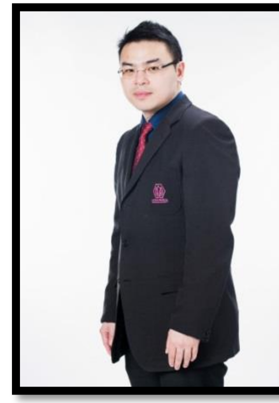
เทคโนโลยี BIM และ Big Data กับการ disrupt งานวิศวกรรมระบบปรับอากาศ



ผศ. ดร. เด่นชัย วรเดชจำเริญ

Head and Founder of Intelligent Building Collaboration (IBC) Research Unit

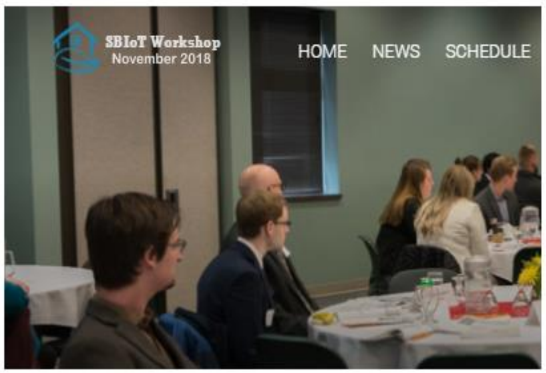
Department of Mechanical System and Industrial Innovation

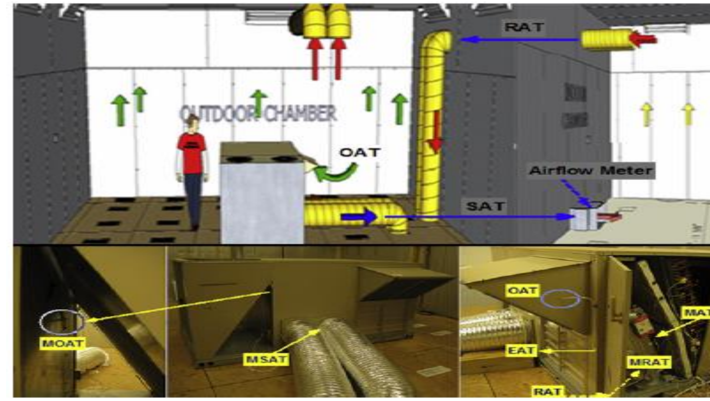
Sripatum University

Chief Executive Officer and Co-founder – TIE Smart Solutions

Study and Research Backgrounds

The Nebraska Building Environment and Energy Engineering Research Group (N-BE³RG) is a group of faculty and graduate students who research topics related to high-performance buildings. Our focus is specifically on the mechanical systems in buildings and the indoor environment that they control. We meet every two or three weeks to hear a formal presentation by a researcher, and then discuss the research with the presenter. N-BE³RG was started in November 2014.





Experiences for Smart HVAC&R (5-years research in Thailand)

- **อาคารอัจฉริยะ โดยเฉพาะด้าน ระบบปรับอากาศ และระบายอากาศ มากกว่า 10 ปี**
- **พัฒนาระบบวินิจฉัยระบบปรับอากาศแบบอัตโนมัติด้วย AI platform**
- **พัฒนาระบบ IoT and Monitoring based Commissioning (MBCx) for all type HVAC systems**

Research Assistant – Smart Building Lab

- **ASHRAE RP 1615 – Fault Diagnostics for supermarket systems (USA)**
- **ASHRAE RP 1486 – Fault diagnostics for a chiller system (USA)**

Projects

- **การพัฒนากระบวนการการใช้งานระบบอาคารอัตโนมัติสำหรับการประหยัดพลังงานระบบปรับอากาศและระบายอากาศ ด้วย EMIS tool – ระยะที่ 1 ทุน กฟผ – สกว ปี 2562 – 2563**
- ระบบวินิจฉัยความผิดพลาดอัจฉริยะระบบปรับอากาศแบบ Variable refrigerant volume
- **ระบบควบคุมเพื่อการฟื้นฟูประสิทธิภาพระบบปรับอากาศขนาดใหญ่แบบอัตโนมัติ (CPMS Control)**
- ต้นแบบอาคารอัจฉริยะเพื่อการวินิจฉัยความผิดปกติของระบบชิลเลอร์อัตโนมัติ (Chiller Diagnostics)
- **การพัฒนามาตรฐานการคอมมิชชันนิ่งด้วยระบบตรวจวัด (Monitoring based Commissioning)**
- การออกแบบมาตรฐานระบบวินิจฉัยความผิดพลาดระบบปรับอากาศและระบายอากาศ (AFDD standard)
- **การสร้างฐานข้อมูลออนไลน์ระบบปรับอากาศจากระบบอัตโนมัติให้ประเทศไทย Phase II (Big data for diagnostics)**
- ไอโอทีแพลตฟอร์มอัจฉริยะสำหรับระบบควบคุมของระบบปรับอากาศแบบแยกส่วนหลายเครื่องสำหรับ (AC Control)
- **Smart BIM for smart facility management**
- AI command center for smart city

Intelligent Building Collaboration (IBC) Research Unit

Established since 2015 by engineers with expertise in HVAC and advanced telecommunication. We transform building data into meaning full analytics and advantage resolutions to not only optimize building operation but also keep satisfy thermal environmental comfort by

IBC Research Unit - TIE Smart Solutions

Smart Technologies for buildings and factories

IBC
Intelligent Building Collaboration
School of Engineering @ SPU

ACAT

Consulting

- Monitoring based commissioning (MBCx)
- LEED EBOM
- Energy Audit
- Sustainable building consultant

Digital Doctor Energy Platform

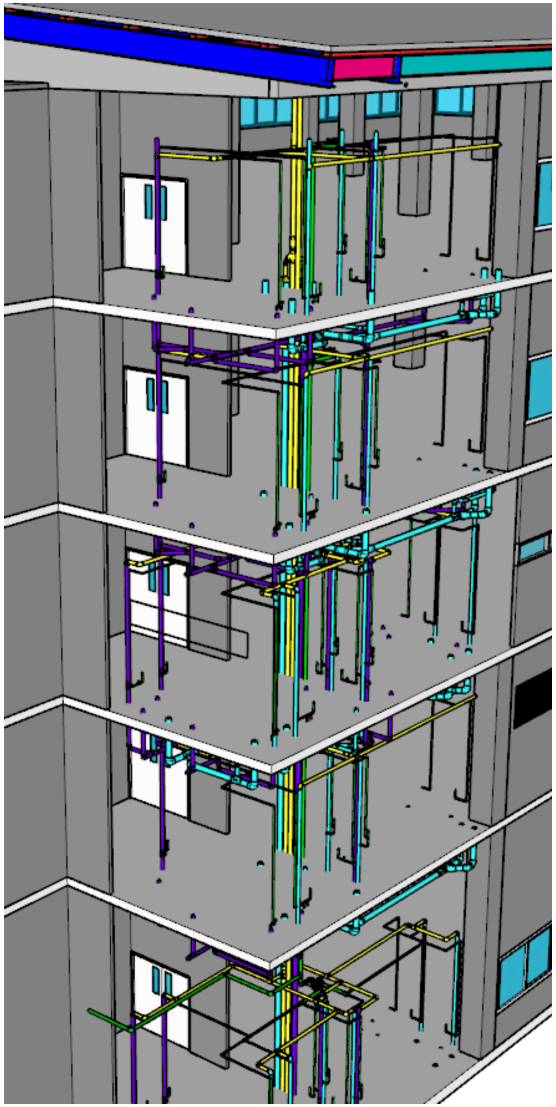
- Building big data
- Automated Fault Detection and Diagnostics
- Intelligent self recovery
- Auto optimization for HVACs
- Smart advisory report

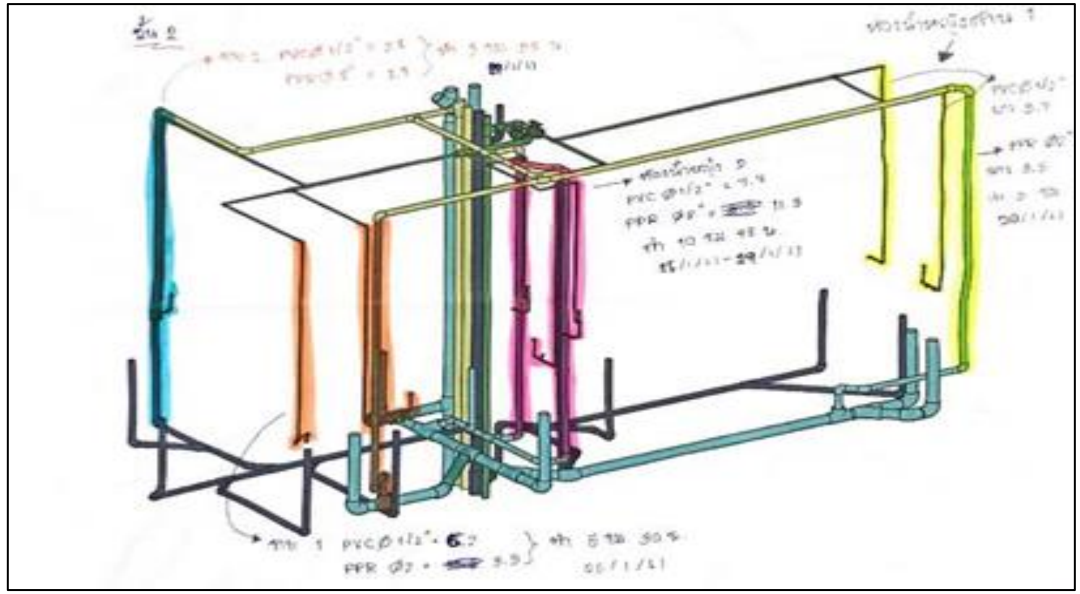
IoT sensor network

- Building application
- Food factory application

Data > 40 high-rise buildings and 30 factories

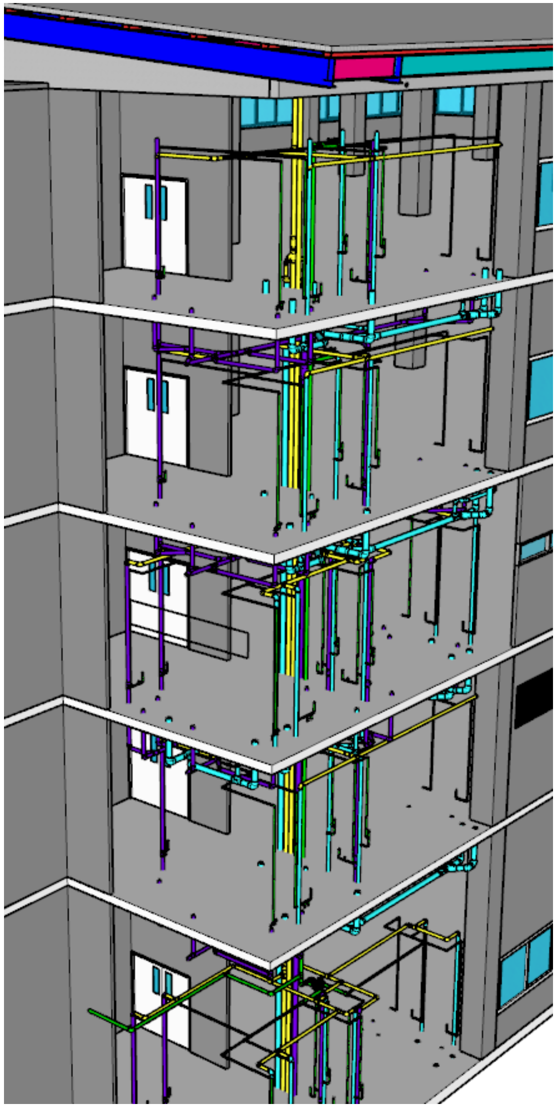
BIM in Thailand – BOQ

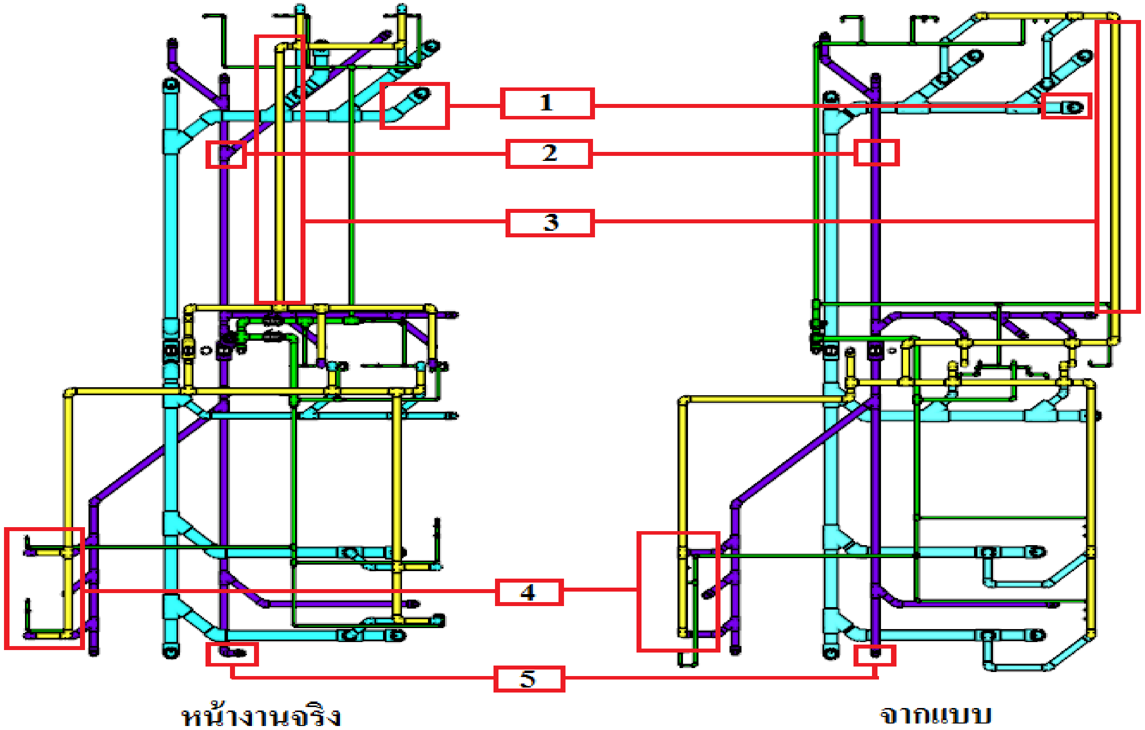




ตารางขนาดและจำนวนท่อจากหน้างาน				
ขนาดท่อ	เมตร			
ท่อน้ำประปา PPR PN10				
- ขนาด Ø 1/2"	42			
- ขนาด Ø 3/4"	4			
- ขนาด Ø 1"	6			
- ขนาด Ø 2"	7			
ข้อต่อและอุปกรณ์				
ท่อประปา	ขนาด Ø 1/2"	ขนาด Ø 3/4"	ขนาด Ø 1"	ขนาด Ø 2"
- 3 ทาง 90°	16		1	3
- ข้องอ 90°	52	1		2

BIM in Thailand – Productivity





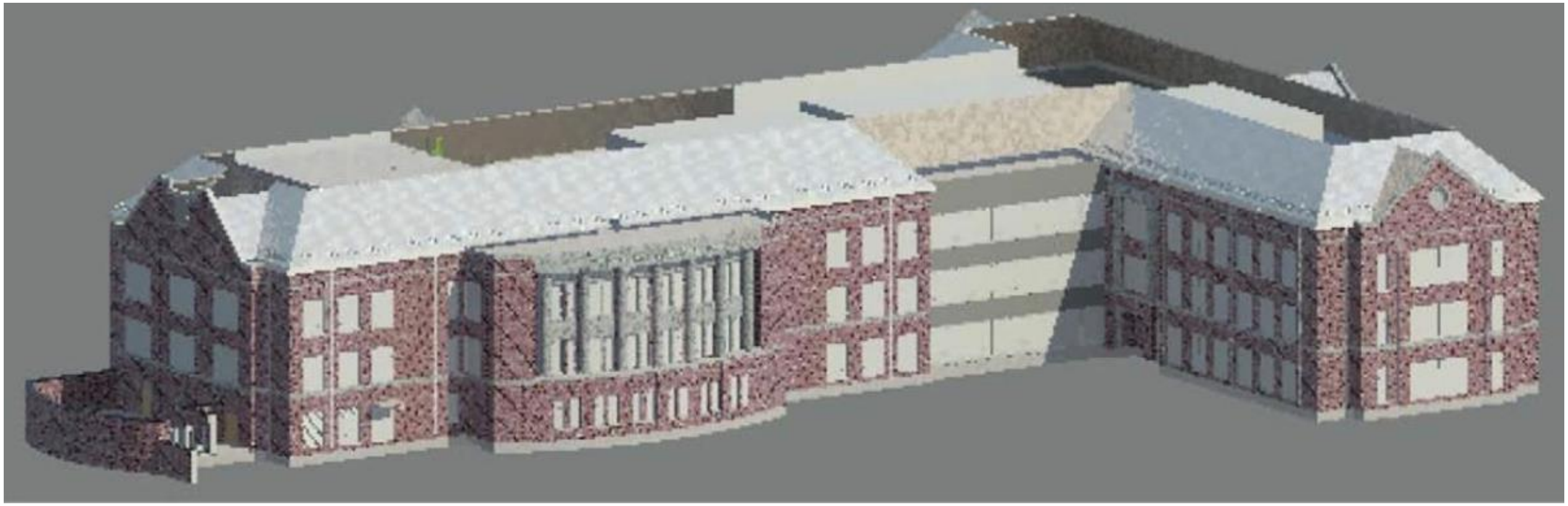
1.การ crash กับงานระบบไฟฟ้า

2.ผู้ควบคุมงานก่อสร้างเพิ่มท่อระบายน้ำ

3.เจ้าของงานไม่ต้องการให้เจาะกำแพงจึงเปลี่ยนการต่อท่อ

4.การต่อท่อจากแบบติดกับระบบเซ็นเซอร์ของอ่างล้างมือทำให้ต้องต่อท่อต่างจากแบบ

BIM in developed countries – LEED applications



Perdue building project description.

Item	Description
Project	Perdue School of Business, Salisbury University
Client	University of Maryland System of Schools/Salisbury University
Construction start date	07/27/2009
Construction end date	06/09/2011
Construction budget	$39,000,000
Delivery method	CM-at-risk
Construction manager	Holder Construction Company, Atlanta
Architect	Richter Cornbrooks Gribble (RCG)
Size	112,000 ft^2, 3-stories with enclosed penthouse
Building system	Foundations: auger cast concrete piles, grade beams and strip footings Superstructure: structural steel Floors: concrete slab on grade and slab on deck Interior partitions: gypsum board on metal studs Exterior skin: brick masonry with precast accents, glazing, and some CMU Roof: vertical mansard roof screen wall with built-up roof

> 10,000 m2

Building information modeling for sustainable design and LEED® rating analysis

Salman Azhar [a,*], Wade A. Carlton [a], Darren Olsen [a], Irtishad Ahmad [b]
[a] McWhorter School of Building Science, Auburn University, Auburn, AL, USA
[b] Department of Construction Management, Florida International University, Miami, FL, USA Automation in Construction 20 (2011) 217–224

BIM in developed countries - LEED

Relationship between BIM-based sustainability analyses types and LEED® credits.

Sustainable analysis types with relationships to LEED®-NC credits (ver. 2.2)		Sustainable design related analysis types						
		Energy analysis	Daylighting/solar analysis	Acoustic analysis	Material documentation	Value/cost analysis	Site analysis	Water use
LEED® Credits	LEED® Points							
Minimum energy performance	Required	●				●		
Fundamental refrigerant management	Required	●						
Optimize energy performance	10	●				●		
Renewable energy	3							
Enhanced commissioning	1							
Enhanced refrigerant management	1							
Measurement and verification	1	●, ♦						
Building reuse – existing walls, floors and roof	2				♦			
Building reuse – existing interior nonstructural elements	1				♦			
Indoor environmental quality	Max. 15							
Minimum indoor air quality (IAQ) performance	Required							
Increase ventilation	1							
Construction IAQ MGT plan – during construction	1	●						
Construction IAQ MGT plan – before occupancy	1	●						
Controllability of systems – thermal comfort	1							
Thermal comfort – design	1	●	●					
Thermal comfort – verification	1	●	●					

⅄ Pre-design stage, ● Design stage, ♦ Construction stage.

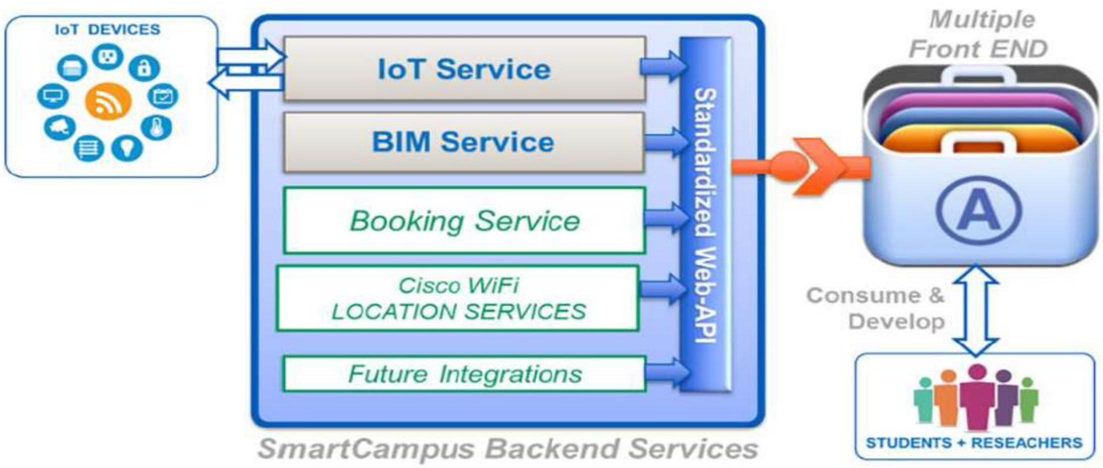
ต้นทุนการดำเนินการที่แตกต่าง – BIM for LEED rating to reduce time-consuming issue

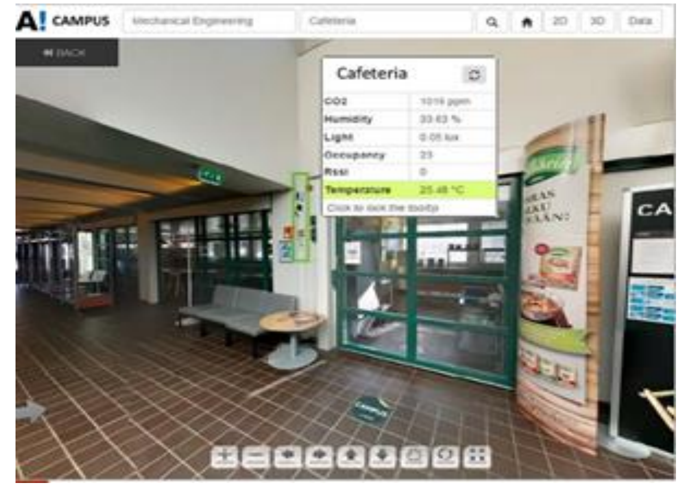
BIM in developed countries - LEED

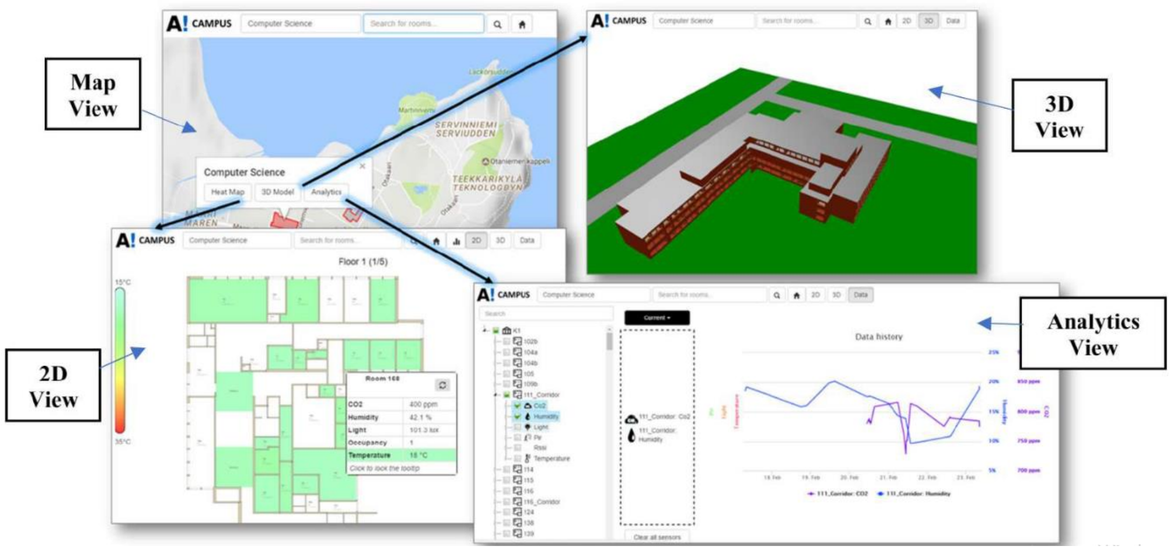
LEED® credits that can be documented using results of BIM software.

LEED®-NC credits that can be earned using BIM-based performance analysis software			Can the LEED® credit be earned using BIM? (yes/no)	Performance analysis software that could be or was used? VE/REVIT	Is the credit being attempted by Salisbury Building?	Was the credit validated in the case study? (yes/no)
LEED credit	Credit description	LEED® points				
Energy and atmosphere						
EAp1	Fundamental building systems commissioning	Required	No		Yes	
EAp2	Minimum energy performance	Required	Yes	VE	Yes	Yes
EAp3	Fundamental refrigerant management	Required	No		Yes	
EAc1	Optimize energy performance	10	Yes	VE	Yes	Yes
EAc2	Renewable energy	3	No		No	
EAc3	Enhanced commissioning	1	No		Yes	
EAc4	Enhanced refrigerant management	1	No		Yes	
EAc5	Measurement and verification	1	No		No	
EAc6	Green power	1	No		No	

BIM in developed countries – BIM IoT





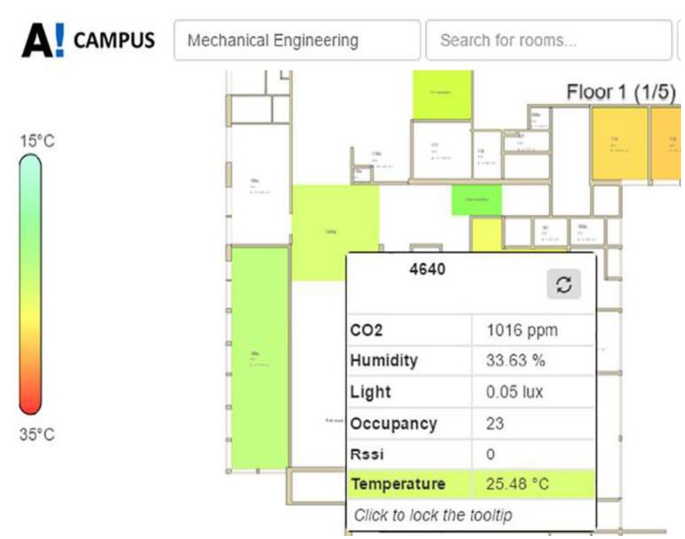


Automation in Construction 110 (2020) 103049

BIM assisted Building Automation System information exchange using BACnet and IFC

Shu Tang[a,*], Dennis R. Shelden[a], Charles M. Eastman[a], Pardis Pishdad-Bozorgi[b], Xinghua Gao[c]

[a] School of Architecture, Georgia Institute of Technology, 245 4th St NW, Atlanta, GA 30332, USA
[b] School of Building Construction, Georgia Institute of Technology, 280 Ferst Dr., Atlanta, GA 30332, USA
[c] Myers-Lawson School of Construction, Virginia Polytechnic Institute and State University, 1345 Perry St., Blacksburg, VA 24061, USA



BAS GUI as BIM service

BIM in developed countries – BIM IoT (IBC)

3. AHU label info

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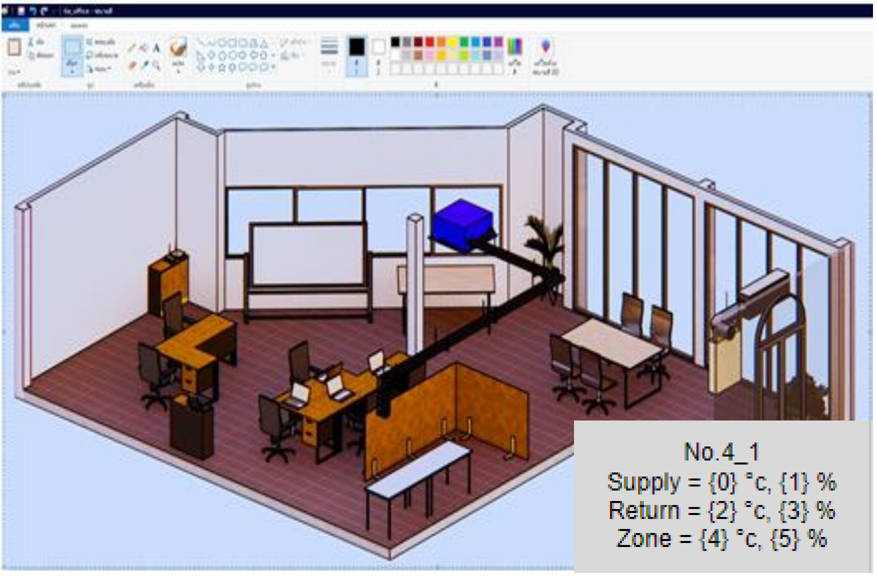
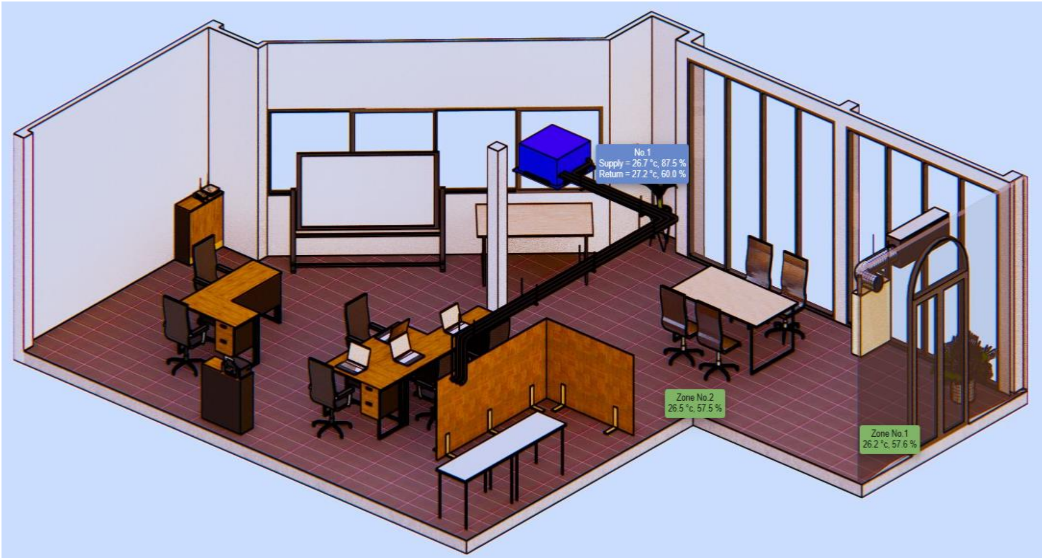
	site	tab_code	type	top	left	code	height	custom_msg	custom_variables
466	tieoffice	air_cond_unit	supply	200	950	-		No.1 Supply = {0} °c, {1} % Return = {2} °c, {3} %	s1|temp , s1|rh , r1|temp , r1|rh
467	tieoffice	air_cond_unit	zone	590	1370	-		Zone No.1 {0} °c, {1} %	z1|temp , z1|rh
468	tieoffice	air_cond_unit	zone	540	1060	-		Zone No.2 {0} °c, {1} %	z2|temp , z2|rh
469	tisco	tisco_7_overall	return	182	344	-		AHU 1 Supply = {0} °c, {1} % Return (Duct) = {2} °c, {3} % Return (Grill) = {4} °c, {5} %	s0|temp , s0|rh , r0|temp , r0|rh , r8|temp , r8|rh

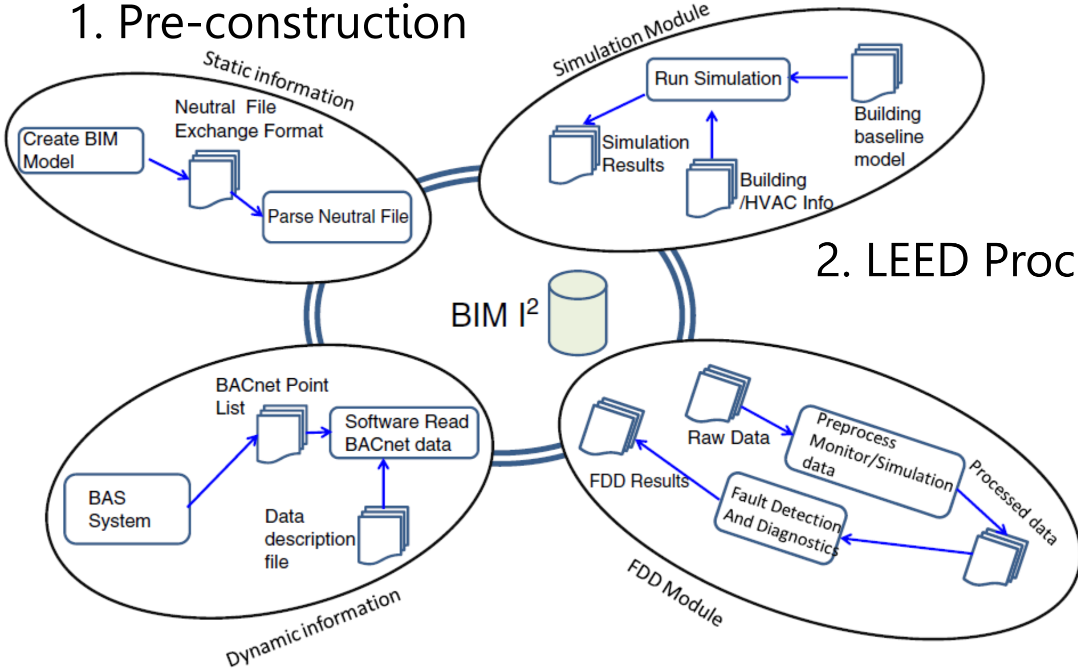




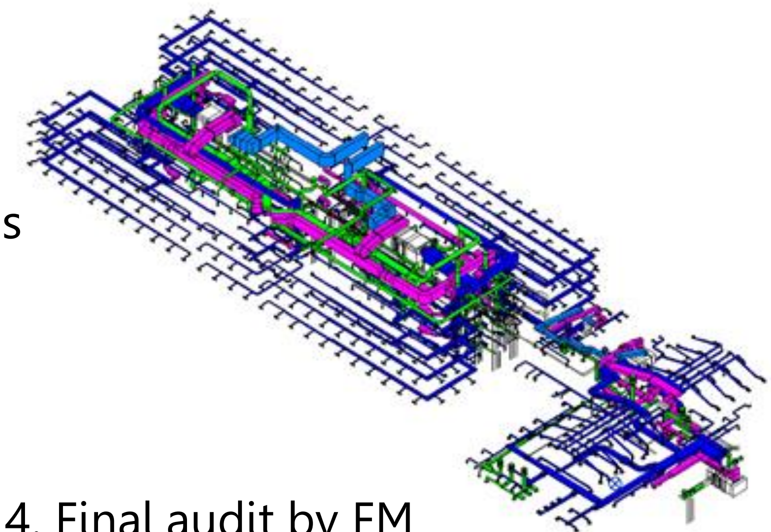
BIM in developed countries – BIM for AFDD

B. Dong et al. / Automation in Construction 44 (2014) 197–211

1. Pre-construction



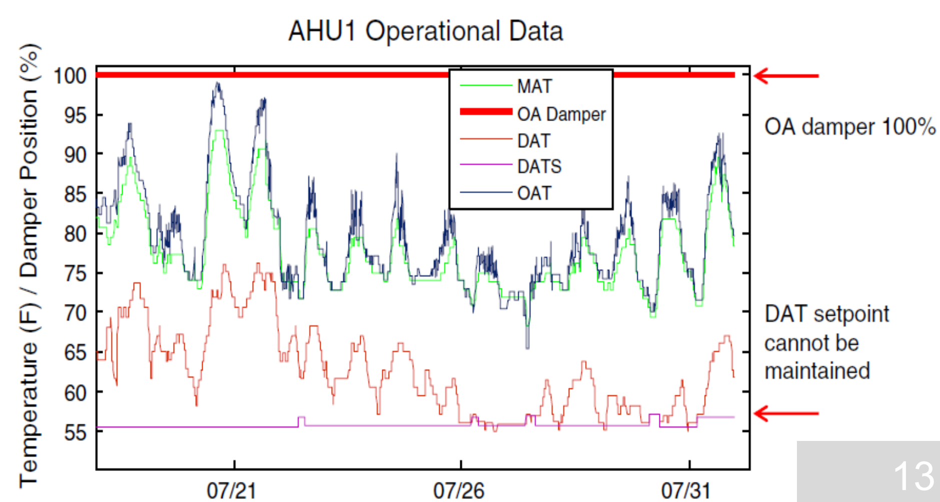
2. LEED Process



4. Final audit by FM

3. BAS Data

5. Operations versus static and BAS data



A BIM-enabled information infrastructure for building energy Fault Detection and Diagnostics

Bing Dong [a,*], Zheng O'Neill [b], Zhengwei Li [c]

Automation in Construction 44 (2014) 197–211

[a] Department of Mechanical Engineering, The University of Texas at San Antonio, San Antonio, TX 78249, USA
[b] Department of Mechanical Engineering, The University of Alabama, Tuscaloosa, AL 35401, USA
[c] School of Mechanical and Energy Engineering, Tongji University, PR China

BIM in developed countries – BIM for AFDD (IBC)

Manu Line

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	A	B	C	D	E
1	site	unit	cq1	cq2	band
2	*	*	0.1,0	0.1,0	0.7871890921
3	bot1	chiller_interface_1	0.1474,0.103	0.0972,0.2499	0.7871890921
4	bot1	chiller_interface_2	0.1474,0.103	0.0972,0.2499	0.7871890921
5	bot1	chiller_interface_3	0.15,0	0.0972,0.2588	0.7871890921
6	bot1	chiller_interface_4	0.15,0	0.0936,0.5804	0.7871890921
7	aia_sathorn_tower	chiller_interface_1	-1.1352e-06, 0.00031539, -0.031637, 1.3496, -8.5513	0.092635,-0.0092617	0.7871890921
8	aia_sathorn_tower	chiller_interface_2	-1.1352e-06, 0.00031539, -0.031637, 1.3496, -8.5513	0.092635,-0.0092617	0.7871890921
9	aia_sathorn_tower	chiller_interface_3	-1.1352e-06, 0.00031539, -0.031637, 1.3496, -8.5513	0.092635,-0.0092617	0.7871890921
10	aia_sathorn_tower	chiller_interface_4	-1.2121e-06, 0.00033364, -0.033083, 1.3911, -8.7974	0.09278, 0.036721	0.7871890921
11	aia_sathorn_tower	chiller_interface_5	-1.2121e-06, 0.00033364, -0.033083, 1.3911, -8.7974	0.09278, 0.036721	0.7871890921
12	set_ratchada	chiller_interface_1	0.12,0	0.0922,0.1978	0.7871890921
13	set_ratchada	chiller_interface_2	0.12,0	0.0922,0.1978	0.7871890921
14	set_ratchada	chiller_interface_3	0.1225,-0.25	0.0912,0.475	0.7871890921
15	set_ratchada	chiller_interface_4	0.1225,-0.25	0.0575,0.15	0.7871890921
16	kbank	chiller_interface_1	0.1474,0.103	0.0972,0.2499	0.7871890921
17	aia_capital_center	chiller_interface_1	0.15,0	0.0972,0.2499	0.7871890921
18	aia_capital_center	chiller_interface_2	0.15,0	0.0972,0.2499	0.7871890921
19	aia_capital_center	chiller_interface_3	0.15,0	0.0972,0.2499	0.7871890921
20	aia_capital_center	chiller_interface_4	0.15,0	0.0972,0.2499	0.7871890921
21	aia_capital_center	chiller_interface_5	0.15,0	0.0972,0.2499	0.7871890921
22	aia_capital_center	chiller_interface_6	0.15,0	0.0972,0.2499	0.7871890921
23	egat_102	chiller_interface_1	0.15,0	0.0972,0.2499	0.7871890921
24	egat_102	chiller_interface_2	0.15,0	0.0972,0.2499	0.7871890921
25	egat_102	chiller_interface_3	0.15,0	0.0972,0.2499	0.7871890921

Input all data to Gsheet

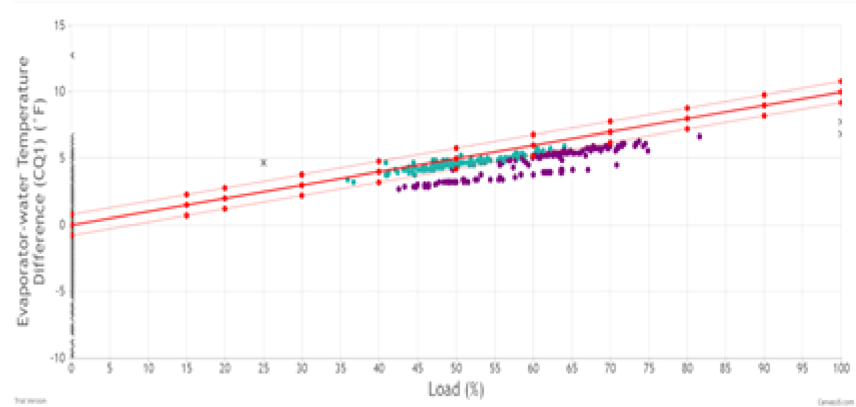
Table 1. Chiller manufacturers' rating output example.

Percent load	T_{cdi} (°C (°F))	T_{evo} (°C (°F))	FWC (L/S (cfm))	FEW (L/S (cfm))	W_{ac} (kW)	P_{cond} (Kpa (psi))	P_{evap} (Kpa (psi))	T_{sc} (°C (°F))	T_{sh} (°C (°F))
100	30.0 (86.0)	7.0 (44.6)	104.3 (1655.6)	91.6 (1454.0)	311.0	821.0 (119.0)	268.0 (38.9)	4.6 (8.3)	0.6 (1.1)
90	27.7 (81.9)	7.0 (44.6)	104.3 (1655.6)	91.6 (1454.0)	253.3	748.1 (108.5)	269.0 (39.0)	4.2 (7.6)	0.6 (1.1)
80	25.3 (77.5)	7.0 (44.6)	104.3 (1655.6)	91.6 (1454.0)	211.9	678.3 (98.4)	269.9 (39.1)	3.8 (6.8)	0.6 (1.1)
70	23.0 (73.4)	7.0 (44.6)	104.3 (1655.6)	91.6 (1454.0)	181.3	615.4 (89.2)	270.9 (39.3)	3.4 (6.1)	0.6 (1.1)
60	20.7 (69.3)	7.0 (44.6)	104.3 (1655.6)	91.6 (1454.0)	156.8	556.7 (80.7)	271.8 (39.4)	3.0 (5.4)	0.6 (1.1)
50	18.3 (64.9)	7.0 (44.6)	104.3 (1655.6)	91.6 (1454.0)	135.8	500.1	272.8 (39.6)	2.6 (4.7)	0.6 (1.1)
40	18.3(64.9)	7.0 (44.6)	104.3 (1655.6)	91.6 (1454.0)	121.9	489.4 (71.0)	273.8 (39.7)	2.2 (4.0)	0.6 (1.1)
30	18.3 (64.9)	7.0 (44.6)	104.3 (1655.6)	91.6 (1454.0)	106.2	478.7 (69.4)	274.7 (39.8)	1.7 (3.1)	0.6 (1.1)
20	18.3 (64.9)	7.0 (44.6)	104.3 (1655.6)	91.6 (1454.0)	86.4	467.9 (67.8)	275.7 (40.0)	1.2 (2.2)	0.6 (1.1)
10	18.3 (64.9)	7.0 (44.6)	104.3 (1655.6)	91.6 (1454)	57.7	456.8 (66.2)	276.7 (40.1)	0.6 (1.1)	0.6 (1.1)

FWC: Condenser water flow rate; FWE: evaporator water flow rate.

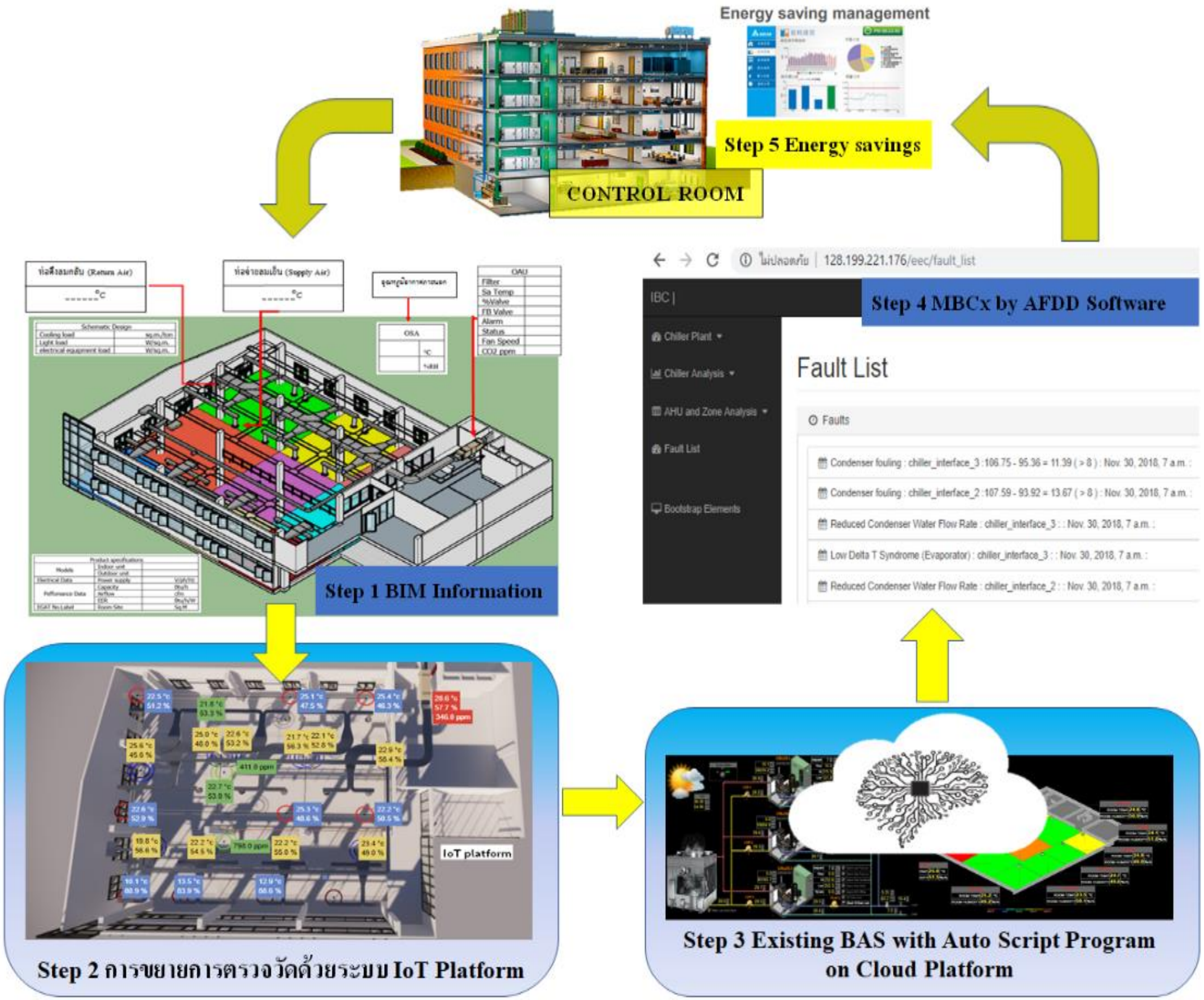
Static data from manufacturers

Low Delta T Syndrome (Evaporator) Detection eec | chiller_interface_1 , Oct. 17, 2020, 4:36 p.m. to Nov. 17, 2020, 4:36 p.m.



Monitoring based commissioning

Big Data for Building information modeling (BIM)



Big Data for BIM data design in Thailand

Building life cycle – AC system information

Static data – Design data

Commissioning Data – AC contractor

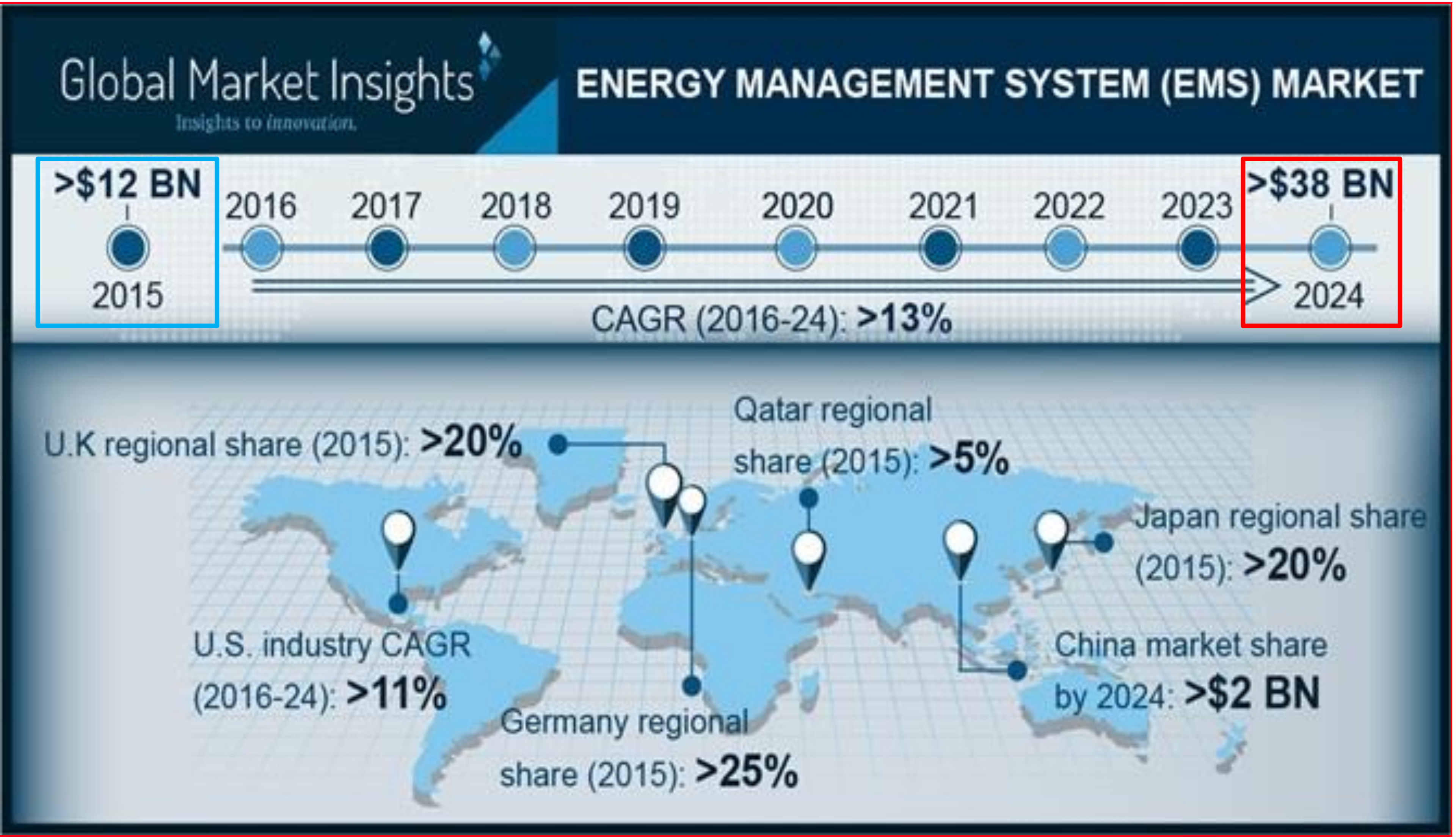
Baseline operation data – BAS contractor (dynamic data)

updated static data for FM

All data used for other buildings

Static data include: commissioning data conditions and design data

Current Status of Building Technologies



Global Market Insights, Inc.

World BAS Survey

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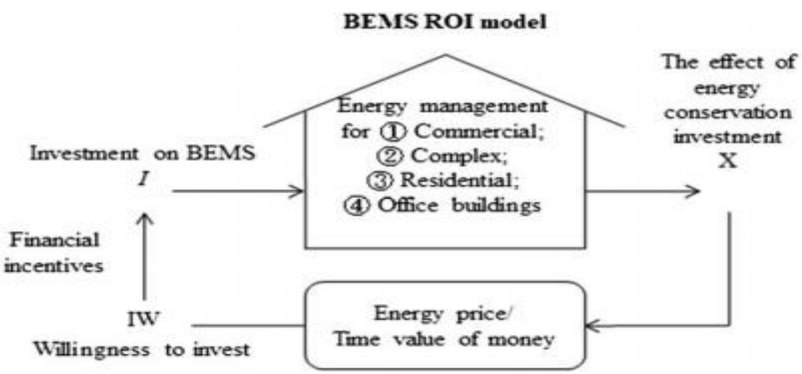
DOI: 10.1002/er.4159

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. ($P = 0.002 < 0.05$)

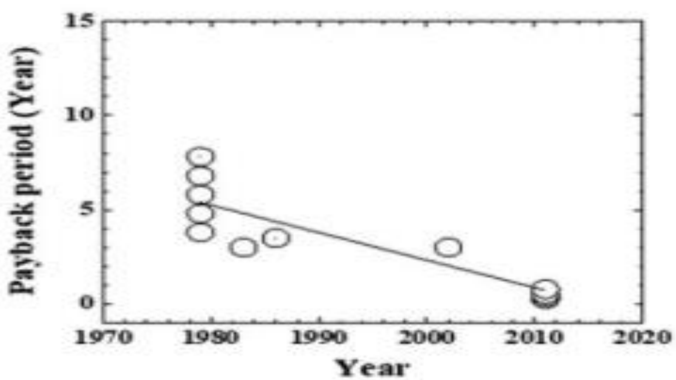


FIGURE 2 Payback periods of building energy management system (BEMS) for commercial buildings

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

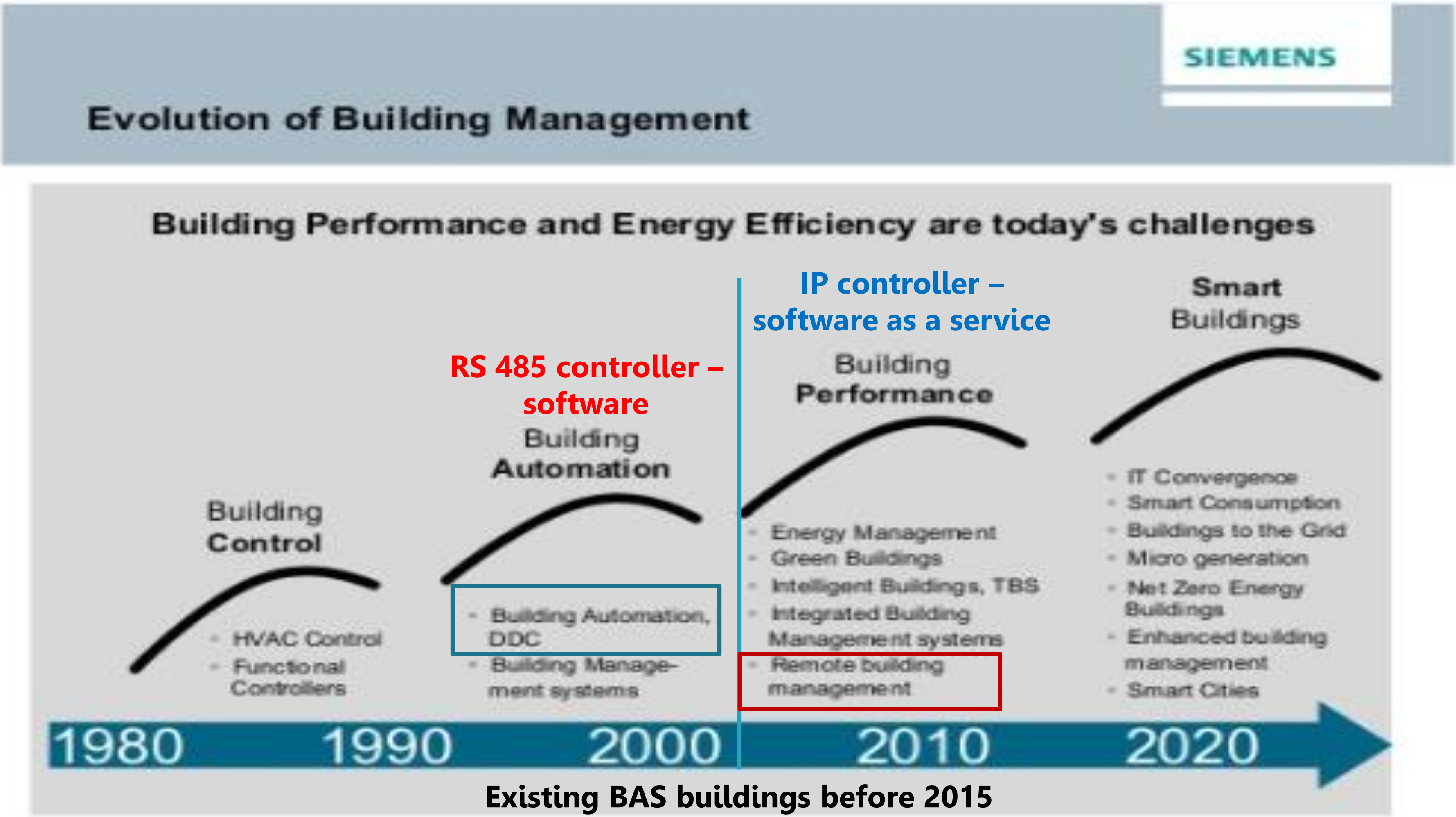
Technologies (1980 - 2010)

- **Schedule control of central plant system**
- **Thermal comfort ตามมาตรฐานอาคาร Variable speed control (VSD)**
- **Occupant-based control ควบคุมการเปิดปิดไฟฟ้า**
- **การควบคุมระบบแสงสว่าง**

ROI (Return of investment)

- **1980: 5 – 8 years**
- **2010: reduced from 5.4 to 0.7 years**
- **How?**

Current Status of Building Technologies



ใช้เทคโนโลยีไม่คุ้มกับราคา และเกิดความผิดพลาด เรียนรู้ใหม่เพื่อปรับแก้

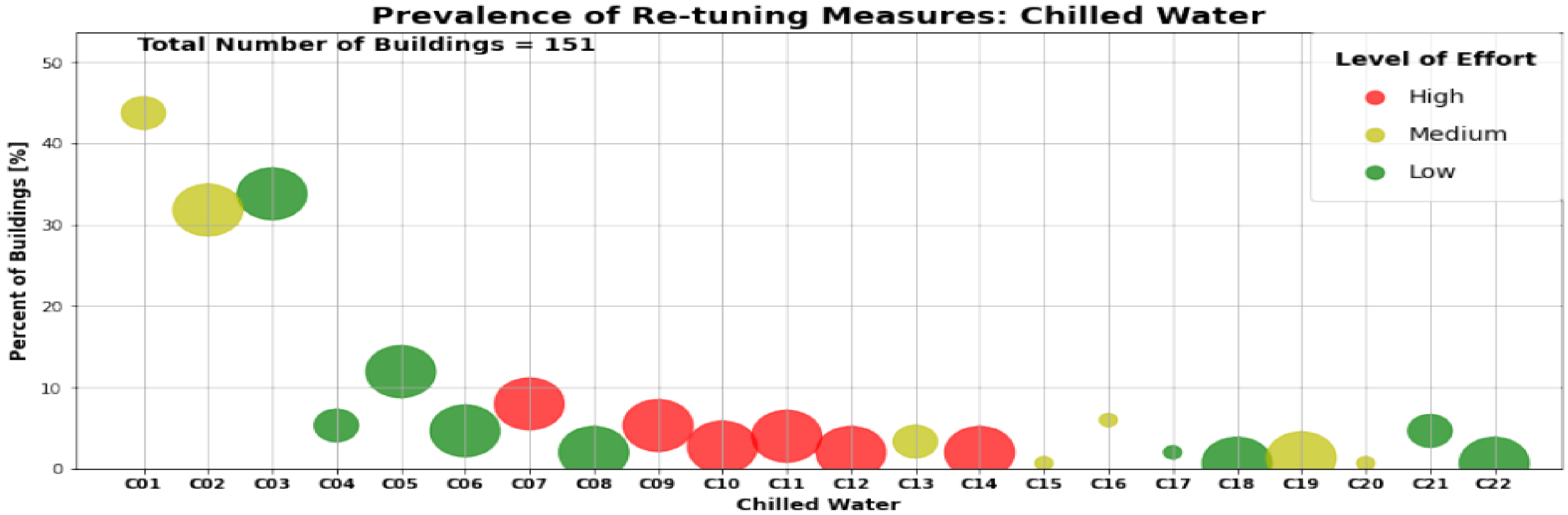
https://www.slideshare.net/liegecreative/smart-buildings-in-smart-cities-par-serge-molinari.

Big Data for Building Operations (PNNL source)

Pacific Northwest NATIONAL LABORATORY

Chilled Water Re-tuning Measures

C01: Implement chilled water supply temperature reset
C02: Implement condenser water temperature reset
C03: Implement loop differential pressure reset/reduction and convert 3-way valves to 2-way valves if required
C04: Run parallel VFD chilled water pumps together instead of staging them (both chilled water and condenser water)
C05: Lockout chiller based on demand or OAT
C06: Control chilled water pumps by chilled water valve position or loop delta-temperature and open manual isolation valves
C07: Install VFD on chilled water pump
C08: Clean and repair cooling tower
C09: Install VFD on cooling tower fans
C10: Install VFD on condenser water pumps
C11: Code and test water-side economizer implementation
C12: Evaluate using rejected heat to interior spaces during winter months
C13: Enable chiller isolation valve controls so chiller isolation valve is closed when respective chiller is off
C14: Insulate all exposed chiller piping and fittings
C15: Replace failed check valves on chilled water pumps
C16: Investigate staging issues with chillers (e.g. short-cycling)
C17: Improve control of cooling tower basin heaters
C18: Use electric chillers in lieu of steam turbine chillers whenever possible
C19: Fix or replace chilled water coil valves
C20: Chiller soft start
C21: Disable chilled water pumps when chillers are not running
C22: Run one parallel condenser water pump instead of two (second not needed)



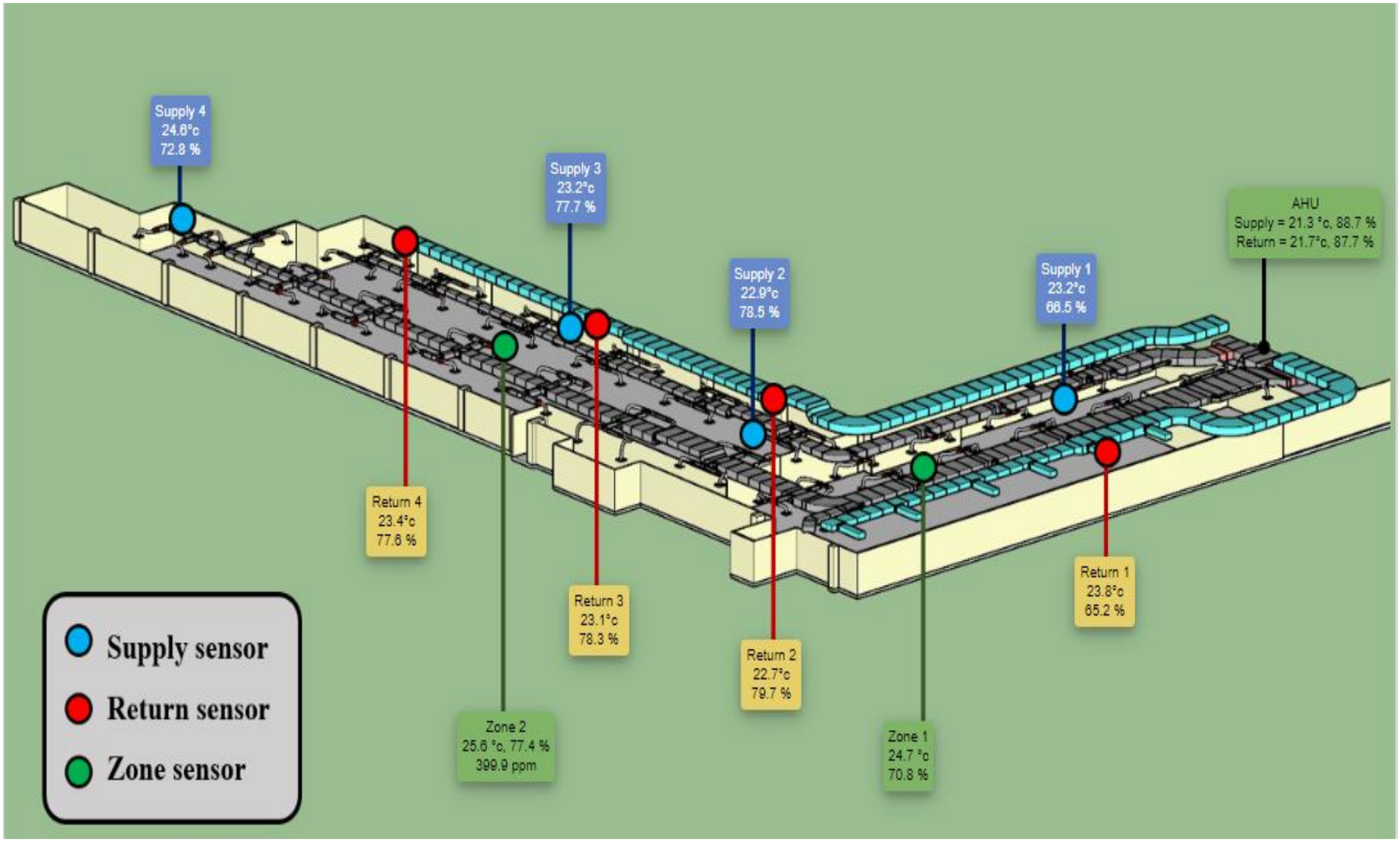
Big Data คือข้อมูลที่จัดระเบียบเพื่อประโยชน์ในการใช้งาน

ปัญหาที่พบจาก 30 อาคารประเทศไทย – CPMS Big Data

Chiller faults Building	1	2	3	4	5	6	7
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	×	×	×	×	√	×	√

เครื่องหมาย × หมายถึงเกิด fault ชนิดนั้น, เครื่องหมาย √ หมายถึงสามารถตรวจสอบได้และเครื่องหมาย – หมายถึงไม่สามารถตรวจสอบได้เนื่องจากขาดข้อมูลในระบบ BAS

ปัญหาที่พบจาก 30 อาคารประเทศไทย – CAV Big Data



การออกแบบตามทฤษฎี ควรมีข้อมูลมาช่วยในการตรวจสอบ (designers)

การตรวจงานควรใช้ข้อมูลยืนยันผลที่เกิด (consults)

ควรเก็บผลงานการออกแบบและติดตั้งด้วย index การวัดผล (contractors)

CAV system

Dirty coil

Too high chilled water

Faulty PAU

Stuck closed damper

Stuck full damper

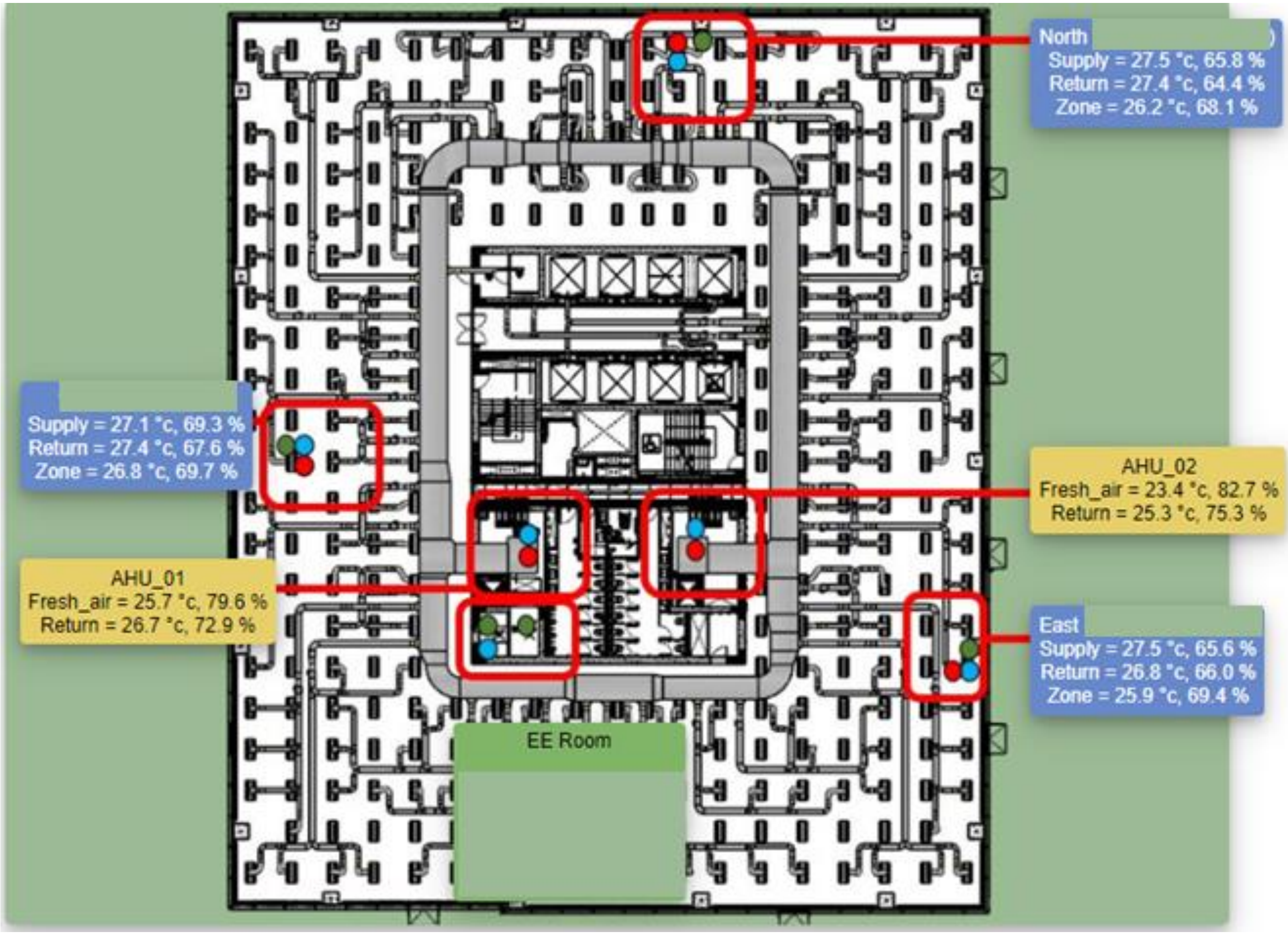
Faulty air circulation

Faulty pressure setting

Too high return temperature (Tr)

Too low Tr

ปัญหาที่พบจาก 30 อาคารประเทศไทย – Big Data



VAV system

Too minimum CFM

Too maximum CFM

Too low zone thermostat

Too high zone thermostat

Stuck full damper

Stuck closed damper

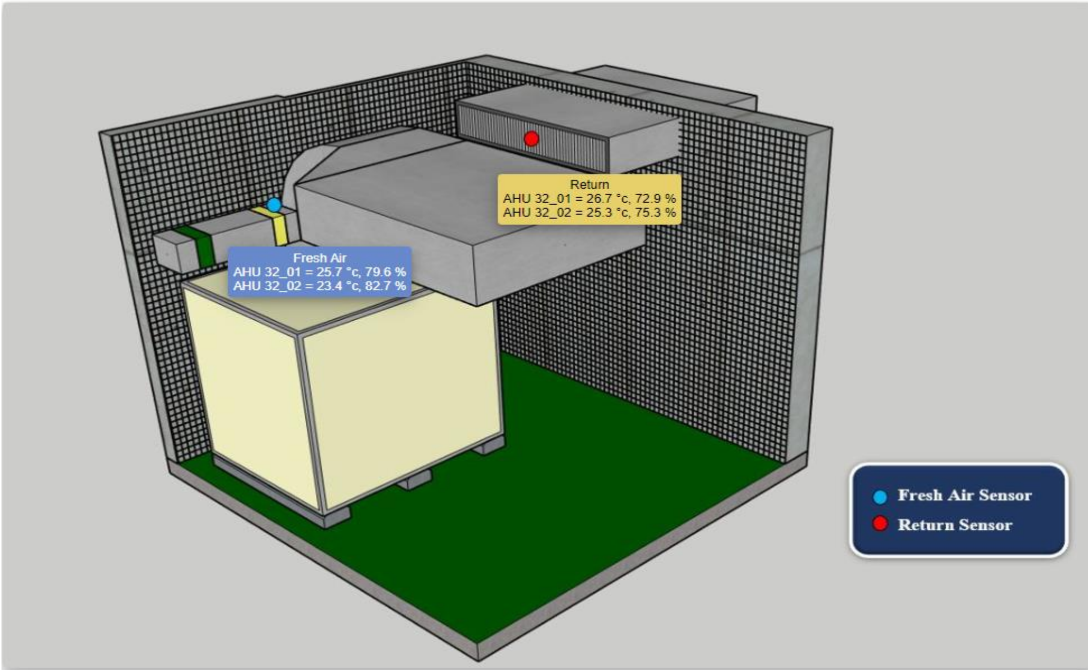
Faulty air circulation

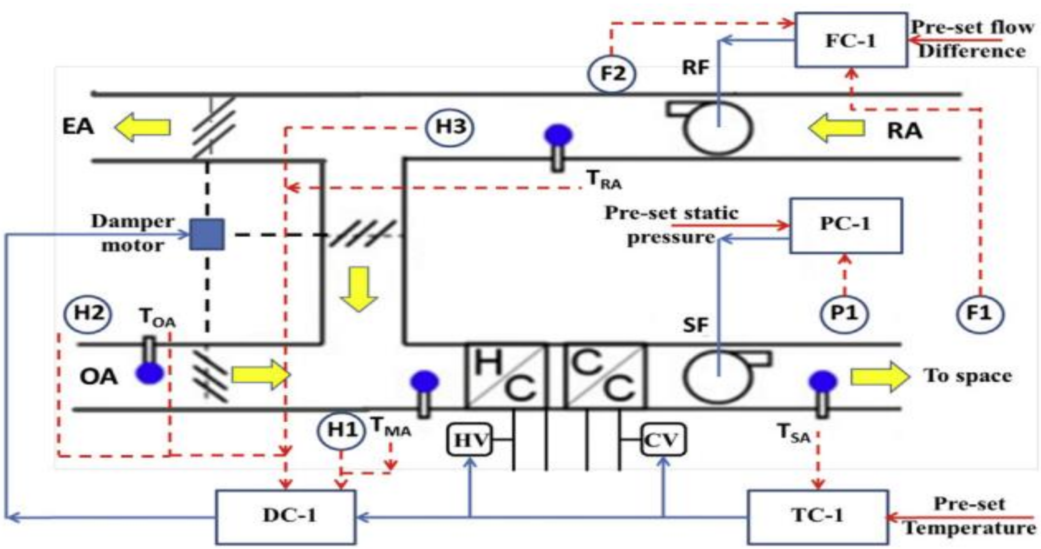
Faulty pressure setting

Too high Ts

Too low Ts

ปัญหาที่พบจาก 30 อาคารประเทศไทย – Big Data





Pre-cool (PAU)

Too low fresh air

Too high fresh air

Dirty cooling coil

Stuck full coil valve

Stuck closed coil valve

Faulty fan VSD

Faulty pressure setting

Faulty supply temperature control

Faulty P control

BIM for Cooling Load – Why BIM?

Cooling load – Pre-construction

ดำเนินการได้โดยไม่มี BIM

Cooling load เท่ากับ energy หรือไม่

Cooling load ใช้เลือก equipment มีข้อเสียอย่างไร

การเปลี่ยนข้อมูลแบบ layout ส่งผลอย่างไร

Cooling load แบบเดิมเป็น forward model without feedback validation

ประโยชน์ ในมุม IBC Lab

Cooling load ในการทำนายการทำงานล่วงหน้าของระบบ CPMS

Cooling load ตรวจสอบ energy modeling

Cooling load ตรวจสอบการเลือกอุปกรณ์ผู้ผลิต

BIM for Cooling Load – Cooling load ในการทำนายการทำงานล่วงหน้าของระบบ CPMS

- 4x800 RT
  - 1x 800 MBC
  - 1x 800 VSD
  - 1x 800#x1
  - 1x 800#2
- Primary pumps

Total of 2,400 RT

Table 1. Chiller manufacturers' rating output example.

Percent load	T_{cdi} (°C (°F))	T_{evo} (°C (°F))	FWC (L/S (cfm))	FEW (L/S (cfm))	W_{ac} (kW)	P_{cond} (Kpa (psi))	P_{evap} (Kpa (psi))	T_{sc} (°C (°F))	T_{sh} (°C (°F))
100	30.0 (86.0)	7.0 (44.6)	104.3 (1655.6)	91.6 (1454.0)	311.0	821.0 (119.0)	268.0 (38.9)	4.6 (8.3)	0.6 (1.1)
90	27.7 (81.9)	7.0 (44.6)	104.3 (1655.6)	91.6 (1454.0)	253.3	748.1 (108.5)	269.0 (39.0)	4.2 (7.6)	0.6 (1.1)
80	25.3 (77.5)	7.0 (44.6)	104.3 (1655.6)	91.6 (1454.0)	211.9	678.3 (98.4)	269.9 (39.1)	3.8 (6.8)	0.6 (1.1)
70	23.0 (73.4)	7.0 (44.6)	104.3 (1655.6)	91.6 (1454.0)	181.3	615.4 (89.2)	270.9 (39.3)	3.4 (6.1)	0.6 (1.1)
60	20.7 (69.3)	7.0 (44.6)	104.3 (1655.6)	91.6 (1454.0)	156.8	556.7 (80.7)	271.8 (39.4)	3.0 (5.4)	0.6 (1.1)
50	18.3 (64.9)	7.0 (44.6)	104.3 (1655.6)	91.6 (1454.0)	135.8	500.1	272.8 (39.6)	2.6 (4.7)	0.6 (1.1)
40	18.3(64.9)	7.0 (44.6)	104.3 (1655.6)	91.6 (1454.0)	121.9	489.4 (71.0)	273.8 (39.7)	2.2 (4.0)	0.6 (1.1)
30	18.3 (64.9)	7.0 (44.6)	104.3 (1655.6)	91.6 (1454.0)	106.2	478.7 (69.4)	274.7 (39.8)	1.7 (3.1)	0.6 (1.1)
20	18.3 (64.9)	7.0 (44.6)	104.3 (1655.6)	91.6 (1454.0)	86.4	467.9 (67.8)	275.7 (40.0)	1.2 (2.2)	0.6 (1.1)
10	18.3 (64.9)	7.0 (44.6)	104.3 (1655.6)	91.6 (1454)	57.7	456.8 (66.2)	276.7 (40.1)	0.6 (1.1)	0.6 (1.1)

FWC: Condenser water flow rate; FWE: evaporator water flow rate.

Project: CPN Project	Consultant: 111
Location:	Date: 6/10/20 8:43 AM
PERFORMANCE SUMMARY	Tag: CHILLER DCLC D-2
	Location:

AHRI CERTIFIED®

Centrifugal Compressor Water Cooled Package Chiller

Model #	DCLCD800E	Component code	D50D52DF56FM51
Quantity	1	Rating version	DCLC1.21
Manufacturer	DBM	Refrigerant	R-134a

Physical Specifications

Compressors (Qty)	CDFFM(1)	Impeller (Qty)	DF56(2)
Unit Length (in)	174.76	Shipping weight (lb)	25477
Unit Width (in)	88.39	Operating weight (lb)	30320
Unit Height (in)	94.02	Approx. refrigerant charge (lb)	1,808

Conditions of service

Percent of full load	100%	Unit power (kW)	477.8
Capacity (Tons)	800.0	Cooling Efficiency (kW/Ton)	0.5972
		NPLV.IP (kW/Ton)	0.5184

Evaporator		Condenser	
Model (Qty)	D50(1)	Model (Qty)	D52(1)
Number of passes	2	Number of passes	2
Fluid	Water	Fluid	Water
Fluid flow rate (USgpm)	1280	Fluid flow rate (USgpm)	2400
Entering fluid temp. (°F)	58.97	Entering fluid temp. (°F)	90.00
Leaving fluid temp. (°F)	44.00	Leaving fluid temp. (°F)	99.41
Fouling factor (h·ft²·°F/Btu)	0.000100	Fouling factor (h·ft²·°F/Btu)	0.000250
Pressure drop (psi/ft.H2O)	4.31/9.95	Pressure drop (psi/ft.H2O)	8.74/20.2
Fluid freezing point (°F)	32.00	Fluid freezing point (°F)	32.00

Electrical characteristics

Unit power supply	380V/3/50	Motor Rated Current (Amp)	815
Motor starter mode	Soft starter	Motor Starting Current (Amp)	2,642

Notes

- ETL listed for US and Canada region, optional for 50Hz series and other 60Hz.
- Certified in accordance with the AHRI Water Cooled Water-Chilling and Heap Pump Water-Heating Packages Using the Vapor Compression Cycle Certification Program, which is based on AHRI Standard-550/590(I-P) and AHRI Standard 551/591(SI). Certified units may be found in the AHRI Directory at www.ahridirectory.org.

Sound Data

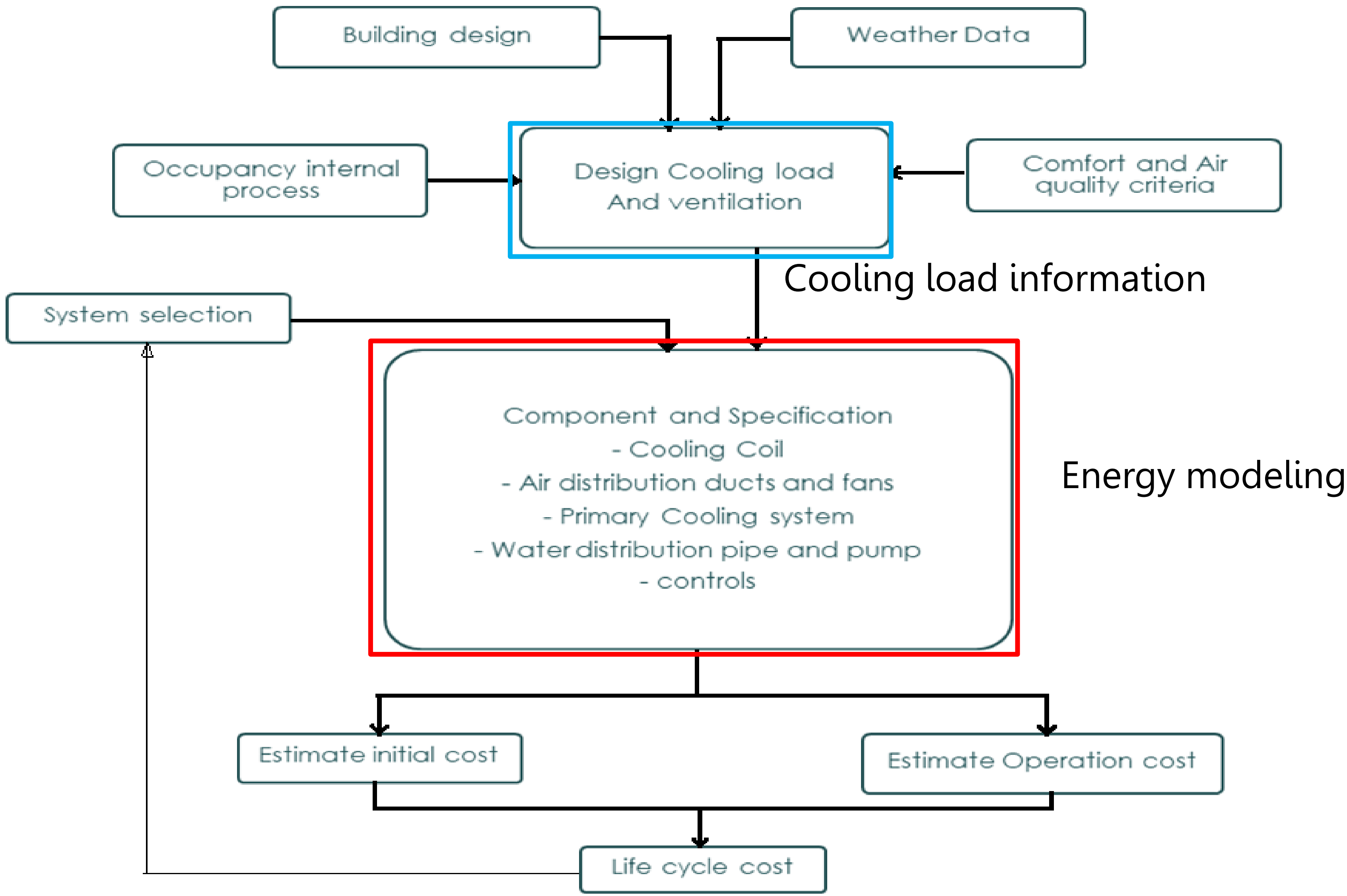
Frequency (Hz)	63	125	250	500	1000	2000	4000	8000	Total dB(A)
Sound Pressure Level (free field) at 3.28 ft	77	82	79	79	80	80	77	74	83

*Sound Pressure Level (free field) ± 2 dB(A) Tolerance

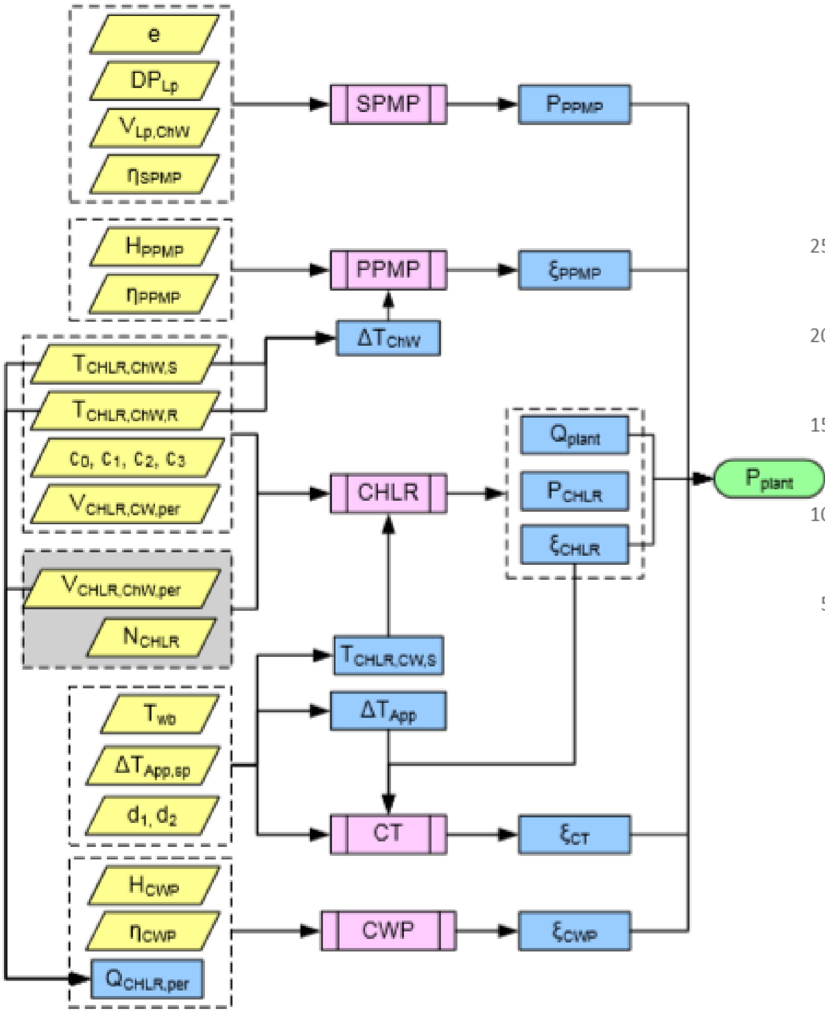
NPLV.IP Points

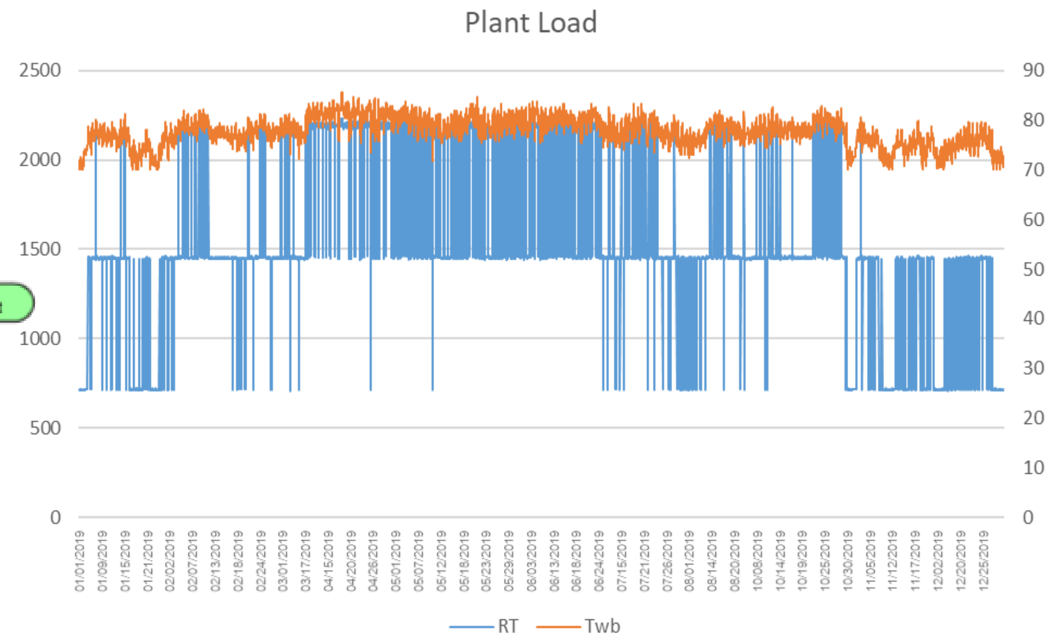
% Full load	Tons	Unit kW	kW/Ton	Evap.EFT (°F)	Evap.LFT (°F)	Evap Flow(USgp	Evap PD(psi)	Cond.EFT (°F)	Cond.LFT (°F)	Cond Flow(USgp	Cond PD(psi)	Type
100%	800.0	477.8	0.5972	58.97	44.00	1280	4.31	90.00	99.41	2400	8.740	Actual
75%	600.0	312.1	0.5202	55.23	44.00	1280	4.37	77.47	84.40	2400	9.074	Actual
50%	400.0	196.4	0.4910	51.49	44.00	1280	4.43	65.00	69.57	2400	9.460	Actual
25%	200.0	127.4	0.6370	47.74	44.00	1280	4.49	65.00	67.36	2400	9.460	Actual

BIM for Cooling Load – Cooling load ตรวจสอบ energy modeling



BIM for Cooling Load – Cooling load ในการทำนายการทำงานล่วงหน้าของระบบ CPMS





BIM for Cooling Load – Cooling load ในการทำนายการทำงานล่วงหน้าของระบบ CPMS

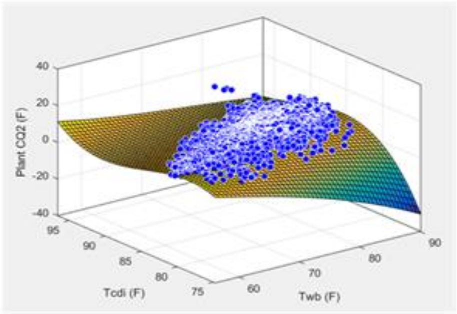
Plant model at Tcdi between 80-90F

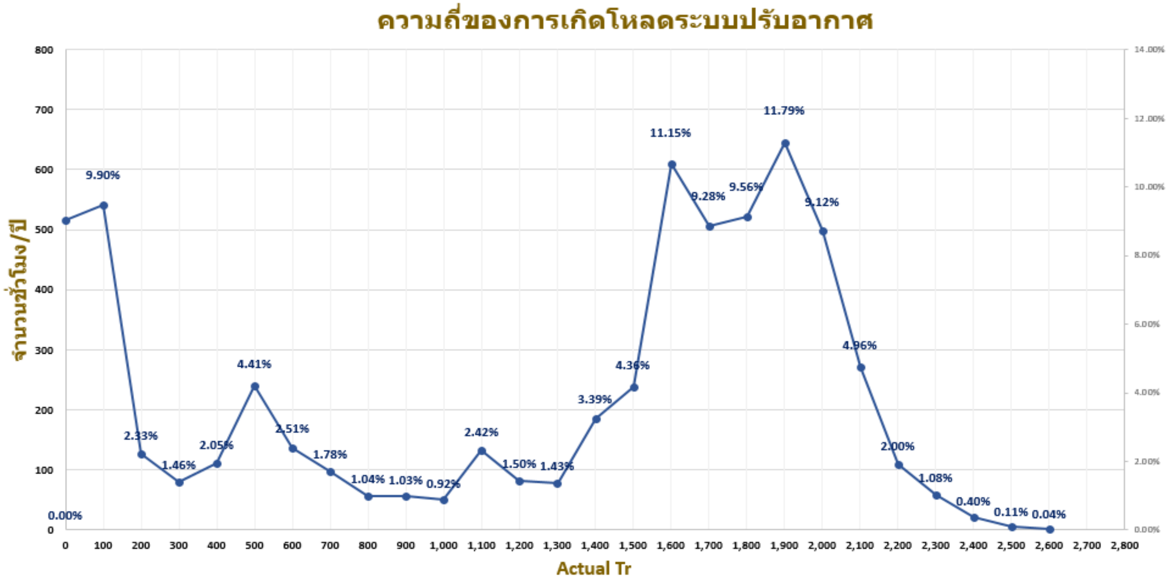
Weather data from location A

Manufacturing data

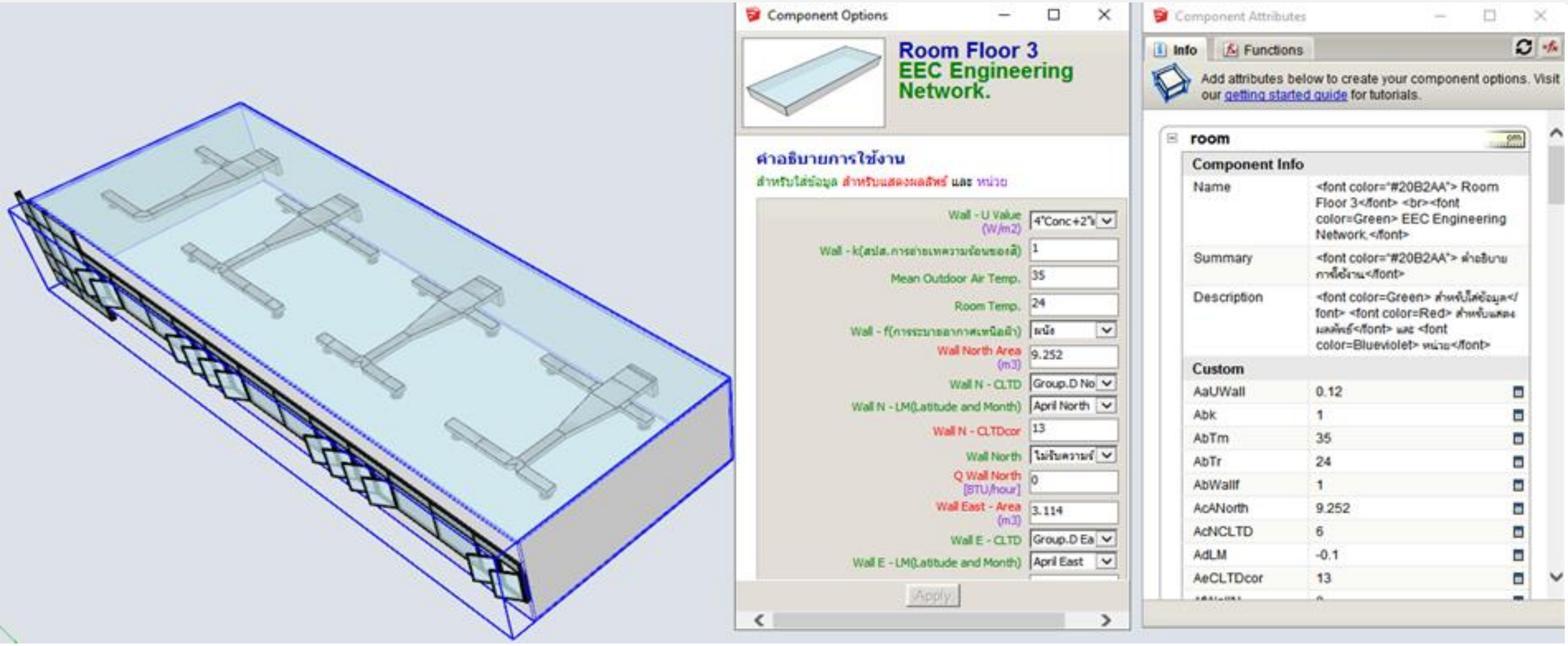
AHRI CERTIFIED®

Forward modeling vs. Inverse modeling





BIM for Cooling Load



การคำนวณโหลดต้องใส่ข้อมูลตามกระบวนการ ประกอบด้วย พื้นที่, กรอบอาคาร ช่วงเวลาของอุณภูมิอากาศภายนอก

BIM for Cooling Load

Wall - U Value (W/m2)	4"Conc+2"ins+gypsum Group.D
Wall - k(สปส.การถ่ายเทความร้อนของสี)	1
Mean Outdoor Air Temp.	35
Room Temp.	24
Wall - f(การระบายอากาศเหนือฝ้า)	ผนัง
Wall North Area (m3)	9.252
Wall N - CLTD	Group.D North 14:00
Wall N - LM(Latitude and Month)	April North
Wall N - CLTDcor	13
Wall North	ไม่รับความร้อนจากแดด
Q Wall North [BTU/hour]	0
Wall East - Area (m3)	3.114
Wall E - CLTD	Group.D East 14:00
Wall E - LM(Latitude and Month)	April East
Wall E - CLTDcor	24.6
Wall East	ไม่รับความร้อนจากแดด
Q Wall East (BTU/hour)	0
Wall South - Area (m3)	9.252
Wall S - CLTD	Group.D South 14:00
Wall S - LM(Latitude and Month)	April South
Wall S - CLTDcor	12.7
Wall South	รับความร้อนจากแดด
Q Wall South (BTU/hour)	48.111366
Wall West - Area (m3)	3.114
Wall W - CLTD	Group.D South 14:00
Wall S - LM(Latitude and Month)	April West
Wall W - CLTDcor	12.6
Wall West	รับความร้อนจากแดด
Q Wall West (BTU/hour)	16.06562
Q External Wall (BTU/hour)	64.176986

q1 = U x A x CLTDcor

จากรูปเป็นในส่วนของผนังห้อง

ส่วนของกระจก

Glass - SC(Shading Cofficients)	กระจกใส+ฟิล์ม
Glass - ความกว้าง (m)	1.85
Glass - ความสูง (m)	1.3
Glass - จำนวนกระจก	12
Glass - Area (m2)	28.86
Glass - CLF	South 14:00
Glass - SHGF	April South
Q Glass 1 (BTU/hour)	2015.57439
Glass - U	กระจกใส
Glass - CLTD	14:00
Glass - CLTDcor	14.1
Q Glass 2 (BTU/hour)	1527.338225

q2 = A x SC x SHGF x CLF

จากรูปเป็นในส่วนของหลังคา

Roof - U Value	4"L.W.Concrete
Roof - Area (m2)	230
Roof - CLTD	4"L.W.Concrete 14:00
Roof	ด้านบนไม่ใช่หลังคา
Q Roof (BTU/hour)	0

q3=U x A x CLTDcor

BIM for Cooling Load

ส่วนของ Partition

$q5 = U \times A \times (T_{External} - T_{Internal})$

Partition - Area	77.4
Partition - Temp.External	95.3
Partition - Temp.Internal	75
Q Partition (BTU/hour)	188.5464

แสงสว่างและเครื่องใช้ต่างๆ

q6 = Watt of Lighting
q7 = Watt of Equipment

Floor Area (m2)	222.305
Lighting (Watt/m2)	6
Q Lighting (BTU/hour)	4551.217364
Equipment (Watt/m2)	14
Q Equipment (BTU/hour)	10619.507182

จำนวนคน

q8= N x Sensible Heat Gain
q9 = N x Latent Heat Gain

People - Number	38
People - Sensible Heat (BTU/hour)	Office
People - Latent Heat (BTU/hour)	Office
Q People (BTU/hour)	15200

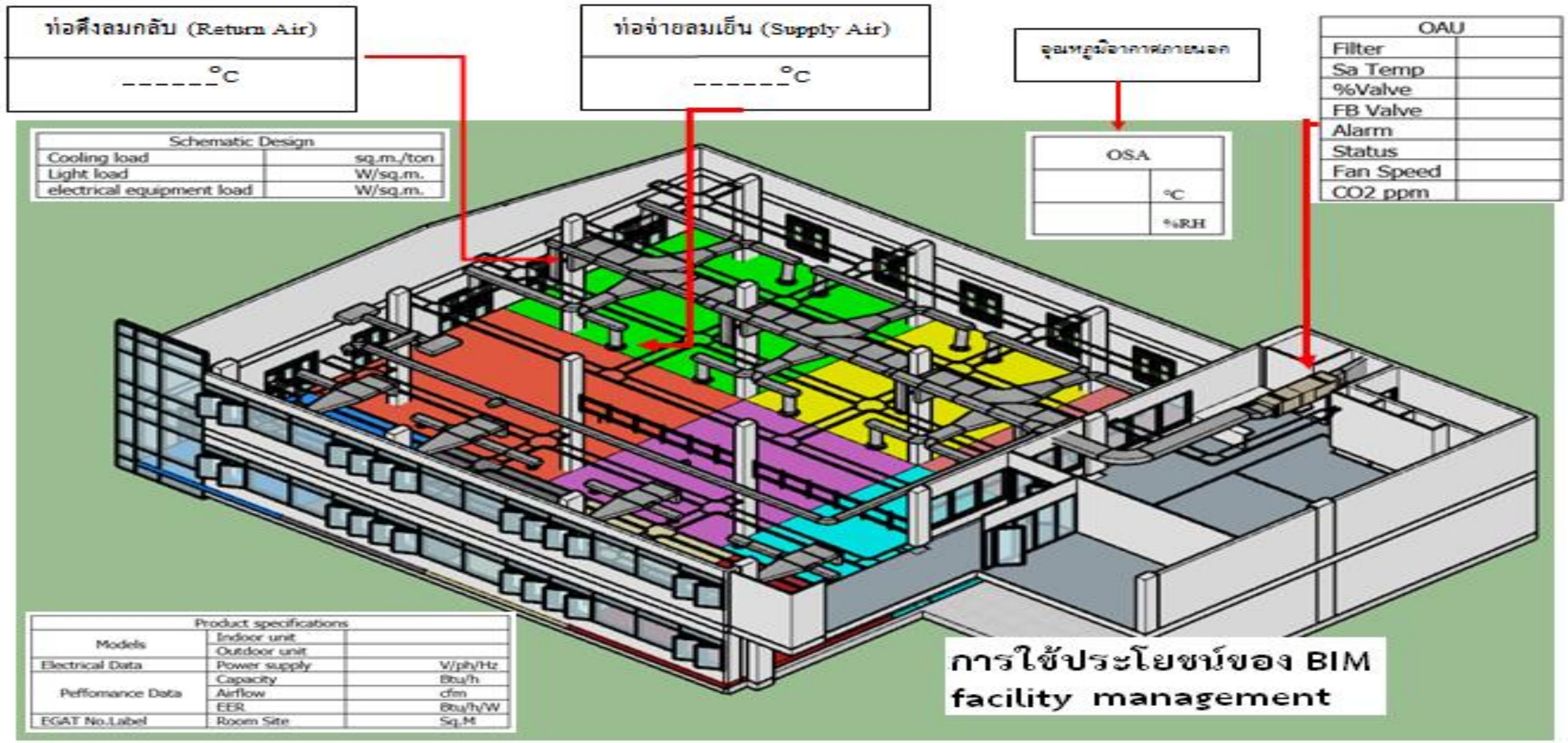
อัตราการระบายอากาศตามกฎหมาย

Ventilation - Width (m)	8.65
Ventilation - Length (m)	25.7
Ventilation - Height (m)	3.6
อัตราการระบายอากาศบริเวณที่ปรับอากาศ(พรบ.33) (ACH)	Office
Ventilation (CFM)	942.075592
Sensible (Constants)	1.09
Sensible - Temp.External	95.3
Sensible - Temp.Internal	75
Q Sensible (BTU/hour)	20845.306624
Latent (Constants)	4840
Latent - Humidity ratio External	35°C / 55%
Latent - Humidity ratio Internal	24°C / 55%
Q Latent (BTU/hour)	49244.175345

จากรูปเป็นในส่วนของ Q รวมทั้งหมด

Q All (BTU/hour)	104255.842516
Q All (kW)	30.554368

BIM for FM (Cooling load and Commissioning Data)



Static data include: commissioning data conditions and design data

Dynamic Data – BAS (BAS control sequence)

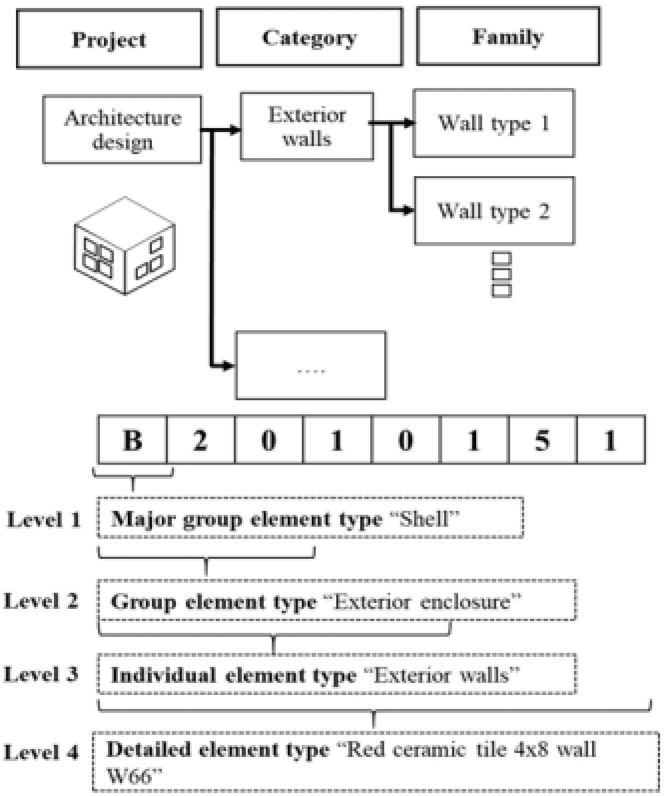
Final Structured data are sent in terms of BIM file

Available static data are used for FM

END OF THE PRESENTATION

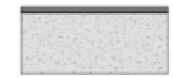
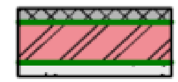
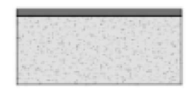
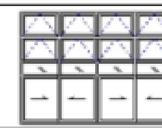
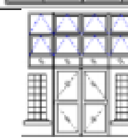
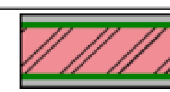
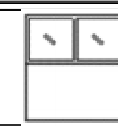
THANK YOU

A BIM-Integrated Relational Database Management System



Example of the hierarchical coding structure of a BIM model.

Table 1. LOD of the building elements in the BIM models for building LCCA.

Category	Model content requirements for the building LCCA	LOD	Graphical illustration
Floor	_ Geometry (length, height, thick of material layers) _ Non-Geometry (element type code, construction unit rate, annual service unit rate, expected service life)	300	
Exterior wall	_ Geometry (length, height, thick of material layers) _ Non-Geometry (element type code, construction unit rate, annual service unit rate, expected service life, heat transfer coefficient, equivalent temperature difference)	300	
Roof	_ Geometry (length, height, thick of material layers) _ Non-Geometry (element type code, construction unit rate, annual service unit rate, expected service life, heat transfer coefficient, equivalent temperature difference)	300	
Exterior window	_ Geometry (length, height, thick of material) _ Non-Geometry (element type code, construction unit rate, annual service unit rate, expected service life, heat transfer coefficient, solar heat gain coefficient)	300	
Door	_ Geometry (length, height, thick of material layers) _ Non-Geometry (element type code, construction unit rate, annual service unit rate, expected service life)	300	
Interior wall	_ Geometry (length, height, thick of material layers) _ Non-Geometry (element type code, construction unit rate, annual service unit rate, expected service life)	300	
Interior window	_ Geometry (length, height, thick of material layers) _ Non-Geometry (element type code, construction unit rate, annual service unit rate, expected service life)	300	

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Article

A BIM-Integrated Relational Database Management System for Evaluating Building Life-Cycle Costs

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iBIM (integrated BIM) for Construction tracking

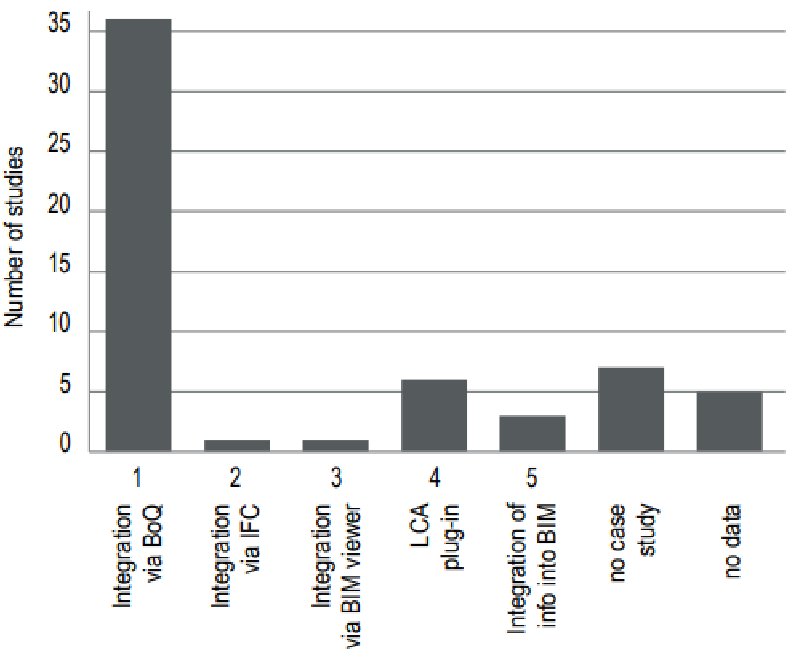

Figure 5. The classification of the workflows in the identified studies.

Review

BIM and LCA Integration: A Systematic Literature Review

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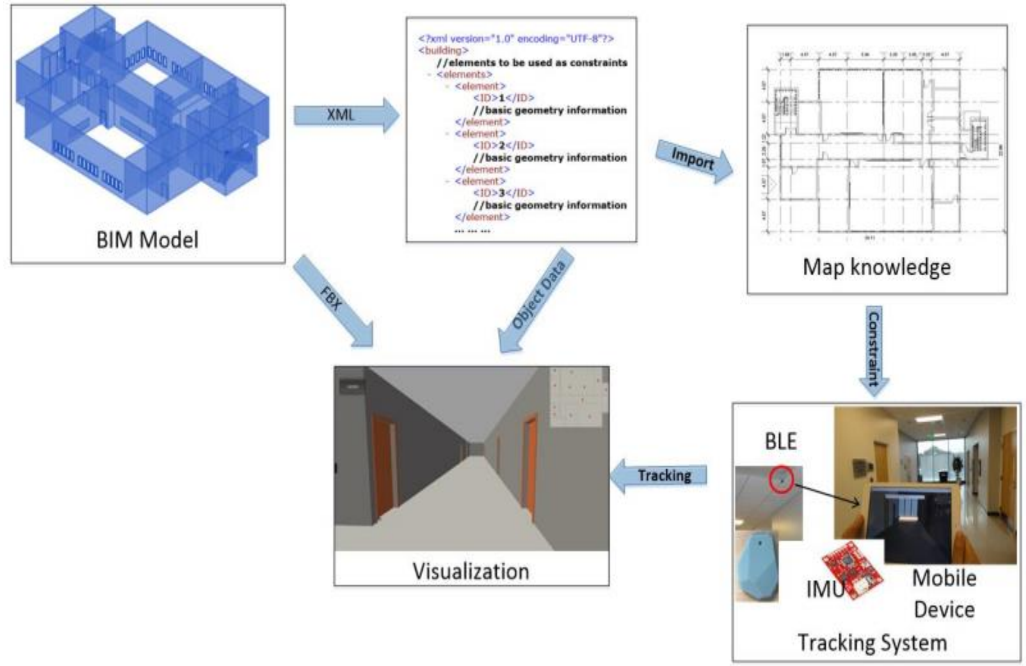

Figure 4: Tracking part of the integrated system

Park, J. and Cho, Y. (2016). "Use of Mobile BIM Application integrated with Asset Tracking and Cloud Computing Technologies." Invited Speech, CRIOCM 21st International Conference on "Advancement of Construction Management and Real Estate" Hong Kong, Dec. 14-17.

Use of a Mobile BIM Application Integrated with Asset Tracking Technology over a Cloud

Park, J.[1] and Cho, Y.K.[2*]

XML ย่อมาจาก Extensible Markup Language เป็นภาษาหนึ่งที่ใช้ในการแสดงผลข้อมูล; FBX หมายเลขตัวเลือก การวาดรูป 2D หรือ 3D ถูกบันทึกในรูปแบบ Autodesk FBX

iBIM (integrated BIM) for building energy life cycle

So what is necessary to approach a world where a BIM exists for every building with each BIM including all the information necessary to simulate energy requirements, indoor air conditions, acoustical performance, and lighting along with the associated occupant and environmental impacts? We believe that there are two enabling sets of technologies that are needed that require significant research and development effort: 1) definition and development of an integrated building information model (iBIM) for existing buildings that includes both the models and data necessary to provide a holistic virtual representation of the building environment (visual, thermal, air quality, lighting, and acoustical along with energy performance) and 2) easy-to-use and automated methods to allow non-expert users to create and update iBIMs for existing buildings.

Integrated BIMs (iBIMs) are needed because the modeling approaches and input data requirements are inextricably linked and existing buildings might best be represented using a combination of white-box (physical), gray-box (semi-empirical), and black-box modeling approaches that require a mixture of physical characteristics and empirical parameters derived from in-situ tests. The iBIMs should also include real-time building operating information/status. Given the large number of buildings and their tendencies to change over time, we believe that the only practical approach for creating and maintaining iBIMs would be to engage occupants in collecting information for their own buildings. However, the general population lacks the knowledge and possibly patience to obtain much of the information that would be needed for traditional forward and physically-based modeling approaches. Therefore, the creation and updating of an iBIM for an existing building should be fast and performed in an automated or semiautomated fashion with minimum data required and at low cost.

Braun, J., Cho, Y., and Li, H. (2010). "Editorial: Expanding BIM to Meet the Grand Challenges in Buildings—What is Needed?" Journal of HVAC & R Research, 16(5), pp. 543-544.

EDITORIAL:

Expanding BIM to Meet the Grand Challenges in Buildings—What is Needed?

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