence to suggest that the uptake of PV has increased since the introduction of incentivising PV systems through various programmes of governments (Ahmad et al., 2015; Khare et al., 2013; Moosavian et al., 2013). Among the policy mechanisms present in Thailand, Feed in Tariffs (FiT) and Board of Investment incentives are the most effective in encouraging adoption of PV technology (Macdonald, 2012). The government of Thailand has developed 10-year Alternative Energy and Development Plan (AEDP), with the aim of increasing alternative energy consumption from 7413 ktoe (kilo tonnes of oil equivalent) in 2012 to 25,000 ktoe in 2021 (Thailand Board of Investment, 2015). In addition, the Solar PV Roadmap initiative by the government of Thailand recommends strategic industry development to capture the full value of PV along its supply chain, encourage upstream manufacturing, attract foreign investment, and establish Thailand as a regional Research and Development hub for future solar developments (Tongsopit et al., 2015). These programmes and policy schemes highlight the significance of PV implementation in Thailand to meeting renewable energy policy targets (Tongsopit et al., 2015). Following the success of PV programmes in Thailand, programmes such as the “Soorya Bala Sangramaya” in Sri Lanka also can be expected to have a positive effect on PV adoption.

2. Method

This study examines local factors, which influence adoption of PV in Sri Lanka, before the introduction of the “Soorya Bala Sangramaya” programme. The study of diffusion of innovations through space intertwines geographical, demographic and social dimensions. Rogers (2003) establishes categories of adopters, depending on the timeline of adoption, as innovators, early adopters, early majority, late majority and laggards. The applicability of the Rogers adoption innovation curve and factors affecting adoption, in a developing country context, has several concerns given the social structure and gaps in socioeconomic conditions (Rogers, 2003).

In Sri Lanka, less than 0.0009% of the total electrified households had adopted PV systems in 2016, clearly indicating that the country is in its early adoption stage. The lack of empirical evidence on spatial diffusion of PV systems from developing countries at the micro-scale is perhaps because innovation does not take place in the developing world to the intensity of the developed world. For example, with high-tech exports at 0.836% of total exports in 2015 (World Bank, 2015), Sri Lanka was ranked 91 out of 128 countries in the global innovation index (Cornell University et al., 2016). As a result, there is no PV panel commercial production in Sri Lanka, the inverters and PV panels are imported. However, developed countries such as Australia also depend on imported PV systems (Moosavian et al., 2013). Therefore, Sri Lanka can still expect to green the electricity supply through micro generation PV due to leapfrogging technology. Here the term leapfrogging refers to the adoption of a technology that is not manufactured locally. Especially in areas of renewable energy, leapfrogging technologies are essential to finding a sustainable solution for the energy problems in developing countries (Levin and Thomas, 2016).

Identifying local factors that affect PV deployment can inform policies to have the right blend of incentives to best promote PV adoption. Many studies have been conducted in developed countries to understand the factors affecting PV adoption ((Balta-Ozkan et al., 2015;