Parliamentary Commissioner for the Environment
Te Kaitiaki Taiao a Te Whare Pāremata

Appendix to '*Evaluating solar water heating: Sun renewable energy and climate change*'

This appendix has six sections:

1. Number of EECA grants for solar water heaters
2. Cost of electricity at different times
3. Types of generation at different times
4. Solar performance in midwinter
5. Heat pump water heater performance over a year
6. Demand growth and new build

A.1 Number of EECA grants for solar water heating

Table 1 shows the number of installations of solar water heating systems that received a grant from EECA, as part of their Energywise funding for efficient water heating.

Table 1. EECA grants for solar systems[1] .

Year	Number of systems installed
2006/2007	1120
2007/2008	700
2008/2009	1980
2009/2010	2906
2010/2011	2457
2011/2012	2300[2]
Total	11463

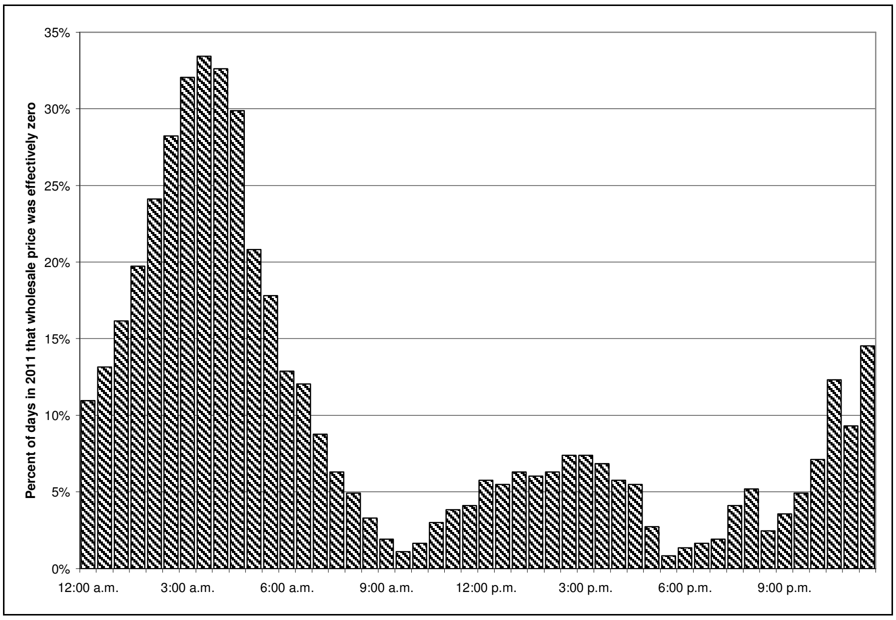
[1] Source EECA

[2] Full year estimate the final numbers are unavailable until December 2012, when all final claims have been made with EECA. This is because grants are paid after systems are installed, not just initial decision to purchase.

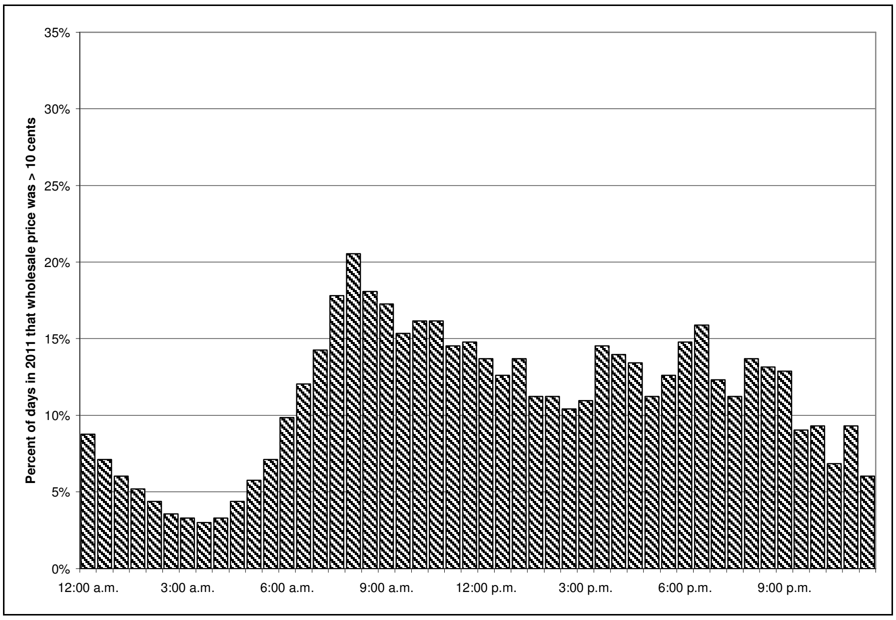
A.2 Cost of electricity at different times

In general electricity use is cheap at night and expensive during the day. In the early hours of the morning, the price of generated electricity often falls close to zero, indicating the risk of 'wasted' renewable energy. The following graphs, using actual wholesale electric prices in 2011, demonstrate this.[3]

The first graph (a) shows the percentage of days that each half hour period of electricity use was less than 1 cent per kWh (i.e., effectively zero). The second graph (b) shows the percentage of days that each half hour period of electricity use was greater than 10 cents per kWh.



(a) Cheap electricity – prices less than 1 cent per ***kWh***



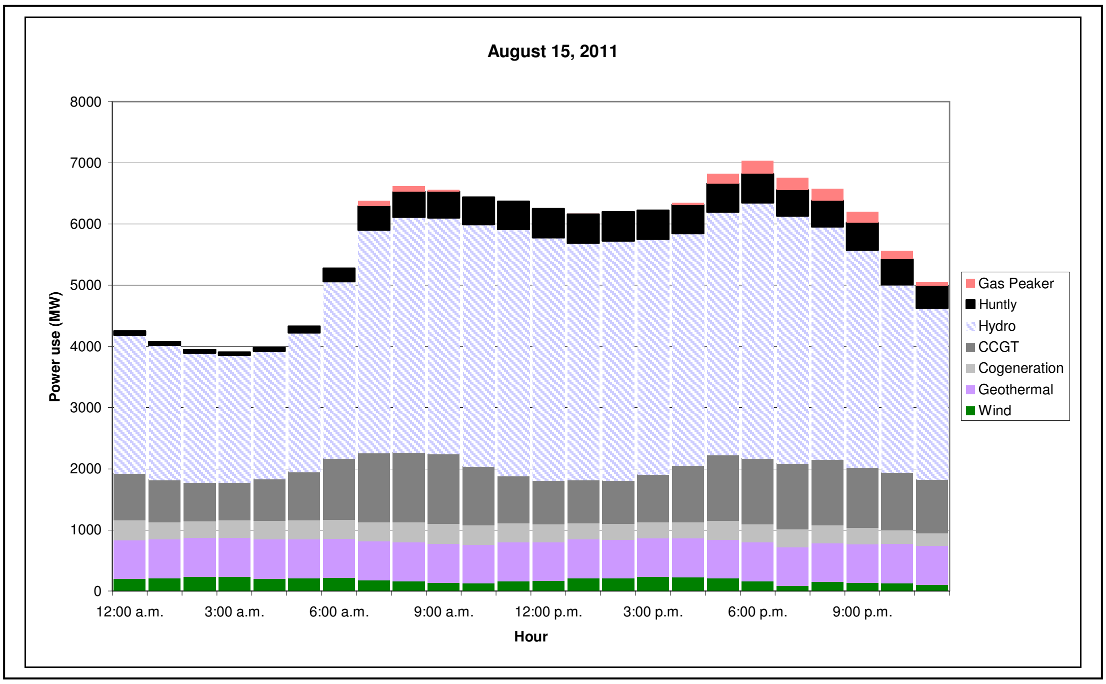
[3] Calculated using the half hourly prices from Haywards node.

(b) Expensive electricity – prices greater than 10 cents per kWh

A.3 Types of generation at different times

Reducing electricity use when demand is high is more valuable from an environmental perspective (and from an economic perspective) than reducing demand at other times.

For example, on the day of the big snow in August 2011, most (if not all) the power stations in New Zealand would have been running for all or part of the day. The figure below shows how the very high demand for electricity on that day was met.



In the New Zealand electricity system, generators bid amounts of electricity in 'merit order' into the grid every half hour. This figure shows the electricity that met the demand on the particularly cold day of 15 August 2011.

As on any day of the year, first, second and third to be 'bid' into the grid on that cold winter day was the electricity from wind, geothermal, and cogeneration. All these three are "use it or lose it" types of electricity – if the energy is not used it is lost.

The relative order that CCGT, hydro, Huntly, and gas peakers are 'bid' into the grid varies depending on the relative prices of generating using water, gas and coal at different times.

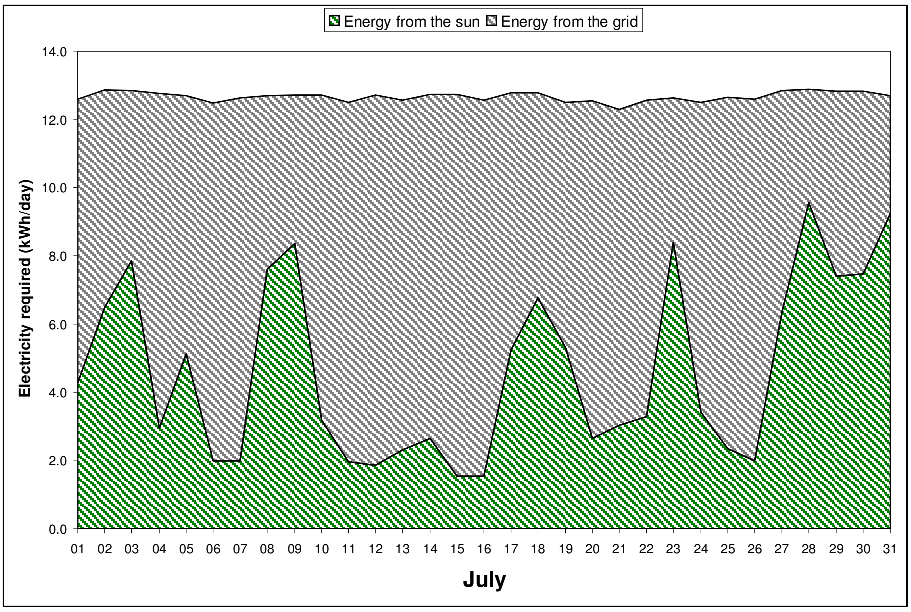
Gas peakers were used at the morning peak and more in the late afternoon and evening. Just below is the electricity generated by the Huntly power station which appears to have begun to run at full capacity early around 7:00 am.[4] The amount of electricity from combined cycle gas turbines also increases during the morning and evening peaks.[5]

Hydroelectricity is, of course, New Zealand's major type of electricity. It contributes to both baseload and to peakload.[6]

[4] Huntly has four big generation units that switch between coal and gas depending on their relative prices.
[5] Combined cycle gas turbines cannot be used as peakers because they cannot respond quickly to fluctuating demand.
[6] Some hydroelectric power stations that can store water behind dams also contribute to baseload. Some do this because they store relatively little water. Others (such as the Karapiro power plant on the Waikato River) must let a certain amount of water through the turbines to maintain a minimum flow downstream for environmental reasons.

A.4 Solar performance in midwinter

The figure below shows the day-to-day variation in solar water heater performance in the winter month of July.[7] This high day-to-day variation does not occur in summer.

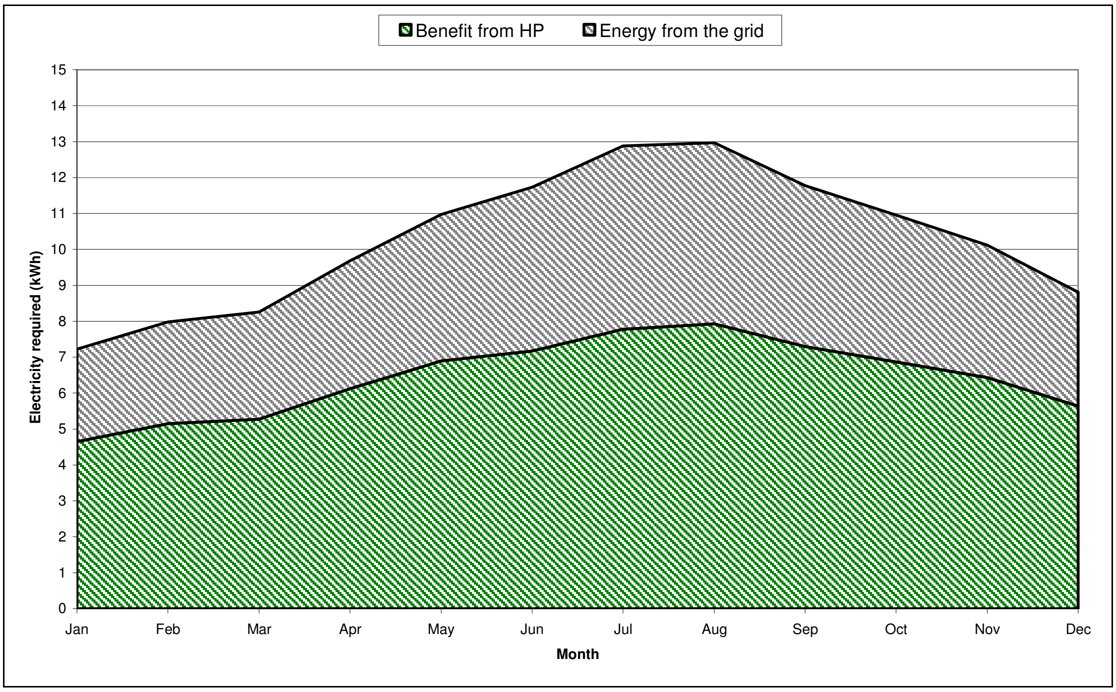


There is big day-to-day variation in the relative amounts of sunlight and electricity used to heat water in a solar water heating system in winter months

[7] For a medium user household averaged across the six cities (see 'Comparison of solar and heat pump water heaters in New Zealand' available at www.pce.parliament.nz).

A.5 Heat pump water heaters performance over a year

Heat pump water heaters save more electricity in winter than in summer as shown in the figure below.[8]



Heat pump water heater electricity use over a year – monthly averages

[8] As in Chapter 3, this is based on the modelling results in "*Comparison of solar and heat pump water heaters in New Zealand"*. The graph is for a medium user averaged across the six cities. A lot more energy is required for heating water in winter, even though the proportion of energy saved by a heat pump is lower in winter.

A.6 Demand growth and new build

In the long-run, the types of new power plants that are built to meet rising demand are what drive carbon dioxide emissions from electricity generation. Building fossil-fuelled power plants will lock in greenhouse gas emissions for years to come.

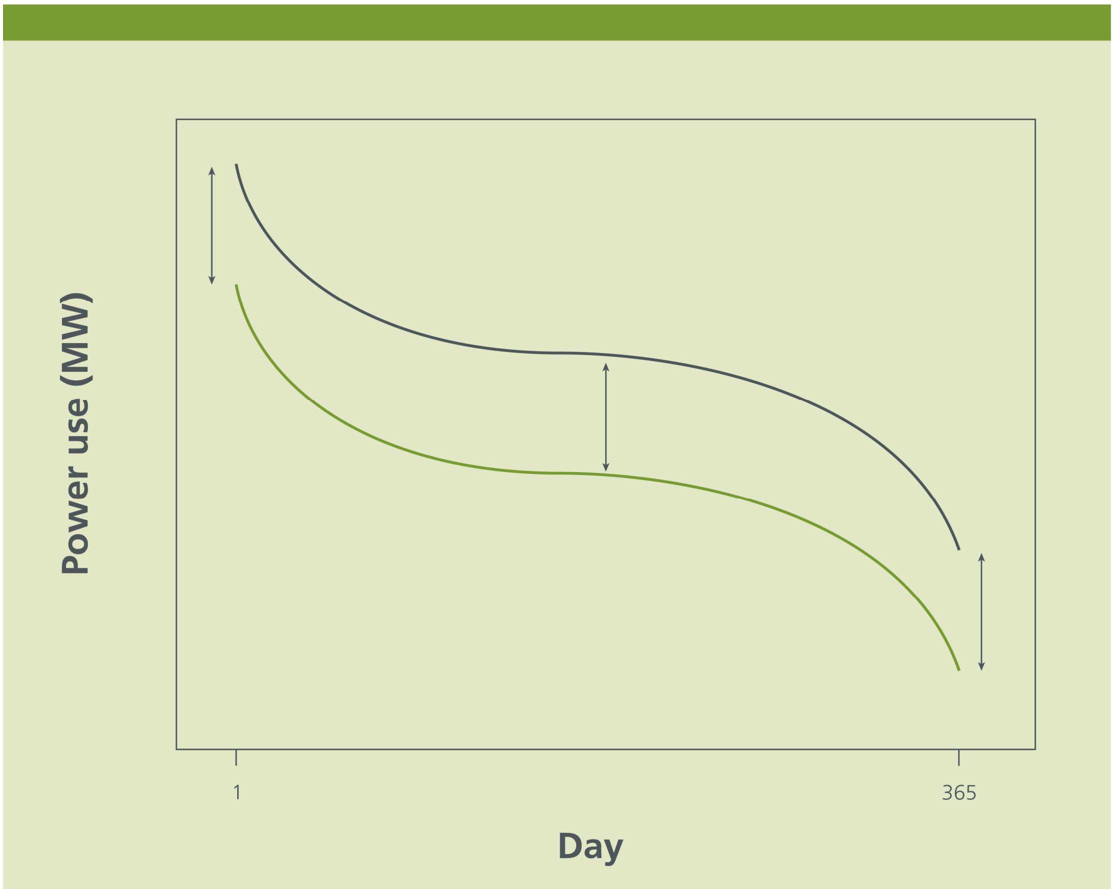
The nature of demand growth determines the types of generation that will be built to meet this growth. This can be illustrated by considering two simplified scenarios at either end of the spectrum:

Scenario 1

If demand growth is fairly even across all half hour periods, then growth would probably be met by building new baseload plant.

While this could be met by fossil-fuelled baseload generation, renewable options such as wind and geothermal would be well suited to supply this type of demand increase.

This scenario is illustrated in the figure below, which depicts a stylised load duration curve. The vertical axis shows demand for electricity. The horizontal axis orders the days of the year from the highest demand to lowest demand. Growth that is consistent across the year would result in this curve shifting upwards (figure below).



Scenario 1 – Load growth that is even across the year can be met by baseload generation (e.g. wind, geothermal, run-of-river hydro)

What would solar water heaters do?
This type of demand growth (as Scenario 1) could be in part offset by installing solar water heating systems and therefore avoid some new baseload generation being built.

However, solar water heating would be an expensive option. Other options that could provide baseload low carbon generation, for example wind generation, are around half the cost per kWh.[9]

[9] A kWh of electricity generated from wind farms and transmitted and distributed is currently about half of the cost of a kWh of electricity 'generated' by a solar water heater. Electricity LRMC model www.med.govt.nz [accessed 11 July 2012]. This spreadsheet lists 17 wind farms that are either under construction, in the consent process, or have been proposed. The estimated cost of generating electricity from these wind farms is between 9 and 15 cents per kWh. The cost of delivering this electricity to households would add perhaps 4 cents per kWh. The KEMA Efficiency Potential Study in 2007 estimated costs for solar water heaters expressed as an electricity price as being 30 cents per kWh for new builds and 37 cents per kWh for retrofits.

Scenario 2

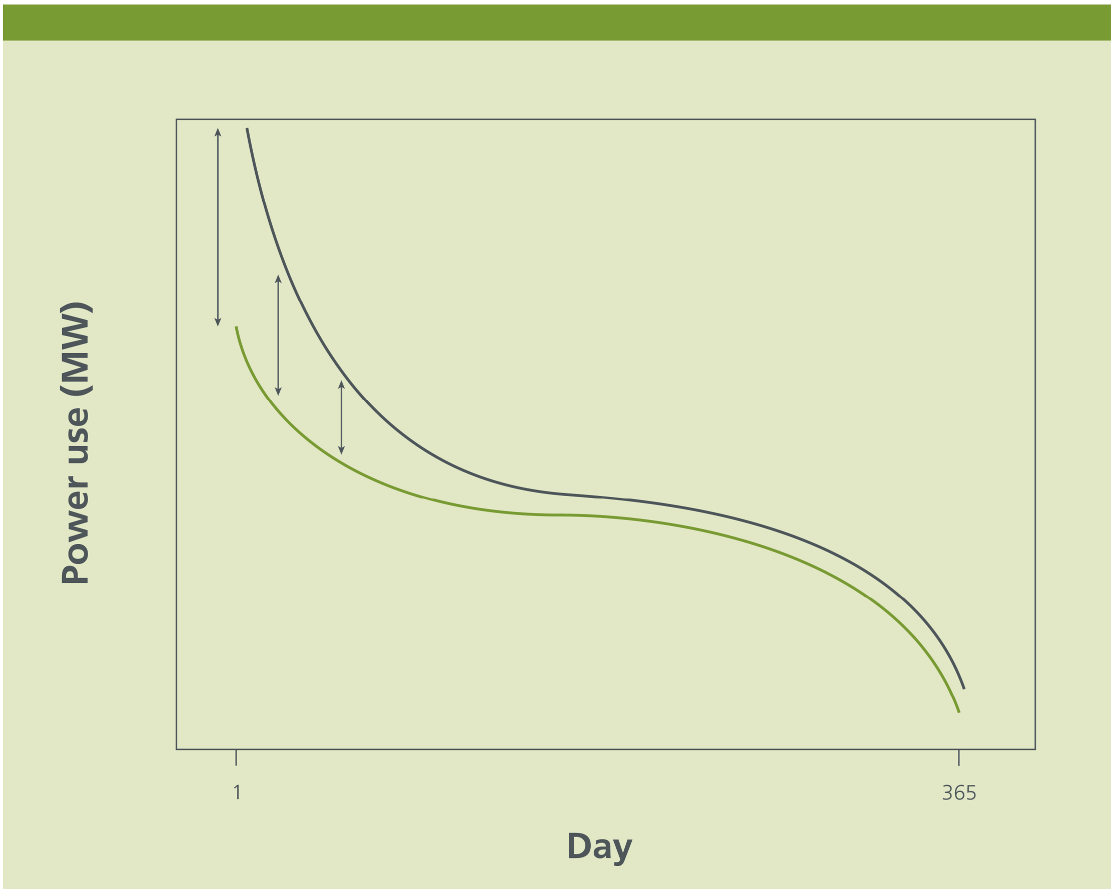
If growth is skewed towards the peak and there is limited capacity (MW) in the system (peak constrained), then growth would probably be met by building new peaking power plants (see figure below).[10]

These will generally be either new fossil-fuelled power plants or new hydro storage, both being well-suited for peaking. Other types of renewables (wind, geothermal), however, are not well-suited.

If that demand growth is focussed at the very peak (the extreme left in the figure below), then the new plant will be more likely to be an open-cycle gas turbine plant or diesel peakers. This is because these have a relatively lower capital cost and therefore will be a more economic option if they will only need to be run for a small number of days or weeks a year. However, they are inefficient per kWh from an emissions point of view, although are not as bad as coal.

If that demand growth is more spread out but still weighted toward the peak, it becomes more likely that the new plant would be a combined-cycle gas turbine plant. These have a relatively higher capital cost, so need to be used more often to offset the upfront cost, but have lower carbon emissions per kWh.

[10] If growth is mostly at the peak, but there are still plenty of additional MW in the system, the growth could be met by building new baseload plant and keeping more water in hydro storage to meet the very peak. However, as the capacity limit is approached, new peaking plant would become necessary.



Scenario 2 – If peak load grows faster than growth at other times then fossil fuelled power plants (or hydro storage) are needed

What would solar water heating do?

Installing solar water heating with electric back-up offers only a limited benefit in terms of reducing the peaks, and so would not help reduce the need for new fossil fuelled power plants (or new hydro storage) to any significant degree. This is because it provides the least electricity savings during the coldest, stormiest days in winter, which are the days with the highest peaks.[11]

In contrast, *night-only* water heaters would lower this peak growth because they would not use electricity at these peak times.

[11] A solar water heater could be used with a night-only tariff which would then help reduce peak demand but the solar water heater has a high capital cost.