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Transition dynamics in state-influenced niche empowerments: Experiences from India's electricity sector

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ABSTRACT

India experiences transitional changes in its electricity sector from fossil fuels towards renewable sources. An electricity sector with 0% wind and solar (of 16 GW total installed capacity) in 1974 has been transformed and reached a status with 11% wind and solar (of 302 GW total installed capacity) in 2016. The observed changes have complex dynamics, shaped by the decisions of public and private actors in a semi-liberalised market condition, while profoundly influenced by government's supporting policies. It is called a state-influenced empowerment of the renewable niches in the electricity sector. This paper presents an empirically-underpinned theoretical framework to explain the specific dynamics of this context. Understanding of the dynamics provides strategic insights on how government's policies have driven the niche empowerment to date and what should be done to further promote this transition in future. The core concepts of the framework are developed through an iterative process between theoretical deduction from the existing theories in the sustainability transitions field and empirical grounding in the Indian on-grid solar electricity as a case study. Four strategic insights for the further empowerment of solar electricity in future are identified based on the implementation of the framework in the case study.

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1. Introduction

The global commitments to reduce greenhouse gas (GHG) emissions as well as the national interest in improving energy security have pushed India's electricity sector towards renewable sources of electricity generation. The installation of agricultural and irrigation systems has increased the electricity demand and raised the importance of alternative energy sources (Valipour et al., 2015; Yannopoulos et al., 2015). India relies heavily on fossil fuels (~70%) for the electricity generation, and consequently it had the third highest carbon dioxide emissions worldwide in 2010. However, the Government of India has largely supported renewable energy sources such as wind and solar. Since early 1990s, the share of renewables in the total on-grid electricity generation

has increased from zero to about 14% in 2016, positioning as a growing niche in the electricity sector.

Like many developing countries, India has a partially liberalised electricity sector with an important role to play for public and private sectors in the adoption of alternative energy sources. The semi-rational and self-interested actors in a partially market condition decide to invest in conventional or renewable projects with an aim to maximise their individual profits. However, since individual optimal decisions and systemic failures can divert the generation of electricity from renewables towards conventional sources (coal, oil and gas), the Indian government is needed to influence actors' interactions and to rectify the failures. The important role of government's influence in the empowerment of renewable electricity in the context of developing countries has been also advocated in the previous studies (Moallemi et al., 2014a, b, 2015; Moghaddam et al., 2012). Understanding the state-influenced dynamics of the empowerment of the renewable niche is crucial to support a transition towards a sustainable electricity generation system with effective interventions.

The field of sustainability transitions provides a number of – typically high-level – theoretical frameworks to study the transition dynamics. However, a detailed framework is still required to understand the multi-dimensional aspects of the dynamics as a state-influenced niche empowerment, i.e. the interactions between the economic rationale of

Abbreviations: CEL, Central Electronics Limited; CERC, Central Electricity Regulatory Commission; FIT, Feed-in Tariff; Gol, Government of India; JNNISM, Jawaharlal Nehru National Solar Mission; MATISSE, Methods and Tools for Integrated Sustainability Assessment; MLP, Multi-Level Perspective; MNRE, Ministry of New and Renewable Energy; MoP, Ministry of Power; NAPCC, National Action Plan on Climate Change; Pol, Parliament of India; REC, Renewable Energy Credit; RPO, Renewable Purchase Obligation; SERC, State Electricity Regulatory Commission; TP, National Tariff Policy 2006.

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the actors' decisions and the policy instruments available to states throughout the different phases of the transitions.

The review of the past studies in sustainability transitions highlights the presence of theoretical and empirical gaps in this specific context. Most of the previous studies have been dealing with the theoretical and empirical experiences in the coordinated market economies, such as Netherlands, where deliberative and collaborative relations (e.g. monitoring of behaviours, research networks, exchange of information, etc.), in addition to market, coordinate actors' interactions in transitions. There have been some recent works studying sustainability transitions in energy sectors in India (Jolly and Raven, 2015, 2016). They are successful experiences which can inform the current study, however, they focus only on one aspect of the dynamics (i.e. niche protection and the role of institutions on niche development) and do not analyse the multi-level interactions of transitions. Also, among the few related theoretical works, Safarzyńska (2013) has explored the interplay of market competition and government policies. However, it did not study the influence of the broader interactions between the environment, the dominant system and emerging systems. It was not also supported by empirical experiences from the relevant context. There are some studies which advocate the inclusion of actors' dynamics. Geels (2010) has emphasised the importance of rational choice and causal agents as ontology and the role of Neo-classical economics as its exemplar in the future theoretical extensions of transition dynamics. Smith et al. (2005) and Markard et al. (2012) have also commented on the underlying conceptualisation of transition dynamics with actors and the necessity to explicitly take them into account.

This paper presents an empirically underpinned theoretical framework to explain the transition dynamics of state-influenced niche empowerments. While sustainability transitions concept focuses generally on how to protect niches from market, this paper discusses how niches can take advantage of the market's benefits in transitions. It aims to provide a basis for the effective policymaking and the strategic planning of governments to promote the dynamics of sustainability transitions.

The study is conducted in two steps: theoretical integration and conceptual description. In the first step, the core concepts from sustainability transitions are extracted and a theoretical framework is constructed. The framework is based upon the established transition-theoretical frameworks including the multi-level perspective (Geels, 2002), the multi-pattern approach (de Haan and Rotmans, 2011), Frantzeskaki's framework (Frantzeskaki, 2011) and the actor-option framework (Yücel, 2010). In the conceptual description step, the framework is applied to the empowerment of solar on-grid electricity in India (from 1970s to 2014) to answer how governmental interventions and systems' interactions have influenced the transition of the electricity sector. Explanatory case study (Yin, 1989) is a method used in this step. Data related to the case study is collected through archival research (i.e. review of government and international organisations' documents) and is analysed through categorising and linking to the core concepts in the theoretical framework.

India's electricity sector is an attractive case to study. First, it is a typical model of what may happen in the emergence of renewables in other developing countries as it shares some of their basic features, e.g. rapid growth in electricity demand, the necessity for expansion of infrastructure, the limitation in available resources and the presence of interventionist governments. Although India's electricity sector is our case study, the resulting framework is generic and is capable of being applied to other cases of state-influenced niche empowerments as well. Second, the development process of the Indian solar electricity is aligned with the theoretical concepts in sustainability transitions on which the framework is based. The empowerment of on-grid solar in India's electricity sector started several years ago. Despite a failed take-off in early 2000s, solar electricity has had an increasing growth in investment (about \$4.7 billion in 2011 (UNEP, 2012)) and in installed capacity (from 2 MW in 2007 to 5248 MW in 2015 and to (targeted) 100 GW by 2022). The Jawaharlal Nehru National Solar Mission (JNNSM) is the

major policy framework for the development of solar electricity and is believed to have a crucial role for its success (MNRE, 2010). This corresponds to the theoretical ideas by Geels (2002) and de Haan and Rotmans (2011) in the way that the influence of policy measures from outside (conceptualised as the landscape) destabilises the dominant conventional electricity system (known as regime) and opens a window of opportunity for the growth of emerging renewable systems (known as niches). The Indian solar empowerment also confirms the assumptions we made about the interactions between the state influence and the actors' decisions in market condition. About 77% of 31 GW total renewable installed capacity (in 2014) was operated by private entities whose decision was to maximise private benefits (Bhushan et al., 2014; CEA, 2015). At the same time, their behaviours have been identified highly dependent on Feed-in Tariff (FITs) granted by the government.

The paper is structured as follows. After this introduction, the complementary features of different theories in explaining dynamics in our context are reviewed (Section 2). Section 3 presents the core concepts of the framework from the existing theories with reference to the Indian renewables empowerment. Section 4 explains the dynamics of state-influenced niche empowerment, applied to the case study and using the proposed framework. Section 5 presents the discussion on the developed framework, and finally conclusions are presented in Section 6.

2. The review of theories of dynamics in sustainability transitions

'Sustainability transitions' is an interdisciplinary field, with roots in innovation studies (Rogers, 1962), evolutionary economics (Nelson and Winter, 1977) and integrated assessment¹ (Rotmans, 1998), and are traced back to late 1980s and early 1990s. The field seeks to conceptualise and influence long-term, irreversible and evolutionary processes of change known as transitions. While it is still young, sustainability transitions concept has found rapidly growing applications in addressing sustainability challenges in energy sector. Because of the long-term and evolutionary characteristics of transitions, several theories have focused on explaining transition dynamics. Here, a review of these theories, including the Multi-Level Perspective (MLP), the Multi-Pattern Approach (MPA), Frantzeskaki's framework, the actor-option framework and the MATISSE (Methods and Tools for Integrated Sustainability Assessment) model is provided in order to assess how our framework can benefit from them.

The MLP, originally developed by Rip and Kemp (1998) and further developed extensively by Geels (2002), is the best known, widely applied and in some cases the basis for other frameworks. The MLP describes the patterns and pathways of transitions as an answer to *how* transitions unfold. The dynamics is described at the three nested and analytical levels of change: *niches*, the *regime* and the *landscape*. The levels represent the influences of radical novelties, the established system and the external forces on transitions respectively. The MLP defines a transition as a change from one socio-technical regime to another, and conceptualises its dynamics as the interactions of the regime with niches and the landscape.

The Multi-Pattern Approach (MPA, also referred to as Pillar Theory) has been developed by de Haan (2010) and de Haan and Rotmans (2011) through theoretical deductions. The MPA describes the overall pathways of transitions. It discusses the specific patterns that make up these pathways and the conditions under which they form. As apparent from its name (i.e. Pillar Theory) the framework bases the understanding of dynamics on three pillars, namely *conditions* that drive dynamics, *patterns* that describe their shape of emergence and *paths* that depict the sequence of patterns from initial to new state of a system in

¹ Integrated Assessment is "a structured process of dealing with complex issues, using knowledge from various scientific disciplines and/or stakeholders, such that integrated insights are made available to decision makers" (Rotmans, 1998).

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