



Using PI Data for Predictive Analytics

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Agenda

- About Genesis Energy
- Our journey to date
- The PI System and how we're using it
- Predictive analytics and some successful examples
- Where to from here

Introduction to New Zealand

and my accent...

- Small country in the southwest Pacific Ocean
- From a power generation perspective
 - ~43,000 GWh annually
 - ~9000 MW installed capacity
- 2018 **annual** primary energy supply equivalent to **3½ days** for USA

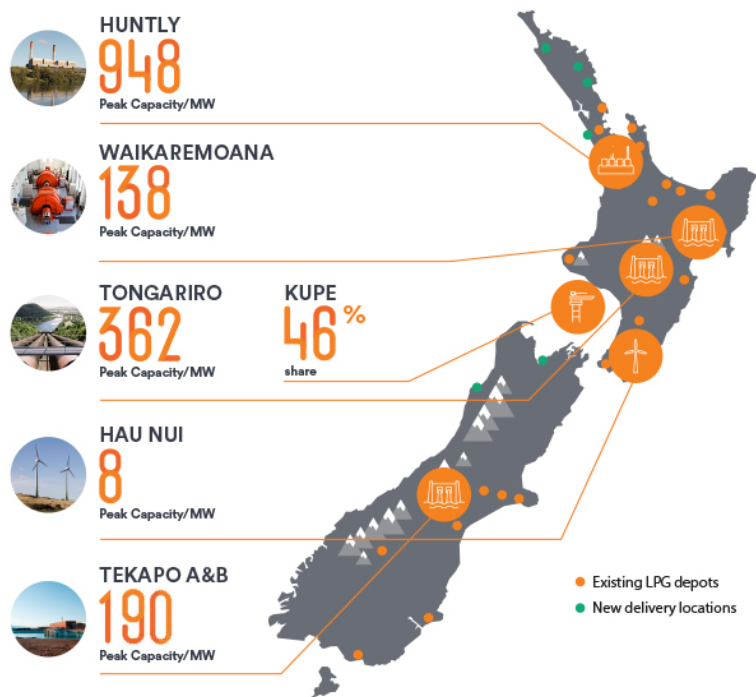
Accent

- 'e' is usually elongated and sounds like 'i'
 - 'yes' sounds like 'yis'
 - 'Beth' sounds like 'Bith'
- 'i' is usually pronounced like 'u'
 - 'fish and chips' sounds like 'fush and chups'
- lazy use of 'L' after a vowel
 - 'milk' sounds like 'miuk'



About Genesis Energy

An integrated energy management company, New Zealand's largest energy retailer generating electricity from coal, gas, hydro and wind and an interest in an oil and gas field.



500,000 +

customers

⚡ 25% electricity market share

🛢️ 38% gas market share

💧 19% LPG market share

24

%

Dual
Fuel

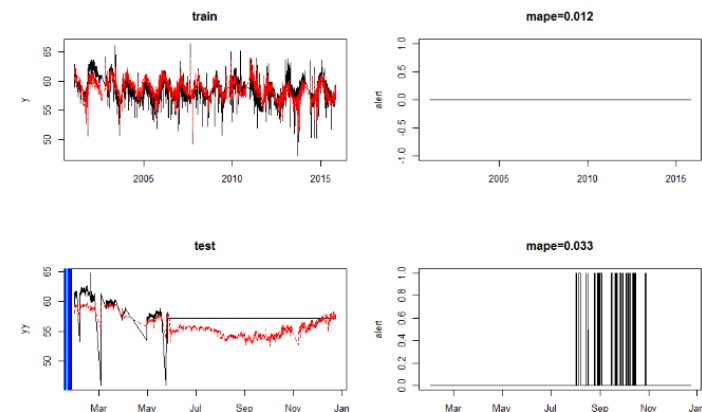
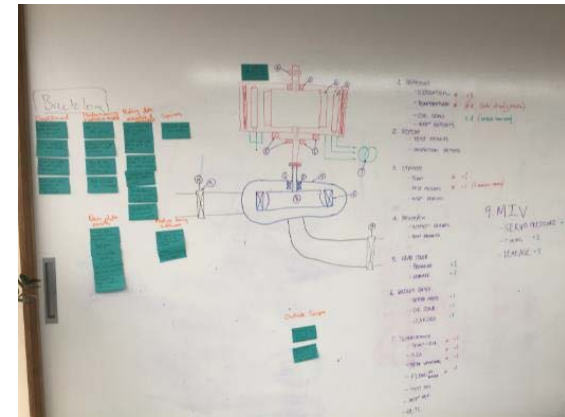
PURPOSE:

reimagine energy to put
control in our customers' hands



Genesis Journey

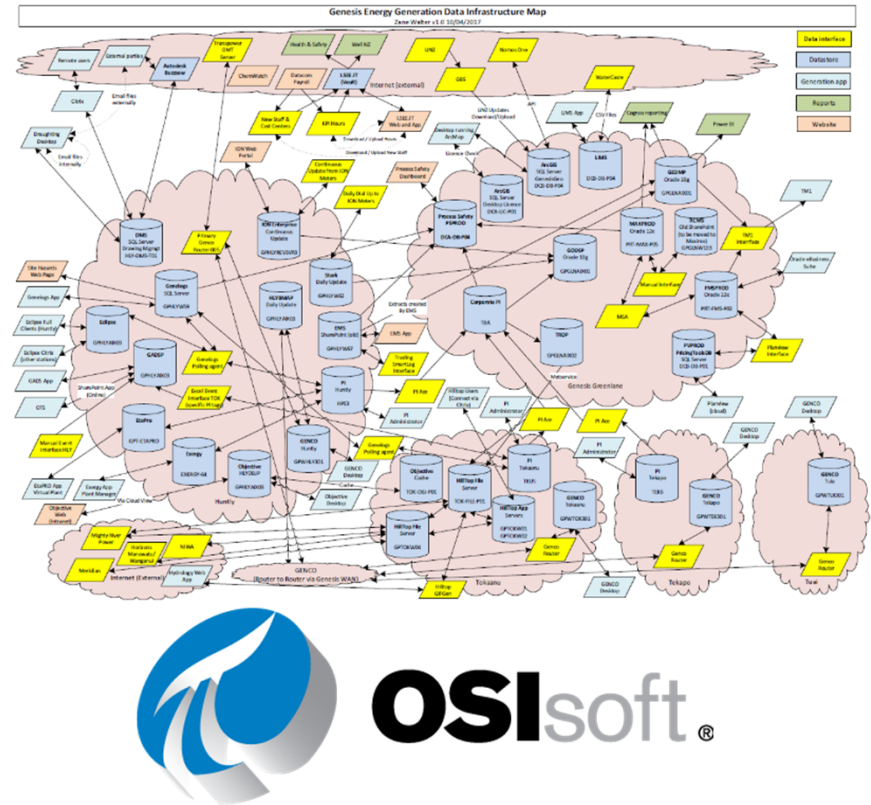
- 2017 – workshop to identify what data we have, how we can be more effective with, how to assist with decision making, identified the potential.
- 2017 and 2018 – testing in-house data science capability
- 2018 – developed generation specific data warehouse project – PI Integrator was a key
- End of 2018 – investigate external software vs internal data science capability
- 2019 – committed to internal development/deployment, ~800 models created
- What resources we've relied on
 - Open source software
 - PI Integrator, Microsoft Azure Datawarehouse
 - Data scientists, data architects/engineers, generation engineers



How did the PI System fit in?

PI Server Asset Framework (AF) and PI Integrator

- Data warehouse project – combining all high use generation related data into one location
- PI Historian a key dataset, had existing extraction method;
 - resolution of 10 or 30 min data only
 - managed by consultant
 - have to request what tag, what type of calculation; average, total, point in time etc and a cost per request
- PI Integrator was available and meant we could manage internally
- Didn't have functioning PI Server Asset Framework so this was required as part of project



PI Server Asset Framework

- PI Server Asset Framework is necessary for PI Integrator – we hadn't deployed AF
- Duplicated existing CMMS hierarchy to an AF hierarchy
- OSIsoft Partner managed deployment and aligning 70% of tags into hierarchy
- PI Server Asset Framework also has a lot of potential that we are not using at this stage

The screenshot displays the PI Server Asset Framework interface. On the left, a hierarchical tree structure shows the organization of assets. The tree is rooted at 'STATIONS' and branches into 'HUNTLY', 'HLY01: UNIT 1', 'HLY02: UNIT 2', 'HLY04: UNIT 4', 'HLY05: UNIT 5', 'HLY06: UNIT 6', 'HLYCS: COMMON SERVICES', 'REN: RENEWABLE ENERGY', and 'WPS: WAIKAREMOANA POWER SCHEME'. Each unit further branches into specific systems and equipment, such as 'A: UNIT TRANSMISSION AND DISTRIBUTION', 'B: POWER STATION ELECTRICAL SYSTEM', 'C: INSTRUMENTATION AND CONTROL EQUIPMENT SYSTEMS', 'E: FUEL SUPPLY AND ASH AND DUST DISPOSAL SYSTEM', 'G: WATER SUPPLY AND DISCHARGE SYSTEM', 'H: BOILER SYSTEM', 'L: STEAM WATER AND GAS CYCLES SYSTEM', 'M: MAIN MACHINES SYSTEM', 'MA: STEAM TURBINE PLANT INCLUDING CONDENSER', 'MK: GENERATOR PLANT', 'MP: COMMON INSTALLATIONS FOR MAIN MACHINES', 'MY: LUB. OIL SUPPLY - MAIN MACHINE', 'MX: CONTROL FLUID SUPPLY', 'MY: CONTROL REGULATING AND PROTECTION EQUIPMENT', 'P: COOLING WATER PLANT', 'Q: UNITISED STATION AUX SYSTEMS (EG AIRCHILLED H2O ETC)', 'S: ANCILLARY SYSTEMS', 'U: STRUCTURES', and 'Z: MAINTENANCE LABORATORY AND OFFICE EQUIPMENT'.

On the right, the 'HLY01: UNIT 1' details panel is shown. It includes tabs for 'General', 'Child Elements', 'Attributes', 'Ports', 'Analyses', and 'Version'. The 'General' tab is active, displaying a table of attributes and their values. The table has columns for 'Name' and 'Value'. The attributes listed include 'Actual frequency window' (0 MW), 'ACTUAL MW DEVIATION DETECTED ALARM' (False), 'Auxiliary MW correction (unit auxiliary MW + station auxiliary MW port...)' (0 MW), 'DISPATCH ON AUTO MODE' (False), 'Dispatched nett MW setpoint agc load setpoint' (0 MW), 'Genco dispatch FIR (from transpower)' (0 MW), 'Genco dispatch SIR (from transpower)' (0 MW), 'KKS CODE' (HLY01), 'MW due to frequency control' (0 MW), 'MW SETPOINT DEVIATION DETECTED ALARM' (False), 'Unit gross MW setpoint input' (50 MW), 'Unit gross MW setpoint output' (0 MW), 'Unit MVAR output' (0 MVAR), 'Unit MW Nett' (0), 'Unit MW output' (0 MW), and 'Unit MW SP' (0 MW).

Source Assets

Server

GEPIAF

Database

Genesis Assets

Assets

STATIONS

HUNTLY

REN: RENEWABLE ENERGY

RENC: RENEWABLE ENERGY COMMON

TEK : TEKAPO POWER SCHEME

TPS : TONGARIRO POWER SCHEME

WAI: WAIRARAPA GENERATION FACILITIES

WPS : WAIKAREMOANA POWER SCHEME

KTW : KAITAWA POWER STATION

PRI : PIRIPAUA POWER STATION

TUI : TUAI POWER STATION

TUI/ZFQ : HYDROLOGY

TUI01 : UNIT 1

TUI02 : UNIT 2

TUI03 : UNIT 3

TUIS : TUAI STATION SERVICES

Attributes

Filter

Select All

15 MINUTE WARNING OF FREQUENCY CONTROL

DRAINAGE SUMP PUMP 2 WATER LEVEL HIGH -START

FLOOD PROTECTION DC P/S

Frequency control MW bias

FREQUENCY CONTROL ON

Genco counter #1

Genco counter #2

Genco kaitawa FIR

Genco kaitawa kV

Genco kaitawa MVAR

Genco kaitawa MW

Genco kaitawa rdn

Genco kaitawa rup

Genco kaitawa SIR

Search Shape

Asset Shape

WPS : WAIKAREMOANA POWER SCHEME

KTW : KAITAWA POWER STATION

KTW Cooling Water Temperature

KTW Cooling Water Temperature 24 hour average

KTW Cooling Water Temperature 7 day average

PRI : PIRIPAUA POWER STATION

Tuai Ambient Air Temperature 24 hour moving average

Tuai Ambient Air Temperature 7 day moving average

Tuai Rainfall 24 hour average

Tuai Rainfall today

TUI : TUAI POWER STATION

TUI/ZFQ : HYDROLOGY

Kaitawa Lake Level

Tuai Surge Chamber Level

Whakamarino Lake Level

TUI01 : UNIT 1

Turbine flow

Unit MVA

Unit MVAR output

Unit MW output

Unit total current

Unit voltage

Unit winter kennedy pressure

Unit winter kennedy turbine flow

TUI01/B : ELECTRICAL SYSTEMS

TUI01/BAT : TRANSFORMER

T1 oil H2 level

T1 oil h20 level

T1 top oil temperature

T1 winding temperature

TUI01/L : WATER STORAGE INTAKE AND PENSTOCKS

TUI01/LPC : PENSTOCK SYSTEM

Penstock pressure

TUI01/ME : TURBINE PLANT

TUI01/MEA : TURBINE AND ASSOCIATED EQUIPMENT

TUI01/MEA50 : BEARING ASSEMBLIES

Bearings oil temp

Turbine bearing temp

Matches

Found 1 Match

WPS : WAIKAREMOANA POWER SCHEME

9

Select Data > [Modify View](#) > Publish

Back Next

+ Add Column 101 columns			▼ Edit Row Filters 0 Row Filters		≡ Edit Value Mode Interpolated Values Every 90 minutes		Start Time 1/01/16 12:00:00 AM			End Time *			Apply
TimeStamp	TUI01_Unit_MW	TUI01_Unit_MVA	TUI01_Unit_MVAr	TUI01_Unit_Current	TUI01_Unit_Voltage	TUI01_Unit_WinterKennedyPressure	TUI01_Unit_WinterKennedyTurbineFlow	TUI01_Unit_TurbineFlow	TUI01_Penstock_Pressure	TUI01_WicketGates_Position	TUI01_TurbineBearing_Temperature	TUI01_GeneratorBearing_Temperature	
1/01/2016 12:00:00 AM	8.007		-8.024		10.986	124.737	9.803	10.181	19.563	32.500	41.890	37.604	
1/01/2016 12:30:00 AM	8.018		-7.934		10.986	126.265	9.851	10.181	19.547	32.800	41.886	37.598	
1/01/2016 1:00:00 AM	7.986		-8.128		10.986	126.083	9.826	10.182	19.550	32.900	41.883	37.592	
1/01/2016 1:30:00 AM	7.987		-8.33		10.986	128.675	9.844	10.182	19.556	32.600	41.879	37.586	
1/01/2016 2:00:00 AM	7.993		-8.598		10.986	127.897	9.864	10.183	19.541	32.700	41.875	37.580	
1/01/2016 2:30:00 AM	7.994		-8.734		10.986	125.499	9.866	10.183	19.547	32.600	41.927	37.575	
1/01/2016 3:00:00 AM	7.986		-8.848		10.986	126.949	9.815	10.184	19.552	32.600	41.917	37.569	
1/01/2016 3:30:00 AM	8.062		-8.811		10.986	127.722	9.883	10.184	19.552	32.800	41.908	37.563	
1/01/2016 4:00:00 AM	7.974		-8.86		10.986	127.115	9.881	10.185	19.559	32.500	41.898	37.557	
1/01/2016 4:30:00 AM	7.988		-8.882		10.986	127.626	9.897	10.185	19.554	32.400	41.889	37.551	
1/01/2016 5:00:00 AM	7.964		-8.736		10.986	126.103	9.909	10.186	19.557	32.300	41.879	37.545	
1/01/2016 5:30:00 AM	7.938		-8.638		10.986	129.189	9.848	10.186	19.557	32.500	41.870	37.539	
1/01/2016 6:00:00 AM	7.937		-11.946		10.886	128.995	9.859	10.187	19.551	32.600	41.860	37.533	
1/01/2016 6:30:00 AM	8.001		-10.778		10.954	128.931	9.827	10.187	19.554	32.900	41.851	37.528	
1/01/2016 7:00:00 AM	7.942		-11.735		10.919	126.924	9.947	10.188	19.566	33.200	41.851	37.522	
1/01/2016 7:30:00 AM	8.028		-11.01		10.915	127.891	9.935	10.188	19.566	33.433	41.857	37.536	
1/01/2016 8:00:00 AM	8.12		-10.633		10.912	120.010	9.094	10.109	19.542	34.200	41.063	37.552	
1/01/2016 8:30:00 AM	8.011		-10.267		10.909	129.424	9.869	10.189	19.552	32.400	41.869	37.568	
1/01/2016 9:00:00 AM	7.996		-7.689		11.001	126.049	9.847	10.190	19.556	31.900	41.874	37.584	
1/01/2016 9:30:00 AM	8.008		-7.575		11.015	125.099	9.847	10.190	19.575	32.000	41.896	37.600	
1/01/2016 10:00:00 AM	8.035		-5.595		11.132	125.630	9.854	10.191	19.556	32.100	41.917	37.615	
1/01/2016 10:30:00 AM	7.975		-5.73		11.131	128.405	9.914	10.191	19.576	32.100	41.938	37.631	
1/01/2016 11:00:00 AM	7.927		-5.298		11.129	125.648	9.878	10.192	19.548	32.059	41.960	37.647	
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1/01/2016 12:30:00 PM	8.053		-6.128		11.052	128.008	9.920	10.193	19.554	31.900	42.024	37.695	
1/01/2016 1:00:00 PM	7.972		-5.538		11.142	128.222	9.925	10.194	19.552	32.100	42.045	37.711	
1/01/2016 1:30:00 PM	8.005		-5.553		11.135	129.890	9.887	10.194	19.555	32.100	42.067	37.727	
1/01/2016 2:00:00 PM	8		-5.072		11.128	126.282	9.898	10.194	19.547	32.000	42.088	37.743	
1/01/2016 2:30:00 PM	7.997		-5.046		11.121	126.076	9.813	10.195	19.571	32.000	42.109	37.759	
1/01/2016 3:00:00 PM	7.958		-2.827		11.233	125.763	9.864	10.195	19.547	31.700	42.131	37.775	
1/01/2016 3:30:00 PM	7.979		-2.922		11.234	129.059	9.878	10.196	19.561	32.100	42.152	37.791	
1/01/2016 4:00:00 PM	7.984		-3.021		11.234	128.606	9.896	10.196	19.550	31.900	42.173	37.807	
1/01/2016 4:30:00 PM	7.969		-2.234		11.235	129.986	9.832	10.197	19.564	32.900	42.195	37.823	
1/01/2016 5:00:00 PM	8		-2.201		11.236	128.523	9.838	10.197	19.566	32.900	42.216	37.839	
1/01/2016 5:30:00 PM	8.01		-1.834		11.236	126.848	9.841	10.198	19.551	32.700	42.238	37.846	
1/01/2016 6:00:00 PM	7.96		-2.057		11.237	129.277	9.863	10.198	19.570	32.800	42.252	37.824	
1/01/2016 6:30:00 PM	7.965		-2.3		11.238	127.422	9.802	10.199	19.574	32.800	42.262	37.802	

Object Explorer

Connect

- pi.Dispatch_Compliance_Reporting
- pi.HLY_CoalAndAshModelling
- pi.HLY_Fuels
- pi.HLY_RankineHeatrate
- pi.HLY_RankineModelling
- pi.HLY_RiverHeatingModelling
- pi.HLY_WEATHER_STATION
- pi.HLYRankine_Modelling
- pi.KTW_Modelling
- pi.PRI_Modelling
- pi.RIVERTEMPERATUREMODELLING
- pi.RPO_Brushgeared
- pi.RPO_Modelling
- pi.TEK_Modelling
- pi.TKA_Modelling
- pi.TKU_Modelling
- pi.TKU_Modelling_Test
- pi.TKU01_Modes
- pi.TUI_Modelling
 - Columns
 - Id (bigint, not null)
 - TimeStamp (datetime, null)
 - TUI01_Unit_MW (float, null)
 - TUI01_Unit_MVA (real, null)
 - TUI01_Unit_MVAr (float, null)
 - TUI01_Unit_Current (real, null)
 - TUI01_Unit_Voltage (real, null)
 - TUI01_Unit_WinterKennedyPressure (real, null)
 - TUI01_Unit_WinterKennedyTurbineFlow (real, null)
 - TUI01_Unit_TurbineFlow (real, null)
 - TUI01_Penstock_Pressure (real, null)
 - TUI01_WicketGates_Position (real, null)
 - TUI01_TurbineBearing_Temperature (real, null)
 - TUI01_GeneratorBearing_Temperature (real, null)
 - TUI01_ThrustBearing_Temperature (real, null)
 - TUI01_BearingsOil_Temperature (real, null)
 - TUI01_TurbineBearing_XVibration (real, null)
 - TUI01_TurbineBearing_YVibration (real, null)
 - TUI01_GeneratorBearing_XVibration (real, null)
 - TUI01_GeneratorBearing_YVibration (real, null)
 - TUI01_TransformerOil_H2OLevel (real, null)
 - TUI01_TransformerOil_TopOilTemperature (real, null)
 - TUI01_TransformerWinding_Temperature (real, null)
 - TUI01_GeneratorStator_Temperature1 (real, null)
 - TUI01_GeneratorStator_Temperature2 (real, null)

SQLQuery1.sql - ge...energy.co.nz (257)*

```

/***** Script for SelectTopNRows command from SSMS *****/
SELECT TOP (1000) [Id]
, [TimeStamp]
, [TUI01_Unit_MW]
, [TUI01_Unit_MVA]
, [TUI01_Unit_MVAr]
, [TUI01_Unit_Current]
, [TUI01_Unit_Voltage]
, [TUI01_Unit_WinterKennedyPressure]
, [TUI01_Unit_WinterKennedyTurbineFlow]
, [TUI01_Unit_TurbineFlow]
, [TUI01_Penstock_Pressure]
, [TUI01_WicketGates_Position]
, [TUI01_TurbineBearing_Temperature]
, [TUI01_GeneratorBearing_Temperature]
, [TUI01_ThrustBearing_Temperature]
, [TUI01_BearingsOil_Temperature]
, [TUI01_TurbineBearing_XVibration]
, [TUI01_TurbineBearing_YVibration]
, [TUI01_GeneratorBearing_XVibration]
, [TUI01_GeneratorBearing_YVibration]
, [TUI01_TransformerOil_H2OLevel]
, [TUI01_TransformerOil_H2OLevel]
, [TUI01_TransformerOil_TopOilTemperature]
, [TUI01_TransformerWinding_Temperature]
, [TUI01_GeneratorStator_Temperature1]
, [TUI01_GeneratorStator_Temperature2]

```

100 %

Results Messages

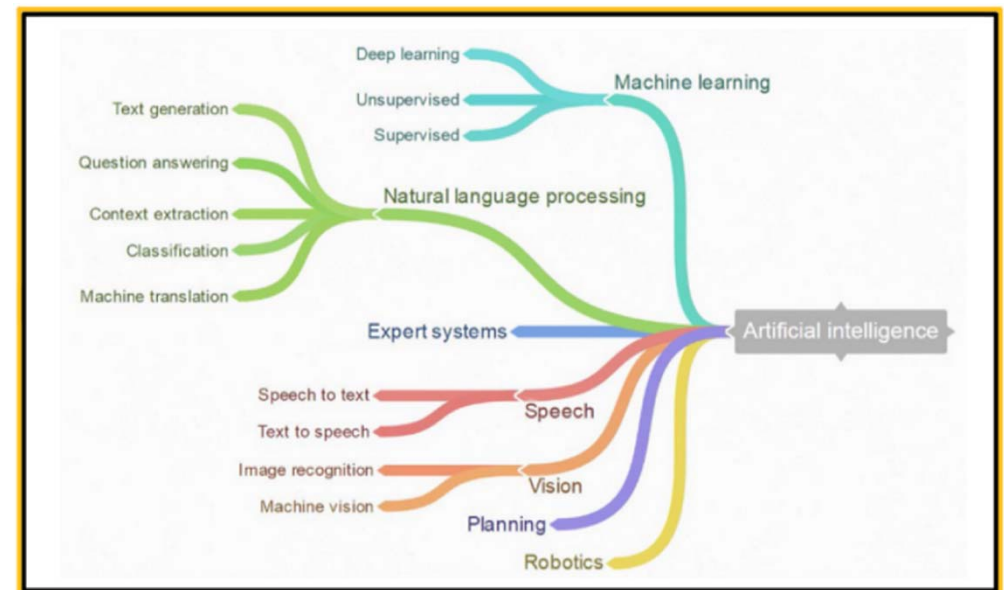
Id	TimeStamp	TUI01_Unit_MW	TUI01_Unit_MVA	TUI01_Unit_MVAr	TUI01_Unit_Current	TUI01_Unit_Voltage	TUI01_Unit_WinterKennedyPressure	TUI01_Unit_WinterKennedyTurbineFlow	TUI01_Unit_TurbineFlow	TUI01_Penstock_Pressure	TUI01_WicketGates_Position	TUI01_TurbineBearing_Temperature	TUI01_GeneratorBearing_Temperature	TUI01_ThrustBearing_Temperature	TUI01_BearingsOil_Temperature	TUI01_TurbineBearing_XVibration	TUI01_TurbineBearing_YVibration	TUI01_GeneratorBearing_XVibration	TUI01_GeneratorBearing_YVibration	TUI01_TransformerOil_H2OLevel	TUI01_TransformerOil_TopOilTemperature	TUI01_TransformerWinding_Temperature	TUI01_GeneratorStator_Temperature1	TUI01_GeneratorStator_Temperature2
1	2016-01-01 00:00:00.000	8.006667137146	NULL	-8.02396392822266	NULL	10.98629	124.7375																	
2	2016-01-01 00:30:00.000	8.01835250854492	NULL	-7.93408918380737	NULL	10.9863	126.265																	
3	2016-01-01 01:00:00.000	7.98593091964722	NULL	-8.12808227539063	NULL	10.98631	126.0832																	
4	2016-01-01 01:30:00.000	7.98651266098022	NULL	-8.33005142211914	NULL	10.98631	128.6747																	
5	2016-01-01 02:00:00.000	7.99331665039063	NULL	-8.59836006164551	NULL	10.98632	127.8968																	
6	2016-01-01 02:30:00.000	7.99444532394409	NULL	-8.735262298584	NULL	10.98633	125.4995																	
7	2016-01-01 03:00:00.000	7.98563861846924	NULL	-8.84783458709717	NULL	10.98634	126.9487																	
8	2016-01-01 03:30:00.000	8.06240653991699	NULL	-8.81133937835693	NULL	10.98635	127.7219																	
9	2016-01-01 04:00:00.000	7.97382164001465	NULL	-8.86044216156006	NULL	10.98635	127.1146																	
10	2016-01-01 04:30:00.000	7.98819303512573	NULL	-8.88173866271973	NULL	10.98636	127.6265																	
11	2016-01-01 05:00:00.000	7.96359491348267	NULL	-8.73585891723633	NULL	10.98637	126.1029																	
12	2016-01-01 05:30:00.000	7.9375853385132	NULL	-8.63767719268799	NULL	10.98638	129.1888																	
13	2016-01-01 06:00:00.000	7.93740510940552	NULL	-11.9456214904785	NULL	10.88606	128.9955																	
14	2016-01-01 06:30:00.000	8.00050735473633	NULL	-10.7779397964478	NULL	10.95437	128.9307																	
15	2016-01-01 07:00:00.000	7.94243288040161	NULL	-11.734959602356	NULL	10.91864	126.9245																	
16	2016-01-01 07:30:00.000	8.02792453765869	NULL	-11.0102958679199	NULL	10.91531	127.8907																	
17	2016-01-01 08:00:00.000	8.11966896057129	NULL	-10.6327905654907	NULL	10.91198	128.8177																	
18	2016-01-01 08:30:00.000	8.01126670837402	NULL	-10.2672309875488	NULL	10.90865	129.424																	

Artificial Intelligence, Machine Learning, Predictive Analytics

- Artificial intelligence (AI) - Ability to **make decisions** through interpreting information
- Machine Learning – fancy name for data science. Learning from data to create a relationship/algorithm. Think $y = mx + c$
- Predictive Analytics – Genesis Energy take on machine learning focused on enhancing our maintenance management

Requirements

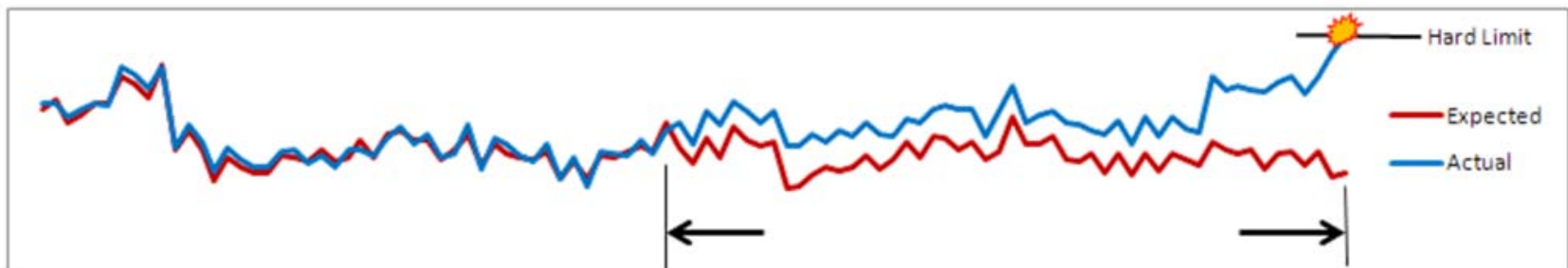
- Data warehouse/historian – key
- Other data possibilities – CMMS, software diagnostics, market data, weather
- ‘Sandbox’/platform to model data/develop algorithms without having to code



<https://hackernoon.com/jump-start-to-artificial-intelligence>

Predictive Analytics

Proactively monitoring asset health to reduce cost and increase plant reliability



Benefits/Targets

Reduced Preventative Maintenance

Moving from Calendar based to Analytics triggered

Reduced Defects

Picking up on defects before they escalate.

Reduced Forced Outages

Picking up on issues before they escalate to forced outages.

It is not...

- Replacing DCS/SCADA alarming
- Real time alerting

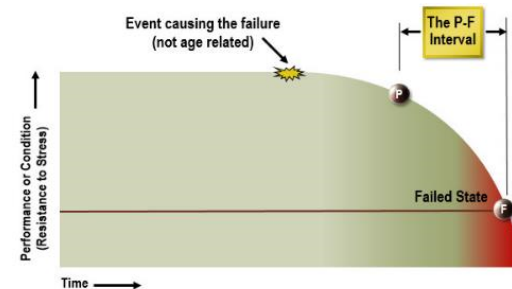
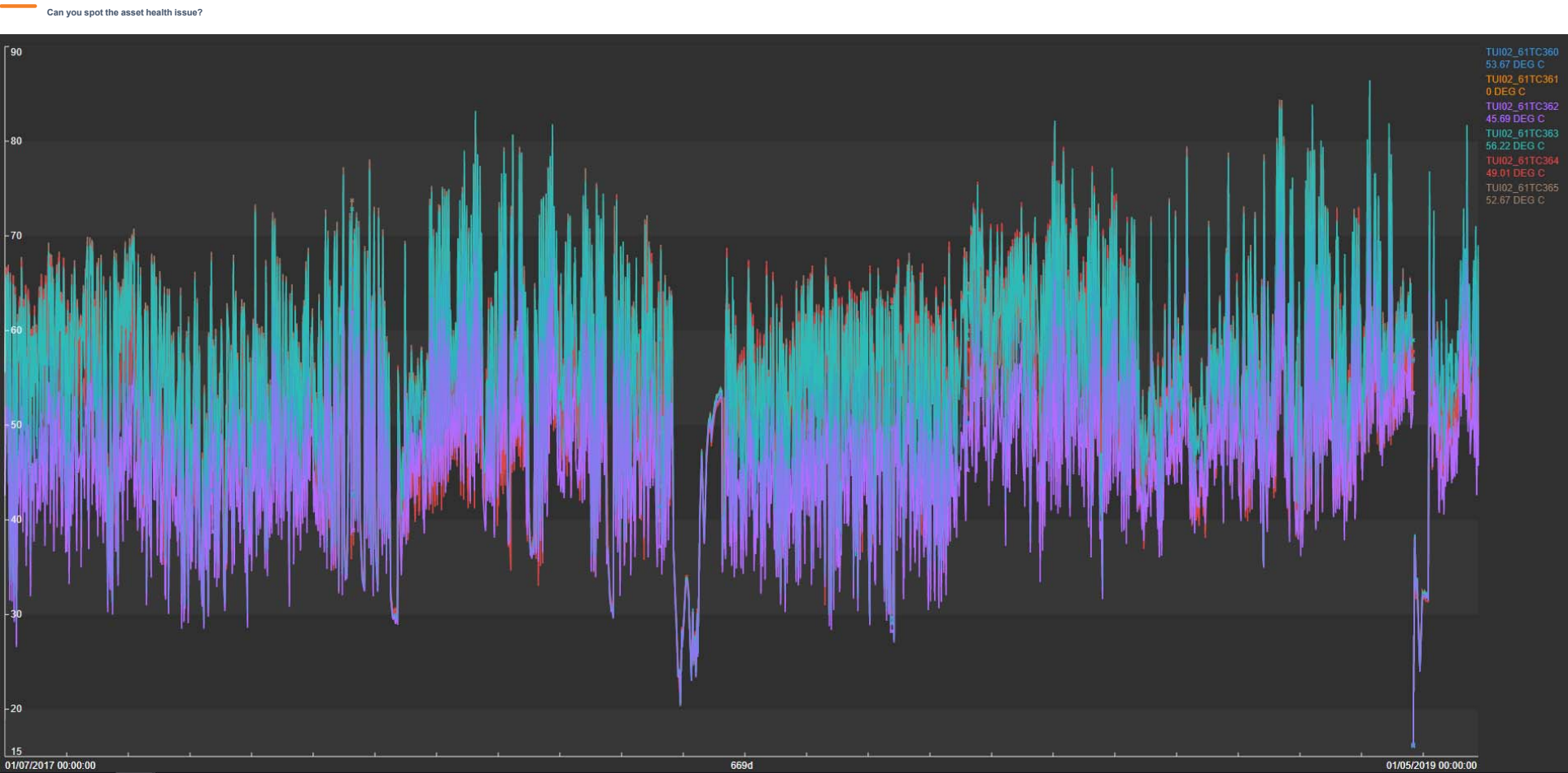


Figure1: The P-F Curve

PI Vision - Stator Temp Last 2 Years



PI Integrator

Select Data > Modify View > Publish

Source Assets

Server: GEPIAF

Database: Genesis Assets

Assets

- STATIONS
 - HUNTLY
 - REN: RENEWABLE ENERGY
 - RENC: RENEWABLE ENERGY COMMON
 - TEK: TEKAPO POWER SCHEME
 - TPS: TONGARIRO POWER SCHEME
 - WAI: WAIRAPA GENERATION FACILITIES
 - WPS: WAIKAREMOANA POWER SCHEME
 - KTW: KAITAWA POWER STATION
 - PRI: PIRIPAUA POWER STATION
 - TUI: TUIAI POWER STATION
 - TUI/ZFQ: HYDROLOGY
 - TUI01: UNIT 1
 - TUI02: UNIT 2
 - TUI03: UNIT 3
 - TUIS: TUIAI STATION SERVICES

Attributes Filter

Select All

15 MINUTE WARNING OF FREQUENCY CONTROL

DRAINAGE SUMP PUMP 2 WATER LEVEL HIGH-START

FLOOD PROTECTION DC P/S

Frequency control MW bias

FREQUENCY CONTROL ON

Genco counter #1

Genco counter #2

Genco kaitawa FIR

Genco kaitawa KV

Genco kaitawa MVAR

Genco kaitawa MW

Genco kaitawa rdn

Genco kaitawa rup

Genco kaitawa SIR

Search Shape

Asset Shape

WPS: WAIKAREMOANA POWER SCHEME

- KTW: KAITAWA POWER STATION
 - KTW Cooling Water Temperature
 - KTW Cooling Water Temperature 24 hour average
 - KTW Cooling Water Temperature 7 day average
- PRI: PIRIPAUA POWER STATION
 - Tuai Ambient Air Temperature 24 hour moving average
 - Tuai Ambient Air Temperature 7 day moving average
 - Tuai Rainfall 24 hour average
 - Tuai Rainfall today
- TUI: TUIAI POWER STATION
 - TUI/ZFQ: HYDROLOGY
 - Kaitawa Lake Level
 - Tuai Surge Chamber Level
 - Whakamarino Lake Level
 - TUI01: UNIT 1
 - Turbine flow
 - Unit MVA
 - Unit MVAR output
 - Unit MW output
 - Unit total current
 - Unit voltage
 - Unit winter Kennedy pressure
 - Unit winter Kennedy turbine flow
 - TUI01/B: ELECTRICAL SYSTEMS
 - TUI01/BAT: TRANSFORMER
 - T1 oil H2 level
 - T1 oil h20 level
 - T1 top oil temperature
 - T1 winding temperature
 - TUI01/L: WATER STORAGE INTAKE AND PENSTOCKS
 - TUI01/LFC: PENSTOCK SYSTEM
 - Penstock pressure
 - TUI01/ME: TURBINE PLANT
 - TUI01/MEA: TURBINE AND ASSOCIATED EQUIPMENT
 - TUI01/MEA50: BEARING ASSEMBLIES
 - Bearings oil temp
 - Turbine bearing temp

Matches

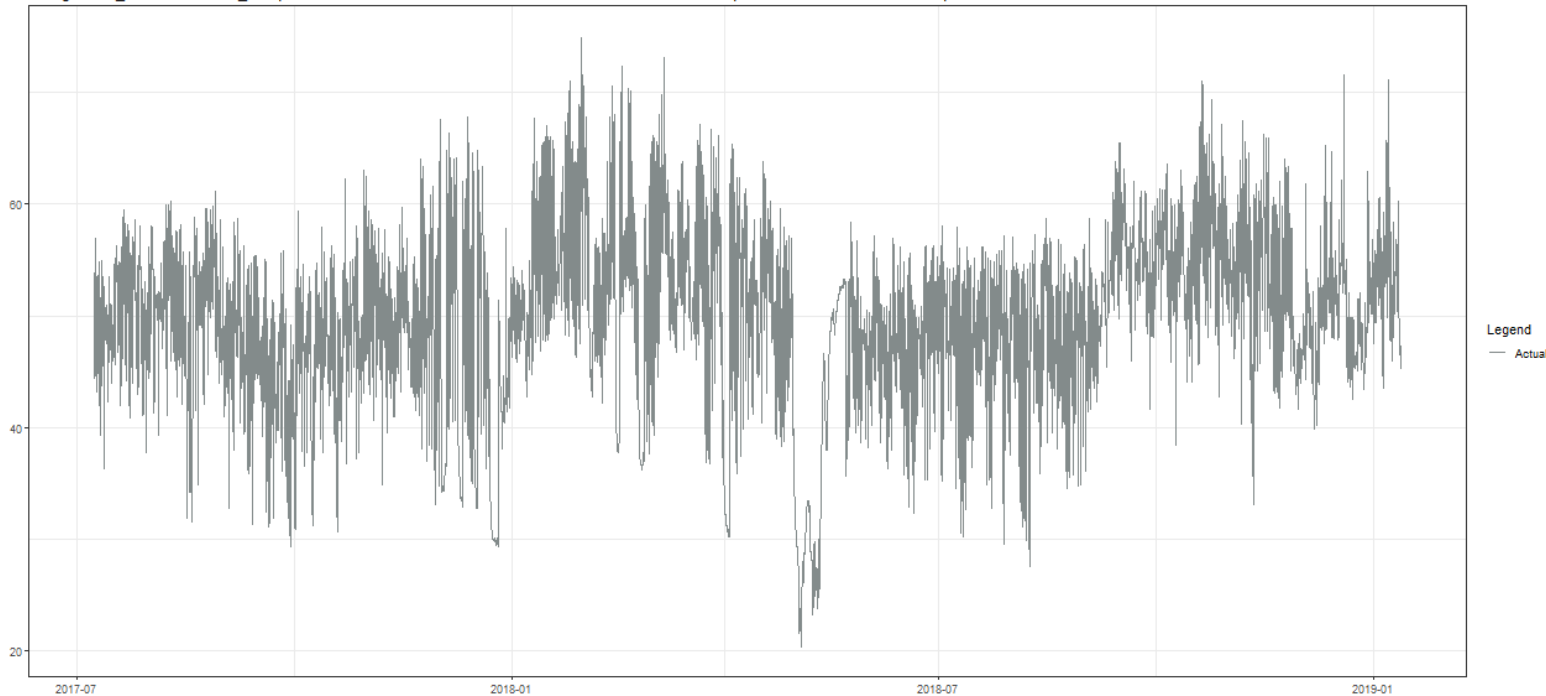
Found 1 Match

WPS: WAIKAREMOANA POWER SCHEME

PI Integrator makes the data accessible for analytics in our tool

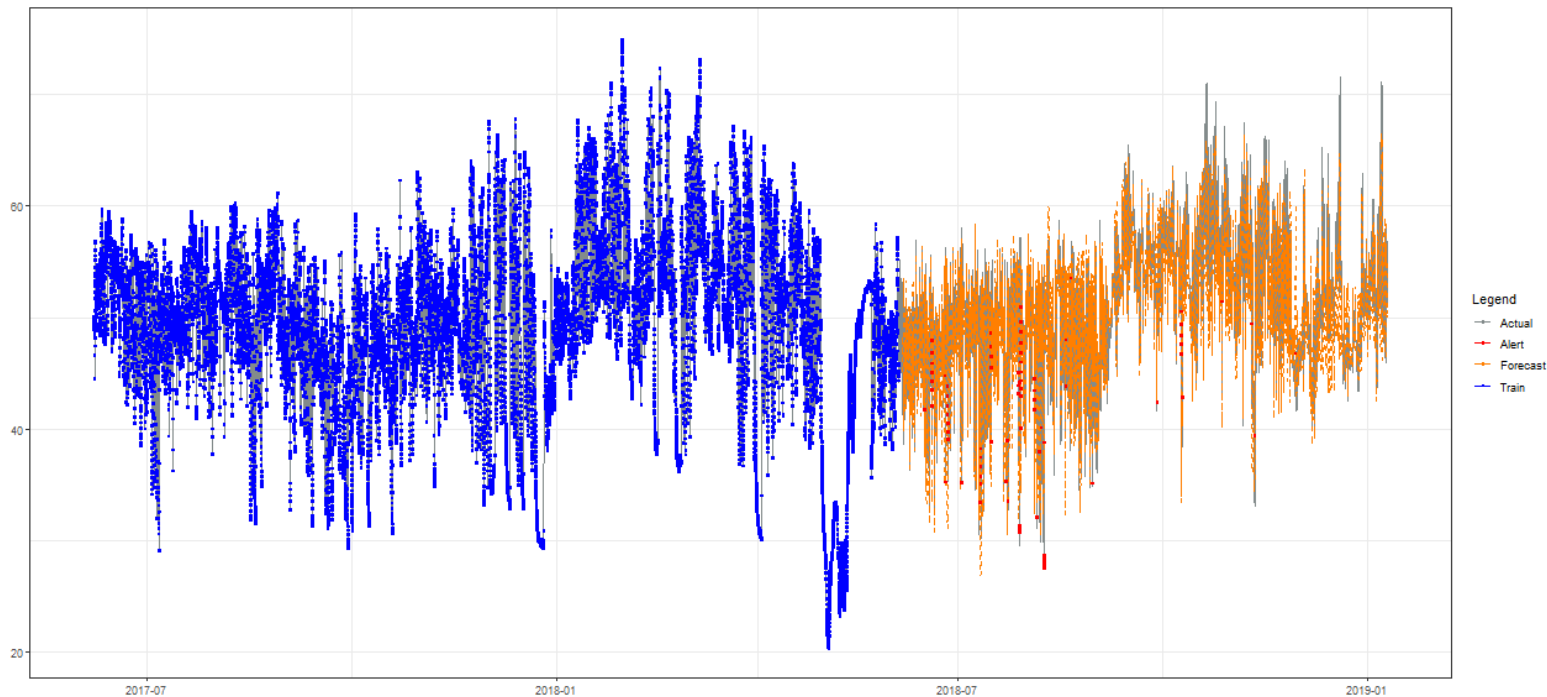
Our In-house Tool

PI tag: TUI02_GeneratorStator_Temperature1 with Train-MAPE: NA Forecast-MAPE: 0.038 Train-RSquare: 0.759 and Forecast-RSquare: 0.85



Ability to select input variables, remove unrelated data (eg plant in outage), training periods and forecasting check to validate model

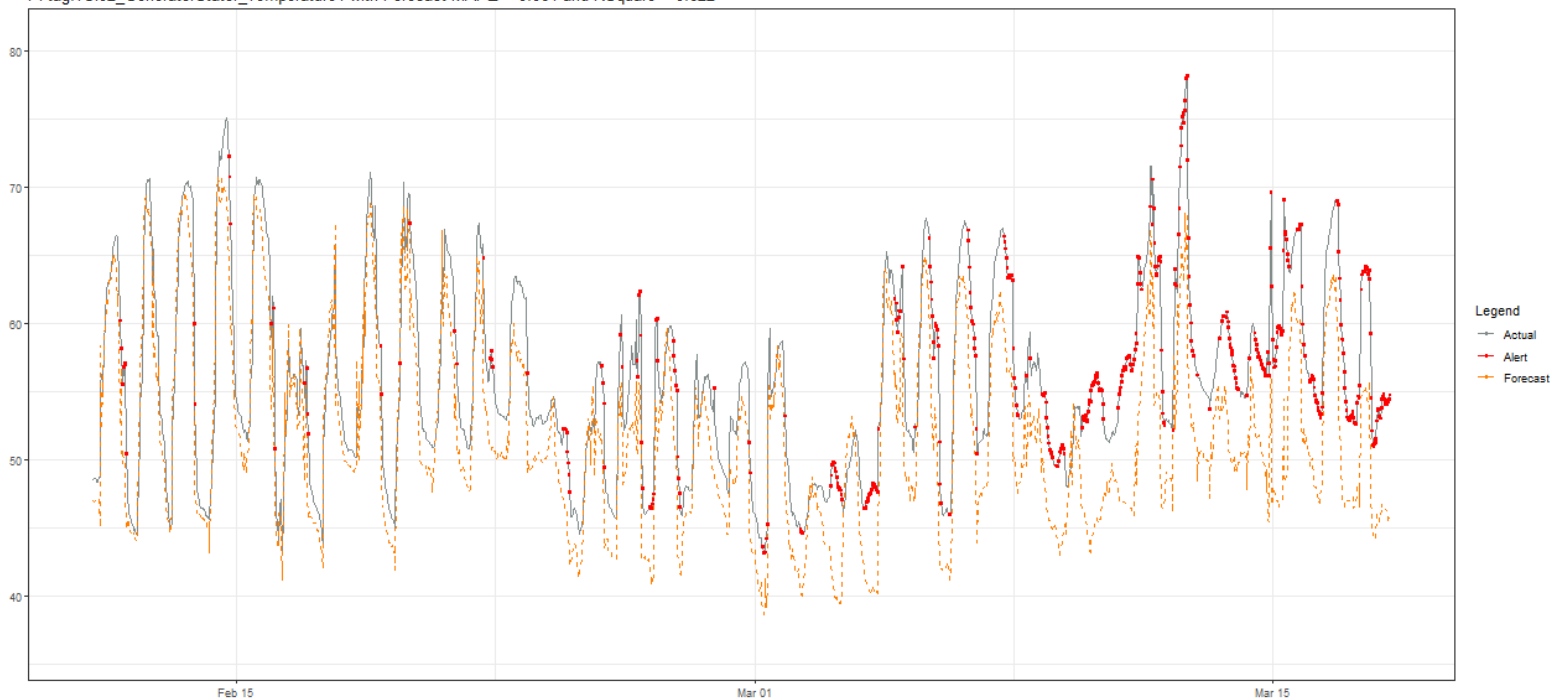
Generator Stator Temperature



This shows an example of a training period (blue), forecasted period (orange) with a good model fit (3.8% error)

Generator Stator Temperature – With Model

PI tag: TUI02_GeneratorStator_Temperature1 with Forecast MAPE = 0.064 and RSquare = 0.622

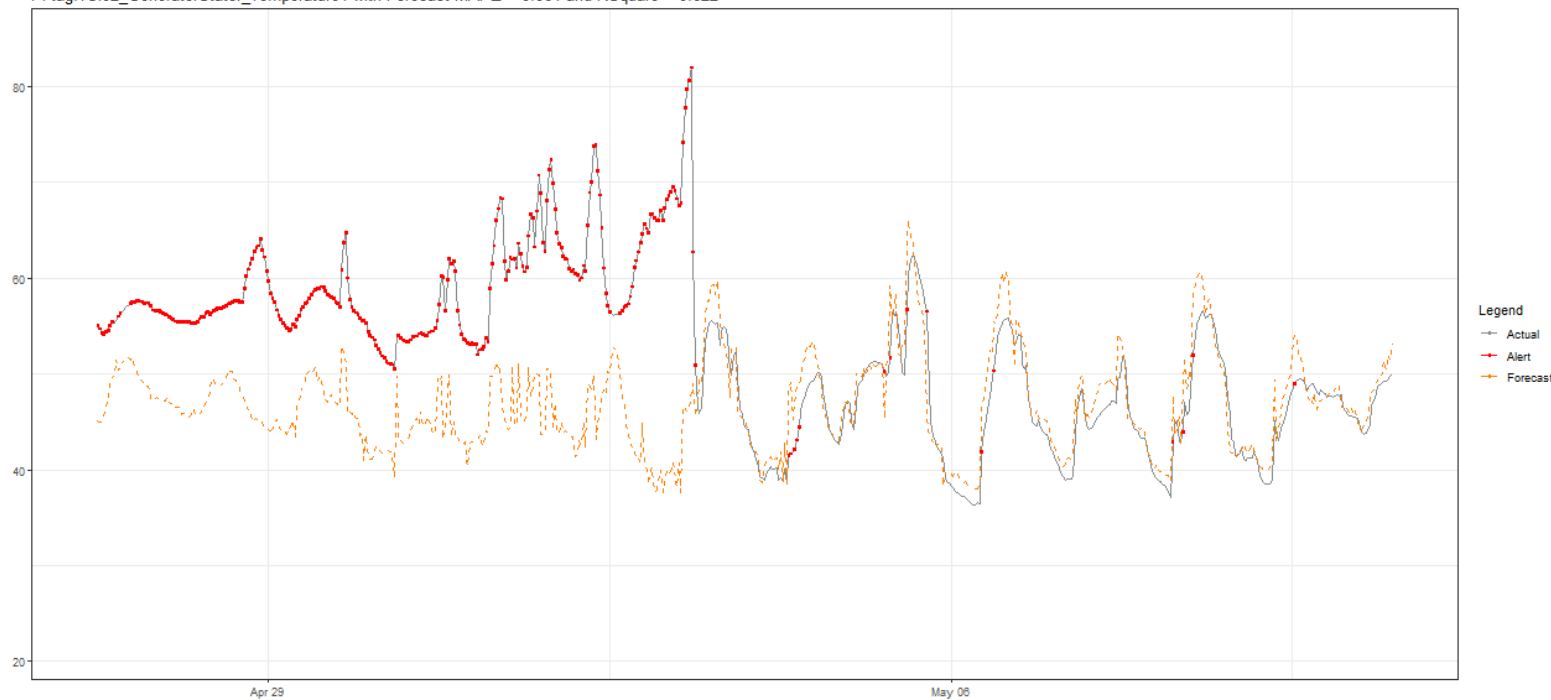


This is the start of the divergence of the actual temperature to the model.

They both start out in sync then the actual temperature starts to rise.

Generator Stator Temperature – With Model

PI tag: TUI02_GeneratorStator_Temperature1 with Forecast MAPE = 0.064 and RSquare = 0.622



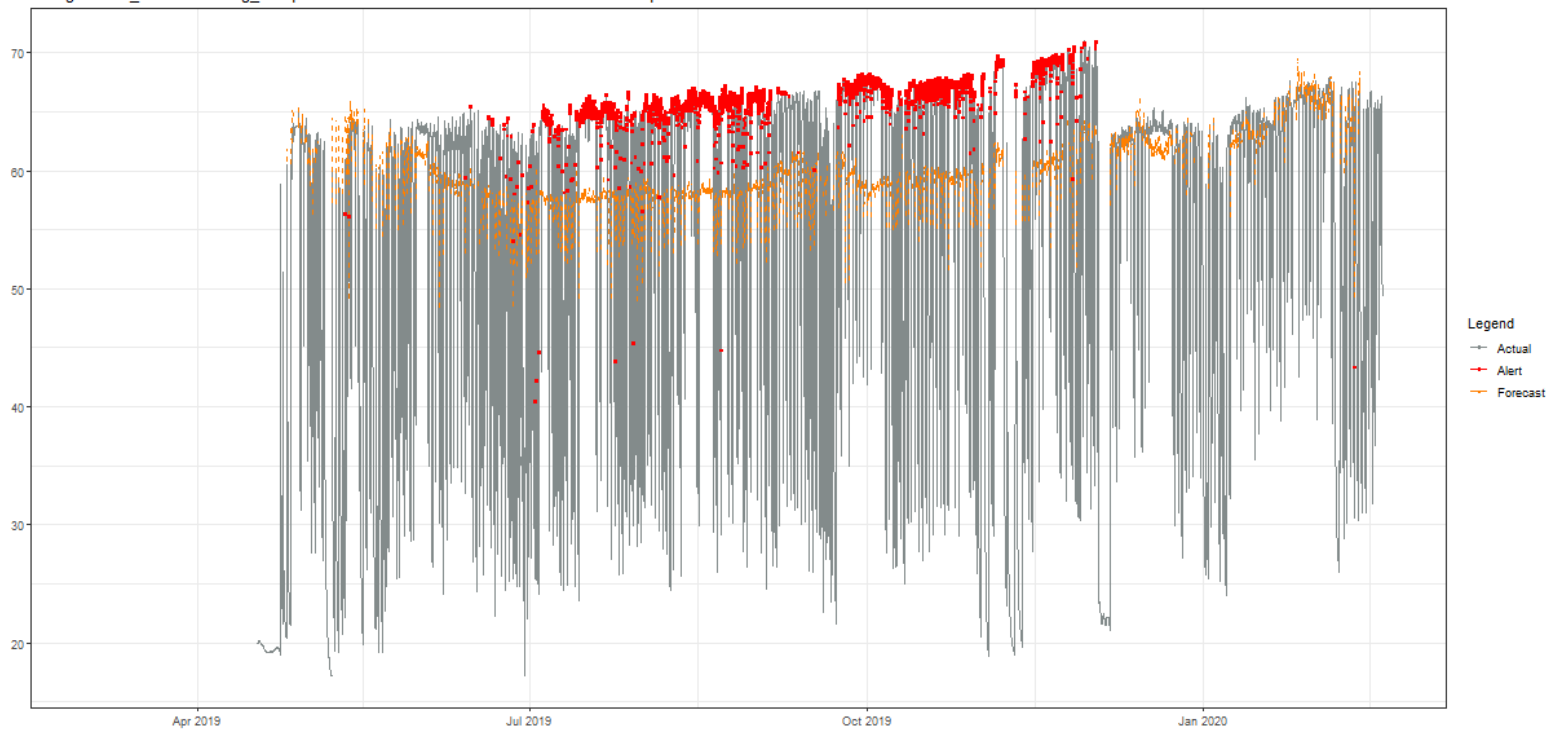
Here the issue was resolved. There was a particularly blocked air filter which meant cooling was limited.

Post repair you can see the model and actual match well again

Turbine Bearing Temperature

Modelled considering performance of other bearings

PI tag:TKU03_TurbineBearing_Temperature1 with Forecast MAPE = 0.078 and RSquare = 0.06

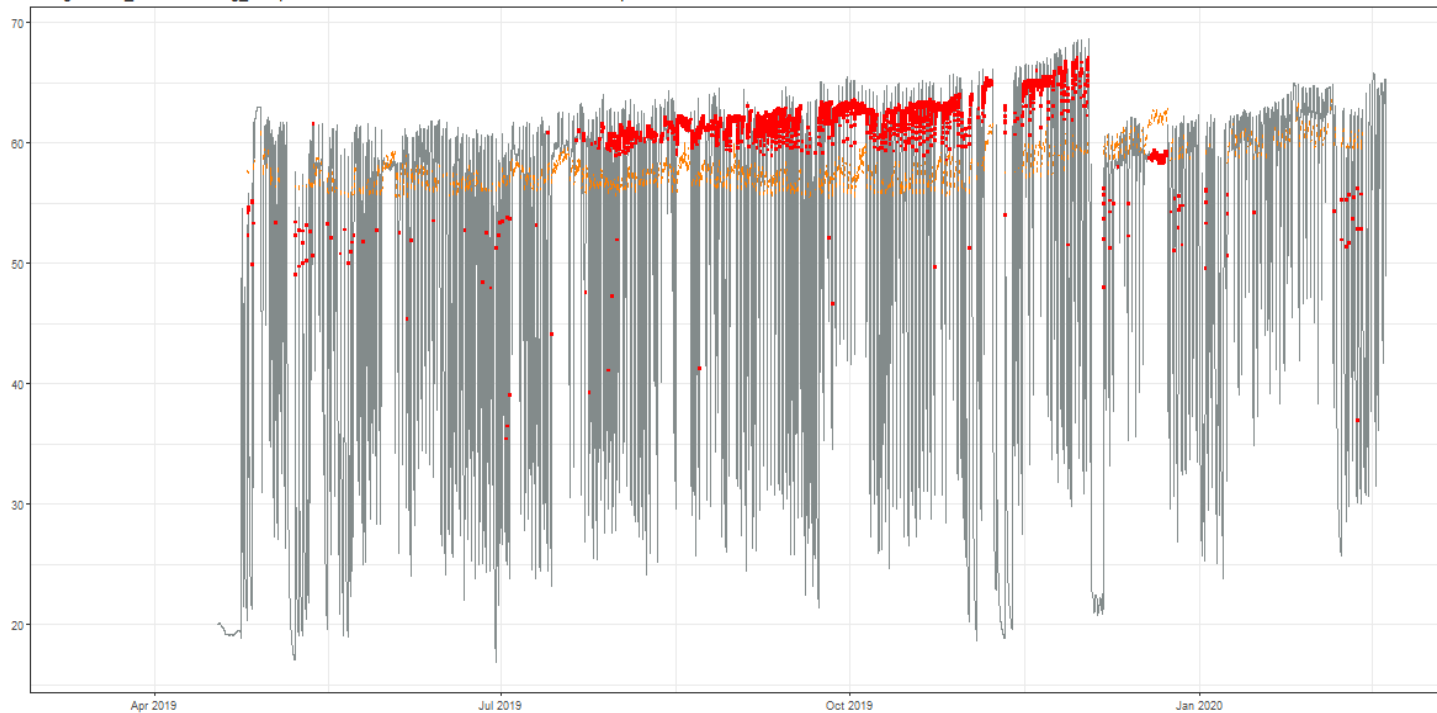


Second example monitoring bearing temperatures. This particular one is modelling temperature relative to the other bearings

Turbine Bearing Temperature

Modelled considering MW

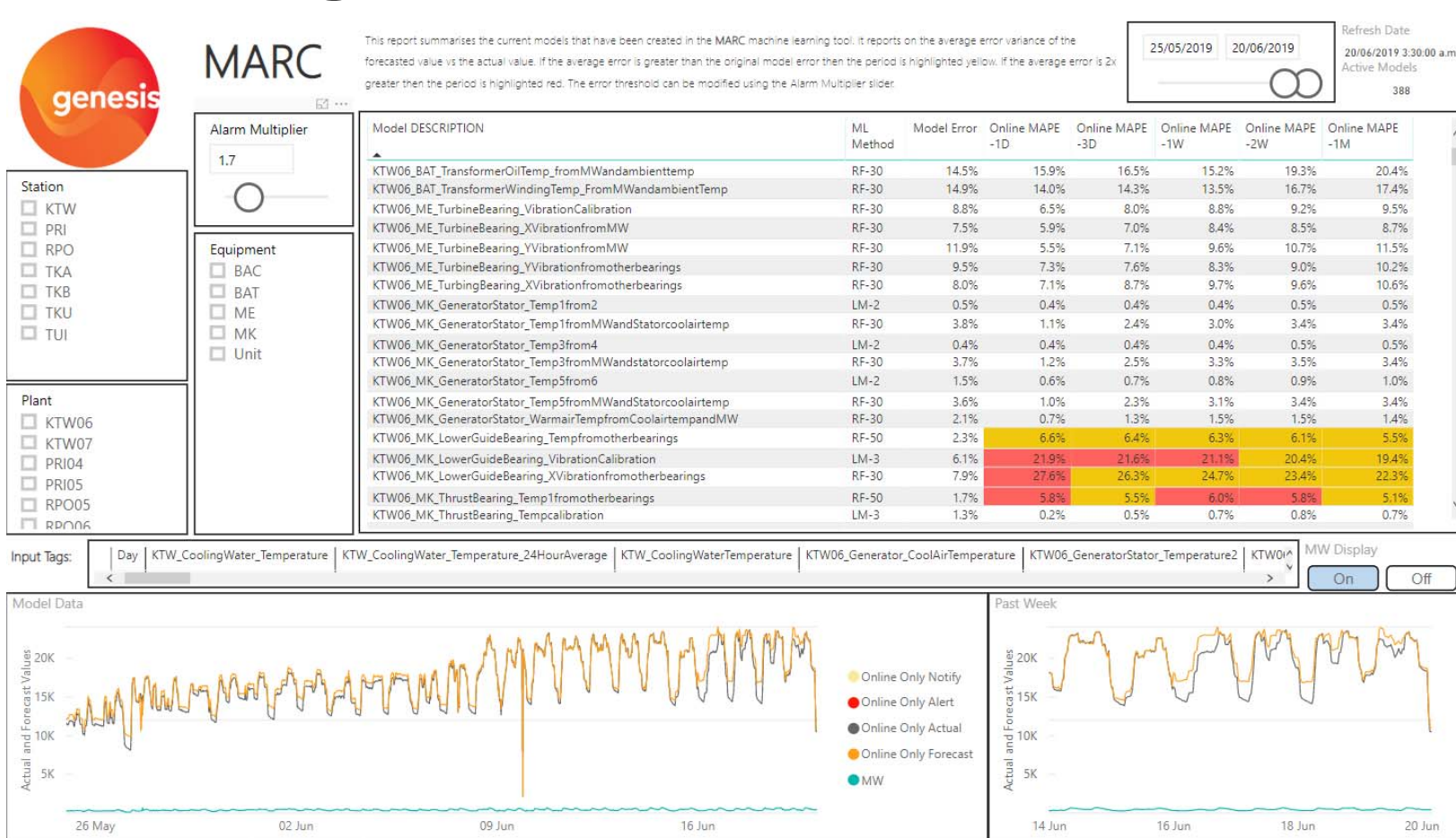
PI tag: TKU03_TurbineBearing_Temperature2 with Forecast MAPE = 0.047 and RSquare = 0.054



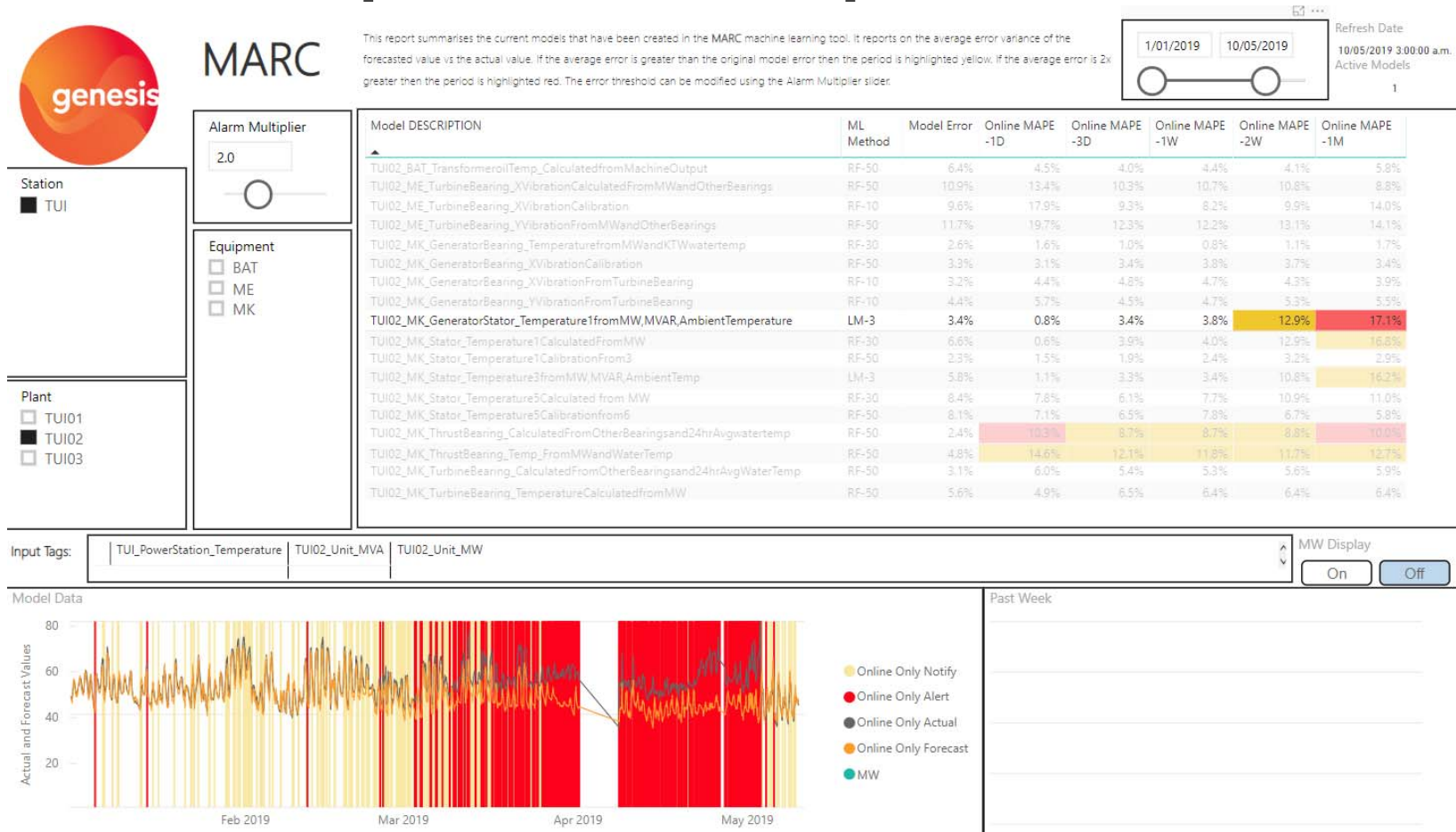
This models based on machine output and ambient conditions.

Bearing was repaired end of 2019, avoided 2 week outage extension and recasting

How to Manage Multiple Models – Power BI



Generator temperature example from before



How to we track benefits?

C. Jewell				+
63	2	19	38	4
All issues	To validate	Open	Closed	Cancelled
Search...	Location	Sort by	TicketNumber	Descending
To validate	Issue # 69 open low priority	3° increase on pad 2 temp following outage PRI05_ThrustBearing_TemperaturePad2 Thrust bearing pad 2 temp increased after annual outage. Temperature rise still looks normal and possibly due to probe arrangement in PRI thrust bearings. Will continue to monitor to see		Reported date: 17/02/2020
Open	Issue # 64 open low priority	Turbine Y vibration dropped down TUI01_TurbineBearing_YVibration y vibration readings dropped quite low on about 20th December. Discussed with Kobus, follow up with site (Neal) to see if they modified draft tube vacuum vales.		Reported date: 15/01/2020
Closed	Issue # 63 open low priority	Need to build Sync Con models TKU01_TurbineBearing_XVibration TKU01 is running alot recently on Synchronis condensing, this does not fit our existing models.		Reported date: 14/01/2020
Cancelled	Issue # 61 open medium priority	Turbine Bearing hotter than expected TKU02_TurbineBearing_TemperaturePad2 Tokaanu G2 turbine bearing hotter than expected. TA not concerned as the temp is similar to other units		Reported date: 18/12/2019
All	Issue # 60 open medium priority	Vibration step change TKU02_TurbineBearing_XVibration Turbine bearing x vibration has a step change around 1st December 2019. Needs further investigation. Looks like Y vibration doesn't change as significant.		Reported date: 17/12/2019
Total benefits:	Issue # 58 open low priority	TKB03_TurbineBearing_TemperaturePadA Turbine Bearing Pad A and B have step changes in temps e.g. 5th December at 11:30pm. . This appears to happen when there is a change over of pumps, however this doesn't seem to		Reported date: 13/12/2019
\$	Issue # 56 open	RPO05_LowerGuideBearing_YVibration		Reported date: 12/12/2019

Have a register to track issues. Assign priorities, actions, dates etc.

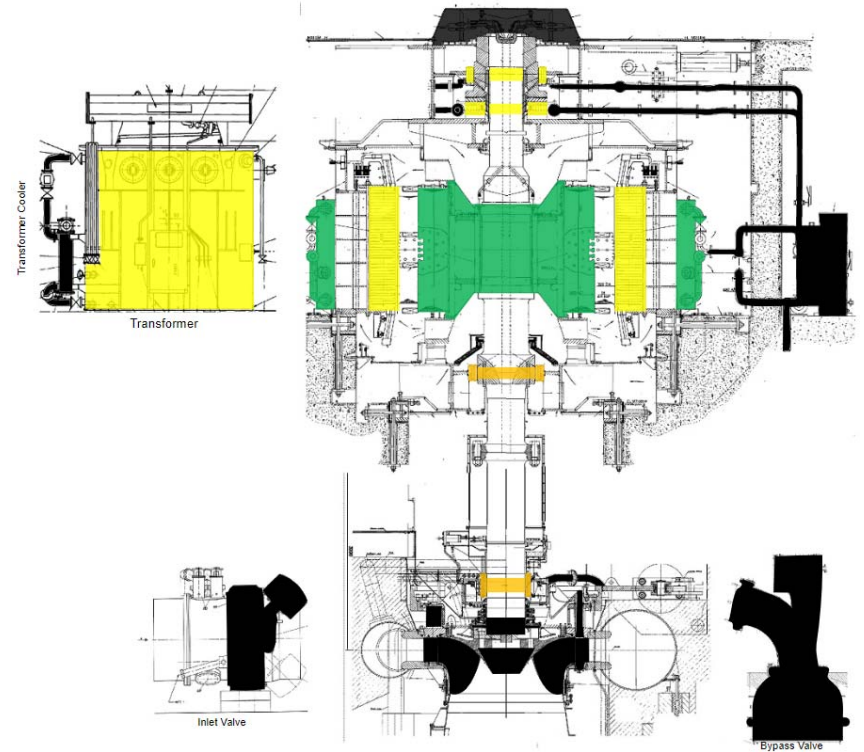
Benefits calculated from resulting failure considering likelihood of becoming genuine issue, likelihood it could have been detected prior

Achievements so far

- From Feb 2019 developed over 800 models on thermal and hydro plant
- Developed with 50% FTE and predominately internal resource costs
- Have used open source software and low code solutions
- 50+ validated issues identified
- Proven savings and avoided outages
- Good engineering buy in for ones that have been involved with an issue
- Have a large backlog of potential models still to create

Going Forward

- Better visual representation of models' performance (digital twins anyone?)
- More modelling potential; transient operations (starts and stops), long term forecasting
- Building the business process on how to manage Model 'alerts' and cultural engagement
- Confidence that modelling can replace time based maintenance
- Install more sensors to capture data and fill current data/modelling gaps



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