Energy Policy 37 (2009) 3336–3347

Contents lists available at ScienceDirect

Energy Policy

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

Economic efficiency of solar hot water policy in New Zealand

Kenneth Gillingham *

Stanford University, Department of Management Science & Engineering, and University of Auckland Energy Centre, P.O. Box 16336, Stanford, CA 94309, USA

ARTICLE INFO

Article history:
Received 5 August 2008
Accepted 7 January 2009
Available online 14 February 2009

Keywords:
Solar
Greenhouse gases
Electricity

ABSTRACT

New Zealand has recently followed the path of several other countries in promoting solar hot water (SHW) systems in the effort to reduce greenhouse gas emissions, yet the economic efficiency of large-scale policies to encourage SHW remains a pressing question for policymakers. This paper develops an economic framework to examine policies to promote SHW in New Zealand, including the current information, training, and subsidy policy. The economic framework points to environmental, energy security, and average-cost electricity retail pricing market failures as motivation for SHW policy, with the global climate change externality the most important of these. The results indicate that domestic SHW systems are close to being financially attractive from a consumer perspective, but a more substantial subsidy policy would be necessary for SHW to appeal to a wider audience. Such a policy is far more likely to have positive net benefits than a policy of mandating SHW on all homes or all new homes in New Zealand, and could be justified on economic efficiency grounds under reasonable assumptions. However, this result reverses under an economy-wide carbon trading system that internalizes the environmental externality.

1. Introduction

With the threat of global climate change a high priority for policymakers around the world, policies to promote renewable energy technologies have come into fashion. Some of the most common policies focus on solar energy technologies, such as solar photovoltaics (PV) and solar hot water (SHW) heaters. Germany, Japan, and California have implemented large-scale subsidy policies to promote solar PV. Similarly, there are significant subsidy policies for SHW heaters in Germany, Austria, Sweden, the Netherlands, and France, and mandatory installation policies in Spain and Israel (Roulleau and Lloyd, 2008). Some of these policies began decades ago during the oil crises in the 1970s for energy security reasons, but both the number and extent of the policies have gained steam in recent years as part of broader efforts to reduce greenhouse gas emissions.

New Zealand solar policy follows a similar pattern. From 1978 to 1982 New Zealand experimented with a SHW subsidy policy for energy security reasons. The NZ$500 subsidy policy was discontinued largely due to low take-up and poor system performance. With concerns about global climate change growing, New Zealand revived the solar subsidy program in 2002 with a NZ$300 subsidy towards the interest on a loan to finance the SHW installation, along with training and information policies. In 2006, the subsidy was increased to NZ$500 that could be taken directly as a grant or used towards the interest on a loan. One notable aspect of this new policy is that this subsidy will only be granted for purchases of systems that meet a cost-effectiveness threshold set by the Energy Efficiency and Conservation Authority (EECA) (EECA, 2007).

New Zealand's policy has been met with some initial success in increasing diffusion of SHW systems, with SHW annual sales increasing from approximately 1000 in 2002 to 3500 in 2006 (EECA, 2006a). However, in the broader picture, SHW reduces both peak and total electricity demand by such an insignificant amount that the Ministry of Economic Development (MED) does not even examine SHW explicitly in its Energy Data File (MED, 2007a). Moreover, it remains unclear whether the 2006 policy changes will be successful in fostering a sustainable SHW market.

There are several open questions pertaining to New Zealand SHW policy that have broader implications for SHW policy throughout the world. First, what does it mean for a SHW policy to be economic efficiency-improving? In other words, under what conditions would a SHW policy improve social welfare by reducing market failures? Second, is SHW in New Zealand currently financially attractive and if New Zealand is serious about promoting SHW, how large of a subsidy policy might be needed to ensure SHW is financially attractive? Third, what are the implications of large-scale SHW policies for electricity use and greenhouse gas emissions? Finally, would these policies be economic efficiency-improving?

Previous publications that address the economics of SHW policy in New Zealand (e.g., EECA (2006a), EHMS (2006), EECA

* Tel.: 650 353 6578; fax: 650 350 4330.
E-mail address: kgilling@stanford.edu

0301-4215/$ - see front matter © 2009 Elsevier Ltd. All rights reserved.
doi:10.1016/j.enpol.2009.01.005

(2001), Sumner (2004), and McChesney (2005)) have provided useful technical overviews of the financial attractiveness of individual systems or examined the maximum technical potential for solar in New Zealand. This paper aims to address the questions posed above by presenting an economic framework for examining SHW policy based on market failures, and then using this framework as guidance for an economic analysis of several large-scale SHW policies.

The rest of this paper is organized as follows. Section 2 provides this framework for examining the economic efficiency of SHW markets. Section 3 contains an analysis of the financial attractiveness of typical SHW systems to New Zealand consumers. Section 4 examines the implications of several larger-scale SHW policies than the current EECA policies. Section 5 concludes.

2. Economic efficiency in SHW markets

In many respects, solar technologies are no different than any fledgling technology. For any technology, improvements in the technology based on research and development or learning-by-doing can lead to improved performance and lower costs with additional research effort or cumulative installations. Lower costs imply increased sales and possibly greater consumer benefits. Yet we do not subsidize the market for every new gadget. So, why is solar different?

Clearly, there is the environmental externality, which has been the primary motivation for solar policy around the world. But there are several other market failures that may provide additional motivation, some of which are unique to solar in New Zealand.[1] The following sections discuss market failures that could be argued to exist in the New Zealand SHW market in order to provide an economic basis for SHW policy analysis.

2.1. Environmental externalities

The environmental externalities avoided by installing SHW are the primary motivation for SHW policy throughout the world. In New Zealand, over 70% of hot water heaters use electricity, with most of the remainder using natural gas (Isaacs et al., 2006). Thus, from the perspective of the SHW market, there is a positive externality from the installation of each additional SHW system due to reduced use of fossil fuels in the generation of electricity or combustion of natural gas. Quantifying the externality provides guidance for policy intervention.

The magnitude of the global climate change externality is significantly more controversial and uncertain than whether or not the externality exists. Gillingham et al. (2004, 2006) perform a literature review of several economic studies on the value of carbon dioxide external damages, and find a mean value of US$30 per tonne of carbon (approximately NZ$43) and a median value of US$26 per tonne of carbon (approximately NZ$37).[2] However, these studies are far from definitive, for estimating the value of external damages implicitly requires ethical judgments about the value of human life and biodiversity. Thus, it is not uncommon to see an estimate of US$100 per tonne of carbon (NZ$142) or above for the value of the external costs. With such uncertainty, the economic analysis in the later sections of this paper is neutral on magnitude of the external costs by providing insight into the implications of policies under different assumptions of the external costs.

There is also an externality due to emissions of sulfur dioxide (SO_2), nitrogen oxides (NO_X), particulate matter (e.g., PM_{10}, $PM_{2.5}$), and mercury from fossil-fuel-based electricity generation, all of which are known to have health consequences. New Zealand benefits from a relatively small amount of fossil-based electricity generation and a copious amount of wind, so emissions of these pollutants are often quickly spread over a large area and out to sea. Thus these costs are not likely to be important in New Zealand, but may be important in other countries. As a benchmark, Gillingham et al. (2004), combine the results of several studies in the United States to find that the external costs from these other pollutants are roughly half of the external cost of carbon dioxide. Assuming the ratio of carbon to the other pollutants is roughly constant among all thermal generators, and taking the NZ$43 mean value of external damages from carbon dioxide, this implies that air pollutants impose an additional external cost of around US$22 (NZ$31) per tonne of carbon.

2.2. Energy security externality

The case for an energy security externality has been argued from a few angles. One is that importing fuel leaves the economy vulnerable to the macroeconomic effects of price shocks, a factor that is not reflected in the price consumers pay for fuel. Another is that for countries like the United States, there is a national security and international diplomacy external cost. The idea behind this external cost is that consumers purchasing fuel do not take into account the cost of military and diplomatic expenditures to ensure a reliable supply of fuel (Bohi and Toman, 1996). This argument is mostly used in the context of imported oil.

Neither of these cases appears to apply very strongly to the New Zealand electricity market at the current time. Sixty-two percent of electricity generation is supplied by hydropower and geothermal electricity generation. The only imported feedstock for electricity generation is Indonesian coal for use at the Huntly thermal plant (12% of electricity generation in 2006).[3] All of the natural gas currently used in New Zealand is supplied by domestic fields (21% of electricity generation in 2006). This may change in the future as New Zealand natural gas reserves become depleted and pressure builds for the construction of LNG facilities, but currently it appears that the energy security externalities in the electricity market are small.

2.3. Average-cost electricity pricing market failure

As in most countries, New Zealand residential electricity consumers are charged a price per kWh by the retailer that reflects the average cost of electricity and not only does not vary during the day, but often does not vary even by the season. However, demand fluctuates throughout the day, and supply in New Zealand fluctuates seasonally due to constrained supply of hydropower during dry winters. As noted in Joskow and Tirole (2007), price signals may fail to appropriately reflect the scarcity of electricity on the market under average-cost pricing. Assuming a competitive market, the average-cost electricity price is set to smooth out the fluctuations in wholesale spot prices, but ensure the retailer covers its costs. Hence, the use of electricity by consumers during peak times has an external cost, due to the

[1] Absent market failures, economic theory suggests that the competitive market without intervention maximizes social welfare, and thus the justification for any policy intervention would have to be made on equity grounds (i.e., for ethical reasons due to distributional consequences).

[2] All dollar values in this paper are denominated in 2007 New Zealand dollars unless otherwise specified.

[3] Roughly 50% of Huntly coal generation is from New Zealand coal and 50% is from Indonesia (Genesis Energy, 2007).