Solar Thermal Generation: The Answer to Australia’s Renewable Energy Needs?

by Adrian Kemp

Introduction
Globally, electricity generated from renewable fuel sources is rapidly expanding as countries look to reduce greenhouse gas emissions to satisfy international reduction commitments. This is leading governments to develop policies that encourage both renewable generation investment and renewable energy research and development, including emissions trading schemes, renewable energy targets, feed-in tariffs to promote small scale renewable generation, and direct public investments in developing lower emissions technologies.

While wind technology still dominates the renewable generation investment profile, new technologies like solar thermal generation and geothermal generation are being developed. Of these, solar thermal has reached the point where full-scale plants are being planned for California and Australia. Ultimately the financial viability of such investments in the absence of government policy or direct financial assistance will depend on a range of parameters including the capital costs of these plants, changes in competitive generator fuel costs, the resulting carbon prices, and, importantly, the solar radiation available in a plant’s specific location.

NERA has developed a stochastic model to analyse the value of generation investments that directly takes into account future uncertainties that can influence these values. This proprietary model allows generation investors to evaluate the financial risks involved in a systematic manner and so alleviates some of the uncertainty. Additionally, the model has been designed explicitly to assess renewable generation given the different dispatch characteristics of these plants compared with traditional coal or gas-fired thermal plants.

This paper applies these modelling tools to estimate the value of a hypothetical 250 MW solar thermal generation investment in the Australian National Electricity Market (NEM). The results provide insight on the parameters that affect the financial returns to solar thermal generation. With the Australian government about to embark on major public investments in solar generation, such assessments will be critical to ensuring that any public solar thermal generation investment maximises the potential public returns.

The Australian Renewable Generation Market
In Australia, renewable generation technology is dominated by wind generation. While it remains a small proportion of total installed generation capacity (almost 3% in 2009), wind generation has been growing rapidly, albeit from a low starting base, as shown in Figure 1. In 2001 there was almost no installed wind generation capacity, while currently there is in excess of 1,200 MW of installed capacity.

The Australian government is proposing to support renewable generation investment by expanding its renewable energy target (RET) from 9,500 GWh (as set in 2001) to 45,000 GWh, or approximately 20% of forecast total electricity demand in 2020. To achieve this target, electricity retailers will be required to purchase either 20% of their electricity needs from renewable sources or purchase an equivalent energy value of renewable energy certificates.
As a consequence, we can expect to see a rapid expansion in the number of wind farms in Australia. That said, the Australian government also wants to promote other renewable generation technologies, so it has recently made a significant commitment to the development of low emission technologies in the form of a A$4.5 billion (US$3.7 billion) Clean Energy Initiative, which will operate in parallel to the RET scheme. Specifically, the Clean Energy Initiative is intended to support the research, development, and demonstration of low-emission energy technologies, including industrial-scale carbon capture and storage and solar energy, through three components:

- A A$2.43 (US$1.98) billion Carbon Capture and Storage Flagships Program;
- A A$1.60 (US$1.31) billion Solar Flagships Program (and associated support); and
- A A$465 (US$380) million investment to create Renewables Australia.

The Solar Flagships Program will support the construction and demonstration of up to four solar power stations (both solar thermal and photovoltaic technologies) with a combined target size of 1,000 MW.

Finally, in addition to these renewable-specific programmes, the Australian government has committed to introducing an emission trading scheme called the Carbon Pollution Reduction Scheme (CPRS). The CPRS will be a cap-and-trade scheme with an emissions reduction target, allowing the market to decide how the emissions reductions will be achieved. Electricity generators account for the largest proportion of Australia’s total primary energy use, making them the largest contributors to Australia’s carbon emissions. The introduction of the CPRS is therefore expected to increase the cost of electricity generation and so wholesale power market prices.

What is Solar Thermal Generation?
Solar thermal generation differs from the generation of electricity by photovoltaic cells (so-called PV cells), by using sunlight to create heat, which in turn is used to drive a conventional steam turbine. As it relies on direct solar radiation, solar thermal generation works best in locations where solar radiation is typically high.

The principal technologies required for solar thermal generation are a form of solar radiation concentrator, a receiver, a means of transporting the heat, and a method of converting the heat to power. The main solar thermal generation technologies being developed include parabolic trough, central tower, or parabolic dish technologies, each of which concentrate solar radiation in order to heat a liquid medium to produce steam to drive a steam turbine. These technologies can be used in isolation or in a hybrid arrangement in combination with traditional steam turbine fuels like natural gas or coal.

The principal advantage of solar thermal generation is its capacity to produce large quantities of power at low marginal costs (with fuel costs being zero) and with no greenhouse gas emissions. One square kilometre of land is capable of producing as much as 100-120 GWh of electricity per annum.

Photo 1. 1MW Compact Linear Fresnel Reflector attached to the Liddell Coal Power Station in the Hunter Valley, New South Wales

Source: Photo courtesy of Ausra.

However, the current cost of constructing solar thermal generation plants remains prohibitive, so under current market arrangements these plants are not competitive. We understand that a 250 MW solar thermal generator can cost in excess of $1.2 billion compared to around $400 million for an equivalent-sized gas combined cycle generator. Over time and as the technology matures, we can expect that the capital costs of a solar thermal plant will likely decrease relative to conventional generation technologies.
Assessing the Returns to a Hypothetical 250 MW Solar Thermal Generator

To investigate the influence of government policies to introduce an expanded RET and the CPRS, we have estimated the potential returns to a hypothetical 250 MW solar thermal generator using NERA’s proprietary stochastic model calibrated to the Australian NEM. The model can be used to forecast half-hourly prices for each NEM region under a range of input price scenarios and policy development assumptions. The variables for which uncertainty can be explicitly modelled include:

- Generation coal and gas fuel prices;
- Carbon prices;
- Peak demand growth by NEM region;
- Changes to the renewable energy target; and
- Allocations of carbon emissions permits (as applicable).

In addition, the model has a separate dispatch process for solar thermal and other forms of renewable energy that takes into account the relationship between energy inputs and generation output (e.g., the link between solar radiation and peak load periods). This functionality means that the estimated returns to a proposed solar thermal generation plant explicitly take into account that it is generally available during peak load periods of the day when market prices are high.

We have developed a number of climate change policy development scenarios against which to estimate the returns to the hypothetical solar thermal generation plant for the 18-year period from 2009 to 2027. We have also considered separately how the returns may vary according to the region of the NEM where the plant is located, assuming no change in interconnector capacity limits. Hence, the scenarios we have focused on are:

- Base case: Business as usual with no renewable energy target or carbon pollution reduction scheme;
- 20% RET: Renewable energy target based on the proposed 20% renewable energy target by 2020; and
- 20% RET plus CPRS: Renewable energy target plus a carbon pollution reduction scheme—delivering carbon prices in line with current government modelling expectations.

The results are set out in Figure 2 for New South Wales, Victoria, Queensland, and South Australia. Differences in the returns between each region reflect interactions between the changing demand and supply conditions in each region given the existing interconnection constraints.

The results demonstrate that the return to a hypothetical solar thermal generator under the 20% RET scenario are broadly the same as those under the base case. This outcome is driven by market dispatch prices not changing significantly following the introduction of the RET as growth in demand is met through a combination of lower marginal cost renewable generation and higher-cost gas generation.

For both Queensland and New South Wales, under both the base case scenario and the 20% RET scenario the value of the solar generation plant is less than our assumed capital construction cost of around $1.2 billion. In contrast, the expected solar plant value exceeds our assumed capital costs in Victoria and South Australia. These differences reflect the underlying differences in regional wholesale dispatch prices and generation mix both under the base case and following the introduction of the expanded RET.

Following the introduction of the CPRS, the returns increase substantially, reflecting the need for wholesale prices to be sufficiently large to pay the expected carbon emission price. In these circumstances, renewable generation is expected to benefit considerably from the higher wholesale prices without being burdened by an associated carbon emission cost.

Source: NERA analysis.

Photo 2. 5MW Kimberlina solar thermal generator, Bakersfield CA.

Source: Photo courtesy of Ausra.

<table>
<thead>
<tr>
<th>Region</th>
<th>Base Case</th>
<th>20% RET</th>
<th>20% RET + CPRS</th>
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Source: NERA analysis.
Figure 3 illustrates the distribution of gross margins between 2009 and 2030 following an investment in solar thermal generation in New South Wales, taking into account uncertainty about the load growth assumptions and carbon prices. This distribution provides insights on the impact of risk and uncertainty on the expected returns to the investment.

Our results show that the value of the solar thermal generation is between $942 million and $1.5 billion in the 20% RET plus CPRS scenario. With construction costs of A$1.2 billion, this range of values suggests that in the absence of any other interventions, the introduction of the CPRS should be sufficient to drive investment in solar thermal generation in some locations in Australia.

The results suggest that the value of solar thermal generation investments will rise significantly following the introduction of the CPRS. Depending on how the returns to solar thermal generation investment stack up against the returns to similar wind generation projects, solar thermal generation may very well be the answer to Australia’s renewable energy needs.

EndNotes
2 Total generation capacity in 2009 was 45 GW.
3 AUSRA has a 1 MW demonstration Compact Linear Fresnel Reflector solar thermal plant attached to the 2,000 MW Liddell coal power station in the Hunter Valley, New South Wales.
5 It is not possible to directly compare a 250MW solar thermal generator with a gas combined cycle generator because of the intermittency of solar thermal radiation, which thereby reduces the capacity of the solar thermal generator to generate electricity.
6 The valuations are based on a pre-tax real WACC of 7%.
7 These results do not include any additional revenue that might be earned by a renewable generator through the sale of renewable energy certificates. We would expect that such revenue would be on top of that earned through the ordinary dispatch of renewable generation into the market, and will reflect the marginal price of renewable investment to satisfy the renewable energy target requirements.

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Conclusion
Understanding the interactions between carbon emission reduction policies and the value of renewable generation investments is increasingly important for the financing of future renewable generation projects. NERA’s modelling tools can be used to undertake these assessments and to identify the relative financial benefits of the CPRS as compared to the expanded RET for solar thermal generation investors.

That said, these results are indicative only and will vary according to the particular parameters of each solar thermal generation project. A key benefit of the NERA modelling tools is that the drivers of uncertainty for generator value can be modelled quickly and easily, allowing the implications of these uncertainties to be assessed as part of the due diligence process for a specific project. In addition, the models forecast half-hourly electricity market prices taking into account different carbon price and renewable energy target scenarios, and so make them useful for the assessment of conventional investments too.
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