FULCRUM3D WIND FORECASTING FOR THE NEM PROJECT (2018/ARP167)

PROJECT RESULTS AND LESSONS LEARNT

Lead organisation:	Fulcrum3D		
Project commencement date:	12 March 2019	**Completion date:**	31 January 2021
Date published:	15 February 2021		
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Acknowledgement:

This Project received funding from ARENA as part of ARENA's Advancing Renewables Program

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Executive Summary

The objective of this project was to provide high accuracy short-term power forecasts utilising peripheral sodars and state-of-the-art software at three Pacific Hydro wind farms: Clements Gap (SA), Crowlands (VIC) and Taralga (NSW).

The key driver for this project was to reduce Causer Pays charges which can be enacted when a semi-scheduled generator is unable to meet the generation target set by the Australian Energy Market Operator (AEMO) dispatch system. In 2018 AEMO enabled semi-scheduled generators to submit their own five-minute forecasts through their MP5F API. It was expected that self-forecasts that are more accurate than AEMO's forecasts would lower the solar farm's Causer Pays penalties.

Fulcrum3D installed Sodars upstream of the wind farm prevailing wind directions: two at Taralga and one each at Clements Gap and Crowlands. A detailed power model for each wind farm was developed using real time data inputs from power station SCADA. These models are used to calculate the current unconstrained generation capability, produce five-minute wind farm output forecasts and submit them to AEMO via their MP5F API.

The project's core achievement was demonstrating that it is possible to satisfy AEMO's accuracy requirements and achieve zero Causer Pays charges at wind farms via MP5F with generators operating under normal conditions.

Our forecasts are now being used in dispatch at all three wind farms and are consistently outperforming AWEFS. The project met its contracted outcomes.

Project Overview

Project scope

The objective of this project was to provide high accuracy short-term power forecasts utilising peripheral sodars and state-of-the-art software at three Pacific Hydro wind farms: Clements Gap (SA), Crowlands (VIC) and Taralga (NSW).

The key driver for this project was to reduce Causer Pays charges which can be enacted when a semi-scheduled generator is unable to meet the generation target set by the Australian Energy Market Operator (AEMO) dispatch system. In 2018 AEMO enabled semi-scheduled generators to submit their own five-minute forecasts through their MP5F API. It was expected that self-forecasts that are more accurate than AEMO's forecasts would lower the solar farm's Causer Pays penalties.

Outcomes

Fulcrum3D installed Sodars upstream of the wind farm prevailing wind directions: two at Taralga and one each at Clements Gap and Crowlands. A detailed power model for each wind farm was developed using real time data inputs from power station SCADA. These models are used to calculate the current unconstrained generation capability, produce five-minute wind farm output forecasts and submit them to AEMO via their MP5F API.

The key achievement was demonstrating that it is possible to satisfy AEMO's accuracy requirements and achieve zero Causer Pays charges at wind farms via MP5F with generators operating under normal conditions. It is important to note that higher accuracy forecasts alone did not necessarily reduce Causer Pays charges. Our modelling of the FCAS Causer Pays system led to greater reductions than even perfect forecasts could achieve.

Our forecasts are now being used in dispatch at all three wind farms and other commercial sites and are consistently outperforming AWEFS.

Key lessons learnt throughout the project are outlined in the sections below. Some of these lessons have already been published in previous lessons learnt reports and are also provided in our solar forecasting report as most of the key lessons learnt are applicable to both projects. EWe have selected the most valuable of the previously published lessons for this report which contains the following lessons learnt:

1. Most self-forecasting on the NEM is enabling Causer Pays savings (page 6)
2. Self-forecasting can reduce Causer Pays charges to as low as zero (page 8)
3. Self-forecasting can be challenging during periods with generation caps (page 9)
4. The NEM Dispatch Engine zeros negative self-forecasts (page 11)
5. A rounding feature in AEMO's dispatch engine appears to affect forecast accuracy (page 12)
6. Some plants cannot ramp at the rate set by the dispatch engine (page 13)
7. The MP5F API is increasingly robust and reliable (page 14)
8. SCADA integration is now the most complex part of the self-forecasting system (page 15)
9. Remote SCADA access needs to be reliable with high availability to be useful in applications like real time forecasting (page 16)

Transferability

Fulcrum3D self-forecasting for the NEM has been commercialised and is now available to all NEM connected semi-scheduled wind and solar farms.

The hardware and software developed through this project is immediately transferable to these generators and requires minimal site-specific integration and tuning.

Fulcrum3D has shared the knowledge developed through discussions with NEM participants, our website, media articles (these are also published on our website) and ARENA Lessons Learnt reports.

Conclusion and next steps

Our key conclusions are that self-forecasting is:

- Helping to improve NEM health by reducing forecast error.
- Providing self-forecasters with the opportunity to reduce their Causer Pays charges (often to as low as zero).
- Commercially viable.
- Enabled by a stable effective IT system.

We would like to congratulate AEMO on the initiative and thank ARENA and AEMO for establishing this self-forecasting demonstration program.

We would also like to acknowledge the incredibly valuable contribution that Pacific Hydro have made. They are excellent partners.

Lessons Learnt

Lessons Learnt Report 1: Most self-forecasting on the NEM is enabling Causer Pays savings

Project Name: *Fulcrum3D Wind Forecasting for the NEM*

Knowledge Category:	Financial
Knowledge Type:	Operation and maintenance
Technology Type:	Wind
State/Territory:	All NEM states

Background

Objectives or project requirements

To assess the technical and economic viability of wind and solar farms self-forecasting on the NEM.

Process undertaken

Fulcrum3D developed a Causer Pays model as part of the Project and generated the above table by:

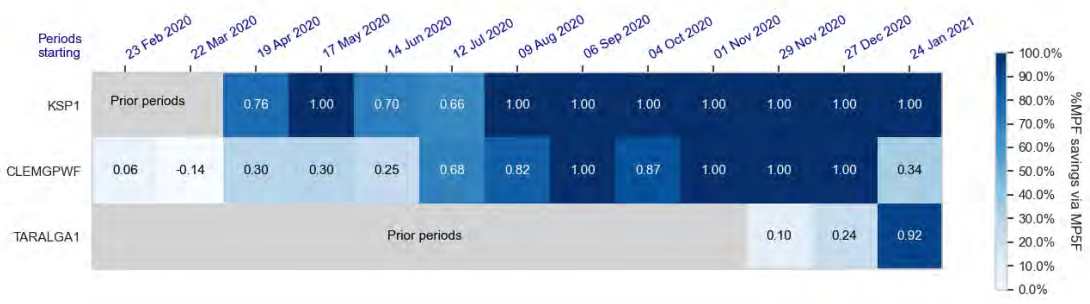
1. Using publicly available NEMWeb data to model FI. 4-second power measurements from NEMWeb for all metered generators and loads are then used to reconstruct the FCAS Regulation raise and lower factors for the entire NEM.

2. Comparing a generators actual Causer Pays charges with those that would have been incurred if they were not self-forecasting and AEMO were instead using the five-minute forecasts from AWEFS or ASEFS. This requires AEMO excluded dispatch intervals to be accurate.

Key learning

The key project learning is that our analysis has found that most wind and solar farms that are self-forecasting through AEMO's MP5F self-forecasting facility are achieving Causer Pays savings. The savings at Fulcrum3D forecasting sites are shown in the figure below.

Figure 1: Causer Pays savings at Fulcrum3D Project sites:



Knowledge gap

Establishing whether self-forecasting can benefit the grid, market and/or consumers.

Implications for future projects

Future projects could explore other potential benefits of short-term forecasting to generators and the grid system. Particularly as the market moves to five-minute settlement.

Lessons Learnt Report 2: Self-forecasting can reduce Causer Pays charges to as low as zero.

Project Name: *Fulcrum3D Wind Forecasting for the NEM*

Knowledge Category:	Financial
Knowledge Type:	Operation and maintenance
Technology Type:	Wind
State/Territory:	All NEM states

Background

Objectives or project requirements

To assess the technical and economic viability of wind and solar farms self-forecasting on the NEM.

Process undertaken

We found that we could reduce the MPF (Market Participant Factor) and resulting Causer Pays charges to as low as zero in some months.

Key learning

It is possible to satisfy AEMO's accuracy requirements and achieve zero Causer Pays charges at wind and solar farms via MP5F with generators operating under normal conditions.

This reduction in Causer Pays penalties lowers the cost of operating solar farms and should ultimately benefit consumers through lower power prices. The reduction in forecast error also helps to improve grid stability.

Knowledge gap

Establishing whether self-forecasting can benefit the grid, market and/or consumers.

Lessons Learnt Report 3: Self-forecasting can be challenging during periods with generation caps.

Project Name: *Fulcrum3D Wind Forecasting for the NEM*

Knowledge Category:	Technical
Knowledge Type:	Operation and maintenance
Technology Type:	Wind
State/Territory:	All NEM states

Background

Objectives or project requirements

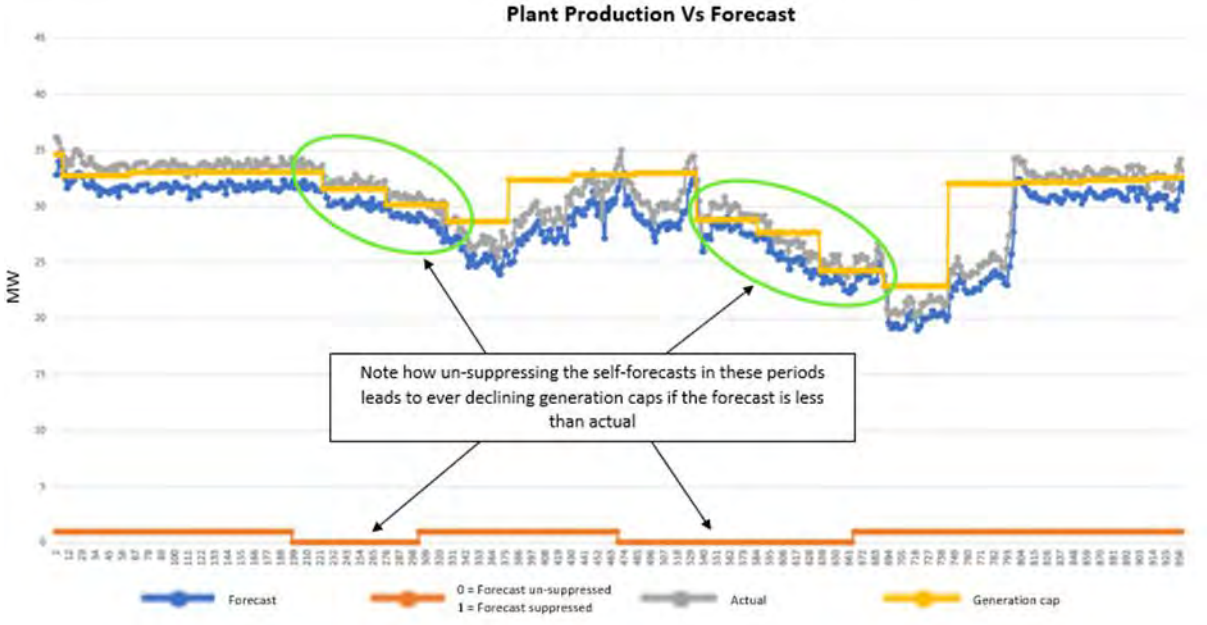
To assess the technical and economic viability of wind and solar farms self-forecasting on the NEM.

Process undertaken

Fulcrum3D studied the effectiveness of self-forecasts during generation caps and, for the reasons outlined above, concluded that it is currently prudent to suppress self-forecasts during these events.

Key learning

Self-forecasting can be challenging during periods with generation caps. We have observed the risk of ever declining forecasts on South Australian wind farms during periods of generation caps as shown in the plot below. This is in line with AEMO's comments in the initial press release for this self-forecasting trial "Wind and solar farms […] can be required to curtail their generation to match an overly conservative forecast."



Self-forecasting during periods with generation caps. *Source: Fulcrum3D*

It is currently prudent to suppress self-forecasts during generation caps because small errors in forecasts or the plant control system can start a continuous exponential decline in output as shown above. This is driven by non-linear behaviour in some plant controllers which is not captured in the current forecast and dispatch system.

Methods to negate control system issues (such as slightly overestimating actual production), can result in significant Causer Pays charges.

Implications for future projects

There is potential to overcome this if more information can be shared between the generator and AEMO about dispatch intervals with dispatch caps.

Knowledge gap

Knowledge around whether there are any limitations in the efficacy of self-forecasts.

Lessons Learnt Report 4: The NEM Dispatch Engine zeros negative self-forecasts.

Project Name: *Fulcrum3D Wind Forecasting for the NEM*

Knowledge Category:	Technical
Knowledge Type:	Operation and maintenance
Technology Type:	Wind
State/Territory:	All NEM states

Background

Objectives or project requirements

To assess the technical and economic viability of wind and solar farms self-forecasting on the NEM.

Process undertaken

Fulcrum3D observed increased Causer Pays during negative generation at some plants and found that this was due to the NEM Dispatch Engine zeroing negative self-forecasts at those plants.

Key learning

The NEM dispatch engine sets a zero floor for the dispatch target but the FCAS calculation uses negative numbers when generation is negative (i.e. the plant is a net consumer). So when plants are not generating power but consuming from the grid they can incur FCAS costs that cannot be managed by self-forecasting because MP5F and subsequent pipelines within AEMO's dispatch engine do not allow negative dispatch targets. Operational forecasting meeting notes from 2018 said MP5F would allow negative submissions but this is not the case. AEMO have been able to validate our internal analysis that this effect can contribute 10-20% to a generator's MPF.

It is worth noting that of all the semi-scheduled generators on the NEM, only four solar farms show negative generation for more than 5% of the time, but there are 25 wind farms that do. There appears to be a systematic modification of some SCADA power feeds which may bias FCAS Causer Pays costs towards wind farms.

Implications for future projects

A future project could explore whether the NEM dispatch engine could be modified to deliver negative dispatch targets.

Knowledge gap

Knowledge around whether there are any limitations in the efficacy of self-forecasts.

Lessons Learnt Report 5: A rounding feature in AEMO's dispatch engine appears to affect forecast accuracy.

Project Name: *Fulcrum3D Wind Forecasting for the NEM*

Knowledge Category:	Technical
Knowledge Type:	Operation and maintenance
Technology Type:	Wind
State/Territory:	All NEM states

Background

Objectives or project requirements

To assess the technical and economic viability of wind and solar farms self-forecasting on the NEM.

Process undertaken

Fulcrum3D observed unexpected Causer Pays charges when plants were unconstrained, forecasting maximum capacity and operating at that capacity. We found that this was because the NEM Dispatch Engine was rounding the dispatch target down to the nearest MW.

Key learning

A rounding feature in AEMO's dispatch engine appears to make it impossible to forecast accurately when the plant is at full capacity.

A setting in AEMO's system appears to round the dispatch target down to the nearest MW in the dispatch engine. This means that it is impossible to forecast accurately when the plant is permitted to produce at full capacity and is doing so.

Implications for future projects

A future project could explore whether the NEM dispatch engine could be modified so that it does not round down to the nearest MW.

Knowledge gap

Knowledge around whether there are any limitations in the efficacy of self-forecasts.

Lessons Learnt Report 6: Some plants cannot ramp at the rate set by the dispatch engine.

Project Name: *Fulcrum3D Wind Forecasting for the NEM*

Knowledge Category:	Technical
Knowledge Type:	Operation and maintenance
Technology Type:	Wind
State/Territory:	All NEM states

Background

Objectives or project requirements

To assess the technical and economic viability of wind and solar farms self-forecasting on the NEM.

Process undertaken

Fulcrum3D observed unexpected Causer Pays charges when generation caps were lifted. We found that this was because the plant could not ramp fast enough to meet the new dispatch target in one period and the NEM Dispatch Engine was not accounting for these ramping limitations.

Key learning

Generators may wish to assess the ability of their plant to ramp at the rate set by the dispatch engine. If a generation cap is lifted, some control systems may not be able to ramp the plant fast enough to meet the dispatch target in one period. The plant could then incur Causer Pays charges.

Implications for future projects

A future project could explore whether the NEM dispatch engine could be modified to include plant ramp rate capabilities.

Knowledge gap

Knowledge around whether there are any limitations in the efficacy of self-forecasts.

Lessons Learnt Report 7: The MP5F API is increasingly robust and reliable.

Project Name: *Fulcrum3D Wind Forecasting for the NEM*

Knowledge Category:	Technical
Knowledge Type:	Operation and maintenance
Technology Type:	Wind
State/Territory:	All NEM states

Background

Objectives or project requirements

To assess the technical and economic viability of wind and solar farms self-forecasting on the NEM.

Process undertaken

Fulcrum3D has effectively integrated with the MP5F API and is now using it on over twelve sites.

Key learning

The MP5F API is increasingly robust and reliable. The MP5F API is stable and has been materially streamlined in the last 12 months. This process was recently further improved with an API to enable the password changes that are regularly required. This password change API is also working well.

Implications for future projects

Future projects can proceed with confidence that the MP5F API is robust and reliable.

Knowledge gap

Whether the proposed API could enable effective self-forecasting.

Lessons Learnt Report 8: SCADA integration is now the most complex part of the self-forecasting system.

Project Name: *Fulcrum3D Wind Forecasting for the NEM*

Knowledge Category:	Technical
Knowledge Type:	Operation and maintenance
Technology Type:	Wind
State/Territory:	All NEM states

Background

Objectives or project requirements

To assess the technical and economic viability of wind and solar farms self-forecasting on the NEM.

Process undertaken

Fulcrum3D have integrated our forecasting system with plant SCADA on over twelve NEM plants. Some SCADA systems are old or complex. We have always been successful, but it is worth noting that this integration to establish near real-time plant data feeds is now the most complex aspect of establishing self-forecasting on a new wind or solar farm.

Key learning

SCADA integration is now the most complex part of deploying a self-forecasting system. Real-time integration with the solar or wind farm SCADA system is critical to effective self-forecasting.

While the MP5F API and our self-forecasting system have matured to the extent they are easily repeatable across sites, site-specific SCADA integration is now the most variable component in the establishment of a self-forecasting system. While this task is not necessarily technically challenging for experienced personal, it can be highly time consuming to configure interfaces and QA all SCADA tags.

Implications for future projects

Awareness that integration with plant SCADA is sometimes not trivial.

Knowledge gap

Challenges associated with self-forecasting.

Lessons Learnt Report 9: Remote SCADA access needs to be reliable with high availability to be useful in applications like real time forecasting.

Project Name: *Fulcrum3D Wind Forecasting for the NEM*

Knowledge Category:	Technical
Knowledge Type:	Operation and maintenance
Technology Type:	Wind
State/Territory:	All NEM states

Background

Objectives or project requirements

To assess the technical and economic viability of wind and solar farms self-forecasting on the NEM.

Process undertaken

We were optimistic that Pacific Hydro's remote SCADA access system (the GOS or Global Operating System) would provide streamlined access to real time plant data at Clements Gap, Taralga and Crowlands and remove the need for onsite loggers.

On some sites the GOS availability has not been high enough for this type of real time application and other solutions have been deployed including and onsite logger at Crowlands.

The lesson is that cloud-based systems like the GOS that are not built for real time controls may not be suitable for use in these types of forecasting applications. The GOS is a plant monitoring tool so did not require (and was therefore not built with) very robust continuous communications capability.

A useful comparison is the Kidston SCADA data integration which was trivial from a technical point of view. It used onsite hardware and a dedicated RTU and continues to run smoothly.

Key learning

Remote SCADA access via cloud services need to be reliable with high availability to be useful in applications like real time forecasting.

Implications for future projects

Onsite polling of SCADA data may be the best option if remote SCADA access is unreliable or delayed.

Knowledge Gap

Challenges associated with self-forecasting.