Framing the problem

Solar photovoltaic (PV) power use is increasing. Globally, in the decade to 2010, solar PV generation expanded by 42%.1 In Australia, the number of household solar PV installations increased from 2,629 in 2007 to 1,246,775 in 2013. 1.62% of national electricity was produced by solar PV in 2013;2 the Energy White Paper 2012 estimates that this will increase to 29% by 2050.3 Whilst this increased uptake is in part due to government initiatives, such as feed-in-tariffs and small-scale technology certificates, it is also due to market forces. The cost of PV has fallen annually by approximately 45%,4 and the price of electricity is continuing to rise – providing an incentive for residential solar PV uptake.5

Take home message: solar PV power use will continue to increase, regardless of the political climate.

The output of distributed power generators is variable. Electricity produced by solar PV is ‘distributed’: it is produced near or at the point of consumption. Distributed generators such as solar PV are subject to changes in weather, and may suddenly begin or stop producing electricity, leading to decreases or increases in electricity network demand. These increases and decreases can be planned for if they are forecasted – however, whilst much has been done to forecast changes in wind-power, little has been done to forecast changes in solar PV power.6

Take home message: solar PV production can change rapidly, affecting the demands of the electricity network. However, if forecasted, these events can be planned for.

The A.C.T. is a global pioneer in renewable energy use. The A.C.T. has legislated for 90% of its electricity to be produced from renewable sources by 2020 – the most ambitious of national, state and territory renewable energy targets. The exact impact of un-forecasted changes in solar PV on the electricity network is not yet known; the concern is that, with heavy reliance on renewable energies, these impacts will be felt much more acutely in the A.C.T. In order to prepare for increased renewable energy use, we must understand the impact of sudden changes in distributed power output on the electricity network.

Take home message: We currently do not know what impact sudden changes in solar PV output will have on the electricity grid. It is important we collaborate to answer this question, as the A.C.T. will soon derive 90% of its electricity from renewable sources.

The research and its findings

This research identified weather events that produced rapid changes in collective solar PV output in Canberra. Emphasis was placed on changes that occur on the scale of minutes to an hour as they are not easily forecast, yet affect electricity network operations. Only weather events that affect the whole of the A.C.T. (rather than individual suburbs) were analysed, as these have the greatest potential for disrupting the electricity network. 35 events were identified between the period January 2012 and July 2014 (see Table 1). Positive ramp events (when solar PV output increases rapidly) were often morning events, and
occurred most often when north-west cloud-bands moved away from the A.C.T., or morning fog dissipation was experienced. Negative ramp events (when PV output decreases rapidly) were often afternoon events, caused most frequently by thunderstorms or passing cold fronts. Several weather events that produced changes in PV output were not placed into a weather category as it is unlikely the will reoccur with frequency; if we are to predict ramp events, emphasis should be placed on reoccurring weather event types.

Table 1: This table shows what weather events caused sudden increases in PV output (positive ramp events) and sudden decreases in PV output (negative ramp events).

<table>
<thead>
<tr>
<th>Positive ramp event</th>
<th>Frequency</th>
<th>Negative ramp event</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>NW cloud-band</td>
<td>5</td>
<td>Thunderstorm</td>
<td>4</td>
</tr>
<tr>
<td>Fog dissipation</td>
<td>4</td>
<td>Cold front</td>
<td>4</td>
</tr>
<tr>
<td>Easterly dips; east coast lows</td>
<td>3</td>
<td>NW cloud-band</td>
<td>3</td>
</tr>
<tr>
<td>Easterly trough</td>
<td>2</td>
<td>Easterly trough</td>
<td>2</td>
</tr>
<tr>
<td>Other</td>
<td>4</td>
<td>Other</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>19</strong></td>
<td><strong>Total</strong></td>
<td><strong>16</strong></td>
</tr>
</tbody>
</table>

Take home message: Several types of weather event produce rapid changes in solar PV output in the A.C.T. Most of these events have lead times of 12+ hours and are well forecast by modern weather modelling techniques. Efforts should be made to integrate weather forecasts with solar PV forecasts, so that the electricity network can plan for these occurrences.

**Recommended action**

Addressing this problem needs the bipartisan support of researchers (both private and governmental), industry, and policy-makers. Each area can provide support:

**Policy and politicians:**

- Encouraging A.C.T. solar farms to share energy generation with researchers.
- Providing support for a research project characterising PV ramp events for all major Australian cities (ARENA grant, early 2015).
- Encouraging households to make real-time PV output data available.
- Including researchers and industry in discussions relating to future solar farm locations.

**Researchers:**

- Providing open access to current and historical weather model output, so that each weather event can be analysed more completely (enabling better quality forecasting).

**Industry:**

- Providing updated PV system metadata, including the location of PV systems.
- Delivering this data in groupings by major electrical grid nodes so we can test for regions vulnerable to collective ramp events.

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6 Ibid.