The contribution of residential solar energy systems to the reduction of greenhouse gas emissions in the Borough of Queenscliffe

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October 2013

Introduction

The Borough of Queenscliffe has identified the importance of reducing its greenhouse gas emissions and aims to become a carbon zero municipality by 2020. For a house, suburb or town to become carbon neutral ideally it produces an equivalent amount of energy from renewable resources to that which it consumes. By increasing the number of solar systems, both photovoltaic (PV) and hot water, in the residential sector, greenhouse gas emissions will be reduced. The number of solar systems located in the Borough of Queenscliffe has been estimated and a database of these systems has been created, including the size and panel orientation. The energy generated by each solar system, in addition to the reductions in greenhouse gas emissions, has been calculated for an average year.

Methodology

The research methodology adopted is similar to that of Street (2011). NearMap was used to determine the number of PV panels and solar hot water systems on the roofs of the houses in Queenscliff and Point Lonsdale. Nearmap allows the user to view aerial photographs of the Earth at a high resolution. The most recent photographs, taken on 25/2/2012, have been used to calculate the number of solar systems in the Borough. In addition to recording the number of solar systems, the address, orientation and, in the case of solar hot water systems, whether it was a roof- or ground-mounted tank has also been recorded. An earlier NearMap aerial photograph (9/11/2009) has been used to determine the growth of solar system installations in the Borough.

To estimate a PV system size (kW) and the annual energy (kWh) generated from a known number of panels, it is necessary to estimate the average panel wattage (W). Panel wattage can vary depending on the installer. Without information about each individual system, certain assumptions were necessary for this study. The average panel wattage was determined by phoning three solar PV system installers on the Bellarine Peninsula and asking them what was the common panel wattage they used in the area. In the last five years, the average panel size was found to be 250 W. Prior to 2007, one company had been installing 150 W panels, but since the number of these had been small, this study has assumed that the average panel size was 250 W. Using the average panel wattage, the system size (kW) on each house was estimated by multiplying the number of panels by the average panel wattage.

With the system size, it was then possible to calculate the annual energy generation by using the estimate of average daily energy production for PV systems located in Melbourne (CEC, 2012). Interpolation was used to estimate the output of non-standard system sizes. It was also assumed that trees and neighbouring buildings did not shade the panels and that they were not inclined at angles of less than 10°. These assumptions were made due to the limitations of Nearmap. The orientation of the systems was not considered since most panels faced a direction between northwest and northeast. The reduction in greenhouse gas emissions was calculated by multiplying the total energy produced (kWh) by the PV systems by the average amount of CO_2-e emitted per kWh of electricity in Victoria using brown coal i.e. 1.37 kg (DCCEE, 2010, Table 40).

Since it was not possible to identify if a solar hot water system was gas- or electric-boosted with Nearmap, it was decided to assume that all the solar hot water systems would be gas-boosted. Gas hot water systems are the most common hot water systems in Victoria. Each gas-boosted solar hot water system has been assumed to be capable of saving 60% of the energy and associated emissions used to produce hot water (Sustainability Victoria, 2011). The annual energy used by a standard gas-boosted hot water heater in a medium-sized household was found on average to be 7023 kWh (25.3 GJ) (Wilkenfeld, 2005). The amount of energy that is saved by a solar hot water gas-boosted system has been calculated by multiplying the percentage savings with the average energy used for a gas-boosted system. The reduction in greenhouse gas emissions was calculated by multiplying the total energy saved (GJ) by the solar hot water systems by the average amount of CO_2-e emitted per GJ using gas in Victoria i.e. 51.33 kg (DCCEE, 2010, Table 2).

Solar System Numbers

Figures 1 and 2 show the number of solar power systems installed in Point Lonsdale and Queensliff respectively. The yellow dots indicate photovoltaic panels, green dots indicate solar hot water systems and the pink dots indicate both types of system. It is interesting to note that a high concentration of solar power systems are found on the north side of Point Lonsdale where more recent houses have been built.

Figure 1: Distribution of solar PV and hot water systems in Point Lonsdale on the 25/2/2012

Figure 2: Distribution of solar PV and hot water systems in the Queenscliff on the 25/2/2012

At the end of 2009 there were 39 dwellings with solar PV systems, 33 of which were located in Point Lonsdale. At the same time, 53 dwellings had solar hot water systems, 37 of which were located in Point Lonsdale. By February 2012, the number of solar PV and solar hot water systems installed in the Borough had increased significantly. There were 133 and 104 solar PV and hot water systems respectively in the two towns (Table 1). The number of solar PV panels installed varied between four and 30 panels. In early 2012, according to Morton (2012), approximately one in twenty Victorian houses had solar PV panels, compared with nearly one in ten nationally (Morton, 2012). In 2011, there were 2745 private dwellings in the Borough (profile_id, 2013), indicating that only 4.8% had solar PV systems on their roofs. It should be remembered that over half of the Borough's private dwellings are classified as unoccupied since they are holiday houses. In 2008, 7% of Australian households used solar energy for heating water (ABS, 2010). In early 2012, 104 private dwellings in the Borough had solar hot water heaters. If it is assumed that only occupied houses in the Borough have installed a solar water heater, this means that nearly 8% of households used this solar technology. The majority of the solar hot water systems had two panels, but some had a single panel while the maximum number was three. These figures indicate that while there has been a lower uptake of solar PV technology in the Borough than in Victoria and nationally, use of solar water heating is comparable with the national average.

Table 1: Number of solar PV and hot water systems in November 2009 and February 2012

	9/11/2009		25/2/2012	
Location	**Solar PV**	**Solar hot water**	**Solar PV**	**Solar hot water**
Point Lonsdale	33	37	103	69
Queenscliff	6	16	30	35
Total	**39**	**53**	**133**	**104**

Greenhouse Gas Reductions

In 2007, the residential electricity consumption in the Borough of Queenscliffe was 9,125 GWh (DSE, 2009). The greenhouse gas emissions associated with this electricity use was 12,501 t.CO_2-e. Domestic electricity consumption made up 55% of the total electricity consumed in the Borough, which makes it the largest user of electricity followed by commercial sector with 42% (BoQ, 2012). In 2007, the residential gas consumption in the Borough of Queenscliffe was 64,216 GJ (DSE, 2009). The greenhouse gas emissions associated with this usage was 3,296 t.CO_2-e

Collectively the 133 solar PV systems in the Borough have been estimated to generate 410.8 MWh of electricity annually. Using the DCCEE emission coefficient for brown coal electricity generation, this indicates that 562.7 tonnes of CO_2-e have been avoided regardless of whether the electricity generated by the solar system was used immediately or exported to the grid. This means that there has effectively been a 4.5% reduction in the Borough's residential electricty emissions from the solar PV systems, assuming that residential electricity consumption has remained relatively constant since 2007.

Collectively the 104 solar hot water systems in the Borough have been estimated to reduce emissions of CO_2-e by 81 tonnes annually. This means that there has been a 2.5% reduction in the Borough's residential gas emissions from the solar hot water systems, assuming that residential gas consumption has remained relatively constant since 2007.

Conclusions

The total greenhouse gas emissions saved from the solar PV panels and hot water systems installed in the Borough are 644 t.CO2-e. This figure represents approximately 4% of the emissions produced by the total gas and electricity usage from the Borough's residential sector. The percentage of installed solar PV systems in the Borough is low by national standards while the percentage of households with a solar water heater appears to be comparable with the national figure. The analysis indicates that local home owners need further encouragement to embrace these technologies, particularly if the Borough is going to meet its goal of carbon neutrality by 2020.

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