solar analytics

Accelerating the growth development of energy monitoring for solar households and small businesses

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Executive Summary

One of the key challenges facing the electricity industry in the transition to 100% renewable energy is how to equitably and cost effectively manage the increasing amounts of Distributed Energy Resources (DER) such as rooftop solar and batteries. It is essential that consumers continue to be able to install DER to reduce their electricity costs, while maintaining grid reliability and providing equitable outcomes for all electricity customers.

There are 3 million rooftop solar systems installed across Australia, with a combined generation capacity of 15GW[1], approximately 20% of the total Australian generation capacity or 7% of electricity generation. In South Australia, Rooftop Solar has provided up to 84% of total electricity demand (34% nationally)[2].

However almost all of this DER is invisible to the network operator, and it cannot be remotely controlled to manage its interactions with the electricity network or maximise the benefit for the solar owner on a day -to-day basis. This lack of data and control is hampering the network operators' ability to manage the electricity grids, and reducing the benefits of DER to both solar consumers and the wider community.

Solar Analytics provides solar energy management services for rooftop solar photovoltaic (PV) energy systems. The aim of this project was to accelerate the deployment of technology to monitor the performance of residential solar PV systems and provide low-cost analytics and fault diagnostics.

Over the course of this three-year project, this project has delivered:

- 20,000+ Rooftop solar systems with intelligent analytics and fault diagnostics
- 1000+ Rooftop solar systems from integrations with global inverter partners Sungrow and Fronius, with agreements signed and work underway on two more (GoodWe and GroWatt)
- 700+ Rooftop solar systems with active control and the ability to control battery storage
- Energy Plan Optimiser functionality launched nationally that can save solar consumers over $400pa through intelligent electricity retail plan analysis and recommendations
- A demonstration of the value of accurate solar monitoring, being $107pa for a typical residential customer and $3,052pa for a typical commercial customer

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[1] Solar in review, AEC Oct 2021

[2] https://reneweconomy.com.au/rooftop-pv-meets-84-pct-of-south-australia-demand-sends-operating-demand-to-new-low/, Renew Economy, Sep 2021

- Energy data to AEMO, 14 universities, 5 network operators and 5 other energy market participants
- A follow-on project with AEMO to deliver high granularity sub-second data around grid events, eg voltage, frequency excursions
- An industry initiative to establish the DER Visibility and Monitoring Best Practice Guide[3]
- And the exploration and launch of a trial shared solar program. This was not launched commercially at scale as it was determined that the access to smart meter data is required to make it viable (waiting on Consumer Data Right (CDR) implementation or similar)
- the technical groundwork required for Solar Analytics to provide a market leading distributed energy resources management to facilitate higher penetration of roof-top solar.

Togther, these outcomes are helping the Australian electricity grid to transition from a predominately central fossil fuel powered grid to a lower cost 100% renewable energy grid, with Distributed Energy Resources (DER) such as rooftop solar becoming a major source of electricity generation.

Project Overview

This project had four streams of work to enhance the value of DER for both network operators and solar consumers.

Solar Monitoring

Overall, this project has enabled Solar Analytics to provide over 20,000 new solar customers with active solar monitoring and deliver 37 GWh of distributed rooftop solar electricity per year, with an energy production valued at $9.1 million per year.

The key benefits of active solar monitoring were demonstrated to be:

1. Increased solar generation.
    - Use of monitoring allows for early identification of solar system issues in the first 6 months leading to an increase in solar production of 4.8% for small systems and 7.6% for large systems.
    - A further increase of 3% for small systems and 11.9% for large systems can be attributed to the detection of zero generation faults.

[3] https://www.dermonitoring.guide/

- Together, this increase in solar generation leads to annual savings of $132 per site ($107 p.a. for residential customers and $3,052 for commercial customers).

2. Better management of energy consumption. Solar owners were able to increase their savings through shifting the energy load of major load appliances such as hot water, air-conditioning, pool pumps and electric vehicles. This active management of load patterns saved customers up to $350 pa, however it was highly variable across customer segments based on their ability and inclination to shift these energy appliances.
3. Optimal selection of retail electricity plan. Switching energy plans can save residential solar customers an additional $400pa, including the choice of a Flat or Time of Use tariff.

DER Control

For rooftop solar to become the largest source of electricity generation, it is not sufficient to simply have actively monitored DER and high data visibility. As DER penetration increases it will also become necessary to be able to remotely and automatically control this DER to optimise the benefit for the solar owner, and respond appropriately to wider electricity network requirements.

One of the fastest and lowest cost methods to provide this intelligent control is through connection to the solar inverter. In this project, Solar Analytics launched a new Integrated product solution that provided the required level of control, and at a lower cost than the Classic hardware enabled monitoring solution.

This new Integrated solution has been launched in the market with global inverter partners Sungrow and Fronius, and agreements have been signed and work is underway with GoodWe and GroWatt. To date over 1,000 Integrated systems have been installed.

The key benefits of this Integrated solution are:

- Lower cost (approximately 50% of the cost of the Classic solution)
- Able to be applied to existing solar systems
- Able to decrease the solar generation if required in response to network events
- Able to control energy storage through the inverter, including consumption and generation

This new product forms the foundation of a market leading distributed energy resources management product that will play a key role in managing higher penetration of roof-top solar PV.

Shared Solar

Solar Analytics developed “Shared Solar” to connect residential solar owners with non-solar owners through a shared energy trading platform. This platform enabled solar homeowners to select from a range of options for how they sell their surplus solar, and non-solar households to purchase this lower cost solar electricity. The successful implementation of this project would see a substantial increase in the number of consumers who could benefit from the uptake of rooftop solar. The project would demonstrate a community electricity trading platform ready to facilitate the future uptake of home energy storage and EVs, and suitable for deployment internationally.

The solution was highly customer focused and developed using Lean Startup Methodology. Solar Analytics defined the model, provided the monitoring and analytics, developed the platform, and established and leveraged partnerships. Initial development relied on the participation of a retailer to maintain the trading ledger.

While there was extensive consumer interest in the trialled offering, there were two key barriers that prevented a commercial launch of the product:

1. Simplicity. The value proposition for consumers is both technically difficult to convey, and the effort required to participate is relatively high. Hence, take-up was low.
2. Price. The cost of providing the service using dedicated hardware was high, and due to the current network tariff structures, there is negligible savings from sharing electricity locally.

It is anticipated that these two barriers would be addressed through two industry wide reforms:

a) the implementation of Consumer Data Rights (CDR), which would enable customers to give access to the smart meter data to third parties like Solar Analytics. This would enable a low cost, simple, digital on-line sign-up process.
b) Locational pricing. This is the ability of network operators or energy retailers to differentially charge based on the distance the electrons travel.

Data visibility

Almost every energy industry report published in the last three years has stated that one of the key barriers to the renewable energy transition is a lack of data and visibility of DER. This project provided historical and real time electricity data to network operators, regulators, academic institutions, and mark participants to help address this critical lack of DER visibility.

The project also delivered an industry wide collaboration to establish the DER Visibility and Monitoring Best Practice Guide to accelerate the provision of high granularity energy data.

Finally, the project explored the value of more granular DER data with AEMO and network operators.

The Project included the delivery of two demonstration data products.

1) Live Data Product (LDP) - 100 sites of data per DNSP with semi-live data available at 5-minute intervals.
2) Historic Low Voltage Data Product (HLV) - 1,000 sites nationally with 12 months of historical data available at 5-minute intervals.

The data was used for research purposes to:

- gain an understanding of the value of improved visibility across the low voltage network;
- enhance network modelling;
- improve reliability and efficiency; and
- support the increased uptake of distributed energy resources (DER).

Project Outcomes and Learnings

Solar Monitoring

The key learnings from this project are:

1. Active performance monitoring increased solar generation by 14% (or an average of $107 p.a. for residential customers and $3,052 for commercial customers) due to faster fault detection and rectification.

2. By monitoring both solar generation and electricity consumption, residential customers also save up to $350 p.a. by shifting their loads to times of high solar generation.

3. Through the optimal selection of retail electricity plans, residential solar customers can save an additional $400 p.a., and generate savings of $200 p.a. for solar customers. This includes choosing flat or Time-of-Use tariff structures. There is significant variability depending on the customer's location and energy profile.

4. Buying solar is confusing, with consumers struggling to compare between solar offers and often deciding on price alone. This makes presenting the value of solar monitoring challenging at the point of sale due the amount of new information being presented.

The costs of Active Monitoring are paid for by the system owner. The costs are around $800 for standard residential and $1500 for commercial solar systems across 10 years. This includes the monitoring device, installation of the device, and ten years of active monitoring.

In addition to saving business and households thousands of dollars in electricity costs, increasing our total renewable energy generation and helping us meet our climate change commitments, rooftop solar has been demonstrated to provide savings for all energy consumers through:

a) reduced severity and length of peak demand periods,
b) reduced wholesale electricity costs[4] - saving $2.2 - $3.3 billion for NSW electricity customers alone in 2016/17[5], and
c) increased grid resilience through autonomous DER response[6].

The key for a consumer to be able to better manage their electricity costs is visibility and readily actionable information of what actions they can take. Empowering the solar owners to better manage their solar and energy profile includes the following.

a) Savings can be made from increasing self-consumption and lowering the amount of energy imported from the grid. For example, by changing large energy using appliances such as hot-water heaters and pool pumps to be operating during daytime hours rather than at night. Detailed savings expected in each state can be seen in a Solar Analytics blog post on energy shifting[7].
b) Active monitoring with additional measurement of these large energy appliances allows for identification of an appliance fault that otherwise would have gone detected. An example is given in a recent Solar Analytics blog post in which leakage from a hot water was identified early and rectified[8].
c) Active monitoring gives the customer a better overview of their energy usage, making it easier to choose the best electricity tariff to match their consumption. Once the customer can see how much energy they are using in shoulder and peak times, and how much of this is a shiftable load, they can pick a tariff to maximise their savings.
d) A further benefit of this visibility is the provision of an accurate assessment of what the ideal battery size would be for the customer's specific energy profile. Once the optimal battery size is determined, the cost and savings (in both energy and dollars) can be presented, enabling the customer to make an informed choice of if and when to add battery storage to their solar system.
e) The ability to see live and historical energy production and consumption in a clear and easily understandable format, also enables customers to become energy knowledgeable. For example, live energy data allows a customer to see exactly which appliances draw greater amounts of electricity.

There are two main types of electricity tariff – flat and Time-of-Use (TOU). A flat tariff has the same price of electricity throughout the day. A TOU tariff will vary the price of electricity depending on the time of day, i.e. more expensive during the period of high national electricity

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[4] https://www.aemc.gov.au/news-centre/media-releases/electricity-prices-falling-across-whole-supply-chain-first-time
[5] https://energysynapse.com.au/small-solar-pv-nsw-wholesale-electricity-market/ Oct 2017, Energy Synapse
[6] Technical Integration of Distributed Energy Resources, Apr 2019, AEMO
[7] https://www.solaranalytics.com/au/blog/energy-load-shifting-made-easy
[8] https://www.solaranalytics.com/au/blog/how-checking-in-on-your-energy-usage-from-time-to-time-can-save-you-money

usage (typically 3pm – 10pm), and cheaper during periods of low electricity usage (typically 10pm-6am).

A further complication is that the time of use charges vary depending on the location, and may be different for the energy purchased from the grid (energy retailer tariff), and the energy sold back to the grid (Feed-in tariff).

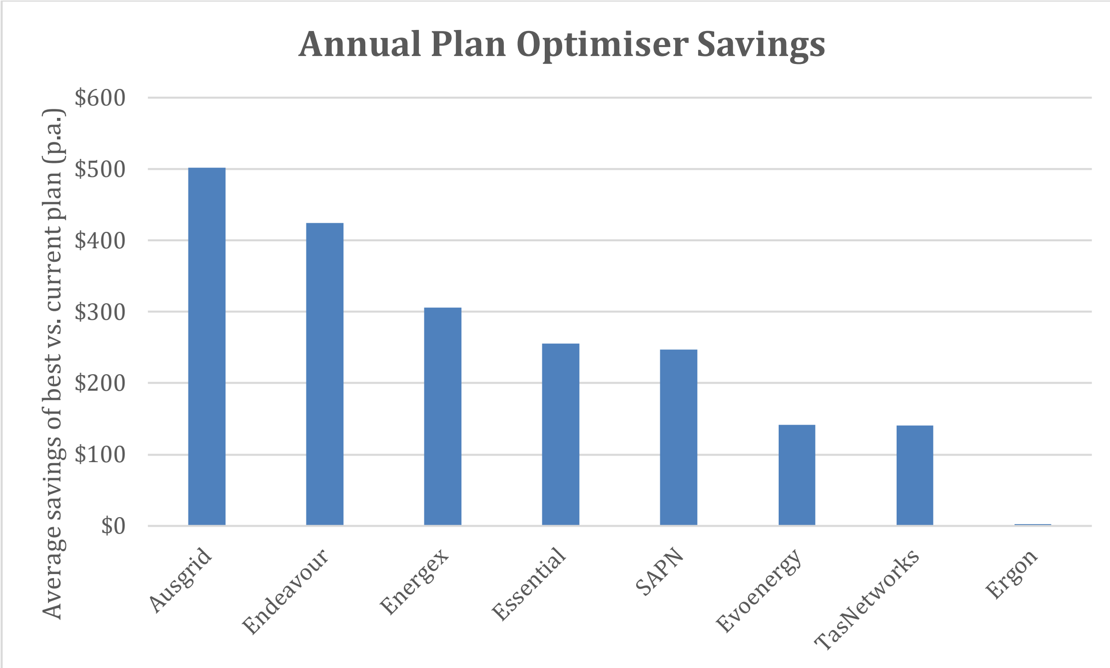
By analysing the fleet of solar systems monitored throughout this project, it was shown that the orientation of a solar system (i.e. the direction the solar panels on the roof are facing) can determine which electricity tariff will generate the most savings for the customer.

With flat feed-in tariffs, the profits from solar energy being sold back to the grid is directly in proportion to the amount of solar energy exported.

However, when the feed-in tariffs are TOU, the orientation of the solar system has a significant impact on the energy savings. The actual savings achieved from the TOU tariff will vary between households, and is heavily dependent on the following factors:

- The specific electricity tariffs available
- The proportion of electricity generated that is consumed by the household, i.e. % self-consumption (the average is 42% of solar being consumed on site)
- The energy usage patterns of the household, i.e. how much energy is consumed during peak periods
- The ability of the household to shift loads away from peak periods

The key to choosing the right tariff structure, and when best to use your large energy appliances, is to first choose the best retail electricity plan. Electricity retail competition varies significantly across the country, with high levels of competition and tariff variability in NSW and VIC, and minimal levels in WA, NT and regional QLD. Below is an analysis of the savings available to Solar Analytics customers who have entered in their current energy plan details. On average, they can save over $400 p.a. depending on their location and energy profile. Of course, the best energy plan will change when energy usage patterns change.



Average annual savings calculated per customer across different DNSPs comparing current plan with the best possible plan in the market.

One of the key learnings of this project was the pace of change in the energy retail market. In the states with high energy retail competition, the best offer changes on a monthly or even faster basis as market offers come and go. To maximise consumer benefit, it is therefore important to regularly compare the market, and automatically notify them if a significantly better offer emerges. Solar owners who are already on a good plan also provided feedback that this knowledge was valued. It is one less thing they need to think about, and further increases their solar satisfaction.

DER control

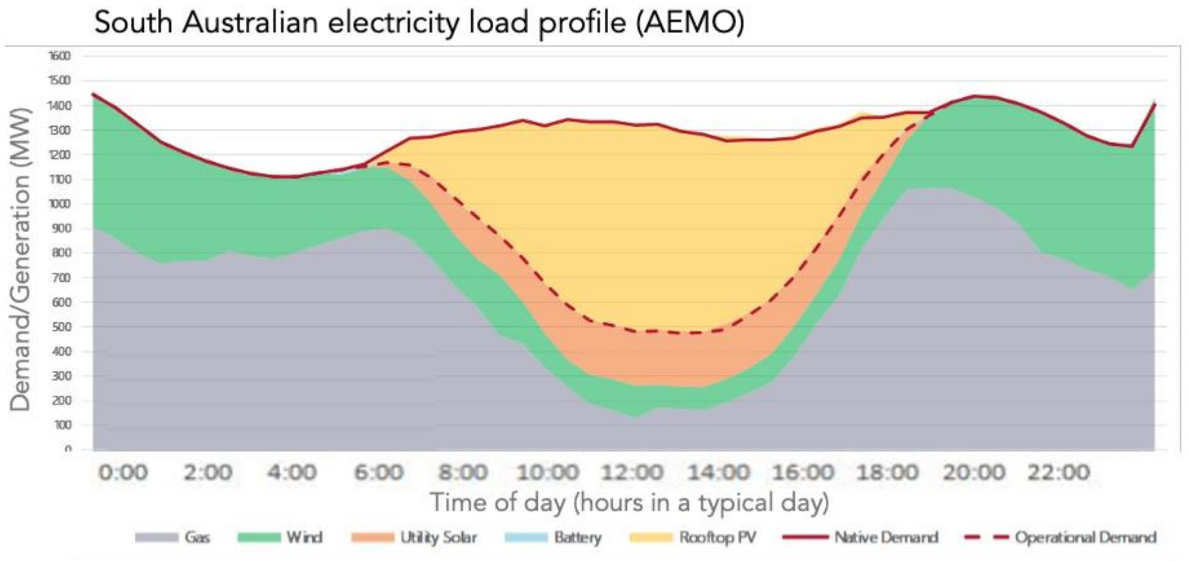
With the increasing penetration of DER on the Australian grid, it is becoming essential for this DER to be actively controlled to avoid negative grid impacts. "The electricity grid is at risk from too much uncontrolled rooftop solar generation".[9]

The first implementation of mandated control has been in South Australia, where all new solar systems are required to appoint a Relevant Agent who can respond to commands from SAPN to either disconnect the solar system for a specified period, or limit the system to zero export.

[9] Australian Energy Market Operator, Integrated System Plan, 2020

Solar Analytics is registered as a Relevant Agent, and has several hundred solar systems that respond to these commands.

South Australia Power Network (SAPN) issued the first disconnect command in March 2021, and has issued several more since. This is expected to become more frequent, especially in Spring and Autumn, as rooftop solar continues to grow.



Average daily electricity load profile in South Australia, taken from Integrated System Plan, AEMO, 2020.

Integration was achieved with Sungrow and Fronius inverters, including almost all of their current range of inverters. This also included their hybrid inverters that have battery control, although Fronius has not yet released their control Application Programming Interface (API) so the control functionality has only been tested on Sungrow inverters.

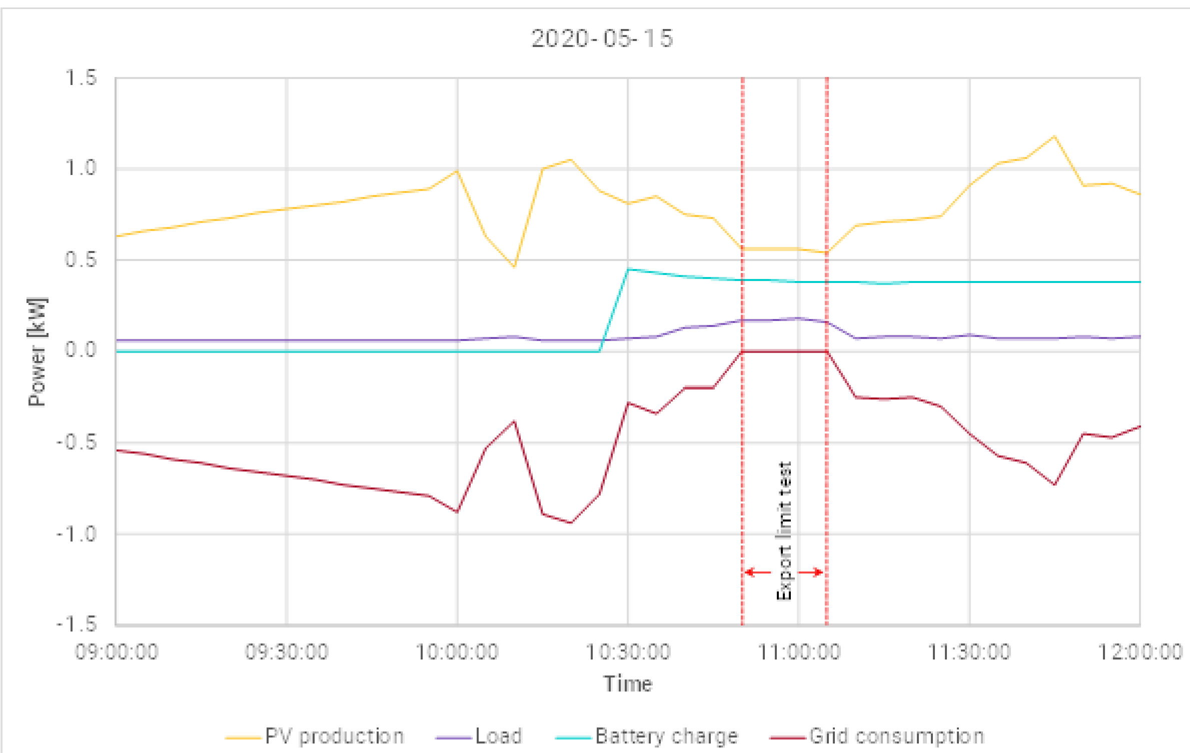
Sungrow is one of the largest manufacturers of solar inverters world-wide and leads the market in Australian residential solar inverters. Hence, they are a promising partner for future large scale roll out of DER Control and eventually orchestrated Virtual Power Plant (VPP) operation.

The Sungrow inverter communicates via local Wi-Fi to Sungrow servers, providing a large array of operational data. Solar Analytics has built the required pipelines to connect to the Sungrow API to retrieve these data and store on the Solar Analytics servers and display on the Solar Analytics dashboard. We have also tested use of the API to change inverter settings, facilitating the control tests presented below.

The following control was implemented:

- Adjust export limit, i.e. kilowatts (kW) about to be exported to the grid
- Forced charge, i.e. manual battery charge cycle
- Production limit, i.e. solar energy production set to zero or a specified maximum
- Dashboard verification, confirmation of results between Sungrow and Solar Analytics dashboards

Hardware and software required for Solar Analytics integrated product



Operational data showing export limit functionality being applied to a single Sungrow inverter.

Shared Solar

The initial phase of the project was research-focused to uncover the primary drivers of user interest, engagement and value discovery. Online surveys were conducted with ~700 energy consumers, both solar owners and non-solar owners. We then conducted 50 face-to-face interviews to collect qualitative information that was designed to first introduce the idea of Shared Solar and then to gauge overall interest in the concept.

Based on these findings, we sought out an already established community to test our hypotheses with the beta version of the platform. A local high school allowed us to leverage its network and communication channels to recruit 20 users, 10 with solar and 10 without. We partnered with Energy Locals as the retailer who would manage the actual transactions.

We built the algorithms on the back-end to manage the energy data flows and to calculate the results of the trades between prosumers and consumers. This data was then used to populate the user dashboards and provide insights to drive the behaviour. Additional pages were developed on the front-end to facilitate social connections and trading.

The final iteration of the project became a community Dashboard included as part of the Solar Analytics platform for a subset of (~450) users. While some users found the platform to be informative and useful, the general levels of engagement were not high enough to warrant releasing the feature to all Solar Analytics users.

Unfortunately, we were unable to find a successful model to deliver on the project goals in terms of both a viable business model to earn the company additional revenue or as an engaging product for users to derive value. Despite several adjustments to the focus of the project, we have decided not to pursue development further and will not continue to offer the Shared Solar functionality to the market in its current form. There have been significant learnings gained from the project which will ultimately inform work on future, similar feature builds. We feel that, while peer to peer energy trading as a stand-alone capability may not be fully viable, as part of a wider effort to enable homeowners more access to two-way energy markets, this project has provided great insight.

Insight #1 People really don't like to give their solar back to the grid

It’s not a secret that Australians don’t have great relationships with the energy companies. The feeling of being under the thumb of the big energy was so pronounced that prosumers indicated that they would rather donate their excess if they felt the benefit would be realised by someone they knew, rather than allowing the energy companies to gain a perceived profit. This dislike was so strong that respondents were willing to consider the economic irrational decision to forego their own financial gains in order to “stick it to the man.” These results from the early research guided us toward our first main hypothesis that other values beyond financial drivers would lead to the success of the platform.

Insight #2 Peer to Peer energy is technically and functionally very complicated

Right from the start, we had no illusions that building a P2P trading platform would have significant barriers to implement within the confines of the current market structure. We had been paying attention to other trials within Australia and around the globe, and were very aware of the challenges. However, you never fully understand until you try something for yourself, and to that end, we learned how difficult it is to shoehorn a new business model into an existing paradigm. In a cost stack involving a commodity, multiple players in a value chain and consumers, we were unable to find a way to capture economic gains in an already crowded equation. On the technology side, all the component parts are functionally available, including using distributed ledger technology to manage data transactions. As new models for DER to grid integrations emerge, such as VPP, more elegant solutions are being developed to combine the component parts into a viable solution for enabling individuals to participate in two way energy markets.

Insight #3 Consumer expectation about what is possible is unrealistic (at this time).

Right from the start, managing the expectations of the consumers (and prosumers) proved to be a significant challenge. Without deep understanding of the market dynamics and requirements for facilitating transactions, consumers found it difficult to grasp why they could not simply buy and sell solar energy as if in a fully open market. Unsurprisingly, consumers struggled to understand the basic concepts about how the energy markets and grid physics worked, oftentimes thinking that their solar would be connected directly to their trading partners. The further the reality of our model departed from these visions, users became more confused and less engaged.

Data Visibility

The key learnings from this project were:

1. Data is gold. Academic institutions that study the electricity system were starved of the granular data needed to accurately model our grid and test alternative regulatory and policy settings.
2. Data delivers insights, but funds are tight. It is only with the provision of this high granularity data that organisations can explore how this data can be used to improve network operations and regulatory settings. Network operators are highly regulated, and it is challenging to secure funding to explore new data use cases.
3. More data needed. Even though Solar Analytics has a large and growing customer base, network operators ideally need data at every feeder to provide the ability to respond to

network events and issues. As a result of this learning, Solar Analytics led an industry wide consortium in the development of the DER Visibility and Monitoring Best Practice Guide[10] to accelerate the provision of high granularity energy data.

4. There are specific requirements for event-based voltage and frequency data to assist AEMO analyse these events to help maintain grid reliability and ensure adequate response mechanisms are in place for future events.

Solar Analytics contacted all fifteen network operators and the Australian Energy Market Operator (AEMO), and has shared near real time data via and Application Programming Interface (API) or "cloud to cloud" with five network operators and AEMO.

The five network operators in Victoria already have access to similar data from smart meters. Although this smart meter data is not as real time or granular, and does not provide total solar generation, it is available on almost all sites in Victoria, hence the monitoring dataset from Solar Analytics is less attractive than for network operators who do not have access to the smart meter data.

It was also noted that for some of the smaller network operators, such as ActewAGL, Solar Analytics has fewer sites available and hence the dataset is less valuable for providing actionable insights.

The Live Data Product was delivered to six organisations with the following data:

- 100 sites of data per DNSP
- Near real-time data available at 5-minute intervals (via API) for 12 months
- Site address to feeder level
- Grid side voltage, PV power generated, and power factor in each 5 min period

There were more challenges with sharing live API data with the network operators. This related to the additional security and access requirements. Feedback enabled Solar Analytics to improve the documentation and delivery method, e.g. extending the time window for retrieval to 48 hours to match their existing systems. Depending on the use case for the data, some users had challenges with data consistency such as:

- New sites being added to the data stream
- Some sites losing data, e.g. communications fault
- Shading impacts on solar generation
- Accounting for time zones

Overall, there was strong interest from the network operators, however the network operators are heavily regulated organisations that require significant planning and review to implement new projects. This means that it is challenging for a network operator or market regulator to effectively use this data for the following reasons:

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10 https://www.dermonitoring.guide/

- They typically work on year-long budget period projects, which are required to be reviewed and approved by senior management. This includes the allocation of funding or internal resources
- Connecting to the data stream requires internal resources from their technical department to collect the data and make it available to the engineers or analysts
- Utilising the data requires significant engineer or analyst time to combine with internal data sources and assess how the data can be utilised
- It is challenging to thoroughly scope out the project without first being able to explore that data and spend the time required to understand how it could be beneficially utilised. Hence, somewhat of a chicken and egg situation

The historic data product was delivered to 14 universities and research institutions for the purpose of research, generating publications and teaching. The data set provided including the following data:

- 1000 residential sites with rooftop solar distributed across urban and regional Australia
- site postcode
- 12 months of 5 min granularity data (Jan – Dec 2019)
- Grid side voltage - maximum and minimum voltage in each 5 min period
- solar photovoltaic (PV) energy generated in each 5 min period

Each of the academic institutions were able to readily use and analyse this data for their research projects. Feedback was provided from the academic institutions on the data quality and format, leading to minor improvements in how the data was prepared.

The most common use cases for the data was in their research on the following areas:

- Simulations of solar generation in microgrid systems, i.e. small islanded electricity networks not connected to the main electricity grid
- PV production modelling, e.g. analysing how increased solar penetration will impact the electricity network
- PV production forecasting, e.g. combining the data with weather data to forecast solar generation

Another important application of this dataset is for teaching. This is a great application to allow students to explore the real data and generate insights from the data. There are many directions where this dataset can potentially be used in future, including:

- Maximum voltage data to explore grid events and how it will impact the distribution network
- PV production data and maximum voltage data to explore the interaction between the two, for example the amount of solar being curtailed due to voltages exceeding the maximum allowed voltage level

- Detecting and accounting for shading from fixed elements such as trees and buildings and using this to help understand the loss that customers are getting (currently provided by Solar Analytics for our customers)
- PV system fault diagnosis
- Examining the impacts of draft regulatory proposals

Almost all of the data recipients had a strong interest in accessing more data, both types of energy data and for a larger number of sites. However, there was a wide range of expectations, including:

- Energy consumption data for the same sites – enables increased modelling and simulations
- Sub-load data from individual appliances such as hot water, air conditioning and batteries
- Adding in the NMI field to correlate
- More than 12 months of data – improves modelling accuracy and seasonal analysis
- Higher resolution data – even sub second data for some applications
- Event based data – ability to obtain more granular data around specific network events
- Additional parameters such as power factor, max/min power in period, PV capacity and other site information
- Network topology to map solar data to network operations
- Solar density on the applicable network feeder
- Increased numbers of sites, ideally two per feeder, which would require over 1 million sites across Australia

It is noted that all of the data provided under this project was compliant with Australian Privacy Law and Solar Analytics Privacy Policy. Some of the above requested data would not be able to be provided if it contravened either of these requirements that protect our customers privacy.

Over a period of twelve months, based on the expressed needs of the network operators, Solar Analytics led an industry initiative to establish a common data format and set of requirements to meet the need for much greater increased data visibility. This resulted in the development and publishing of the DER Visibility and Monitoring Best Practice Guide[11] that has been developed and is supported by the following organisations.

[11] https://www.dermonitoring.guide/

Group of organisations that have supported and helped develop the DER Visibility and Monitoring Best Practice Guide.

Conclusion and Next Steps

This project provided significant outcomes to accelerate our renewable energy transition through increased solar consumer value and increased DER visibility and control. By enabling consumers and network operators to optimise increased amounts of DER, this is helping the Australian electricity grid to transition from a predominately central fossil fuel powered grid to a lower cost 100% renewable energy grid.

The next steps to continue this transition are:

- Implement the DER Visibility and Monitoring Best Practice Guide[12]
- Expand the collection and utilisation of sub-second event-based data
- Accelerate the shift from passive rooftop solar to actively monitored and controlled DER though a combination of regulatory reform to enable DER to access the full value stack, and resulting compelling and innovative DER consumer product offerings
- Once CDR is implemented, trial shared solar programs to bring the benefits of DER to those who cannot put solar on their roof

Future projects should focus on how to deliver the benefit of active solar monitoring to more customers. This could include lower upfront cost for the consumer, improved messaging at point of sale, or integration with other products and services so that the benefit is inherently included. This will increase the total amount of rooftop solar electricity generated and provide these benefits to more solar owners.

[12] https://www.dermonitoring.guide/

Consumer education remains a key barrier to better electricity outcomes and lower costs for both solar and non-solar owners. Future projects could build on this work by refining how the message is delivered to the customer, with specific focus on providing readily actionable insights with estimated financial benefit.