

AVEVA PI WORLD

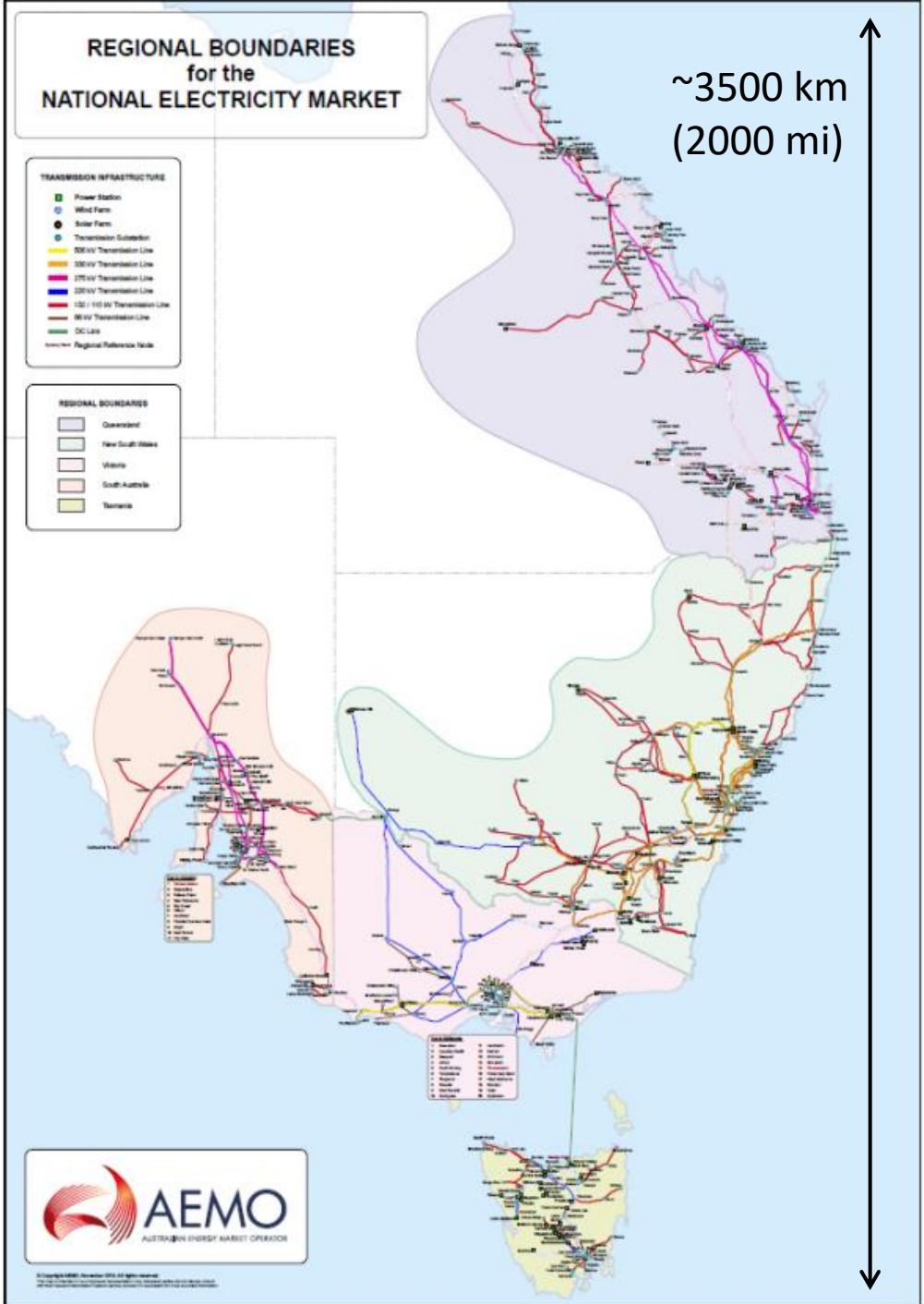
Building an event-based assessment system in Pi

AGL's frequency response verification tool

David Bowly

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AGL Asset Intelligence

AVEVA



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

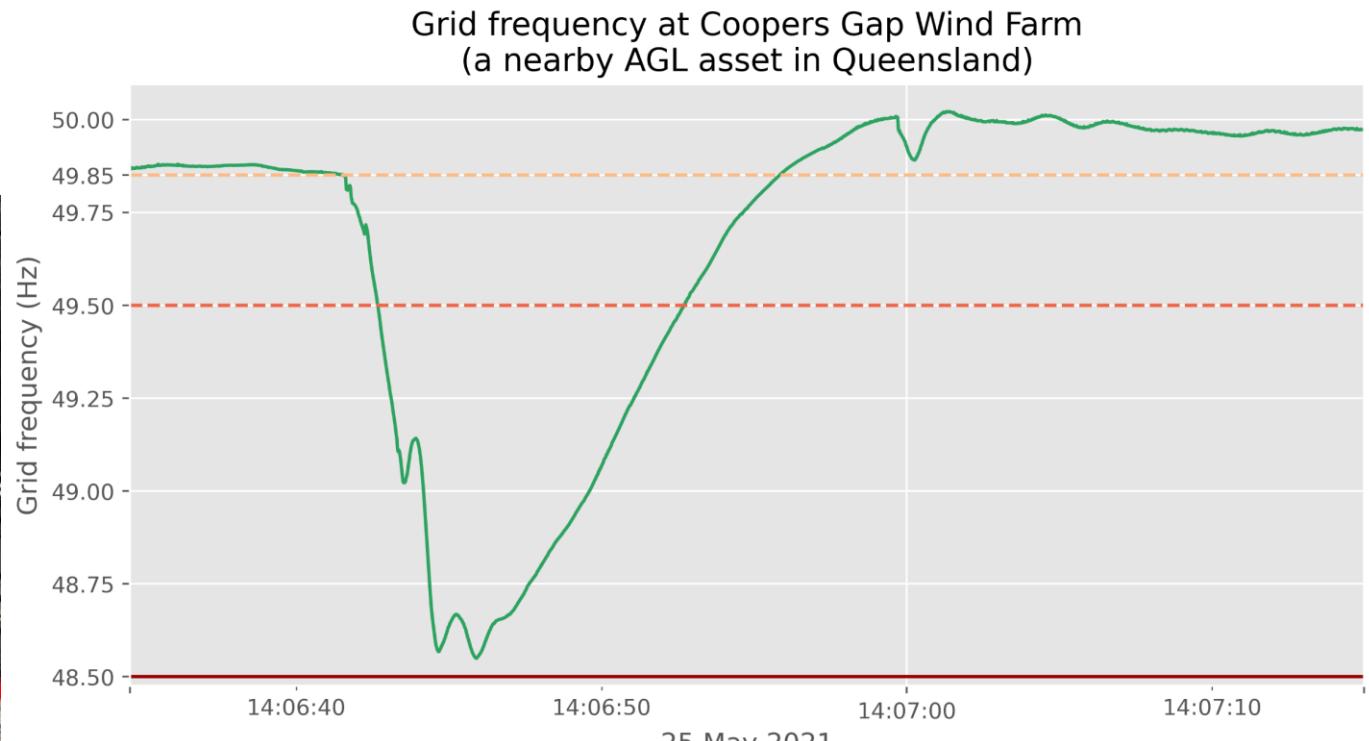
Callide C Power station, 25 May 2021
(Fortunately **not** an AGL Energy asset!)



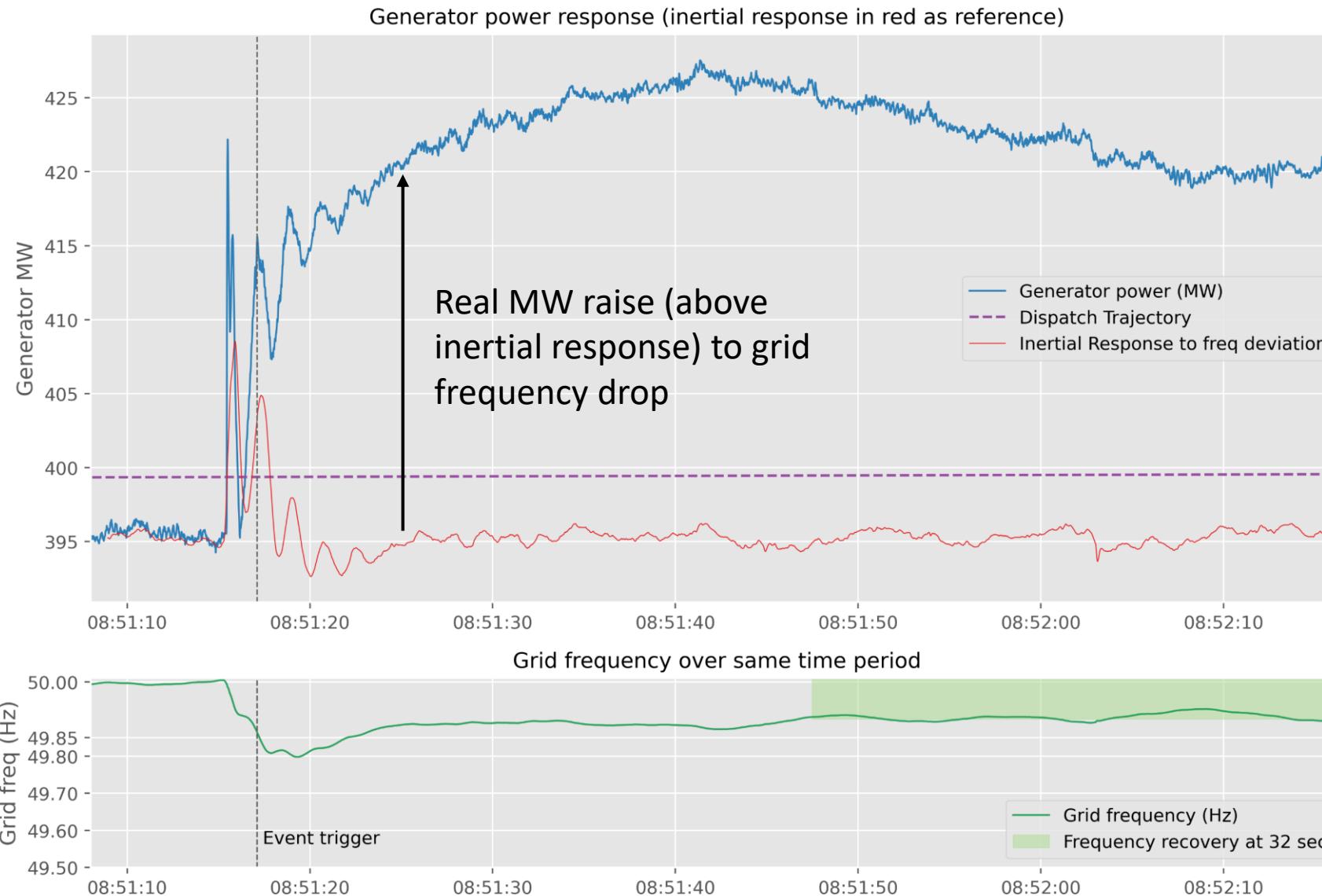
A quick introduction: Why we need Contingency Frequency control

Callide C Power station, 25 May 2021

(Fortunately **not** an AGL Energy asset!)



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

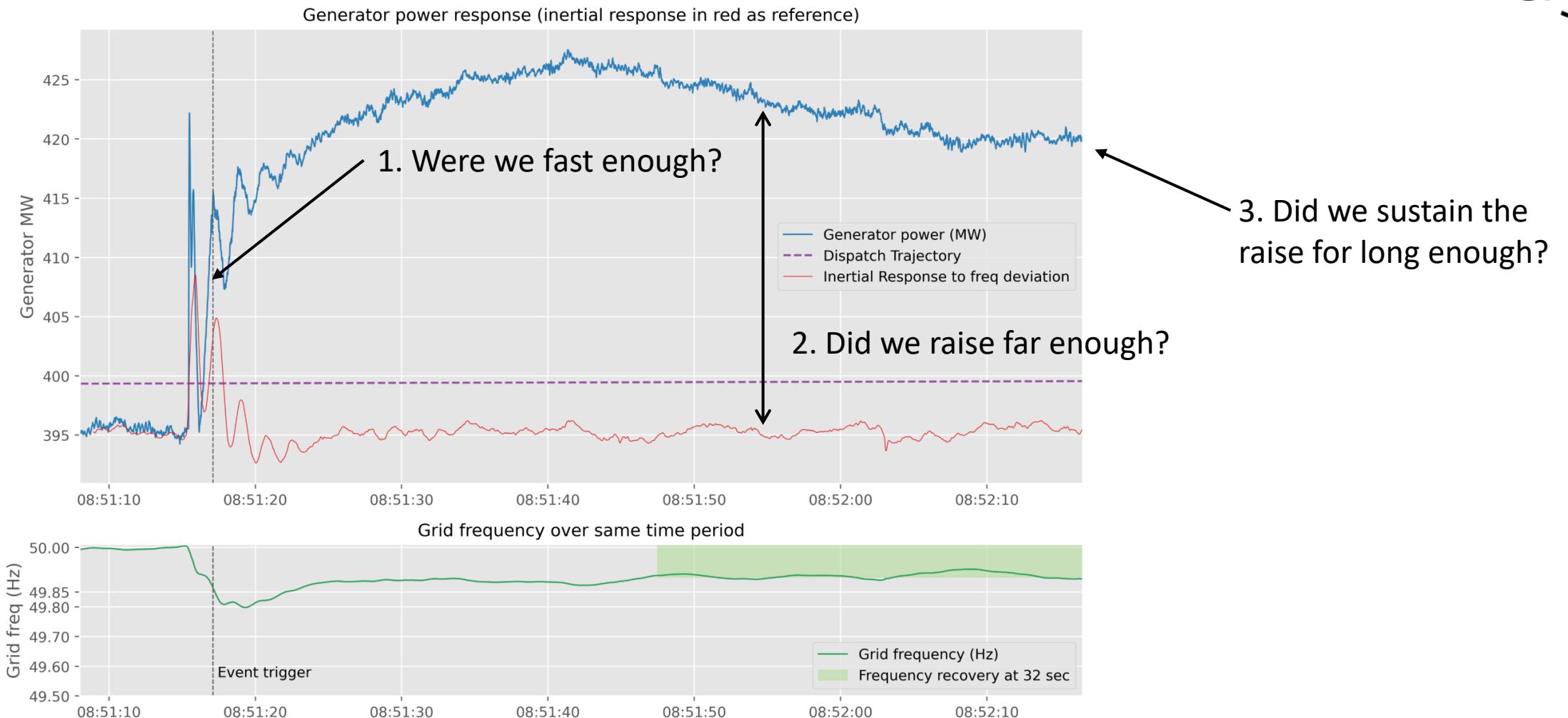
- Process high speed meter data
- Determine what we were contracted to achieve
- Calculate whether we achieved it
- Report and alert areas of concern

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





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 a Microsoft Excel spreadsheet titled "EXTERNAL FCAS Verification Tool v400 for MASS v6.xlsx". The spreadsheet is organized into two main sections: "INPUTS" (Rows 1-21) and "RESULTS" (Rows 22-33).
Inputs Section:

- Plant Information:** Includes fields for Plant Name (MyGenUnit), Plant inertia (0.022913179), Allocated Frequency Setting, Boost (1), Sample Rate of Frequency (0.02), Sample Rate of Frequency (4), Sample Rate of Frequency (4), Sample Rate of Frequency (4), Frequency Dead-band Lower Limit (50), and Generator or Load? (GENERATOR).
- Incident and Dispatch Information:** Includes fields for High speed data start time (15:10:14), Low speed data Start time (15:10:05), Contingency Event Offset (0.3), and service enablements (Fast Service Enabled, Slow Service Enabled, Delayed Service Enabled) with values 5, 10, and 10 respectively.
- Initial MW for dispatch interval:** Lists intervals from 15:10 to 15:25 with corresponding initial MW values: 575.5, 579.5, 645.3, and 651.1.
- Dispatch Targets for dispatch interval:** Lists intervals from 15:10 to 15:25 with dispatch targets: 580.0, 600.0, 620.3, and 630.0.
- Applicable MASS Parameters:** Lists parameters like Raise reference frequency (49.5) and Region (MAINLAND).

Results Section:

- Fast Raise (MW):** Shows values for FA (555.34), FB (39), FC (74.5), and FD (63.5). A note indicates these are inputs to be entered by the user.
- Fast Raise 4s tab (NOT a reliable estimate of Fast Raise):** Shows values for FA (estimate) (557.4), FB (estimate) (62.8), FC (estimate) (163.5), and FD (estimate) (164.5).
- Slow Raise (MW):** Shows values for SA (557.4), SB (152.2), SC (181.0), and SE (171.0). A note indicates these are participant supplied fast data used for calculation.
- Delayed Raise (MW):** Shows values for DA (557.4), DB (109.0), and DC (62.8).

The data challenge: Disparate sources, complex processing steps



High speed meters

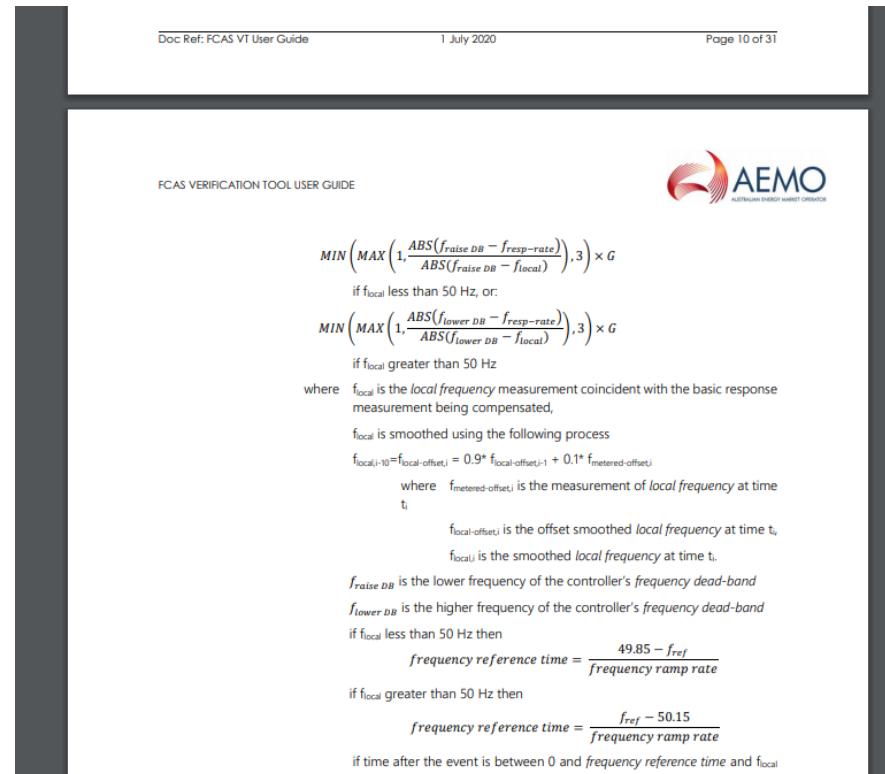
Collect data at 20ms and 4s scan rates
Only trigger on frequency excursions
Varying suppliers



Machine characteristics

Unique to each generator

31 page document describes the data processing steps required



A screenshot of a document page titled "FCAS VERIFICATION TOOL USER GUIDE". At the top, it says "Doc Ref: FCAS VT User Guide", "1 July 2020", and "Page 10 of 31". On the right, the AEMO logo is visible. The page contains mathematical formulas and text describing frequency response calculations. It includes formulas for calculating frequency reference time based on local frequency measurements and offset smoothed local frequencies, as well as conditions for different frequency ranges (less than 50 Hz, greater than 50 Hz).

MIN $\left(\text{MAX} \left(1, \frac{\text{ABS}(f_{raise DB} - f_{resp-rate})}{\text{ABS}(f_{raise DB} - f_{local})} \right), 3 \right) \times G$
if f_{local} less than 50 Hz, or:
MIN $\left(\text{MAX} \left(1, \frac{\text{ABS}(f_{lower DB} - f_{resp-rate})}{\text{ABS}(f_{lower DB} - f_{local})} \right), 3 \right) \times G$
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
 $f_{local(i)} = f_{local-offset(i)} = 0.9^* f_{local-offset(i-1)} + 0.1^* f_{metered-offset(i)}$
where $f_{metered-offset(t)}$ is the measurement of local frequency at time t ,
 $f_{local-offset(t)}$ is the offset smoothed local frequency at time t ,
 $f_{local(i)}$ is the smoothed local frequency at time 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
$$\text{frequency reference time} = \frac{49.85 - f_{ref}}{\text{frequency ramp rate}}$$

if f_{local} greater than 50 Hz then
$$\text{frequency reference time} = \frac{f_{ref} - 50.15}{\text{frequency ramp rate}}$$

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

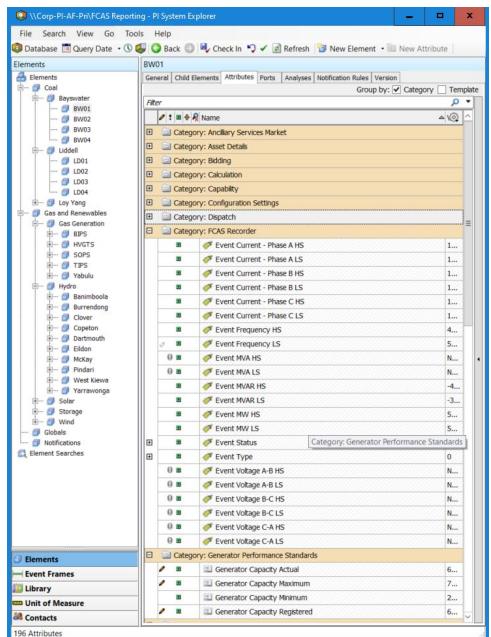
High speed meter triggers and records ~70 seconds of 20ms data



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

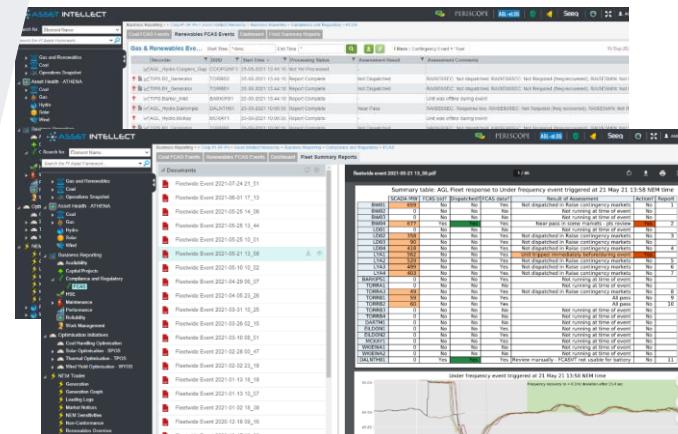
Fleet reports generated



Asset Intellect front end

Notification event frame generated - emails

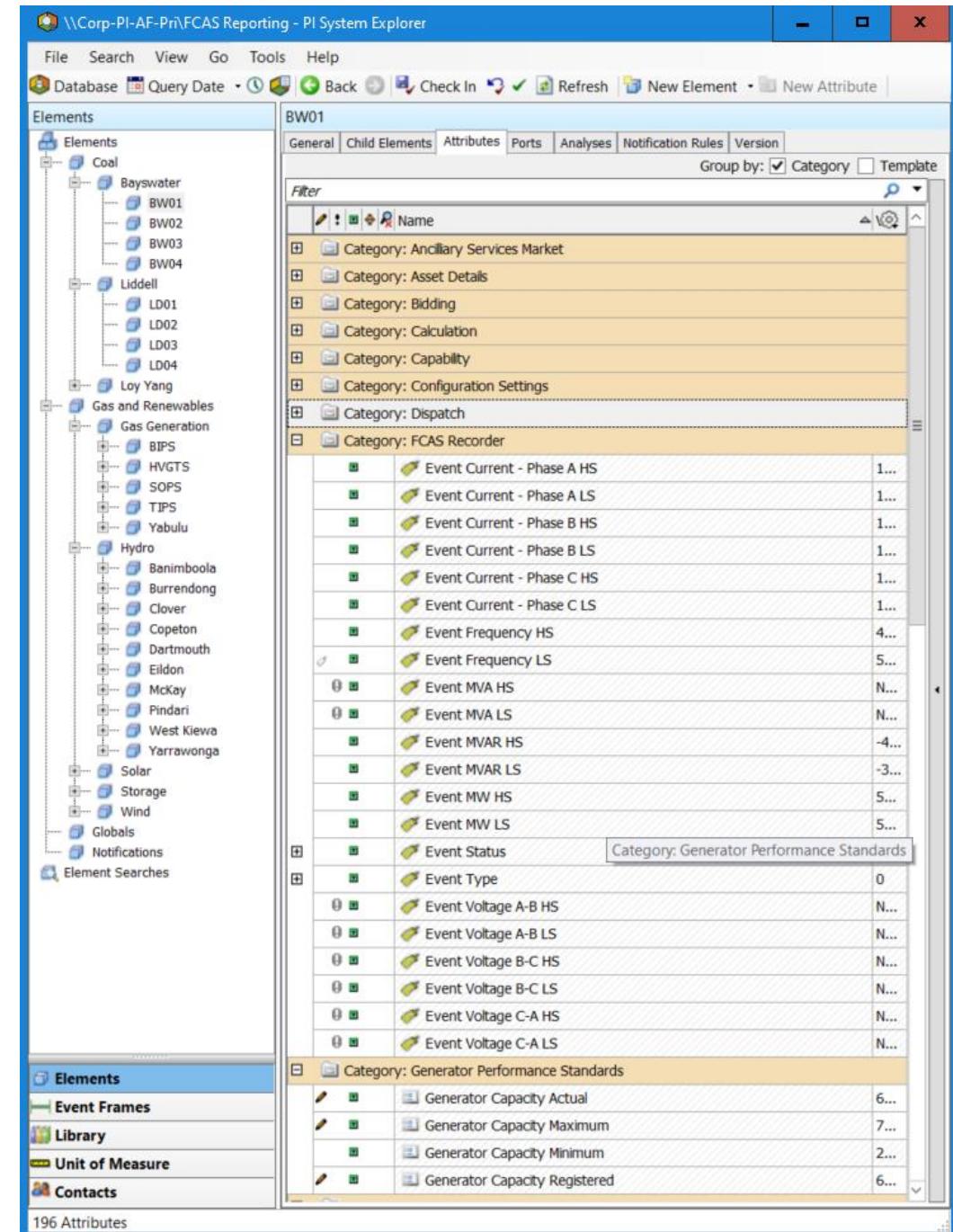
Asset Intellect “serves” results via event frames



A project-specific Asset Framework is highly recommended

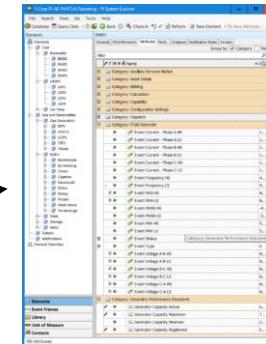
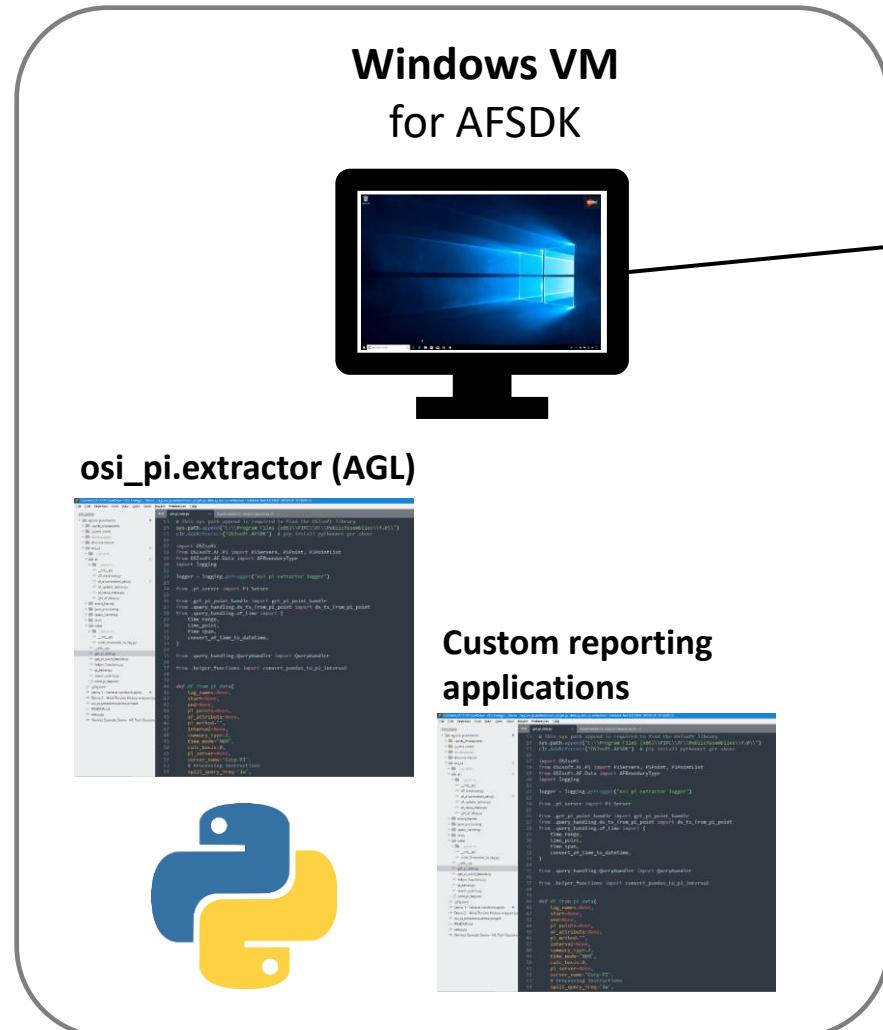
The Asset Framework acts as our visible “documentation” and configuration for the Python processing backend

All generators follow a standard structure regardless of underlying characteristics





Once Event Frame appears: Custom processing



Read/write to Pi using the AF for authentication

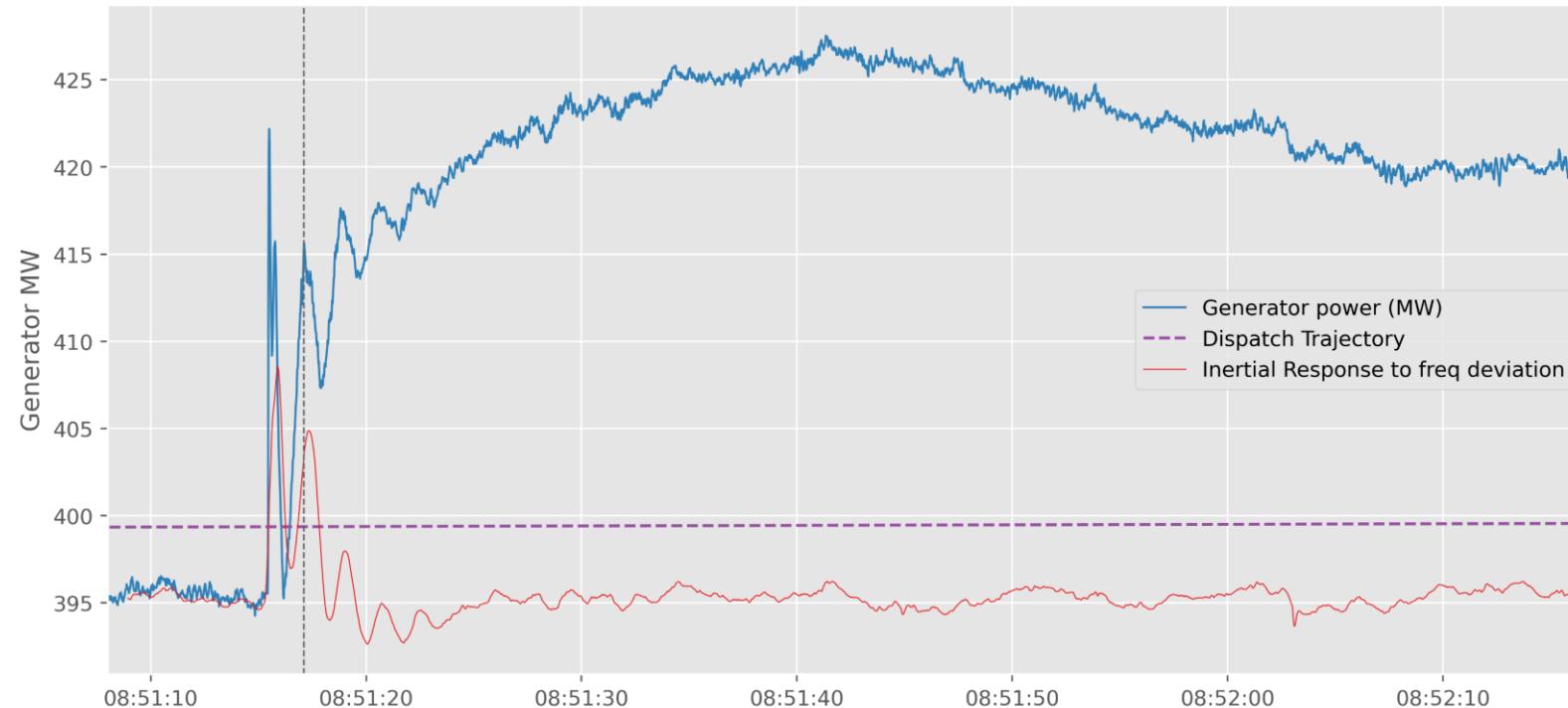
Similar process for most of our reporting applications

- 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

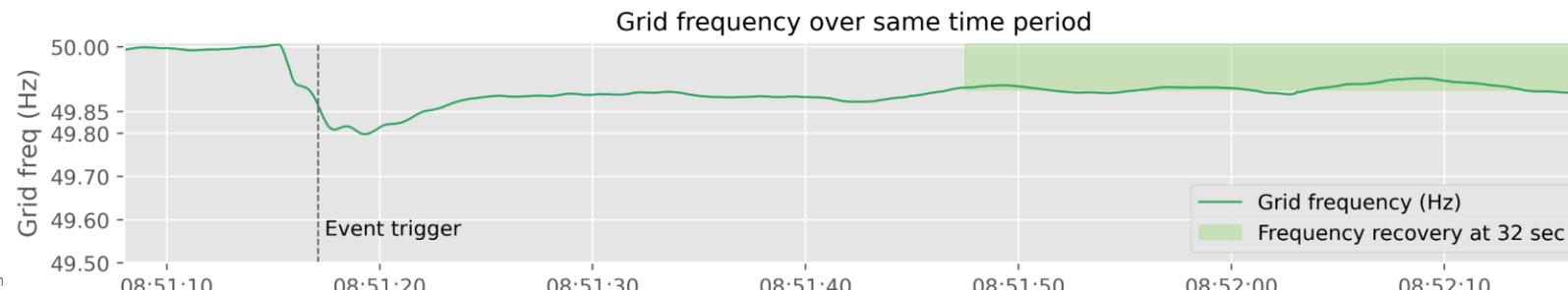
2021-03-10 08:55:00

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





Review the whole fleet in a “fleetwide” view

Summary table: AGL Fleet response to Under frequency event triggered at

NEM time

	SCADA MW	FCAS bid?	Dispatched?	FCAS data?	Result of Assessment	Action?	Report
		No	No	Yes		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	
		Yes	Yes	Yes		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 Events Start Time *-6mo End Time * Filters : Contingency Event = 'True' 16-Sep-2022

	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		

ONE WAS ONLINE DURING EVENT

1 - 93 of 93 items

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



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

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THANK YOU

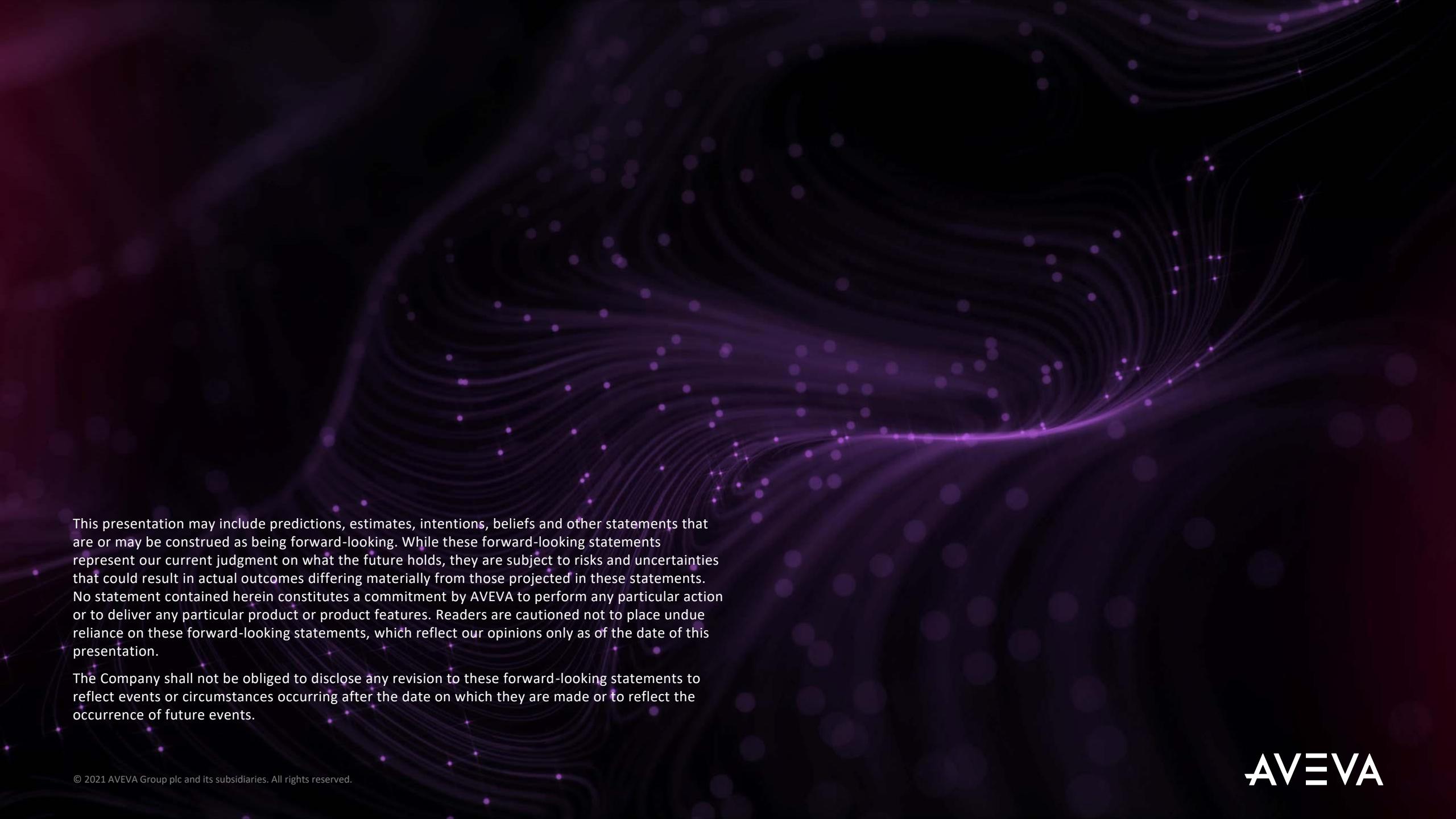
谢谢

DZIĘKUJĘ CI
NGIYABONGA
DANKIE
СПАСИБО GRAZIE
PAKMET СІЗГЕ
GO RAIBH MAITH AGAT
БЛАГОДАРЯ GRACIAS
ТИ БЛАГОДАРАМ
TAK DANKE
RAHMAT MERCI
HATUR NUHUN
CẨM ƠN BẠN
WAZVIITA

TAPADH LEIBH
БАЯРЛАА
TEŞEKKÜR EDERIM
TERIMA KASIH
GRACIES
DANKON
MATUR NUWUN
DANKJE
AČIU
GRAZZI
PAKKA PÉR
FALEMINDERIT
SIPAS JI WERE
UA TSAUG RAU KOJ
ТИ БЛАГОДАРАМ
СИПОС

KEA LEBOHA
MISAOTRA ANAO
WHAKAWHETAI KOE
DANKON TANK TAPADH LEAT
ХВАЛА ВАМ MULTUMESC
고맙습니다 GRAZIE شکری HVALA
EYXARIΣΤΩ GRATIAS TIBI
MAHALO IĀ 'OE TAKK SKAL DU HA
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The background of the slide features a dark purple gradient with a subtle, glowing effect of light trails and particles, creating a sense of motion and depth.

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