



Carnot Innovations

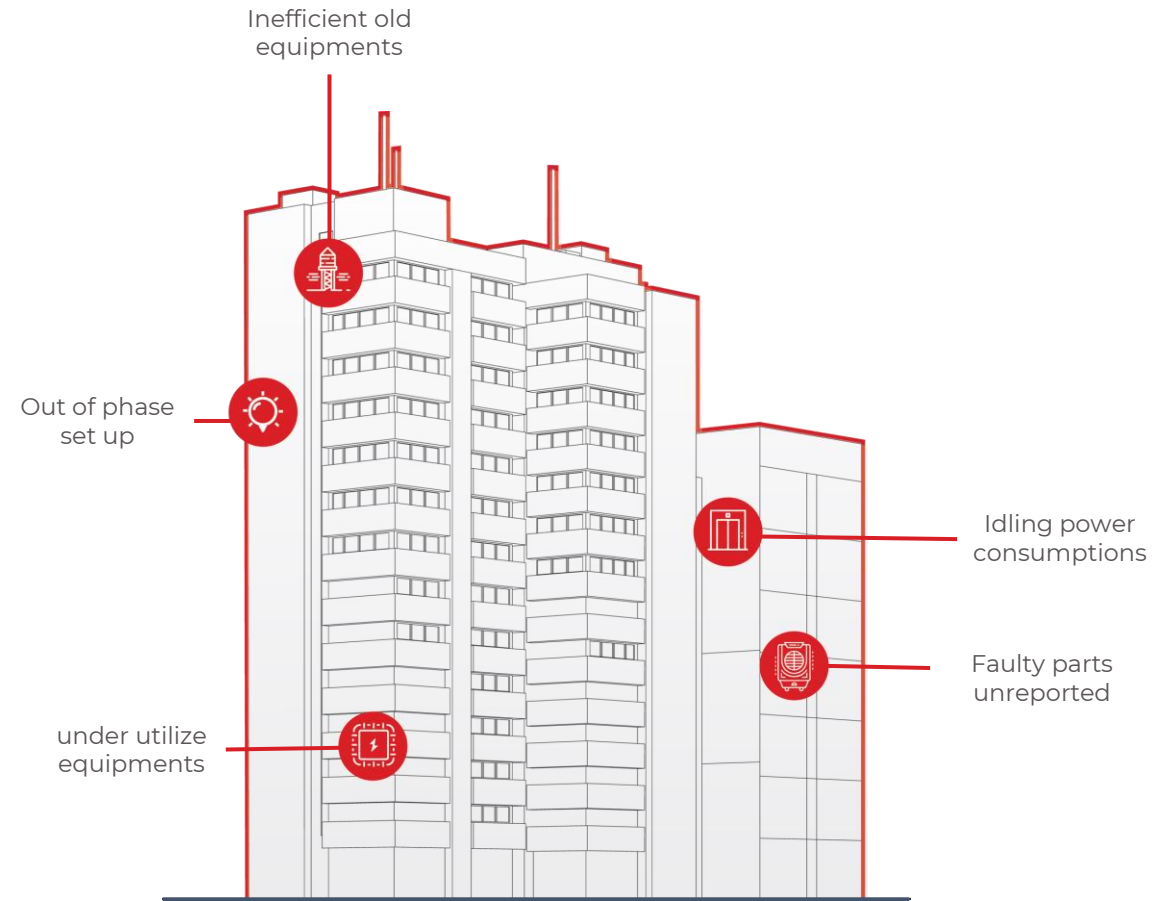
AI Powered Building Optimization Platform

Reducing operational overheads in commercial buildings
through AI analytics and controls

BUSINESS OPPORTUNITY

We are an advanced energy utilization and maintenance platform for commercial buildings

Existing energy management and maintenance practices are inefficient and can waste up to **20%** of building operational budgets, globally this incurs over **20B USD** every year!





Skilled Labor Intensive

Skilled labor is required to perform routine checks every month.



Critical Faults are not dealt with in time

Small faults such as pump failures can have a knock-on effect on entire plant.



Faults stays Undetected for Weeks

Causing higher energy consumption in addition to breakdowns



Inefficient Operations Parameters

Unadaptive operations with poor operational efficiency.



Data Driven Smart Building

Data driven approach generates unique insights through millions of data points.



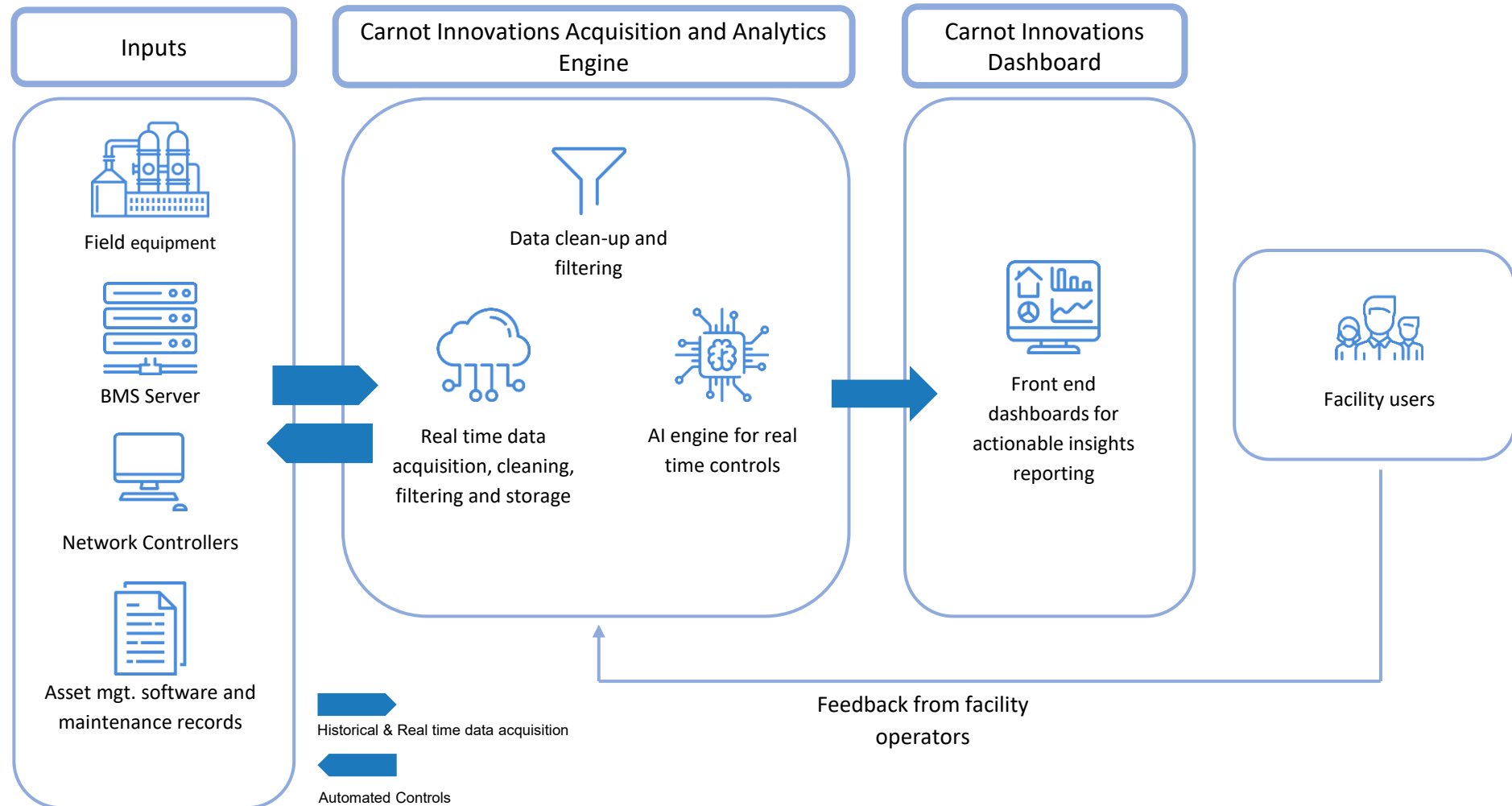
Historical data store



Open data protocol

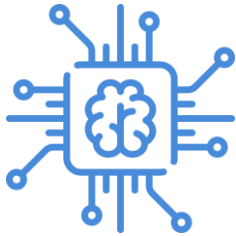
Our process

We deliver data-driven actionable Insights & performs automated controls to help optimize maintenance and energy costs

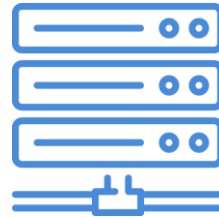


Data-Driven Operation in Smart Building

From Descriptive to Prescriptive Analytics



**Data Driven
Optimized Controls**



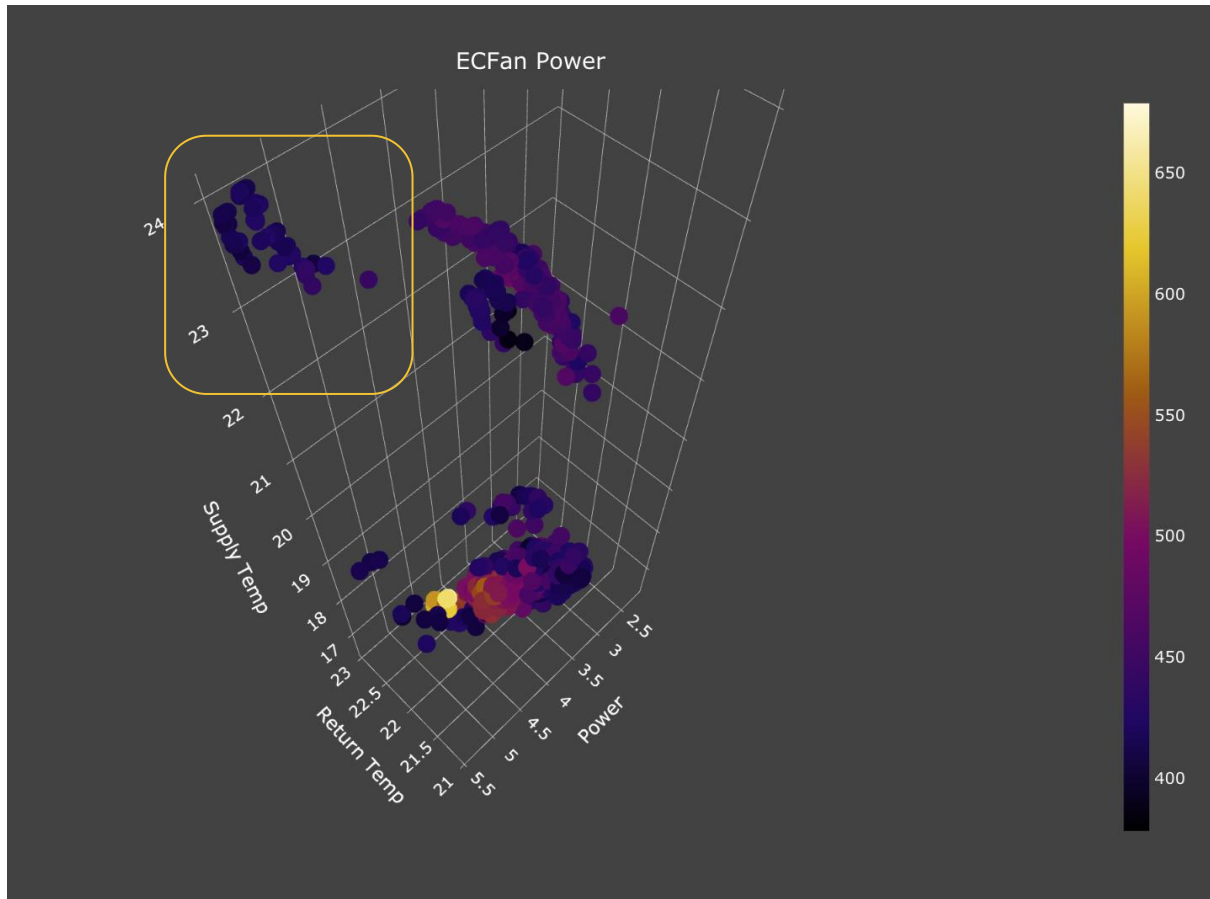
**Anomaly
Detection
Algorithm**



**Rich Data
Visualization**

Diagnostics with advanced visualization

Rich Visualization and insights for better diagnostics

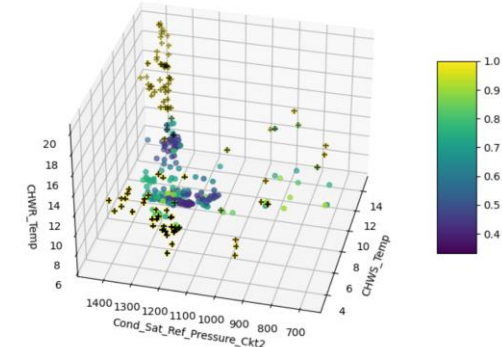
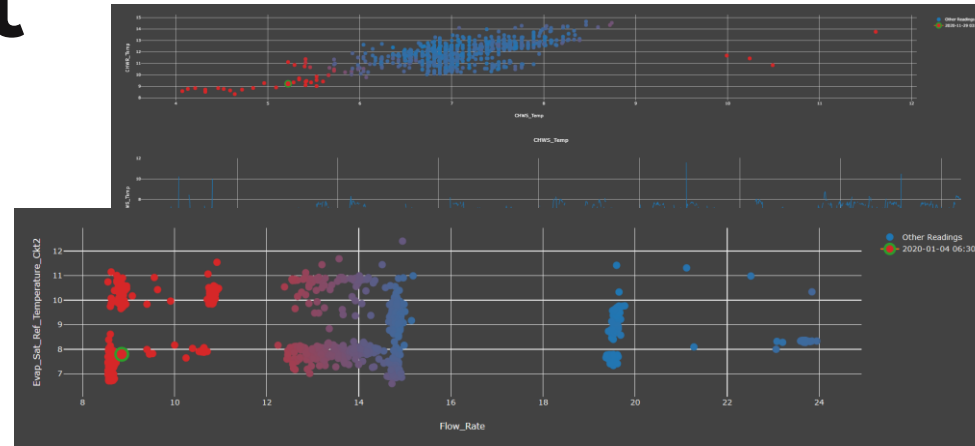


Color indicates CO2 values in ppm

Predictive Fault Diagnostics

We identify, predict and resolve hidden faults before they lead to severe equipment failures

Unsupervised machine learning based fault diagnostics



Logic based Fault Detection & Diagnostics

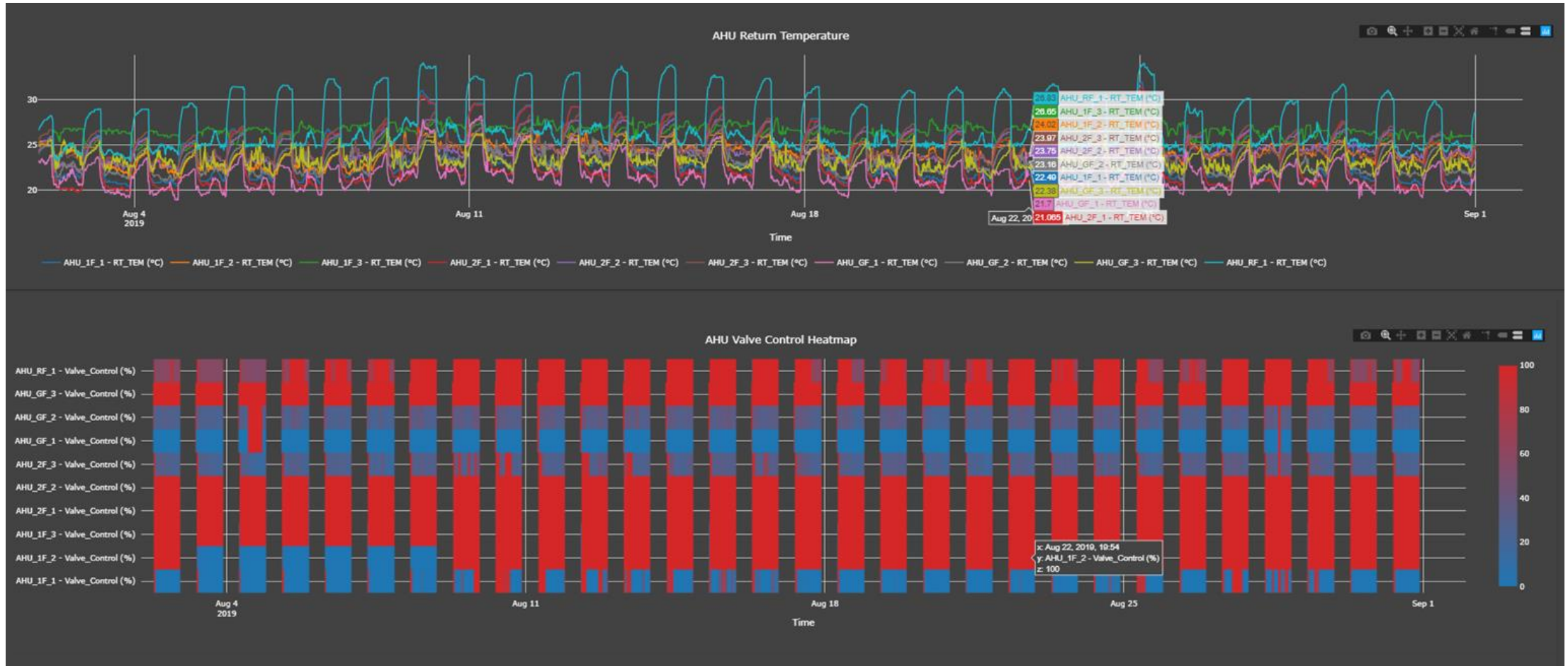
Fault Detection						
2019-06-30 23:45:00		2019-12-31 23:4				
Equipment Name						
Fault	Active (yr)	Severity	Cost	Active (as % of on time)	Last Detected	Actions
Chiller Condenser Supply Return temperature difference is less than 4.5 Deg C	9018	High	0	0%	2019-12-31T23:45:00	
Chiller Condenser differential pressure > 2.5 psi for 2 hrs or more when chiller is on	81	High	0	0%	2019-12-19T09:45:00	
Chiller Short Cycling	10	High	0	0%	2019-12-21T18:00:00	
CHWS_Temp Sensors Ratiomed	126	Low	0	0%	2019-09-22T17:15:00	
CHWS_Temp Sensors Ratiomed	345	Low	0	0%	2019-12-16T17:15:00	
Chilled Water differential pressure is < than 1.45 psi for 2 hours or more when Chiller is running	4	Low	0	0%	2019-12-15T11:15:00	
Condenser differential pressure sensors Ratiomed	423	Low	0	0%	2019-12-16T20:00:00	
Differential pressure sensors Ratiomed	180	Low	0	0%	2019-12-02T13:00:00	
Chilled Water differential pressure > 3 psi when chiller is off for a period of 2 hrs or more	38	Medium	0	0%	2019-07-21T18:45:00	
Efficiency is more than 0.58 Kw per ton (COP of 6) for a period of more than 2 hours	4343	Medium	0	0%	2019-10-16T15:30:00	
VSD feedback and VSD control differ more than 4% for a period of 2 hours	33038	Medium	0	0%	2019-12-31T23:45:00	
When pump is running, VSD control and VSD feedback differ more than 4%	17683	Medium	0	0%	2019-12-31T23:45:00	

Notifications and real time alerts



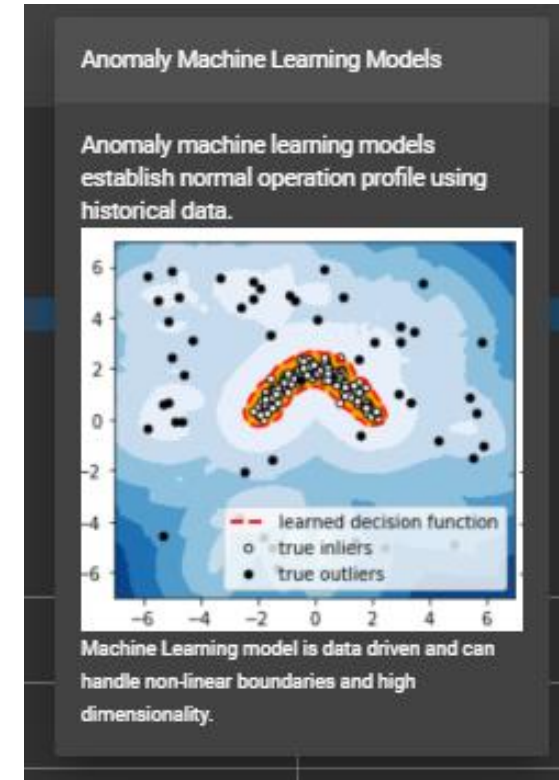
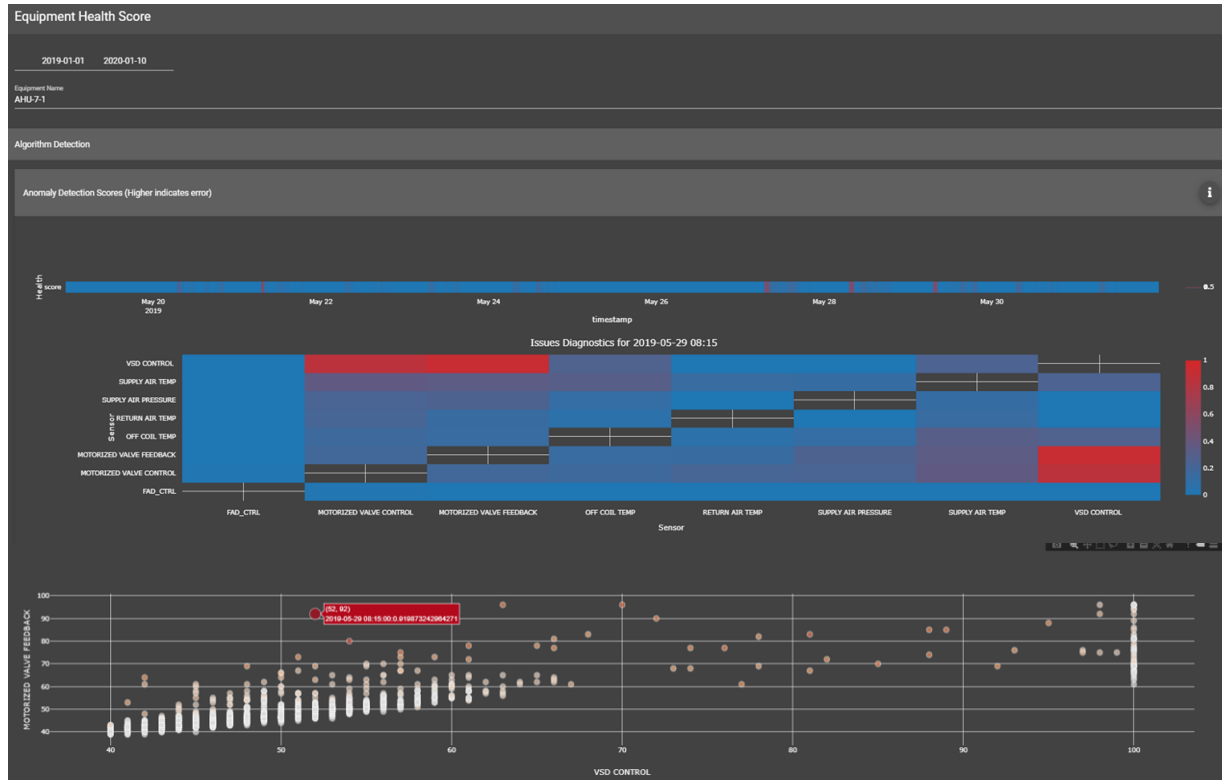
Notifications											
TOTAL	CRITICAL	LOW	MEDIA	HIGH	CRITICAL	Show Unack. Notifications Only					
10686	1366	342	693	331	0	Keyword Filter					
						87 CRITICAL	942 LOW	127 MEDIUM			
Alerts	Equipment	Equipment Type	Type	Floor	Description	Recommended Actions	Start Date	End Date	Severity	Acknowledged	Actions
Terminal Equipment monitoring	ES2_SF_VSD_P01	VSD	operation	ES2-0F	Terminal equipment monitoring (+14 Degree C for 2 hours)	<ul style="list-style-type: none"> Check if VSD Damper is stuck Check Temperature sensor accuracy Check area temperature control logic Check load monitoring Check integrity of supply upstream. Check voltage and electrical stabilization system. Check electrical supply. Check load monitoring. Check integrity of supply upstream. 	2020-08-21T08:00:00	2020-08-21T08:00:00	High		🔍 🗑️ 🔄
PQM line A current THD too high	ES2_SF_PQM_Busway_28L_1100A_A	PQM	energy	ES2-0F	PQM THD Current A > 40% for 2 hours or more when Active Power > 1.5MW	<ul style="list-style-type: none"> Check load monitoring. Check THD Current sensor accuracy Check area temperature control logic Check electrical supply. Check load monitoring. Check integrity of supply upstream. 	2020-08-21T02:45:00	2020-08-21T02:45:00	High		🔍 🗑️ 🔄
PQM power spike	ES1_SF_PQM_Busway_18L1	PQM	energy	ES1-0F	PQM power has increased sharply & dropped down by 100% within 30 minutes interval.	<ul style="list-style-type: none"> Check load monitoring. Check THD Current sensor accuracy Check area temperature control logic Check electrical supply. Check load monitoring. Check integrity of supply upstream. 	2020-08-20T23:30:00	2020-08-20T23:30:00	High		🔍 🗑️ 🔄
PQM line C current THD too high	ES1_SF_PQM_Busway_18L2	PQM	energy	ES1-11F	PQM THD Current C > 40% for 2 hours or more when Active Power > 1.5MW	<ul style="list-style-type: none"> Check load monitoring. Check THD Current sensor accuracy Check area temperature control logic Check electrical supply. Check load monitoring. Check integrity of supply upstream. 	2020-08-20T23:30:00	2020-08-20T23:30:00	High		🔍 🗑️ 🔄
PQM line B current THD too high	ES2_SF_PQM_Busway_28L1_100A_A	PQM	energy	ES2-14F	PQM THD Current B > 40% for 2 hours or more when Active Power > 1.5MW	<ul style="list-style-type: none"> Check load monitoring. Check THD Current sensor accuracy Check area temperature control logic Check electrical supply. Check load monitoring. Check integrity of supply upstream. 	2020-08-20T17:45:00	2020-08-20T17:45:00	High		🔍 🗑️ 🔄
PQM power spike	ES3_SF_PQM_Busway_38T3	PQM	energy	ES3-20F	PQM power has increased sharply & dropped down by 100% within 30 minutes interval.	<ul style="list-style-type: none"> Check load monitoring. Check THD Current sensor accuracy Check area temperature control logic Check electrical supply. Check load monitoring. Check integrity of supply upstream. 	2020-08-20T14:00:00	2020-08-20T14:00:00	High		🔍 🗑️ 🔄
Terminal Equipment monitoring	ES2_SF_VSD_P01	VSD	operation	ES2-0F	Terminal equipment monitoring (+14 Degree C for 2 hours)	<ul style="list-style-type: none"> Check if VSD Damper is stuck Check Temperature sensor accuracy Check area temperature control logic Check load monitoring. Check integrity of supply upstream. Check voltage and electrical stabilization system. Check electrical supply. Check load monitoring. Check integrity of supply upstream. 	2020-08-20T13:00:00	2020-08-20T13:00:00	High		🔍 🗑️ 🔄
PQM line B IGD current spike to ampere by 100%	ES2_SF_PQM_Busway_28L1_100A_A	PQM	energy	ES2-14F	PQM line current B IGD in ampere has increased sharply & dropped down by 100% within 30 minutes interval.	<ul style="list-style-type: none"> Check load monitoring. Check IGD current sensor accuracy Check area temperature control logic Check electrical supply. Check load monitoring. Check integrity of supply upstream. 	2020-08-20T12:00:00	2020-08-20T12:00:00	High		🔍 🗑️ 🔄
PQM line C IGD current spike to ampere by 100%	ES1_SF_PQM_ACC380A_35SA	PQM	energy	ES1-0F	PQM line current C IGD in ampere has increased sharply & dropped down by 100% within 30 minutes interval.	<ul style="list-style-type: none"> Check load monitoring. Check IGD current sensor accuracy Check area temperature control logic Check electrical supply. Check load monitoring. Check integrity of supply upstream. 	2020-08-20T09:30:00	2020-08-20T09:30:00	High		🔍 🗑️ 🔄
PQM line C IGD current spike to ampere by 100%	ES1_SF_PQM_ACC380A_35SA	PQM	energy	ES1-0F	PQM line current C IGD in ampere has increased sharply & dropped down by 100% within 30 minutes interval.	<ul style="list-style-type: none"> Check load monitoring. Check IGD current sensor accuracy Check area temperature control logic Check electrical supply. Check load monitoring. Check integrity of supply upstream. 	2020-08-20T09:30:00	2020-08-20T09:30:00	High		🔍 🗑️ 🔄

Automated Fault Diagnostics and Prediction – Large Shopping Centre Hong Kong



Automatically identified control logic and sensor issues leading to overcooling phenomenon in multiple air side HVAC equipment and visualized them intuitively. Automated reporting lead to proactive issue rectification.

Anomaly model - Fault Detection

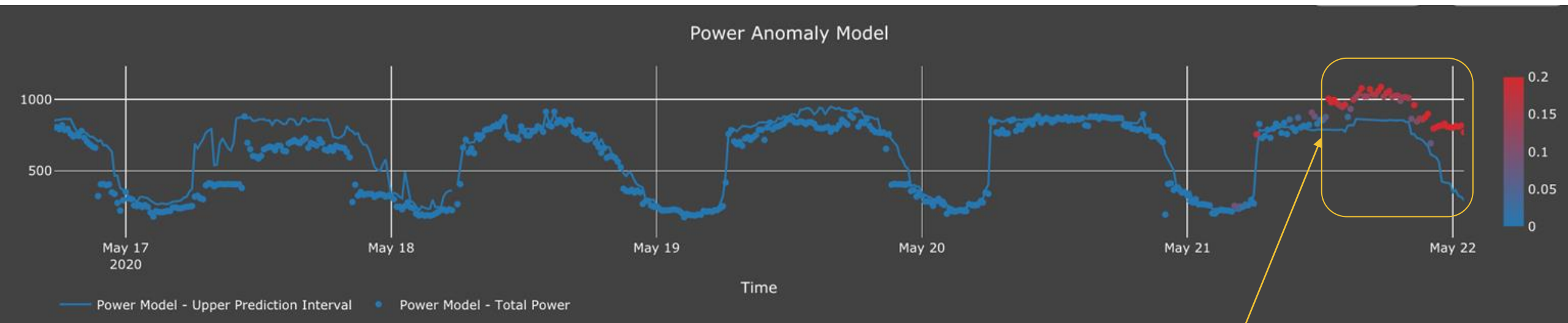


Unsupervised Machine Learning engine detects abnormal deviation of data from normal operation pattern. In this example, VSD control is set to a relatively low value however the motorized valve feedback for the AHU is abnormally high. This suggest faulty controls where supply air is still hot although there is less demand from VAVs.

The engine can detect non linear deviations from normal patterns and predict unknown faults before they seriously affect equipment performance or health.

Anomaly model - Excessive Power Usage

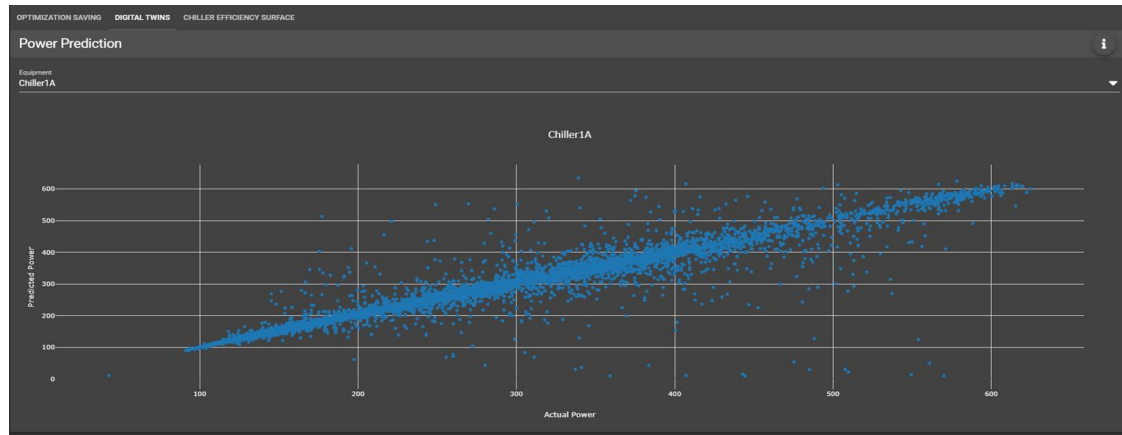
Power anomaly machine learning models



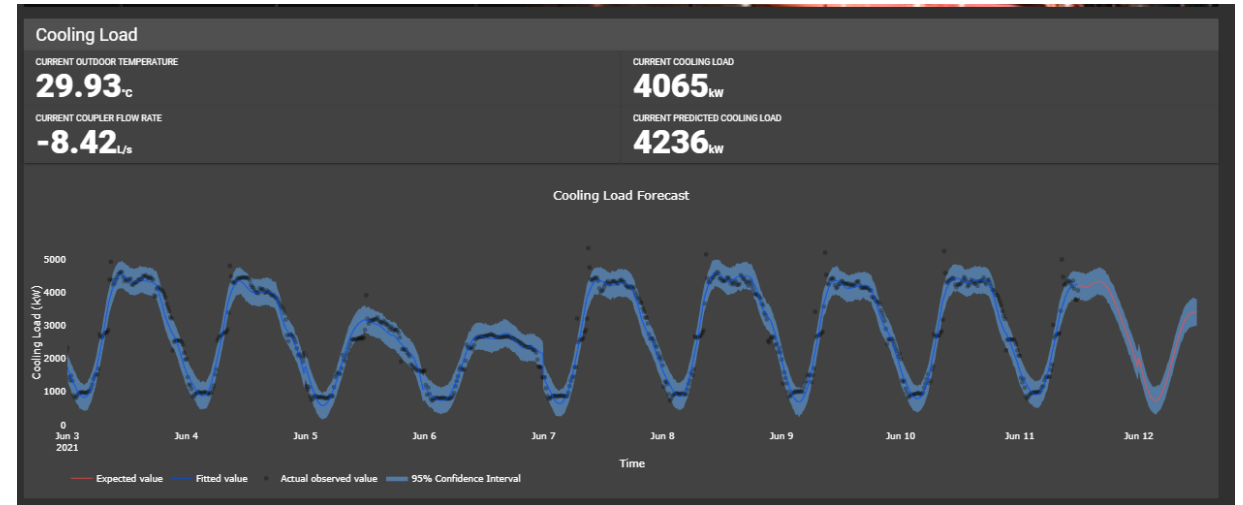
Higher than expected
Chiller Plant Power
consumption

Prescriptive real time controls and savings realization

Digital Twin and power predictions

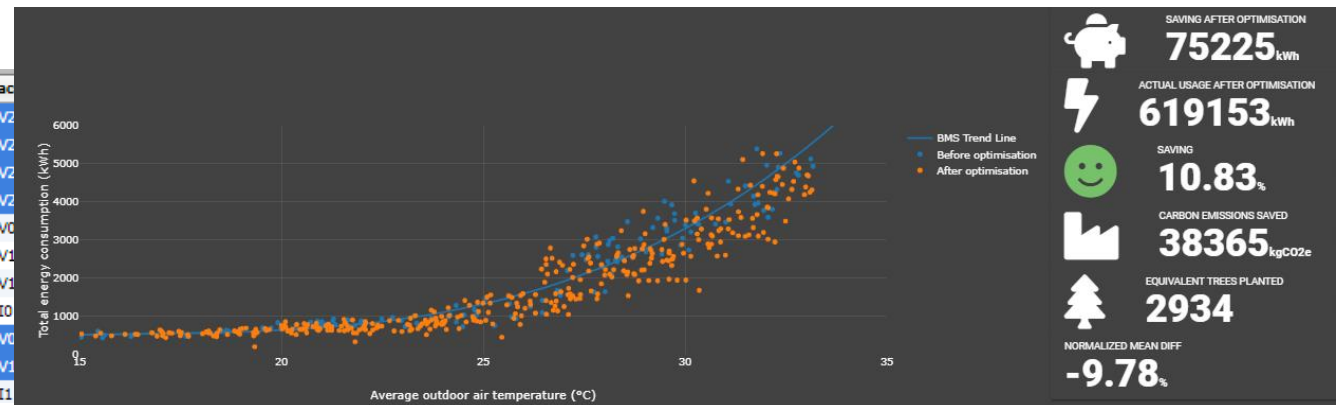


Cooling Load Forecasts



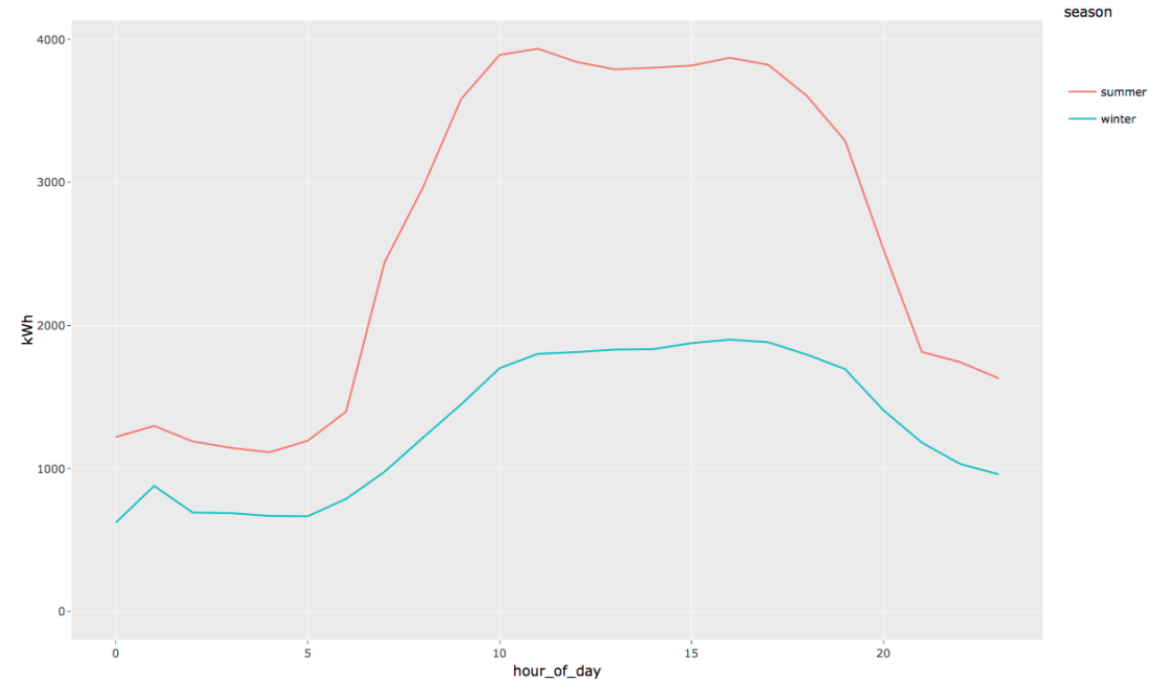
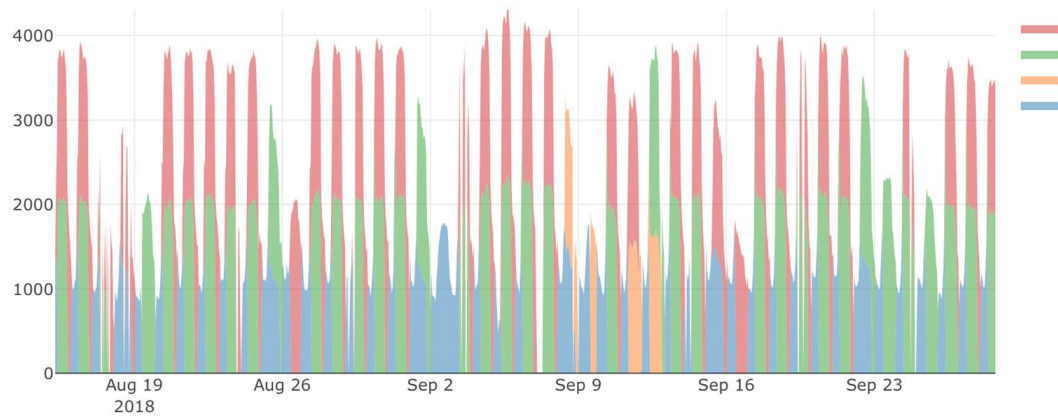
Real Time Controls & Energy Savings Achieved

dis	bacnetConnRef	cur	write	his	connTuningRef	bac
Chiller_Plant_Chiller_Header CH_Optm_SCHWP_QTY	Bacnet PB_Chiller	1	1 @ 8	collect 1min		AV2
Chiller_Plant_Chiller_Header Chiller_Optim_Request	Bacnet PB_Chiller	2	2 @ 8	collect 1min		AV2
Chiller_Plant_Chiller_Header DP_SP_Optimization	Bacnet PB_Chiller	3 psi	3 @ 8	collect 1min		AV2
Chiller_Plant_Chiller_Header Heartbeat	Bacnet PB_Chiller	95	95 @ 8	collect 1min		AV2
Chiller_Plant_Chiller_Header Switch_Optimization	Bacnet PB_Chiller	true	null @ def	collect 1min		BV0
Chiller_Plant_Chiller_Header Switch_Temp_Reset	Bacnet PB_Chiller	true	null @ def	collect 1min		BV1
Chiller_Plant_Chiller1 CHWS_Setpoint	Bacnet PB_Chiller	7.4 °C	7.4 @ 8	collect 1min		AV1
Chiller_Plant_Chiller1 Comm_Fault	Bacnet PB_Chiller	Normal	?	collect 1min		BI0
Chiller_Plant_Chiller1 Priority	Bacnet PB_Chiller	8	8 @ 8	collect 1min		AV0
Chiller_Plant_Chiller2 CHWS_Setpoint	Bacnet PB_Chiller	7.798 °C	7.798 @ 8	collect 1min		AV1
Chiller_Plant_Chiller2 Comm_Fault	Bacnet PB_Chiller	Normal	?	collect 1min		BI1



Time Series Prediction of demand

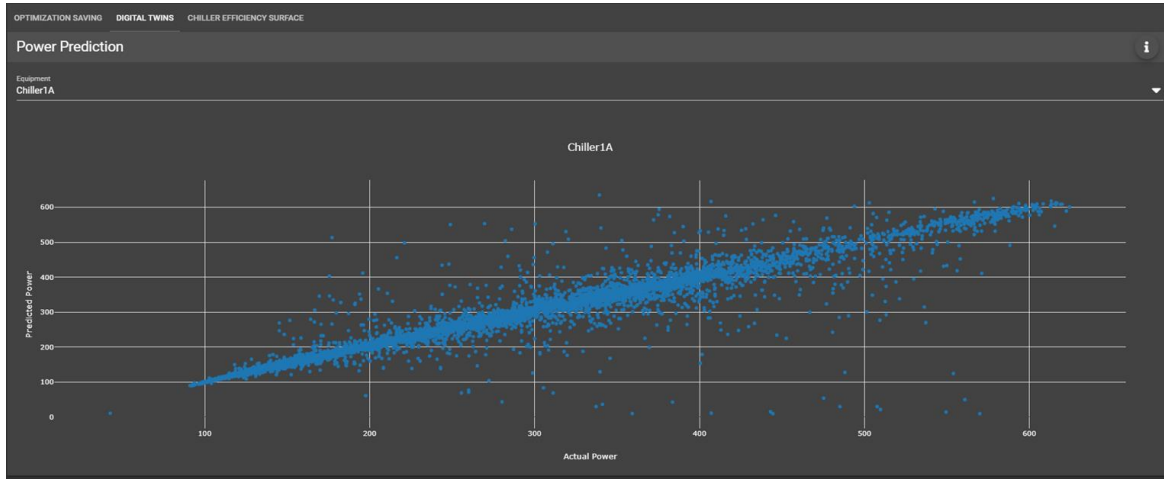
For better staging and peak shifting



Cooling Load vary by hour of day.

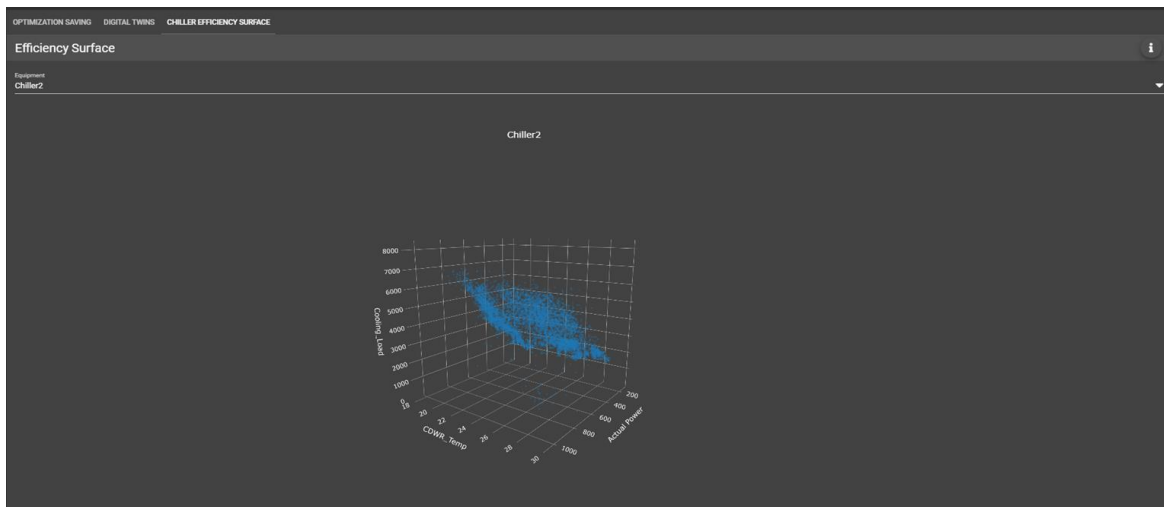
Power Consumption Model of Equipments

Estimate energy consumption under different scenarios



Digital Twins

Energy prediction models for chiller plant equipment are developed to estimate the consumption with new setpoints.



Energy Efficiency Surface

Using the forecasted cooling load and new setpoints, the optimization algorithm identifies the best setpoint combination to achieve highest efficiency. The efficiency surface of a chiller is a 3d variable that is shown here. It depends on the setpoint, the cooling load and OAT.

AI Optimization – Data + Machine Learning + Load Forecast + Optimization Algorithm

Real Time, Data Driven Chiller Plant Optimization

Optimization Formulation

Minimize Energy Consumption



Controls



Optimal number of chillers



Chilled Water Flow Rate



Chilled Water Supply Temperature

Satisfies



Cooling Demand



Design Constraints and Specification such as flow rate

2 Predictive Models + 1 Optimization Algorithm to Achieve the Optimization

2 models to provide us with estimates of



Future Cooling Demand

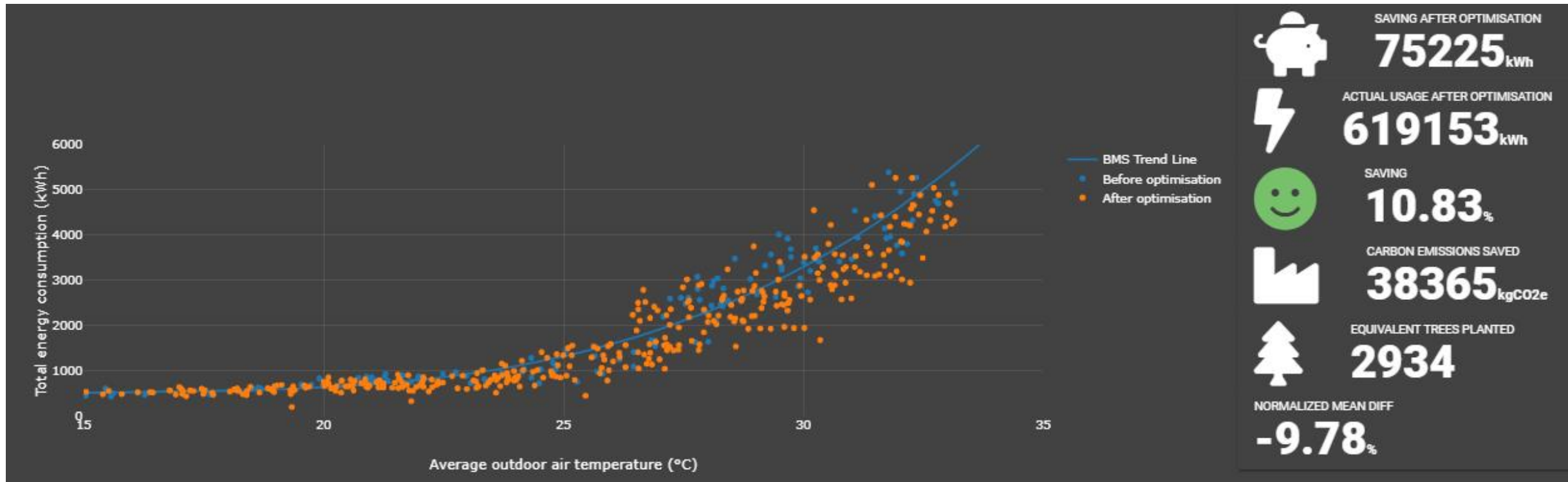


Energy Consumption given the operating parameters

Optimization Algorithm to find the optimal parameters.



Public Infrastructure Facility Chiller Plant Optimization – Hong Kong



Realized 11% Chiller Plant Operational Cost Savings for a public infrastructure building in Hong Kong without additional retro-fits.

Enabled on-going and continuous commissioning for the facility.

ROI = 1.5 Years

Grade A Commercial Building Chiller Plant Optimization – Hong Kong



Improved the Chiller Plant Efficiency of a Grade A Commercial Building by 10% within 3 months of Automated AI Chiller Plant Optimization Deployment.

ROI = 1 Year

International Hospital Chiller Plant Optimization - Thailand



Optimized Chiller Plant Controls and improved over all plant efficiency by 10% while keeping cooling load and humidity within strict design constraints as required by the hospital.

ROI = 10 Months

| OUR PROVEN BENEFITS



**15% proven reduction
in energy costs over
existing controls**



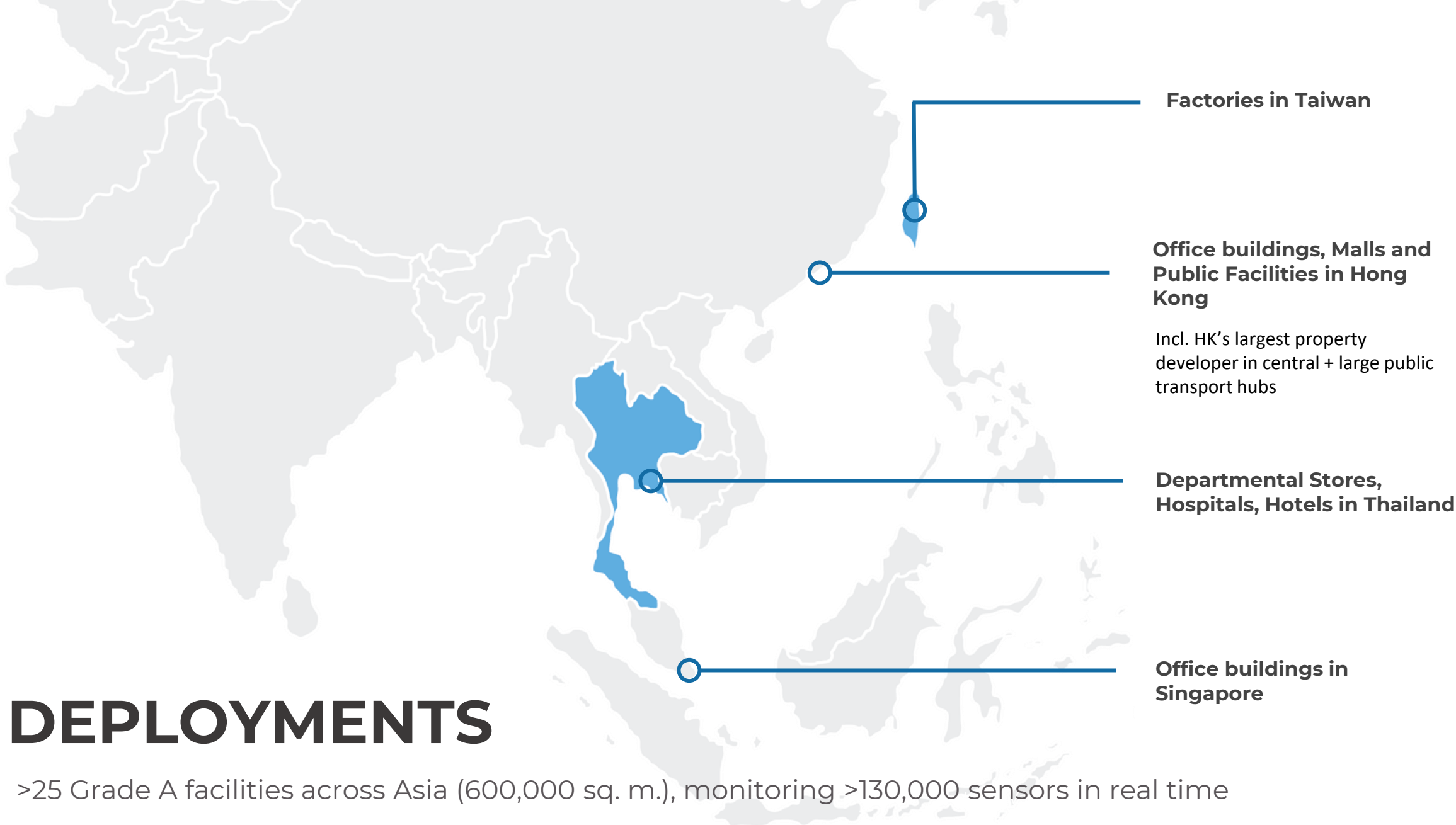
**90% hidden
faults uncovered**



**50% reduction key
operation faults**

Energy Savings > **50,000 USD** per average commercial building* per annum

We are helping companies reduce their **carbon footprint**, meet their **ESG targets** while saving the **environment!**



DEPLOYMENTS

>25 Grade A facilities across Asia (600,000 sq. m.), monitoring >130,000 sensors in real time



POWERFUL ALLIES

We are backed by Global Venture Capital Firms.



MTZ



Carnot Innovations

The brain behind truly smart buildings

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Strictly private and confidential