TIE
IBC
Intelligent Building Collaboration
School of Engineering @ SPU

ECG-RESEARCH
ECG
STARTUP CONNECT

# TIE SMART SOLUTIONS
## AI Energy Platform

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

**Topic:**
**"Integrated BIM (iBIM) development for automated continuous commissioning of HVAC systems in Thailand"**

**"แบบจำลองสารสนเทศอาคารแบบผสมผสาน (iBIM) เพื่องานทดสอบระบบปรับอากาศและระบายอากาศ (HVAC) แบบอัตโนมัติในประเทศไทย"**

**โดย ผศ. ดร. เด่นชัย วรเดชจำเริญ – มหาวิทยาลัยศรีปทุม**

DIPROM
กรมส่งเสริมอุตสาหกรรม

# Study and Research Backgrounds (ASHRAE)

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.



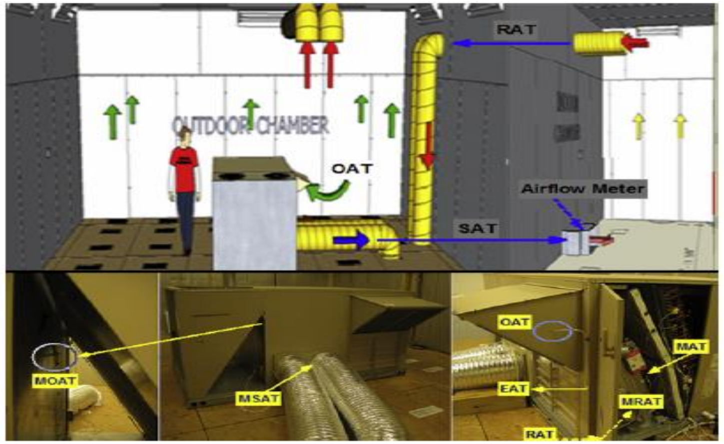
NBE³RG


ASHRAE

Smart Building Systems

ASHRAE Technical Committee 7.5

| Wednesday, June 17, 2020 | Link |
|---|---|
| 3:00 PM - 3:45 PM FDD | Zoom Link |
| 3:45 PM - 4:30 PM Enabling Technologies | Zoom Link |
| 4:30 PM - 5:15 PM Smart Grid | Zoom Link |
| 5:15 PM - 6:00 PM Handbook | Zoom Link |


The American Society of Heating, Refrigerating and Air-Conditioning Engineers

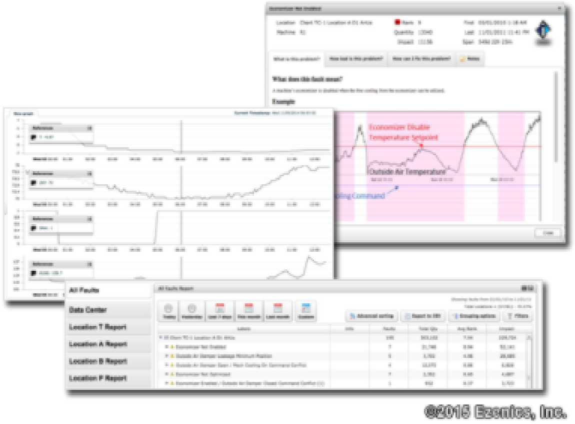
# Study and Research Backgrounds

## Automated, Continuous Commissioning

### Automated Fault Detection, Diagnosis, and Impact™ (AFDDI™)

Applies Ezenics expert analytics to your building systems' data, continuously diagnosing, summarizing, and prioritizing energy, maintenance, and comfort issues and their financial impact.

LEARN MORE




### Operational Guidelines™ (OG™)

Continuously verifies operational compliance with organizational business rules, automatically corrects inconsistencies via BMS controls integration, and manages assets across the portfolio.

LEARN MORE



# Study and Research Backgrounds

- **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, University of Nebraska – Lincoln**

- **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 and optimization)**
- ต้นแบบอาคารอัจฉริยะเพื่อการวินิจฉัยความผิดปกติของระบบชิลเลอร์อัตโนมัติ (Chiller Diagnostics)
- **การพัฒนามาตรฐานการคอมมิชชันนิ่งด้วยระบบตรวจวัด (Monitoring based Commissioning, MBCx)**
- การออกแบบมาตรฐานระบบวินิจฉัยความผิดพลาดระบบปรับอากาศและระบายอากาศ (AFDD standard)
- **การสร้างฐานข้อมูลออนไลน์ระบบปรับอากาศจากระบบอัตโนมัติให้ประเทศไทย Phase II (Big data for diagnostics)**
- ไอโอทีแพลตฟอร์มอัจฉริยะสำหรับระบบควบคุมของระบบปรับอากาศแบบแยกส่วนหลายเครื่องสำหรับ (AC Control)
- **Smart BIM for smart facility management (iBIM)**
- AI command center for smart city

วุฒิการศึกษา :

ปริญญาเอก : Ph.D. in Architectural Engineering: University of Nebraska - Lincoln, USA in 2015

ปริญญาโท : M. Eng in Mechanical Engineering: Chulalongkorn University, Thailand in 2009

ปริญญาตรี : B. Eng in Mechanical Engineering: Chulalongkorn University, Thailand in 2005

ความเชี่ยวชาญ

มีความเชี่ยวชาญทางด้าน Fault detection and diagnosis, Advanced control in HVAC&R, Building data analytics, Virtual sensing and modeling, building simulation platform สำหรับระบบอาคารอัจฉริยะ มากกว่า 10 ปี

ผู้พัฒนาระบบวินิจฉัยระบบปรับอากาศแบบอัตโนมัติ (AFDD), ผู้พัฒนาระบบ IoT เพื่อส่งเสริมกระบวนการ Monitoring based Commissioning (MBCx)

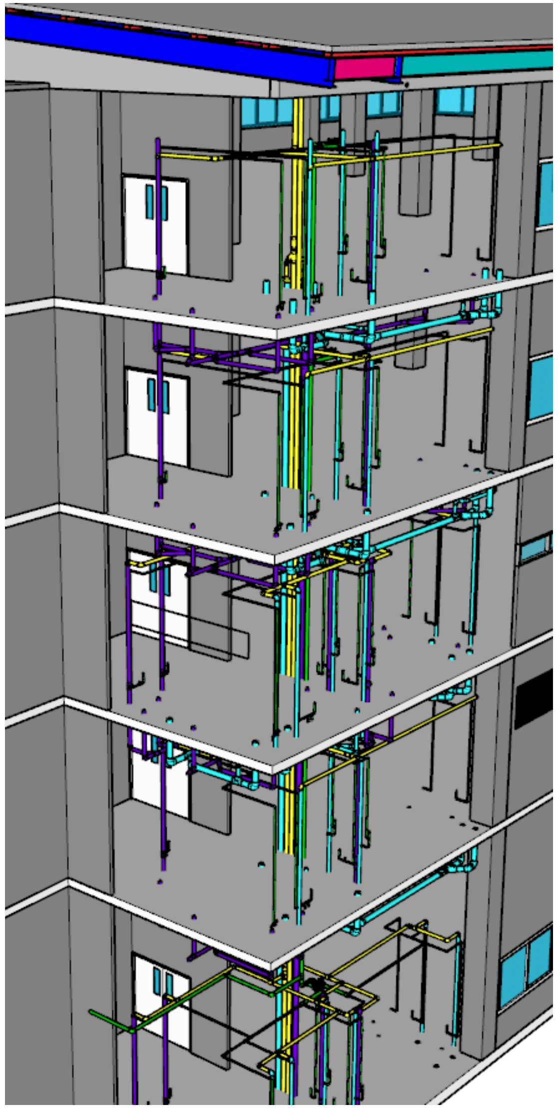
**หัวหน้าโครงการวิจัย**

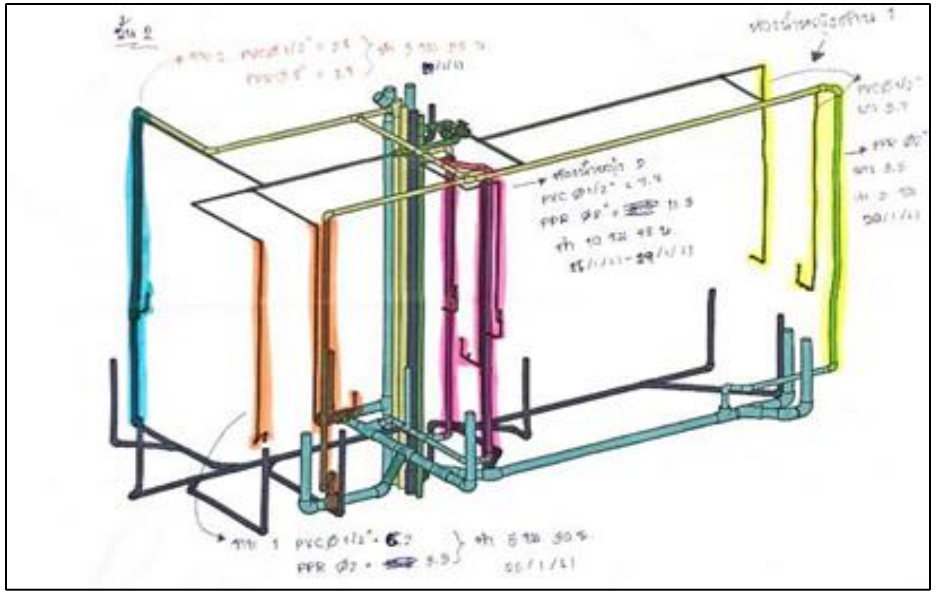
การพัฒนากระบวนการและแนวทางการสร้างมาตรฐานการใช้งานระบบอาคารอัตโนมัติสำหรับการประหยัดพลังงานระบบปรับอากาศและระบายอากาศ ด้วย EMIS tool – ระยะที่ 1 ทุน กฟผ – สกว ปี 2562 – 2563

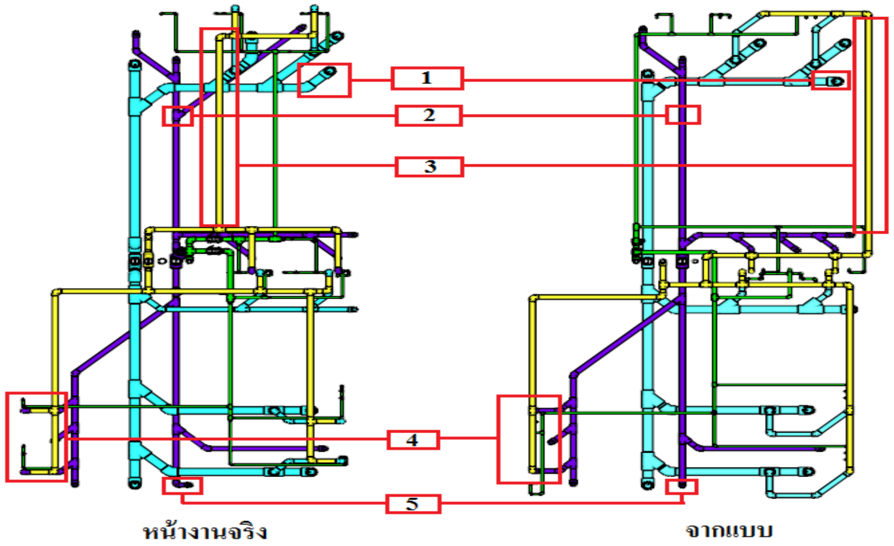
**-หัวหน้าหน่วยวิจัยความร่วมมืออาคารอัจฉริยะ (IBC research unit)**

ภาควิชาวิศวกรรมระบบเครื่องกลและนวัตกรรมอุตสาหกรรม คณะวิศวกรรมศาสตร์ มหาวิทยาลัยศรีปทุม

# BIM for MEP (Mechanical, electrical, and plumbing) in Thailand








| 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 |

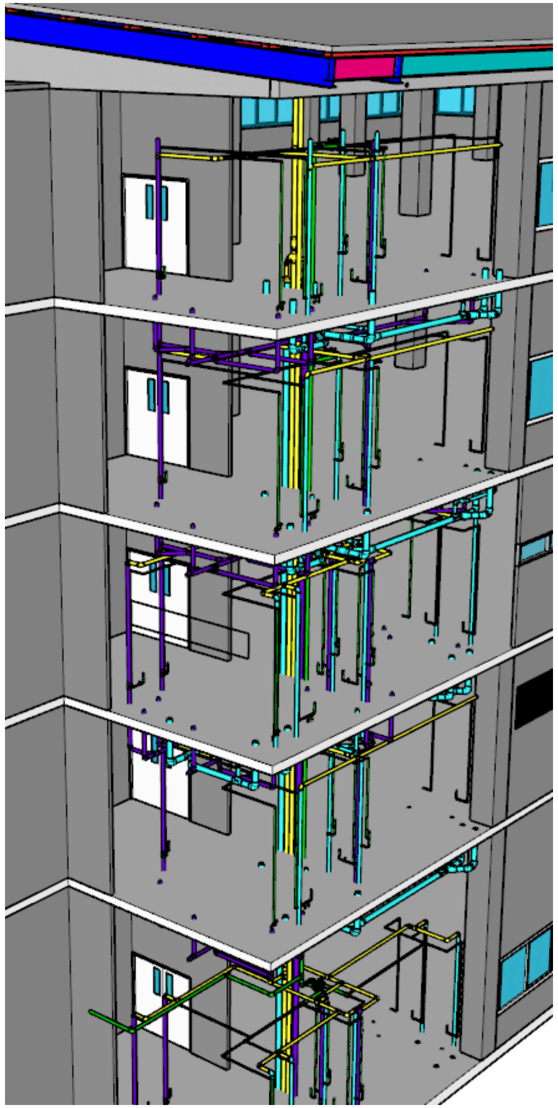
1.การ crash กับงานระบบไฟฟ้า

2.ผู้ควบคุมงานก่อสร้างเพิ่มท่อระบายน้ำ

3.เจ้าของงานไม่ต้องการให้เจาะกำแพงจึงเปลี่ยนการต่อท่อ

4.การต่อท่อจากแบบติดกับระบบเซ็นเซอร์ของอ่างล้างมือทำให้ต้องต่อท่อต่างจากแบบ

# BIM for Mechanical designers in Thailand



**Cooling load – Pre-construction**

ดำเนินการได้โดยไม่มี BIM

Cooling load เท่ากับ energy หรือไม่

Cooling load ใช้เลือก equipment มีข้อเสียอย่างไร

การเปลี่ยนข้อมูลแบบ layout ส่งผลอย่างไร

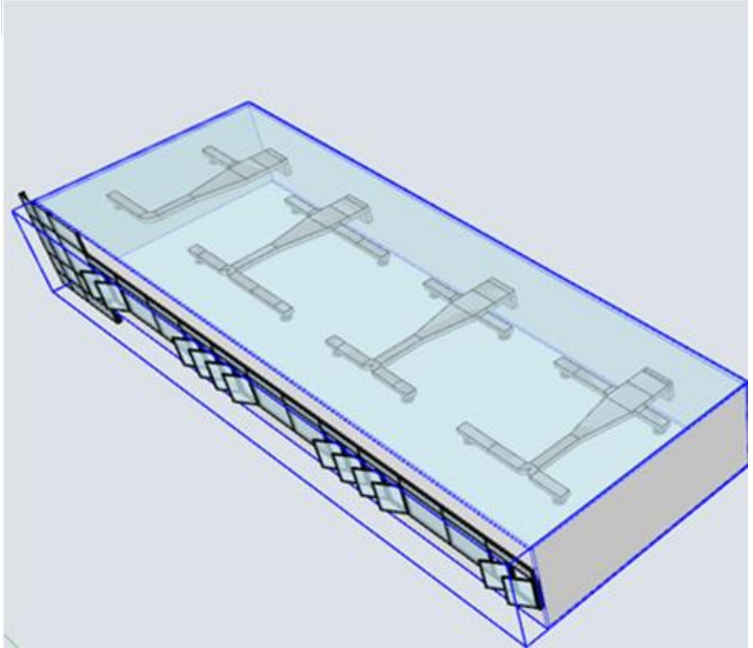
Cooling load แบบเดิมเป็น forward model without feedback validation

**ประโยชน์ ในมุม IBC Lab**

Cooling load ในการทำนายการทำงานล่วงหน้าของระบบ CPMS

Cooling load ตรวจสอบ energy modeling

Cooling load ตรวจสอบการเลือกอุปกรณ์ผู้ผลิต

# BIM in developed countries vs. Thailand

การใช้ประโยชน์ BIM (Building Information Modeling) สำหรับอาคาร
อัจฉริยะ (Smart Buildings) ในประเทศไทย

www.acat.or.th

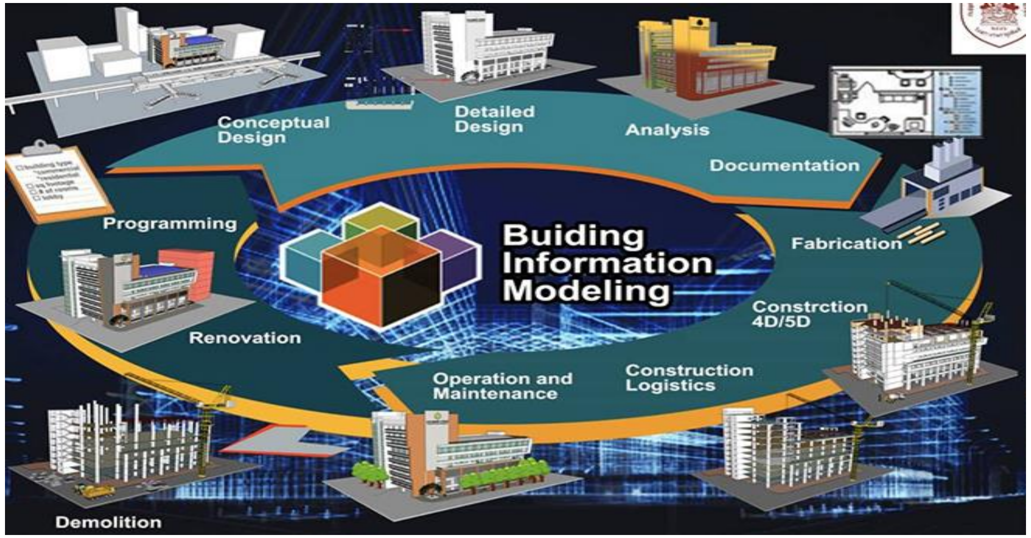
บทความเชิงวิชาการ | ACAT News

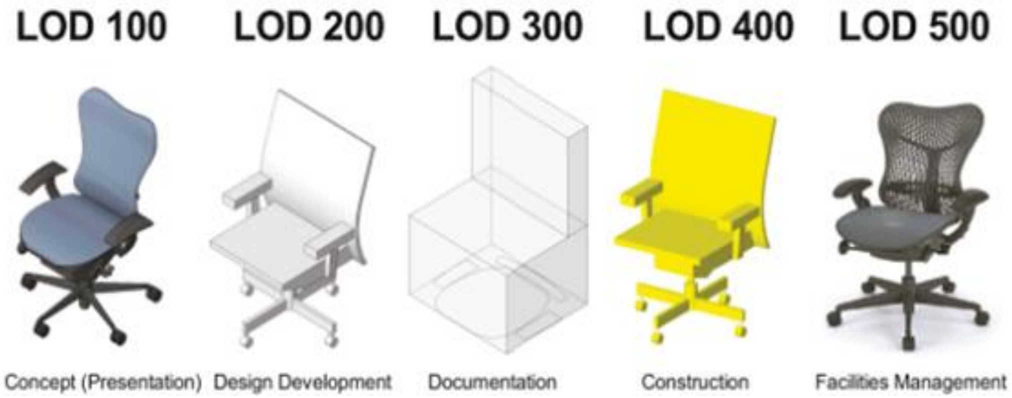
## การพัฒนาแบบจำลองสารสนเทศอาคารแบบผสมผสานเพื่องานทดสอบเครื่องแฟนคอยล์ยูนิตแบบต่อเนื่อง

**Integrated BIM (iBIM) development for continuous commissioning of a fan coil unit**

ผู้ช่วยศาสตราจารย์ ดร. เด่นชัย วรเดชจำเริญ
และ ดร. พุทฒิพงษ์ มหาสุคนธ์

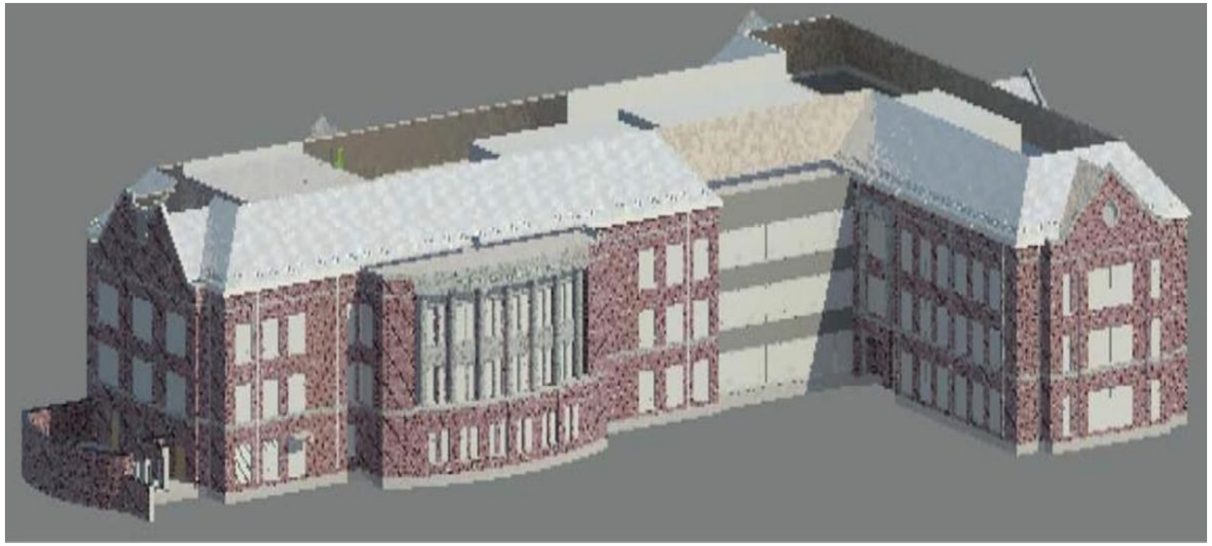
(integrated BIM, iBIM) ในประเทศไทย ทำให้ BIM เป็นเพียงเครื่องมือการสร้างแบบสามมิติและถอดปริมาณงานการก่อสร้างเท่านั้น หากแต่ยังไม่มีการนำไปใช้ในกระบวนการตรวจสอบการทำงานระบบปรับอากาศตั้งแต่ก่อสร้างจนถึงงาน FM บทความนี้มุ่งเน้นการการพัฒนากระบวน iBIM เพื่อยกระดับคุณภาพงานระบบปรับอากาศในประเทศไทย โดยประกอบด้วย 5 ขั้นตอน




Level of development (กวีไกร, 2562)

# 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<br>Superstructure: structural steel<br>Floors: concrete slab on grade and slab on deck<br>Interior partitions: gypsum board on metal studs<br>Exterior skin: brick masonry with precast accents, glazing, and some CMU<br>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

Automation in Construction 24 (2012) 149–159

Contents lists available at SciVerse ScienceDirect

Automation in Construction

journal homepage: www.elsevier.com/locate/autcon

ELSEVIER

How to measure the benefits of BIM — A case study approach

Kristen Barlish *, Kenneth Sullivan

Arizona State University, United States

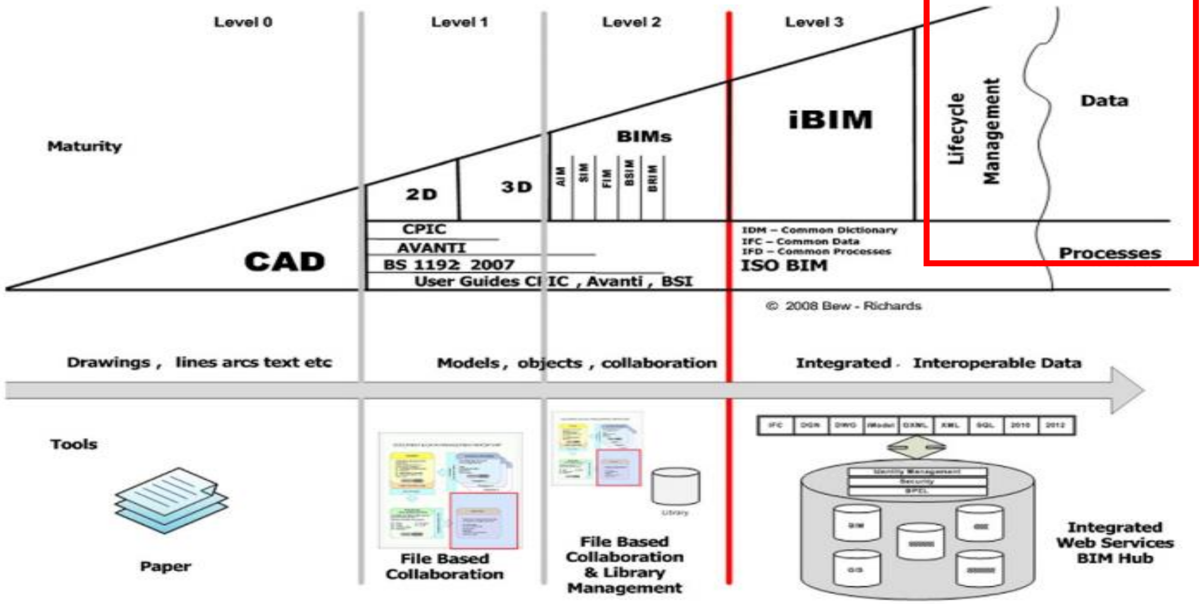


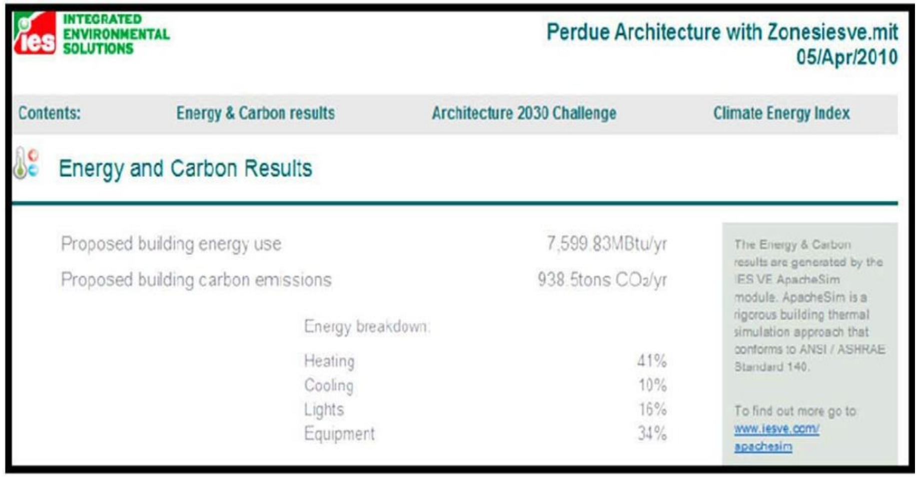

Fig. 2. BIM maturity map [9].

# 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 |
| 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.

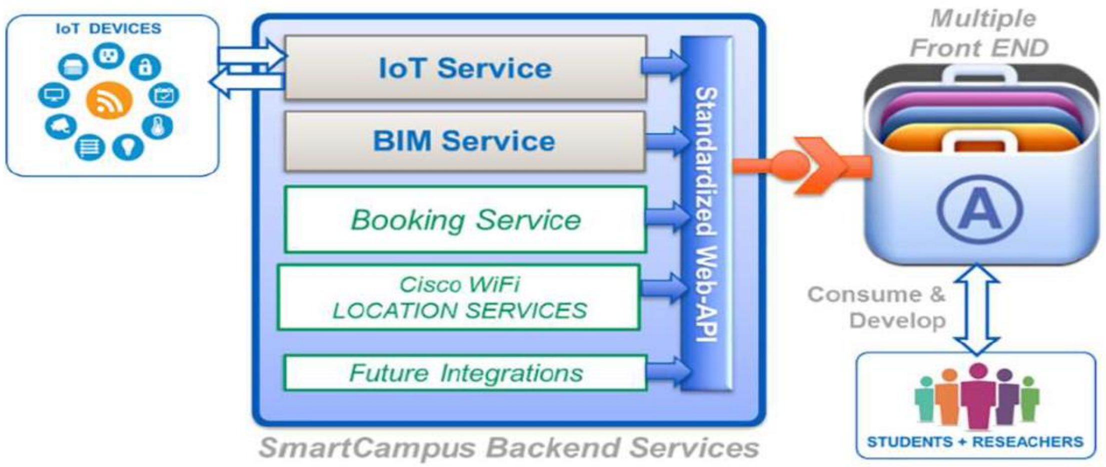



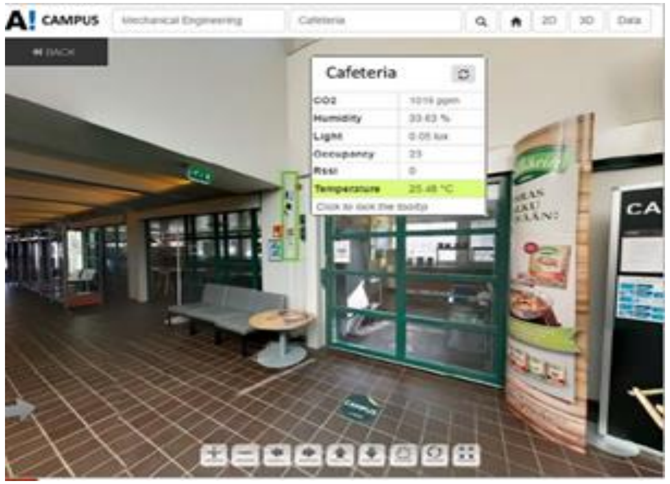

LEED® credits that can be documented using results of BIM software.

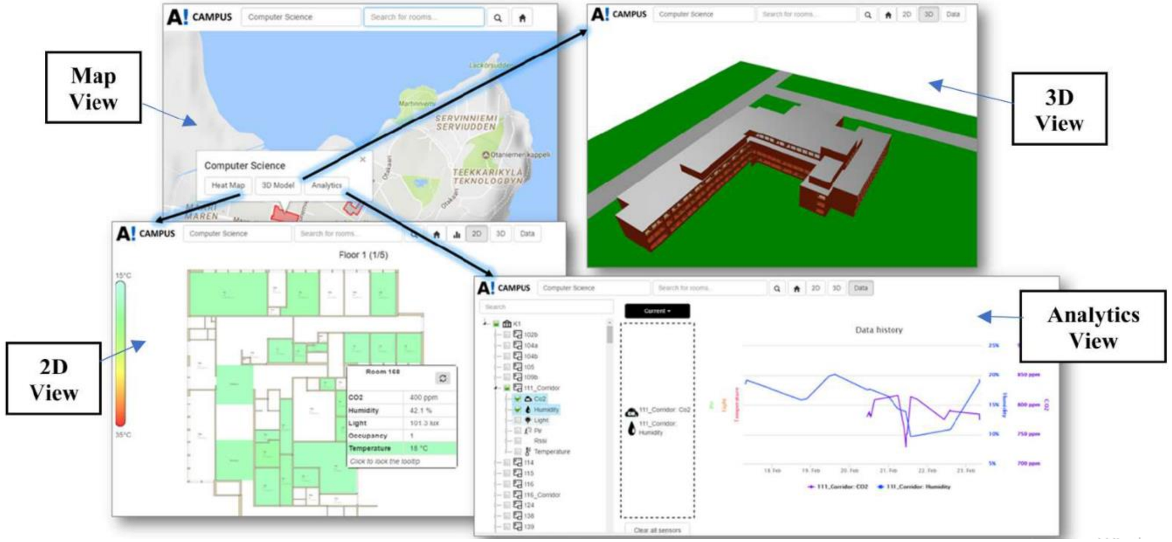
| LEED®-NC credits that can be earned using BIM-based performance analysis software | | | Can the LEED® credit be earned using BIM? (yes/no) | Performance analysis software that could be or was used? VE/REVIT | Is the credit being attempted by Salisbury Building? | Was the credit validated in the case 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 | |

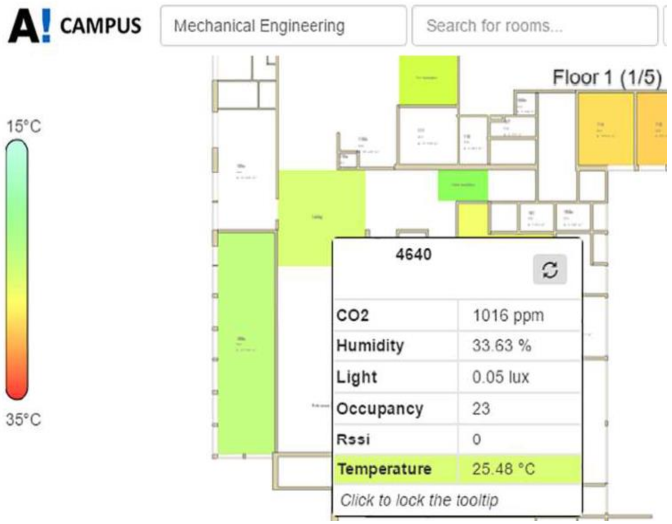
ต้นทุนการดำเนินการที่แตกต่าง – BIM for LEED rating to reduce time-consuming issue

# BIM in developed countries – BIM IoT for Facility Management




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]

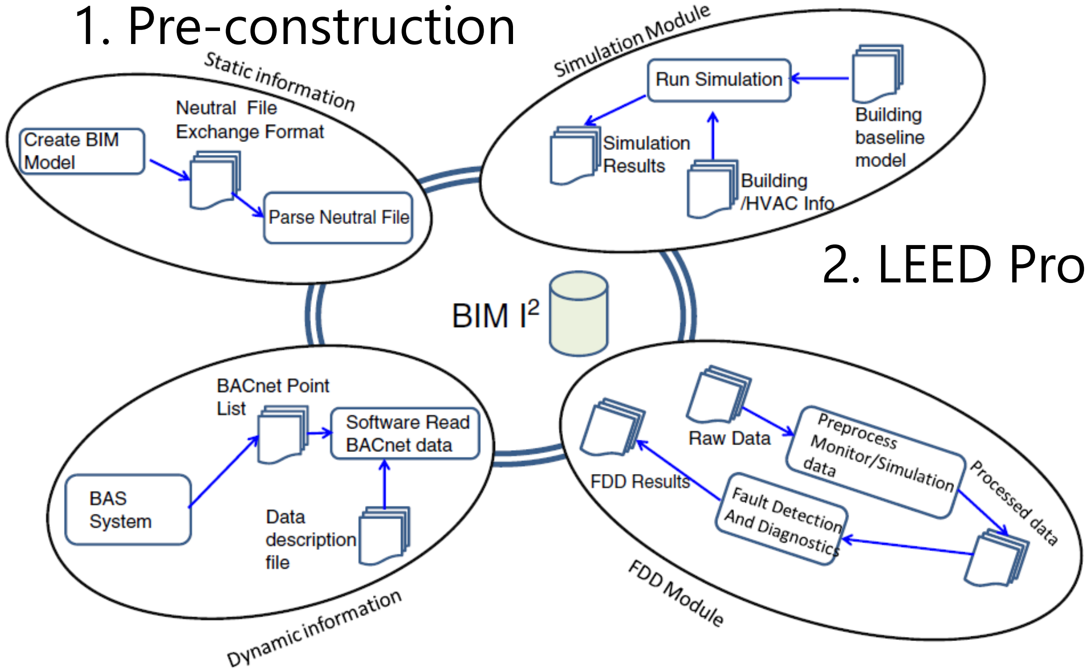
[a] School of Architecture, Georgia Institute of Technology, 245 4th St NW, Atlanta, GA 30332, USA
[b] School of Building Construction, Georgia Institute of Technology, 280 Ferst Dr., Atlanta, GA 30332, USA
[c] Myers-Lawson School of Construction, Virginia Polytechnic Institute and State University,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

7D BIM service for BMS GUI

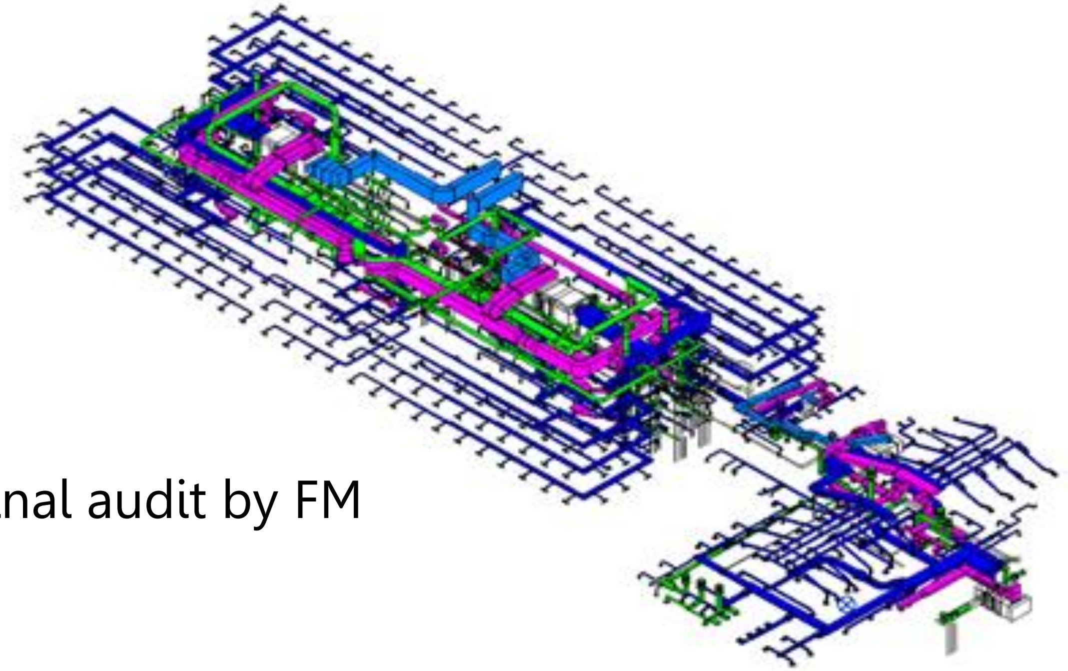
# BIM based automated fault detection and diagnostic (AFDD)

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

1. Pre-construction



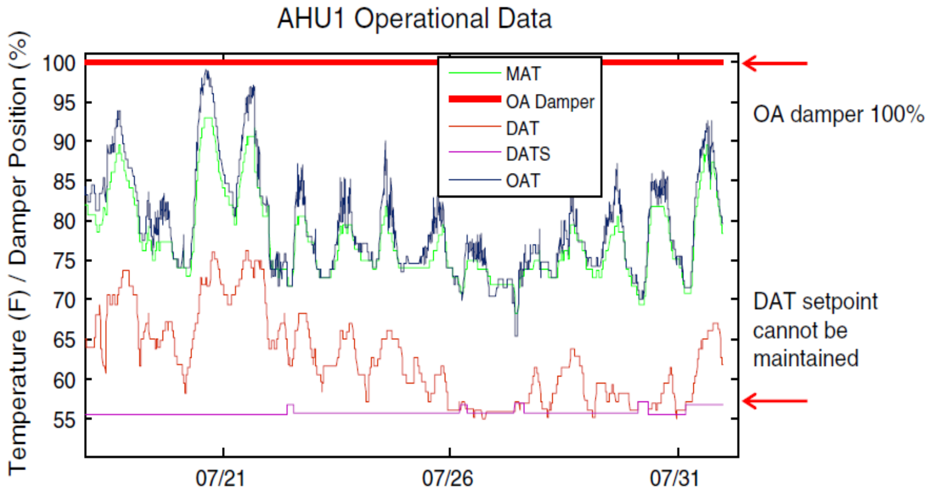

2. LEED Process



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

# iBIM (integrated BIM) for Construction tracking

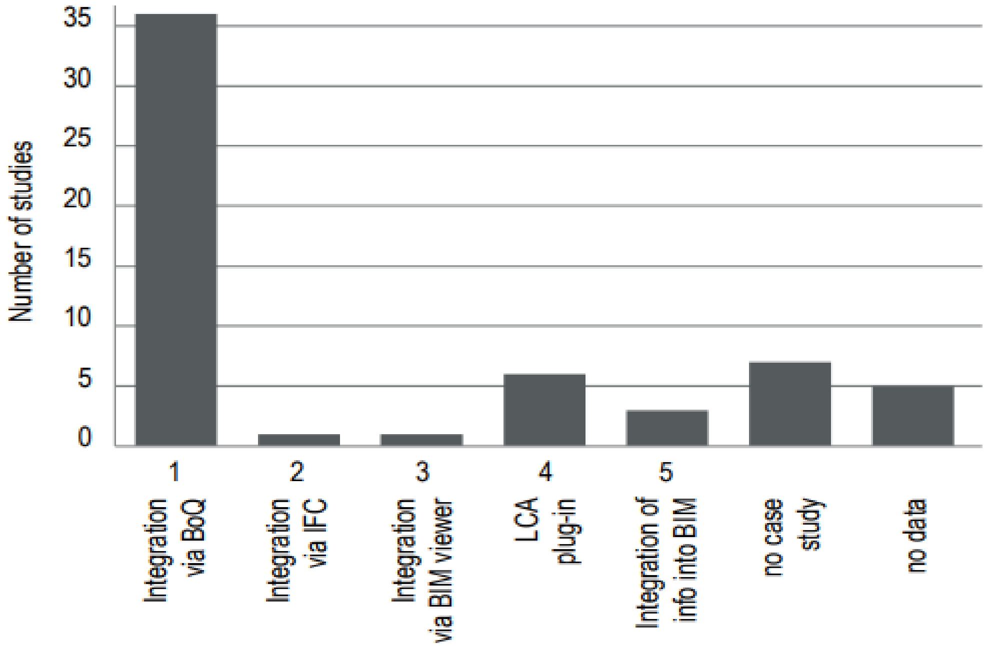



**Figure 5.** The classification of the workflows in the identified studies.

*Review*

## BIM and LCA Integration: A Systematic Literature Review


**Tajda Potrč Obrecht [1], Martin Röck [2,3], Endrit Hoxha [2] and Alexander Passer [2,*]**

[1] Slovenian National Building and Civil Engineering Institute, Dimičeva 12, 1000 Ljubljana, Slovenia; tajda.obrecht@zag.si

[2] Working Group Sustainable Construction, Graz University of Technology, Waagner-Biro-Straße 100, 8020 Graz, Austria; martin.roeck@tugraz.at (M.R.); endrit.hoxha@tugraz.at (E.H.)

[3] Architectural Engineering, Department of Architecture, Faculty of Engineering Science, KU Leuven, Kasteelpark Arenberg 1, 3001 Leuven, Belgium

* Correspondence: alexander.passer@tugraz.at

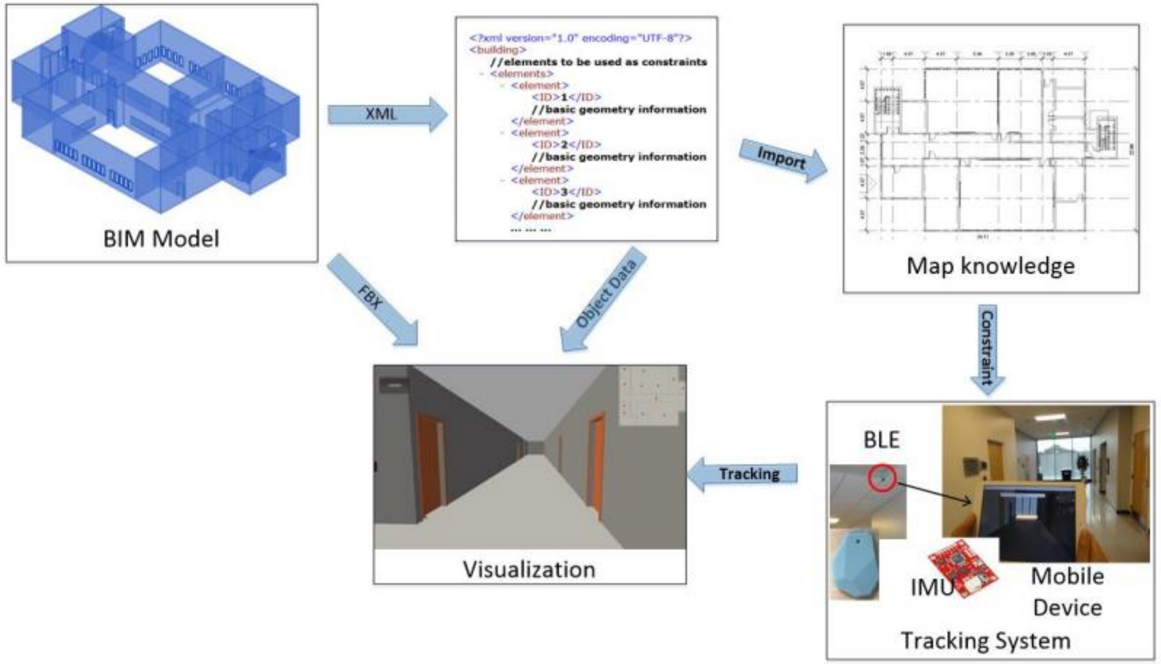




Figure 4: Tracking part of the integrated system

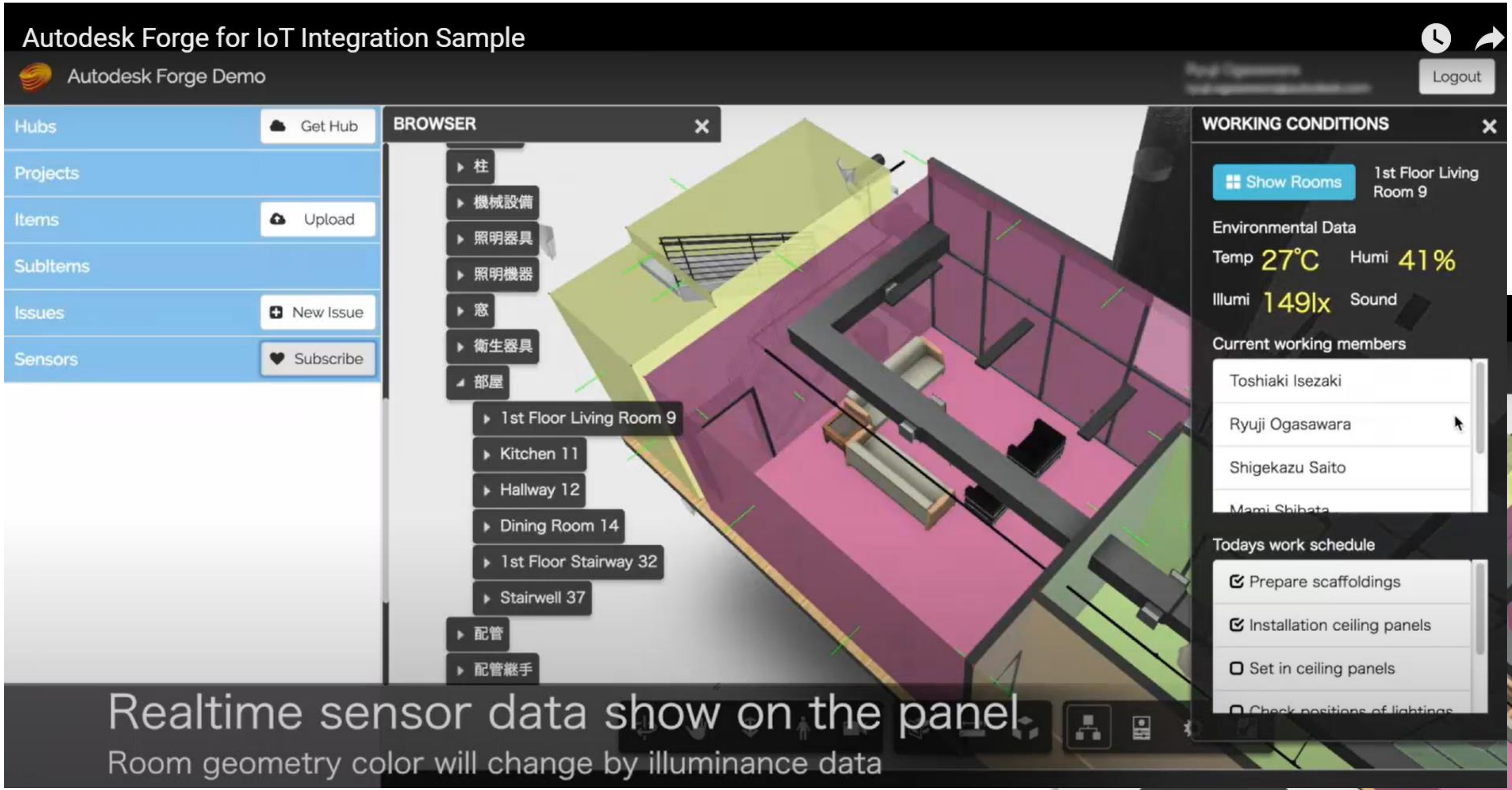

Park, J. and Cho, Y. (2016). "Use of Mobile BIM Application integrated with Asset Tracking and Cloud Computing Technologies." Invited Speech, CRIOCM 21st International Conference on "Advancement of Construction Management and Real Estate" Hong Kong, Dec. 14-17.

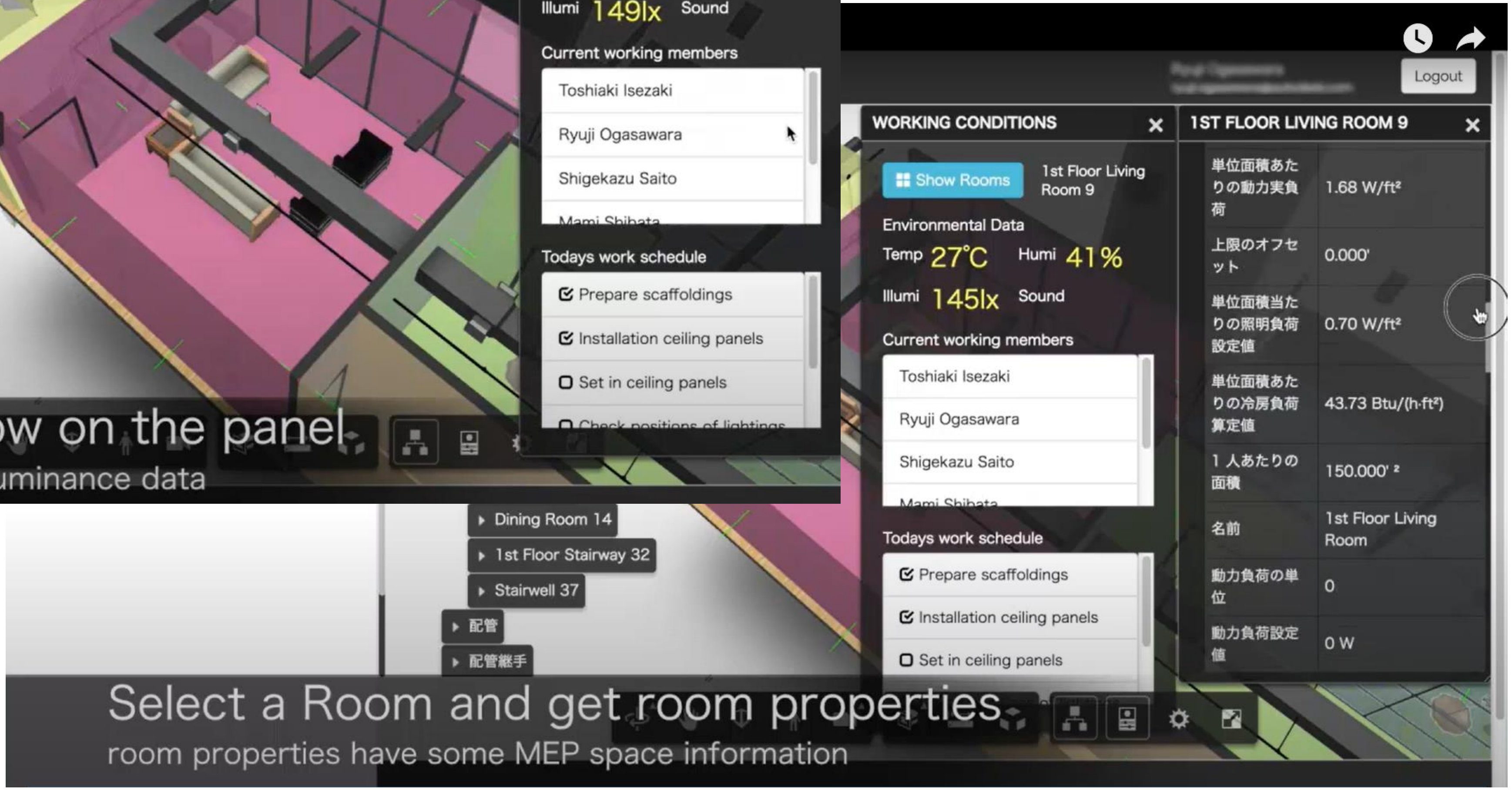

## Use of a Mobile BIM Application Integrated with Asset Tracking Technology over a Cloud


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


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

# Not exact iBIM on Autodesk Forge



# iBIM (integrated BIM) for building energy life cycle

3. AHU label info

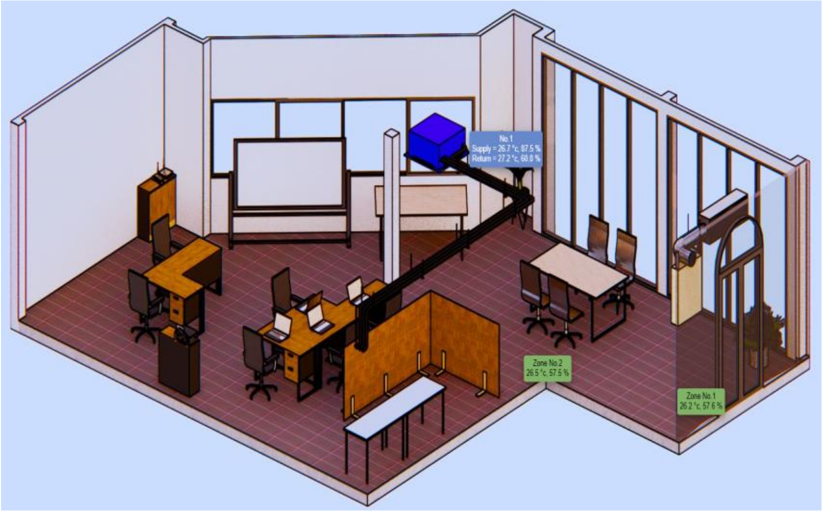
File Edit View Insert Format Data Tools Add-ons Help Last edit was made yesterday at 5:00 PM by Wasok Widsankun

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

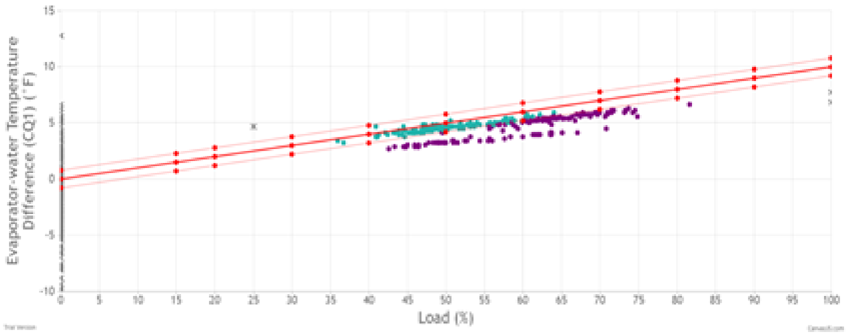
Manu Line

File Edit View Insert Format Data Tools Add-ons Help Last edit was on 25 April

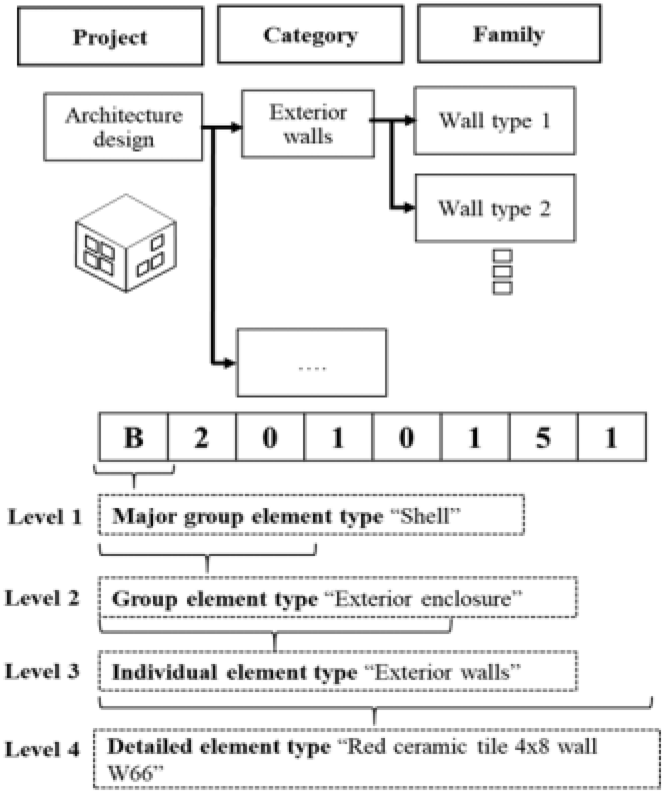
| | A | B | C | D | E |
|---|---|---|---|---|---|
| 1 | site | unit | cq1 | cq2 | band |
| 2 | * | * | 0.1,0 | 0.1,0 | 0.7871890921 |
| 3 | bot1 | chiller_interface_1 | 0.1474,0.103 | 0.0972,0.2499 | 0.7871890921 |
| 4 | bot1 | chiller_interface_2 | 0.1474,0.103 | 0.0972,0.2499 | 0.7871890921 |
| 5 | 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 |



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.

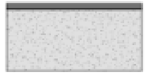
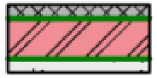
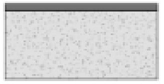
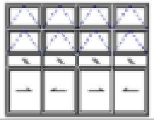
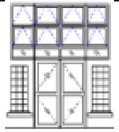
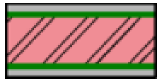
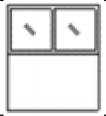


# A BIM-Integrated Relational Database Management System




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)<br>_ 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)<br>_ 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)<br>_ 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)<br>_ 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)<br>_ 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)<br>_ 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)<br>_ Non-Geometry (element type code, construction unit rate, annual service unit rate, expected service life) | 300 |  |

Engineering Journal issn: 0125-8281

Article

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

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2 Division of Sustainable Energy and Environmental Engineering, Osaka University, Osaka, Japan
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# 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.

## Data?

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:

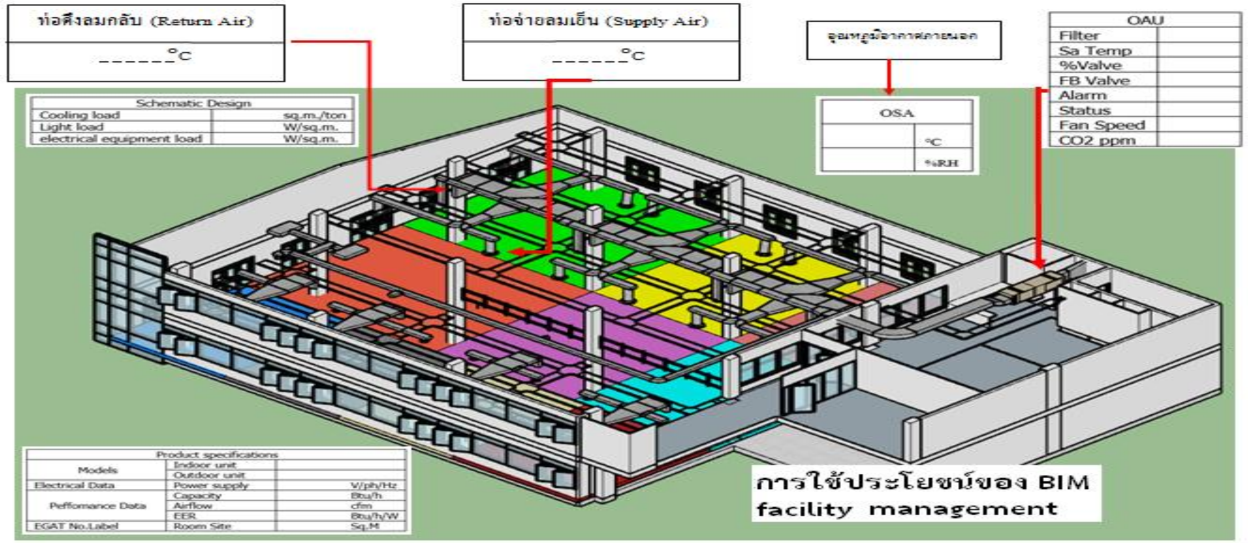
**Expanding BIM to Meet the Grand Challenges in Buildings—What is Needed?**

**Jim Braun, PhD** Fellow ASHRAE

**Yong K. Cho, PhD**

**Haorong Li, PhD** Member ASHRAE

**Jim Braun** is a professor in the Mechanical Engineering department at Purdue University, West Lafayette, IN. **Yong K. Cho** is an assistant professor in the department of Construction Systems and **Haorong Li** is an associate professor in the department of Architectural Engineering at the University of Nebraska–Lincoln, Lincoln, NE.




Static data include: commissioning data conditions and design data

Dynamic Data – BAS (BAS control sequence)

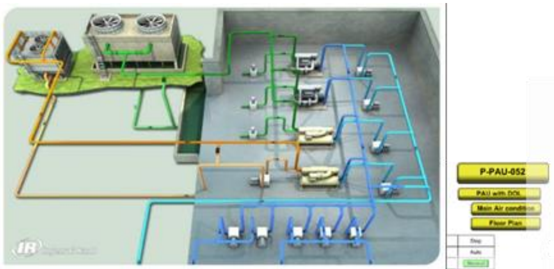
Final Structured data are sent in terms of BIM file

Available static data are used for FM

# Thai Engineer and technician problems

***Facility Manager** lacking **diagnostic tool** and **correct solutions***

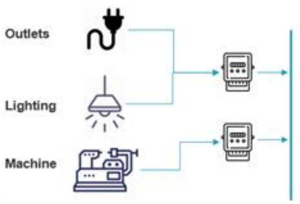

***Incorrect solutions for energy savings** by **startups and contractors***





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

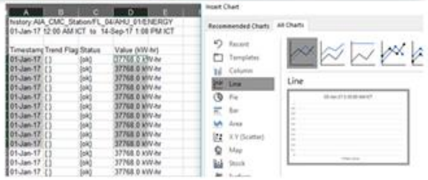
**Building Automation System (BAS)**
AHU | VAV | Air-side systems etc.




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


**Network IoT sensors**
Thermal & Zone parameters

- Data overwhelming
- Lots of data = $$$$$$
- Which data to be used?
- What to look for?
- What to report?
- Wasting of time?
- What are the cost benefits?



# Thai Engineer and technician problems

| ตัวแปรที่ต้องการ | | |
|---|---|---|
| ตัวแปร chiller plant | BAS available | Stored? |
| - Chiller Plant Setpoint Temp (set) | Yes | Yes |
| - Chiller Plant Chilled Water Leaving Temp | Yes | Yes |
| - Chiller Plant Chilled Water Entering Temp | No | No |
| - Chiller Plant Chilled Water Flow (Main Header) | No | No |
| - Chiller Plant Condenser Water Leaving Temp | No | No |
| - Chiller Plant Condenser Water Entering Temp (set) | No | No |
| - Chiller Plant Condenser Water Entering Temp | No | No |
| - Chiller Plant Diff Pressure (set) | Yes | Yes |
| - Chiller Plant Diff Pressure | Yes | Yes |
| - Chiller Plant Ton Plant | No | No |
| - Chiller Plant Kw Plant | No | No |
| - Chiller Plant kW/Ton Plant | No | No |
| - Chiller Plant Ambient Temperature | Yes | Yes |
| - Chiller Plant Ambient Humidity | Yes | Yes |
| - Chiller Plant Wet-Bulb | Yes | Yes |

| ตัวแปรการทำงานของ chiller แต่ละเครื่อง | BAS available | Stored? |
|---|---|---|
| - Chilled Water Setpoint | Yes | Yes |
| - Chilled Water Temp: Leaving | Yes | Yes |
| - Chilled Water Temp: Entering | Yes | Yes |
| - Chilled Water: Flowrate | No | No |
| - Evaporator Approach Temp | No | No |
| - Condenser Water Temp: Leaving | Yes | Yes |
| - Condenser Water Temp: Entering | Yes | Yes |
| - Condenser Water: Flowrate | No | No |
| - Condenser Approach Temp | Yes | Yes |
| - Operating Capacity (Percent load) | Yes | Yes |
| - Ton | No | No |
| - Kw/ Ton | No | No |
| - Unit Power Consumption (kW) | Yes | Yes |
| - Compressor Discharge Temp | No | No |
| - Condenser Refrigerant Pressure | Yes | Yes |
| - Condenser Refrigerant Temp | Yes | Yes |
| - Evaporator Refrigerant Pressure | No | No |
| - Evaporator Refrigerant Temp | No | No |

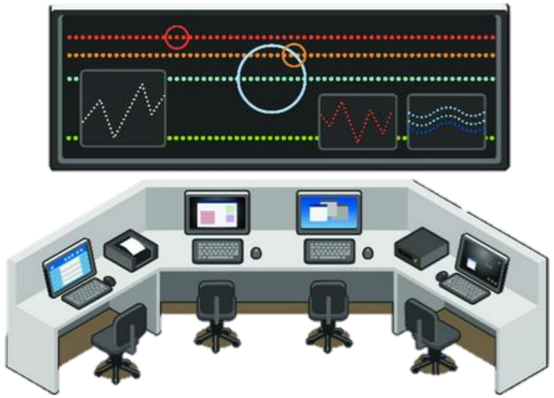
| Parameters - AHU | BAS available | Stored? |
|---|---|---|
| Supply air temperature | N/A | N/A |
| Supply relative humidity | N/A | N/A |
| Supply air temperature set-point | N/A | N/A |
| Return air temperature | Yes | No |
| Return relative humidity | No | No |
| Return air temperature set-point | Yes | No |
| Static pressure | Yes | No |
| Static pressure setpoint | Yes | No |
| Variable Fan % | Yes | No |
| Cooling coil valve % | Yes | No |
| Fresh air temperature | No | No |
| Fresh relative humidity | No | No |
| Carbondioxide level | No | No |
| Carbondioxide level | No | No |
| Mix air temperature | No | No |

| Parameters - PAU | BAS available | Stored? |
|---|---|---|
| Supply air temperature | Yes | No |
| Relative humidity | No | No |
| Supply air temperature set-point | Yes | No |
| AHU air temperature (ambient) | No | No |
| AHU Relative humidity (ambient) | No | No |
| Static pressure | Yes | No |
| Static pressure setpoint | Yes | No |
| Variable Fan | No | No |
| Pre-cooling coil valve % | Yes | No |
| Air temperature enering coil | No | No |
| Relative humidity entering coil | No | No |
| Air temperature leaving coil | No | No |
| Relative humidity leaving coil | No | No |

- ตรวจสอบข้อมูล sensor
- มีการสร้าง trend ข้อมูลของเครื่องทำน้ำเย็น
- ขาด sensor สำคัญหลายตัว เช่น ไม่มีการติดตั้งระบบ water flow sensor และค่าไฟฟ้าของอุปกรณ์ย่อย เช่น cooling tower และปั๊มน้ำ

- พื้นที่สีแดงแสดงตัวแปรที่ไม่มีในระบบ
- ตัวแปรที่มีในระบบก็ไม่มีการบันทึกผ่านการสร้าง trend ข้อมูล

# TIE and IBC Solutions via iBIM



Smart advisory report and control optimization

## *AIoT Energy Platform for Intelligent Solutions*

*where energy consumers can earn correct and suitable solutions*

### *Data Integration*

Utilizing existing data in buildings without additional sensors

### *System Diagnostics*

Diagnose and solve AC problem and other energy loss

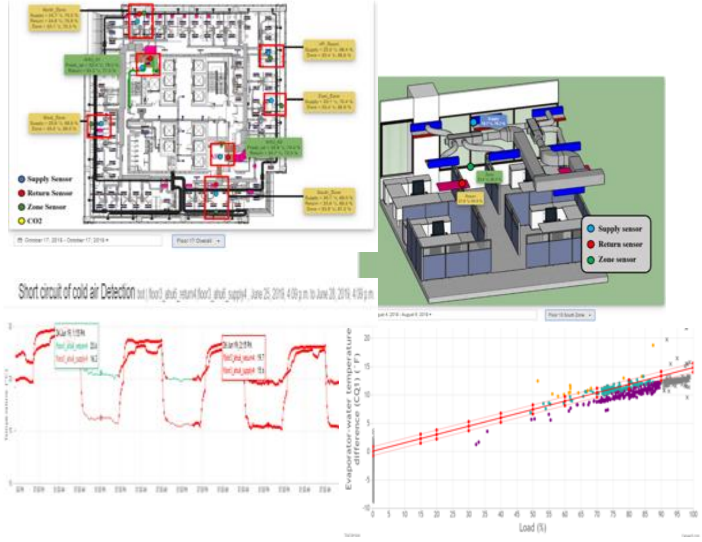
### *Solutions Providers*

AI command solution for Facility manager and team

# TIE and IBC Solutions via iBIM for facility management (FM)

## Automated Data Integration and Diagnostics (AFDD)

**Online analytics and dashboard portal**

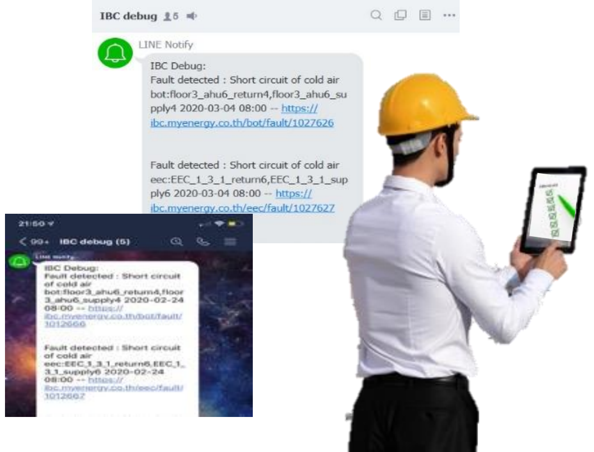



**Report, solve issues and verify performance**

**FM** – Optimize workload, improve efficiency and decision making

**Owners** – Monitoring energy revenue and FM eff.

**Smart advisory report and notification**

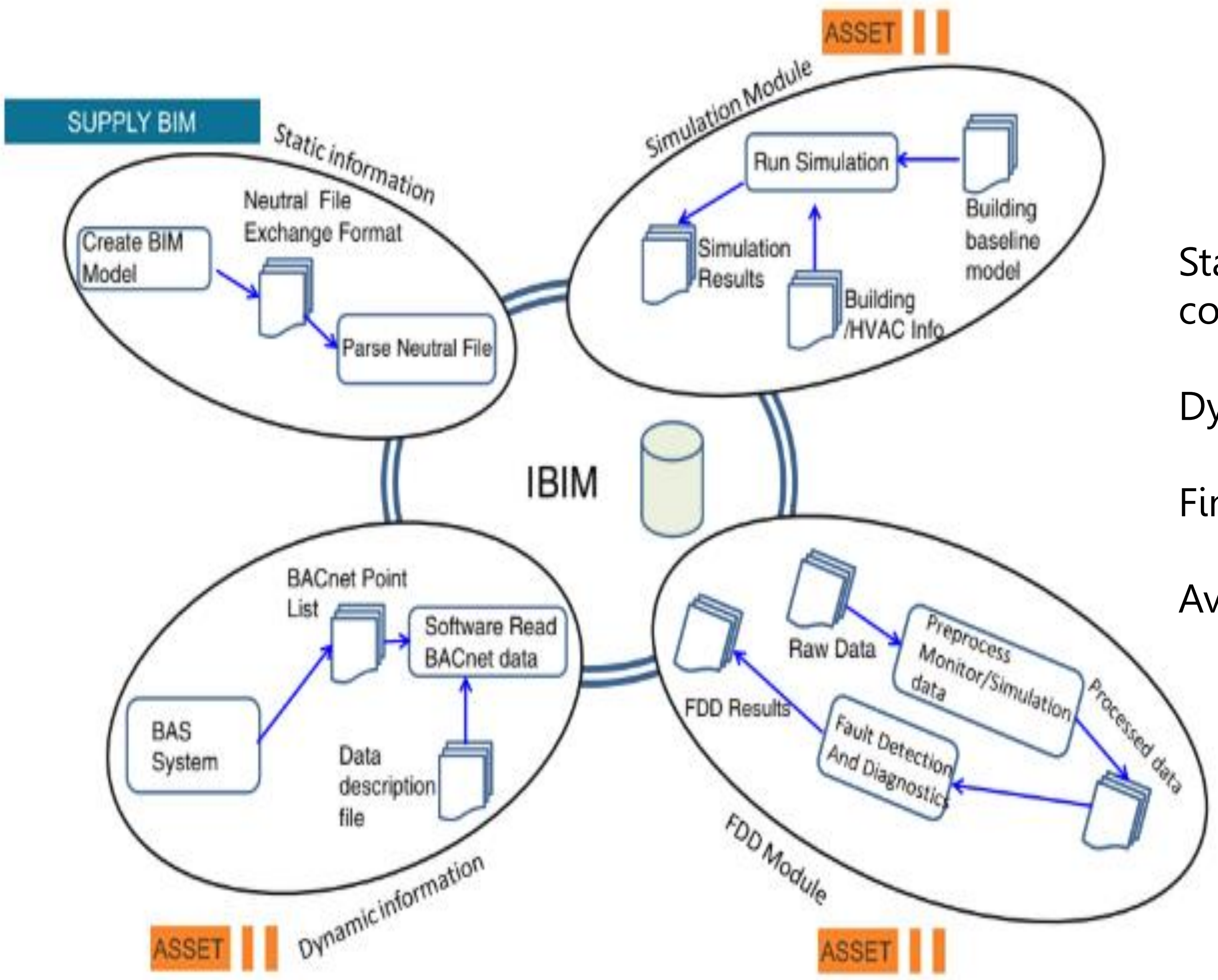



## AI Cloud Platform

## Patenting AFDD

| Chiller faults | 1 |
|---|---|
| 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 | × |

# iBIM (integrated building information modeling)




Static data include: commissioning data conditions and design data

Dynamic Data – BAS (BAS control sequence)

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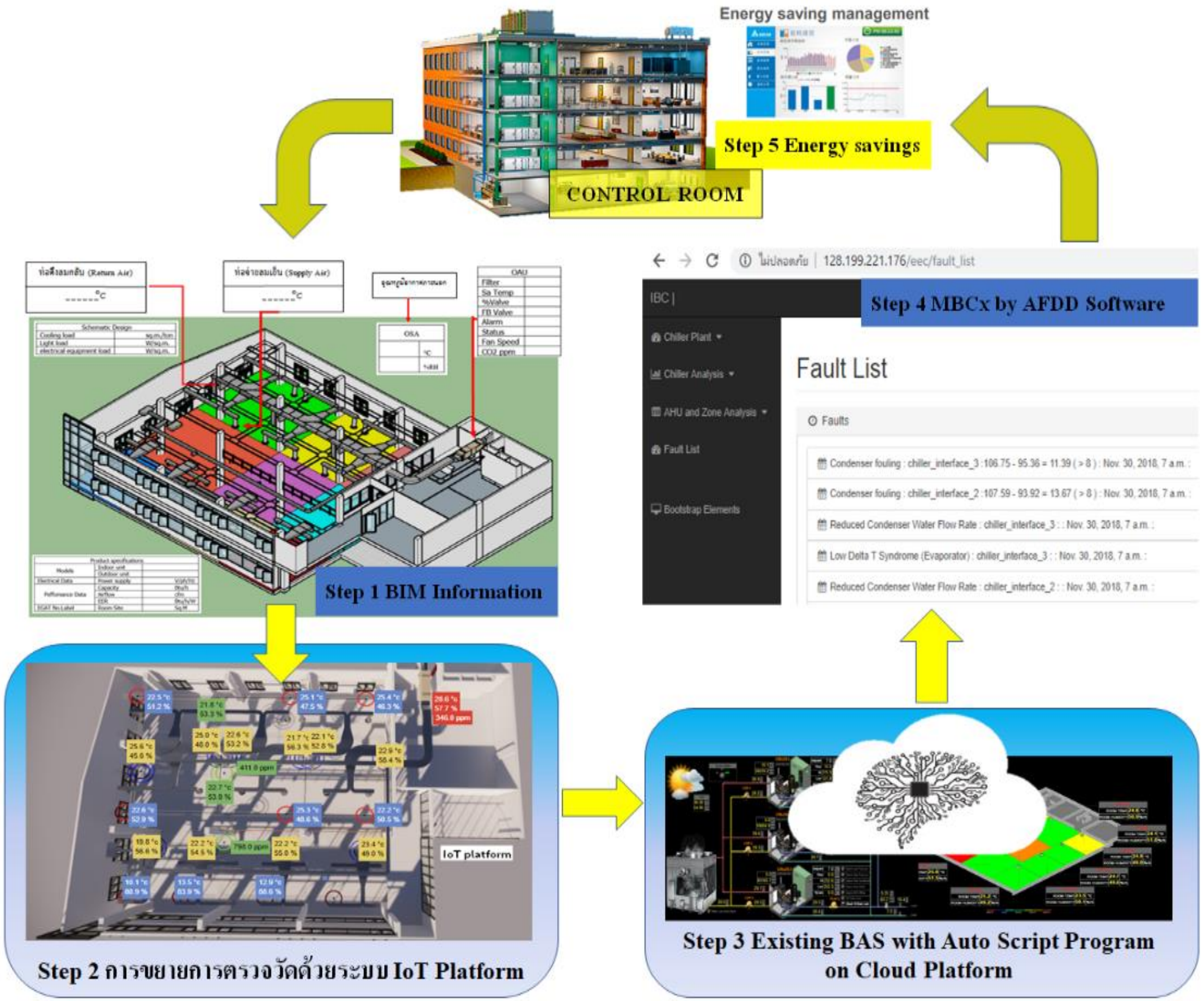
Available static data are used for FM

# iBIM (integrated building information modeling)




## All required Data for AI Command center

Building life cycle – AC system information

BAS Data

IoT Data

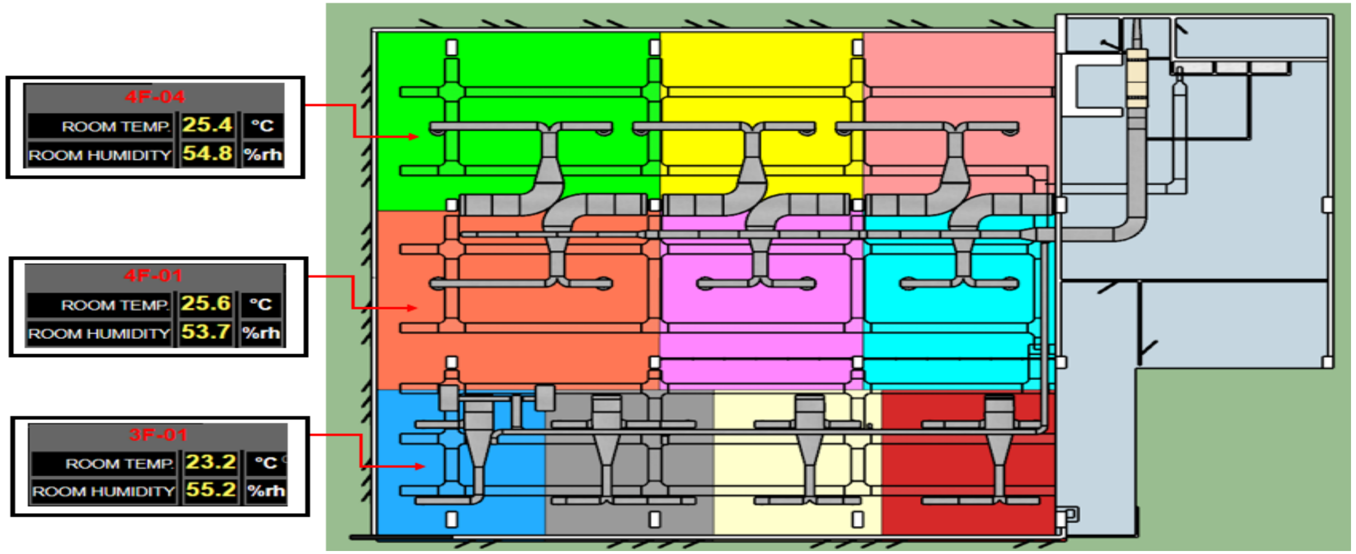
Integrated data via AI

AI decision on Cloud Platform

Feedback information to FM

# iBIM (integrated building information modeling) – Step 1

อุณหภูมิโซน คือ อุณหภูมิและความชื้นที่วัดได้จากโซนนั้นๆ




| UNIT NUMBER | | | | 3F-01 | 3F-02 | 3F-03 | 3F-04 |
|---|---|---|---|---|---|---|---|
| AREA SERVED | | | | สำนักงาน | สำนักงาน | สำนักงาน | สำนักงาน |
| QUANTITY | | | SET (S) | 1 | 1 | 1 | 1 |
| AHU/FCU TYPE | | | | CC | CC | CC | CC |
| DESIGN ROOM CONDITION | | | °CDB/ % RH | 24/55 | 24/55 | 24/55 | 24/55 |
| | TOTAL CAPACITY | | KW | 4.2 | 8.8 | 8.8 | 8.8 |
| | SENSIBLE CAPACITY | | KW | 3.8 | 7.9 | 7.9 | 7.9 |
| | SUPPLY AIR | | L/s | 260 | 550 | 550 | 550 |
| | OUTDOOR AIR | | L/s | | | | |
| | DRAIN PIPE SIZE | | Ø mm | 20 | 25 | 25 | 25 |
| | COOLING COIL COND. | ENT.WATER TEMPT | °C | 7.2 | 7.2 | 7.2 | 7.2 |
| | | LEAV.WATER TEMPT | °C | 12.8 | 12.8 | 12.8 | 12.8 |
| | | ENT.AIR TEMPT. | °CDB/°CWB | 24.6/16.9 | 24.6/16.9 | 24.6/16.9 | 24.6/16.9 |
| | | LEAV.AIR TEMPT | °CDB/°CWB | 12.5/11.8 | 12.5/11.8 | 12.5/11.8 | 12.5/11.8 |

## ข้อมูลที่รวบรวมโดยผู้ออกแบบ สำหรับการดำเนินการ commissioning

ยกตัวอย่าง

3F-02 – Design conditions

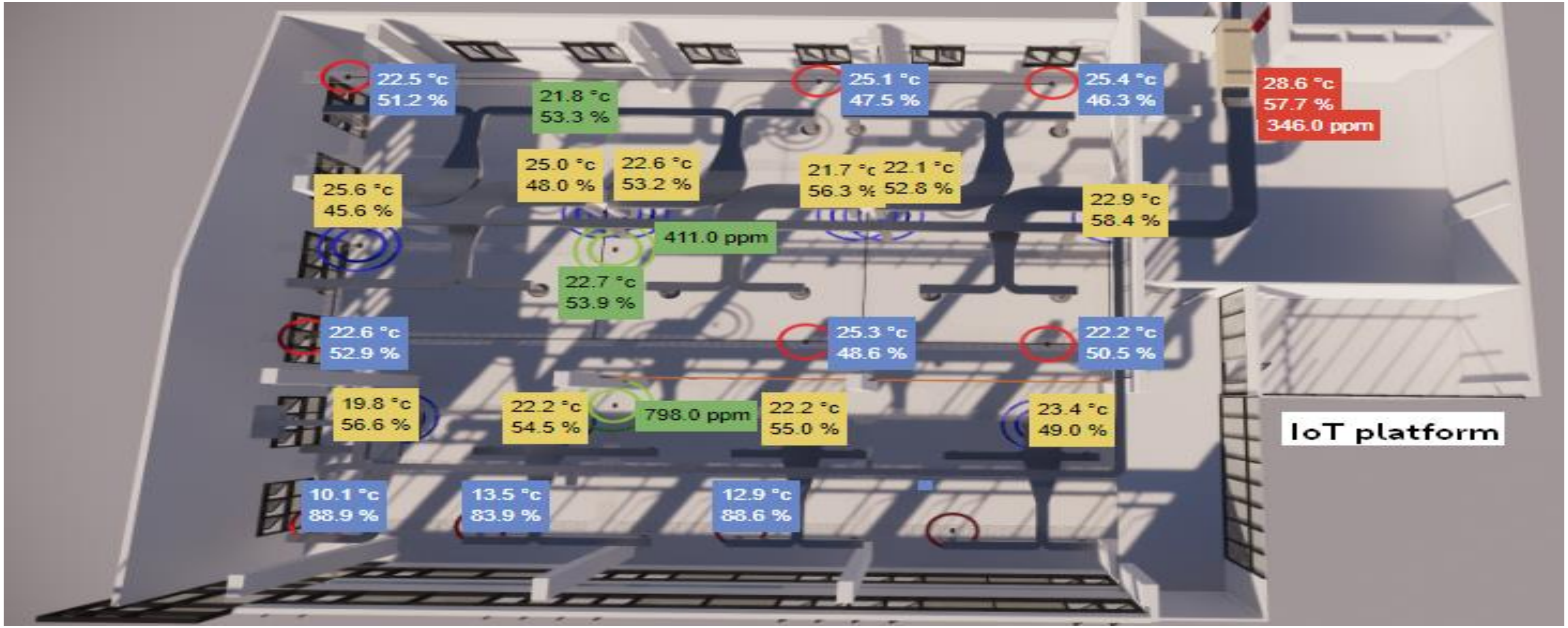
Zone conditions (24 C/55%)

Supply air (1165 CFM/550 L/s) – Sensible 7.9 kW

Chilled water – 7.2 C/12.8 (CQ1 = 5.6 C)

Supply T (12.5 C) & Return T (24.6 C)

# iBIM (integrated building information modeling) – Step 2




3F-02 – Design conditions for Zone conditions (24 C/55%), Cx วัดที่ตำแหน่ง FCU return, BAS zone = 24 C/55%

Supply air (1165 CFM/550 L/s) – วัดลม errors – sensible load 7.9 kW * 3412 = CFM*1.8*(22.2 – 13.5), CFM = 1721 CFM from design 1165 CFM, ตรวจสอบ cooling coil valve or cooling flighting from adjacent zones

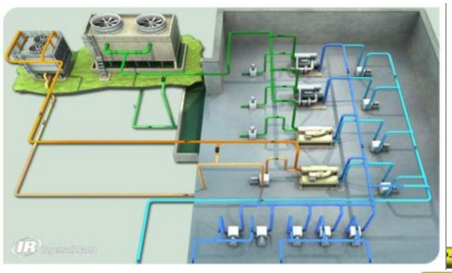
Supply T (12.5 C) & Return T (24.6 C) – return temperature – supply temperature = 8.7 C

Chilled water – 7.2 C/12.8 (CQ1 = 5.6 C), too low water supply temperature or too less cooling coil valve

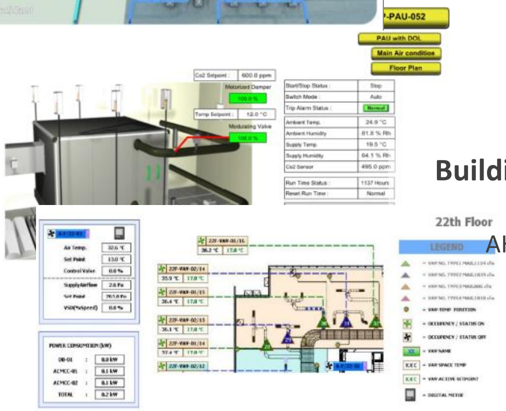
# iBIM (integrated building information modeling) – Step 2

3F-02 – Design conditions for Zone conditions (24 C/55%), Cx วัดที่ตำแหน่ง FCU return, BAS zone = 24 C/55%

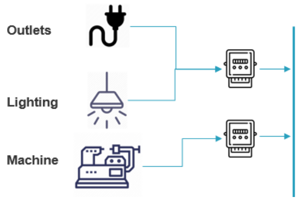
Sensible load 7.9 kW * 3412 = CFM*1.8*(22.2 – 13.5), CFM = 1721 CFM from design 1165 CFM



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




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




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


T, RH and *$CO_2$ Sensors

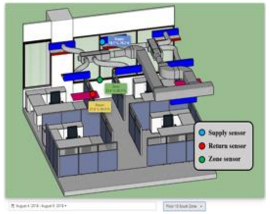
Receiver and logger

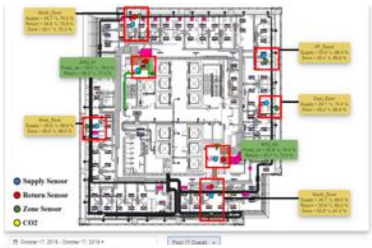
**Network IoT sensors**
Thermal & Zone parameters

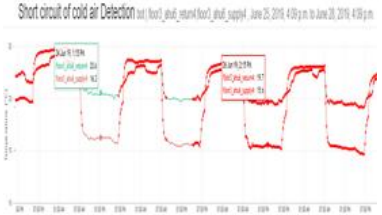
## Automated Data Integration and Diagnostics

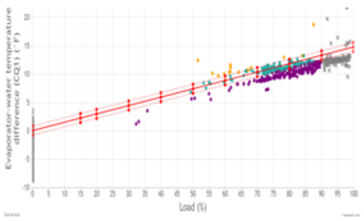
**EMIS – energy management information system**

**Online analytics and dashboard portal**




Source: IBC – TIE Smart Solutions

# iBIM (integrated building information modeling) – Step 4 AFDD

**Normal Checking Operator Control**

**Check Step 1**

Set-points based Load vs. Tevo

Other operations beyond the set-points (abnormal) on Load vs. Tevo

**Check Step 2**

Identify the same rangers on Load vs. CQ1 (evaporator)

**Check Step 3**

Condensing stage operations (Tcdi and Tcdo) at 100% design for cooling tower operations

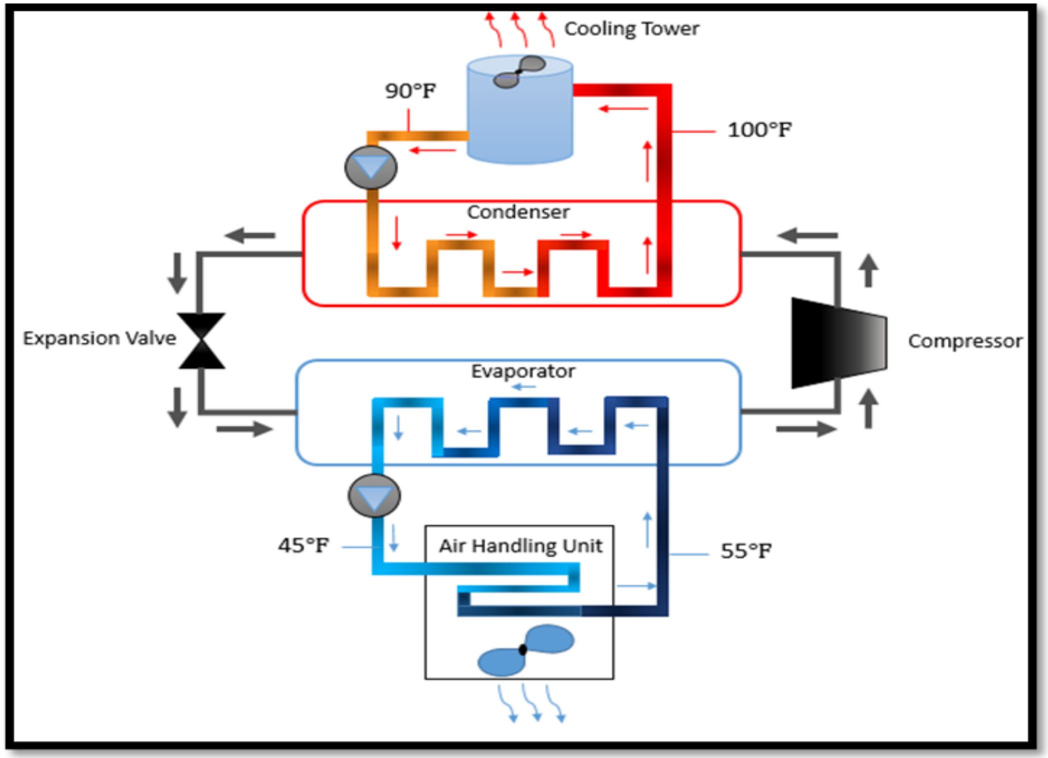
Condensing stage operations (Tcdi) due to Tevo set-points leading

**Check Step 4**

Identify the same rangers on Load vs. CQ2 (condenser)

**Check Step 5**

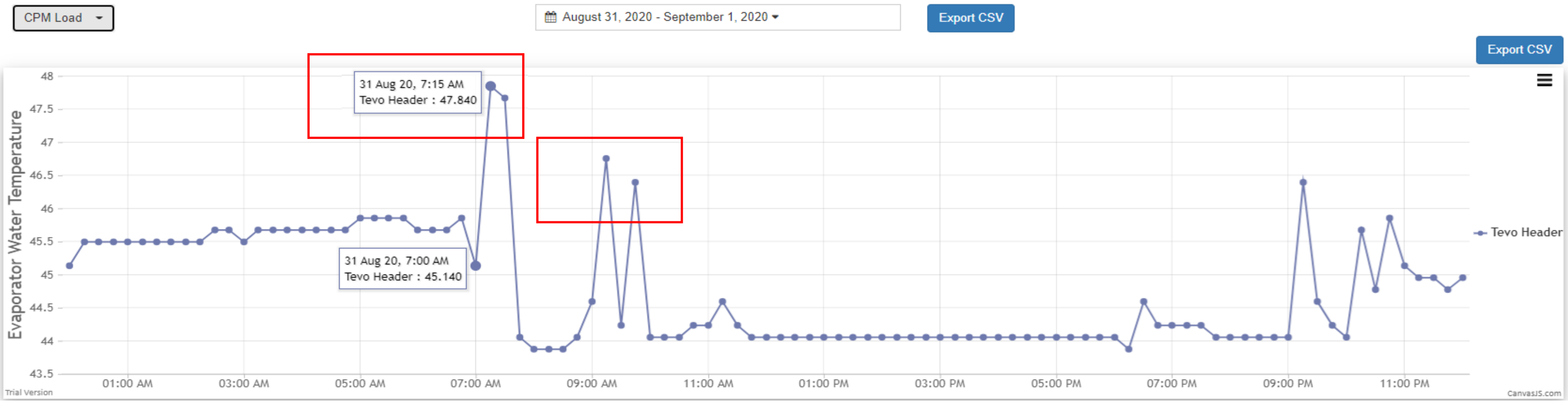
Check CQ6 – approach temperature at 80% and check kW



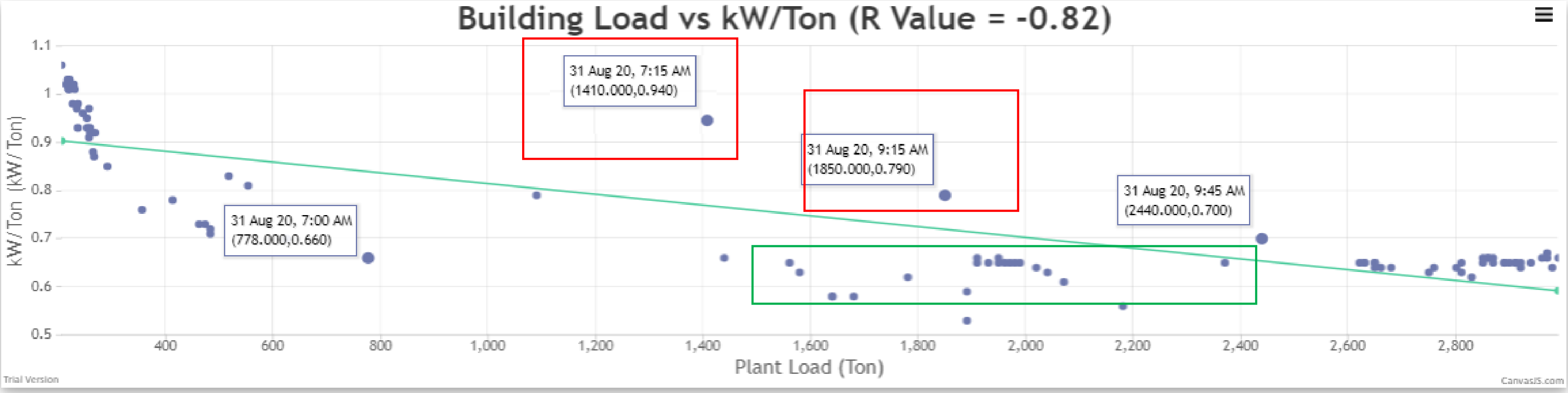

การพัฒนากระบวนการและแนวทางการสร้างมาตรฐานการใช้งานระบบอาคารอัตโนมัติสำหรับการประหยัดพลังงานระบบปรับอากาศและระบายอากาศ ด้วย EMIS tool – ระยะที่ 1

Source: IBC – TIE Smart Solutions

# iBIM (integrated building information modeling) – Step 5 Savings




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




Overall performance versus plant load

Source: IBC – TIE Smart Solutions

# THANKS
# FOR WACTHING

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