Rooftop Solar Photovoltaic Power Forecasting Using Characteristic Generation Profiles*

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ABSTRACT

Rooftop solar photovoltaic generation systems are often subject to location and site-specific factors that affect the shape of the daily generation profile. We propose a novel approach to rooftop solar photovoltaic power forecasting that applies digital filtering to recent historical generation data to determine a site-specific "Characteristic Generation Profile". This profile can subsequently be used on its own, or in combination with any available exogenous variables, to improve the solar power forecasting process. The approach is simple to implement, uniquely customised for every system it is applied to, and computationally efficient.

1 INTRODUCTION AND MOTIVATION

Solar photovoltaic (PV) power forecasting is becoming increasingly important for rooftop solar PV systems. Such forecasts can help to schedule loads, implement intelligent demand response programs, predict and alleviate distribution network impacts, and enable peer-to-peer energy trading systems. Many different factors affect the amount of solar power generated in a particular site (see Table 1). Much of the existing solar forecasting literature addresses temporal, geographic, and environmental factors that affect the amount of solar irradiation reaching the site. For large scale solar PV systems such as solar farms, system-specific and location-specific factors are typically straightforward to model and account for.

However, rooftop solar PV systems are exposed to a number of additional factors that make the conversion of solar irradiation forecasts into actual solar power forecasts more difficult. Such systems are typically installed on existing rooftops which may not have an optimal tilt and orientation. They may be subject to local shading effects, due to nearby buildings, trees, or chimneys. They may be exposed to curtailment, or suffer from losses due to inverter or wiring. Some of these effects can be seasonal or can change over time (such as trees growing, or new structures being built nearby). For such systems, solar irradiation forecasts are not sufficient, and it is necessary to take into account *both* local solar irradiation, *and* other solar power generation impacts.

An example is provided in Figure 2, which shows generation data on two separate sunny days for three sites that are less than 50km apart in Melbourne, Australia. The first site is slightly East-facing and has a standard solar PV generation profile in summer months; but in other months it is subject to morning shading from a neighbouring house. The second site has a shift in generation towards the afternoon since it is West-facing. The third site has two sets of panels with different orientations (North and West); in summer months the larger West-facing set of panels generates a peak at about 2pm, but in winter months the smaller North-facing generates a peak at about 11am. Despite their proximity to one another, these three sites have very different generation profiles due to site-specific and location-specific factors.

*We are grateful to Selectronic Australia for providing data and site access

Table 1: Main factors affecting solar photovoltaic power

Temporal	Time of day, time of year
Geographic	Latitude and longitude, altitude
Environmental	Cloud cover, cloud edge refraction, aerosol levels, temperature
System-specific	System size, panel material and design, orientation and tilt of panels, tracking, installation impacts, software, degradation
Location-specific	Local shading, local reflection or refraction, network impacts, soiling

2 CHARACTERISTIC PROFILE

On sunny days, the shape of a system's generation profile is immediately evident, but in cloudy phases, it is less obvious. However, when multiple consecutive days are plotted on the same x-axis, typically the unique shape becomes evident once again. This is due to the fact that – assuming enough days of recent historical data are observed and compared – the probability of having had a sunny period in a given interval on at least one of the prior days is high. For example, one day may have been sunny in the morning but cloudy in the afternoon, and another may have been cloudy in the morning but sunny in the afternoon. Taken together, they can be used to identify a system-specific "full sun" profile for a full day.

Figure 3 shows the process to find a characteristic generation profile for a given site. Several days of recent generation history are examined. For each interval of the day, the recent historical maximum is recorded. This leads to a profile having several spikes and outliers; a simple digital filter can subsequently be applied to find a smoothed profile for the given site.

This characteristic profile can subsequently be used to deseason the time series. The value of doing this is that we remove from the historical time series not just the seasonality arising from temporal and geographical impacts – we are also removing all of the periodically occurring impacts from system-specific and location-specific factors. As a result we no longer need to forecast solar generation directly; instead, we are forecasting the deviation from the characteristic profile.

3 RESULTS

We evaluated rooftop solar power forecasts that use the characteristic generation profile at three sites over two different times of the year. When applied to SARIMA, linear regression or support vector regression based approaches, it led to improvements in forecasting accuracy of 17%, 42% and 28%, respectively. We intend to extend this evaluation to a broader set of sites and longer time periods.

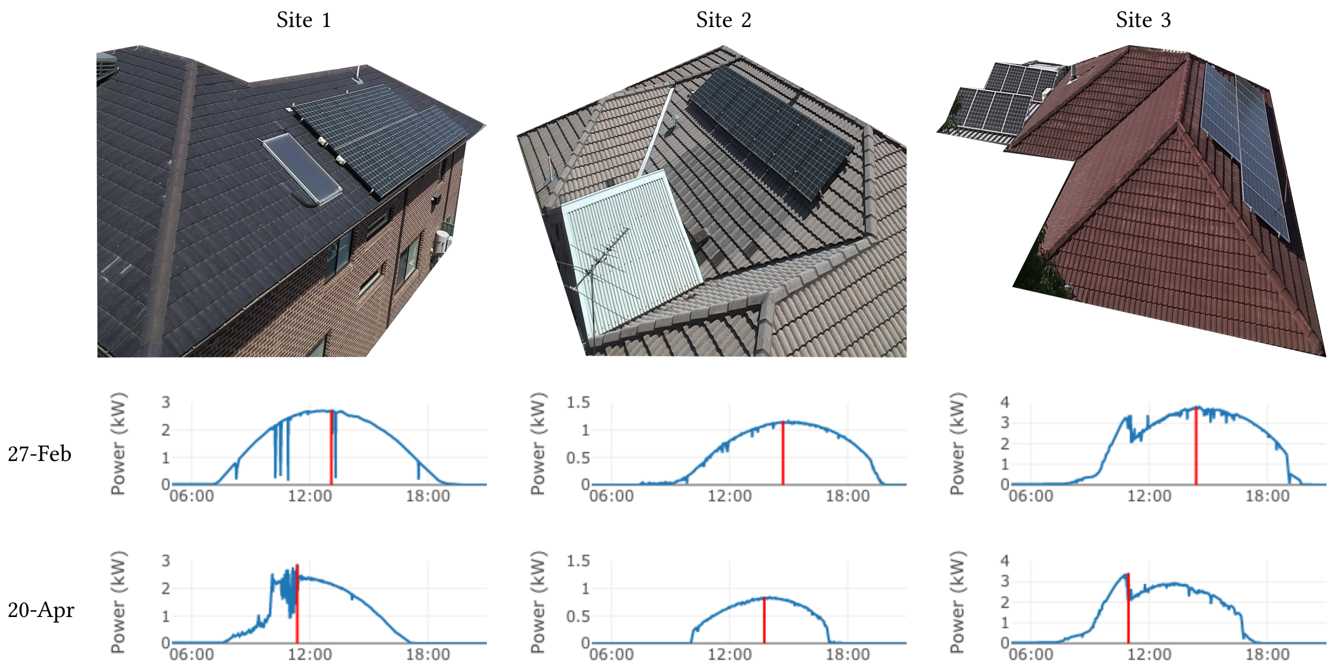

Figure 2: Three rooftop solar photovoltaic generation systems, along with their corresponding generation profiles on two separate sunny days. Red vertical lines indicate peak generation. These systems are all installed fairly close to one another (less than 50km apart), and are affected similarly by temporal, geographic and environmental factors. However, due to system-specific and location-specific factors, their respective generation profiles look very different.

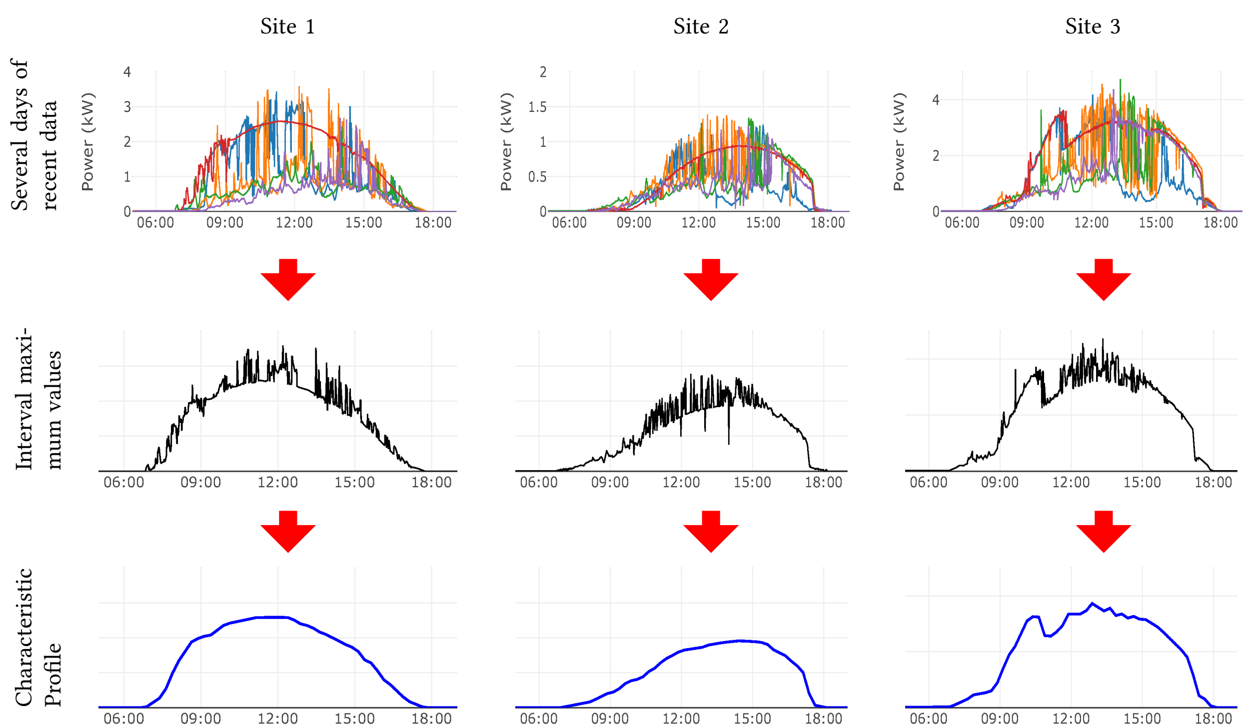

Figure 3: Demonstration of how to determine the characteristic generation profile of three different sites.