



The Energy Conservation Center of Thailand ศูนย์อนุรักษ์พลังงานแห่งประเทศไทย
center@ecct-th.org



TIE SMART SOLUTIONS

AI Energy Platform

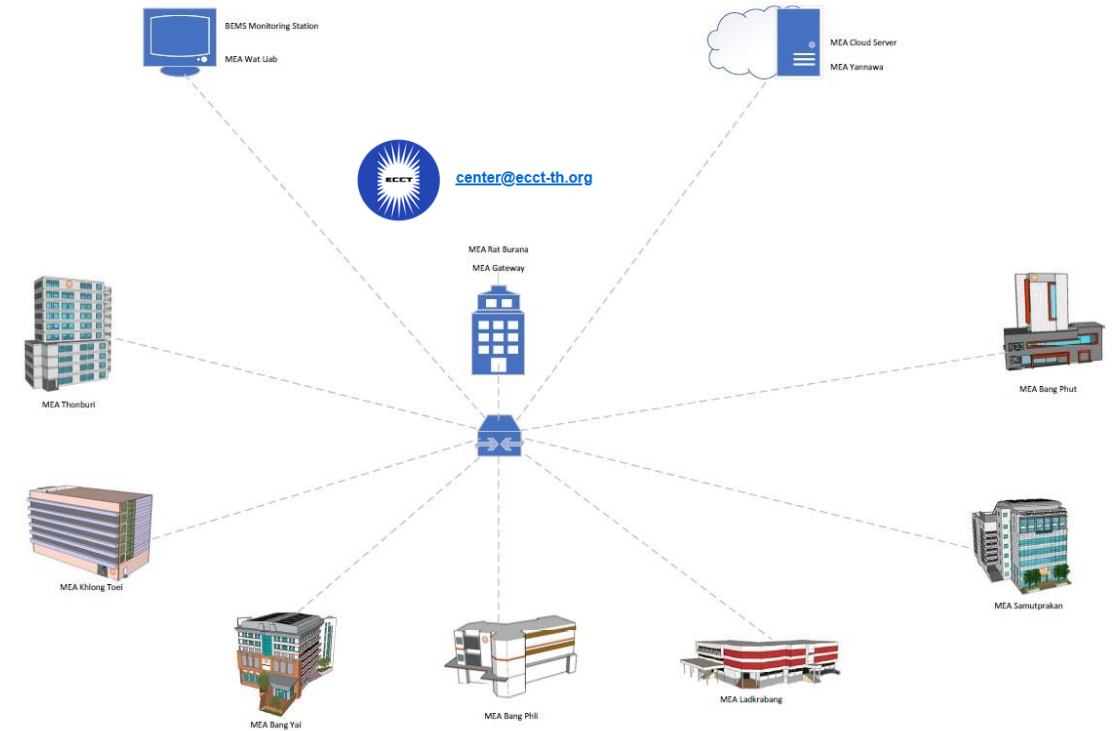
Better Life Quality with Energy Saving by our Big Data and AI Diagnostics

“Modern Technologies for energy optimization”



DIPROM
กรมส่งเสริมการค้าระหว่างประเทศ
กระทรวงพาณิชย์

- LBC lab Introduction
- BEMS vs. EMIS (energy management information system)
- Typical BAS and CPMS Problems
- Communication problems for CPMS and BAS
- Solutions – Analysis and results for new services
- EMIS Example – Diagnostic and AI prediction command center
- Retuning process



STATE THE PROBLEM



Green buildings and Smart Cities - climate change

Loss > 6 Trillion Baht in Southeast Asia
Thailand budget 2 years



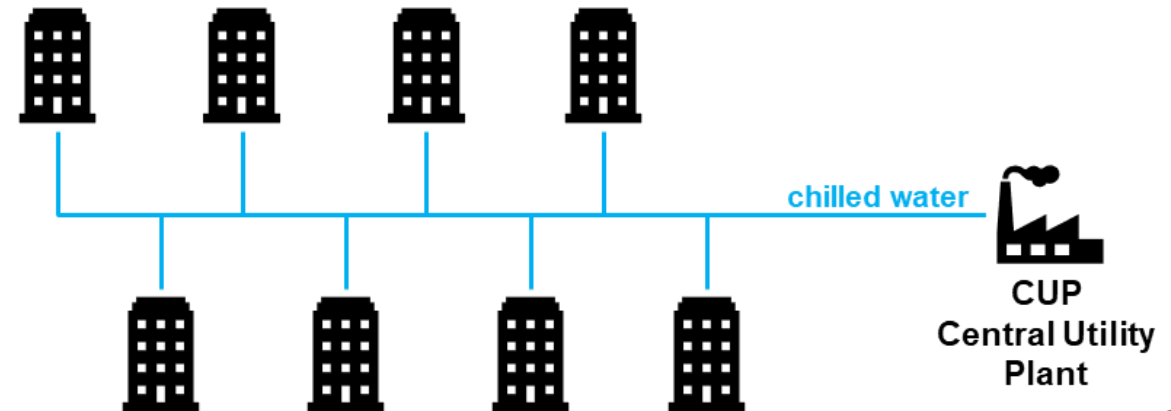
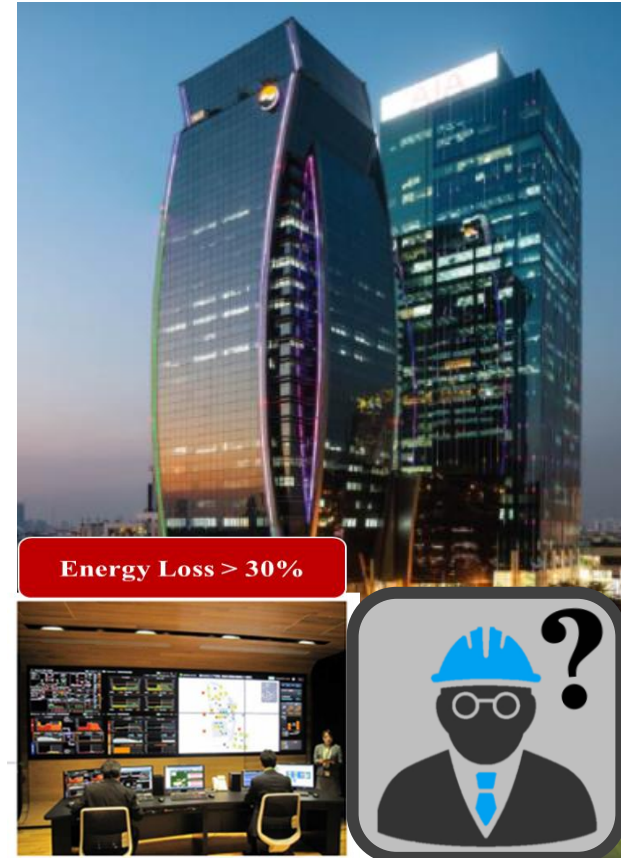
Facility Manager cannot avoid the issues

more complex and complicated operations are, the more intelligent systems are needed in green buildings and smart cities.



No easy way exists to generate data quality and right solutions

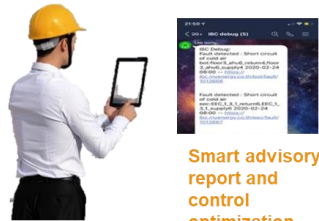
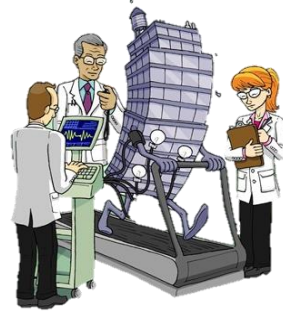
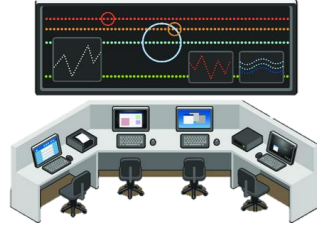
Not achieving correct energy savings and tools by startups and contractors



THE OUR SOLUTION

AIoT Energy Platform for Intelligent Solutions

where energy consumers can earn correct and suitable solutions



Smart advisory report and control optimization

Data and Hardware Integration

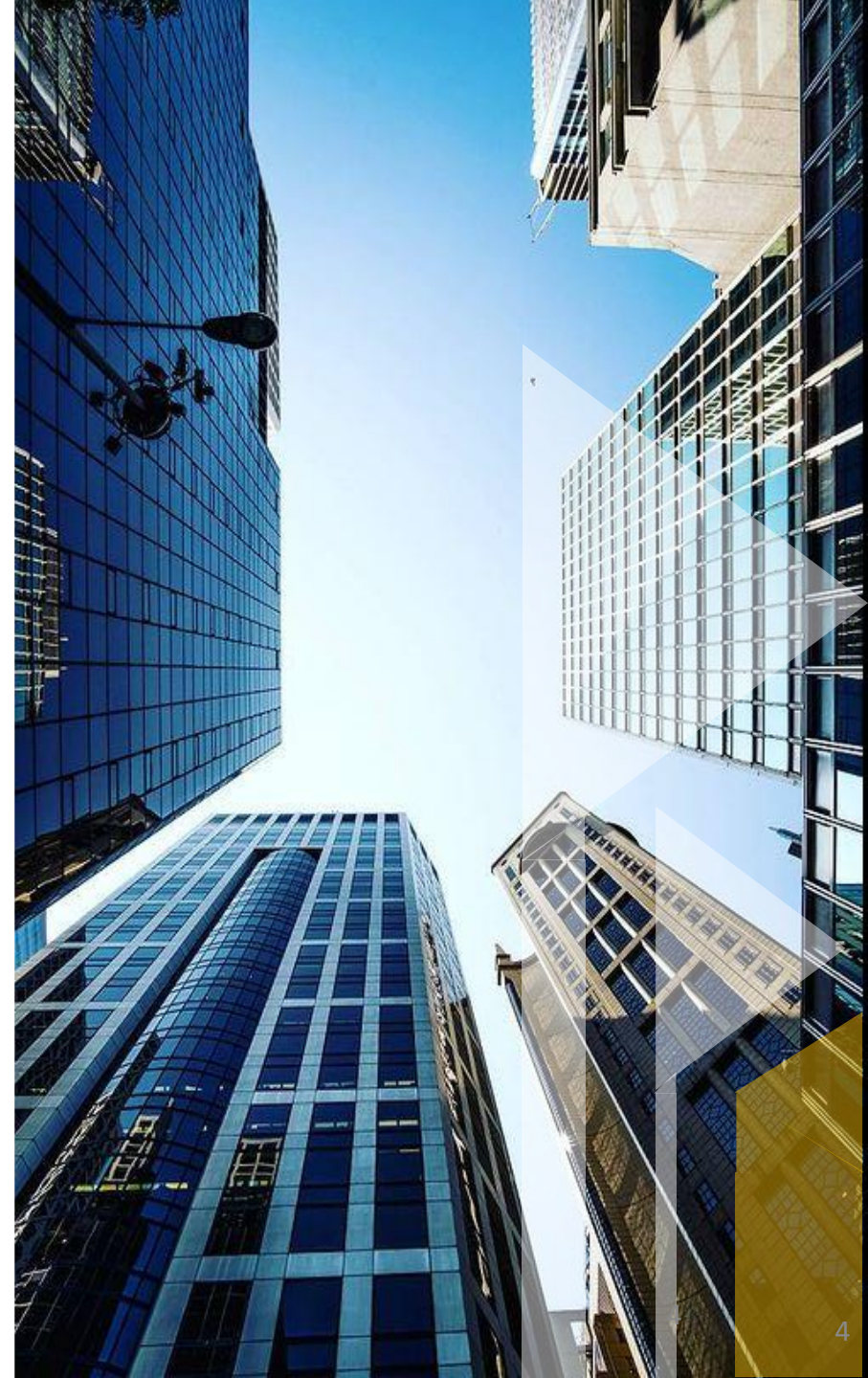
Utilizing existing data in buildings without additional sensors

System Diagnostics

Diagnose and solve Air-conditioning problems and other energy loss

Solutions Providers via TIE devices

AI command solution for Facility manager and team





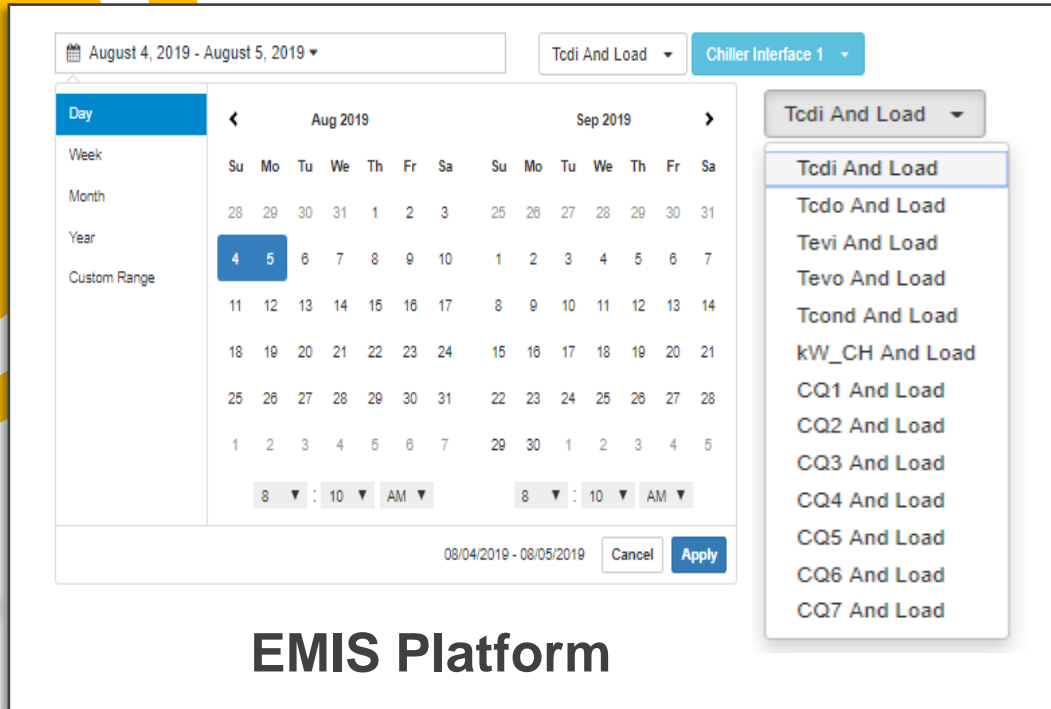
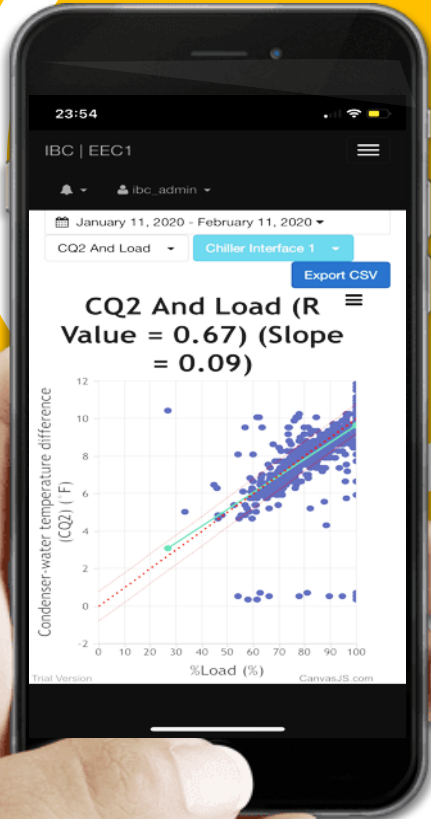
Winner of Innovation Award in 2019 - First AFDD platform

TIE Smart Solutions (TIE)



The winner of **TEIT Award 2019**
AFDD based AI and IoT platform for chiller air-conditioning system

Department of Alternative Energy Development and Efficiency
MINISTRY OF ENERGY

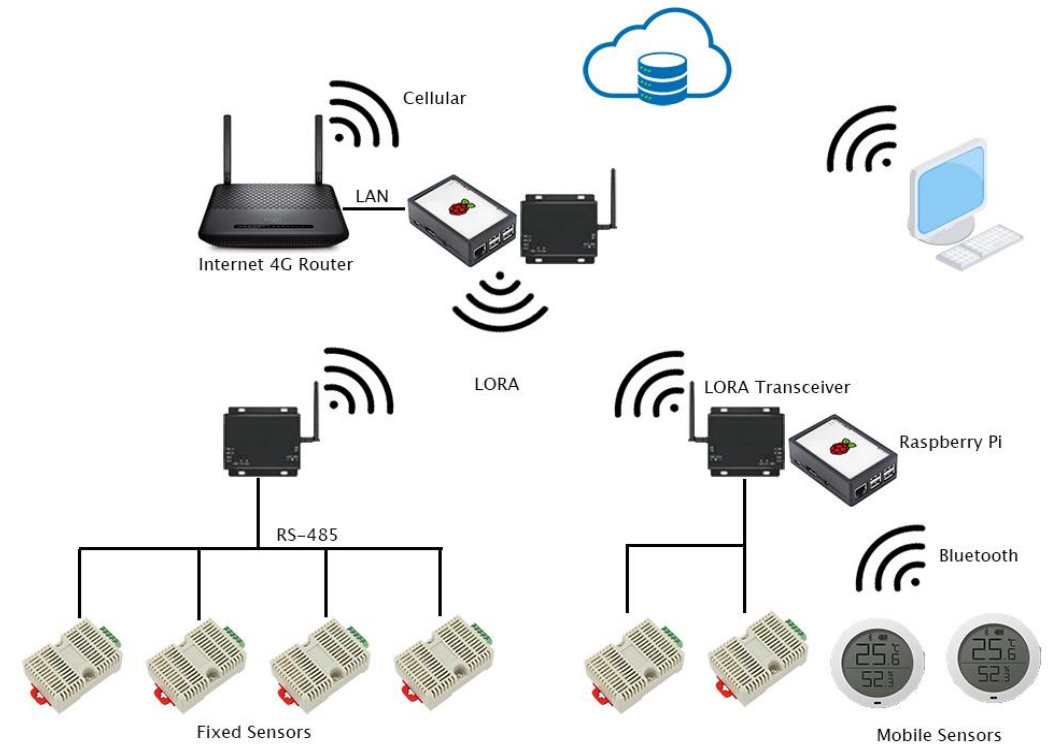
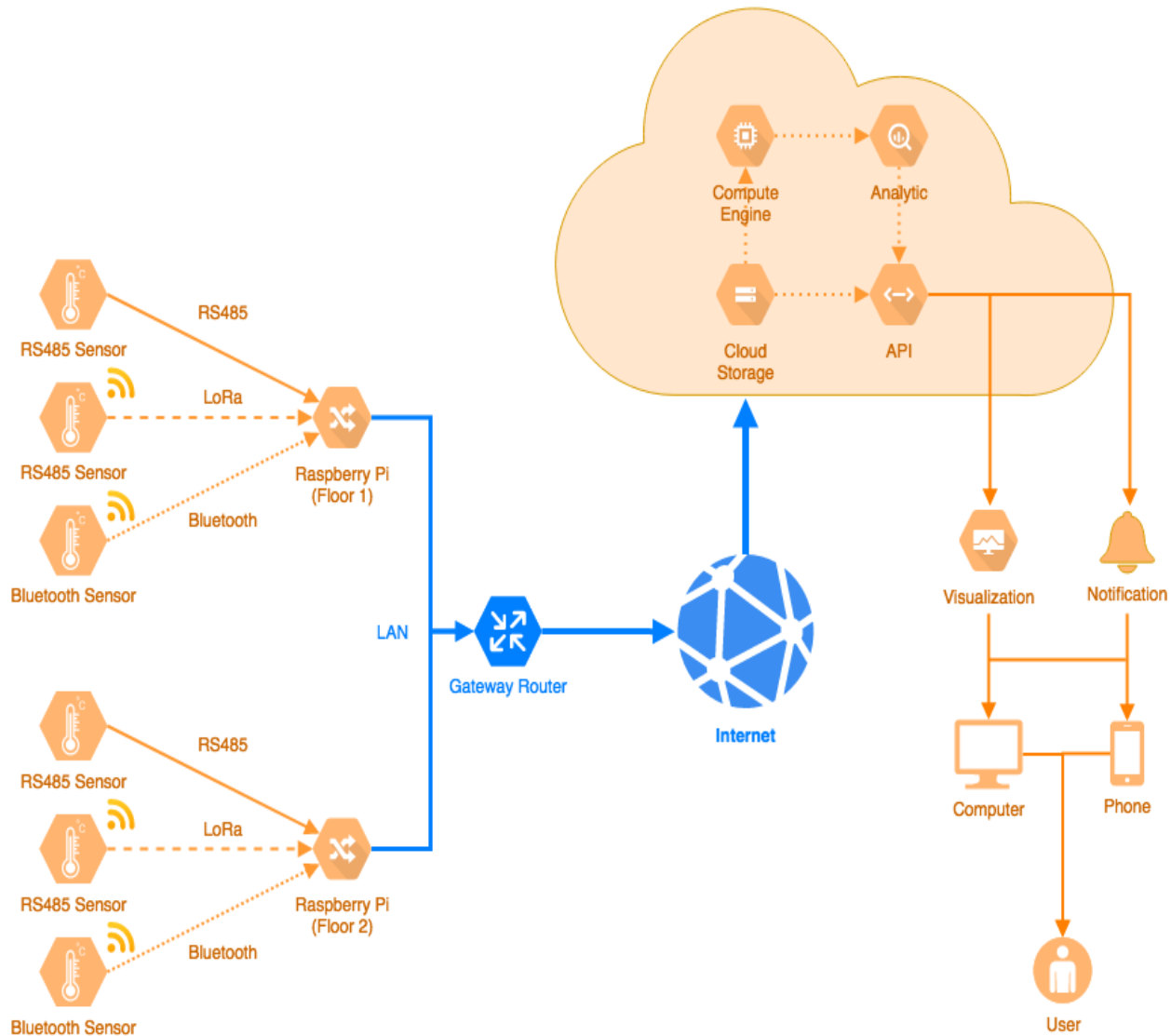


EMIS Platform





TIE (Hybrid LoRa + Zigbee + Bluetooth)



Changed 5G to 6G by using 6G router while using internal LoRa loop network



TIE-MIS – Product 1 (automated fault diagnostics – 10% guarantee)

Smart Monitoring

TIE-MIS



IoT Communicator



TIE AI Cloud



Automated Diagnostic





TI-EMIS – CPMS examples

EMIS function (AFDD) to avoid:

F1: reduce evaporator water temperature flow-rate

F2: reduce condenser water temperature flow-rate

F3: low delta T syndrome

F4: condensing fouling

F5: refrigerant overcharge

F6: refrigerant undercharge

F7: non-condensable gas

F8: surge

Retuning CHP VSD

F9: outlier chiller startup

F10: insufficient chiller load

F11: improper CHP control

F12: faulty CPM sensor

F13: Chiller load loss

F14: too low chilled water return temperature

F15: air-side short circuit

F16: non-thermal comfort

F17: wrong CAV control valve

F18: too high supply air temperature of a AHU

F19: too low supply air temperature of a AHU

F20: air zone condensation

TIE – EMIS software

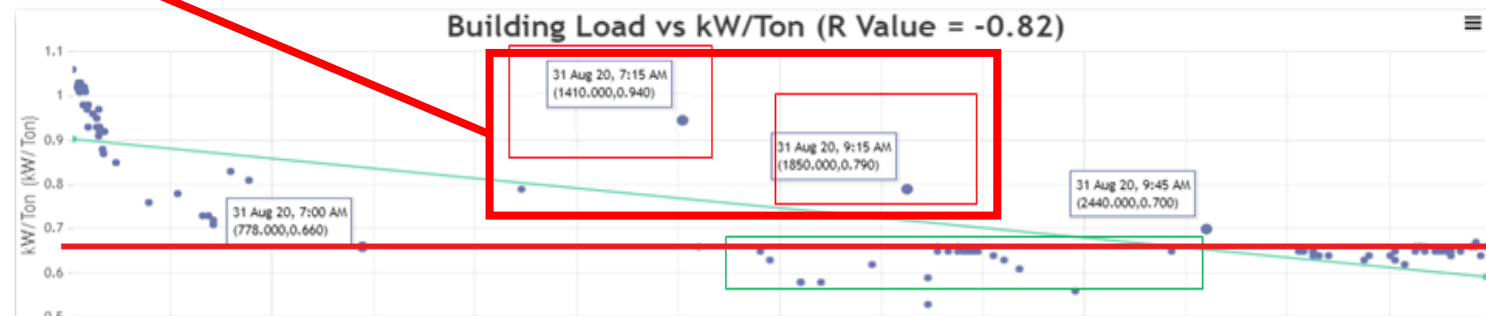
Smart Fault Detect

Fault Detection

- Faulty Interaction (Supply)
- Faulty Interaction (Return)
- Faulty Interaction (Zone)
- Air-side Short Circuit
- Outliers: Insufficient Chiller Load
- Outliers: Start-up Chiller
- Faulty CPM Sensor or Operations
- Reduced Evaporator Water Flow
- Reduced Condenser Water Flow
- Low Delta T Syndrome
- Refrigerant Undercharge
- Refrigerant Overcharge

Typical CPM control

Check Tevo at SP = 44 F; when load is more than 750 tons, Tevo is lifted due to insufficient load



Automated Diagnostic identifies potential root causes



TIE-CON – 2nd product - Intelligent controller for 20% *Energy Savings*

AIoT Controller

TIE-CON



Building Intelligence



Optimization Control



SECTION 2

BEMS vs. EMIS (Energy management information system)

Global Market Insights

Insights to innovation.

ENERGY MANAGEMENT SYSTEM (EMS) MARKET

>\$12 BN

2015

2016

2017

2018

2019

2020

2021

2022

2023

>\$38 BN

2024

CAGR (2016-24): **>13%**

U.K regional share (2015): **>20%**

Qatar regional share (2015): **>5%**

Japan regional share (2015): **>20%**

U.S. industry CAGR (2016-24): **>11%**

Germany regional share (2015): **>25%**

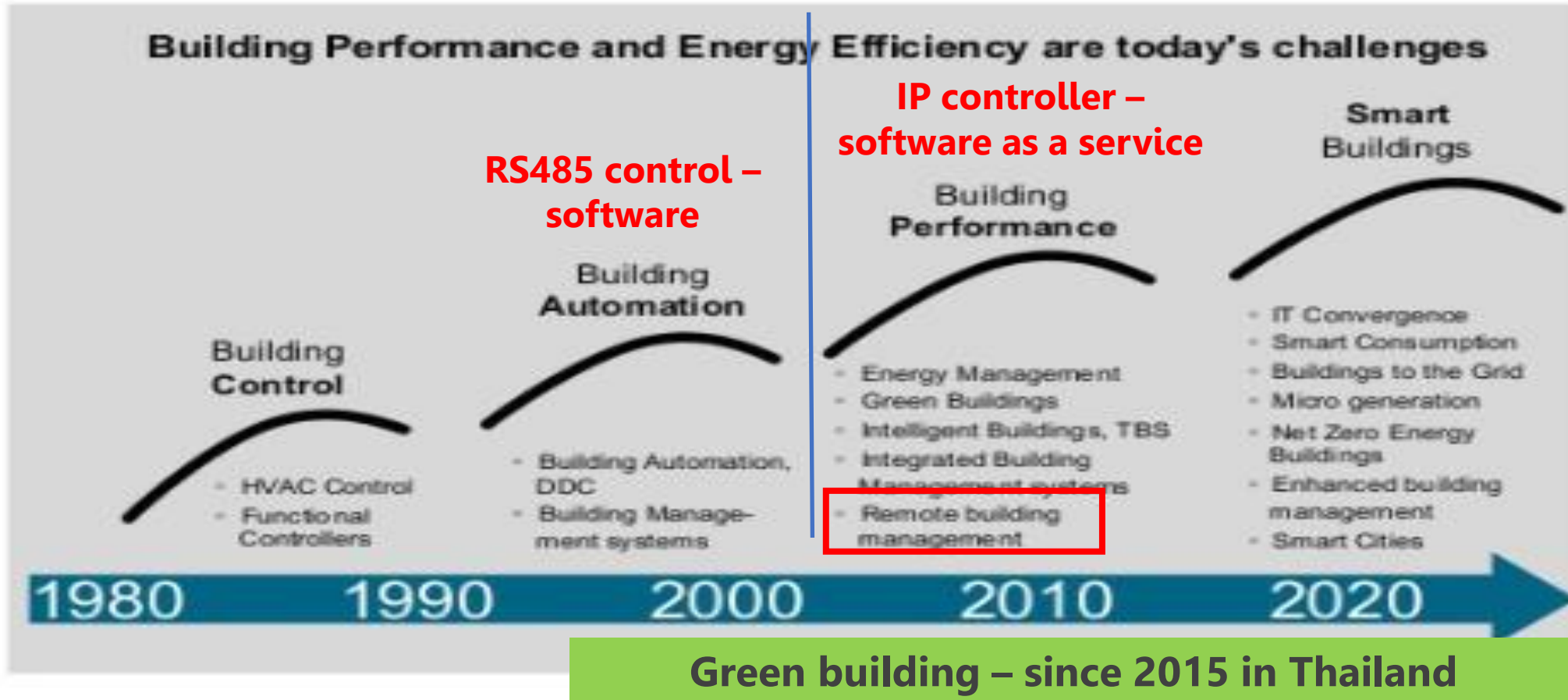
China market share by 2024: **>\$2 BN**



BMS evolution

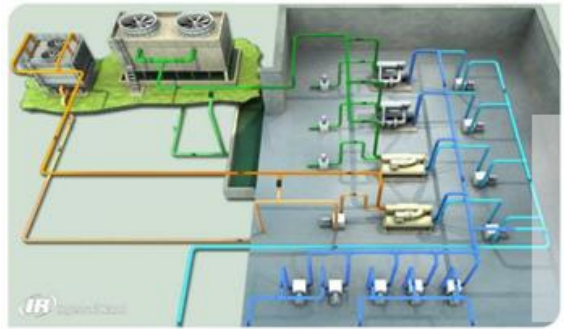
SIEMENS

Evolution of Building Management

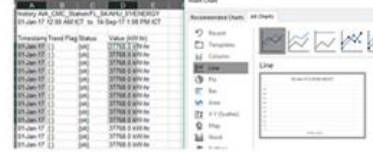




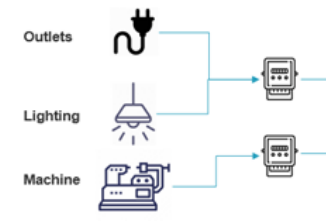
CPMS, BAS, EMS and BEMS (Thailand)



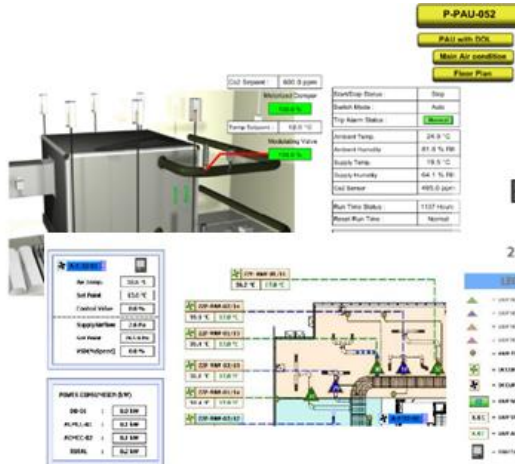
Chiller plant manager (CPM)
Chiller | Pumps | Coolingtower



Data on Cloud



Energy Management System (EMS) or Energy information system (EIS)
Managing energy data, display, benchmarking and predicting



Building Automation System (BAS)
AHU | VAV | Air-side systems etc.



T, RH and *CO₂ Sensors

Receiver and logger

Network IoT sensors
Thermal & Zone parameters



การใช้งาน BAS ในต่างประเทศ

Received: 7 April 2018 | Revised: 11 June 2018 | Accepted: 17 June 2018
DOI: 10.1002/er.4159

REVIEW PAPER

WILEY ENERGY RESEARCH

Return on investment of building energy management system: A review

Chin-Chi Cheng  | Dasheng Lee 

For commercial buildings, technology progress yields payback periods of BEMS decreased from 5.4 yrs to 0.7 yr. ($P = 0.002 < 0.05$)

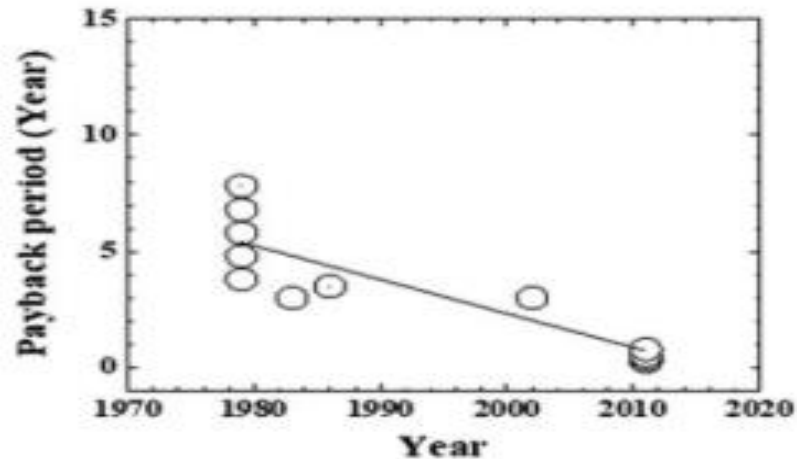


FIGURE 2 Payback periods of building energy management system (BEMS) for commercial buildings

For compound buildings, technology progress yields payback periods of BEMS decreased from 3.74 yrs to 1.8 yrs. ($P = 0.041 < 0.05$)

Technologies

- Schedule control of central plant system
- Optimal control for thermal comfort ตามมาตรฐานอาคาร (temperature, pressure and flow rate)
- Variable speed control (VSD)
- Occupant-based control ควบคุมการเปิดปิดไฟฟ้า
- การใช้ระบบการจัดพลังงานควบคุมระบบแสงสว่าง



CPMS, BAS, EMS and BEMS (Thailand)

BMS ประกอบด้วย 4 levels จาก World market (function-based)

1. Monitoring
2. Schedule control (operator selects set-points)
3. Automated Diagnostic (predictive maintenance)
4. Optimization control (automated set-point)

BMS – Thai market (machine-based)

1. Chiller plant manager system (CPMS) – e.g. Trane แยก package – chiller schedule control (plant kW/ton (efficiency) guarantee using magnetic bearing chiller)
2. Building automation system (BAS) – AHU schedule control or air-conditioning control
3. Building management control system (BMS) – AHU including: lighting control, Security control
4. Energy management system (EMS) – online power meter software (energy monitoring)
5. Building energy management system (BEMS) – AHU schedule control and energy monitoring



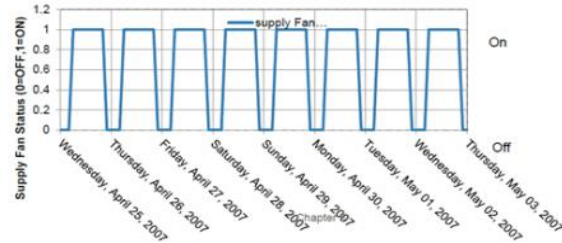
BAS function for HVAC control

*“Traditional BAS are **not designed** to explicitly optimize building operations and minimize energy consumption”*

Source: Pacific Northwest National Laboratory

Using BAS Data to Identify Savings Opportunities

- Example #1: Scheduling
 - Equipment should be operating only when necessary



No weekend setback schedule for supply fan of air-handling unit
Two weeks of supply fan status data is plotted

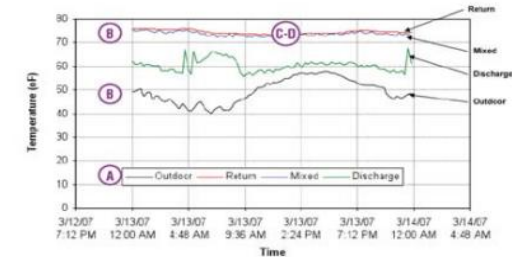
Source: Pacific Northwest National Laboratory

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Energy Exchange: Federal Sustainability for the Next Decade

Using BAS Data to Identify Savings Opportunities

- Example #2: Economizer
 - Ensure proper operation



Faulty economizer operation, outside air damper stuck fully closed
One day of temperature data is plotted: OAT, RAT, MAT, and DAT of air-handling unit

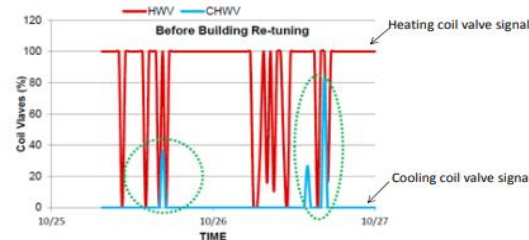
Source: Pacific Northwest National Laboratory

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Energy Exchange: Federal Sustainability for the Next Decade

Using BAS Data to Identify Savings Opportunities

- Example #3 – Optimization
 - Prevent simultaneous heating and cooling



Cooling coil valve of air-handling units don't lockout during winter season
Two days of cooling coil valve and heating coil valve signal data is plotted

Source: Pacific Northwest National Laboratory

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Energy Exchange: Federal Sustainability for the Next Decade

Analytics Tools to Supplement BAS

- Traditional BAS are not designed to explicitly optimize building operations and minimize energy consumption
 - Limited trending (points and time period)
 - Alarms don't typically allow for sophisticated logic
 - Typically monitor system operation data
- Third-party EMIS tools are good supplements to BAS to manage building energy use

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Energy Exchange: Federal Sustainability for the Next Decade

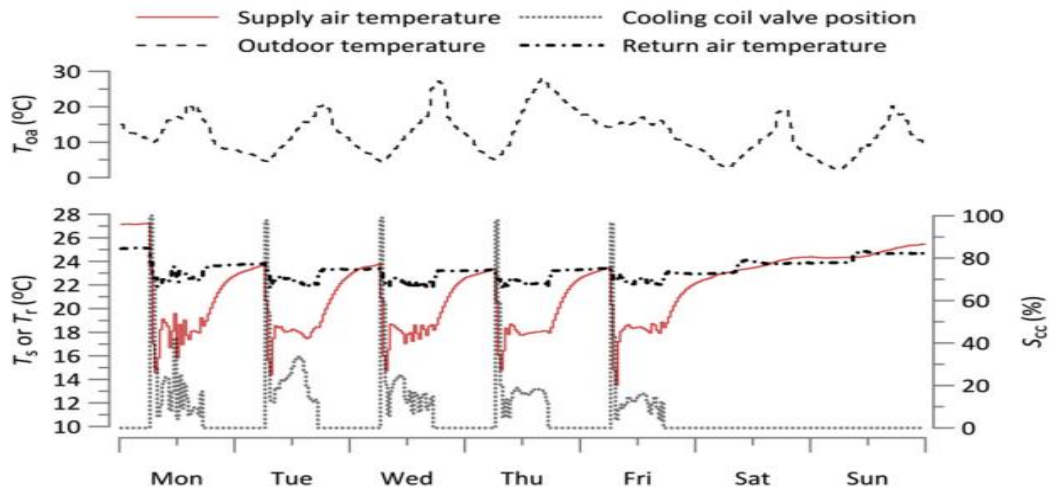
EMIS (Energy management information system) vs. BAS

Analytics Tools to Supplement BAS

- Traditional BAS are not designed to explicitly optimize building operations and minimize energy consumption
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- Third-party EMIS tools are good supplements to BAS to manage building energy use

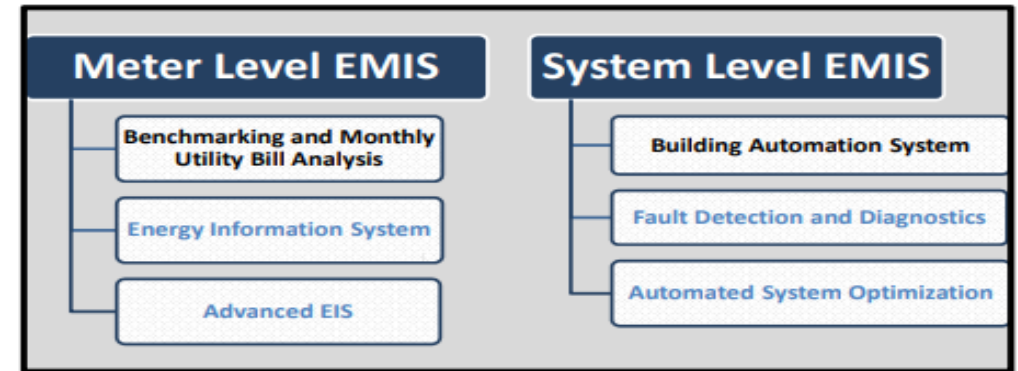
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Energy Exchange: Federal Sustainability for the Next Decade



Energy Management and Information System (EMIS)

- EMIS - a family of tools to monitor, analyze, and control building energy use and system performance



*The lines can be blurry, and specific technologies may cross categories, e.g., Modern building automation system platform with FDD capabilities

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Energy Exchange: Federal Sustainability for the Next Decade

EMIS tool performance and functions

- Automated fault detection and diagnostics
- Automated system optimization control (automated set-point selection)

EMIS (Energy management information system) vs. BMS

MBCx Findings

HVAC Systems Faults

- Over-enabling/unoccupied run-time
- Deficient pressure/fan speed reset
- Sub-optimal SAT reset
- Over or under-ventilation
- Simultaneous heating and cooling
- Faulty, disconnected zone sensors
- Spaces under-heated or cooled

HVAC Plant Faults

- Equipment rapid cycling
- Sub-optimal equipment sequencing
- Lack of or deficient SWT reset
- Lack of pressure/pump speed reset
- Pump over-enabling

Lighting Faults

- Excessive unoccupied use
- Unresponsive occupancy sensor switching
- Faulty photocells

- Complex systems give rise to more points of failure
- Occupant comfort may be maintained while faults persist, wasting \$\$\$

EMIS – Monitoring based commissioning (MBCx)

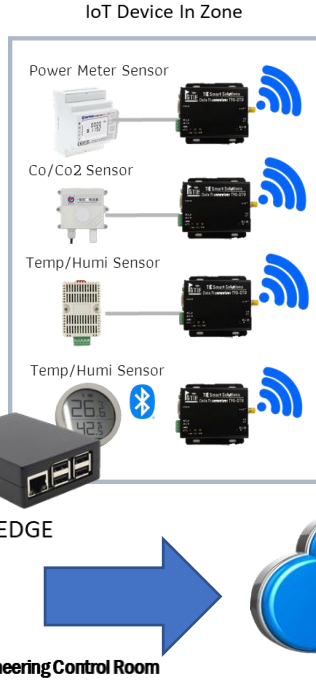
Chiller faults
F1 :Reduced evaporator water flow
F2: Reduced condenser water flow
F3: Low T syndrome
F4: Condenser fouling (CF)
F5: Non-condensable gas (NC)
F6: Refrigerant undercharge based CQ7
F7: Refrigerant overcharge based CQ7
F8: Compressor valve leakage

F9: Surging
F10: improper pump control
F11: Outliers from start-up chiller
F12: Faulty CPM sensor
F13: Insufficient load
F14: Air-side short circuit

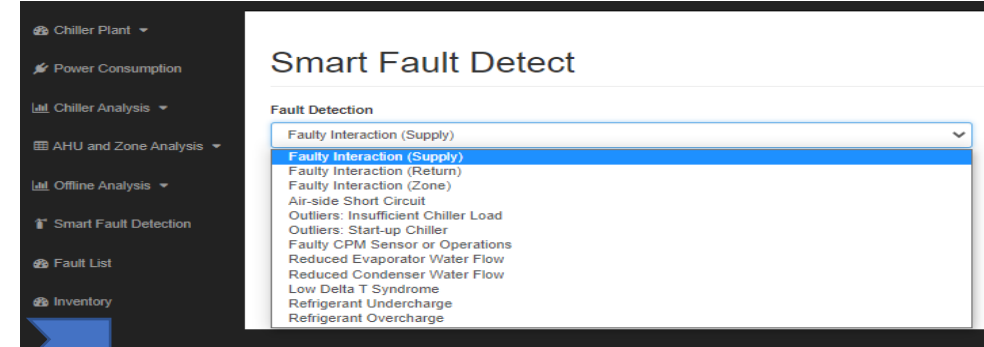


EMIS – System Monitoring, Diagnostic and Control

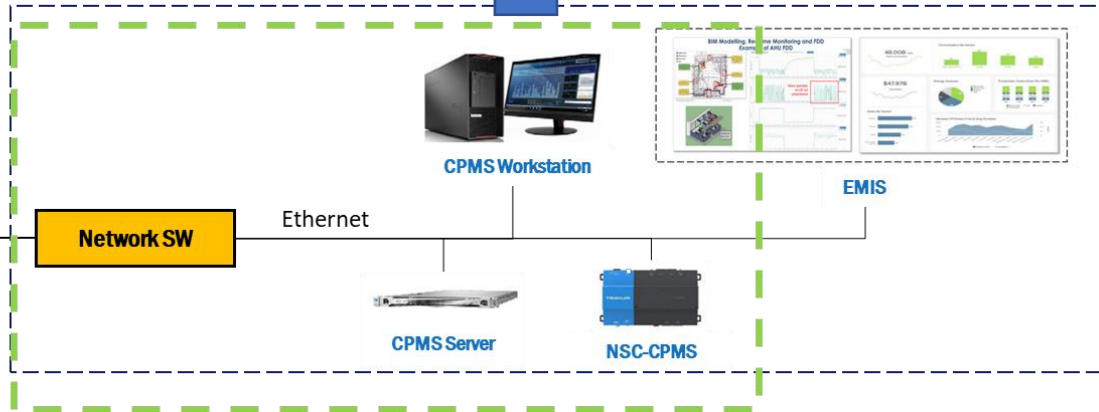
MBCx phase 1 – Data configuration with CPM data interface



MBCx phase 2 – AFDD design and Implementation



MBCx phase 3 – Automated Repair by smart controller



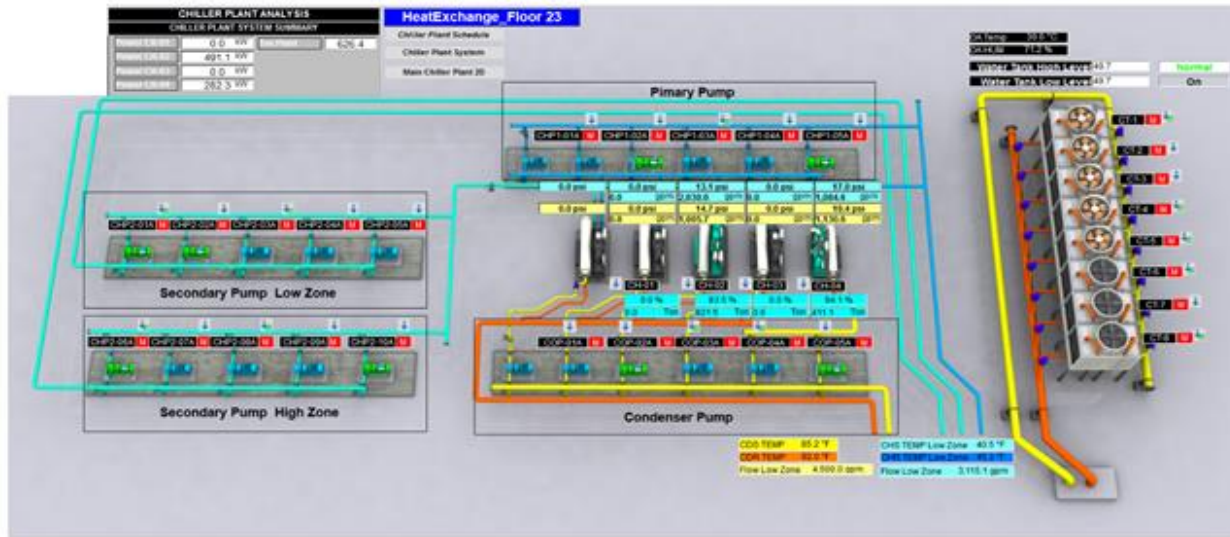
IBC TIE Platform



SECTION 3

Typical Problems – BAS and CPMS

Large Banks

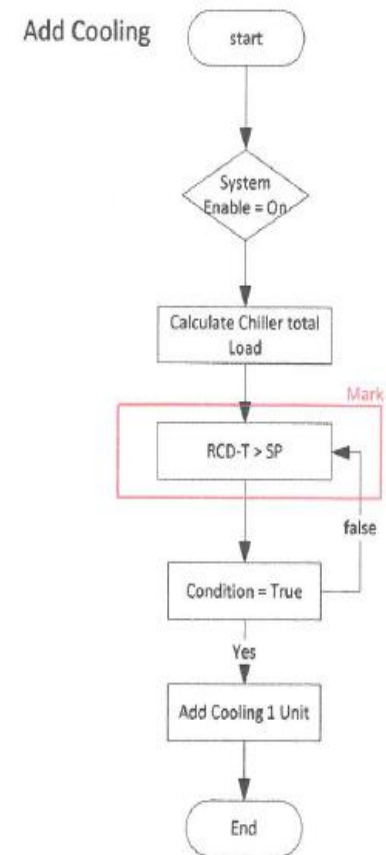
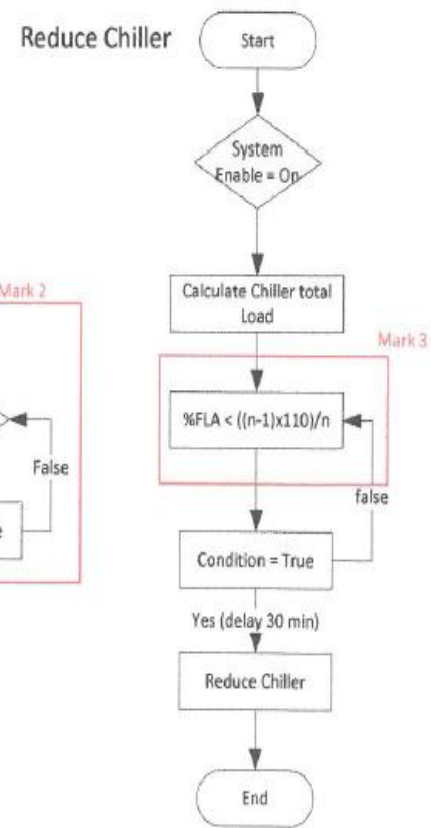
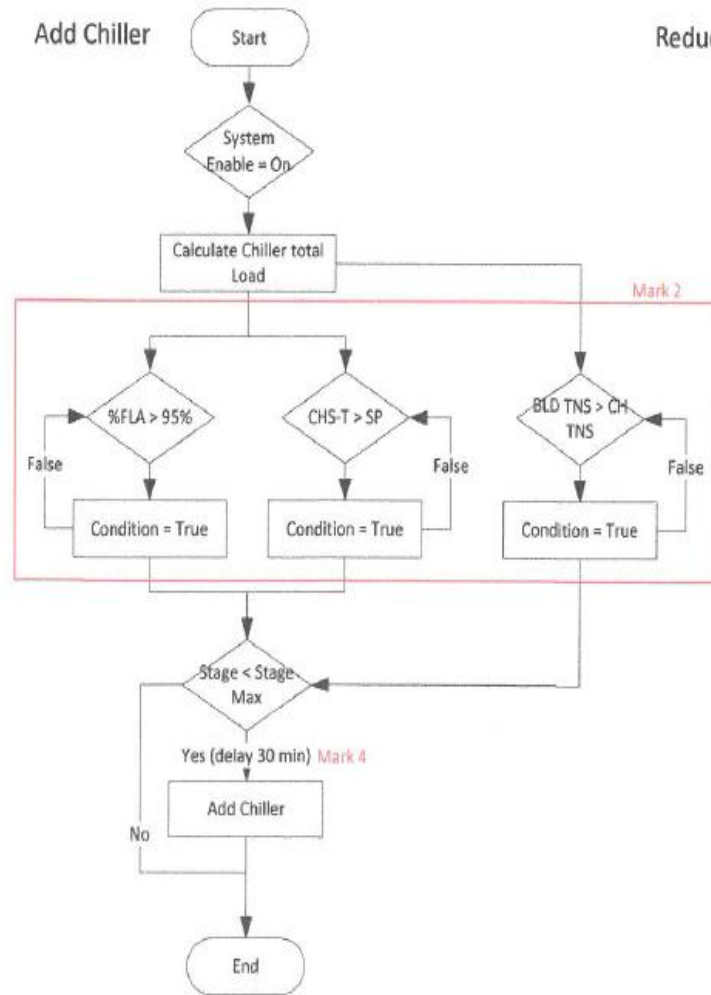


Chiller data

Date	Time	Time Zone	Tset	Tcdi	Tcdo	Tcond	Pcond	CondFlow	Tevi	Tevo	Tevap	Pevap	EvapFlow	kW	Load
22-May-19	10:45:00	Asia/Bangkok	42	85.4	92.8	97.6			52	42.9				282.8	94.2
22-May-19	10:30:00	Asia/Bangkok	42	85.6	93	97.8			52	43				281.8	94.2
22-May-19	10:15:00	Asia/Bangkok	42	85.3	92.6	97.5			51.9	42.9				282.3	94.1
22-May-19	10:00:00	Asia/Bangkok	42	85.2	92.6	97.4			51.9	42.8				282.6	94.4
22-May-19	9:45:00	Asia/Bangkok	42	85.2	92.5	97.3			51.9	42.8				281.9	94.2
22-May-19	9:30:00	Asia/Bangkok	42	85	92.3	97.2			51.8	42.8				281.6	94.1
22-May-19	9:15:00	Asia/Bangkok	42	84.9	92.2	97.1			51.8	42.7				282.8	94.5
22-May-19	9:00:00	Asia/Bangkok	42	84.7	92	96.9			51.6	42.5				281.4	94
22-May-19	8:45:00	Asia/Bangkok	42	84.8	92.1	97			51.5	42.5				281.3	94

ตารางที่ 1 Sensor and set-point	CPM ระบบปัจจุบัน	EMIS และ smart control ตาม TOR
Inlet and outlet condensing temperature (plant)	ติดตั้ง	ใช้หาค่า CQ2 ตาม smart control แต่ยังคงค่า set-point of inlet condenser temperature set-point - ตรวจสอบ ฟังก์ชันควบคุมเพิ่มเติม
Diff pressure (No. 3) for CDP pump	ไม่มีการติดตั้ง	เพิ่มเติม smart control ฟังก์ชัน 4 – condensing approach temperature control
Inlet and outlet evaporator temperature (plant)	ติดตั้ง	ใช้หาค่า CQ 1 ตาม smart control แต่ยังคงค่า set-point แสดงผล - ตรวจสอบ ฟังก์ชันควบคุมเพิ่มเติม
Diff pressure (No. 4) for secondary pump (SCHP)	ไม่มีการติดตั้ง	ขาดการควบคุม SCHP ป้องกัน building load loss ให้สอดคล้องกับ chilled water set-point ตาม smart control
Water flow rate (condenser and evaporator, plant)	ติดตั้ง	ใช้ในการทำ cooling building load และ cooling tower load เพื่อการวัดผลและทำนายภาระล่วงหน้า

CPMS – Data (scheduling control)



Normal Checking CPMS Control

Check Step 1.1

Building Load Pattern

Time domain Tevo and Building Load

Find out Tevo Outliers

Check Step 1.2

Time domain Tevo and CQ1 (evaporator)

Identify Tevo outliers on CQ1 vs. Building Load

Check Step 1.3

Time domain Tevo and CQ2 (condenser)

Identify Tevo outliers on CQ2 vs. Building Load

Check Step 1.4

Time domain Tevo and Pressure transducer

Identify Tevo and Pressure outliers vs. Load

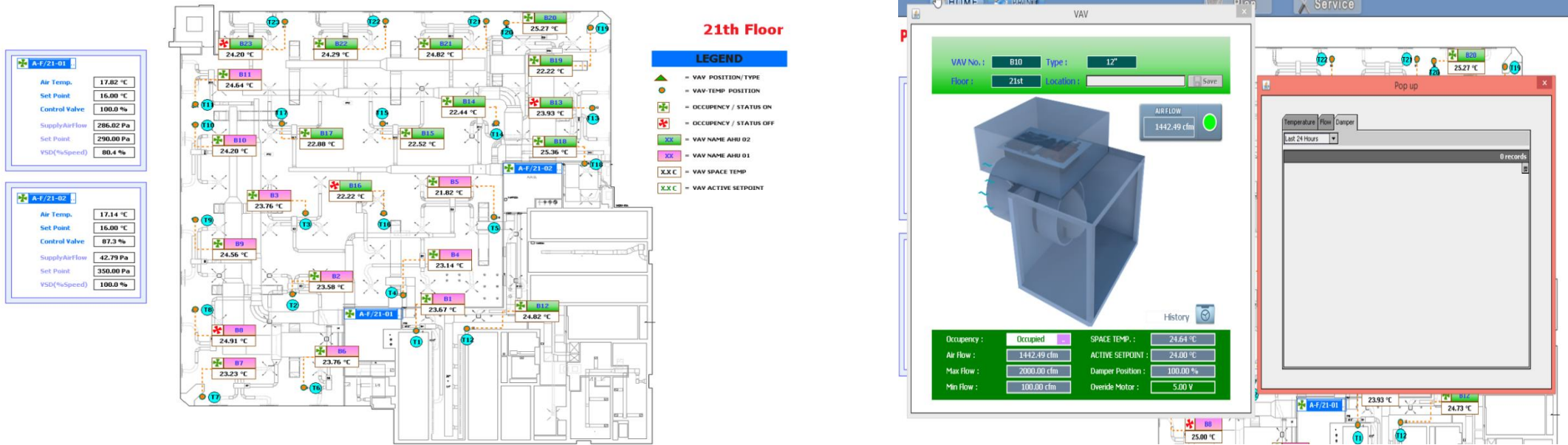
Check Step 1.5

Time domain Tevo and kW/ton

Identify Tevo outliers on kW/ton vs. Load



Typical Building automation system

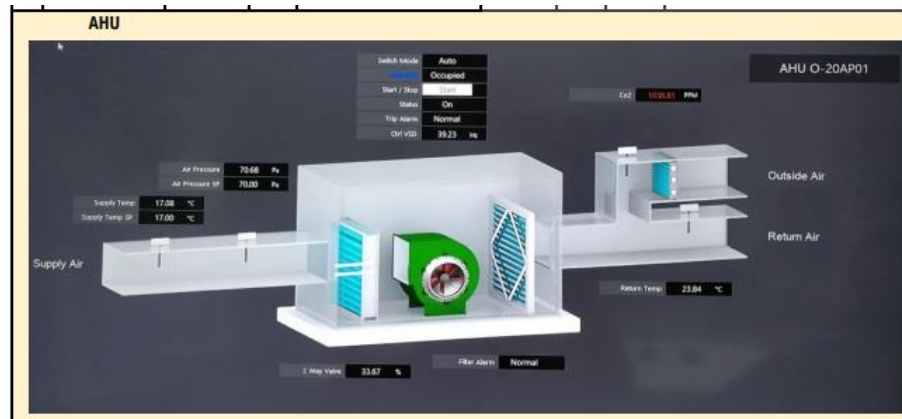
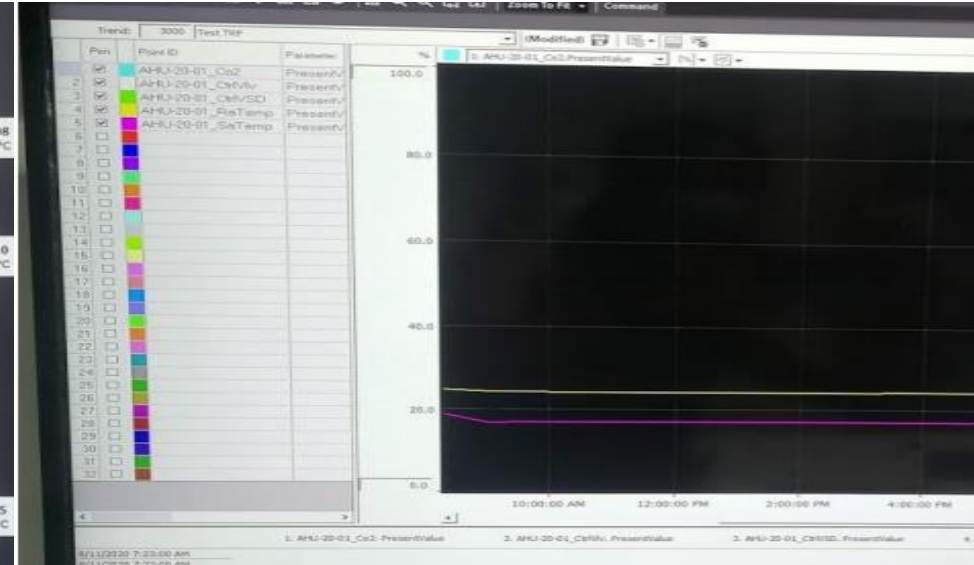
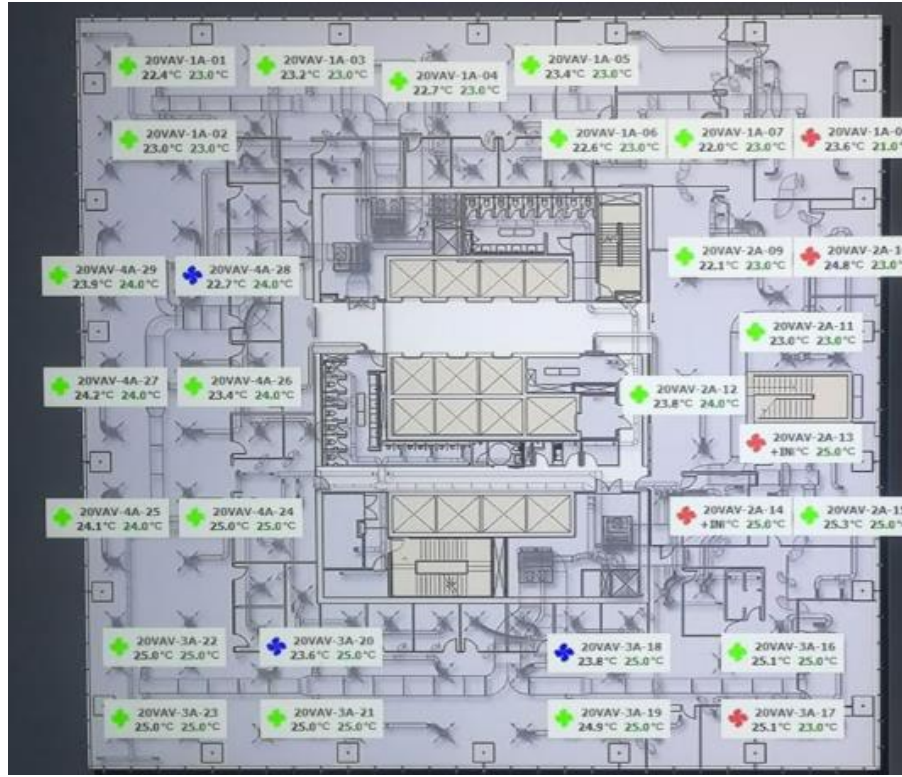


ระบบ BAS	ค่าตัวแปร
AHU system	ไม่มีการ trend ข้อมูลและไม่มีฟังก์ชัน automated export data
VAV box	ไม่มีการ trend ข้อมูลและไม่มีฟังก์ชัน automated export data
PAU	ไม่มีการ trend ข้อมูลและไม่มีฟังก์ชัน automated export data

คาดการณ์เกิดปัญหา AHU-01 และ -02

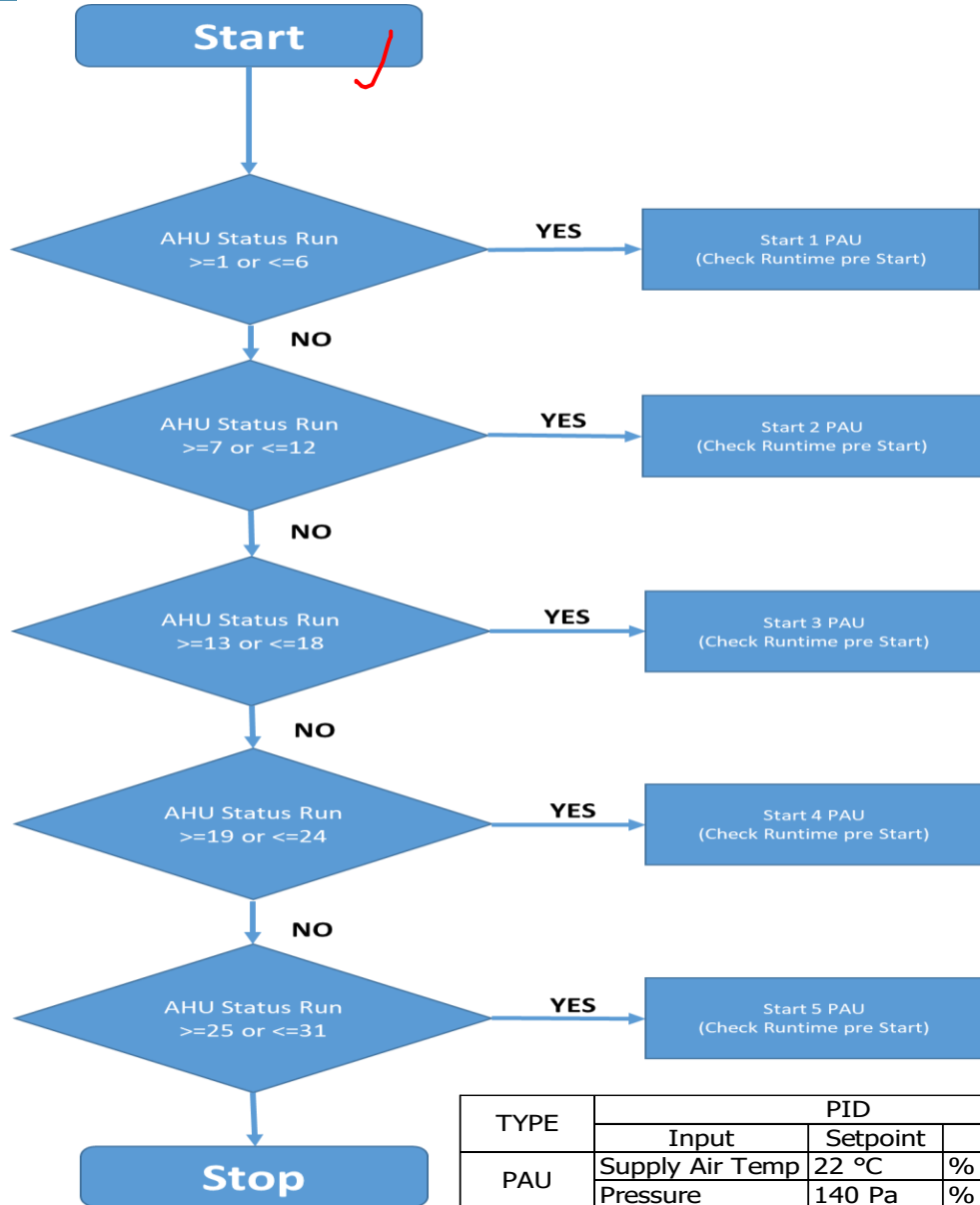
1. AHU sensor short-circuits เนื่องระบบ return temperature มีปัญหา
2. Improper and stuck control valve เนื่องจาก valve ค้าง
3. Improper VSD setting เนื่องจากไม่ตรวจสอบการไหลของอากาศในพื้นที่และขาดการใช้ข้อมูลในการรองรับการทำงานที่เหมาะสม

BAS – Data (ex. Honeywell)

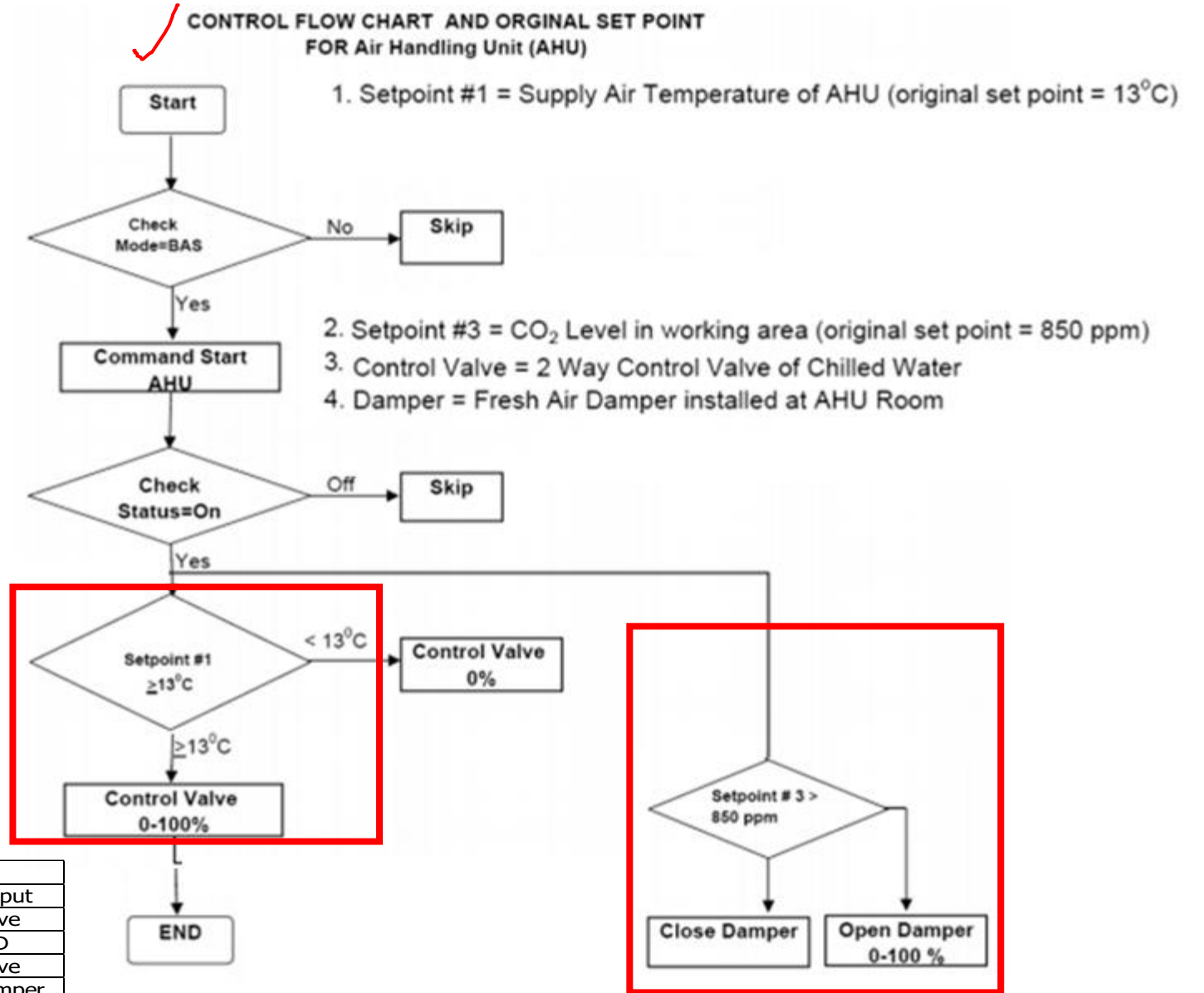


1	AHU Ts	Ts	C	Supply air temperature	Yes	No	No
2	AHU Ts set	Ts set	C	Supply air temperature set-point	Yes	No	No
3	AHU Tr	Tr	C	Return air temperature	Yes	No	No
4	AHU Tr set	Tr set	C	Return air temperature set-point	No	-	-
5	AHU Ps	Ps	Pa	Static pressure	Yes	No	No
6	AHU Ps set	Ps set	Pa	Static pressure setpoint	Yes	No	No
7	AHU vsd	vsd	%	Variable Fan %	Yes	No	No
8	AHU valve	valve	%	Cooling coil valve %	Yes	No	No
9	AHU Tfa	Tfa	C	Fresh air temperature	No	-	-
10	AHU CO2	CO2	ppm	Carbondioxide level	Yes	No	No
11	AHU CO2 set	CO2 set	ppm	Carbondioxide level	Yes	No	No

Scheduling BAS control (ex. Green buildings)



TYPE	PID		
	Input	Setpoint	Output
PAU	Supply Air Temp	22 °C	% Valve
	Pressure	140 Pa	% VSD
AHU	Return Air Temp	25 °C	% Valve
	CO2	1000 ppm	% Damper



Energy management system (EMS)

Auto Excel Report File

EE Demand Configure

General Billing Normal/TOD/TOU Export Billing/Customized Data **Auto Excel Report File** Group of Alarm FTP/SFTP

Enable

Setup Auto Excel Report

Select Type of Data to Export

Report Month Excel file (sheet data in Report_YYYY_MM.xlsx)
 and save Data on CSV file (in ReportEnergyDayData_YYYY_MM.csv)

Report TOU Month Excel file (sheet data in ReportTou_YYYY_MM.xlsx)
 and save Tou Data on CSV file (in ReportEnergyTouData_YYYY_MM.csv)

Report Month Raw Excel file (sheet RawData in ReportRaw_YYYY_MM.xlsx)
 and save RawData on CSV file (in ReportEnergyRawData_YYYY_MM.csv)

Report Year Excel file (ReportYearData.xlsx)

Convert sheet	Report1	to html file	Sample1.htm	in folder	d:\Demand21.dat\WebReport
Convert sheet	Report2	to html file	Sample2.htm	in folder	d:\Demand21.dat\WebReport
Convert sheet	Report3	to html file	Sample3.htm	in folder	d:\Demand21.dat\WebReport
Convert sheet	Report4	to html file	Sample4.htm	in folder	d:\Demand21.dat\WebReport
Convert sheet	Report5	to html file	Sample5.htm	in folder	d:\Demand21.dat\WebReport

Report Year Raw Data (ReportYearRaw.xlsx)

Convert sheet	Report6	to html file	Sample6.htm	in folder	d:\Demand21.dat\WebReport
Convert sheet	Report7	to html file	Sample7.htm	in folder	d:\Demand21.dat\WebReport
Convert sheet	Report8	to html file	Sample8.htm	in folder	d:\Demand21.dat\WebReport
Convert sheet	Report9	to html file	Sample9.htm	in folder	d:\Demand21.dat\WebReport
Convert sheet	Report10	to html file	Sample10.htm	in folder	d:\Demand21.dat\WebReport

เปิด ส่งรายงานอัตโนมัติ File (Report mm-YYYY.xls), ระบบจะใช้ e-mail ใน

8:00 เวลารายงาน Daily

รายงานทุก 15 นาที Weekly on

Monthly on

OK APPLY CANCEL



- โปรแกรมบันทึกค่าจากการสำรวจใช้ Smart EE 5.2 พบปัญหาดังนี้
1. โปรแกรมยังไม่ได้ตั้ง Auto Excel Report File ต้องทำสอบให้สามารถตั้งค่าทุก 15 นาทีได้หรือไม่
 2. มิเตอร์ที่มีอยู่ในระบบ เป็นการรวมกันระหว่าง CHP CDP และ CTX/1 และ CTX/2



Building Energy management system (BEMS)

	Item	OnTime	FoodTemp (C)	SaleTemp (C)	MallTemp (C)	OutdoorTemp (C)	LUX (LUX)
1							
2	1	8/9/64 0:00	30	26	29	27	30
3	5	8/9/64 1:00	29	26	29	27	30
4	9	8/9/64 2:00	29	26	29	26	30
5	13	8/9/64 3:00	29	26	29	26	30
6	17	8/9/64 4:00	29	26	29	26	30
7	21	8/9/64 5:00	29	26	29	26	30
8	25	8/9/64 6:00	29	26	29	26	210
9	29	8/9/64 7:00	29	26	29	26	256
10	33	8/9/64 8:00	29	26	29	27	922
11	37	8/9/64 9:00	28	25	27	28	875
12	41	8/9/64 10:00	27	24	27	30	1,278
13	45	8/9/64 11:00	27	24	27	30	1,152
14	49	8/9/64 12:00	27	25	27	32	1,206
15	53	8/9/64 13:00	28	25	27	35	1,027
16	57	8/9/64 14:00	27	25	28	34	1,050
17	61	8/9/64 15:00	26	25	28	33	1,009

	No	OnTime	AHU (kWh)	Lighting (kWh)	Chiller plant (kWh)	Refirgeration (kWh)	Other (kWh)	Total (kWh)
1								
2	1	1/7/64 0:00	2	8	0	17	39	67
3	2	1/7/64 1:00	7	32	1	73	158	271
4	3	1/7/64 2:00	7	32	2	69	155	265
5	4	1/7/64 3:00	7	32	1	76	156	272
6	5	1/7/64 4:00	7	33	1	76	143	260
7	6	1/7/64 5:00	7	33	2	81	148	271
8	7	1/7/64 6:00	20	38	23	89	158	328
9	8	1/7/64 7:00	30	40	187	91	179	527
10	9	1/7/64 8:00	41	76	346	83	246	792
11	10	1/7/64 9:00	42	83	314	85	314	838
12	11	1/7/64 10:00	53	98	336	92	381	961
13	12	1/7/64 11:00	56	100	382	88	445	1,071
14	13	1/7/64 12:00	57	97	376	91	439	1,060
15	14	1/7/64 13:00	57	97	376	96	444	1,071
16	15	1/7/64 14:00	58	100	381	98	442	1,078
17	16	1/7/64 15:00	58	98	390	93	454	1,094

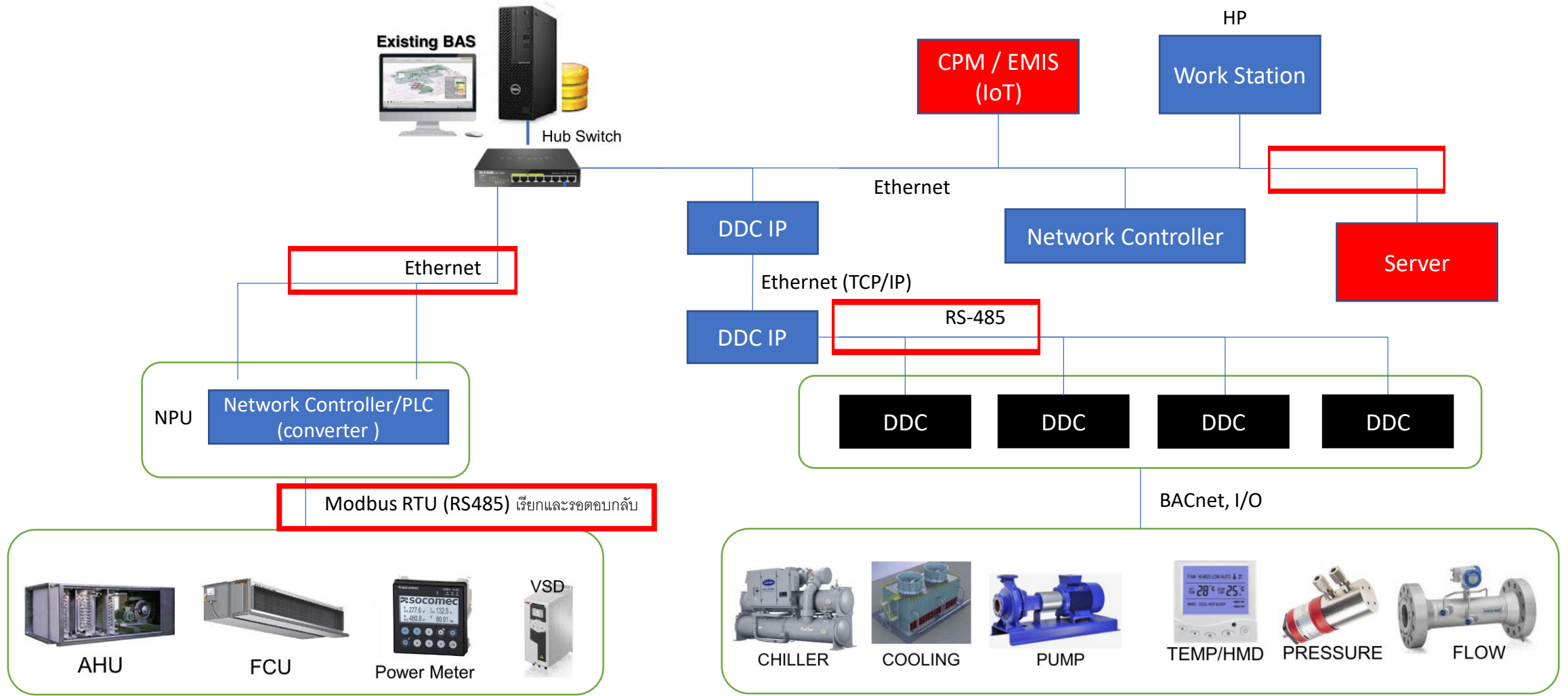
Chain Retail Store

1. Zone monitoring – average temperature and humidity
2. Hourly power and energy consumption

SECTION 4

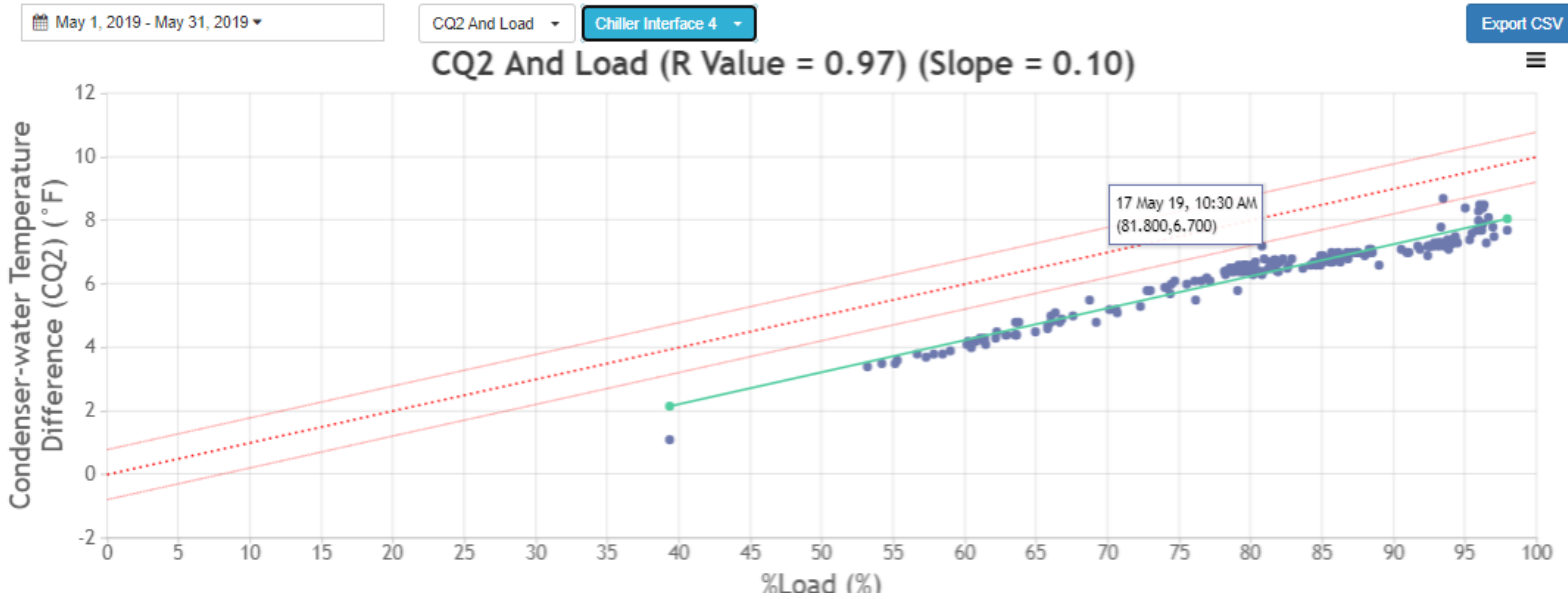
Communication problems for CPMS and BAS

Overall problems for center control





Overall problems - system performance evaluation (Ex.)



1. Ch1 – FLA 78% ข้อมูลผลิตจะทำค่า CQ1 ได้ 7.8 F

หากแต่่วัดค่าได้ 6.2 F ซึ่งหายไป 1.6 F จาก 7.8 F - คิดเป็น 20.5%

2. Low delta T syndrome โดยเทียบค่า CQ1 และ CQ2 ต้องมีค่าเท่าๆกันเช่น Ch1 – FLA 78%

ข้อมูลผลิตจะทำค่า CQ2 ได้ 7.8 F วัดจริง 8.2 F ค่าเกินไป 0.4 F คิดเป็น loss 5.1%

ตารางที่ 2 ผลการวินิจฉัยจาก CQ และ building loss

No.	Setpoint (F)	Tevo (F)	Tevi (F)	Tcdo (F)	Tcdi (F)	FLA (%)	CQ1 (Tevi - Tevo, F)	CQ2 (Tcdo - Tcdi, F)	Loss from Hz	CQ6 (Tcond - Tcdo, F)	Loss between CQ1 and CQ2
CH1	48	48.1	54.3	94.4	86.2	78	6.2	8.2	20.5%	1.4	5.1%
CH2	48	48.0	54.1	94.8	86.4	81	6.1	8.4	24.7%	2.3	3.7%
CH3	48	47.1	54.1	95.6	86.0	88	7.0	9.6	20.5%	3.7	9.1%
CH4	-	-	-	-	-	-	-	-		-	



THANKS
FOR WATCHING

GET IN TOUCH WITH US

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for Energy Savings
in Your Commercial Buildings
and Factories

WEBPAGE ▼

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<https://www.facebook.com/TIESmartSolutions/>



LOCATION ▼

1706/26 Rama VI Rd., Rongmueng,
Pathumwan, Bangkok 10330

PHONE CALL ▼

+66 21023387