

AVEVA PI WORLD

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# PI System for Renewables

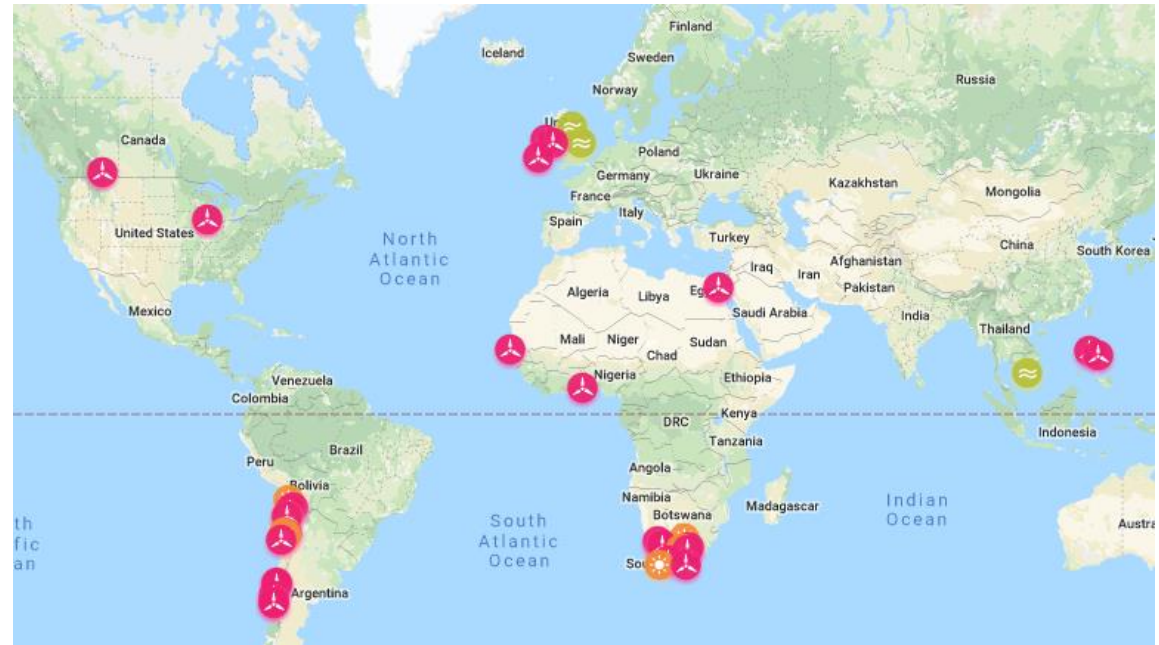
Business Intelligence, Remote Monitoring and OT Health

Presented By: Alan McCarthy

**AVEVA**

# About Mainstream Renewable Power

- 2008 – Company founded
- 2021 - Part of Aker Horizons
- Development pipeline
  - Onshore wind: 5,345 MW
  - Offshore wind: 1,700 MW
  - Solar : 5,931 MW
- In Pre-Construction & Construction
  - Onshore wind: 1264 MW
  - Solar: 350 MW
- Delivered into Operation
  - Onshore wind: 1,143 MW
  - Solar: 100 MW



# About Alan McCarthy

- BE Energy Engineering
- Managed PI System install in Q2 2012
- Previously Managed Wind Farms in Ireland and AB, Canada
- Currently Central Generation Operations and Business Analytics Manager



# Business Challenge

- Multiple Wind/Solar OEMs and Substation SCADAs
- External data sources (HTML, SQL)
- Offices & Sites in 6 continents
  - Reduce time spent
    - Reporting
    - Finding problems
    - Performing Analysis
- Usability and Scalability
- Integrate with
  - MS Office
  - Maintenance Management System (RGC)
  - Preconstruction Energy Analysis System (EAG)
  - Analytics Tools (MS Power BI)

Multiple Data Sources

Dispersed Sites & Staff

Integration, Long-term  
Architecture



# The solution – OSIsoft PI & Complimentary Systems

- OSIsoft PI System as central data historian
  - MS SQL database in parallel
- Integrates with all of data sources/protocols
- Integrates with external systems
  - Preconstruction Energy Analysis (EAG)
  - Maintenance Management System (RGC)
  - MS Power BI
- Excellent online resources and training
- “Off the shelf” software systems
- Asset Framework acts as Asset Register and “link point” for data & documents.
- Remote Monitoring through PI Vision and PI Notifications
- High Resolution data allows for Grid Code Compliance monitoring
- PI SNMP and PI Ping Interfaces used to monitor OT Health



# Today's Agenda

- Remote Assets – PI Interfaces – How we collect data
- OT Health and Cybersecurity
- PI Core – PI Asset Framework, PI Notifications
- Putting the data to work - PI Datalink, PI Vision, MS Power BI

# Interfaces – Traditional and PI MCN

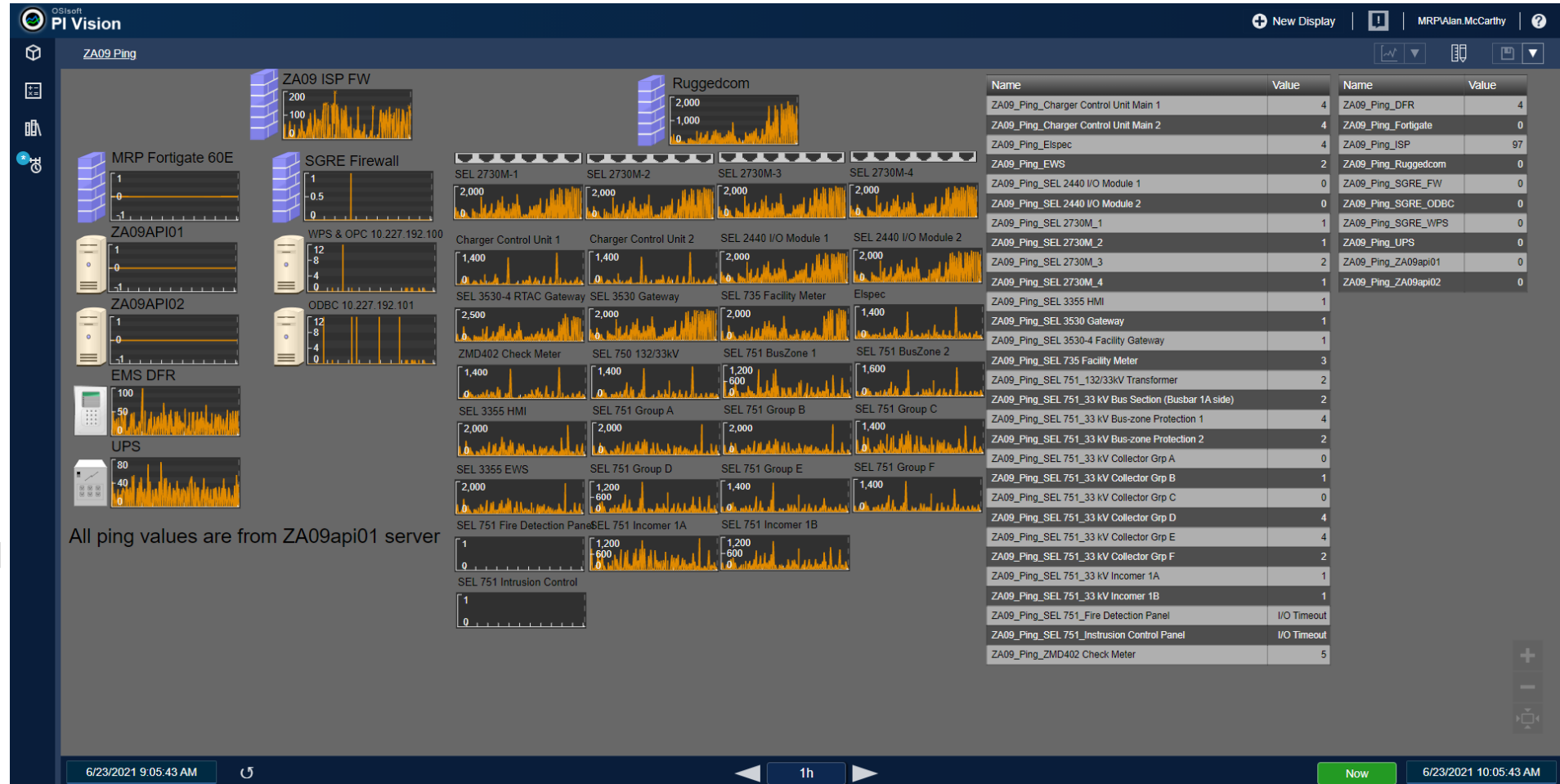
- PI OPC XML DA, PI DNP3 & PI Modbus have been used since inception
  - WTG SCADAs offer OPC DA or OPC XML DA interfaces
  - Substation and BOP SCADA offer Modbus or DNP3 interfaces
- OT Health monitoring is increasingly important on projects that are out of BOP Warranty period
- PI Ping has been rolled out on all projects, with PI Notifications set up to alert if any equipment drops off the network
  - Set up for PI Core and PI API Nodes
  - Set up for OT equipment





# Interfaces – Traditional and PI MCN

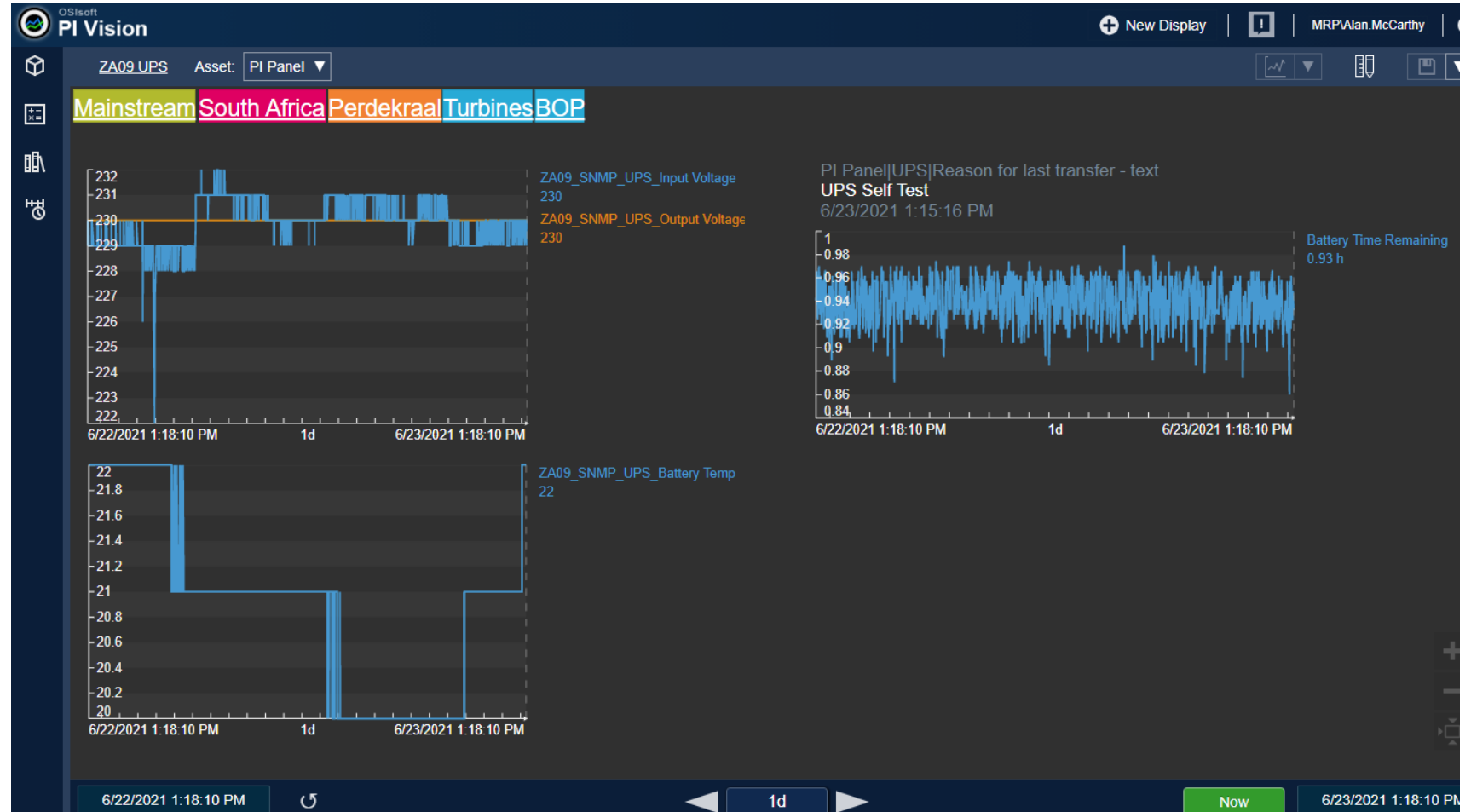
- PI Ping – OT
- Ping
  - Substation Firewall
  - Substation Switches
  - Relays
  - Gateways
  - Meters
  - Servers
  - UPS
- PI Notifications synced with Email to Voice services for critical faults





# Interfaces – Traditional and PI MCN

- PI SNMP – OT
- SNMP
  - UPS
  - Firewalls & Switches
  - Relays
  - Servers
  - Automation PCs (HMI's)
- SNMP rollout in early stages
- APC UPS monitoring
  - Input & Output Voltages
  - Reason for last transfer to Battery
  - PI Notification when on battery power
  - Battery Life Remaining
  - Battery Temp



# Interfaces – Traditional and PI MCN

- SEL 3355 HMI monitoring
  - CPU Load & Core Temp
  - Drive Health
- Switches and Firewall monitoring
  - Will shortly bring main health points into PI
- OT equipment failures are costly
  - Can cause collector circuits to be forced offline
  - Can leave the WF uncontrollable remotely, and at risk of temporary disconnection
- PI SNMP offers a huge increase in our OT health monitoring capabilities



509)332-1890		<b>System Statistics</b>		<b>Diagnostics</b>	
		Active Session(s): 1		Power Supply A:	
		System Uptime: 311d 5h 22m 31s		Model: SEL-9330-A	
		Power Cycles: 129		S/N:	
		Total Runtime: 8601 Hours		Voltage: 12.386	
				Power Supply B:	
				Model: SEL-9330-A	
				S/N:	
				Voltage: 12.253	
				RAM:	
				OK	
				FLASH:	
				OK	
				FPGA:	
				OK	
				Clock:	
				OK	
				Clock Battery:	
				OK	
				Ports 1-8 Temperature:	
				55°C	
				Ports 9-24 Temperature:	
				56°C	

# Interfaces – Traditional and PI MCN

- PI SNMP – Next Steps

- Most Substation OT hardware on our projects have SNMP interfaces
  - This has typically been under utilized – many valuable early warnings on critical plant equipment are not being monitored
    - Would be extremely interested in other users' experiences with this interface
  - Stop waiting for OT equipment to fail when any substation issue can be a major revenue loss
  - By Q4, we are aiming to have all OT equipment's critical SNMP points in PI
- 
- In parallel, we are looking at better backup of config of OT equipment settings
    - A large percentage of our plants OT is SEL equipment – investigating SEL 5045 software package to auto backup configs
    - A library on MS Sharepoint is set up for SCADA Configs for other backups

# Cybersecurity and Infrastructure

- PI Core currently on “on-premises” servers
- Planning to migrate these to Azure AD joined servers
  - PI Vision will be on separate VLAN to PI Data Archive & PI Asset Framework, in line with OSIsoft recommendation
- VPN links between Wind Farms and PI Core is locked to only the required ports and IP addresses
  - FW Policies minimized – specific rules for all traffic, “deny first” approach
- Regular plant based staff increasingly using PI Vision & MS Power BI – minimizing need for VPN access to PI Core
- Windfarm based PI Infrastructure (PI API Nodes) on a separate VLAN to OT equipment – connections limited to necessary only
- Carry out external pen-tests to each Wind Farm
- Investigating rollout of Darktrace AI based cybersecurity on PI API Node VLAN and Substation Automation OT VLAN

# PI Asset Framework – The central link

- “Single Version of the Truth” for asset register
- All Assets are accounted for here
- Avoids a Data Swamp of PI tags
- Unique Identifier codes (PI AF Element ID)
- Replicated in Maintenance Management System (RGC) and Energy Analysis (EAG)
- Enables Process Data and Maintenance Data to be viewed within context

The screenshot displays the PI Asset Framework interface. On the left, a hierarchical tree under 'Elements' shows the asset structure, including locations like Kangnas, Khobab, Loeriesfontein 2, Noupoot, and Perdekraal East, leading down to a specific '132kV Trfr 1 Breaker'. On the right, a detailed view of this breaker is shown with tabs for General, Child Elements, Attributes, Ports, Analyses, Notification Rules, and Version. The 'Attributes' tab is active, displaying a table of key-value pairs for the asset.

Name	Value
Model Number	0
Name	0
Phase Voltage - Average	135.33 kV
Phase Voltage - Imbalance	0.728 kV
Phase Voltage - Imbalance %	0.53794 %
Phase Voltage - Max	135.59 kV
Phase Voltage - Min	134.86 kV
Phase Voltage - Rated	132 kV
Phase Voltage - Setpoint	135.58 kV
Phase Voltage AB	135.59 kV
Phase Voltage BC	134.86 kV
Phase Voltage CA	135.54 kV
PI Vision - Asset	
Power (kW)	-29.946 kW
Power Factor	-0.9990169
RDSPP - Location	0
RDSPP - Code	0
RDSPP - Function	=ZA09ONS1MDY01QA1
RDSPP - Location	0
RDSPP - Product	0
Reactive Power	2.099 MVar
Reactive Power - Nominal	35.561 MVar
RGC - Asset ID	No Data
RGC - Category	Substation
RGC - Code	aec1f392-f9a5-11ea-99c2-6c2b597c3baa

RGC Technologies

Find by: Description

132kv

in: Active Items

Site Location

Code	Description	Is Active	Serial No
e9f8ba32-8b35-11e8-bdf9-5ce0c55e45a1	132kV Surge Arrestor L2	<input checked="" type="checkbox"/>	
e9f8ba35-8b35-11e8-bdf9-5ce0c55e45a1	132kV Surge Arrestor L3	<input checked="" type="checkbox"/>	
f25bc09e-270c-11e6-b951-a0b3cce6a470	132kV Trfr 1 Breaker	<input checked="" type="checkbox"/>	35140507
0ae85606-3d47-11e6-9042-f01faf3c7e0a	132kV Voltage Transformer L1	<input checked="" type="checkbox"/>	D7-2536/4
12bb9364-3d47-11e6-9042-f01faf3c7e0a	132kV Voltage Transformer L2	<input checked="" type="checkbox"/>	D7-2536/5
12bb9367-3d47-11e6-9042-f01faf3c7e0a	132kV Voltage Transformer L3	<input checked="" type="checkbox"/>	D7-2536/6
12			
- Location: ZA15 Spare Assets			
aedec24-8b59-11e8-bdf9-5ce0c55e45a1	132kV Current Transformer Spare 1	<input checked="" type="checkbox"/>	ZA-15-E-BOP
92f39f3e-8b59-11e8-bdf9-5ce0c55e45a1	132kV Surge Arrestor Spare 1	<input checked="" type="checkbox"/>	ZA-15-E-BOP
92f39f41-8b59-11e8-bdf9-5ce0c55e45a1	132kV Surge Arrestor Spare 2	<input checked="" type="checkbox"/>	ZA-15-E-BOP
aedec27-8b59-11e8-bdf9-5ce0c55e45a1	132kV Voltage Transformer Spare 1	<input checked="" type="checkbox"/>	ZA-15-E-BOP
4			
16			
- Site: Perdekraal East			
- Location: ZA09 BOP			
faf0c35a-0251-11eb-99c2-6c2b597c3baa	132kV Current Transformer L1	<input checked="" type="checkbox"/>	E7-1255/1
faf0c35d-0251-11eb-99c2-6c2b597c3baa	132kV Current Transformer L2	<input checked="" type="checkbox"/>	E7-1255/2
faf0c360-0251-11eb-99c2-6c2b597c3baa	132kV Current Transformer L3	<input checked="" type="checkbox"/>	E7-1255/3
fe2b6bdc-0253-11eb-99c2-6c2b597c3baa	132kV Earth Switch Mech Box	<input checked="" type="checkbox"/>	012412/0001/1
fe2b6bdf-0253-11eb-99c2-6c2b597c3baa	132kV Motorised Isolator	<input checked="" type="checkbox"/>	012412/0001/1
08be9118-0254-11eb-99c2-6c2b597c3baa	132kV Motorised Isolator Mech Box	<input checked="" type="checkbox"/>	
0fc61b0e-0254-11eb-99c2-6c2b597c3baa	132kV Protection Panel	<input checked="" type="checkbox"/>	
17312bab-0254-11eb-99c2-6c2b597c3baa	132kV Surge Arrestor L1	<input checked="" type="checkbox"/>	21853604579
17312bae-0254-11eb-99c2-6c2b597c3baa	132kV Surge Arrestor L2	<input checked="" type="checkbox"/>	21853604580
17312bb1-0254-11eb-99c2-6c2b597c3baa	132kV Surge Arrestor L3	<input checked="" type="checkbox"/>	21853604578
aec1f392-f9a5-11ea-99c2-6c2b597c3baa	132kV Trfr 1 Breaker	<input checked="" type="checkbox"/>	2019/23901
1f435488-0254-11eb-99c2-6c2b597c3baa	132kV Voltage Transformer L1	<input checked="" type="checkbox"/>	D7-2901/1
1f43548b-0254-11eb-99c2-6c2b597c3baa	132kV Voltage Transformer L2	<input checked="" type="checkbox"/>	D7-2901/2

## 132kV Trfr 1 Breaker

General Details Finance Notes Attributes Parts List **Jobs** Location History Parts Used

Site	Status	Op. Status	Assigned To	Template	Estimated Start	Logged	Reference	Sort Key
Perdekraal East	-All	-All	-All	-All	-All	-All		
Drag a column header here to group by that column.								
<input type="checkbox"/> Site	Num...	Description	Status	Assigned To	Priority	Estimated Start	Template	Date Logged
<input checked="" type="checkbox"/>								
<input type="checkbox"/>	Perdekraal East	8595	Perdekraal - 132kV Circuit Break...	Closed - C...	Michael Mutele	Low	12/11/2020 09:00	ZA09 - 132kV Cir...
<input type="checkbox"/>	Perdekraal East	8596	Perdekraal - 132kV Circuit Break...	Closed - C...	Christie Koordom	Low	12/12/2020 09:00	ZA09 - 132kV Cir...
<input type="checkbox"/>	Perdekraal East	8597	Perdekraal - 132kV Circuit Break...	Completed	Michael Mutele	Low	12/01/2021 09:00	ZA09 - 132kV Cir...
<input type="checkbox"/>	Perdekraal East	12385	Perdekraal - 132kV Circuit Break...	Completed	Christie Koordom	Low	12/02/2021 09:00	ZA09 - 132kV Cir...
<input type="checkbox"/>	Perdekraal East	12386	Perdekraal - 132kV Circuit Break...	Completed	Christie Koordom	Low	12/03/2021 09:00	ZA09 - 132kV Cir...
<input type="checkbox"/>	Perdekraal East	12387	Perdekraal - 132kV Circuit Break...	Completed	Michael Mutele	Low	12/04/2021 09:00	ZA09 - 132kV Cir...
<input type="checkbox"/>	Perdekraal East	18153	Perdekraal - 132kV Circuit Break...	Completed	Michael Mutele	Low	12/05/2021 09:00	ZA09 - 132kV Cir...
<input type="checkbox"/>	Perdekraal East	18154	Perdekraal - 132kV Circuit Break...	Completed	Christie Koordom	Low	12/06/2021 09:00	ZA09 - 132kV Cir...
<input type="checkbox"/>	Perdekraal East	18155	Perdekraal - 132kV Circuit Break...	Logged		Low	12/07/2021 09:00	ZA09 - 132kV Cir...
<input type="checkbox"/>	Perdekraal East	18156	Perdekraal - 132kV Circuit Break...	Logged		Low	12/08/2021 09:00	ZA09 - 132kV Cir...
<input type="checkbox"/>	Perdekraal East	18157	Perdekraal - 132kV Circuit Break...	Logged		Low	12/09/2021 09:00	ZA09 - 132kV Cir...
<input type="checkbox"/>	Perdekraal East	18158	Perdekraal - 132kV Circuit Break...	Logged		Low	12/10/2021 09:00	ZA09 - 132kV Cir...
<input type="checkbox"/>	Perdekraal East	18159	Perdekraal - 132kV Circuit Break...	Logged		Low	12/11/2021 09:00	ZA09 - 132kV Cir...
<input type="checkbox"/>	Perdekraal East	18160	Perdekraal - 132kV Circuit Break...	Logged		Low	12/12/2021 09:00	ZA09 - 132kV Cir...

14

Bulk Edit

Elements

Event Frames

Library

Unit of Measure

Contacts

Management

RSCP - PRODUCT	
Reactive Power	2.099 MVar
Reactive Power - Nominal	35.561 MVar
RGC - Asset ID	No Data
RGC - Category	Substation
RGC - Code	aec1f392-f9a5-11ea-99c2-6c2b597c3baa



# PI AF Analytics – B.I. – PI Notifications

- PI AF Analytics used for both PI Notifications, ongoing calculations and PI Event Frames
- PI Notifications triggered by certain PI Event Frames
- Emails for non-critical alarms
- Emails for WTG faults/entry to service mode
- Email to voice & SMS service used for critical faults, substation and collector circuit trips

The screenshot displays the PI System Explorer application. On the left, a tree view shows the hierarchy of elements, including 'Turbines' and 'Turbine 01'. The main window is titled 'Turbine 01' and contains several tabs: 'General', 'Child Elements', 'Attributes', 'Ports', 'Analyses', 'Notification Rules', and 'Version'. The 'Notification Rules' tab is active, showing a table of rules for 'Turbine 01'. The table has columns for 'Name', 'Backfilling', and 'Status'. The rules listed are: 'Turbine Fault', 'Turbine Service', 'Wind Speed - 10 minute Average', 'Wind Speed - 10 minute Rolling A...', 'Wind speed under 10.5 m/s', and 'Wind speed under 16 m/s'. All rules have a green checkmark in the 'Status' column. To the right of the table, there are fields for 'Name' (Wind speed under 10.5 m/s), 'Description', 'Categories', and 'Analysis Type' (Expression selected). Below the table, there is a section for 'Add a new variable' with a table showing a variable named 'Variable1' with the expression 'timelt('Wind Speed', '\*-10m', '\*', 10.5)' and the output attribute 'Time lower than 10.5 m/s Output'. An 'Evaluate' button is visible in the top right corner of this section.

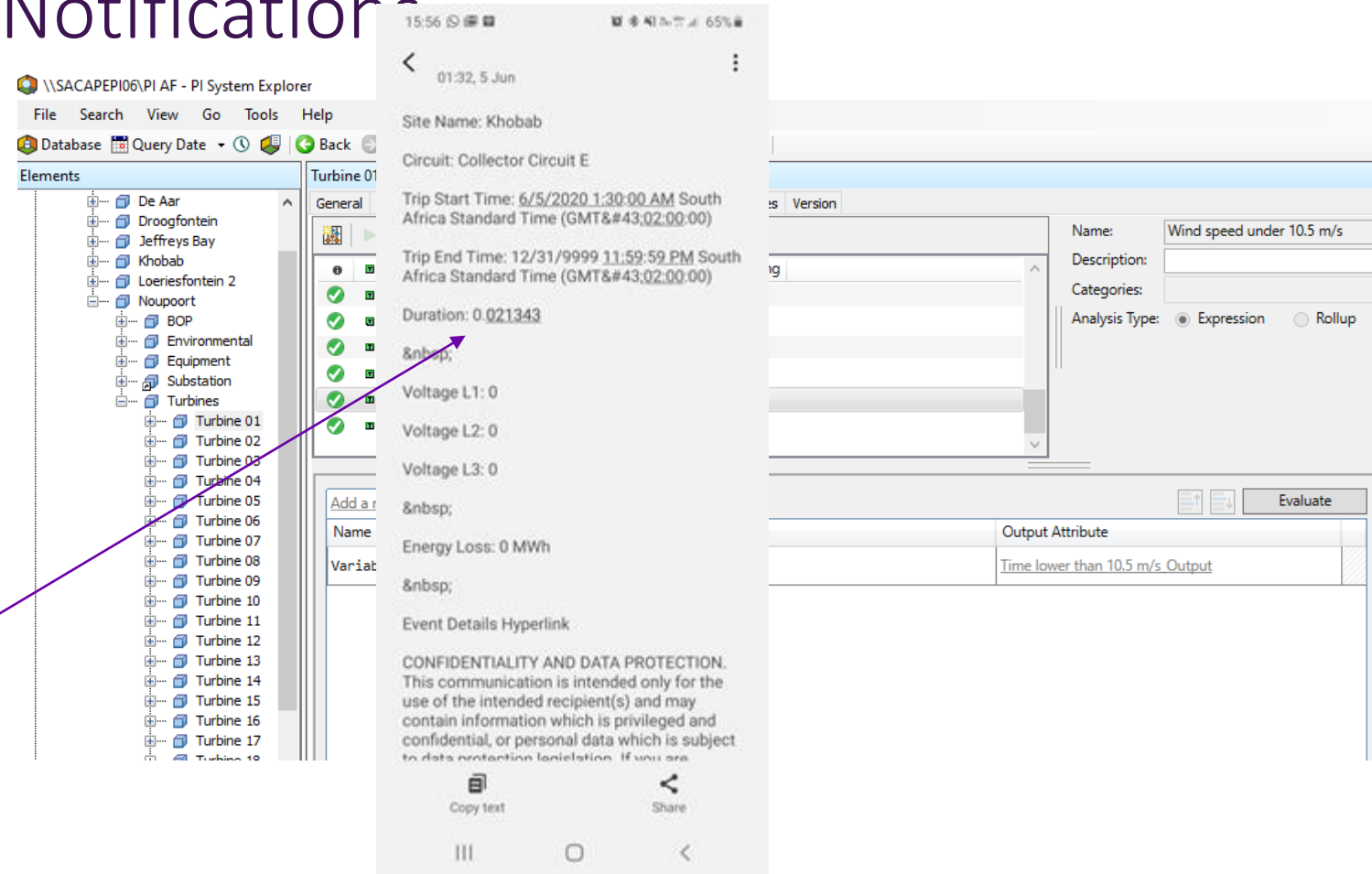
Name	Backfilling	Status
Turbine Fault		✓
Turbine Service		✓
Wind Speed - 10 minute Average		✓
Wind Speed - 10 minute Rolling A...		✓
Wind speed under 10.5 m/s		✓
Wind speed under 16 m/s		✓

Name	Expression	Output Attribute
Variable1	timelt('Wind Speed', '*-10m', '*', 10.5)	Time lower than 10.5 m/s Output



# PI AF Analytics – B.I. – PI Notification

- PI AF Analytics used for both PI Notifications, ongoing calculations and PI Event Frames
- PI Notifications triggered by certain PI Event Frames
- Emails for non-critical alarms
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- Email to voice & SMS service used for critical faults, substation and collector circuit trips



The image displays two overlapping screenshots from the PI System Explorer and PI Notification software. The background screenshot shows the 'PI System Explorer' window with a tree view of elements including 'De Aar', 'Droogfontein', 'Jeffreys Bay', 'Khabab', 'Loeriesfontein 2', 'Noupoort', 'BOP', 'Environmental', 'Equipment', 'Substation', and 'Turbines'. The 'Turbines' folder is expanded, showing a list of turbines from 'Turbine 01' to 'Turbine 18'. The foreground screenshot shows the 'PI Notification' interface for 'Turbine 01'. It displays a 'General' tab with the following information: Site Name: Khabab, Circuit: Collector Circuit E, Trip Start Time: 6/5/2020 1:30:00 AM South Africa Standard Time (GMT+43:02:00:00), Trip End Time: 12/31/9999 11:59:59 PM South Africa Standard Time (GMT+43:02:00:00), Duration: 0.021343, Voltage L1: 0, Voltage L2: 0, Voltage L3: 0, Energy Loss: 0 MWh, and a link to 'Event Details Hyperlink'. A purple arrow points from the 'Turbine 01' entry in the background screenshot to the 'Turbine 01' entry in the foreground screenshot. The foreground screenshot also shows a 'Name' field, a 'Variat' field, and a 'Copy text' button. The bottom of the foreground screenshot shows a mobile interface with a 'Copy text' button and a 'Share' button.

# PI Notifications – B.I. – Work Order Integration

- Interlink PI Notifications/PI Event Frames with Work Orders
- Inbox Monitor in RGC
- Autogenerates Work Order using common Element ID from PI AF

The screenshot displays the 'Job 581, 80 - Vibration Sensor - PI Notifications' page in the Mainstream Renewable Power system. The page includes a header with the company logo, user information (Hello, Alan.McCarthy! | Log off), and navigation links (Assets, Create Work Order, All Work Orders, My W.O., My Timesheets). The job title is 'Job 581, 80 - Vibration Sensor - PI Notifications' with a status of 'Logged'. Below the title are tabs for 'General', 'Job Steps', 'Parts Estimate', 'Parts Used', and 'Documents'. The 'General' tab is active, showing fields for Asset (Nacelle General), Site (Carrickeeny), Location (IE08 WTG001), Assigned to, Est. Start (04/03/2015 15:39:18), Est. End (06/03/2015 15:39:18), Logged (04/03/2015 14:53:59), Priority (Medium), Actual Start, Actual End, and Reference (InboxMonitor). The 'Op. Status' is set to 'Awaiting permission'. A 'Notes' section contains three entries: 'Status Name: Vibration Sensor', 'PI Webparts Ad Hoc' with a URL, and 'PI Webparts Site Page' with a URL. The 'PI Coresight Site Page' URL is also listed.

Job 581, 80 - Vibration Sensor - PI Notifications		Status: Logged	
<b>General</b>   Job Steps   Parts Estimate   Parts Used   Documents			
<b>Asset</b>	Nacelle General	<b>Est. Start</b>	04/03/2015 15:39:18
<b>Site</b>	Carrickeeny	<b>Est. End</b>	06/03/2015 15:39:18
<b>Location</b>	IE08 WTG001	<b>Logged</b>	04/03/2015 14:53:59
<b>Assigned to</b>		<b>Priority</b>	Medium
<b>Op. Status</b>	Awaiting permission ▼		
<b>Notes</b>	<p>Status Name: Vibration Sensor</p> <p>PI Webparts Ad Hoc: <a href="http://pace.mainstreamrp.com/RtWebPartResources/adhochtrendUrl.aspx?StartTime=1440078752.30791&amp;EndTime=0&amp;TriggerTime=1440078752.30791&amp;NotificationID=cbb3a817-ed3c-4537-a3b3-31a6d0470628&amp;InstanceID=0&amp;TriggerValue=Test+State&amp;Priority=Test+Priority&amp;Data=%5c%5cieddcppi01%5cIE08WTUR001WSLGTurStLog1%5c%5cieddcppi01%5cIE08WTUR001MainStatus">http://pace.mainstreamrp.com/RtWebPartResources/adhochtrendUrl.aspx?StartTime=1440078752.30791&amp;EndTime=0&amp;TriggerTime=1440078752.30791&amp;NotificationID=cbb3a817-ed3c-4537-a3b3-31a6d0470628&amp;InstanceID=0&amp;TriggerValue=Test+State&amp;Priority=Test+Priority&amp;Data=%5c%5cieddcppi01%5cIE08WTUR001WSLGTurStLog1%5c%5cieddcppi01%5cIE08WTUR001MainStatus</a></p> <p>PI Webparts Site Page: <a href="http://pace.mainstreamrp.com/project/IE08/docs/14%20Operations%20and%20Maintenance/14-07%20Asset%20Information/Webparts/Turbine.svg">http://pace.mainstreamrp.com/project/IE08/docs/14%20Operations%20and%20Maintenance/14-07%20Asset%20Information/Webparts/Turbine.svg</a></p> <p>PI Coresight Site Page: <a href="https://pi.mainstreamrp.com/Coresight/#/Displays/7/Carrickeeny-Mobile">https://pi.mainstreamrp.com/Coresight/#/Displays/7/Carrickeeny-Mobile</a></p>		

# PI Notifications – B.I. – Work Order Integration

- The unique IDs from PI AF are used in RGC so that all Inspections and Maintenance are tagged against specific equipment
  - QR codes are printed for each asset on site
- Allows easily searchable maintenance records
- Overlay WTG fault data from PI with Work Orders in MS Power BI
- Specific triggered faults can have specific checksheets to be carried out on mobile app
- Eg Circuit Breaker Trips require an Electrical Switching Work Order



80a4d3c6-fb19-11e5-b577-a0b3cce6a16e  
Turbine 31  
2309206



06bf7aa2-47ad-11e6-93b8-f01faf3c7e0a  
WTG 008 2.7 MVA  
Pad Mounted  
Transformer  
303397-26

15:58 73%

← Checklist

Step Name

Checklist

chipped or broken rain sheds.?  
A maximum of 20 % of chipped or broken sheds is permitted on

Ok ✓

Are the contacts on all three-phases properly closed and in alignment with each other?

Not Ok ✓

Is the flexible earth strap to the operating handle (if fitted) connected and the conductor strands not frayed?

Ok ✓

Is the labelling as close as possible to the operating point, but not on the moveable section of the isolator, obscuring when

Ok ✓

Are the isolator lock in position?

Ok ✓

Any additional comments ✓

Test

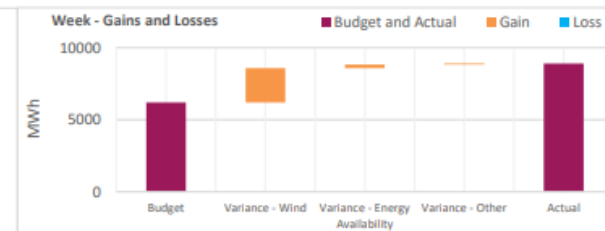
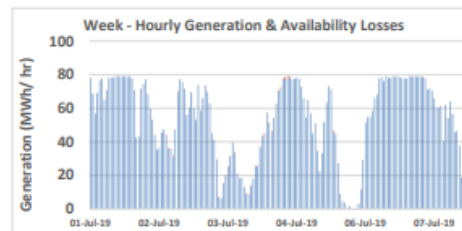
✓ Action: ☐

# PI Datalink

- Weekly, Monthly, Quarterly, Annual reports generated automatically in excel and exported to pdf
- Additional data required (costs, budget) stored in PI Asset Framework tables
- Maintenance Data from Site embedded in reports

## 1. Executive Summary

	Week Actual	Week Target	Variance	% of Target	Month Actual	Month Target	Variance	% of Target
<b>Energy Production</b>								
MWh sold (Espec)	8,905	6,201	43.6%	143.6%	9,043	6,201	45.8%	145.8%
Revenue Electricity (ZAR)	10,094,000	7,029,376	43.6%	143.6%	10,250,847	7,029,376	45.8%	145.8%
MWh Budget P50		6,201				27,462		
MWh Budget P90		5,245				23,228		
<b>Availability and Capacity Factor</b>								
Technical Availability	99.3%	97.0%	2.4%		99.3%	97.0%	2.4%	
Capacity Factor	67.1%	46.7%	43.6%		68.1%	46.7%	45.8%	
<b>Maintenance Schedule</b>								
Turbine Scheduled Maintenance				100.0%				100.0%
BoP Scheduled Maintenance				100.0%				100.0%
<b>Financials</b>								
Total Revenue (ZAR)	10,094,000	7,029,376	43.6%	143.6%	10,250,847	7,029,376	45.8%	145.8%
Price per MWh	1,134	1,134	0.0%	100.0%	1,134	1,134	0.0%	100.0%
<b>Site Performance</b>								
Turbine Contractual Availability	99.3%	98.0%	1.3%		99.3%	98.0%	1.3%	
Curtailment (MWh)	-	-	0		-	-	0	
Wind Speed (m/s)	9.5				9.5			



# MS Power BI – Weekly Reports

- New Weekly Reports take PI data into MS Power BI
- PI ODBC interfaces are used in conjunction with MS Power BI Gateway and MS Power BI Dataflows
- SQL Data imported into the Weekly Report data models
- CMMS and Health and Safety data imported into the Weekly Report data
- Next Steps:
  - Use Event Frames to more accurately calculate Energy/Yield Availability for the Weekly Reports

Power BI Asset Operations

ZA18 - Weekly Report | Data updated 6/22/21

Pages

- ZA18 KPI table
- ZA18 KPI Graphs
- ZA18 KPI Graphs - PI B...
- Page 1
- Page 2
- Individual WTGs

	Week Actual	Week Target	Variance	% of Target
MWh Budget P50	8,585	9,272	-7.41%	92.59%
MWh Budget P90	8,585	8,762	-2.02%	97.98%

**Availability**

Technical Availability	99.09%	97.00%	2.09%	
Turbine Availability	99.69%	97.50%	2.19%	
Network Availability	100.00%	99.00%	1.00%	

**Financials**

Revenue (ZARm)	9,615,689	10,385,308	-7.41%	92.59%
Price per MWh	1120.08			

**Site Performance**

Capacity Factor	37.03%	39.99%	-7.41%	
Wind Speed (m/s)	7.37			

**Maintenance Schedule**

WTG Maintenance	49.02%	49.43%	0.83%	99.17%
Network Maintenance	24	24	0%	100%

# PI DataLink – B.I. – Faults & Event Analysis

- Energy and revenue availability monitored to maximise returns in monthly reports
  - Energy Production varies hour by hour
  - Variable prices in certain markets
  - Many OEMs now offer Energy Availability as a contractual guarantee
- PI Event Frames brought into PI Datalink to calculate lost energy & revenue Event by Event
- Allows staff to focus on biggest revenue losing Assets/Faults

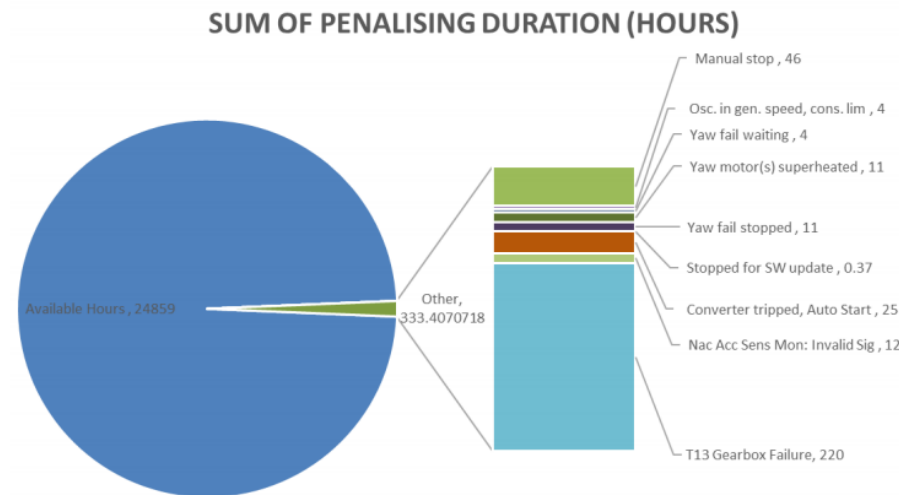
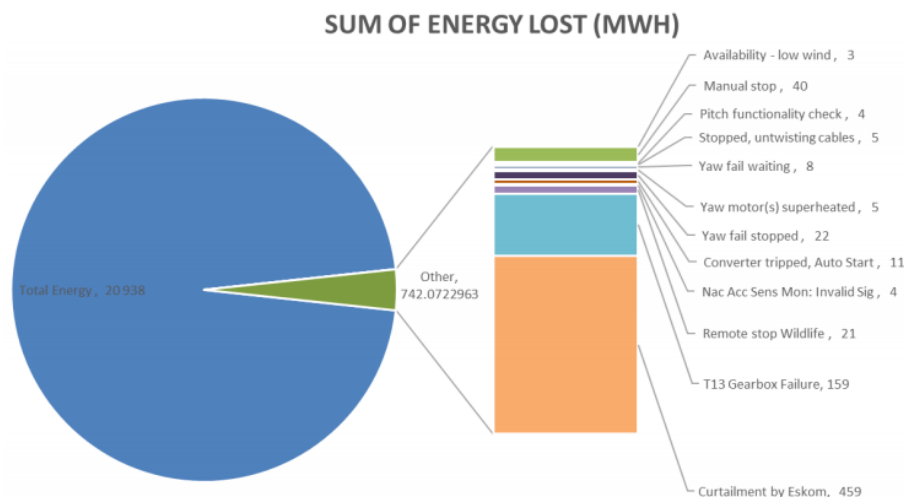


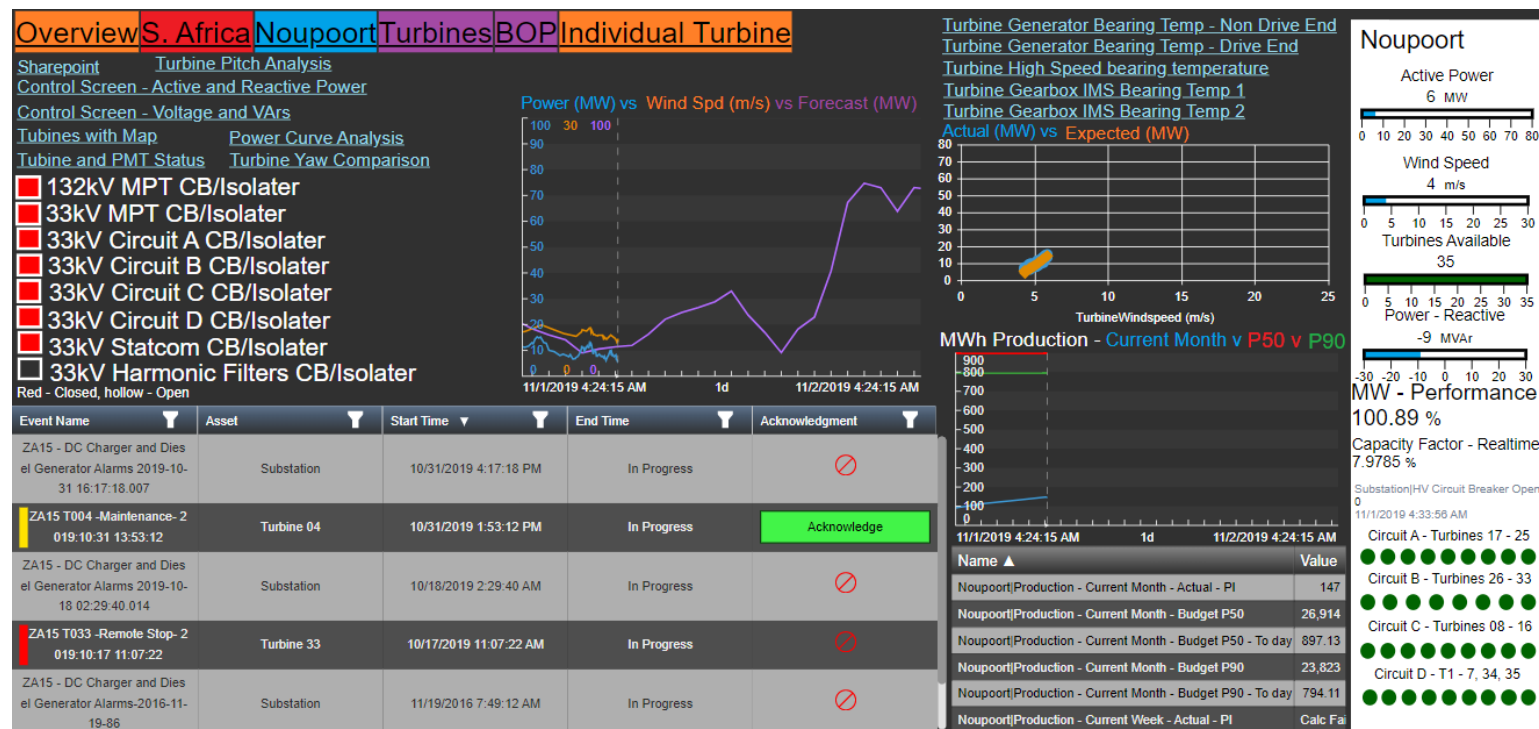
Figure 10: WTG Penalizing Duration Downtime Analysis



# PI Visuals – PI Vision

- Data Visualisation in PI Vision, published externally through [pi.mainstreamrp.com](https://pi.mainstreamrp.com)

- Site “homepage” with all KPIs
- Hyperlinks to further pages
- Fixed data (Budgets)
- Event Frames (Alarms)
- Live Data and Forecast
- Navigation bar at the top of each page mimics PI AF hierarchy





# PI Vision – Grid Code Compliance

- High resolution data allowed Mainstream carry out self testing prior to Grid Code Compliance in South Africa – ironing out any issues before formal testing
- Being able to visualise high resolution data allows for issues to be easily spotted. Without this, it is a “needle in a haystack approach”
- Successful passing of these tests allow the projects to start collecting early revenue.



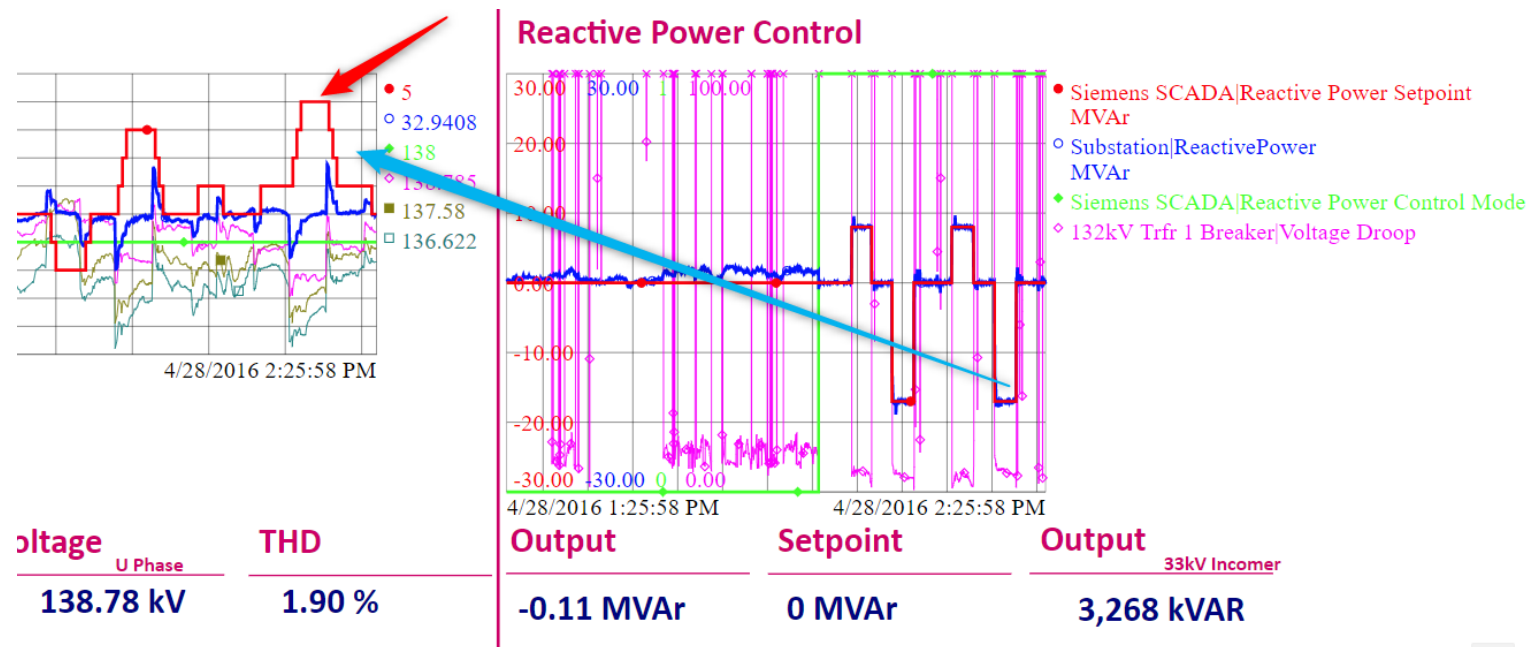
# PI Vision – Grid Code Compliance

- High resolution data allowed Mainstream carry out self testing prior to Grid Code Compliance in South Africa – ironing out any issues before formal testing
- Reactive Power setpoint taking too long to meet a challenging setpoint
- Quickly identified the issue as the Main Power Transformer's tap changer settings
- Retested with success



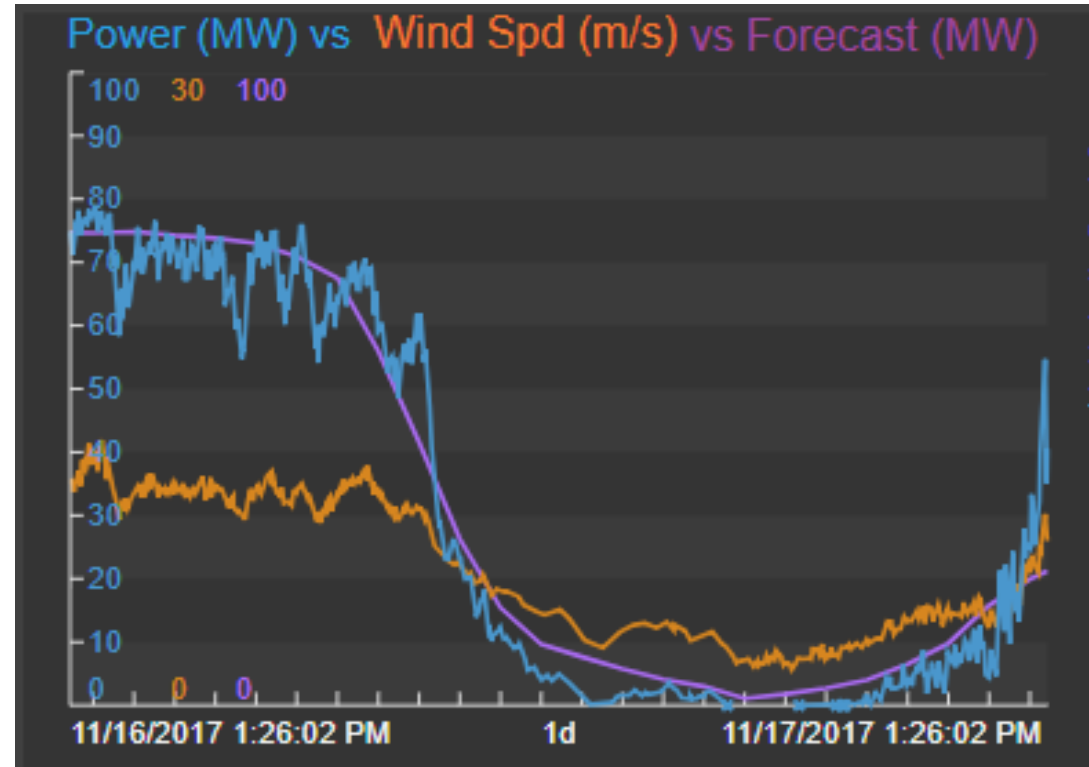
# PI Vision – Grid Code Compliance

- PI allows the full plant to be analysed from different data sources
- Substation Tap Changer (red arrow)
- Power Plant Controller setpoint and ION Meter Reactive Power



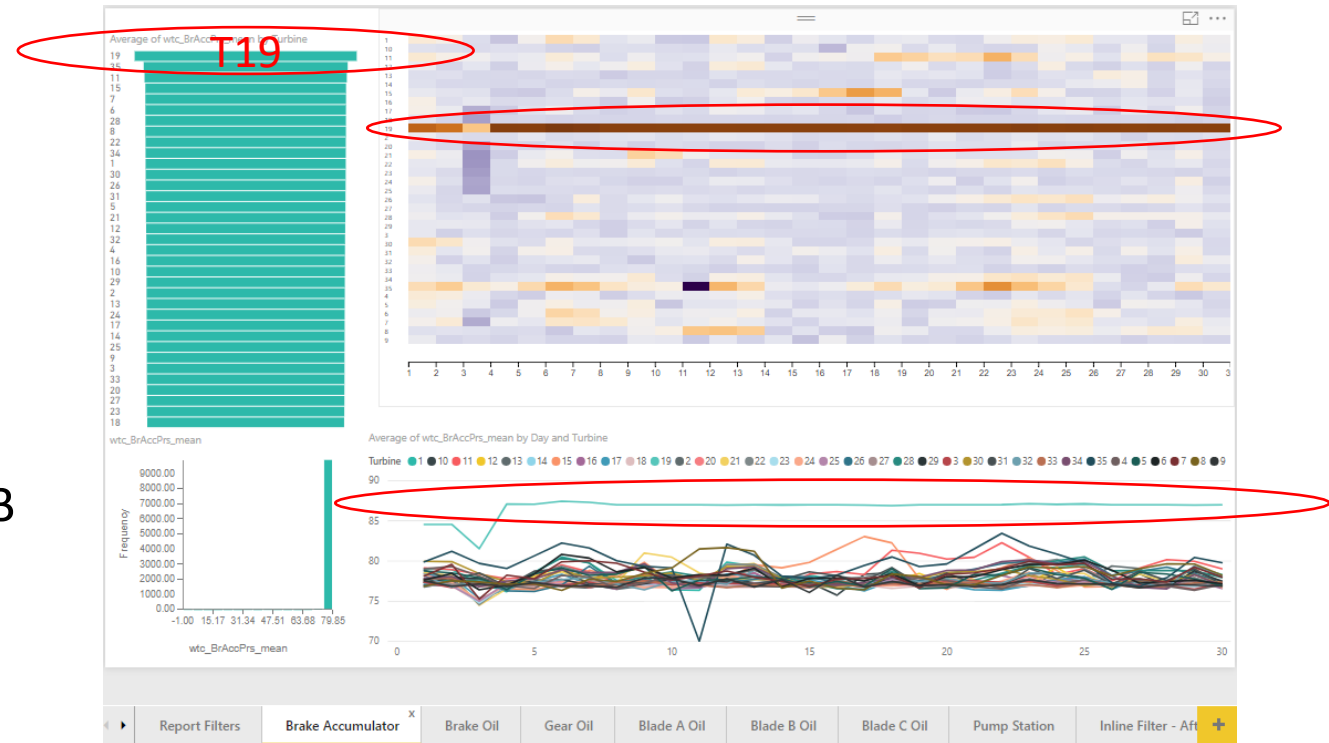
# MS PowerShell ISE – Import and Export Data

- Forecasting data available via ftp
  - Imported to PI via MS PowerShell ISE and piconfig
- Wind Farms in Chile and South Africa auto upload all turbines' power outputs to forecasting providers who train their models to improve accuracy
  - Exported using MS PowerShell ISE and Task Scheduler
- Better planning of maintenance reduces energy lost
- 3 MW turbine off for 12 hours at \$60/MWh is \$2,000 on a windy day
- Minimal revenue lost during maintenance on a calm day



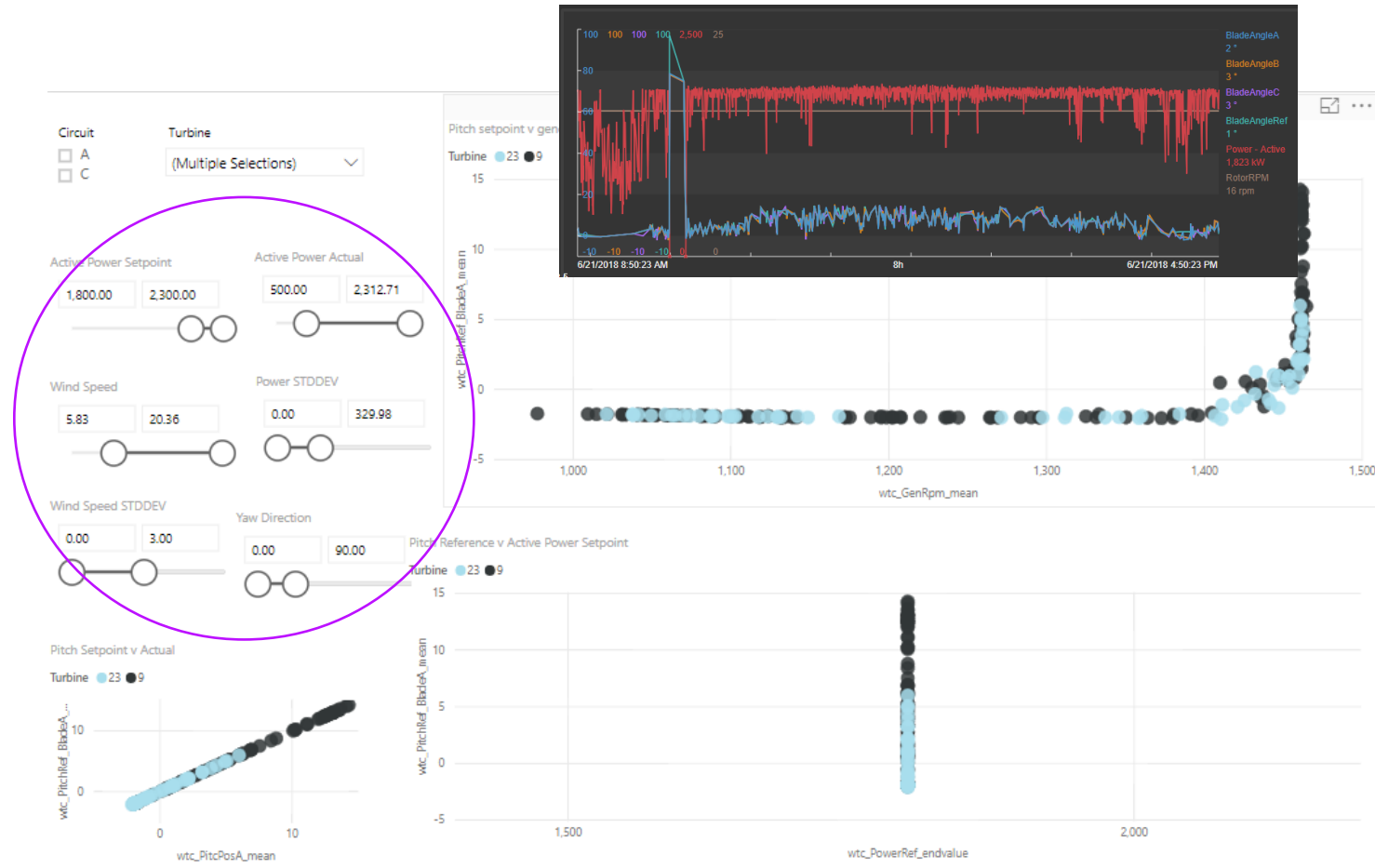
# MS Power BI – B.I. Analytics

- “Portal” in MS Power BI where all component temperature or pressure sensors can be examined on a relative basis against other identical turbines
- Filters can be applied to exclude data during curtailment, fault times
- Fed by PI via PI ODBC Driver, and SQL Server DB
- Filters can be applied to exclude data during curtailment, fault times



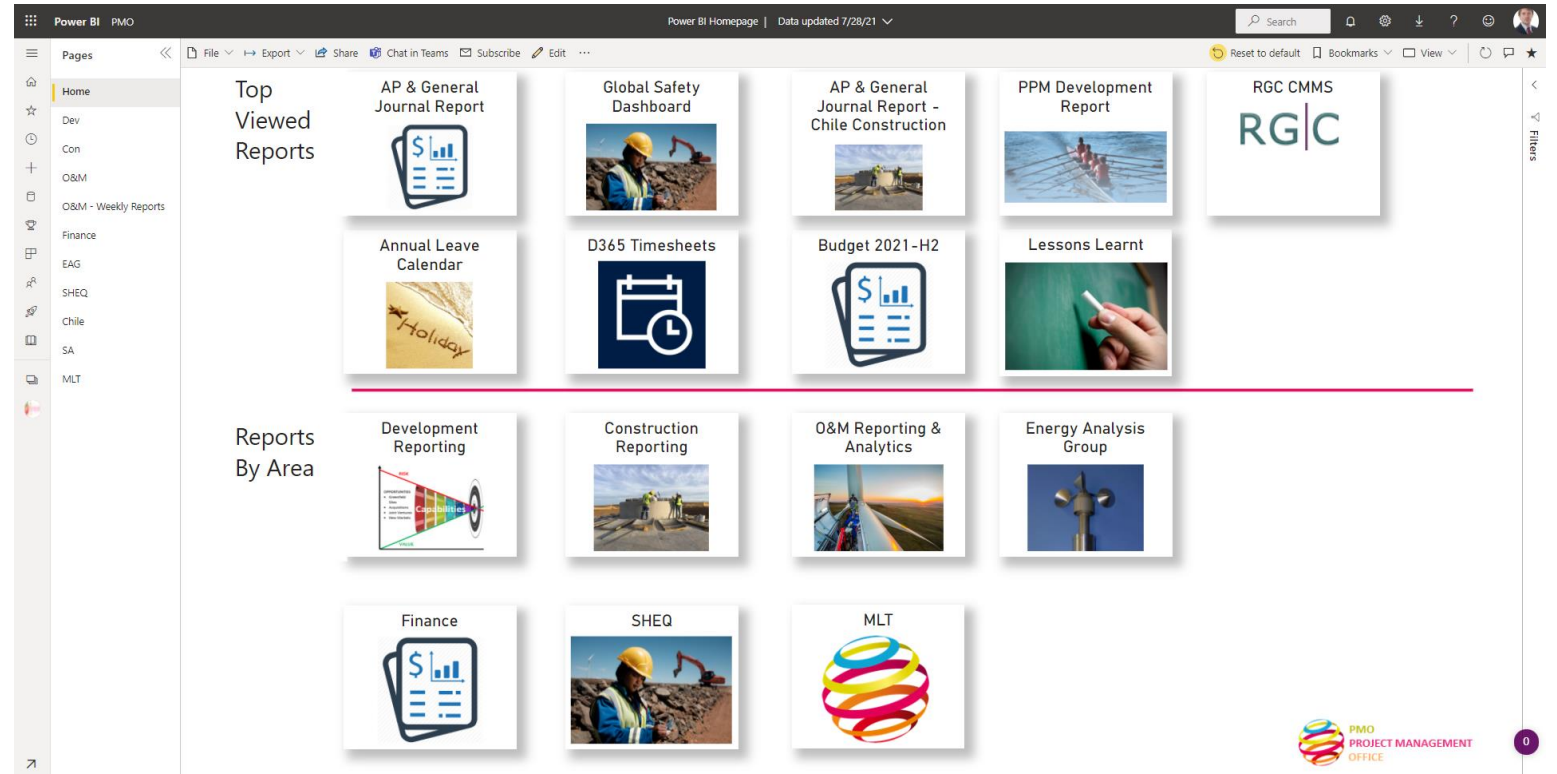
# MS Power BI – B.I. Analytics

- “Portal” in MS Power BI where all component temperature or pressure sensors can be examined on a relative basis against other identical turbines
- Filters can be applied to exclude data during curtailment, fault times
- Fed by PI via PI ODBC Driver, and SQL Server DB
- Fleet wide Performance Analysis
- Power Curves (Wind Speed v Power Output)
- Torque Curves
- Blade Pitch angle analysis (left)
- Outlier points can be analysed in high resolution (1s) in PI Vision



# MS Power BI – B.I. Analytics

- MS Power BI used for PI, SQL and CMMS Data visualisations for O&M Team
- Elsewhere, Mainstream use it to display
  - SHEQ (Safety, Health, Environmental and Quality) statistics logged in MS Sharepoint Online Lists
  - Financial reporting and analytics for MS Dynamics 365 Finance & Operations
  - Development/Permitting progress reporting from MS Project & Portfolio Manager
  - Construction progress reporting from MS Project & Portfolio Manager
  - Companywide Risk management from MS Project & Portfolio Manager
  - Timesheets analysis
- Working towards fully unified reporting
- PI data a central pillar of reporting and analysis during O&M Phase



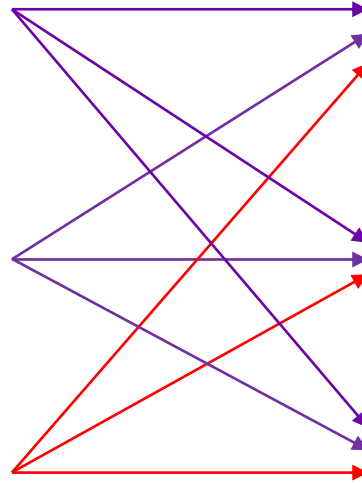


# PI Tools and Complimentary Systems Used

- Asset Framework – Asset Register, PI Data, MS Sharepoint document hyperlinks, Asset Work Order history from RGC web portal hyperlinks
  - Element Structure easily replicated using PI Element ID
  - Data queried though PI ODBC by MS Power BI & EAG team
- PI Interfaces – PI OPC XML DA, PI DNP3, PI SNMP, PI Ping
- Visuals – PI Vision and MS Power BI
- Reporting – PI DataLink and MS Power BI
- Analysis – PI Event Frames, PI DataLink, MS Power BI
- Alerts – PI Notifications
  - Trigger Work Orders in RGC
  - Integrate with Email to Voice services for critical faults
  - Reference PI Vision links

# Results and Benefits

- Single Version of the Truth for all Time Series Data, Asset Registers & Maintenance History
- Easily accessible data to all stakeholders
- Streamlined, automated process for Reports, Analytics, Work Order Creation



- Staff can quickly access all data required with full confidence that it is correct
- Minimize time spent before work has value
- Asset Integrity – ability to see problems before they cause material damage

# The right data finds the right person at the right time



## Challenge

- Multiple Data Sources
- Dispersed Sites & Staff
- Integration, Long Term Architecture

## Solution

- OSIsoft takes in all required data
- Standardised Reports & Visuals
- PI AF Analytics and PI Notifications trigger alerts and Work Orders
- Scalable, integrated management system developed

## Benefits

- Single Version of the Truth for all data, Asset Registers & Maintenance
- Easily accessible data to all stakeholders
- Streamlined, automated process for Reports, Analytics, Work Order Creation



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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

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GRAZIE

شكرا

FAAFETA

ESKERRIK ASKO

HVALA

GO RAIBH MAITH AGAT

БЛАГОДАРЯ

GRACIAS

ТИ БЛАГОДАРАМ

MAHADSANID

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DI OU MÈSI

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GRAZZI

PAKKA PÉR

HATUR NUHUN

PAXMAT CAĠA

CẢM ƠN BẠN

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ありがとうございました

SIPAS JI WERE

TERIMA KASIH

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ТИ БЛАГОДАРАМ

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