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Diffusion of energy-saving innovations in industry and the built environment: Dutch studies as inputs for a more integrated analytical framework

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Abstract

The need to improve eco-efficiency is indisputable, and the way forward is through widespread application of environmental innovations. Yet research into the dissemination of such innovations in the Netherlands has been limited in scope. Most studies tend to focus on the feasibility of a particular technology. Few try to explain how technology spreads throughout society. The explanatory factors discerned in these studies are often not related to each other. In this contribution the authors try to integrate different partial explanations for the diffusion of energy-saving technologies in industry and the built environment into one conceptual framework. This integration is based on a secondary analysis of relatively well-elaborated studies dealing with the diffusion of heat pumps, combined heat and power and condensing boilers in industry and the built environment. Core of the framework is the decision-making process of the potentially adapting actor. Characteristics of the actor and the networks in which the actor participates (government, market, society) could have impact on this decision-making process. Technological and economic characteristics of the innovation and more general context factors are also relevant as factors that influence the considerations made in the decision-making process. This conceptual framework can be used both in more elaborate research projects and in brainstorming projects to improve policymaking.

Keywords: Diffusion; Innovation; Energy-saving technologies

1. Introduction

The goal of a sustainable society implies that in the future consumption of energy and raw materials must not go beyond the earth's capacity to recover its ecological balance. The speed at which fossil resources are being depleted must not be any greater than the pace at which alternatives to the use of those resources become available. Moreover, the resources must be fairly distributed at the global scale. One consequence of pursuing this goal is the unavoidable transition to a less energy- and resource-intensive mode of production and consumption. This calls for considerable improvement in eco-efficiency. Weterings and Opschoor, among others, believe that eco-efficiency should be improved by a factor of 10–20 over the coming 50 years (Weterings and Opschoor, 1994; Jansen, 1997). Other voices have called for an improvement in efficiency by a factor of four, on average, over the coming 25 years (Von Weizsäcker et al., 1998; Raad voor het Milieubeheer, 1996; see also Reijnders, 1998). The Netherlands' environmental policy (specifically, the Policy Document on the Environment and the Economy and the Third and Fourth National Environmental Policy Plans) takes improvement of eco-efficiency as its starting point. For years, in fact, this has been part and parcel of the European Union's environmental policy (Commissie van de Europese Gemeenschappen, 1992, p. 27).

Changes along these lines cannot be made from one day to the next. The transition will depend not only on the presence of alternative technology but also on its

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diffusion, its dissemination and application in society at large. In other words, good technological options should not just lie on the shelf collecting dust. The diffusion of environmental and energy-saving innovations should be accelerated. One way to pave the way for policy aimed at stimulating and accelerating the diffusion of environmental innovations is by providing a coherent overview of the factors that influence the speed of diffusion. An approach, which starts with the demand side of innovations, can provide this insight. In this approach the central focus lies on the potential user or adopter of the innovation. As our review of the literature reveals, attention is paid to the demand side but the necessary insight is sparse and scattered. Moreover, little attention is devoted to efforts to integrate the body of knowledge on innovation and diffusion from the perspective of specific disciplines or specific fields of innovation. So the aim of this paper is the development of a coherent framework for the explanation of the (lack of) successes in the diffusion of energy-saving innovations. We have made an attempt to integrate diverse insights in the field of the diffusion of energy-saving technologies in industry and the built environment. The integration is based on a secondary analysis of existing Dutch studies. The analysis was guided by three central questions: which explanations for the diffusion of are found in the studies and which conclusions are drawn, how can the explanatory factors be clustered and how do these clusters relate to each other.

In this paper, we first review the pertinent literature on diffusion. As the diffusion of heat pumps, combined heat and power and condensing boilers is relatively well studied we concentrate our search for explanations on studies concerning these three innovations. An inventory is made of the explanations found in these studies. The explanations found are clustered into six categories of variables. These partial explanations will be examined first. Finally, we combine these factors to form an integrative framework.

2. Diffusion studies

Following Lambooij (1988, p. 13) innovations are defined as the introduction of something new. A technological innovation aims at a renewal of the production processes of a company. After a first adoption the innovation can also be adopted by other companies or by companies in other branches. Schumpeter (Lambooij, 1988, p. 16) conceptualises this dissemination process by using the term diffusion.

When graphed, the diffusion process usually takes the form of S-curves. These curves indicate how familiarity with and application of a technology develop over time. After a hesitant start comes a breakthrough stage, when knowledge and use of the technology spread rapidly. The pace of adoption levels off again over time. Explanations for the course of the diffusion—the form of the S-curve—are few and far between. As it turns out, individual researchers emphasise different aspects, leading to divergent viewpoints in the literature.

One of the key aspects that has been identified is the transfer of information among a heterogeneous population of potential adapters. Emphasis has also been placed on the role of learning processes and co-operation within innovation networks (Jacobs, 1990). Supply factors such as the economic characteristics of the innovation (trends in the costs of investment and operation, efficiency improvement, time span to recoup the development costs) and actions of suppliers did also get attention (Stoneman, 1983; Thirtle and Ruttan, 1987) as well as factors as the know-how present in the industry and its expectations regarding government policy. The significance of the government as a player is also generally acknowledged (see among others Kline and Rosenberg, 1986; Hemmelskamp, 1997). Various studies concentrate on the effectiveness of governmental policy on environmental technology or on specific incentives offered by that policy (see, e.g., Kemp, 1997; Arentsen and Hofman, 1996; Van der Doelen, 1989). Other authors have investigated how decision-making takes place on the application of innovations, with a special focus on the role of communication (Rogers, 1995).

Over the past few decades, quite a few, often policy supporting, studies were released on the diffusion of energy-saving innovations in industry and the built environment (Brand et al., 1999). Relatively many studies have traced how heat pumps (mechanical vapour compression), combined heat and power and high-efficiency boilers have been adopted. The application of membrane technology, heat exchangers, and impulse drying has also been studied, and so have the introductions of photovoltaic cells and solar energy, as well as the use of insulation materials. Much of the literature consists of feasibility studies, dealing mainly with technical and financial bottlenecks. These studies demonstrate that many innovations do not even make it to the application stage, while many of the innovations that do get that far take a long time to really break through. Various studies show that considerable time (5–10 years) may pass from the point when an energy-saving innovation becomes known until it is actually put to use. As it turns out, however, there are hardly any explicit and empirically grounded explanations of the extent to which energy-efficient innovations have been diffused. Moreover, the theoretical basis of the studies that are available tends to be thin. However, studies dealing with the diffusion of heat pumps, combined heat and power and high-efficiency boilers, do contain interesting starting points.