The Energy Conservation Center of Thailand ศูนย์อนุรักษ์พลังงานแห่งประเทศไทย
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TIE SMART SOLUTIONS

AI Energy Platform

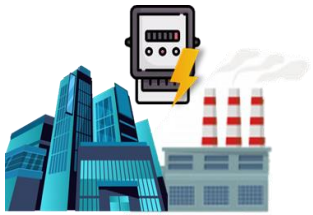
Better Life Quality with Energy Saving by our Big Data and AI Diagnostics

“Modern Technologies for energy optimization”

Agenda

- 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



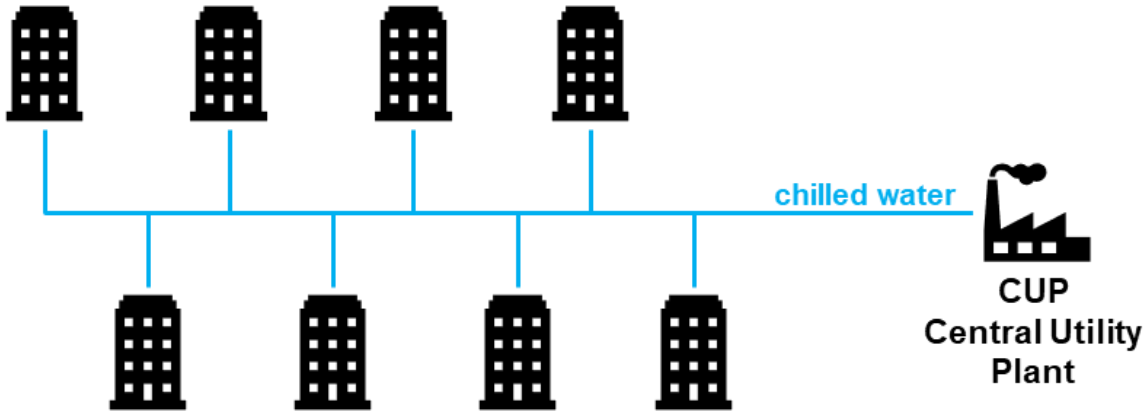
Green buildings and Smart Cities - climate change

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

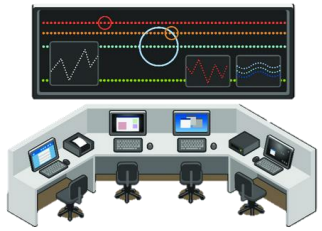


Our main solutions

THE OUR SOLUTION

AIoT Energy Platform
for Intelligent Solutions

where energy consumers can earn correct and suitable solutions



Data and Hardware Integration

Utilizing existing data in buildings without additional sensors

System Diagnostics

Diagnose and solve Air-conditioning problems and other energy loss

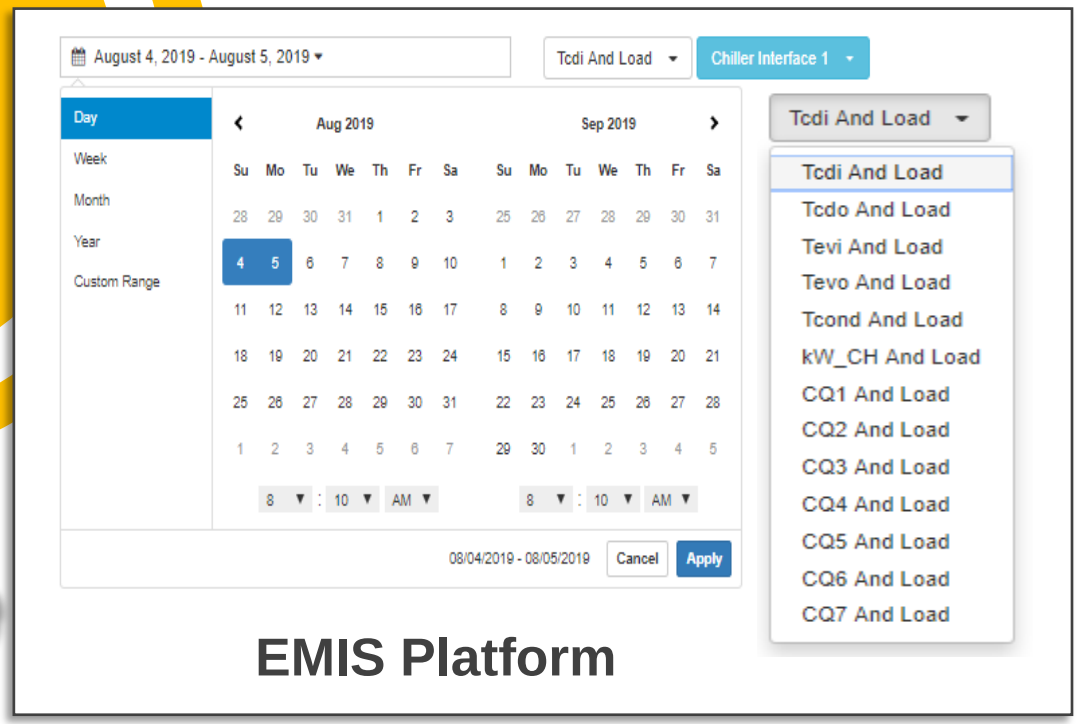
Smart advisory report and control optimization

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)



EMIS Platform

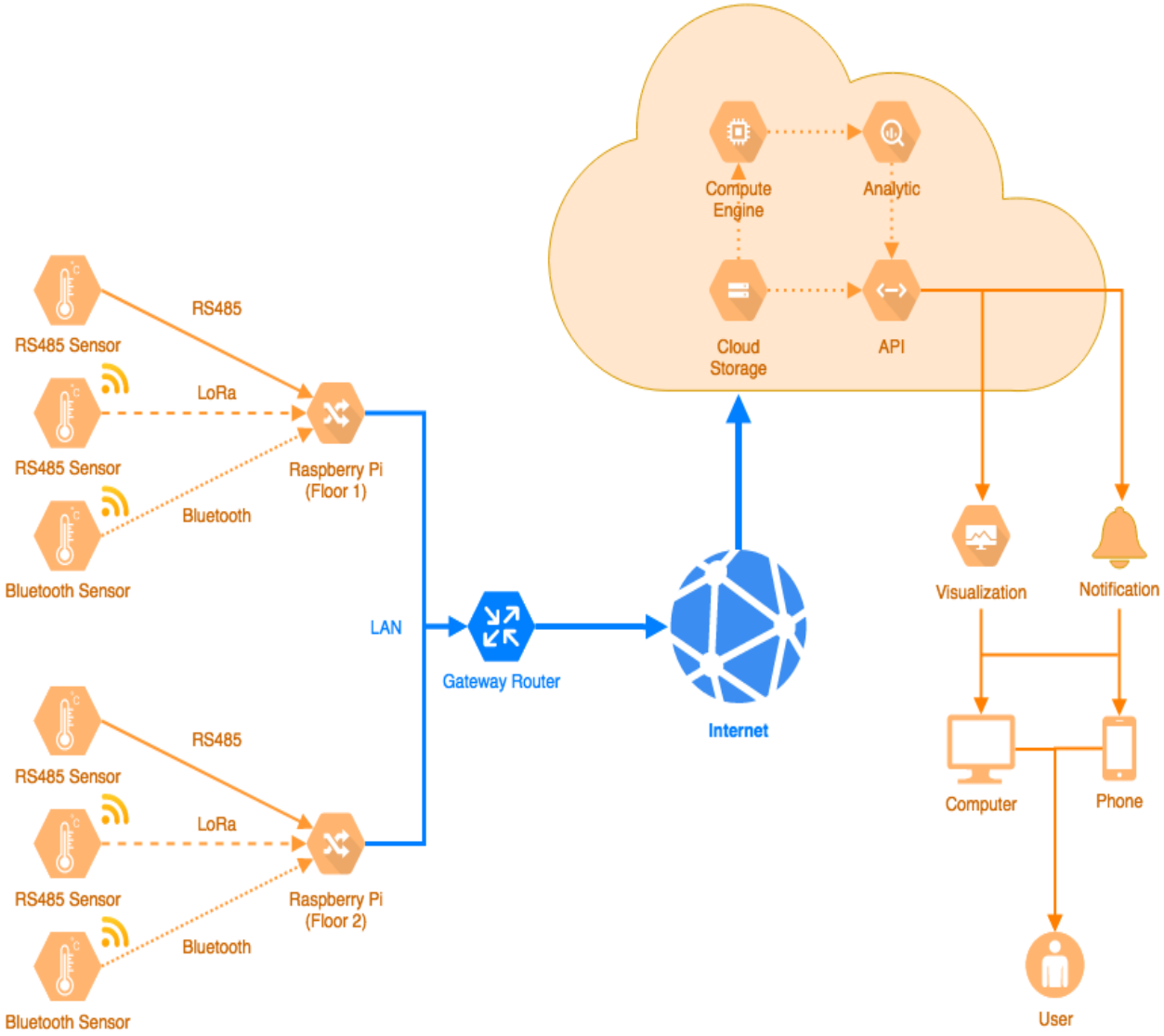
2019 TEIT AWARD

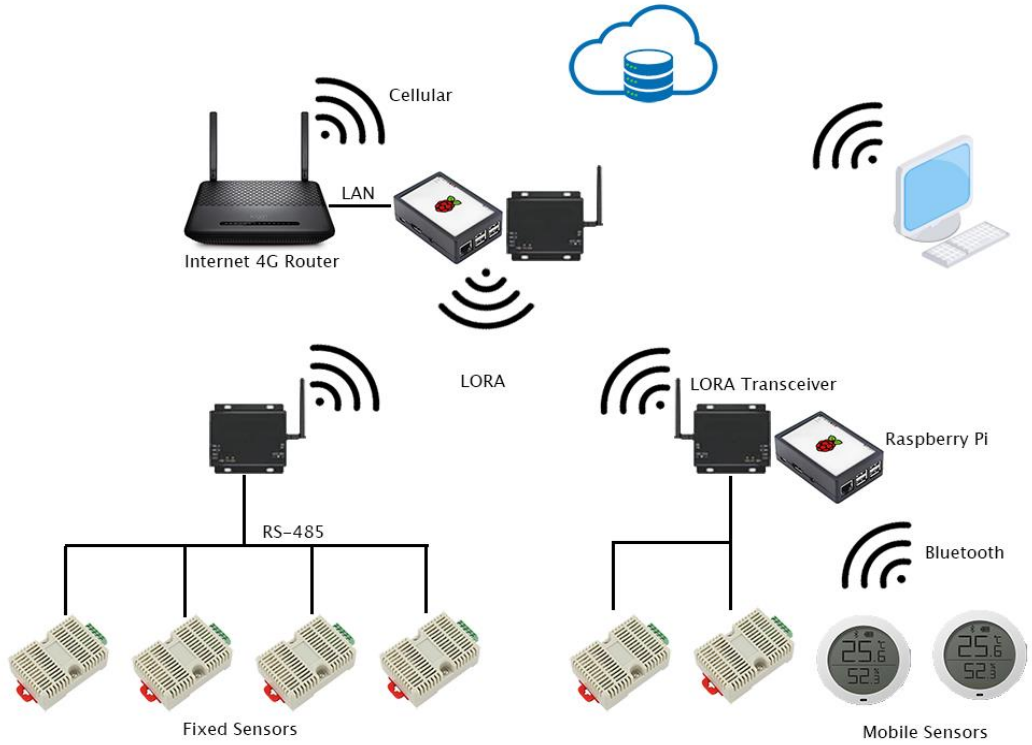
The winner of **TEIT Award 2019**

AFDD based AI and IoT platform for chiller air-conditioning system

Department of Alternative Energy Development and Efficiency
MINISTRY OF ENERGY

TIE (Hybrid LoRa + Zigbee + Bluetooth)



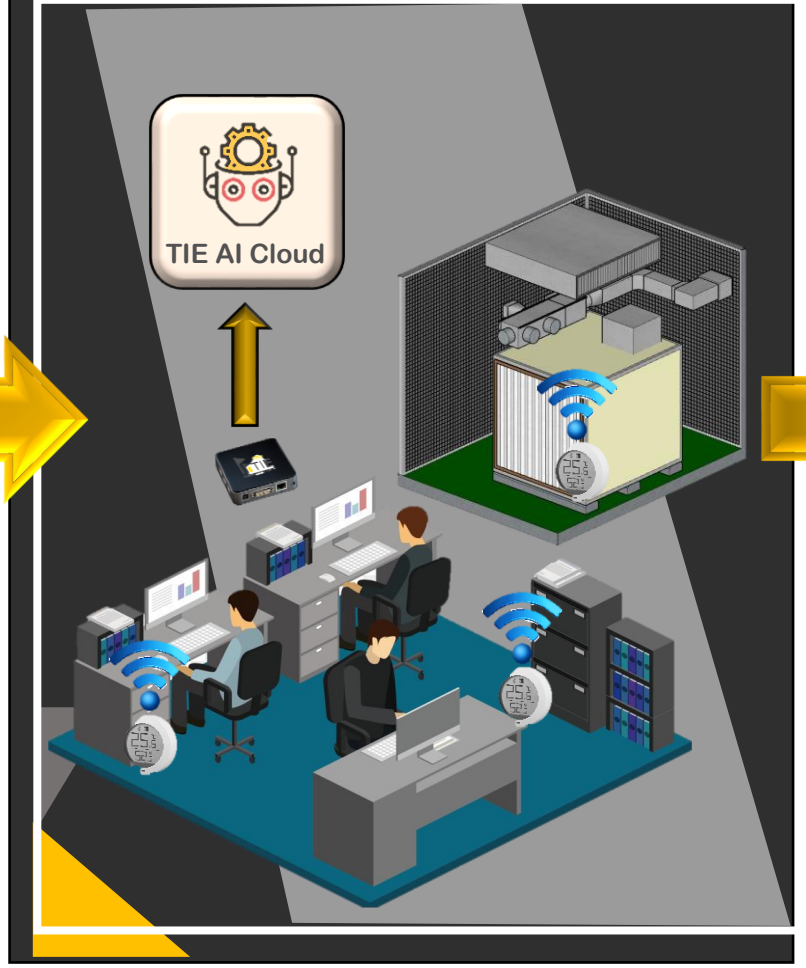


Changed 5G to 6G by using 6G router while using internal LoRa loop network

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

Smart Monitoring

IoT Communicator



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

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

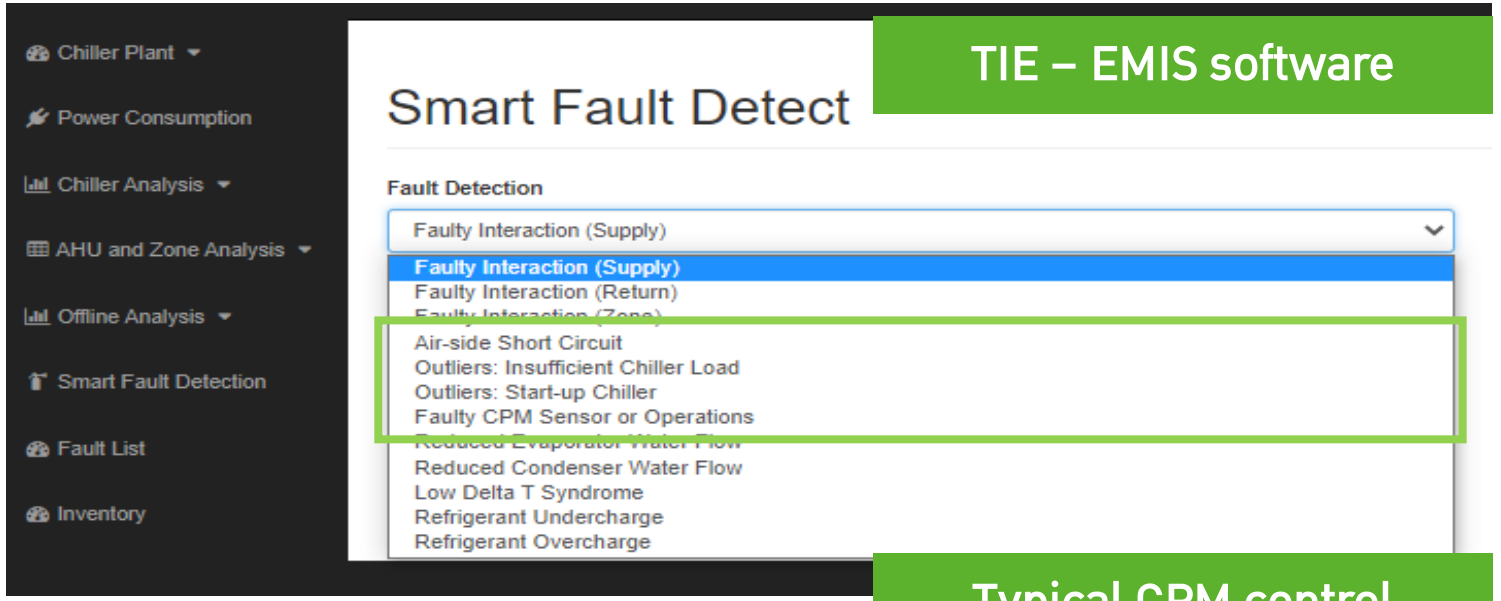
F17: wrong CAV control valve

F18: too high supply air temperature of a AHU

F19: too low supply air temperature of a AHU

F20: air zone condensation

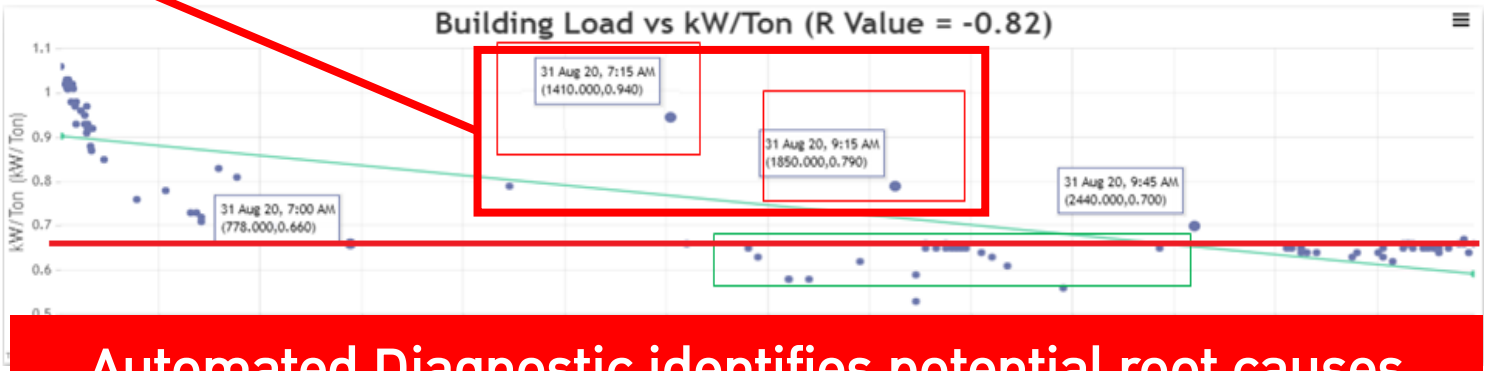
Retuning CHP VSD



TIE – EMIS software

Typical CPM control

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

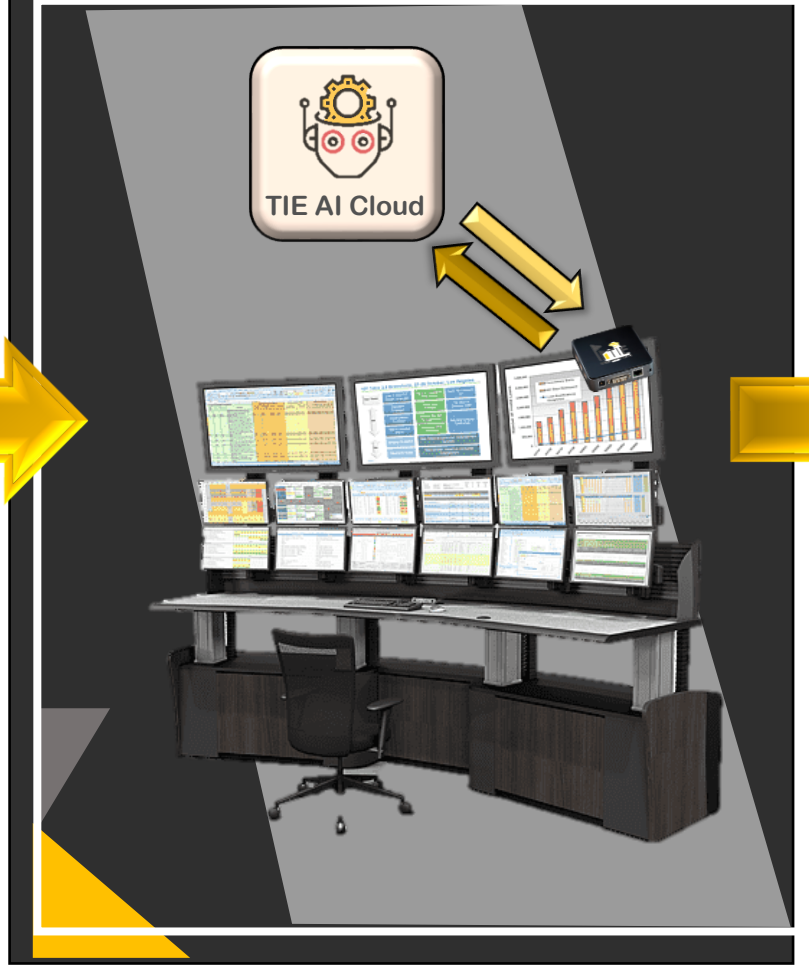


Automated Diagnostic identifies potential root causes

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

AIoT Controller

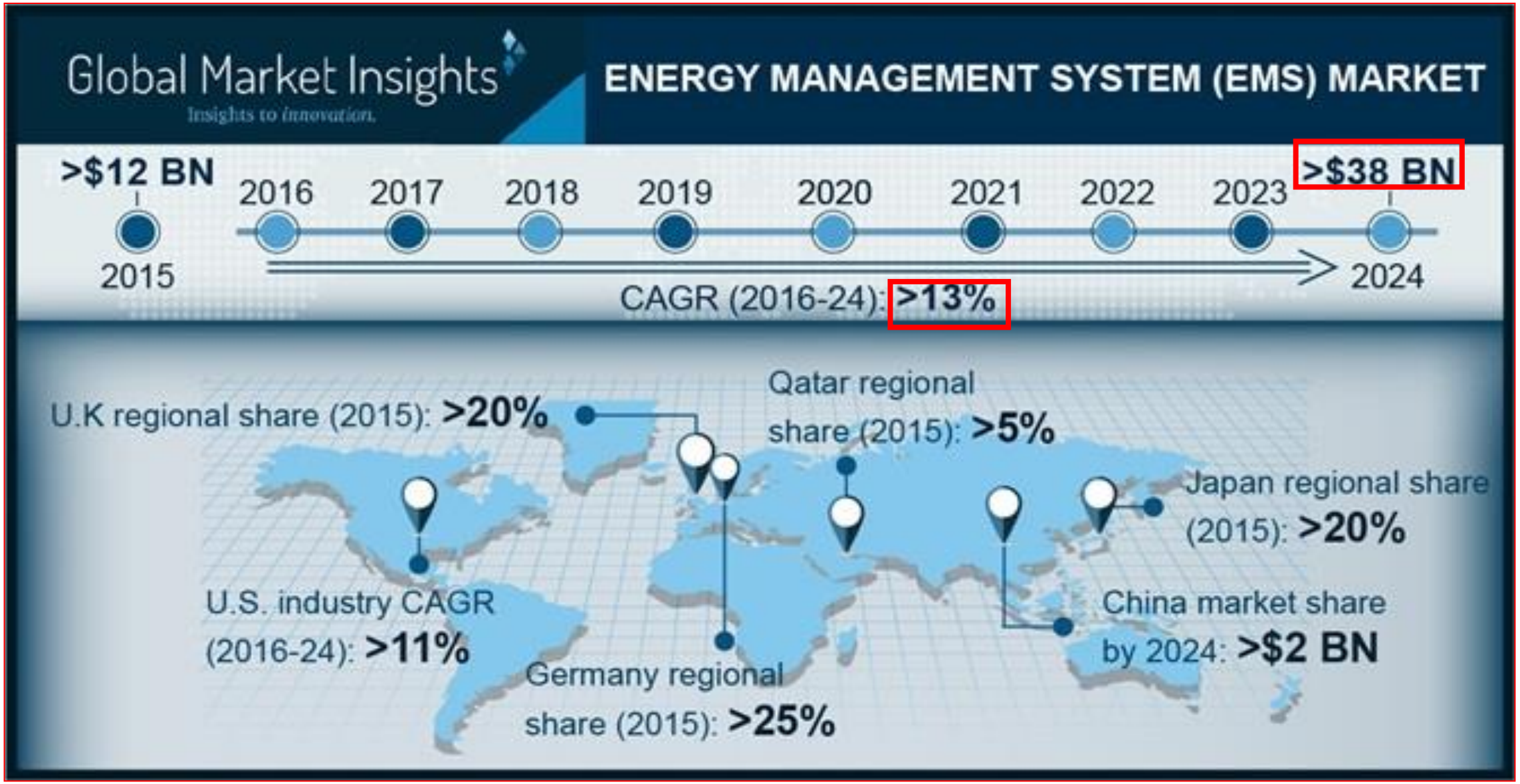
Building Intelligence



Optimization Control

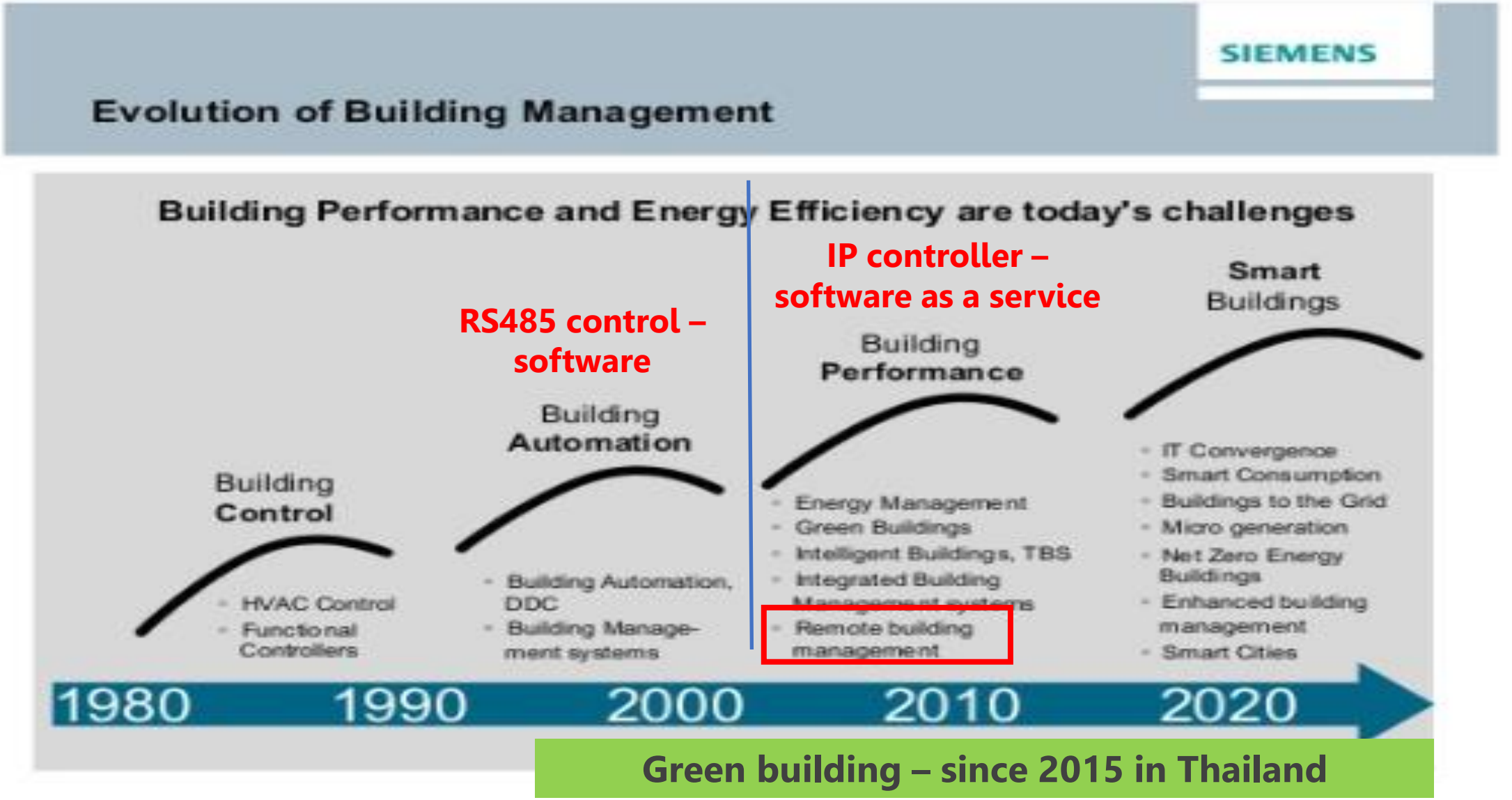
SECTION 2

BEMS vs. EMIS (Energy management information system)



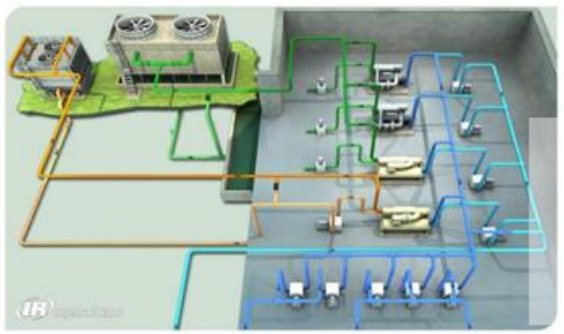
[1] Global Market Insights, Inc.

BMS evolution



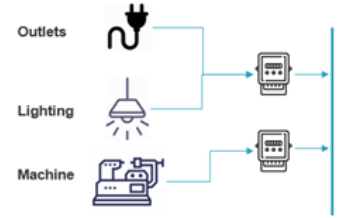
Global Market Insights, Inc.

CPMS, BAS, EMS and BEMS (Thailand)



Chiller plant manager (CPM)
Chiller | Pumps | Cooling tower

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 *CO_2 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)**

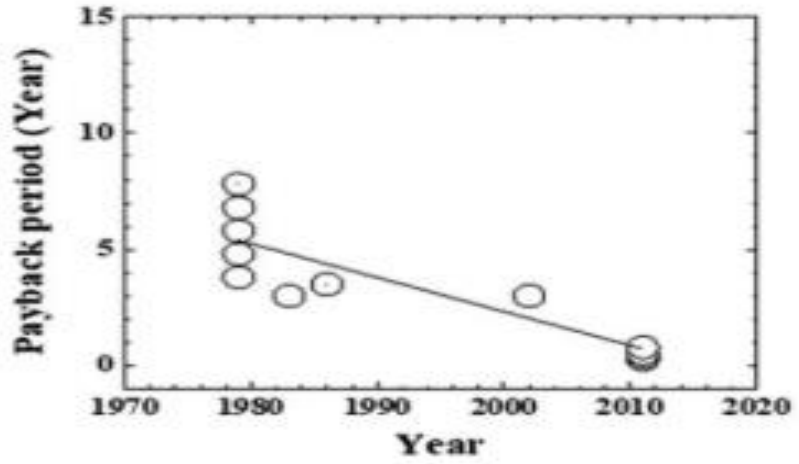


FIGURE 2 Payback periods of building energy management system (BEMS) for commercial buildings

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**

[2] CC Cheng, D. Lee. Return on investment of building energy management system: A review. International Journal of Energy Research 42 (2018); 4034–4053.

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

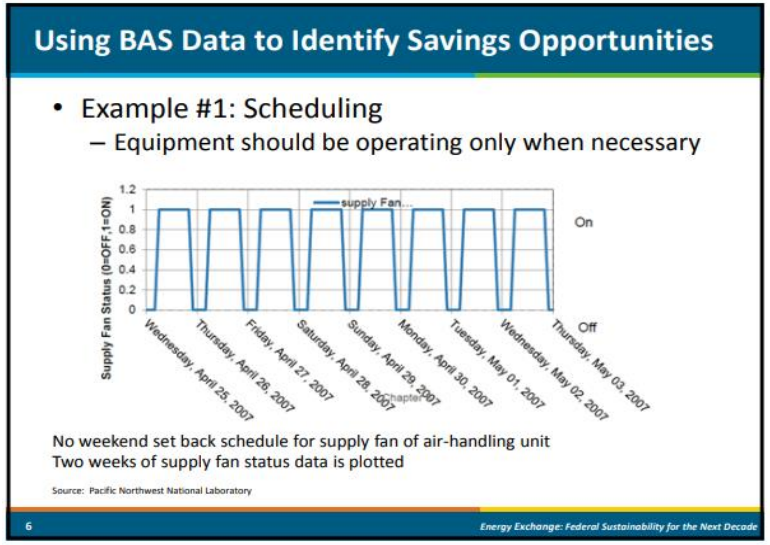
3. Building management control system (BMS) – AHU including: lighting control, Security control
4. Energy management system (EMS) – online power meter software (energy monitoring)

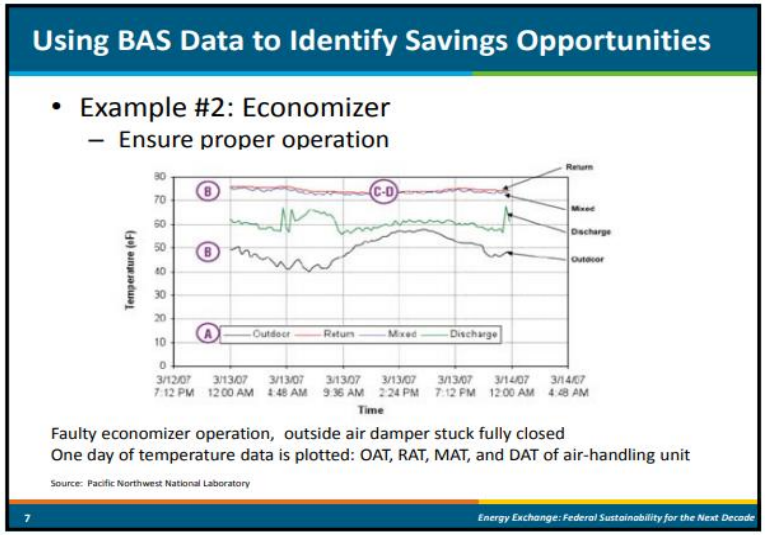
5. Building energy management system (BEMS) – AHU schedule control and energy monitoring

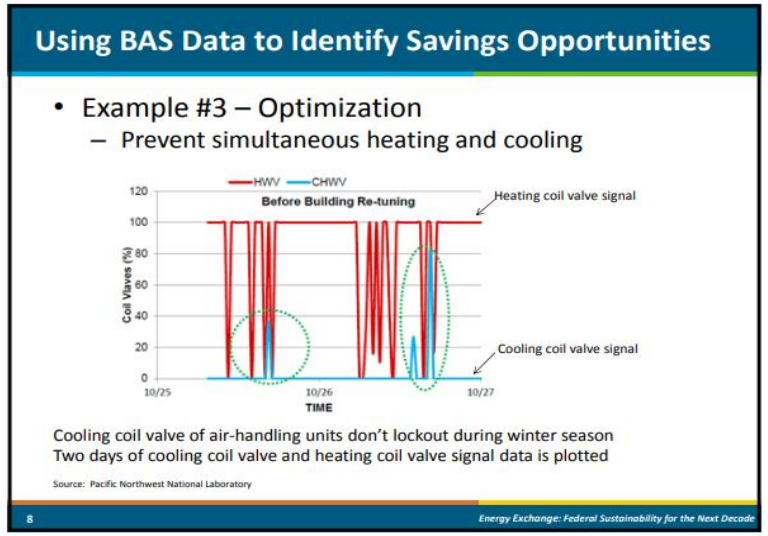
BAS function for HVAC control

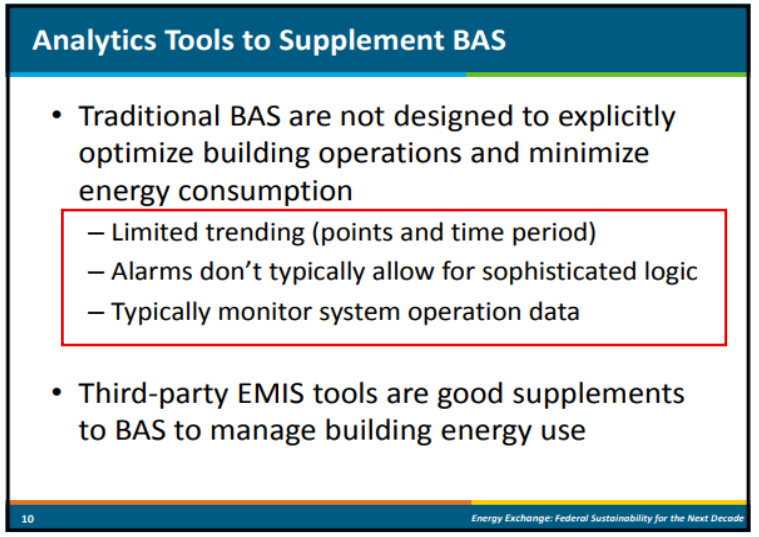
*"Traditional BAS are **not designed** to explicitly optimize building operations and minimize energy consumption"*

Source: Pacific Northwest National Laboratory







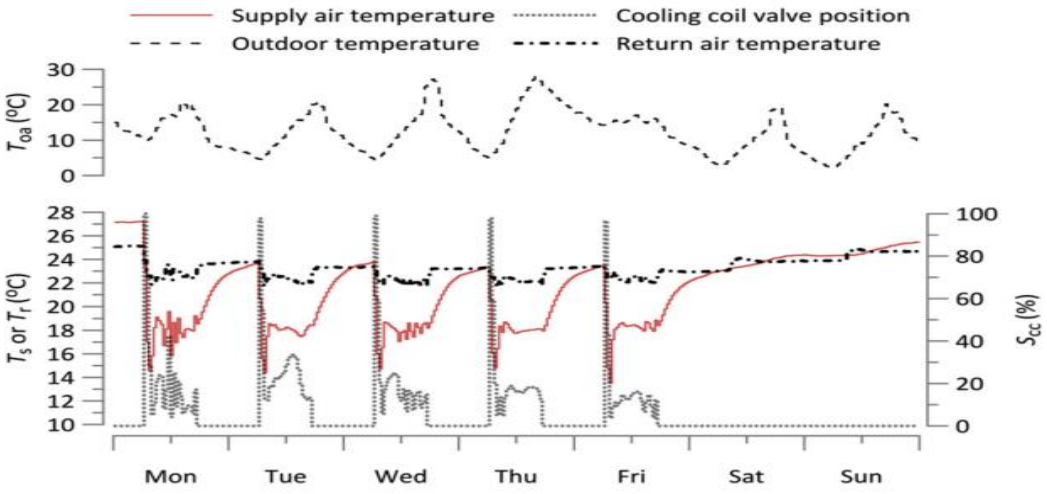


Source: Pacific Northwest National Laboratory

EMIS (Energy management information system) vs. BAS

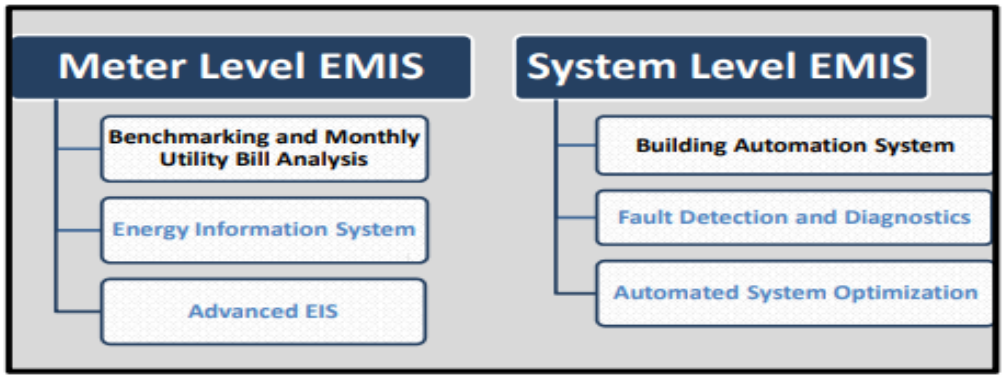
Analytics Tools to Supplement BAS

- Traditional BAS are not designed to explicitly optimize building operations and minimize energy consumption
  - 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



Energy Management and Information System (EMIS)

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

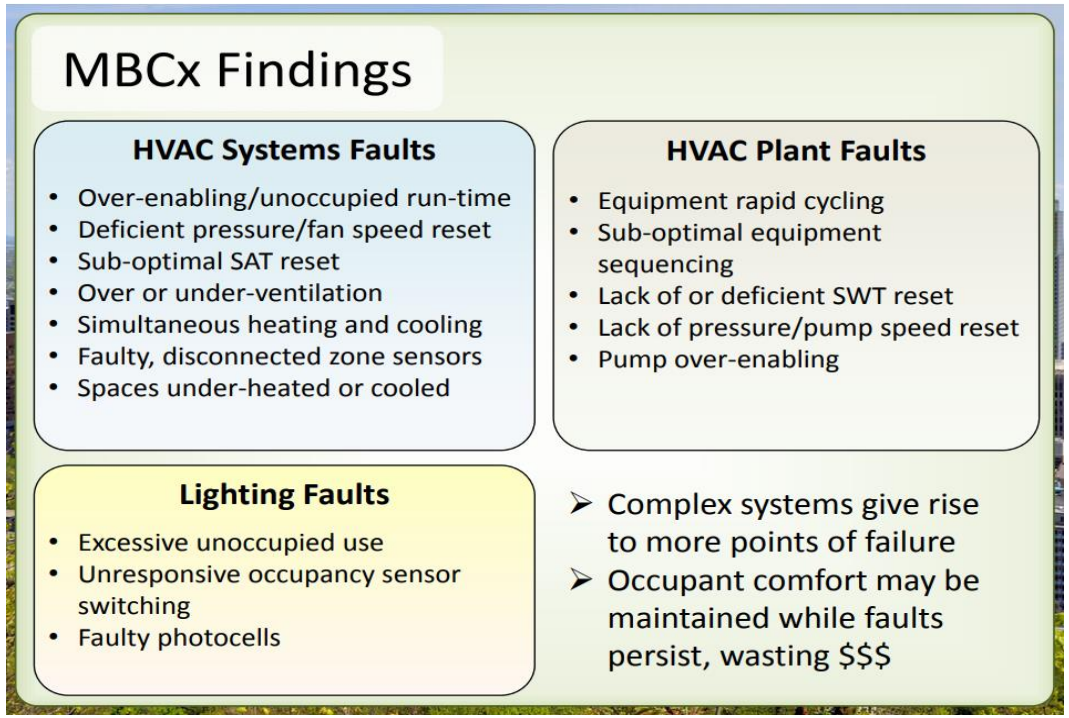


*The lines can be blurry, and specific technologies may cross categories, e.g., Modern building automation system platform with FDD capabilities

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



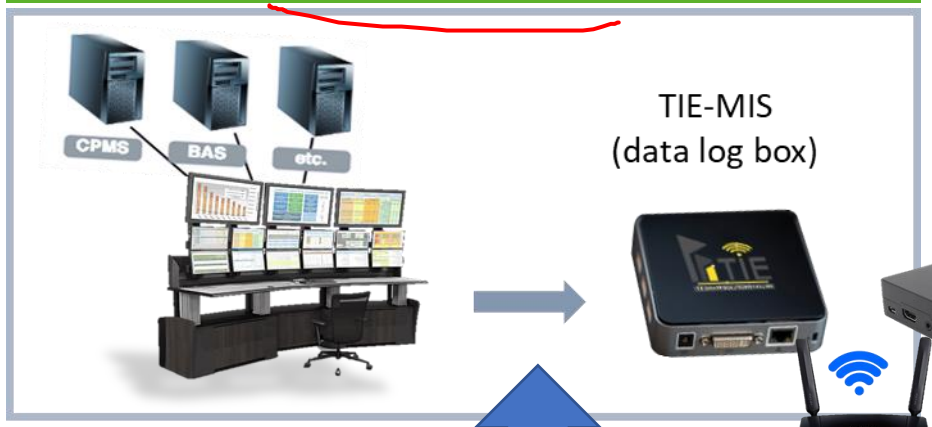
EMIS – Monitoring based commissioning (MBCx)

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

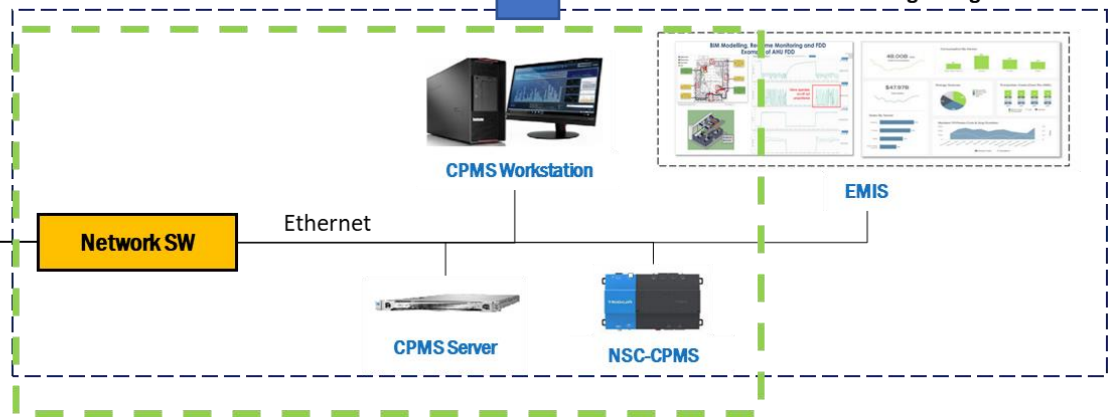
F9: Surging
F10: improper pump control
F11: Outliers from start-up chiller
F12: Faulty CPM sensor
F13: Insufficient load
F14: Air-side short circuit

EMIS – System Monitoring, Diagnostic and Control

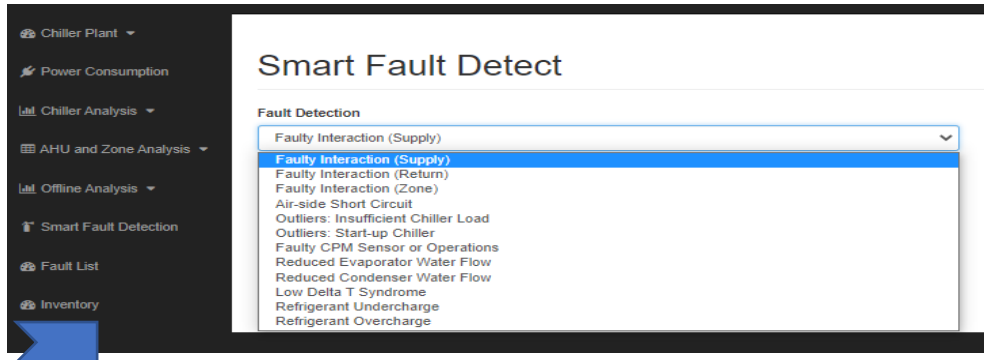
MBCx phase 1 – Data configuration with CPM data interface



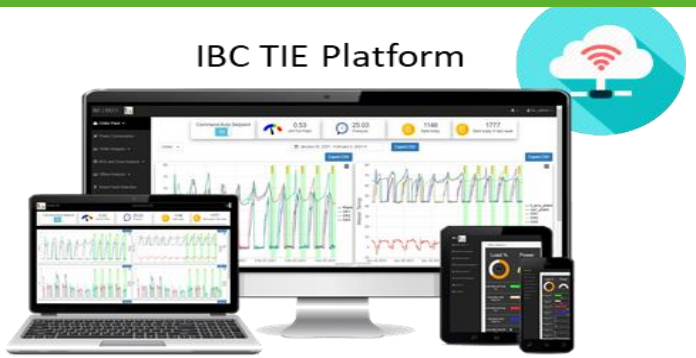
Database & Server



MBCx phase 2 – AFDD design and Implementation



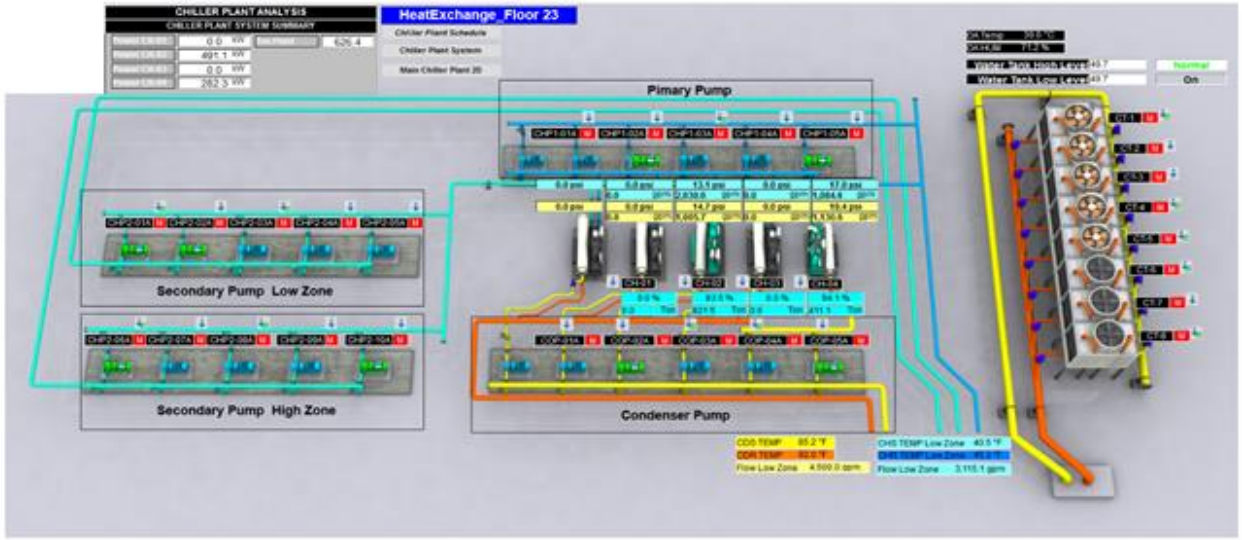
MBCx phase 3 – Automated Repair by smart controller



SECTION 3

Typical Problems – BAS and CPMS

Large Banks

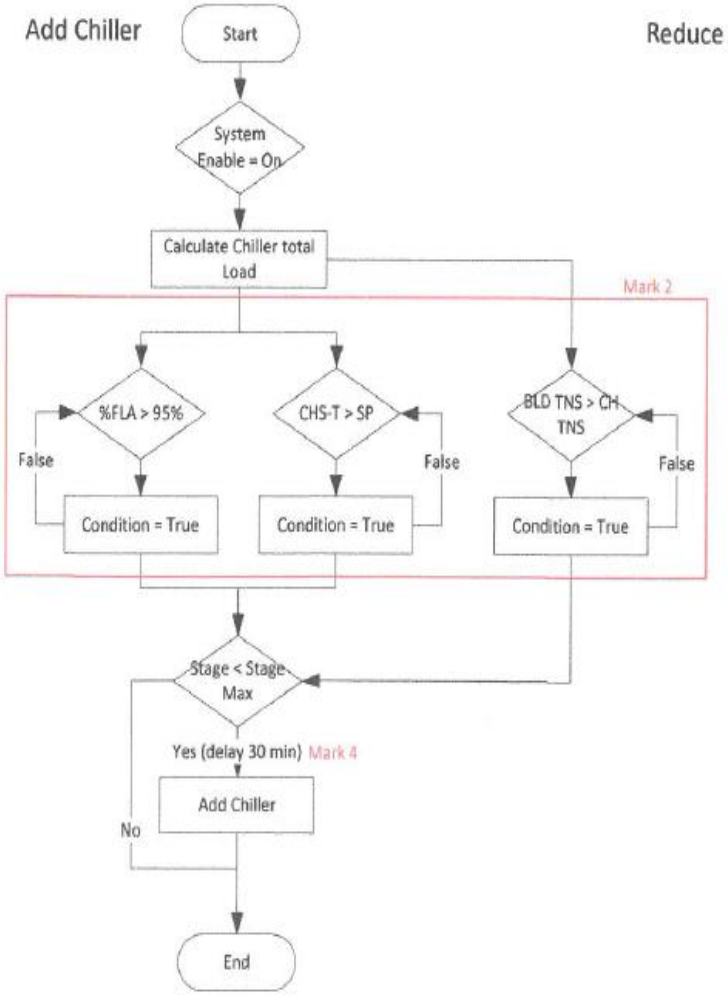


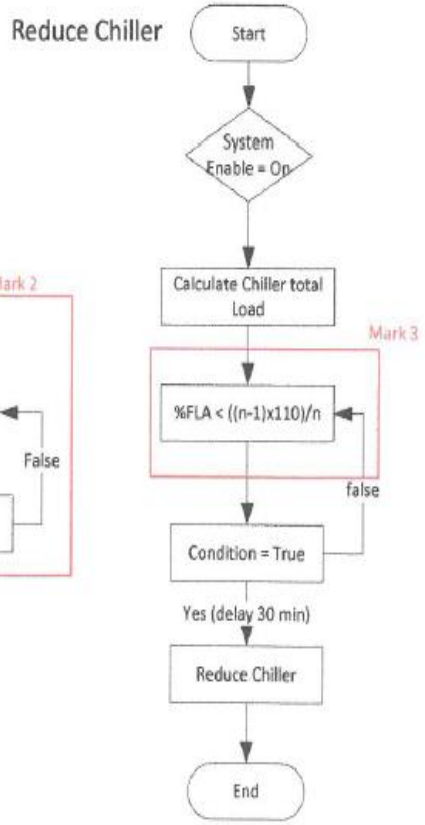
Chiller data

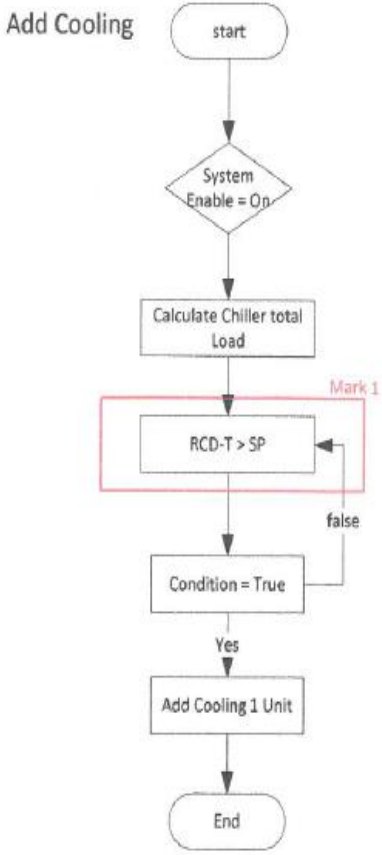
Date	Time	Time Zone	Tset	Tcdi	Tcdo	Tcond	Pcond	CondFlow	Tevi	Tevo	Tevap	Pevap	EvapFlow	kW	Load
22-May-19	10:45:00	Asia/Bangkok	42	85.4	92.8	97.6			52	42.9				282.8	94.2
22-May-19	10:30:00	Asia/Bangkok	42	85.6	93	97.8			52	43				281.8	94.2
22-May-19	10:15:00	Asia/Bangkok	42	85.3	92.6	97.5			51.9	42.9				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 แต่ยังขาดค่า 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 แต่ยังขาดค่า 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	ใช้ในการหา 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

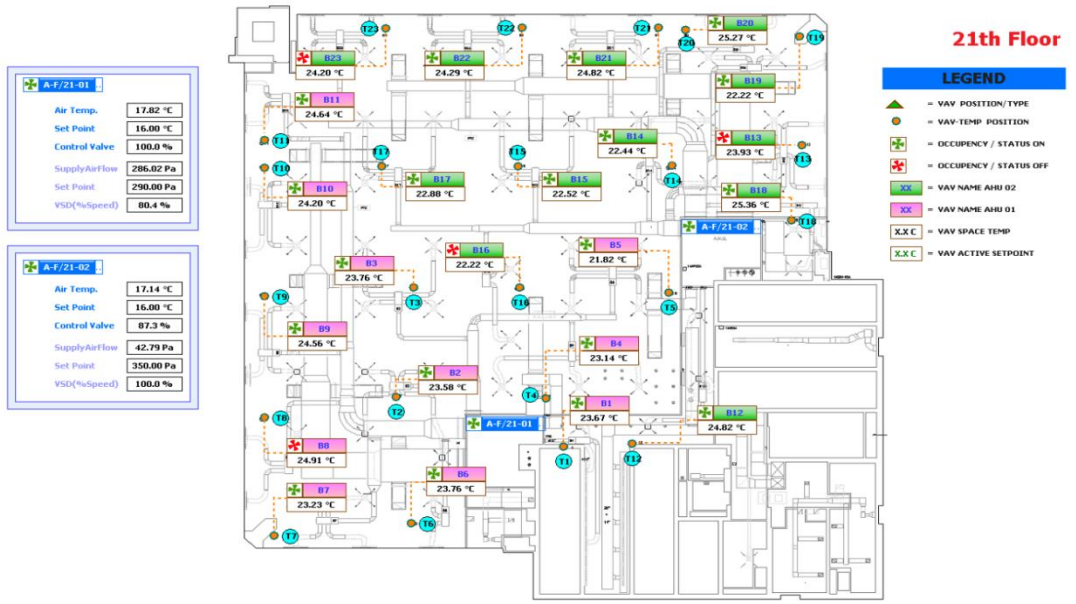
Identify Tevo and Pressure outliers vs. Load

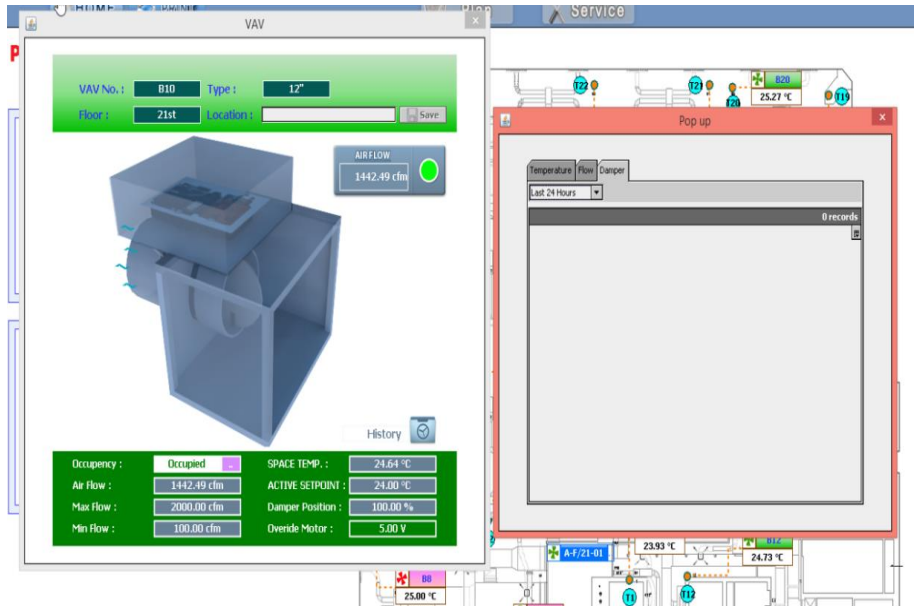
Check Step 1.5

Time domain Tevo and kW/ton

Identify Tevo outliers on kW/ton vs. Load

Typical Building automation system



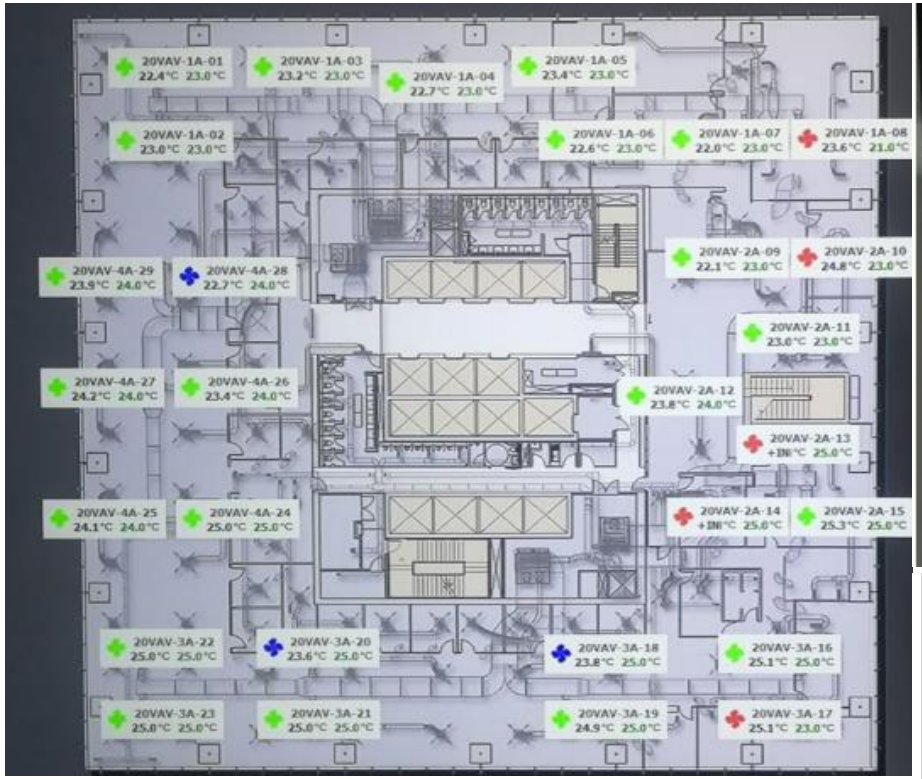


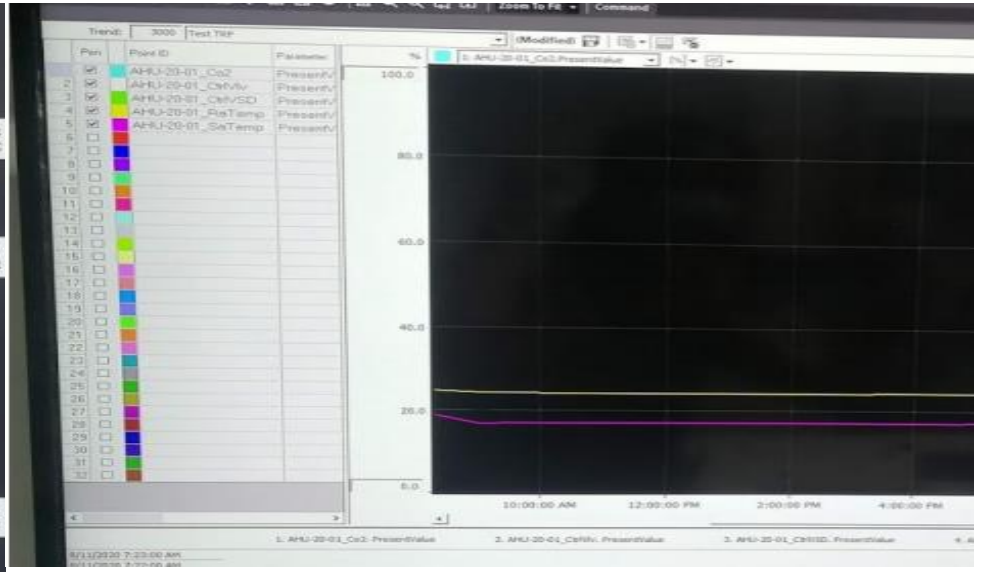
ระบบ BAS	ค่าตัวแปร
AHU system	ไม่มีการ trend ข้อมูลและไม่มีฟังก์ชัน automated export data
VAV box	ไม่มีการ trend ข้อมูลและไม่มีฟังก์ชัน automated export data
PAU	ไม่มีการ trend ข้อมูลและไม่มีฟังก์ชัน automated export data

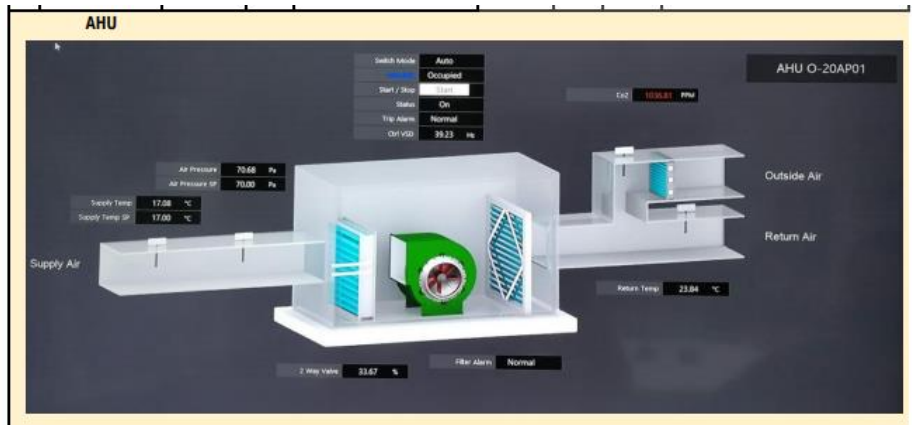
คาดการณ์เกิดปัญหา AHU-01 และ -02

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)

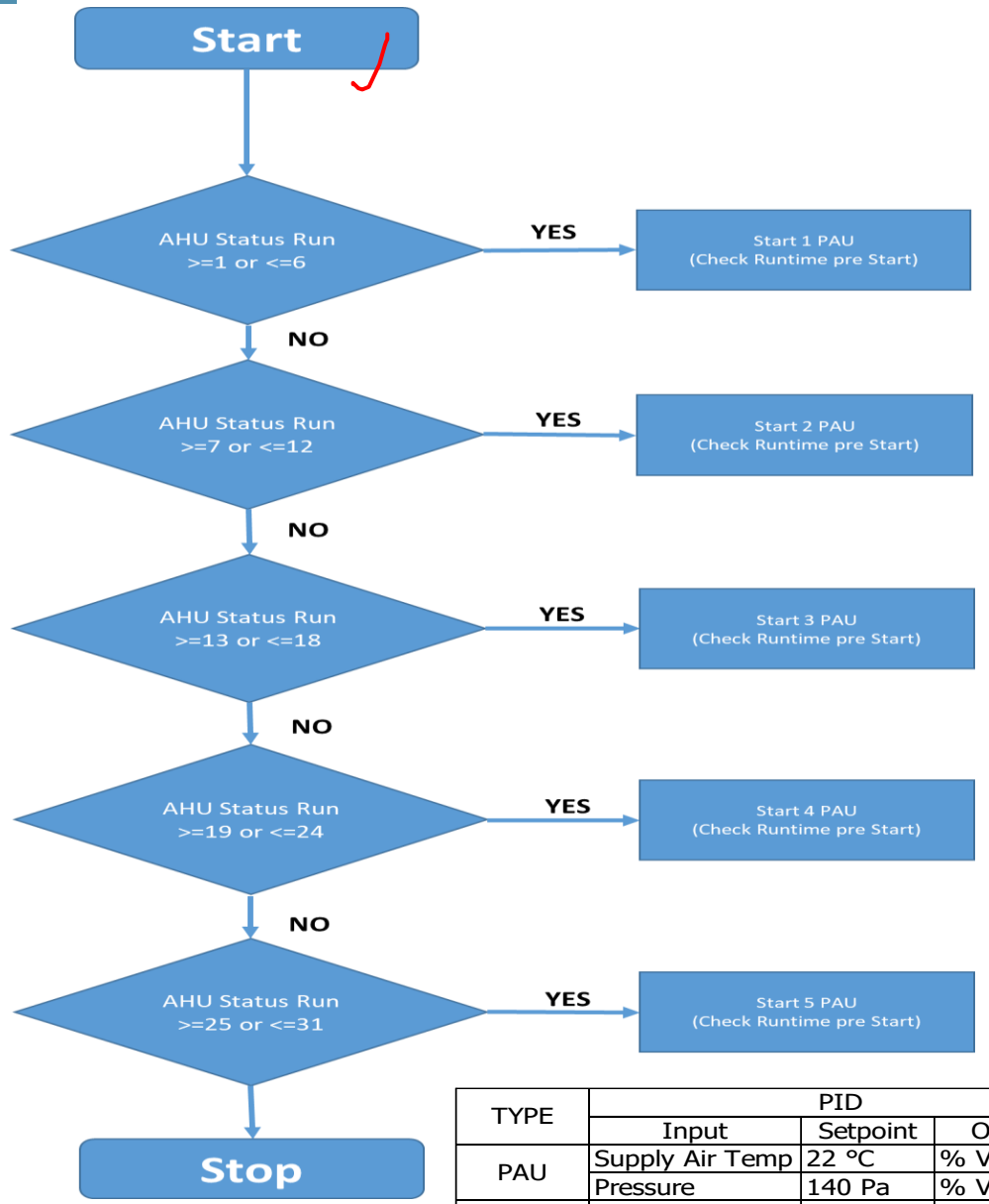




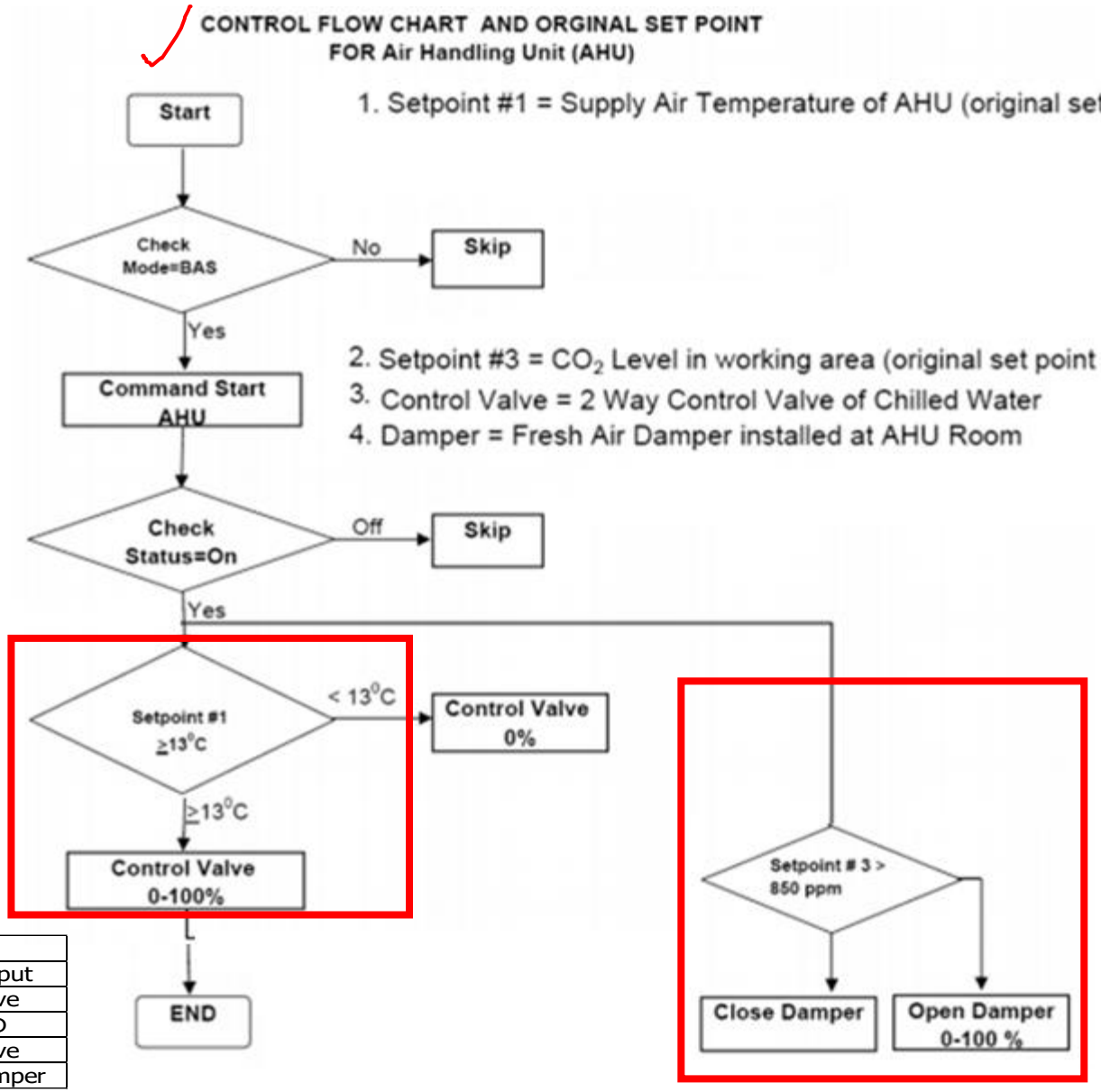


1	AHU Ts	Ts	C	Supply air temperature	Yes	No	No
2	AHU Ts set	Ts set	C	Supply air temperature set-point	Yes	No	No
3	AHU Tr	Tr	C	Return air temperature	Yes	No	No
4	AHU Tr set	Tr set	C	Return air temperature set-point	No	-	-
5	AHU Ps	Ps	Pa	Static pressure	Yes	No	No
6	AHU Ps set	Ps set	Pa	Static pressure 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)

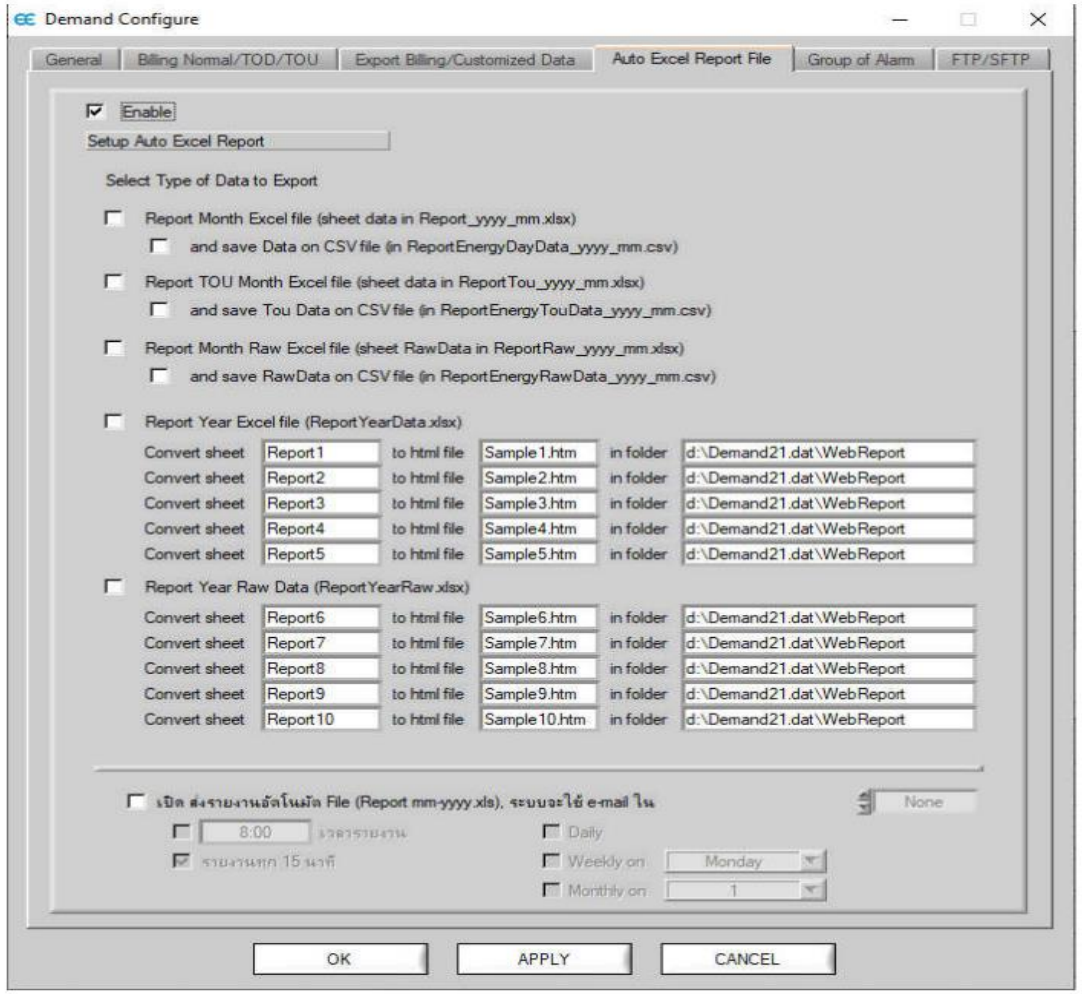


TYPE	PID		
	Input	Setpoint	Output
PAU	Supply Air Temp	22 °C	% Valve
	Pressure	140 Pa	% VSD
AHU	Return Air Temp	25 °C	% Valve
	CO2	1000 ppm	% Damper



Energy management system (EMS)

Auto Excel Report File



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	8/9/64 0:00	30	26	29	27	30
5	8/9/64 1:00	29	26	29	27	30
9	8/9/64 2:00	29	26	29	26	30
13	8/9/64 3:00	29	26	29	26	30
17	8/9/64 4:00	29	26	29	26	30
21	8/9/64 5:00	29	26	29	26	30
25	8/9/64 6:00	29	26	29	26	210
29	8/9/64 7:00	29	26	29	26	256
33	8/9/64 8:00	29	26	29	27	922
37	8/9/64 9:00	28	25	27	28	875
41	8/9/64 10:00	27	24	27	30	1,278
45	8/9/64 11:00	27	24	27	30	1,152
49	8/9/64 12:00	27	25	27	32	1,206
53	8/9/64 13:00	28	25	27	35	1,027
57	8/9/64 14:00	27	25	28	34	1,050
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	1/7/64 0:00	2	8	0	17	39	67
2	1/7/64 1:00	7	32	1	73	158	271
3	1/7/64 2:00	7	32	2	69	155	265
4	1/7/64 3:00	7	32	1	76	156	272
5	1/7/64 4:00	7	33	1	76	143	260
6	1/7/64 5:00	7	33	2	81	148	271
7	1/7/64 6:00	20	38	23	89	158	328
8	1/7/64 7:00	30	40	187	91	179	527
9	1/7/64 8:00	41	76	346	83	246	792
10	1/7/64 9:00	42	83	314	85	314	838
11	1/7/64 10:00	53	98	336	92	381	961
12	1/7/64 11:00	56	100	382	88	445	1,071
13	1/7/64 12:00	57	97	376	91	439	1,060
14	1/7/64 13:00	57	97	376	96	444	1,071
15	1/7/64 14:00	58	100	381	98	442	1,078
16	1/7/64 15:00	58	98	390	93	454	1,094

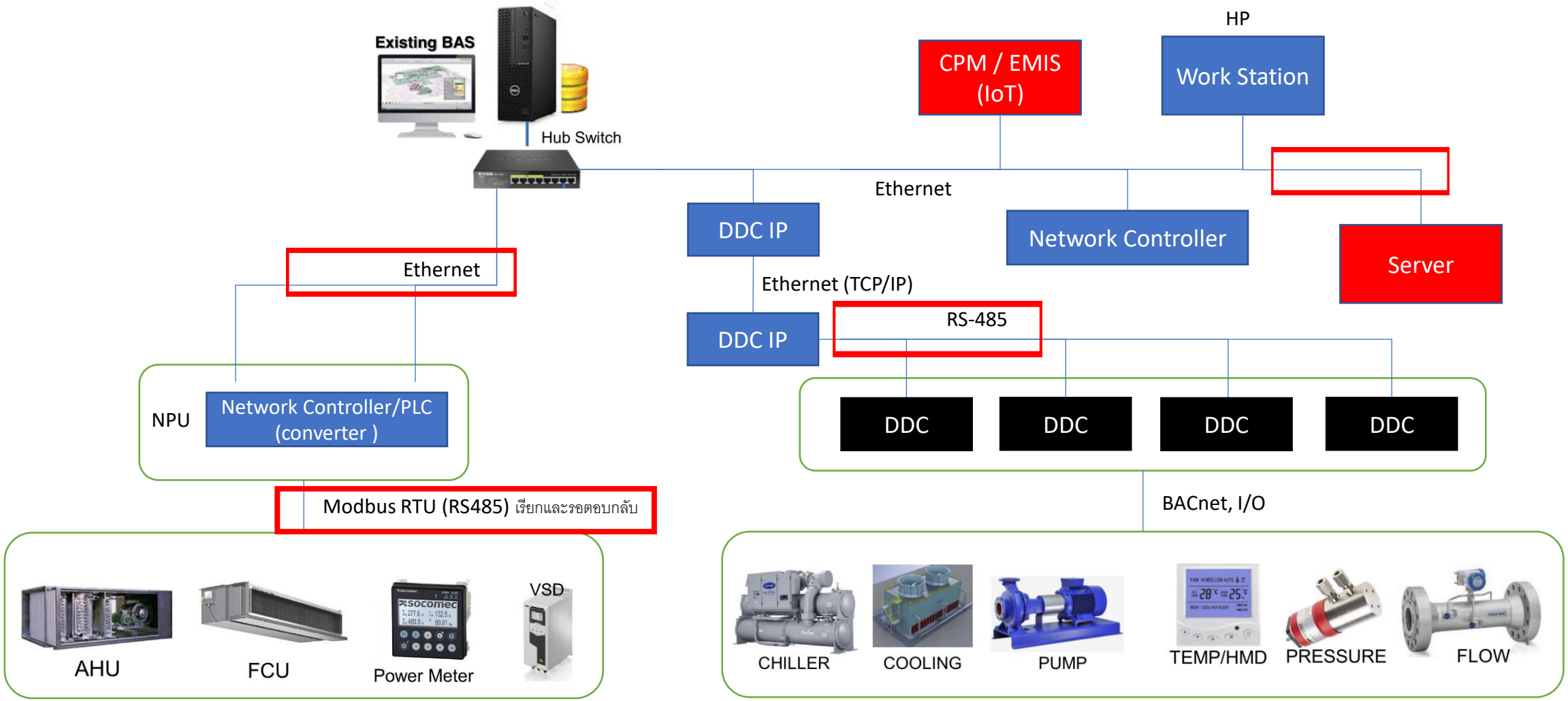
Chain Retail Store

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

SECTION 4

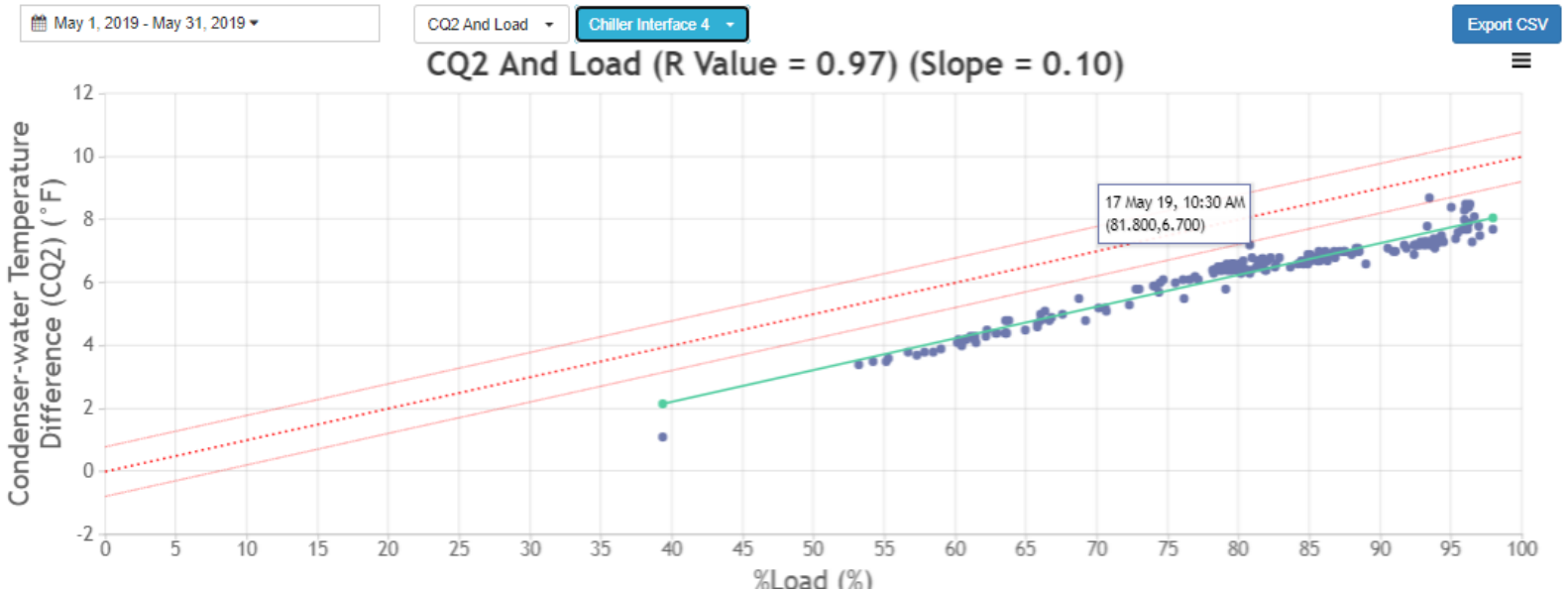
Communication problems for CPMS and BAS

Overall problems for center control



คอขวดสัญญาณ

Overall problems - system performance evaluation (Ex.)



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	-	-	-	-	-	-	-	-		-	

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

หากแต่วัดค่าได้ 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%

THANKS
FOR WACTHING

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