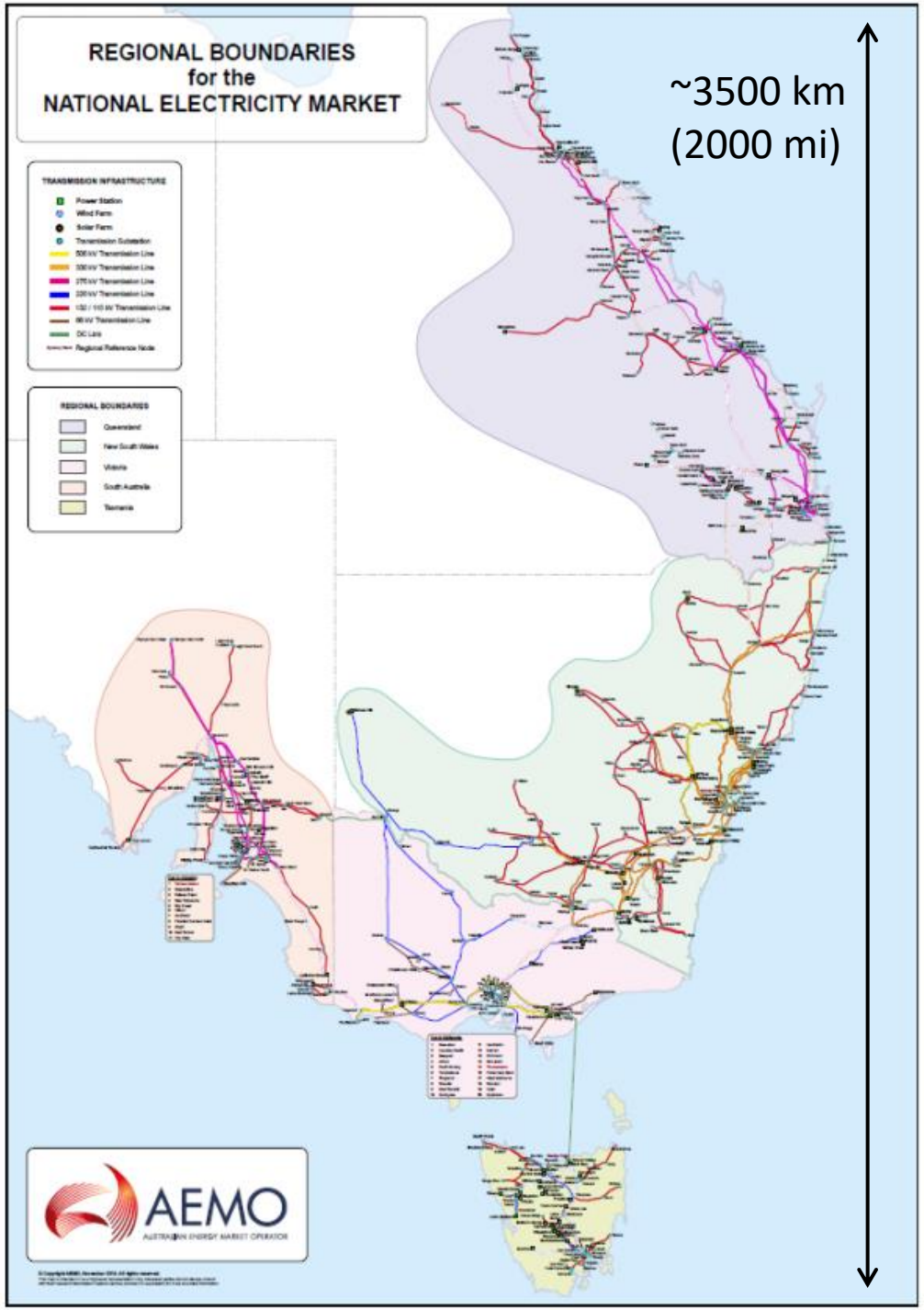
AVEVA PI WORLD

Building an event-based assessment system in Pi

AGL's frequency response verification tool

David Bowly
Senior Engineer, Operational Analytics team
AGL Asset Intelligence



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

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A quick introduction:
Why we need Contingency Frequency control

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

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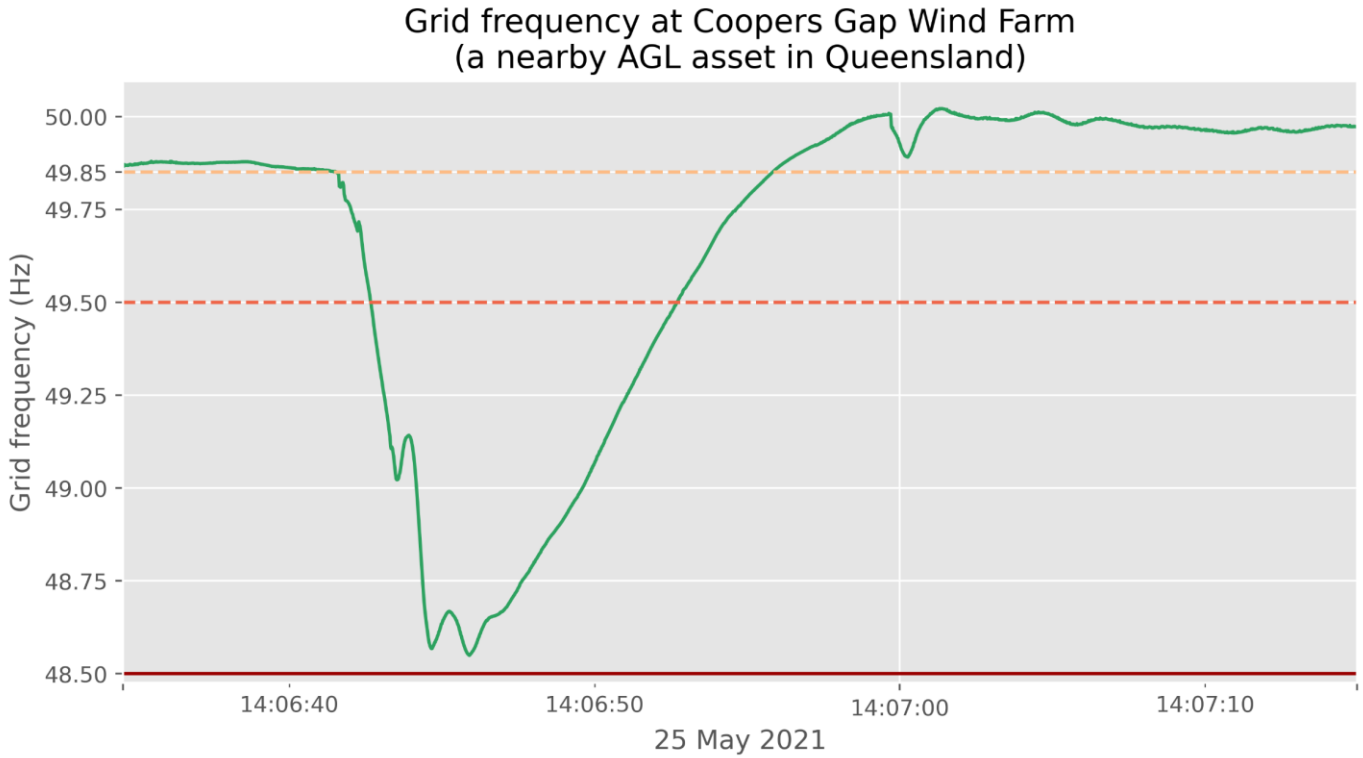
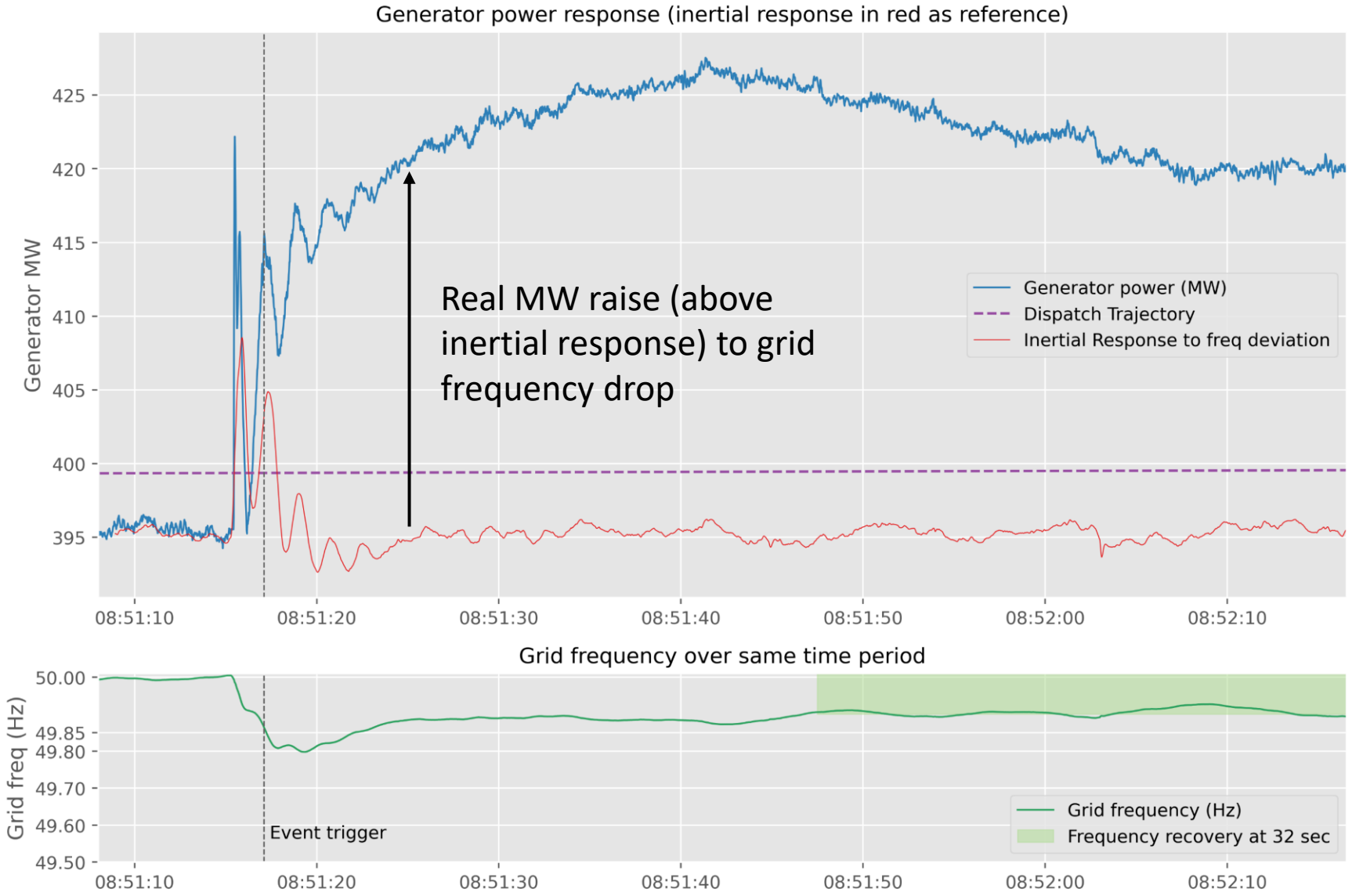


Each generator must respond almost instantly (and independently) when grid frequency drops



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

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?

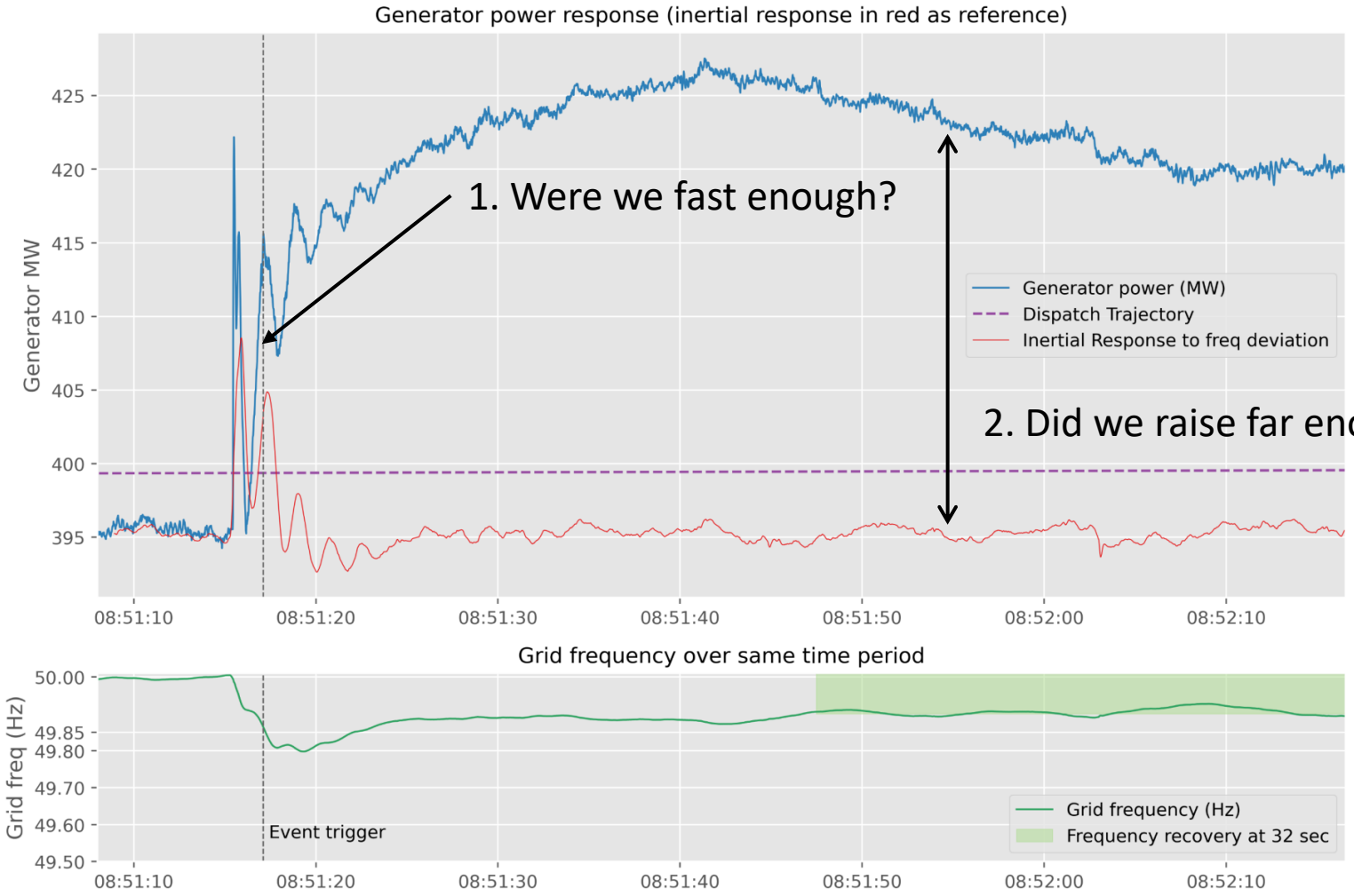
This is a post event assessment challenge

- 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



1. Were we fast enough?

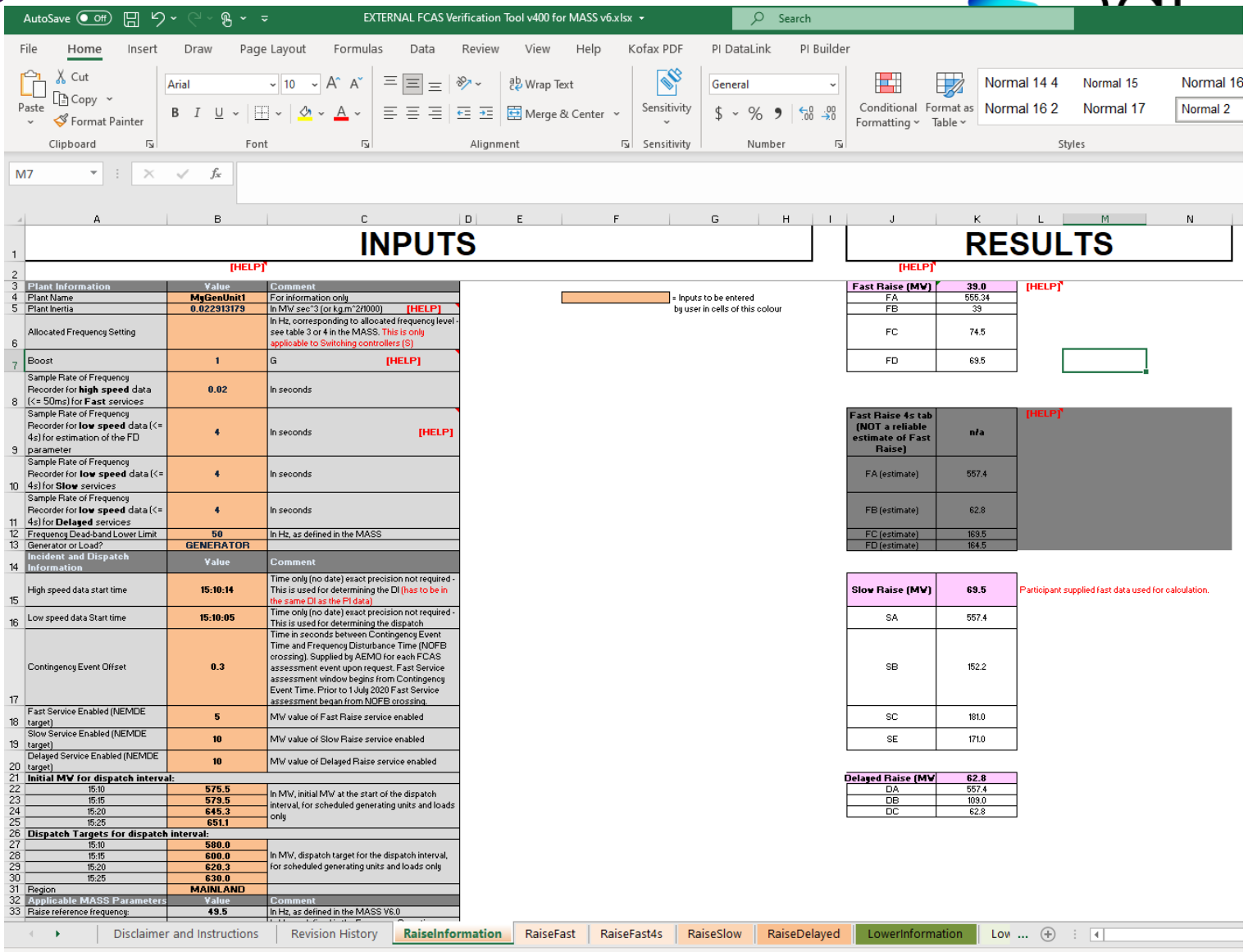
2. Did we raise far enough?

3. Did we sustain the raise for long enough?

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



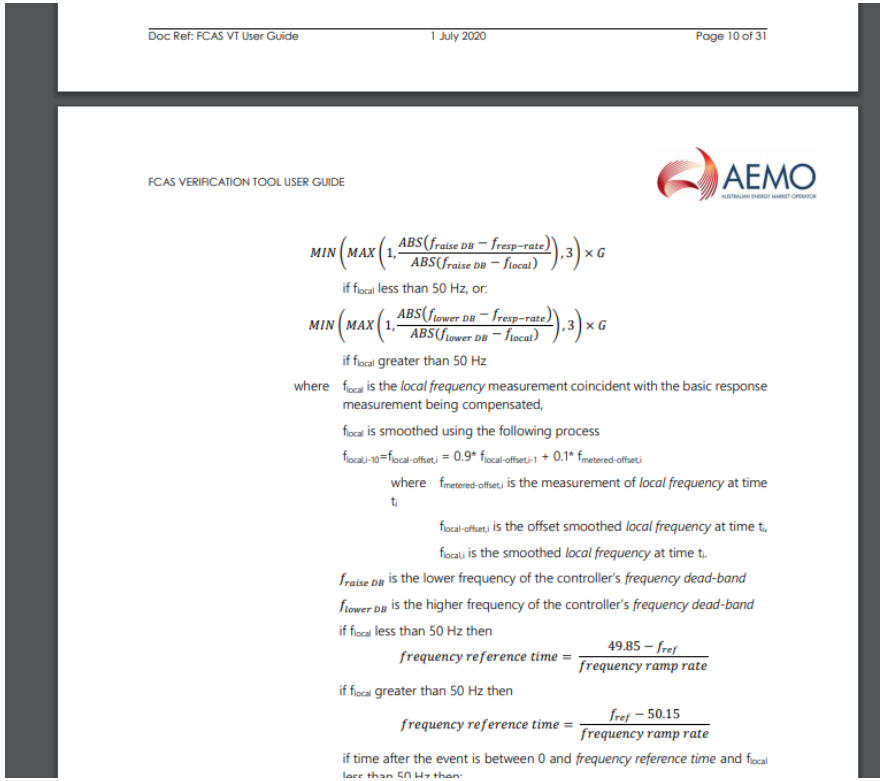
The data challenge: Disparate sources, complex processing steps

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



Doc Ref: FCAS VT User Guide 1 July 2020 Page 10 of 31

FCAS VERIFICATION TOOL USER GUIDE

$$MIN\left(MAX\left(1,\frac{ABS(f_{raise\ DB}-f_{resp-rate})}{ABS(f_{raise\ DB}-f_{local})}\right),3\right)\times G$$

if f_{local} less than 50 Hz, or:

$$MIN\left(MAX\left(1,\frac{ABS(f_{lower\ DB}-f_{resp-rate})}{ABS(f_{lower\ DB}-f_{local})}\right),3\right)\times G$$

if f_{local} greater than 50 Hz

where f_{local} is the *local frequency* measurement coincident with the basic response measurement being compensated,

f_{local} is smoothed using the following process

$f_{local,i-10}=f_{local\text{-}offset,i} = 0.9* f_{local\text{-}offset,i-1} + 0.1* f_{metered\text{-}offset,i}$

where $f_{metered\text{-}offset,i}$ is the measurement of *local frequency* at time t_i

$f_{local\text{-}offset,i}$ is the offset smoothed *local frequency* at time t_i,

$f_{local,i}$ is the smoothed *local frequency* at time t_i.

$f_{raise\ DB}$ is the lower frequency of the controller's *frequency dead-band*

$f_{lower\ DB}$ is the higher frequency of the controller's *frequency dead-band*

if f_{local} less than 50 Hz then

$$frequency\ reference\ time = \frac{49.85 - f_{ref}}{frequency\ ramp\ rate}$$

if f_{local} greater than 50 Hz then

$$frequency\ reference\ time = \frac{f_{ref} - 50.15}{frequency\ ramp\ rate}$$

if time after the event is between 0 and *frequency reference time* and f_{local} less than 50 Hz then:

Our solution: Data flow and analytics process

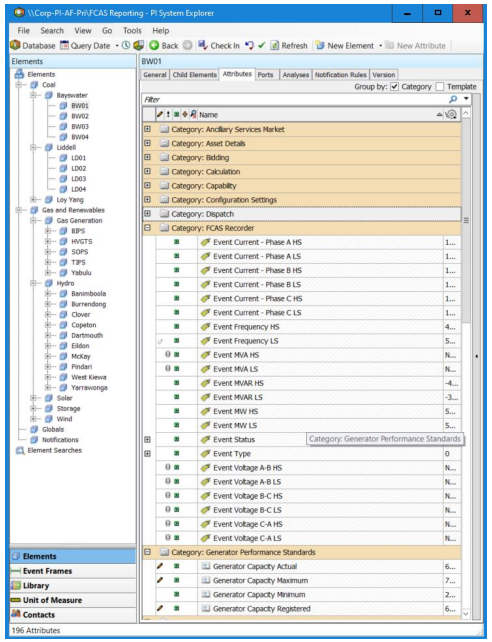
Field data recorded

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

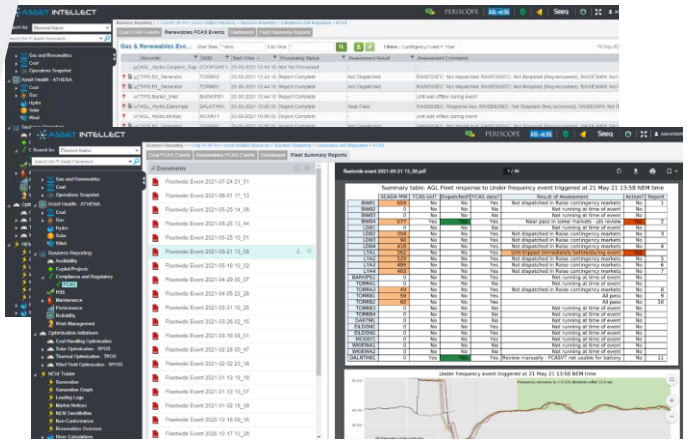
PDF reports generated and attached to EF

Fleet reports generated

Asset Intellect front end

Notification event frame generated - emails

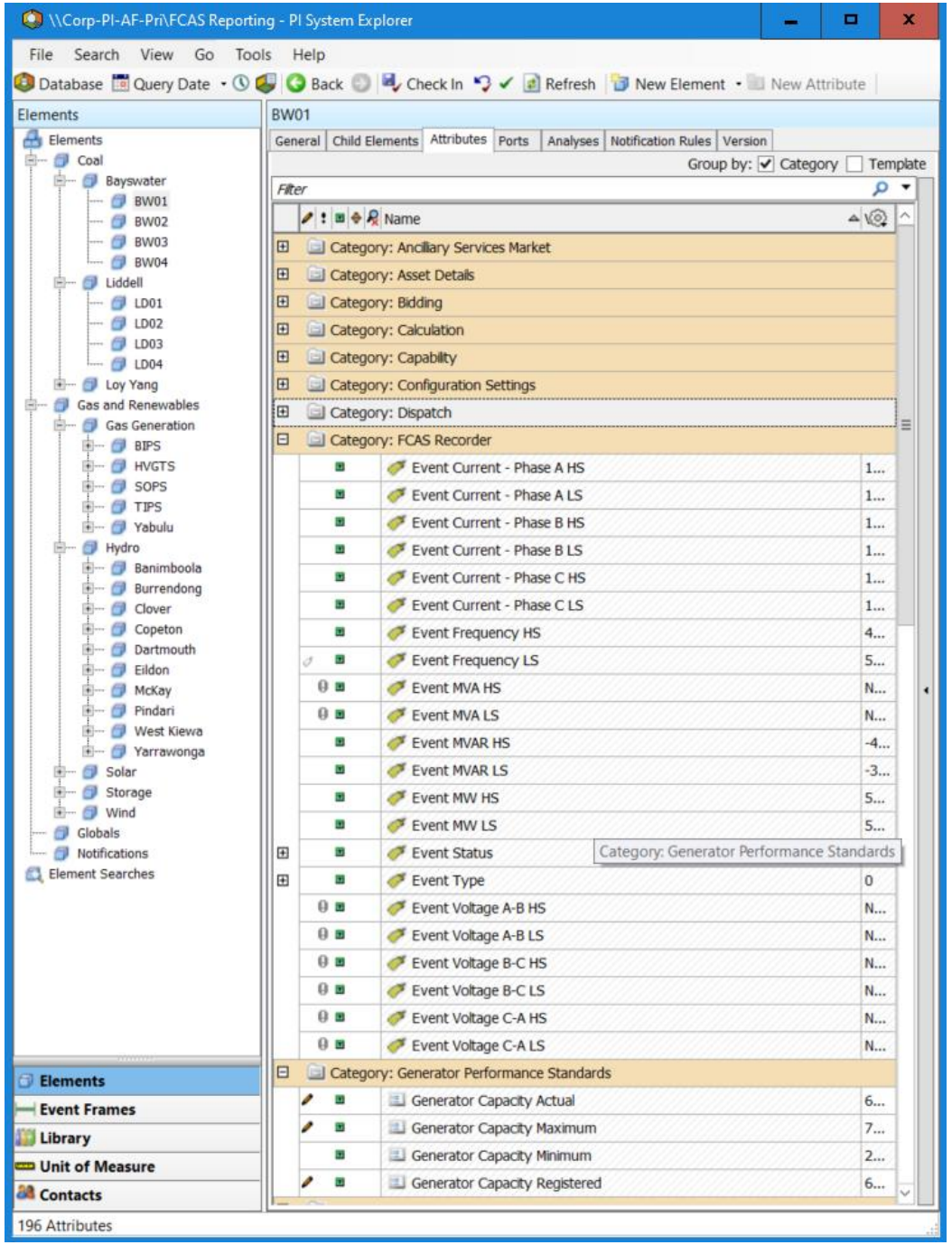
Asset Intellect “serves” results via event frames



A project-specific Asset Framework is highly recommended

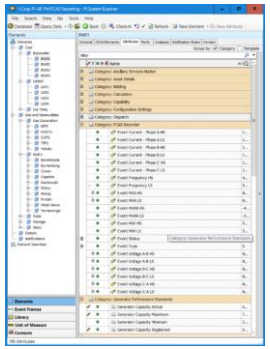
The Asset Framework acts as our visible “documentation” and configuration for the Python processing backend

All generators follow a standard structure regardless of underlying characteristics



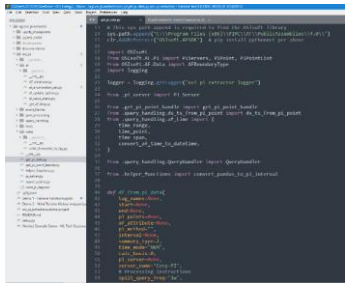
Once Event Frame appears: Custom processing

Windows VM
for AFSDK

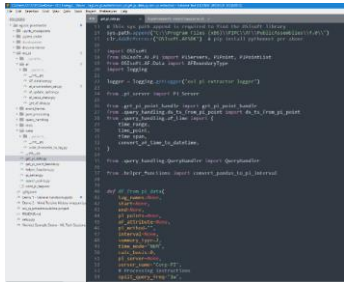


Read/write to Pi using the AF for authentication

osi_pi.extractor (AGL)



Custom reporting applications

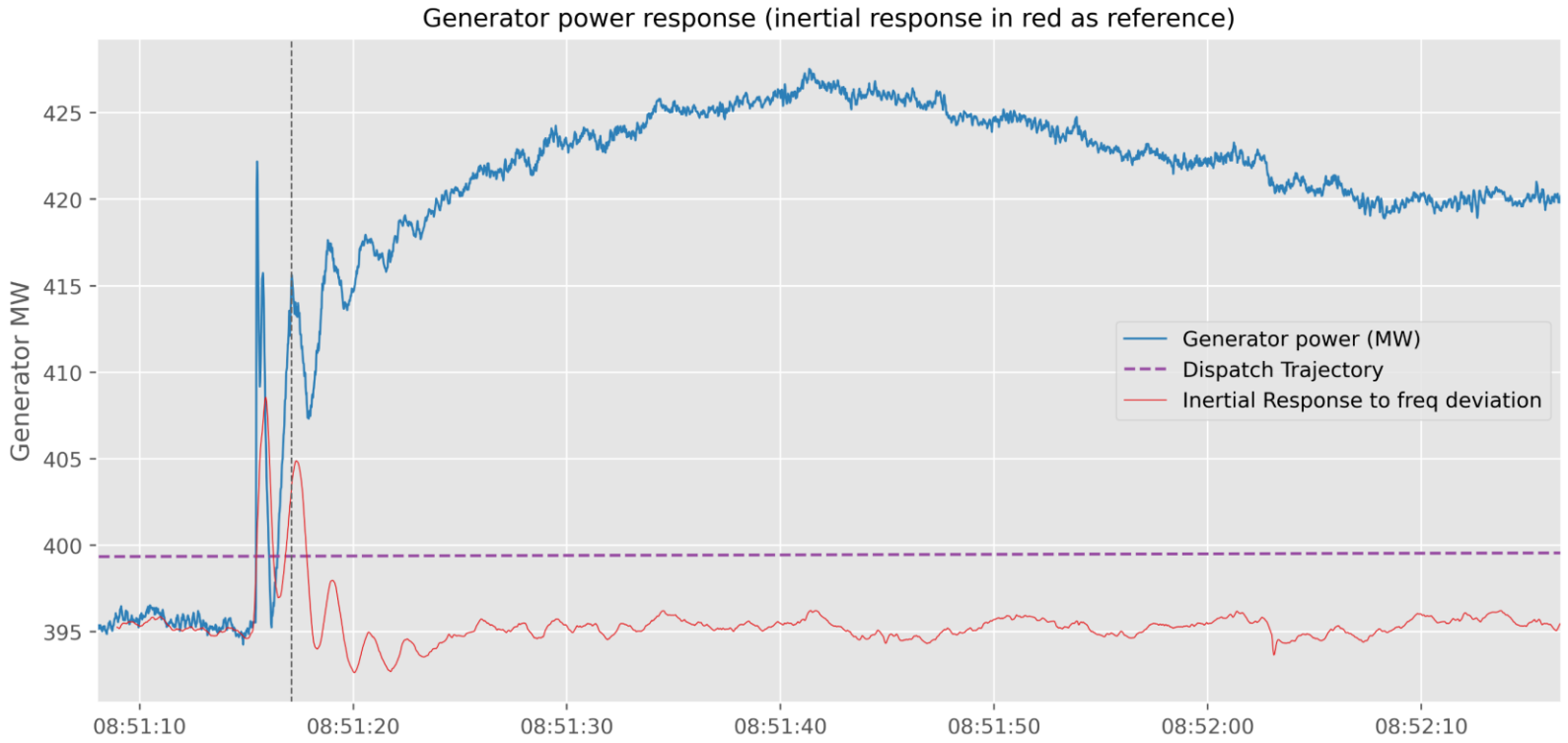


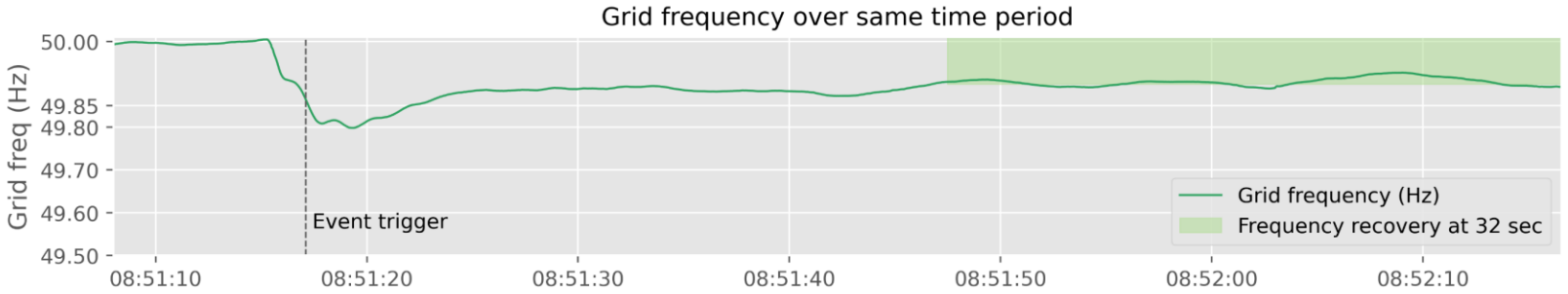
Similar process for most of our reporting applications

- 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

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





DISPATCHLOAD interval

2021-03-10 08:55:00

DUID
AVAILABILITY
INITIALMW
TOTALCLEARED
RAISEREG

[redacted]

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

RAISE contingency markets

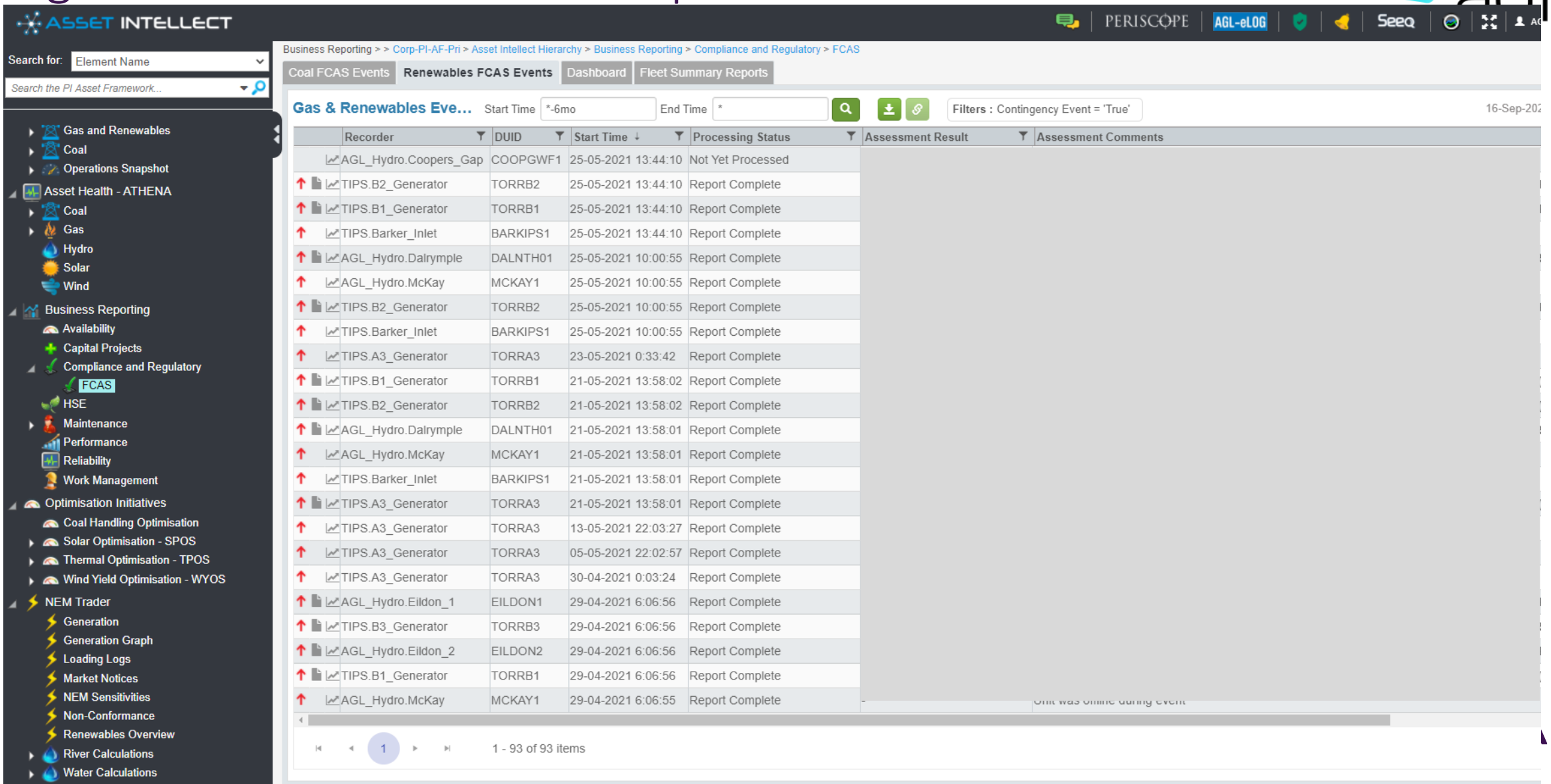
	Enabled	FCASVT
6SEC	25	[redacted]
60SEC	30	[redacted]
5MIN	15	Closed

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]	[redacted]	No	No	Yes	[redacted]	No	1
		No	No	No		No	
		No	No	No		No	
		Yes	Yes	Yes		Yes	2
		No	No	No		No	
		No	No	Yes		No	3
		No	No	Yes		No	
		No	No	Yes		No	4
		No	No	Yes		Yes	
		No	No	Yes		No	5
		No	No	Yes		No	6
		No	No	Yes		No	7
		No	No	Yes		No	
		No	No	No		No	
		No	No	Yes		No	8
		No	No	Yes		No	9
		No	No	Yes		No	10
		No	No	No		No	
		No	No	No		No	
		No	No	No		No	
		No	No	Yes		No	
		No	No	Yes		No	
		No	No	Yes		No	
		No	No	No		No	
		No	No	No		No	
		Yes	Yes	Yes		No	11

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



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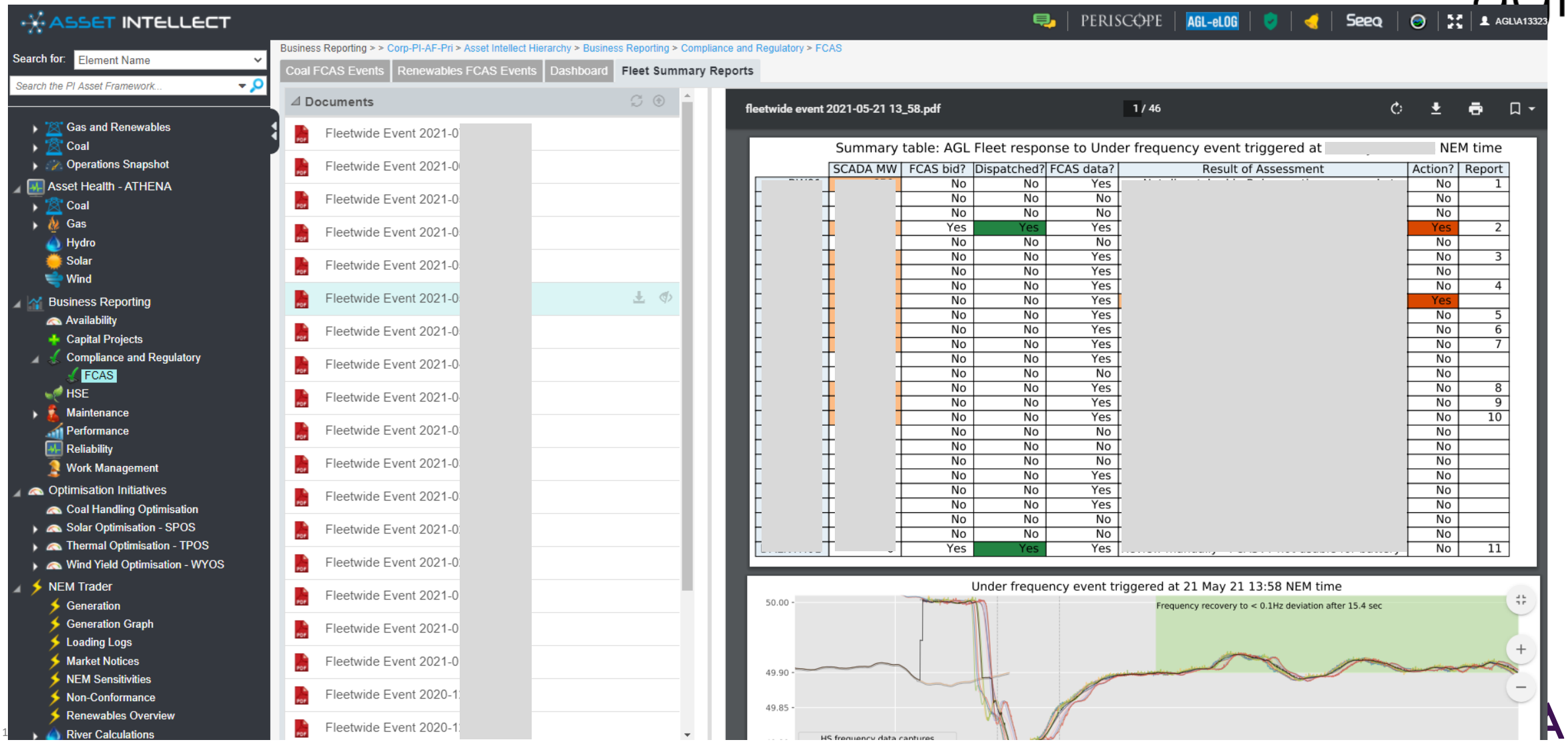

A final note… be prepared to welcome brutal feedback

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David Bowly

Senior Engineer, Operational Analytics team

- AGL Energy
- dbowly@agl.com.au

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

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