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…

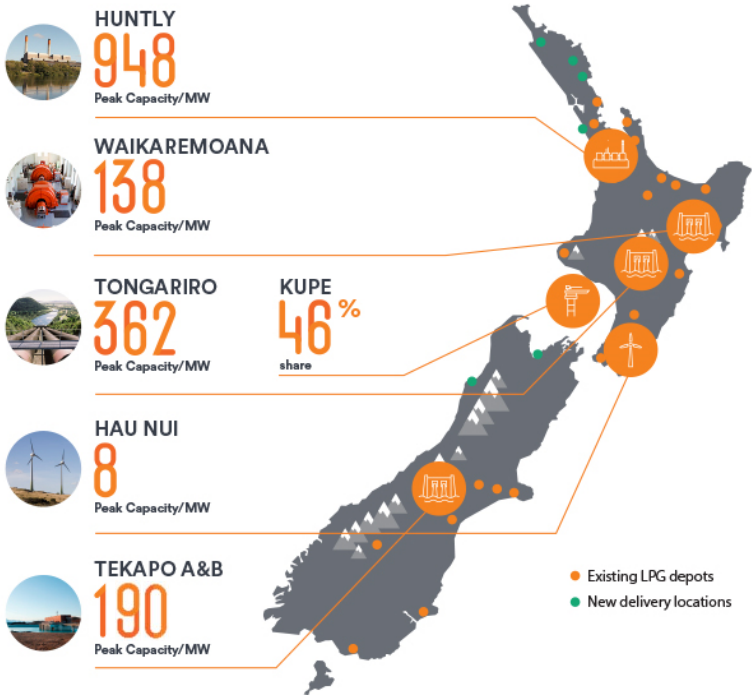
- Small country in the southwest Pacific Ocean
- From a power generation perspective
  - ~43,000 GWh annually
  - ~9000 MW installed capacity
- 2018 **annual** primary energy supply equivalent to **3½ days** for USA

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

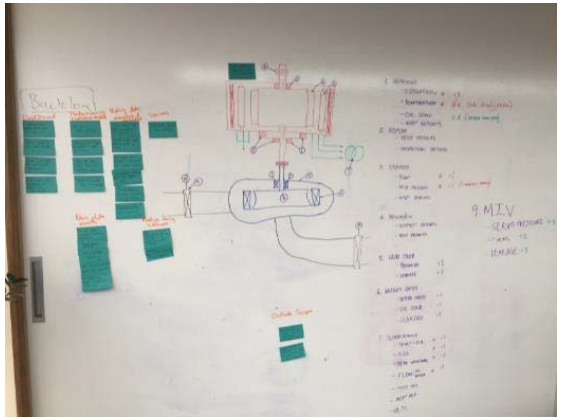
24% Dual Fuel

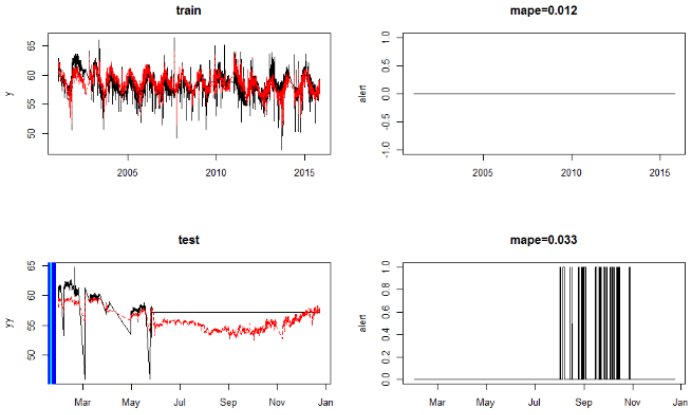
PURPOSE:

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

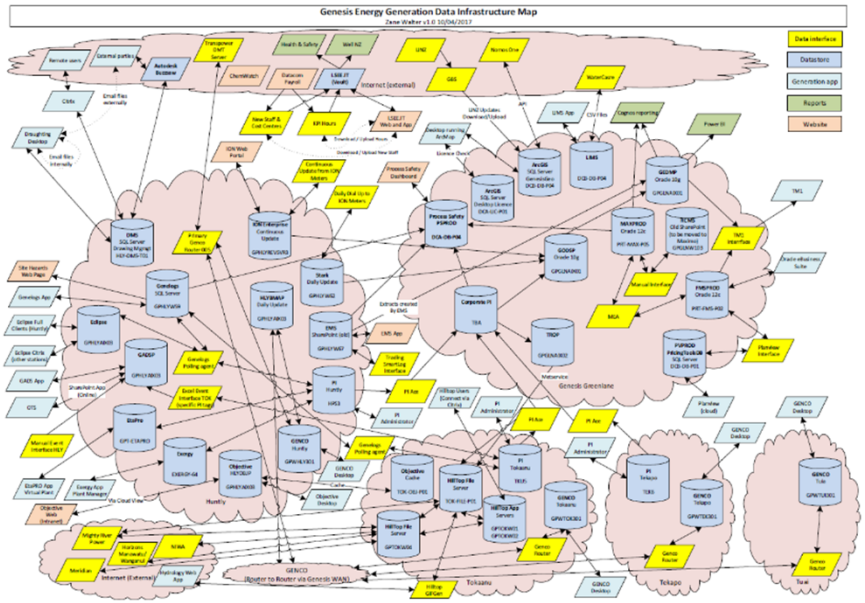




How did the PI System fit in?

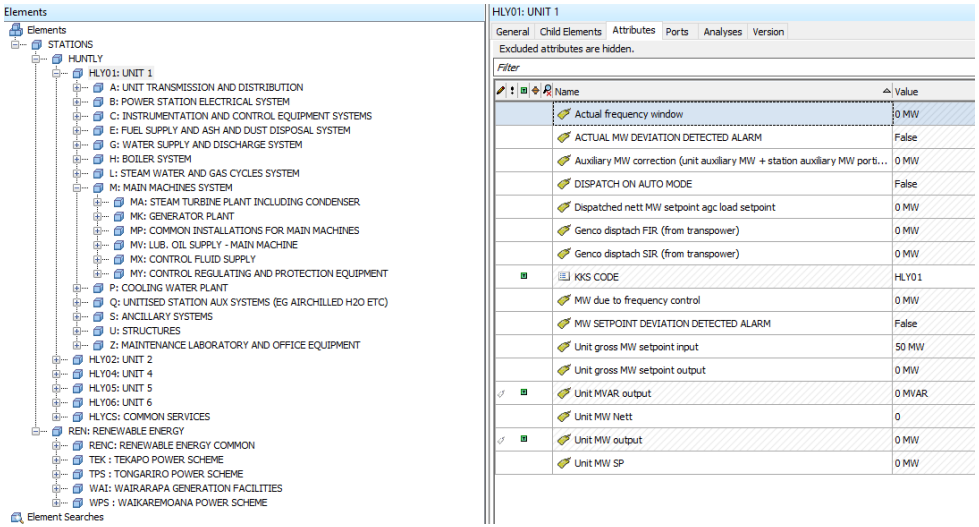
PI Server Asset Framework (AF) and PI Integrator

- 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



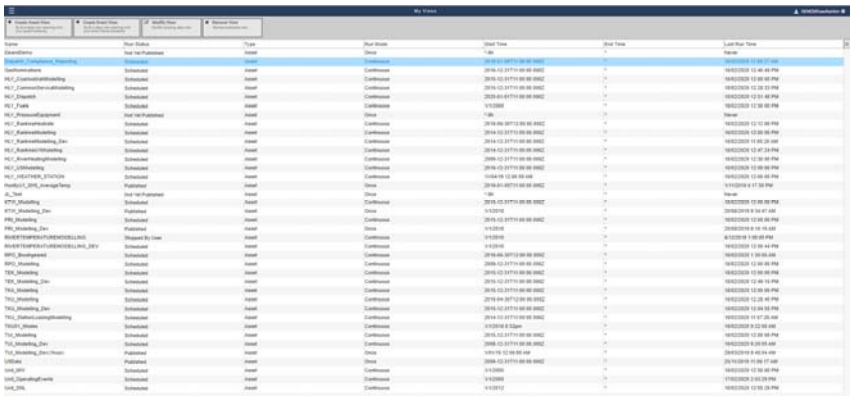
PI Server Asset Framework

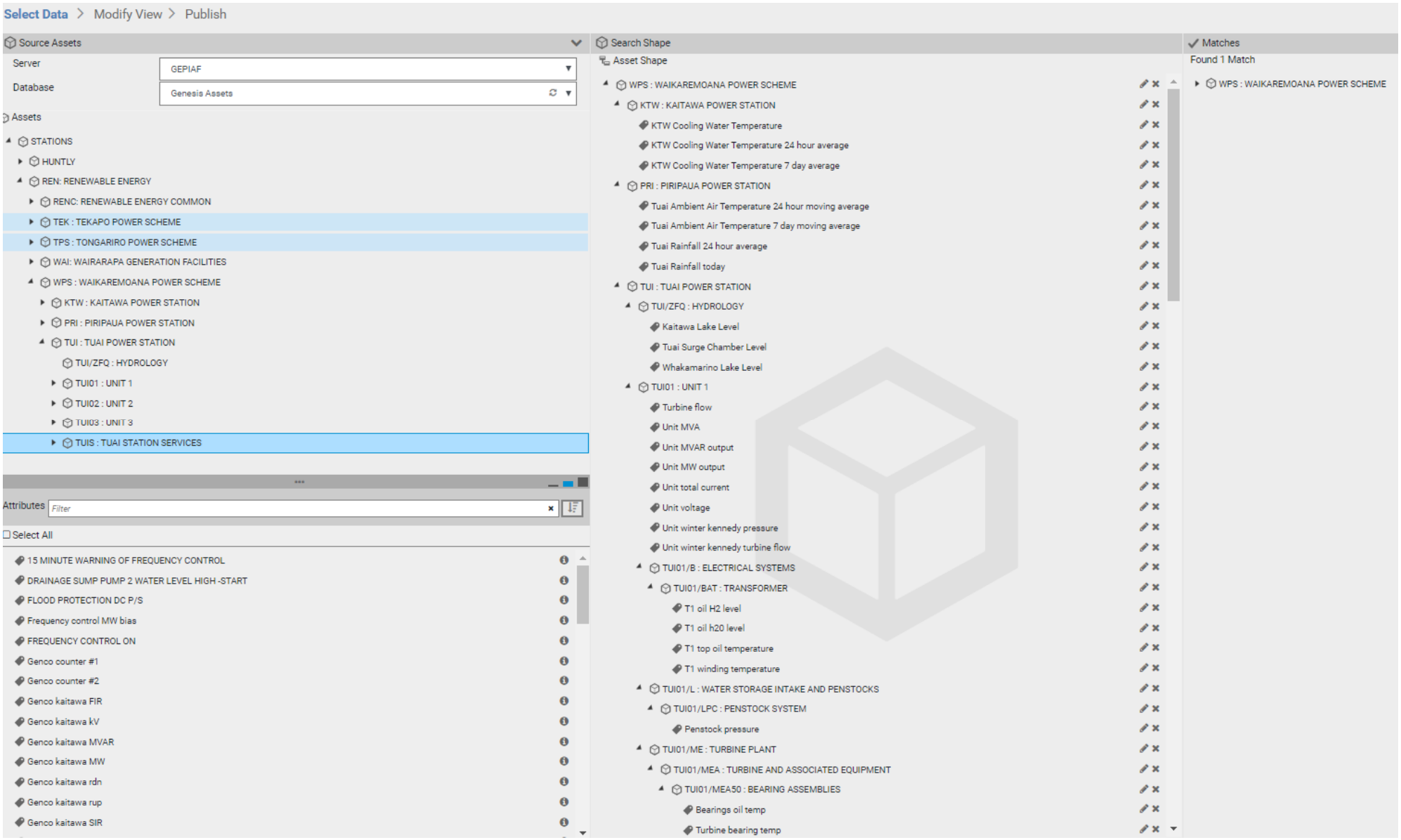
- PI Server Asset Framework is necessary for PI Integrator – we hadn't deployed AF
- Duplicated existing CMMS hierarchy to an AF hierarchy
- OSIsoft Partner managed deployment and aligning 70% of tags into hierarchy
- PI Server Asset Framework also has a lot of potential that we are not using at this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



PI Integrator

- Utilises AF hierarchy
- Pull in necessary tags
- Define interval and data context (eg average, min, max)
- Writes data to data warehouse
- Data can be scheduled or single load
- For us writes to Azure Datawarehouse but are other options (Amazon, Microsoft, Oracle, flat file)

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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

Select Data > **Modify View** > Publish

Back | Next

Add Column
101 columns

Edit Row Filters
0 Row Filters

Edit Value Mode
Interpolated Values
Every 30 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	128.018	9.094	10.109	19.542	34.200	41.063	37.552
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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
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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
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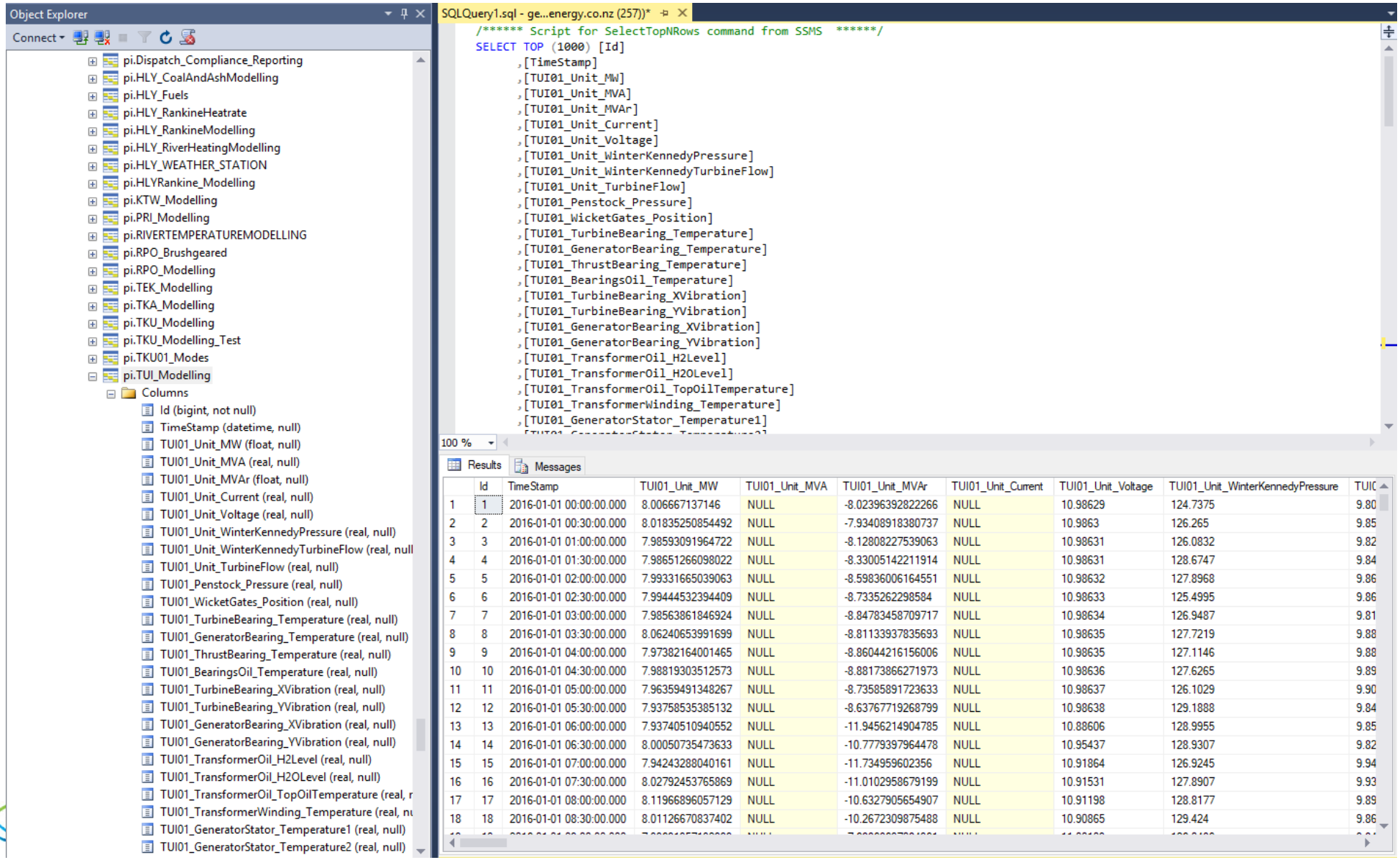
1/01/2016 6:00:00 PM	7.96		-2.057		11.237	129.277	9.863	10.198	19.570	32.800	42.252	37.824
1/01/2016 6:30:00 PM	7.965		-2.3		11.238	127.422	9.802	10.199	19.574	32.800	42.262	37.802



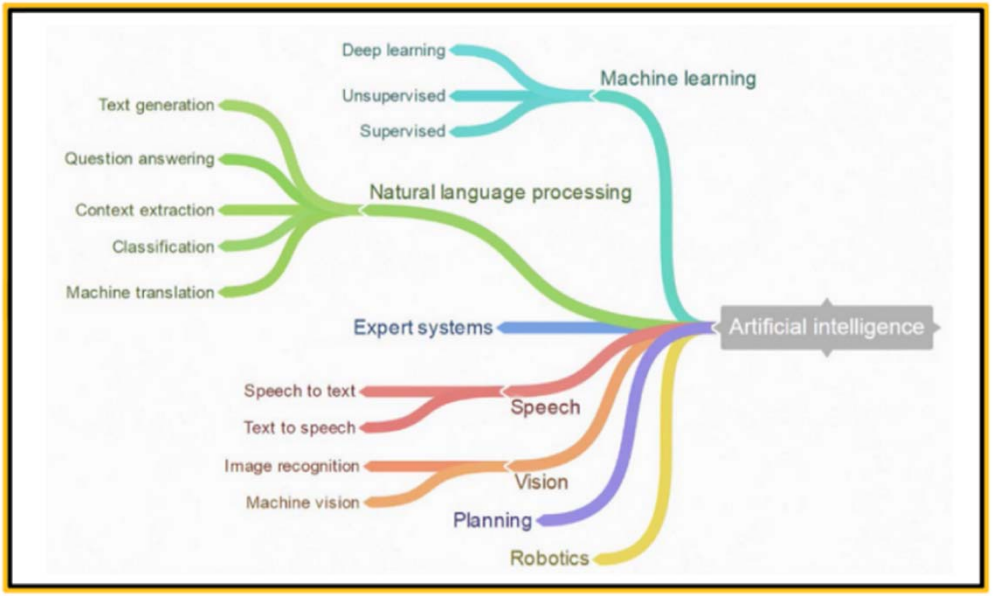
	Id	TimeStamp	TUI01_Unit_MW	TUI01_Unit_MVA	TUI01_Unit_MVAr	TUI01_Unit_Current	TUI01_Unit_Voltage	TUI01_Unit_WinterKennedyPressure	TUI0
1	1	2016-01-01 00:00:00.000	8.006667137146	NULL	-8.02396392822266	NULL	10.98629	124.7375	9.80
2	2	2016-01-01 00:30:00.000	8.01835250854492	NULL	-7.93408918380737	NULL	10.9863	126.265	9.85
3	3	2016-01-01 01:00:00.000	7.98593091964722	NULL	-8.12808227539063	NULL	10.98631	126.0832	9.82
4	4	2016-01-01 01:30:00.000	7.98651266098022	NULL	-8.33005142211914	NULL	10.98631	128.6747	9.84
5	5	2016-01-01 02:00:00.000	7.99331665039063	NULL	-8.59836006164551	NULL	10.98632	127.8968	9.86
6	6	2016-01-01 02:30:00.000	7.99444532394409	NULL	-8.7335262298584	NULL	10.98633	125.4995	9.86
7	7	2016-01-01 03:00:00.000	7.98563861846924	NULL	-8.84783458709717	NULL	10.98634	126.9487	9.81
8	8	2016-01-01 03:30:00.000	8.06240653991699	NULL	-8.81133937835693	NULL	10.98635	127.7219	9.88
9	9	2016-01-01 04:00:00.000	7.97382164001465	NULL	-8.86044216156006	NULL	10.98635	127.1146	9.88
10	10	2016-01-01 04:30:00.000	7.98819303512573	NULL	-8.88173866271973	NULL	10.98636	127.6265	9.89
11	11	2016-01-01 05:00:00.000	7.96359491348267	NULL	-8.73585891723633	NULL	10.98637	126.1029	9.90
12	12	2016-01-01 05:30:00.000	7.93758535385132	NULL	-8.63767719268799	NULL	10.98638	129.1888	9.84
13	13	2016-01-01 06:00:00.000	7.93740510940552	NULL	-11.9456214904785	NULL	10.88606	128.9955	9.85
14	14	2016-01-01 06:30:00.000	8.00050735473633	NULL	-10.7779397964478	NULL	10.95437	128.9307	9.82
15	15	2016-01-01 07:00:00.000	7.94243288040161	NULL	-11.734959602356	NULL	10.91864	126.9245	9.94
16	16	2016-01-01 07:30:00.000	8.02792453765869	NULL	-11.0102958679199	NULL	10.91531	127.8907	9.93
17	17	2016-01-01 08:00:00.000	8.11966896057129	NULL	-10.6327905654907	NULL	10.91198	128.8177	9.89
18	18	2016-01-01 08:30:00.000	8.01126670837402	NULL	-10.2672309875488	NULL	10.90865	129.424	9.86

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

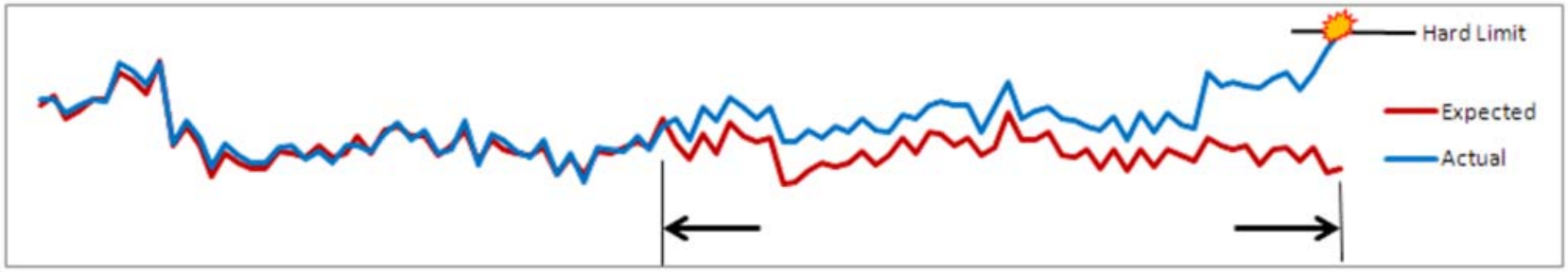
- Data warehouse/historian – key
- Other data possibilities – CMMS, software diagnostics, market data, weather
- 'Sandbox'/platform to model data/develop algorithms without having to code



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

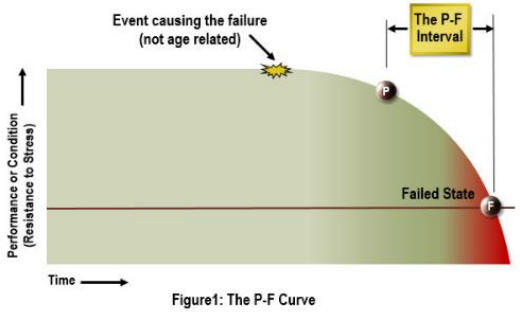
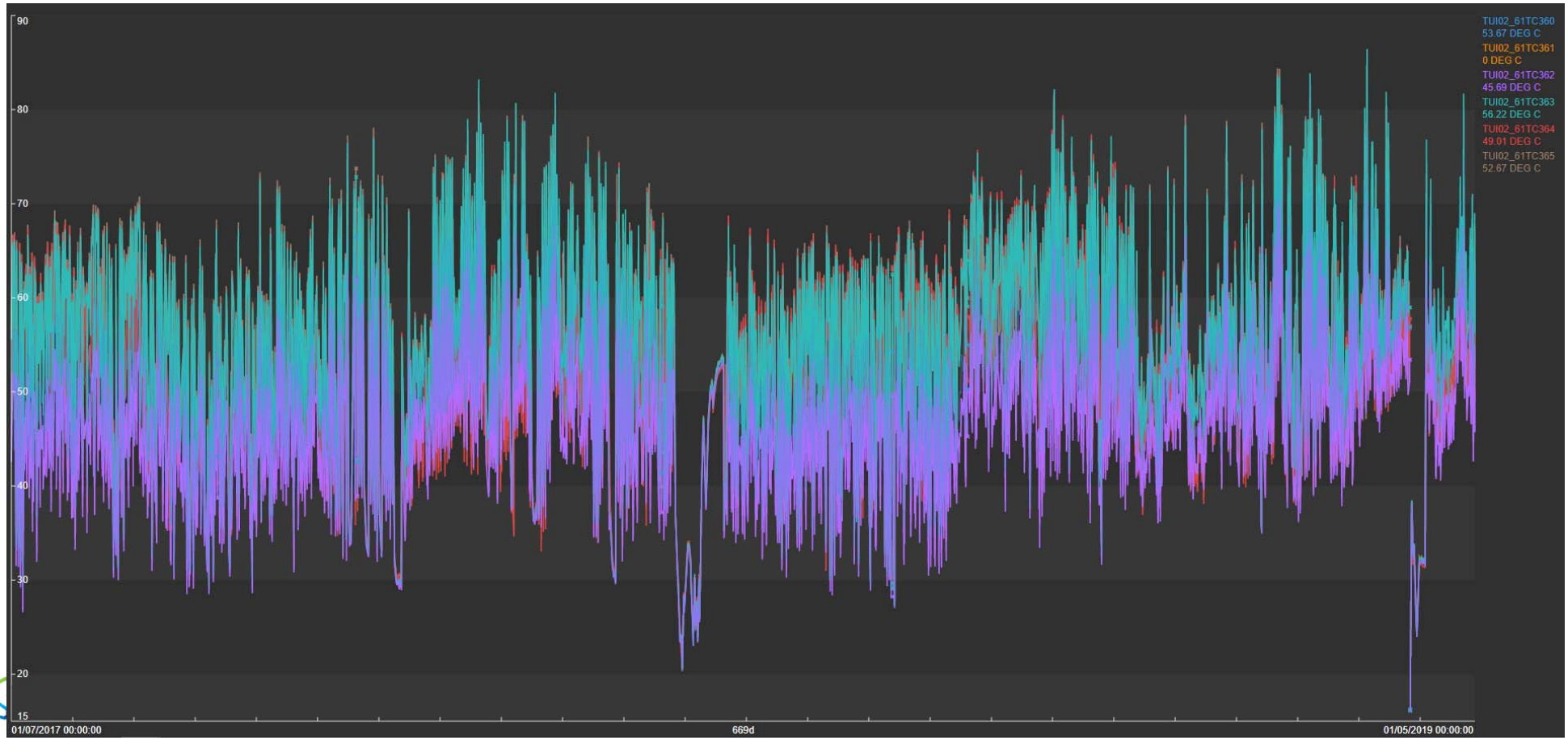


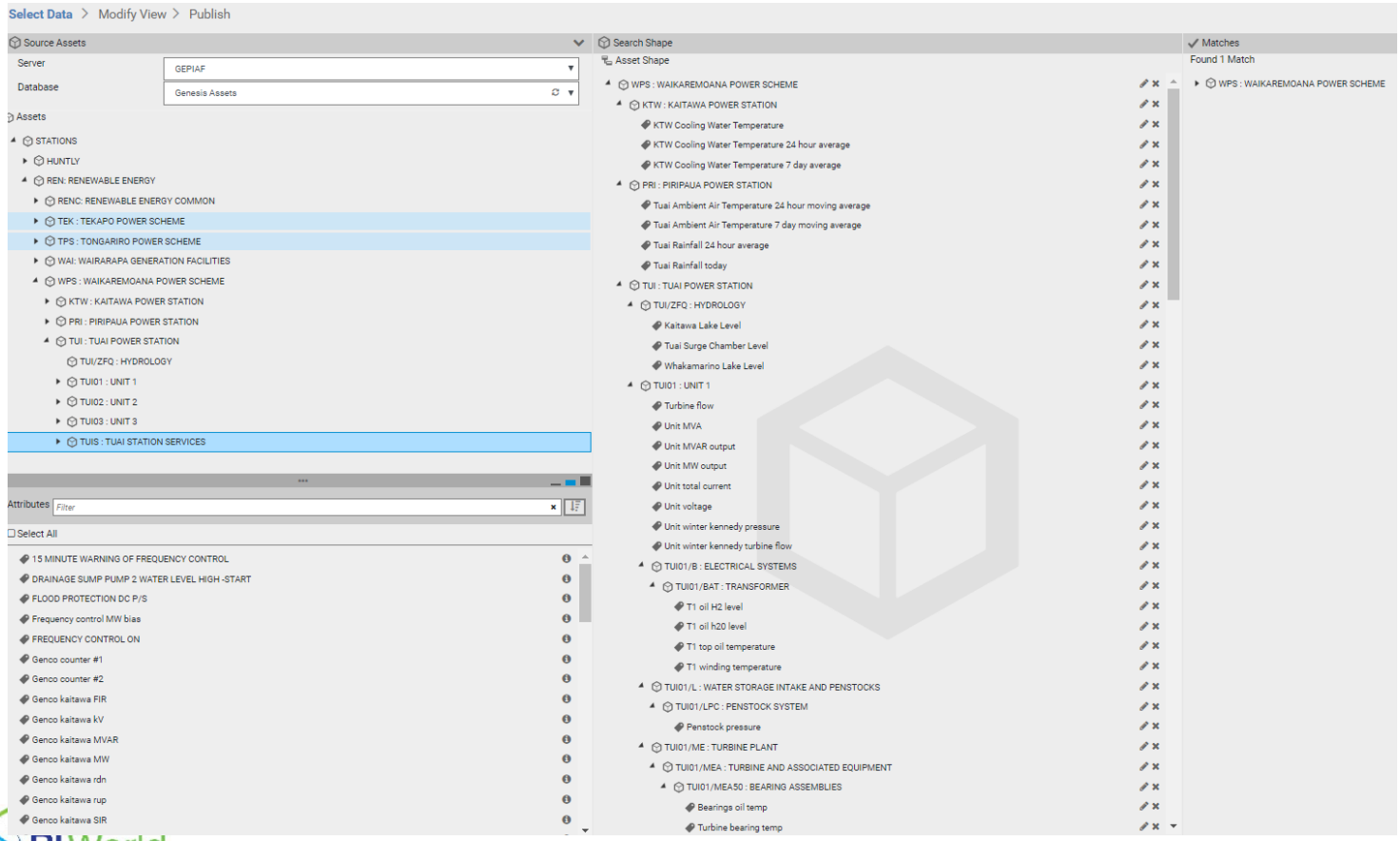
Figure1: The P-F Curve

PI Vision - Stator Temp Last 2 Years

Can you spot the asset health issue?

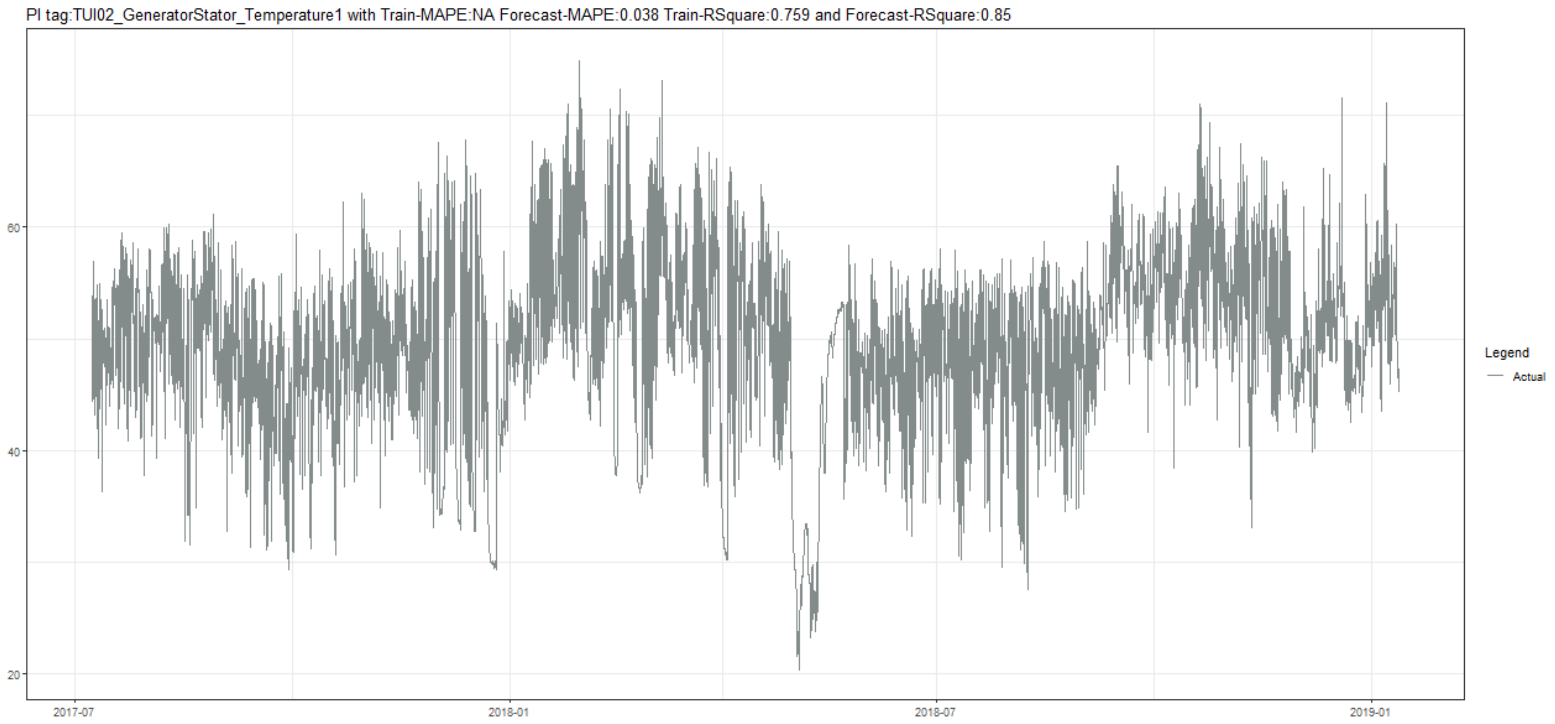


PI Integrator



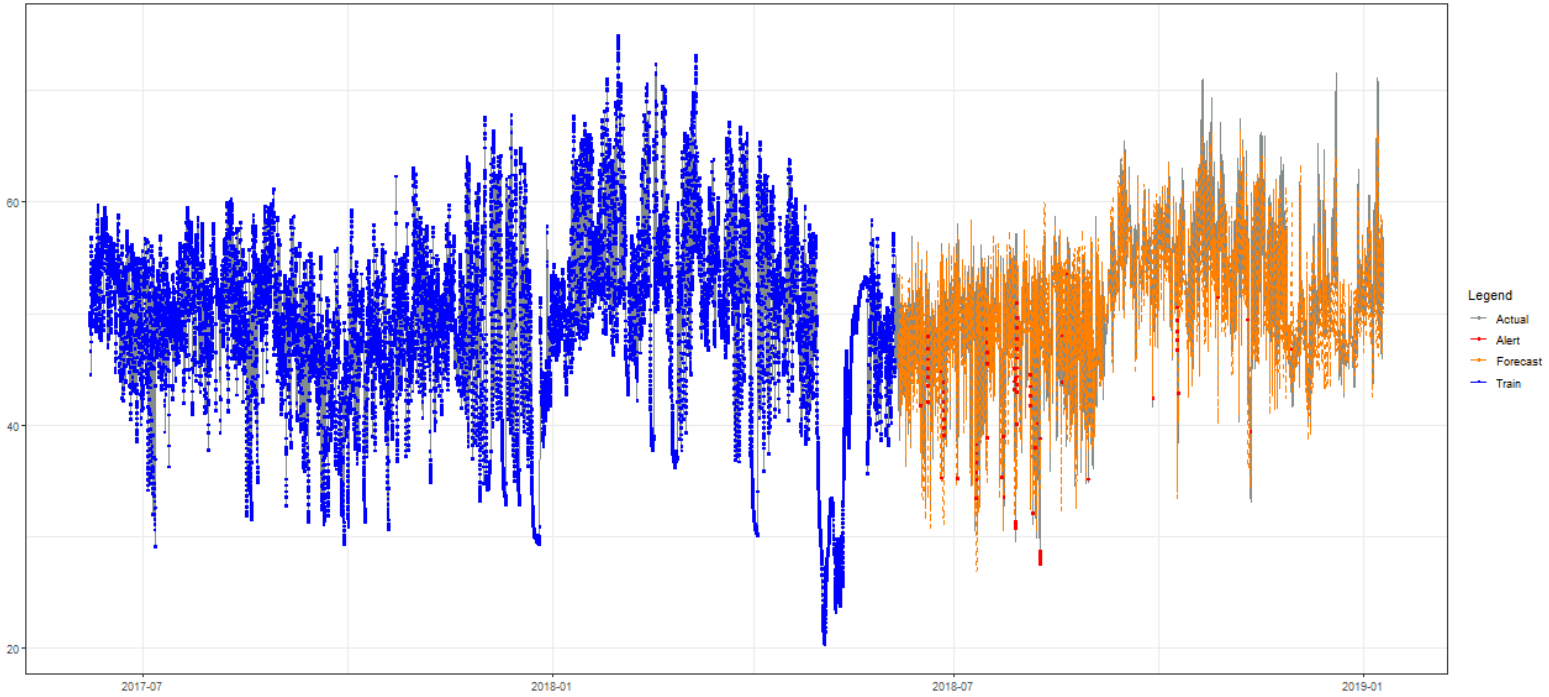
PI Integrator makes the data accessible for analytics in our tool

Our In-house Tool



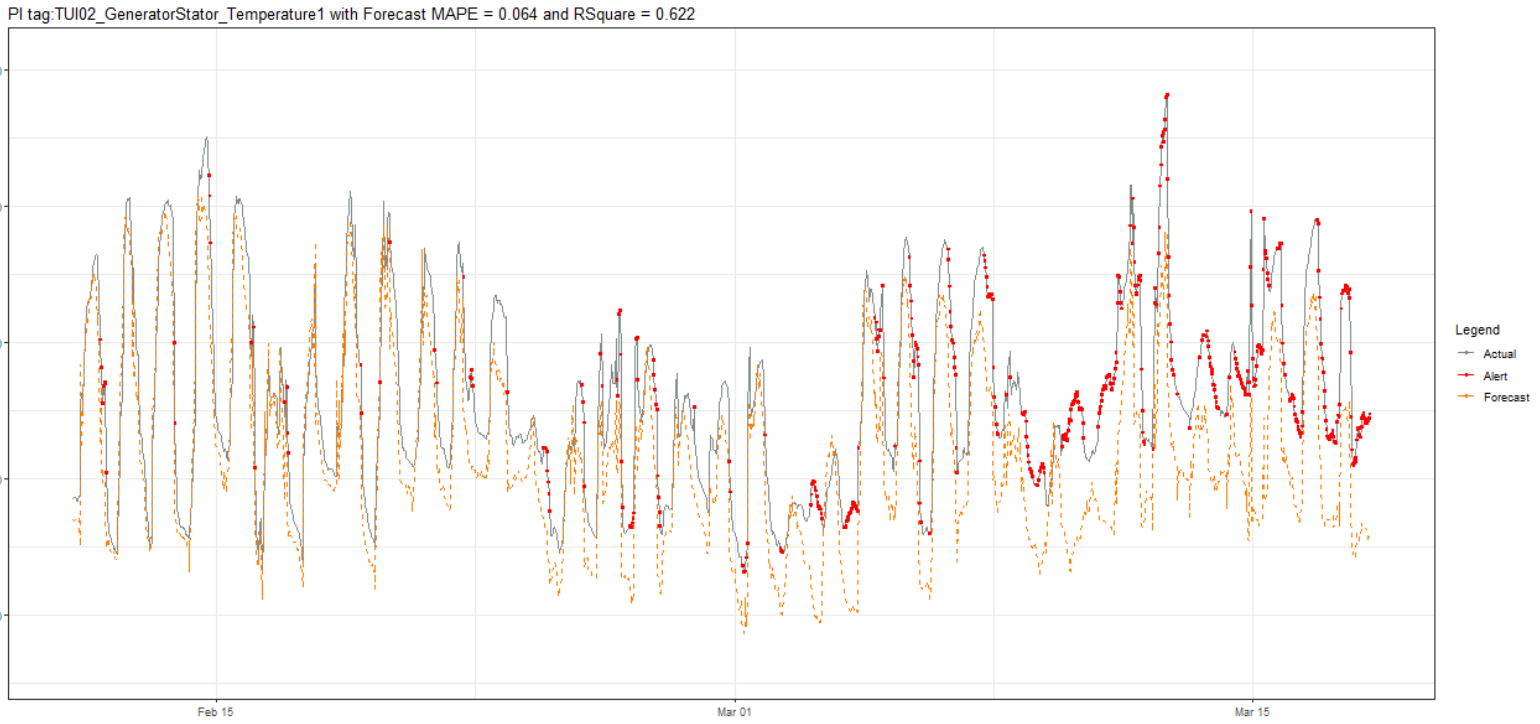
Ability to select input variables, remove unrelated data (eg plant in outage), training periods and forecasting check to validate model

Generator Stator Temperature



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

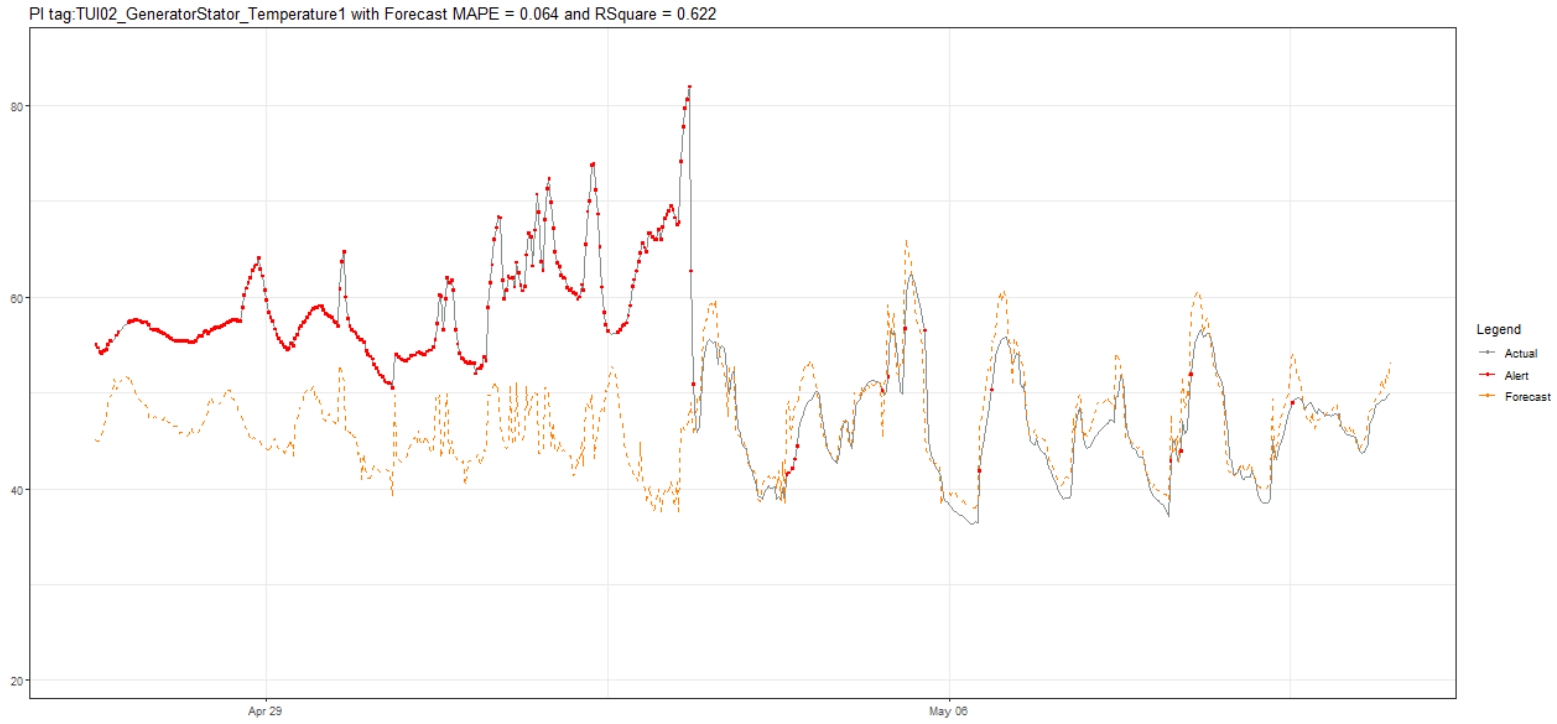
Generator Stator Temperature – With Model



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.

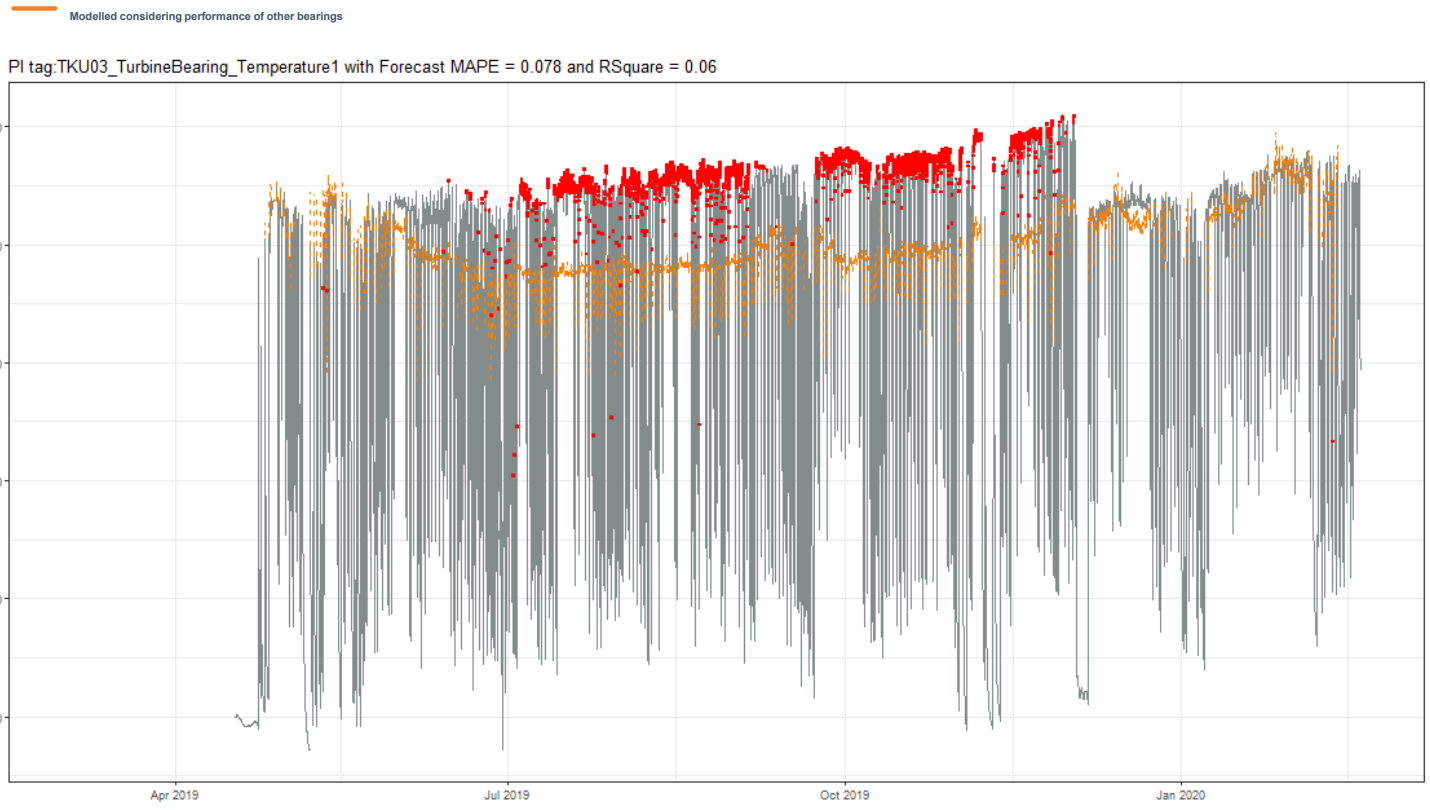
Generator Stator Temperature – With Model



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

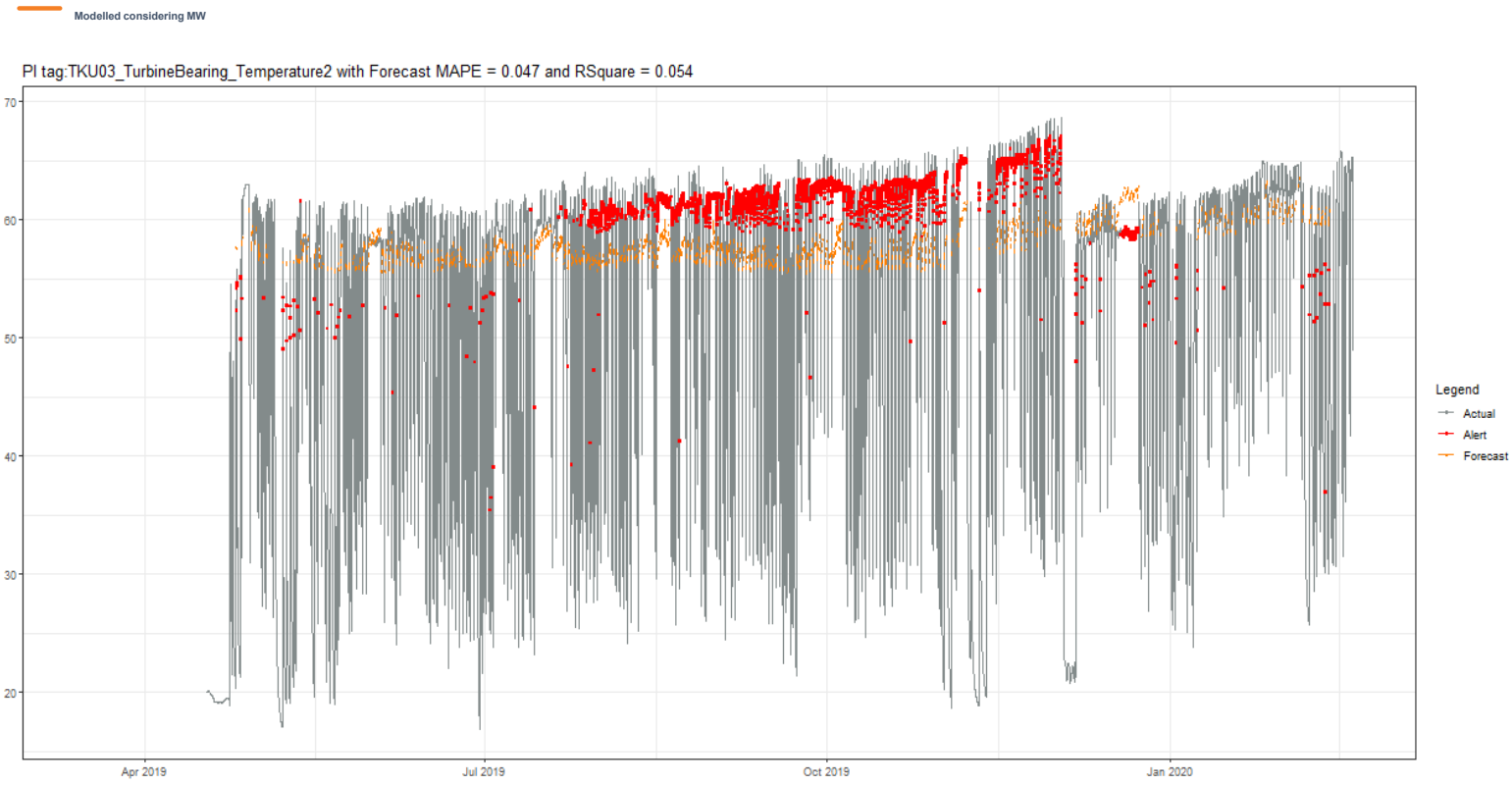
Post repair you can see the model and actual match well again

Turbine Bearing Temperature



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

Turbine Bearing Temperature

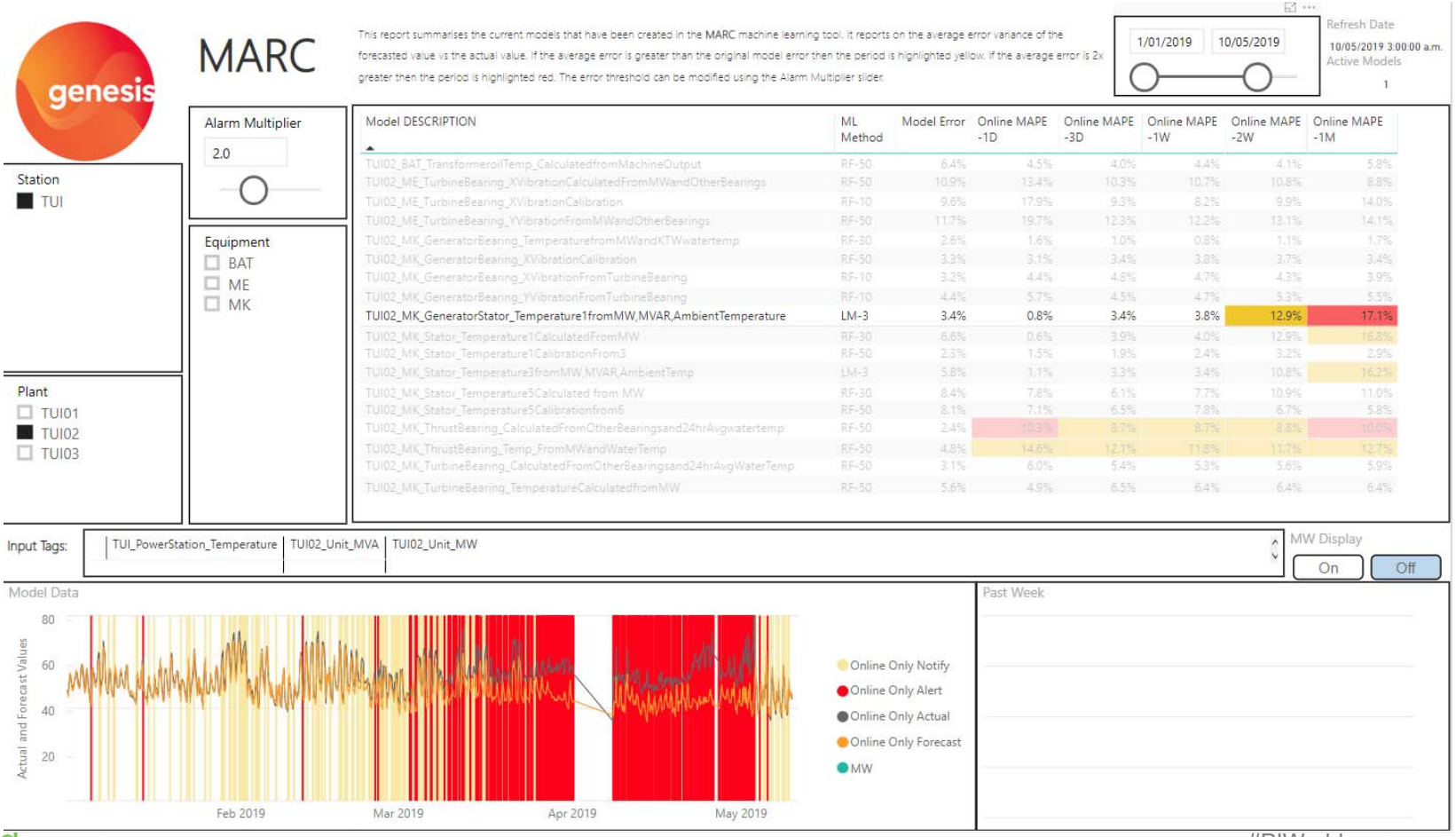


This models based on machine output and ambient conditions.

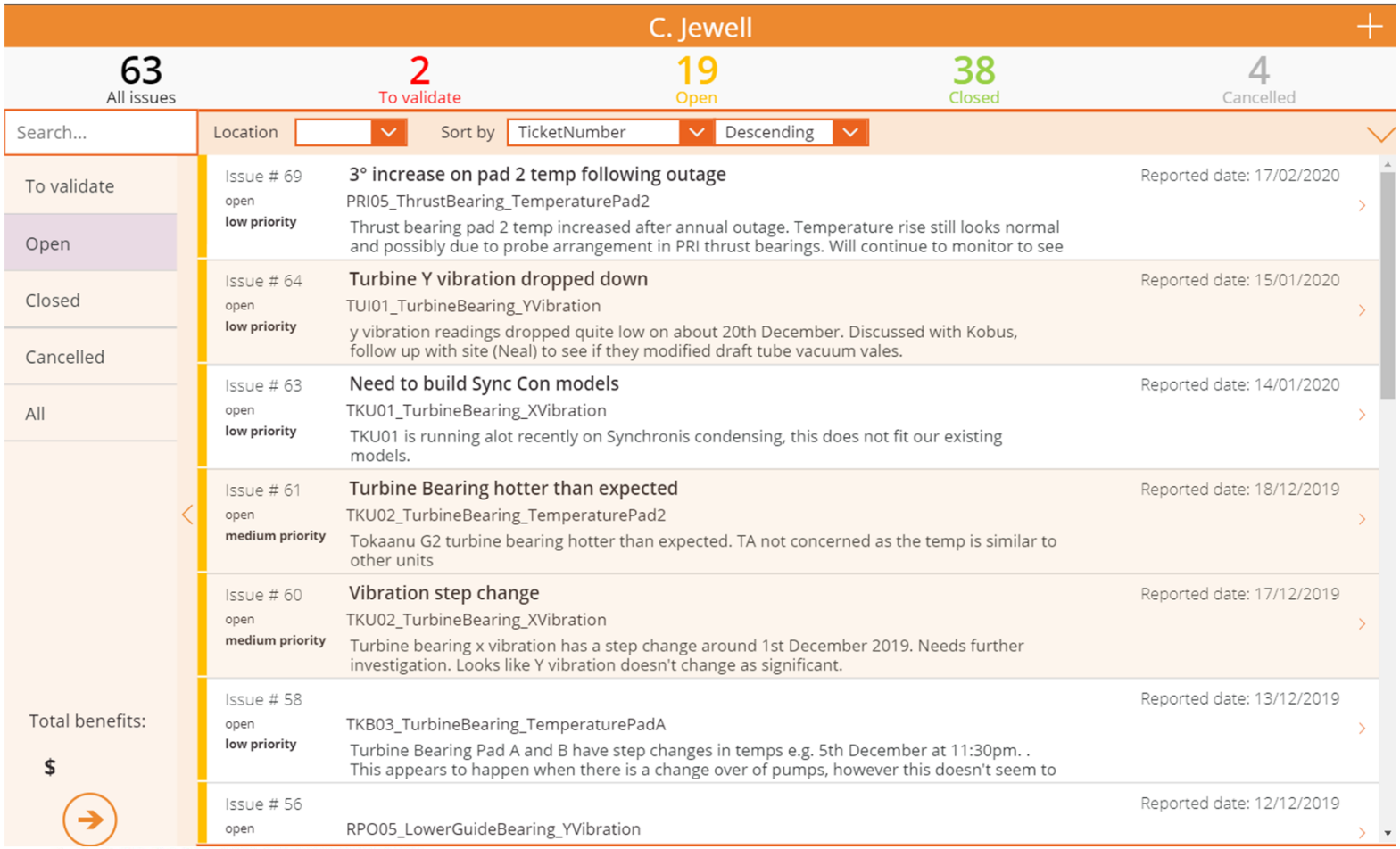
Bearing was repaired end of 2019, avoided 2 week outage extension and recasting

How to Manage Multiple Models – Power BI

Generator temperature example from before



How to we track benefits?



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

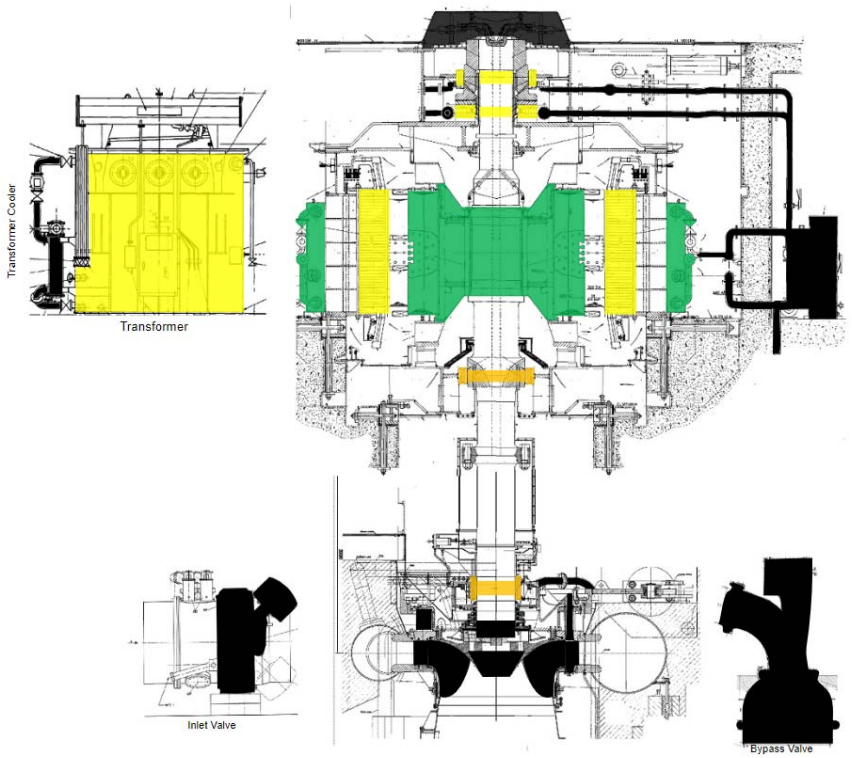
Benefits calculated from resulting failure considering likelihood of becoming genuine issue, likelihood it could have been detected prior

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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