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Introduction of subsidisation in nascent climate-friendly learning technologies and evaluation of its effectiveness

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ABSTRACT

Given its importance as a practical phenomenon underlying the progress of learning technologies, attention should be paid to the role of subsidisation in learning theory, particularly in the case of nascent climate-related sociable learning technologies, in order to examine its benefits. Thus, this study focuses on subsidy procurement of energy technologies in several economies in the context of the component learning track in endogenous global clusters in order to suggest improvements to the adoption mechanism and examine the climate stabilization constraint. At the same time, the study attempts to determine the global progress ratio of the lithium-ion battery in order to analyse various endogenous learning scenarios for hybrid technologies. An integrated energy system model with highly disaggregated global regions (DNE21+) is used to execute this research in a medium time frame. Subsidisation of the learning track of battery technology encourages greater development of plug-in hybrid vehicles, promotes early diffusion of hybrid technologies, and relieves heavy dependency on crude oil and biofuels. The subsidies in the common learning domains in few economies benefit the nearby economies because of the technology spillover that occurs through numerous cross-feedback learning mechanisms. Endogenous learning with subsidies augments diffusion potentials, abates emissions, and shifts sectoral emissions.

1. Introduction

To supply energy in the service of human comfort and a high standard of living, humankind has been extracting carbon from the Earth's crust and releasing it into the atmosphere through the use of pollution-intensive and inefficient technologies. This has caused the cumulative accumulation of global greenhouse gas (GHG) emissions to grow from 285 ppmv in 1870 to 395 ppmv in 2005 (IPCC, 2007). These emissions are becoming a global danger, since they are leading to drastic increases in natural calamities and may result in the extinction of many fauna and flora (Akimoto et al., 2008). Thus, the world urgently needs to decrease its carbon footprint by deploying clean energy technologies (Wigley et al., 1996). Clean energy innovation is crucial to diverting the present emission trajectory and thereby preventing irreversible and dramatic climate change. In this regard, the main problem lies in determining how we can promote innovation diffusion mechanisms geared towards deploying emerging technologies in the global energy system.

All innovations face significant barriers in their path to commercialization owing to insufficient knowledge dissemination, socio-environmental, geo-political, and techno-economical factors (Rout, 2007). Even though many technologies offer technically sound solutions to the current energy and climate problems, considerations over their economic viability hinder the deployment process. Most energy technologies experience high specific costs in the premature stages, which retard the deployment mechanism. In these cases, further development of the cost reduction is required through experience by R&D investments and deployment policies on push-pull mechanisms. Nevertheless, subsidisation plays a large role in establishing push-pull mechanisms such that a technology progresses beyond the crucial evolution stage (e.g. METI has subsidised solar PV technology by maximum 100% (Koizawa, 2006)). Subsidisation of the technology market significantly reduces the economic barriers to the diffusion of a technology and acts as a propellant for goal-oriented policies relating to the technology, such as Japan's Sunshine Project (Kimura and Suzuki, 2006) (through this project, the MITI and other public funds invested US$27 billion in solar PV technology, which drastically reduced its cost, as shown in Fig. 1

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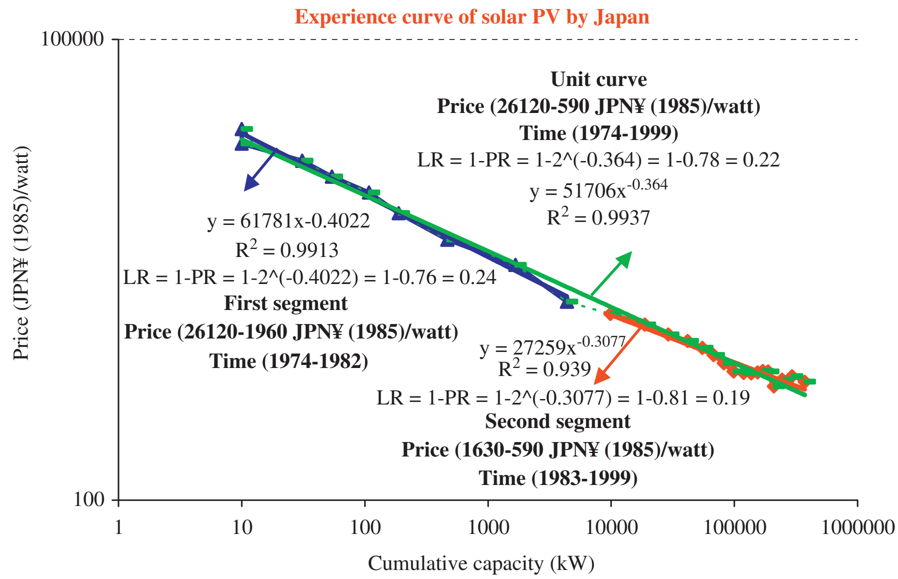

Fig. 1. Variation of learning rates, when plotted in different time and cumulative capacity scales (log–log plot). This is an example of Japan's solar PV development. The price is divided into two categories as provided and plotted against cumulative capacity in different time scale for the derivation of LRs. The sources referred are: IEEJ (1985), Jäger-Waldau (2006), Kimura and Suzuki (2006), RTS Corp. (2006), and Watanabe et al. (2002).

(MITI, 1984; RTS Corp., 2006)). Subsidisation of environmental-friendly technologies also motivates the adoption of green power.

Prominent studies have quantified the annual global subsidies to fossil fuels and commodities as US$ 230–800 billion (Larsen and Shah, 1992; Morgan, 2007; OECD, 1999). These subsidies are geared towards improving the energy development index and human development index, providing energy services to poor communities, and mobilising modern energy services; however, their very nature involves a shift in economic endowment. However, taking climate change issues into consideration, it is evident that direct energy subsidies for finite fossil fuel resources are neither as benevolent nor as beneficial as subsidies for emerging technologies (UNEP and IEA, 2001) because the former raise the price of energy by depleting resources and increase carbon emissions, while the latter undergo experience-based cost reduction and reduce pollution.

Generally, emerging technologies flourish by the subsidy procurement in the developed regions as developing region has not enough economy to fund towards these technologies either through deployment or by R&D spending for unrecovered of their basic problems. Therefore, the technologies are typically subsidised by developed economies, which aim to bring about experience-based cost reductions in the technologies such that all economies can benefit from them. Thus, the question arises of whether the above practical problem relating to nascent learning technologies can be solved through the LP approach to the energy system model, whereby the experience gained from a deployment mechanism is mobilised through subsidies in certain economies. While many researchers have carried out notable works on subsidies (exogenous subsidy funding for technologies and fuels) to assess their benefits, little attention has been paid in the scientific literature to the role and benefits of subsidies introduced in the learning path for the diffusion of learning technologies. Additionally, the management and implementation of component learning strategies based on technological clusters constitute an ever-challenging subject in learning theory. Thus, using an integrated energy system model with highly disaggregated global regions (DNE21+ model), this article attempts to introduce subsidisation (which amount to a fraction of the specific cost in time scale) in the endogenous learning track of energy technologies in order to evaluate the benefits associated with it. Further, this work introduces discontinuous subsidies (i.e. subsidies that are not applied over the entire model horizon) in the deployment process of some economies (namely, developed economies) in order to determine how energy technologies can be strengthened through global learning networks. In addition, we conducted learning simulations for solar PV, wind power, and battery technologies in regional and technological cluster domains with linked technologies in a medium time frame (2000–2050). We used the convergence iteration method for endogenous learning with accepted tolerance values (i.e., CPLEX tolerance parameter values of above zero for endogenous learning) for the solution. Subsidising the technologies of one economy in a regional cluster approach to learning[1] induces technological spillover into nearby economies. This further enhances the adoption mechanism, reducing the cost of the technology and producing a positive effect in the involved economies.

The organization of the paper is as follows. Section 2 presents an overview of some energy technologies considered in this study. Section 3 explains a learning theory that is based on the global cluster approach, the methodological implementation of subsidies applied to the learning curve, the merits of the floor cost approach, the reference energy system (RES) with which the study's learning simulations are conducted, and the data assumptions used in the learning scenarios. The assumptions about learning technologies and the techno-economic parameters required for the formulation of the learning path are presented in this section as well. In addition, the section explains the framework of the DNE21+ model and modelling phenomena. Section 4 presents the results analysis and explains the possible pitfalls of learning theory. The final section concludes by discussing outcomes, implications, policy recommendations, and insights relating to the management of subsidies with different learning approaches.

[1] In regional cluster learning, all regions use the same learning curve for a specific technology.