

AVEVA PI WORLD

Building an event-based assessment system in Pi

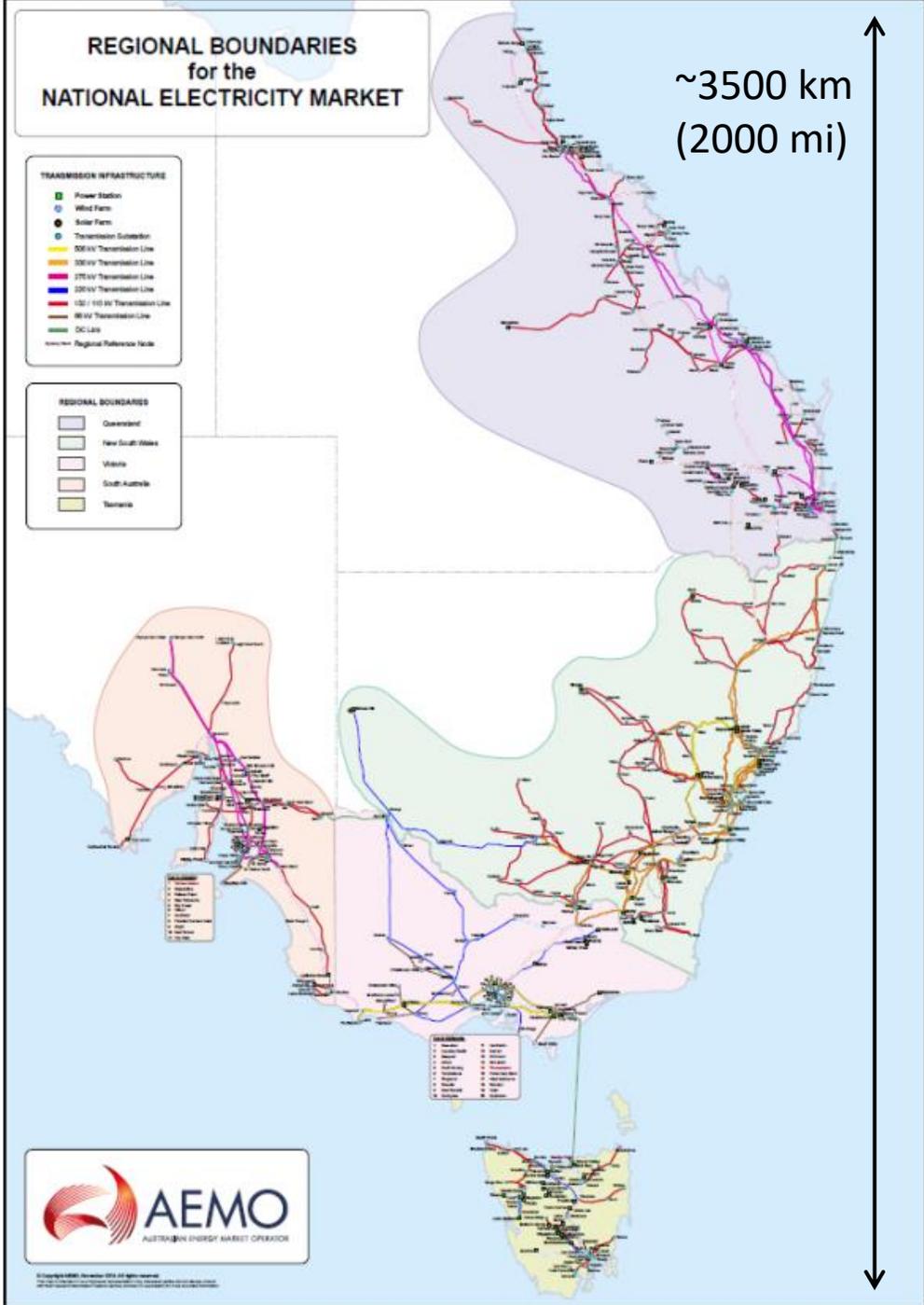
AGL's frequency response verification tool

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AGL Asset Intelligence

The AVEVA logo is displayed in white, bold, uppercase letters. The background of the slide features a dark blue gradient with abstract, glowing patterns of dots and lines in shades of blue, orange, and purple, suggesting a digital or data-driven environment.



AGL Energy, Australia Asset Intelligence team



AGL Energy is the largest generator in Australia (~11GW)

AGL's Asset Intelligence team:

- Build and maintain the Pi system
- Train and tune ML models to identify out-of-normal operation
- Provide analytics services across the fleet



AVEVA

A quick introduction: Why we need Contingency Frequency control

Callide C Power station, 25 May 2021
(Fortunately **not** an AGL Energy asset!)

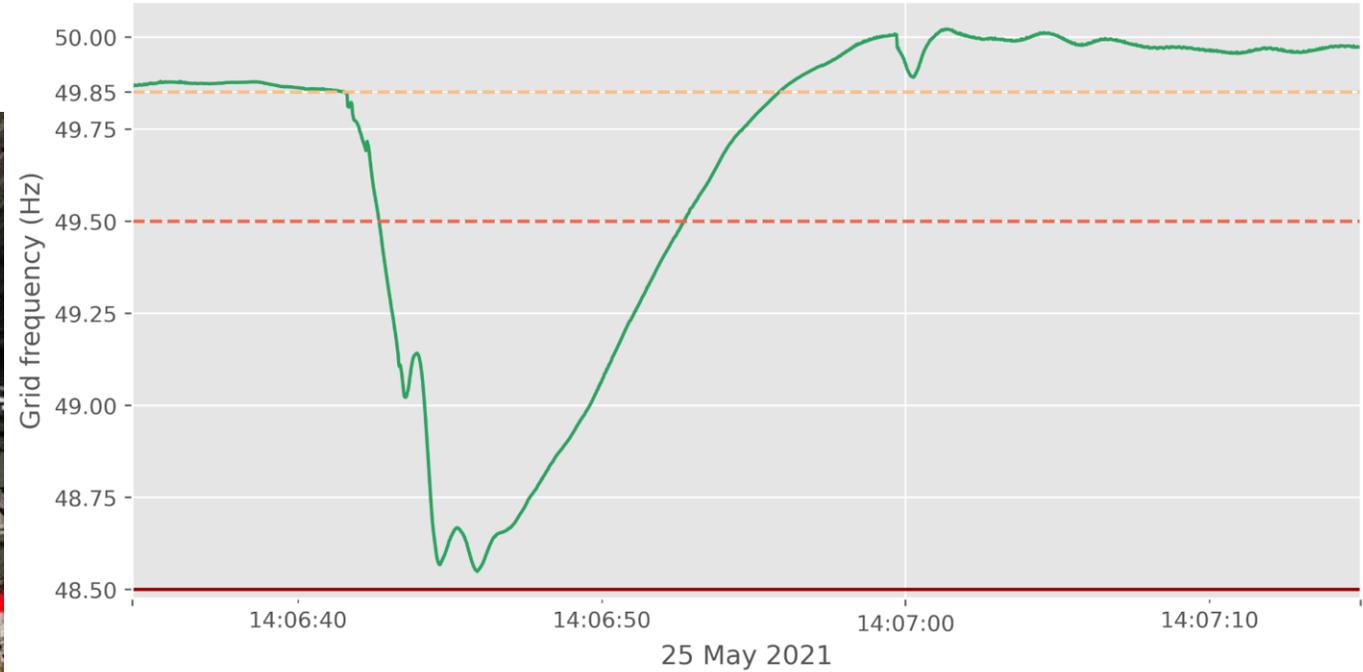


A quick introduction: Why we need Contingency Frequency control

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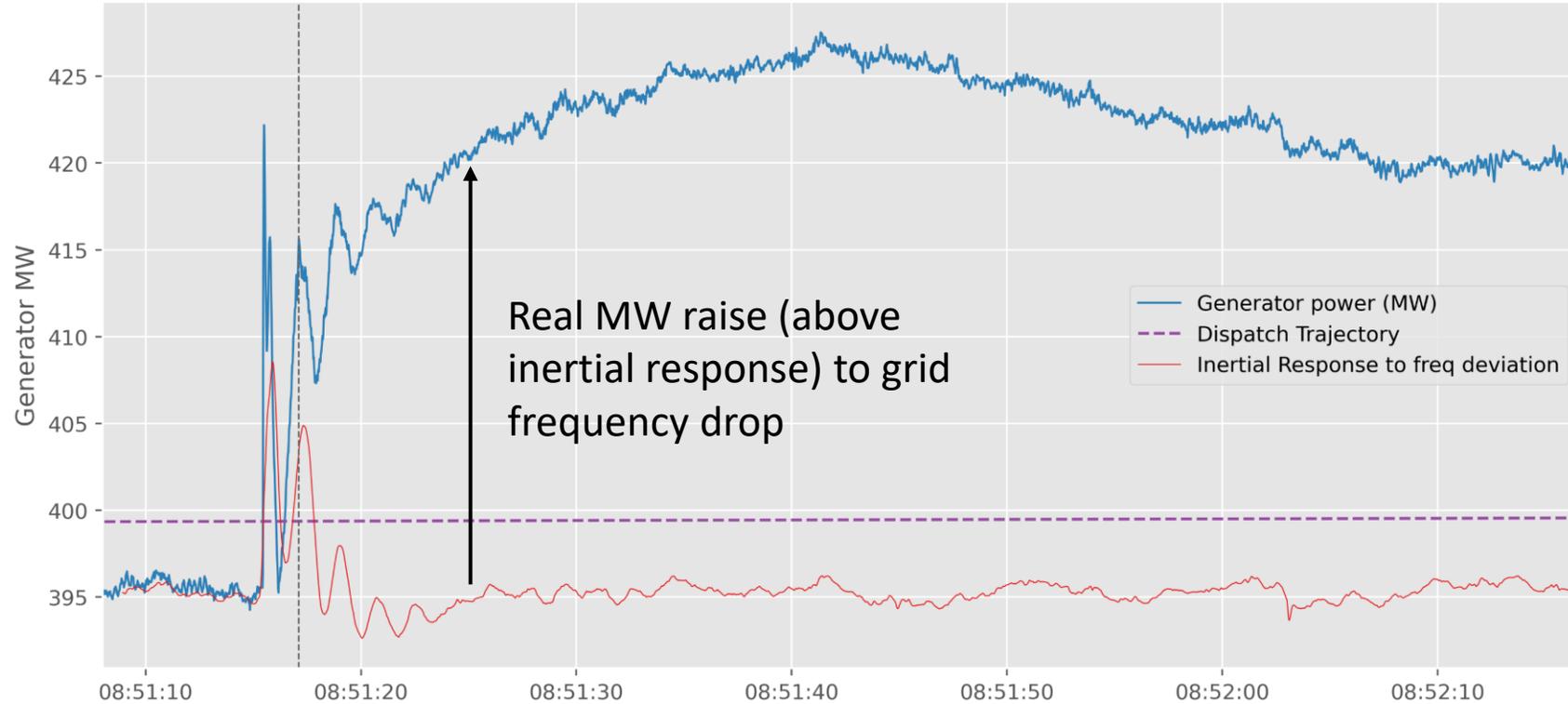
Grid frequency at Coopers Gap Wind Farm
(a nearby AGL asset in Queensland)



Each generator must respond almost instantly (and independently) when grid frequency drops

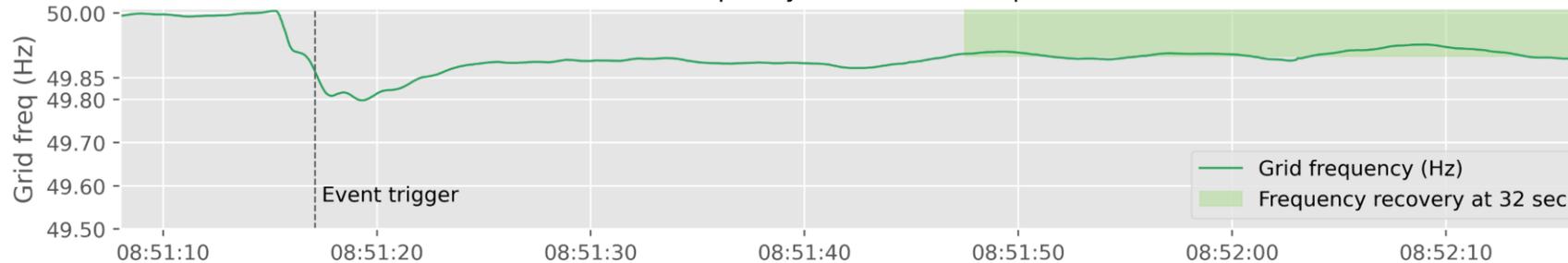


Generator power response (inertial response in red as reference)



Many of our generators are contracted (and paid) to provide a response when a contingency event occurs

Grid frequency over same time period



We must ensure that our generation fleet is responding as contracted



Are we set up to respond as enabled?

This is a real time monitoring challenge

- DCS alarming
- Pi Vision screens compare contingency “offers” with real time assessment of capability
- Pi Event Frame notifications when potentially outside of capability envelope

Did we respond correctly to an event?

This is a post event assessment challenge

- Process high speed meter data
- Determine what we were contracted to achieve
- Calculate whether we achieved it
- Report and alert areas of concern

This post-assessment system is the focus of today’s talk

AGL has a diverse fleet of generators offering (and being paid for) contingency service



The analytics challenge: "Rating" the response



How we used to do things....



1. Obtain and paste into spreadsheet

- Machine characteristics
- Dispatch instructions
- High speed frequency, MW
- Low speed frequency, MW

2. Multiple pages of calculations

3. Results

Slow, prone to errors, not feasible with a growing generation fleet

The screenshot shows the 'EXTERNAL FCAS Verification Tool v400 for MASS v6.xlsx' spreadsheet. The interface includes a ribbon with tabs like File, Home, Insert, Draw, Page Layout, Formulas, Data, Review, View, Help, Kofax PDF, PI DataLink, and PI Builder. The spreadsheet is divided into two main sections: 'INPUTS' and 'RESULTS'.

INPUTS Section:

Plant Information	Value	Comment
Plant Name	MgGenUnit1	For information only
Plant Inertia	0.022913179	In MW sec ² (or kg m ² /1000) [HELP]
Allocated Frequency Setting		In Hz, corresponding to allocated frequency level - see table 3 or 4 in the MASS. This is only applicable to Switching controllers (S)
Boost	1	G [HELP]
Sample Rate of Frequency Recorder for high speed data (<= 50ms) for Fast services	0.02	In seconds
Sample Rate of Frequency Recorder for low speed data (<= 4s) for estimation of the FD parameter	4	In seconds [HELP]
Sample Rate of Frequency Recorder for low speed data (<= 4s) for Slow services	4	In seconds
Sample Rate of Frequency Recorder for low speed data (<= 4s) for Delayed services	4	In seconds
Frequency Dead-band Lower Limit	50	In Hz, as defined in the MASS
Generator or Load?	GENERATOR	
Incident and Dispatch Information	Value	Comment
High speed data start time	15:10:14	Time only (no date) exact precision not required - This is used for determining the DI (has to be in the same DI as the PI data)
Low speed data Start time	15:10:05	Time only (no date) exact precision not required - This is used for determining the dispatch
Contingency Event Offset	0.3	Time in seconds between Contingency Event Time and Frequency Disturbance Time (NDFB crossing). Supplied by AEMG for each FCAS assessment event upon request. Fast Service assessment window begins from Contingency Event Time. Prior to 1 July 2020 Fast Service assessment began from NDFB crossing.
Fast Service Enabled (NEMDE target)	5	MW value of Fast Raise service enabled
Slow Service Enabled (NEMDE target)	10	MW value of Slow Raise service enabled
Delayed Service Enabled (NEMDE target)	10	MW value of Delayed Raise service enabled
Initial MV for dispatch interval:		
15:10	575.5	In MV, initial MV at the start of the dispatch interval, for scheduled generating units and loads only
15:15	579.5	
15:20	645.3	
15:25	651.1	
Dispatch Targets for dispatch interval:		
15:10	580.0	In MV, dispatch target for the dispatch interval, for scheduled generating units and loads only
15:15	600.0	
15:20	620.3	
15:25	630.0	
Region	MAINLAND	
Applicable MASS Parameters	Value	Comment
Raise reference frequency:	49.5	In Hz, as defined in the MASS V6.0

RESULTS Section:

Fast Raise (MW)	Value	[HELP]
FA	565.34	
FB	39	
FC	74.5	
FD	69.5	

Fast Raise 4s tab (NOT a reliable estimate of Fast Raise)

Scenario	Value	[HELP]
FA (estimate)	557.4	
FB (estimate)	62.8	
FC (estimate)	163.5	
FD (estimate)	164.5	

Slow Raise (MW)

Scenario	Value	Participant supplied fast data used for calculation.
SA	557.4	
SB	162.2	
SC	181.0	
SE	171.0	

Delayed Raise (MW)

Scenario	Value
DA	557.4
DB	109.0
DC	62.8

The data challenge: Disparate sources, complex processing steps



High speed meters

- Collect data at 20ms and 4s scan rates
- Only trigger on frequency excursions
- Varying suppliers



Dispatch instructions

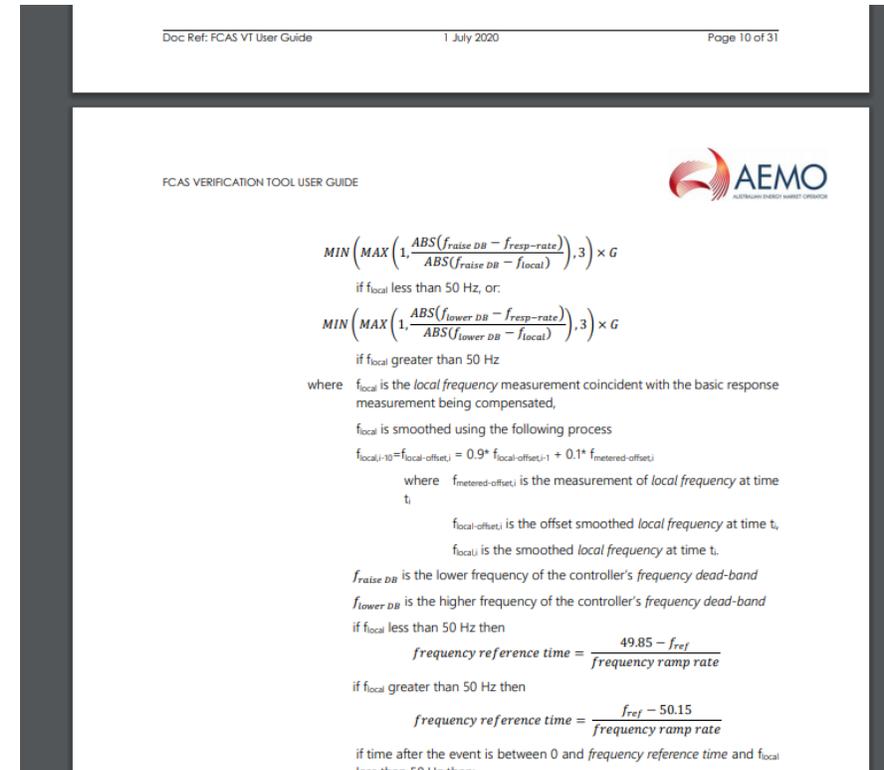
Received from market operator



Machine characteristics

Unique to each generator

31 page document describes the data processing steps required



Our solution: Data flow and analytics process



Field data recorded

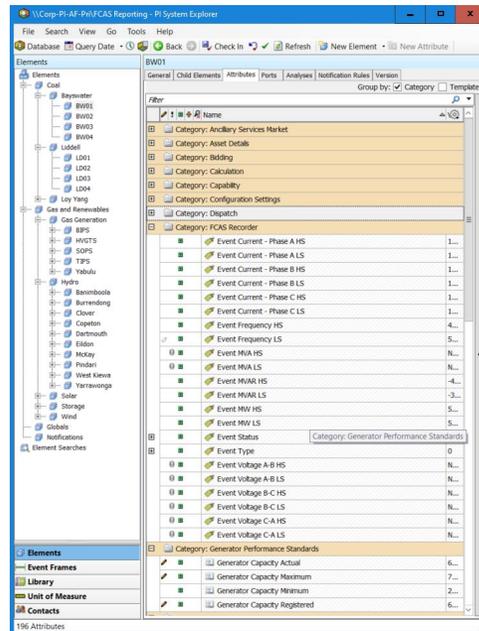
High speed meter triggers and records ~70 seconds of 20ms data



Landed in Pi

20ms and 4s timeseries data loaded via UFL/SQL

Event Frame generated (not assessed yet)



EF processed (Python)

New EF picked up by Python script

Assessment run, results written to EF attributes

PDF reports generated and attached to EF

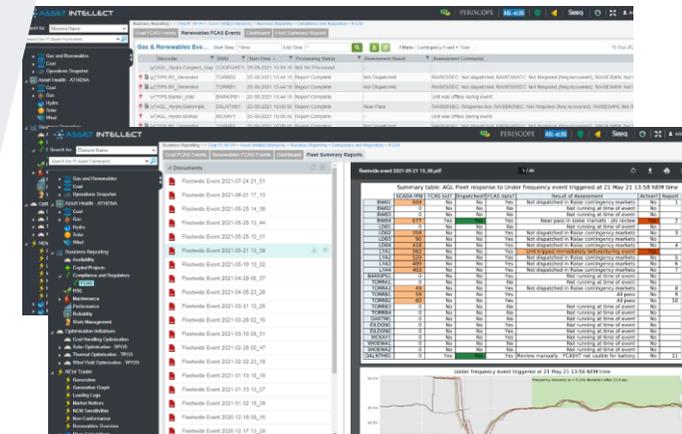
Fleet reports generated



Asset Intellect front end

Notification event frame generated - emails

Asset Intellect "serves" results via event frames



A project-specific Asset Framework is highly recommended

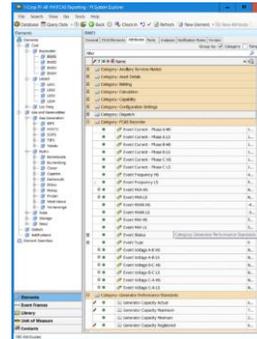
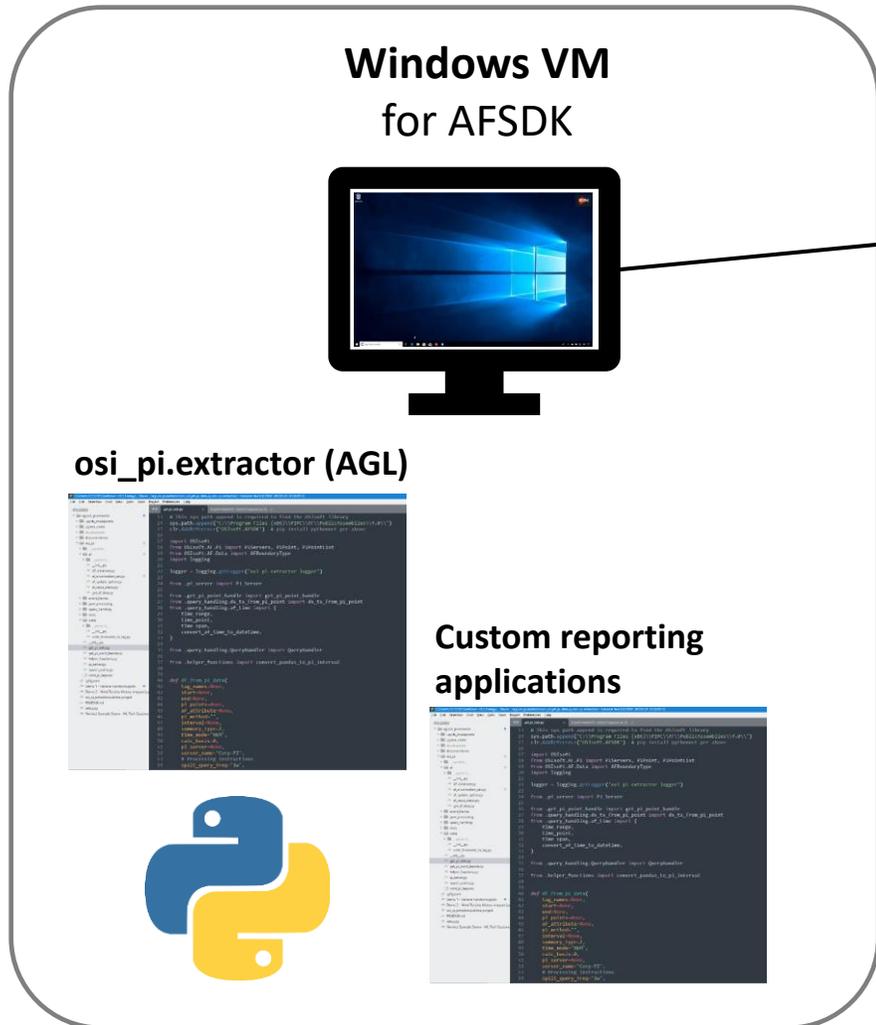
The Asset Framework acts as our visible “documentation” and configuration for the Python processing backend

All generators follow a standard structure regardless of underlying characteristics

The screenshot displays the PI System Explorer interface. On the left, a tree view shows the hierarchy of elements under 'Coal', 'Gas and Renewables', and 'Solar'. The 'BW01' element is selected, and its details are shown in the main pane. The details pane includes tabs for 'General', 'Child Elements', 'Attributes', 'Ports', 'Analyses', 'Notification Rules', and 'Version'. The 'Attributes' tab is active, showing a list of attributes grouped by category. The categories include 'Ancillary Services Market', 'Asset Details', 'Bidding', 'Calculation', 'Capability', 'Configuration Settings', 'Dispatch', 'FCAS Recorder', and 'Generator Performance Standards'. The 'Generator Performance Standards' category is expanded, showing attributes like 'Generator Capacity Actual', 'Generator Capacity Maximum', 'Generator Capacity Minimum', and 'Generator Capacity Registered'.

Category	Attribute Name	Value
Category: Ancillary Services Market		
Category: Asset Details		
Category: Bidding		
Category: Calculation		
Category: Capability		
Category: Configuration Settings		
Category: Dispatch		
Category: FCAS Recorder		
	Event Current - Phase A HS	1...
	Event Current - Phase A LS	1...
	Event Current - Phase B HS	1...
	Event Current - Phase B LS	1...
	Event Current - Phase C HS	1...
	Event Current - Phase C LS	1...
	Event Frequency HS	4...
	Event Frequency LS	5...
	Event MVA HS	N...
	Event MVA LS	N...
	Event MVAR HS	-4...
	Event MVAR LS	-3...
	Event MW HS	5...
	Event MW LS	5...
	Event Status	Category: Generator Performance Standards
	Event Type	0
	Event Voltage A-B HS	N...
	Event Voltage A-B LS	N...
	Event Voltage B-C HS	N...
	Event Voltage B-C LS	N...
	Event Voltage C-A HS	N...
	Event Voltage C-A LS	N...
Category: Generator Performance Standards		
	Generator Capacity Actual	6...
	Generator Capacity Maximum	7...
	Generator Capacity Minimum	2...
	Generator Capacity Registered	6...

Once Event Frame appears: Custom processing



Read/write to Pi using the AF for authentication

Similar process for most of our reporting applications

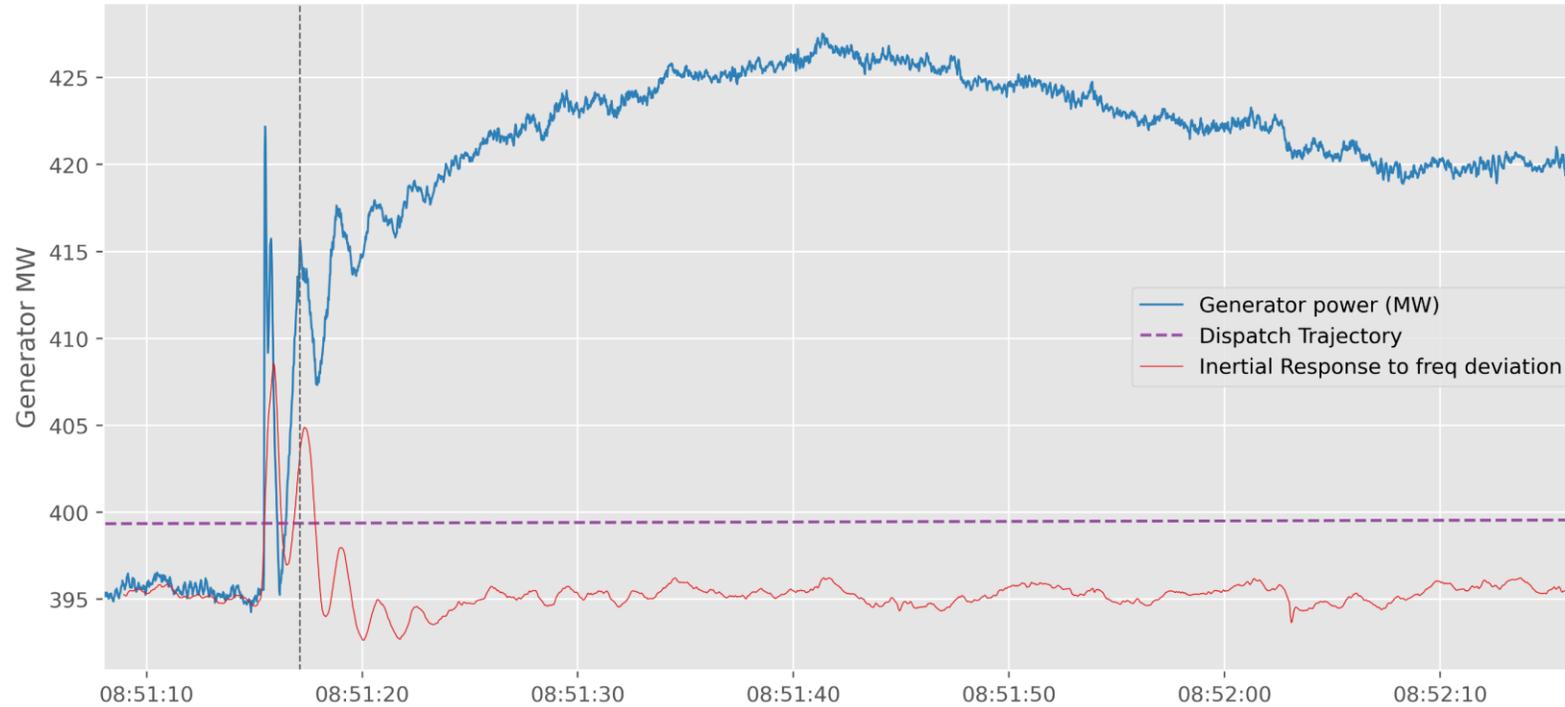
- Query Pi on a schedule – new Event Frame?
- Pull relevant timeseries data, process
- Write results to Event Frame attributes
- Attach PDF reports to Event Frame
- Build Group summary reports: Asset Intellect

Automated report for a single unit



high speed response and FCASVT results for under frequency event - 2021 08:51

Generator power response (inertial response in red as reference)



DISPATCHLOAD interval

2021-03-10 08:55:00

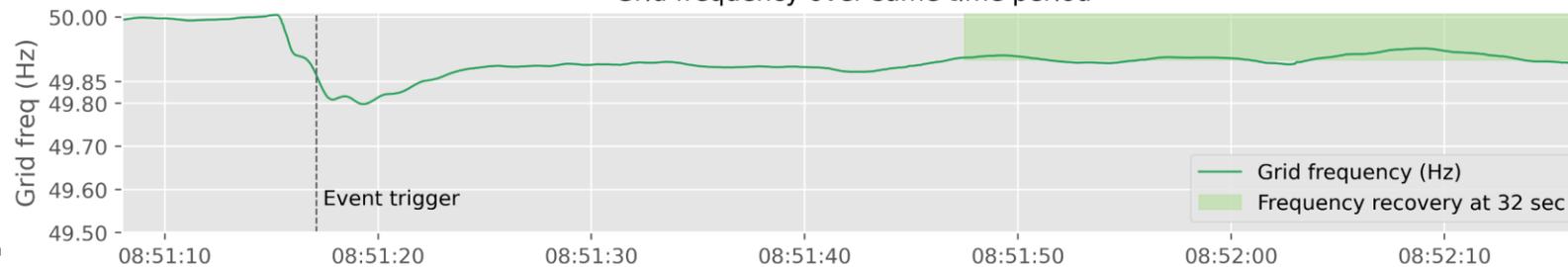
DUID
AVAILABILITY
INITIALMW
TOTALCLEARED
RAISEREG

Comparison of contingency dispatch instruction ("Enabled") with results from AEMO FCASVT tool

RAISE contingency markets

	Enabled	FCASVT
6SEC	25	
60SEC	30	
5MIN	15	Closed

Grid frequency over same time period



Review the whole fleet in a “fleetwide” view



Summary table: AGL Fleet response to Under frequency event triggered at [redacted] NEM time

SCADA MW	FCAS bid?	Dispatched?	FCAS data?	Result of Assessment	Action?	Report
[redacted]	No	No	Yes	[redacted]	No	1
[redacted]	No	No	No	[redacted]	No	
[redacted]	No	No	No	[redacted]	No	
[redacted]	Yes	Yes	Yes	[redacted]	Yes	2
[redacted]	No	No	No	[redacted]	No	
[redacted]	No	No	Yes	[redacted]	No	3
[redacted]	No	No	Yes	[redacted]	No	4
[redacted]	No	No	Yes	[redacted]	Yes	
[redacted]	No	No	Yes	[redacted]	No	5
[redacted]	No	No	Yes	[redacted]	No	6
[redacted]	No	No	Yes	[redacted]	No	7
[redacted]	No	No	Yes	[redacted]	No	
[redacted]	No	No	No	[redacted]	No	
[redacted]	No	No	Yes	[redacted]	No	8
[redacted]	No	No	Yes	[redacted]	No	9
[redacted]	No	No	Yes	[redacted]	No	10
[redacted]	No	No	No	[redacted]	No	
[redacted]	No	No	No	[redacted]	No	
[redacted]	No	No	No	[redacted]	No	
[redacted]	No	No	Yes	[redacted]	No	
[redacted]	No	No	Yes	[redacted]	No	
[redacted]	No	No	Yes	[redacted]	No	
[redacted]	No	No	No	[redacted]	No	
[redacted]	No	No	No	[redacted]	No	
[redacted]	Yes	Yes	Yes	[redacted]	No	11

Front end development can be expensive and a support nightmare: Outsource where possible



ASSET INTELLECT

Search for: Element Name

Search the PI Asset Framework...

Business Reporting >> Corp-PI-AF-Pri > Asset Intellect Hierarchy > Business Reporting > Compliance and Regulatory > FCAS

Coal FCAS Events Renewables FCAS Events Dashboard Fleet Summary Reports

Gas & Renewables Eve... Start Time *-6mo End Time * Filters: Contingency Event = 'True' 16-Sep-202

	Recorder	DUID	Start Time	Processing Status	Assessment Result	Assessment Comments
	AGL_Hydro.Coopers_Gap	COOPGWF1	25-05-2021 13:44:10	Not Yet Processed		
↑	TIPS.B2_Generator	TORRB2	25-05-2021 13:44:10	Report Complete		
↑	TIPS.B1_Generator	TORRB1	25-05-2021 13:44:10	Report Complete		
↑	TIPS.Barker_Inlet	BARKIPS1	25-05-2021 13:44:10	Report Complete		
↑	AGL_Hydro.Dalrymple	DALNTH01	25-05-2021 10:00:55	Report Complete		
↑	AGL_Hydro.McKay	MCKAY1	25-05-2021 10:00:55	Report Complete		
↑	TIPS.B2_Generator	TORRB2	25-05-2021 10:00:55	Report Complete		
↑	TIPS.Barker_Inlet	BARKIPS1	25-05-2021 10:00:55	Report Complete		
↑	TIPS.A3_Generator	TORRA3	23-05-2021 0:33:42	Report Complete		
↑	TIPS.B1_Generator	TORRB1	21-05-2021 13:58:02	Report Complete		
↑	TIPS.B2_Generator	TORRB2	21-05-2021 13:58:02	Report Complete		
↑	AGL_Hydro.Dalrymple	DALNTH01	21-05-2021 13:58:01	Report Complete		
↑	AGL_Hydro.McKay	MCKAY1	21-05-2021 13:58:01	Report Complete		
↑	TIPS.Barker_Inlet	BARKIPS1	21-05-2021 13:58:01	Report Complete		
↑	TIPS.A3_Generator	TORRA3	21-05-2021 13:58:01	Report Complete		
↑	TIPS.A3_Generator	TORRA3	13-05-2021 22:03:27	Report Complete		
↑	TIPS.A3_Generator	TORRA3	05-05-2021 22:02:57	Report Complete		
↑	TIPS.A3_Generator	TORRA3	30-04-2021 0:03:24	Report Complete		
↑	AGL_Hydro.Eildon_1	EILDON1	29-04-2021 6:06:56	Report Complete		
↑	TIPS.B3_Generator	TORRB3	29-04-2021 6:06:56	Report Complete		
↑	AGL_Hydro.Eildon_2	EILDON2	29-04-2021 6:06:56	Report Complete		
↑	TIPS.B1_Generator	TORRB1	29-04-2021 6:06:56	Report Complete		
↑	AGL_Hydro.McKay	MCKAY1	29-04-2021 6:06:55	Report Complete		Unit was offline during event

1 - 93 of 93 items

A final note... be prepared to
welcome brutal feedback





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Craig Ots-Maher

Lead Asset Intelligence System Engineer
(and Pi build genius)

Craig was instrumental in the build of the “data pipeline” and AF for this project

THANK YOU

謝謝

DZIĘKUJĘ CI

NGIYABONGA

TEŞEKKÜR EDERİM

DANKIE

TERIMA KASIH

GRACIES

WHAKAWHETAI KOE

DANKON

TANK

TAPADH LEAT

SALAMAT

SPASIBO

GRAZIE

MATUR NUWUN

ХВАЛА ВАМ

MULŢUMESC

PAKMET CIZGE

고맙습니다

GRAZIE

شكرا

FAAFETAI

ESKERRIK ASKO

GO RAIBH MAITH AGAT

HVALA

HVALA

БЛАГОДАРЯ

GRACIAS

MAHADSANID

TEŞEKKÜR EDERİM

ТИ БЛАГОДАРАМ

DANKJE

EΥΧΑΡΙΣΤΩ

GRATIAS TIBI

OBRIGADO

TAK DANKE

AČIŪ

SALAMAT

MAHALO IĀ 'ŌE

TAKK SKALDU HA

МЕРЦИ

RAHMAT

MERCI

GRAZZI

PAKKA PÉR

ありがとうございました

DI OU MÈSI

ĐAKUJEM

HATUR NUHUN

PAXMAT CAĜA

SIPAS JI WERE

TERIMA KASIH

CẢM ƠN BẠN

UA TSAUG RAU KOJ

ТИ БЛАГОДАРАМ

СИПОС

WAZVIITA

FALEMINDERIT

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