Environmental Innovation and Societal Transitions xxx (2017) xxx–xxx

Contents lists available at ScienceDirect

Environmental Innovation and Societal Transitions

journal homepage: www.elsevier.com/locate/eist

Exploring window of opportunity dynamics in infrastructure transformation

Stefan Tongur*, Mats Engwall

Industrial Economics and Management, Royal Institute of Technology, Sweden

ARTICLE INFO

Article history:
Received 22 December 2015
Received in revised form 4 October 2016
Accepted 20 December 2016
Available online xxx

Keywords:
Niche empowerment
Infrastructure transformation
Window of opportunity dynamics
Zero-emission truck technologies
Chicken-and-egg dilemma
Business models
Electric road system

ABSTRACT

This paper examines how infrastructure investments could create conditions favoring the commercialization of sustainable niche technologies. While the transition literature has traditionally treated existing infrastructure as a barrier, recent research has emphasized that infrastructure transformation can function as a facilitator, helping sustainable niche technologies break through. However, few have investigated the dynamics of such processes. This paper conceptualizes how window of opportunity dynamics can arise during infrastructure transformation. The paper is based on a case study of the planning of the I-710 Project in Southern California, the first infrastructure project in which zero-emission truck technology was to be deployed on a large scale. This paper illustrates how infrastructure transformation can play a contradictory role, acting as a barrier or facilitator depending on the niche empowerment processes. Furthermore, this paper addresses the selection mechanisms of infrastructure projects and the interplay between infrastructure design and the business models underlying niche innovations.

1. Introduction

With ever-increasing growth in road transportation, future improvements of existing vehicle technologies will be inadequate to reach stipulated goals for cleaner transportation. Consequently, policy agencies in many countries are trying to foster a transition to technologies that emit zero emissions (ZE) from vehicle tailpipes. In doing so, roadmaps and visions have been articulated, R&D programs initiated, subsidized demonstration projects executed, and market niches created (Boon and Bakker, 2015; Nilsson et al., 2012). However, despite large investments in various niche activities, ZE technologies are still immature since they lack viable business models for mainstream markets (e.g. Steinhilber et al., 2013; Wells and Nieuwenhuis, 2012).

For alternative vehicle technologies to break through, an alternative to the existing infrastructure of roads and gas stations must be implemented on a large scale (Steinhilber et al., 2013; van der Vooren et al., 2012). This necessity for the simultaneous deployment of a ZE technology and its supporting infrastructure is often described as the “chicken-and-egg” dilemma of alternative fuels: users will not purchase alternative vehicles unless adequate fueling infrastructure is available; manufacturers will not produce vehicles that people will not buy; and fuel providers will not invest in alternative infrastructure for vehicles that do not exist (Romm, 2006; Van Bree et al., 2010). Given the uncertainties of innovation processes, contemporary policymakers struggle with the issue of whether they should “pick a winner” and select one alternative technology

* Corresponding author.
E-mail addresses: tongur@kth.se (S. Tongur), mats.engwall@indek.kth.se (M. Engwall).

http://dx.doi.org/10.1016/j.eist.2016.12.003

and infrastructure development to support, or whether they should stay "technology neutral" and let market mechanisms select the technology that survives (Azar and Sandén, 2011; Bolton and Foxon, 2015a; van der Vooren et al., 2012).

Previous research has paid considerable attention to the necessity of a radical shift to sustainable technologies. Much attention has been paid to the possibility of developing sustainable technologies in socio-technical niches sheltered from the mainstream market, so that these technologies can mature and gain momentum to compete against established, unsustainable technologies (Kemp, 1994; Markard et al., 2012). However, limited attention has been paid to the infrastructure transformation that is needed to make these technologies commercially viable (Andersen, 2014; van den Bergh, 2014) between and beyond the initial local niche projects (Geels and Raven, 2006). So far, infrastructure has primarily been regarded as a barrier that is extremely challenging to eliminate. As established infrastructures, technologies, actors, and institutions have co-evolved over a long period, they have created sunk investments, vested interests, and dominant designs in the established technological configurations (Hughes, 1983; Kaijser, 2004). This creates strong lock-ins to the use of established, unsustainable technologies (Arthur, 1989; Unruh, 2000).

However, a small but growing research stream addresses how infrastructure transformation actually could function as a driver, or enabler, of sustainable transition (Bolton and Foxon, 2015b; Frantzeskaki and Loorbach, 2010; Giordano, 2015; Markard, 2011; Markard and Truffer, 2006). These studies point out that problems of aging and lack of sustainability in current infrastructure raise an urgent need for large infrastructure investments, which might open a window of opportunity (W/O) for niche technology deployment and potential systems transformation. So far, however, little attention has been paid to the dynamics of the periods when such breakthroughs happen. This limits our understanding of the interactions between infrastructure and niche innovations and of how these dynamics hinder, or enable, sustainable transitions.

Our aim in this paper is to examine how infrastructure investments can create conditions for sustainable niche technologies to break through. Anchored in an extensive case study of a major infrastructure project, we focus on the W/O as a key feature of systems innovation. In the following, we conceptualize how the dynamics of W/O arise during infrastructure transformation from a stable state of lock-in, through a state of system renewal or transition, to a new state of stability (Bolton and Foxon, 2015b; Markard, 2011). Drawing on the concept of niche empowerment (Smith and Raven, 2012), we discuss the processes by which niche innovations interact with the socio-technical regime.

The paper is based on a case study of the planning of the I-710 Long Beach Freeway Project in Southern California, the first infrastructure project in the USA in which ZE truck technology was to be deployed on a large scale (Metro.net, 2011). This project was transformed from an ordinary infrastructure expansion project into a pioneering environmental project with great potential to trigger a transition to ZE technologies in much of the trucking industry. The paper scrutinizes the W/O and empowerment processes of this project and inquires into the selection dynamics when alternate niche technologies were competing to become the selected solution. In addition, while the mainstream literature has primarily discussed a transition to ZE technologies for passenger vehicles (cf. Bakker and Farla, 2015), this paper addresses opportunities and challenges in the neglected area of ZE truck technologies.

The paper contributes to the transition literature by illustrating how infrastructure transformation can play contradictory roles, functioning as barrier or facilitator depending on the empowerment processes of the niche innovations. Furthermore, the paper raises several issues for further discussion concerning what triggers W/Os, the selection mechanisms of infrastructure projects that may support or hinder radical solutions, and the interplay between infrastructure design and the business models underlying niche innovations.

The rest of the paper is structured as follows. Section 2 presents the theoretical underpinnings of the paper, including the theory of infrastructure transformation and socio-technical systems with a focus on the W/O and niche empowerment concepts. The methodology is then presented in section 3. Section 4 presents the empirical data, specifically considering the policy process for improving air quality in Southern California and the planning process of the I-710 Project. Finally, sections 5 and 6 present an analysis of the case study and a discussion of the theoretical and practical implications of the findings, respectively.

2. Theory

2.1. Infrastructure transformation and socio-technical transition

The physical infrastructure constitutes a fundamental element in the provision of economic and social services to civil society. Historically, infrastructure has been a prerequisite for the diffusion of new major technologies (Smith, 2002). The success of, for example, cars, electrical products, and mobile phones has depended on extensive public investments in related infrastructure. Much of the research on infrastructure has either sought to understand incremental changes within these established infrastructures or explored how to optimize existing system structures (Finger et al., 2005; Loorbach, 2010).

In his seminal work, the historian Thomas Hughes examined how modern infrastructures evolved and expanded into large socio-technical systems, illustrating how the systems' technological components and the system builders, organizations, and institutions became increasingly intertwined over the years (Hughes, 1983; Jonsson, 2000). Following this line of thought, the evolution of social-technical systems has been described as occurring through three sequential phases (Hughes, 1983). First, in the establishment phase, the high uncertainty of future demand is combined with a strong need for massive investment. Second, in the expansion phase, the system becomes established on an initial market and various economic forces, such as economies of scale, scope, and reach (Kaijser, 2004), create momentum. In this phase dominant designs