วิศวกรรมแห่งชาติ 2564
National Engineering 2021

BIM IFC - FM services in HVAC operations

โดย ผศ. ดร. เด่นชัย วรเดชจำเริญ
กรรมการร่างมาตรฐาน

BIM LAB by EIT

SMART ENGINEERING AND INNOVATION FOR SOCIETY

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)

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

-CEO - บริษัท ทีไออี สมาร์ทโซลูชั่น จำกัด

Deeptech startup ภายใต้การสนับสนุนของ กรมส่งเสริมอุตสาหกรรม กระทรวงอุตสาหกรรม

BIM backgrounds

www.acat.or.th

บทความเชิงวิชาการ | ACAT

การพัฒนาแบบจำลองสารสนเทศอาคารแบบผสมผสานเพื่องานทดสอบเครื่องแฟนคอยล์ยูนิตแบบต่อเนื่อง

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

ผู้ช่วยศาสตราจารย์ ดร. เด่นชัย วรเดชจำเริญ
และ ดร. พุฑฒิพงษ์ มหาสุคนธ์

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

สมาคมวิศวกรเครื่องกลไทย
Thai Society of Mechanical Engineers

ISSUE #03
AUGUST 2021

การใช้ประโยชน์ BIM (Building Information Modeling) สำหรับอาคารอัจฉริยะ (Smart Buildings) ในประเทศไทย

เรียบเรียงโดย
ผศ.ดร.เด่นชัย วรเดชจำเริญ
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หน่วยวิจัยความร่วมมืออาคารอัจฉริยะ
คณะวิศวกรรมศาสตร์
มหาวิทยาลัยศรีปทุม
จังหวัดกรุงเทพมหานคร

รูปที่ 1 BIM process (engineering today, 2019)

BIM และความเข้าใจปัจจุบัน

การใช้ประโยชน์ BIM (Building Information Modeling) สำหรับอาคารอัจฉริยะ (Smart Buildings) ในประเทศไทย

BIM research (use?)

BIM LAB by FIT

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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

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 ft², 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

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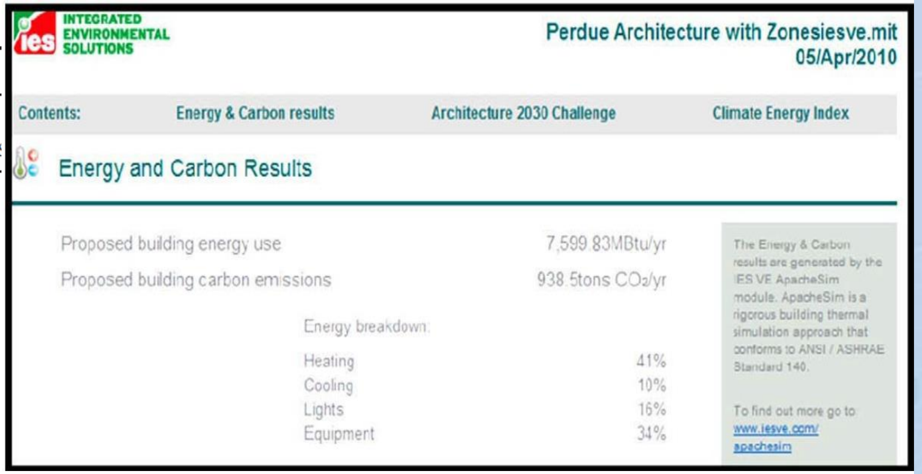
BIM research (green buildings)

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 analys
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.

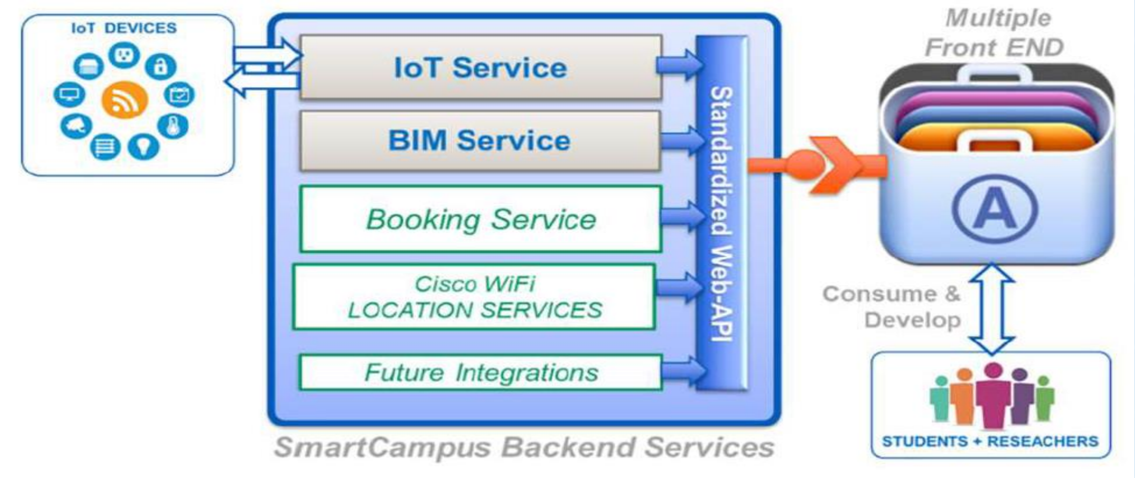


LEED® credits that can be documented using results of BIM software.

LEED credit	Credit description	LEED® points	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)
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 research – IoT and FM

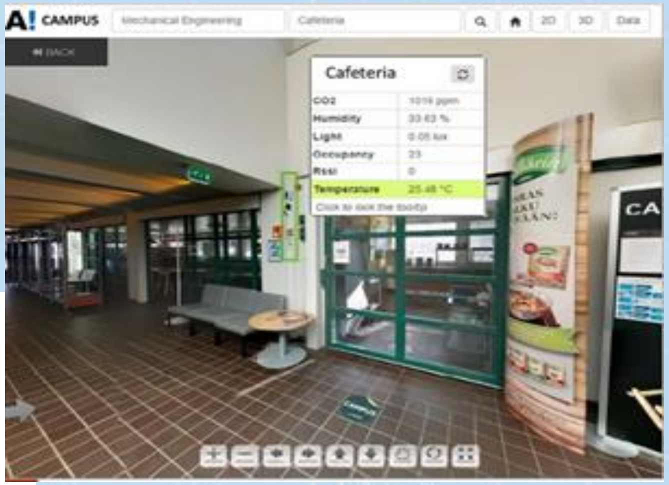


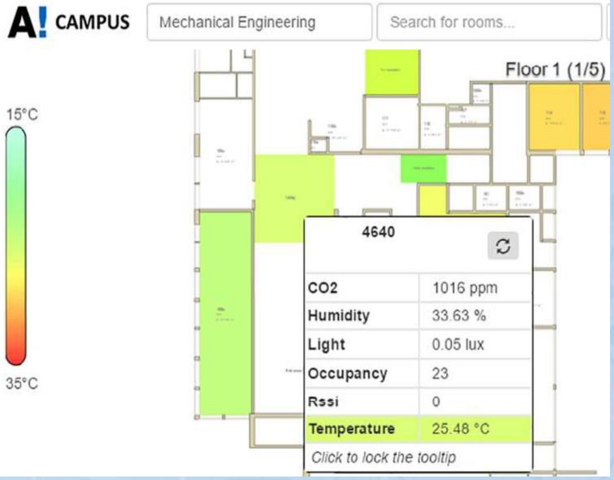
Automation in Construction 110 (2020) 103049

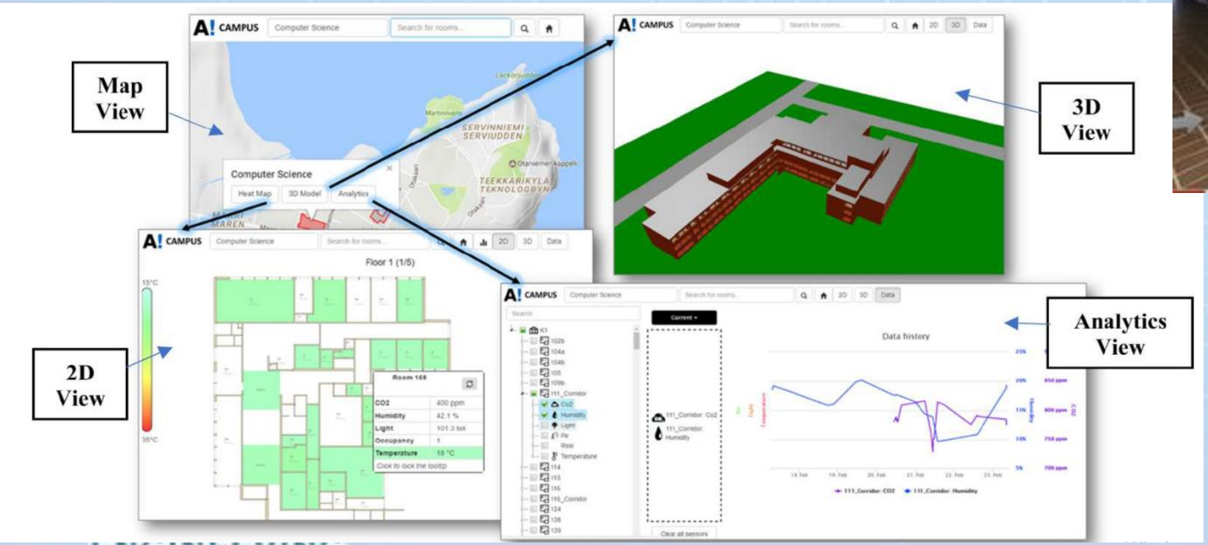
BIM assisted Building Automation System information exchange using BACnet and IFC

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

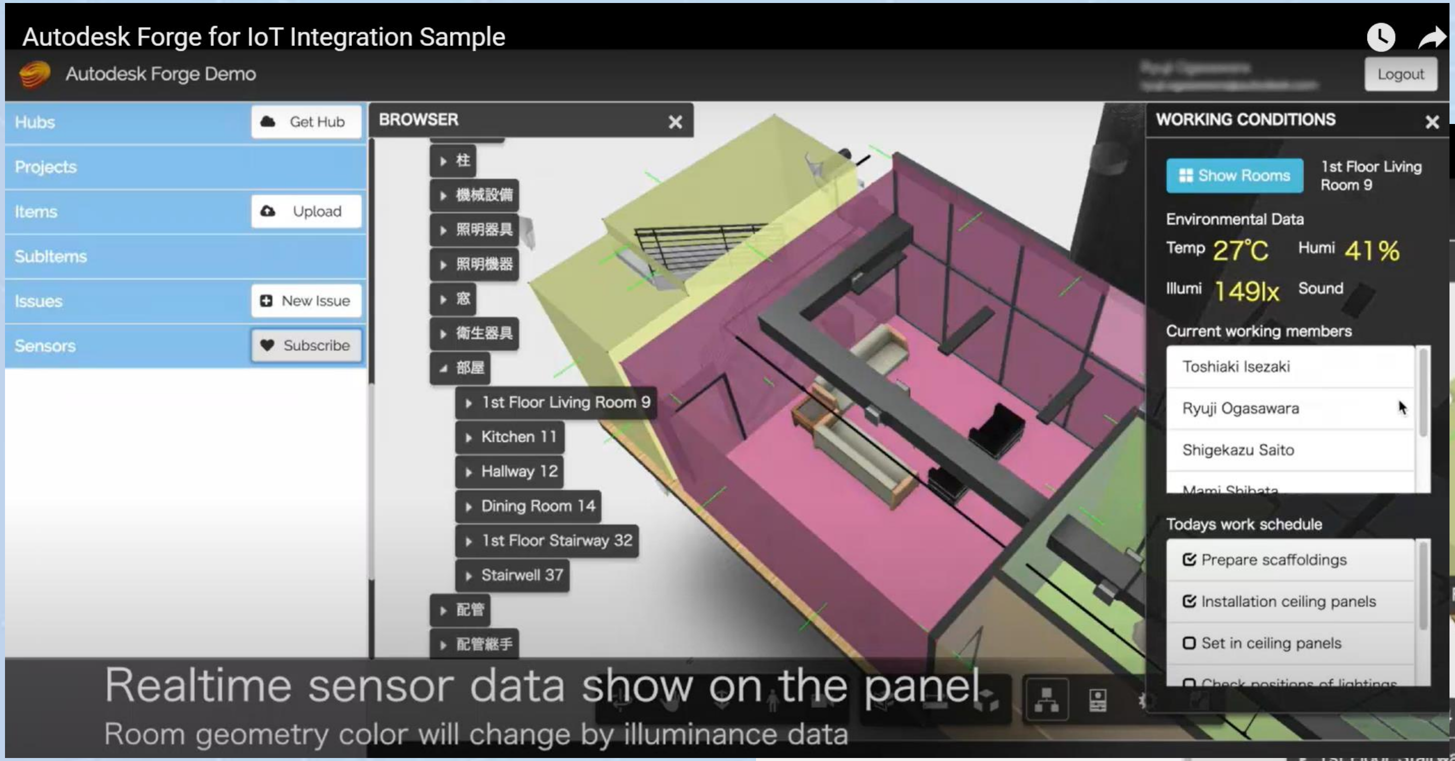


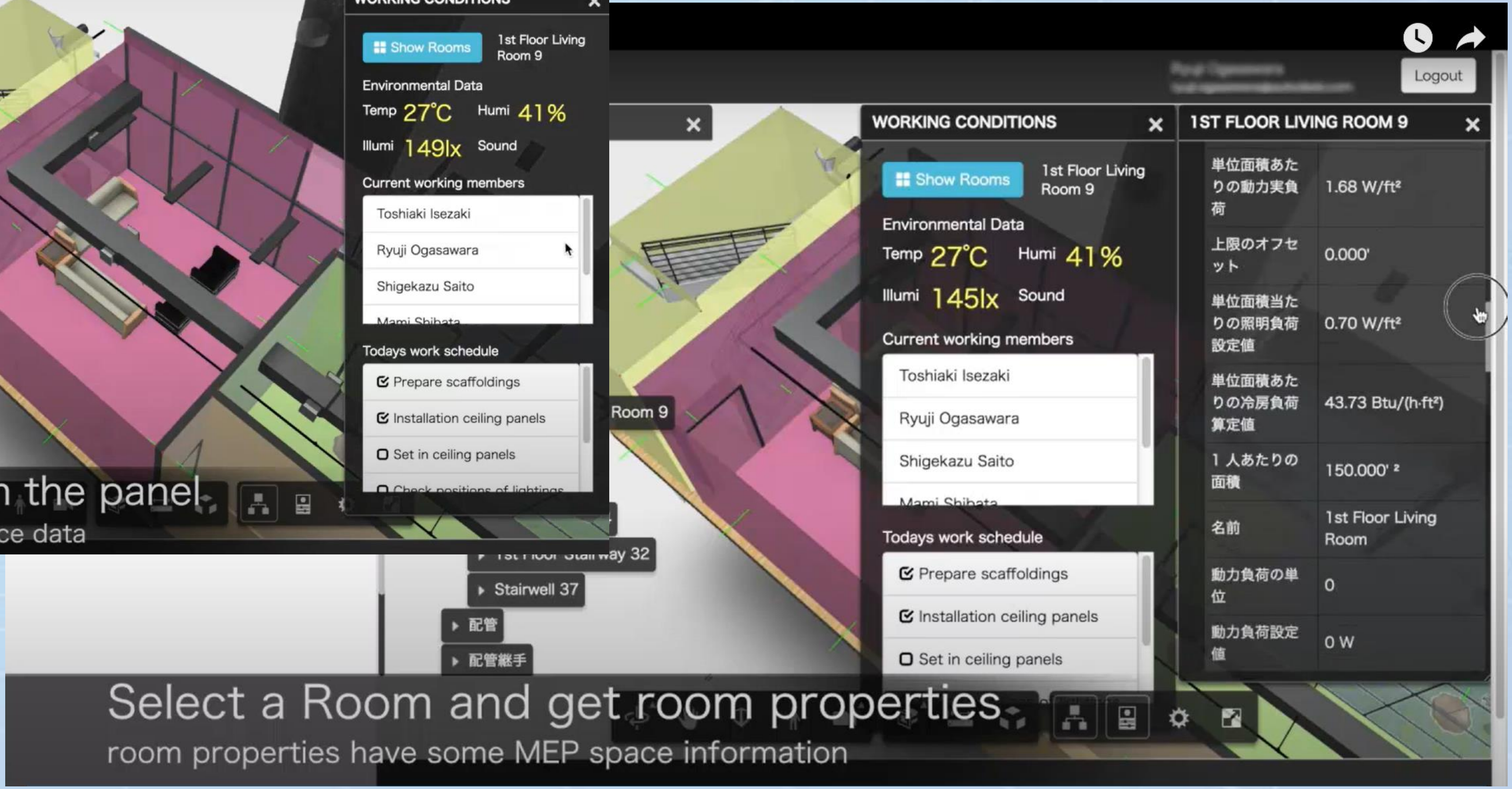




7D BIM service for BMS GUI

7DBIM on Autodesk Forge





BIM research

iBIM definition and use

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?

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

Data?

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BIM research – Fault diagnostics

วิศวกรรมแห่งชาติ 2564
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B. Dong et al. / Automation in Construction 44 (2014) 197–211

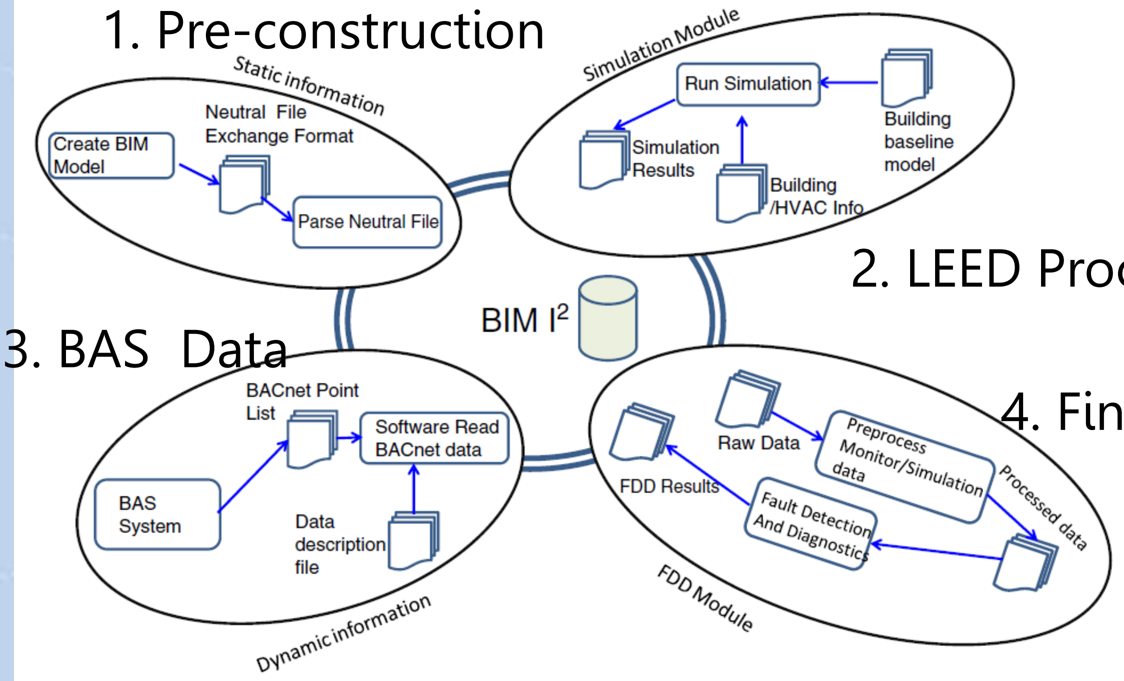
1. Pre-construction

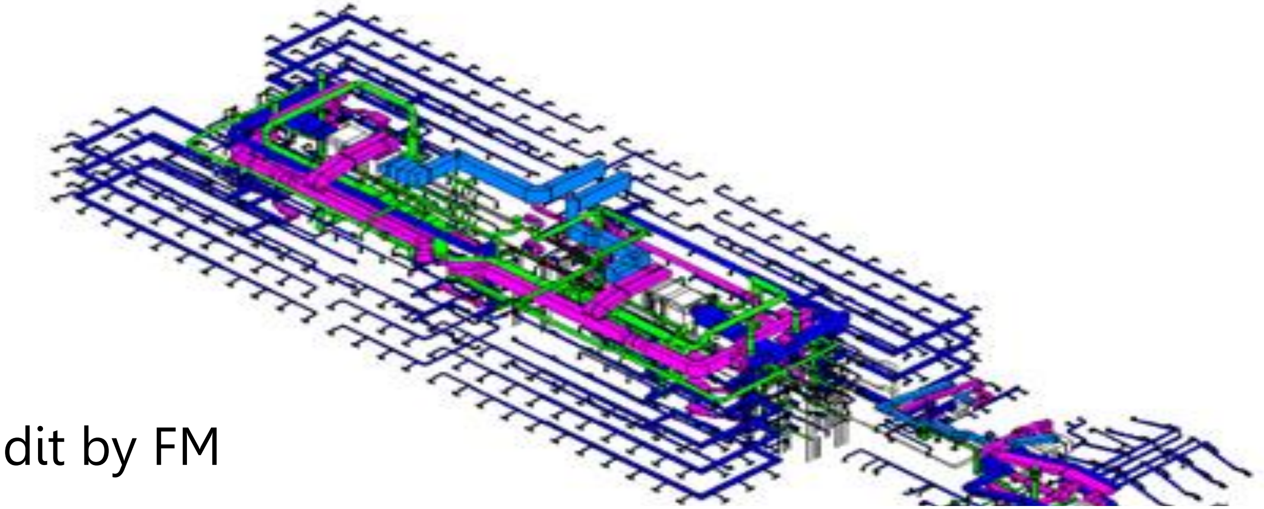
2. LEED Process

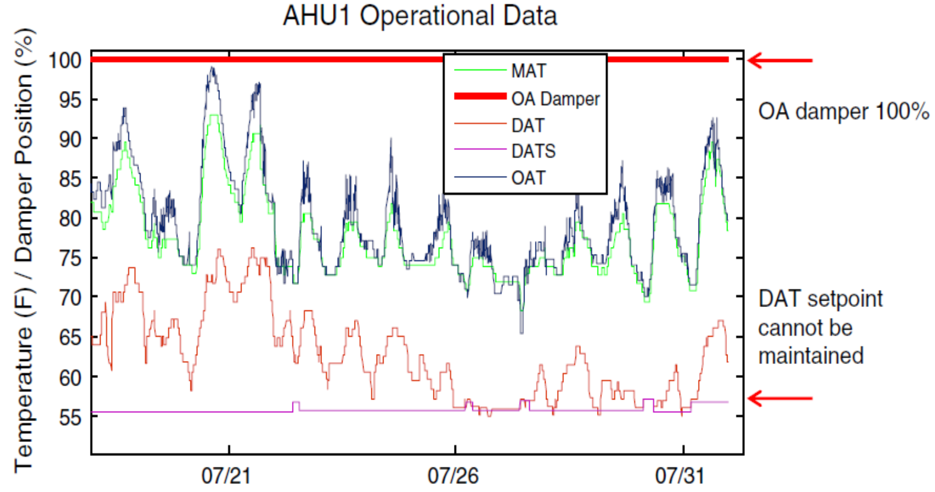
3. BAS Data

4. Final audit by FM

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

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Data from international guide

3 BIM DELIVERABLES

- Site model
- Massing model
- Architectural, structural, MEP models
  - For regulatory submissions
  - For coordination and / or clash detection analysis
  - For visualization
  - For cost estimation
- Schedule (material, time etc) and phasing program (in BIM or spreadsheet)
- Construction and fabrication models
- Shopdrawings
- As-built model (in native proprietary or open formats)
- Data for facility management
- Other additional value-added BIM services

Table 5: Example of a BIM Project Collaboration Map

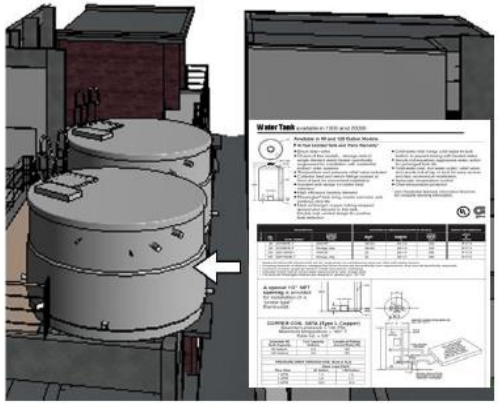
	Employer	Architect	Consulting Engineers	Contractor / Quantity Surveyor
Conceptual Design	Provide requirements related to form, function, cost and schedule	Begin design intent model with massing concepts with site considerations	Provide feedback on initial building performance goals and requirements	Provide feedback on initial building cost, schedule, and constructability *
Schematic Design	Provide design review and to further refine design requirements	Refine Design Model with new input from Employer, Consulting Engineers, and Construction Manager	Provide schematic modelling, analysis and system iterations as Design Model continues to develop	Provide design review and continued feedback on cost, schedule and constructability *
Detailed Design	Design reviews. Final approval of project design and metrics	Continue to refine Design Model. Introduce consultants models and perform model coordination	Create Discipline-specific Design Models and Analyses	Create Construction Model for simulation, coordination, estimates, and schedule *
		Finalize Design model, Tender Documents and Specifications, Regulatory Code Compliance	Finalize Discipline specific Design Models, Tender Documents and Specifications, Code Compliance	Enhance Construction Model and perform final estimate & construction schedule, Manage bid process
Construction	Monitor construction and give input to construction changes and issue	Respond to construction RFI's Perform contract administration, update Design Model with changes	Respond to construction RFI's and update Discipline specific Design Models, field conditions, and commissioning	Manage construction with subcontractors and suppliers, inform changes to Design Model
As-Built		Verify As-built model	Verify As-built model	Prepare As-built model
Facility Management	Engage Architect and Facilities Group for handing over	Coordinate information exchange through model to Facilities Group	Prepare handover documentation	

- **สอบทวน international guide – Data or information**
- **SG – Information transfer guide (Data to FM)**

Coding and Utilization

การจัดและประเมินข้อมูล - FM

Facility Management • O & M	1:50	BIM element is modelled as an actual constructed building component or system and is an as-built representation of the actual completed building.



Water storage tank element with attached specification PDF (Source: HDB)

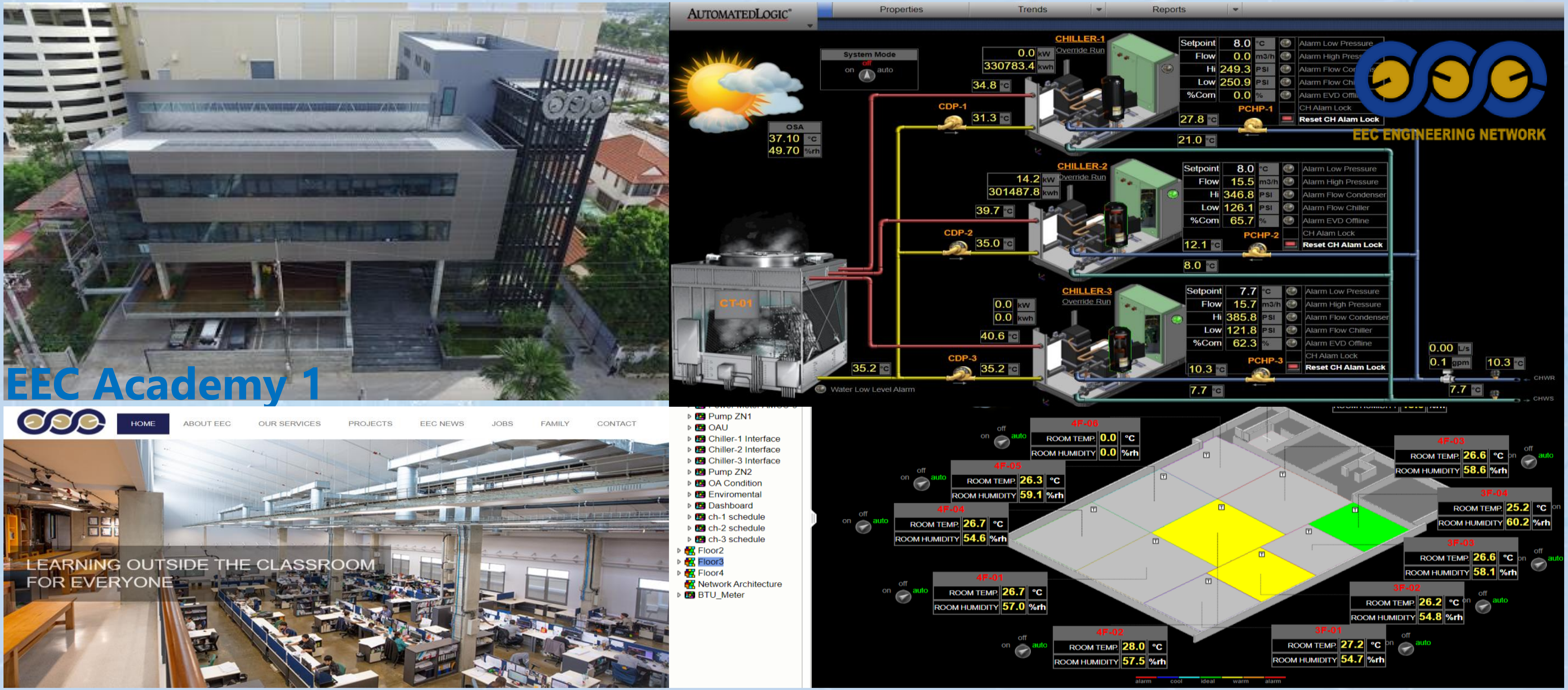
- **SG – Data to FM (O&M)**
- **Survey and synthesis FM information (pdf based and ACMV guide)**

(IV) ACMV BIM ELEMENTS

	Element	Elements or Parameters needed by each non-ACMV discipline
ACMV Equipment	Air Handling unit	
	Chiller unit	
	Variable refrigerant unit	
	Cooling Tower	
	Split-type indoor & outdoor air conditioning units	
	Exhaust or extract air fans	
	Fresh air fans	
	Other fans such as jet fans	
	Heat Exchanges for projects with District Cooling	
ACMV Distribution	Exhaust air ducts (excluding hangars)	
	Fresh air ducts (excluding hangars)	
	Supply air ducts (excluding hangars)	
	Return air ducts (excluding hangars)	
	Transfer air ducts (excluding hangars)	
	Diffusers, air-boots, air grilles, air filters, registers	
	Fire dampers, motorized dampers, volume control dampers, CO_2 sensors, CO sensors	

- **Find out ACMV and SN guide for FM users**
- **Non-standardized elements in Thailand**

แบบจำลอง data information ต้นแบบ



Chiller plant manager (CPM) and building automation system (BAS) with design information

แบบจำลอง data information ต้นแบบ

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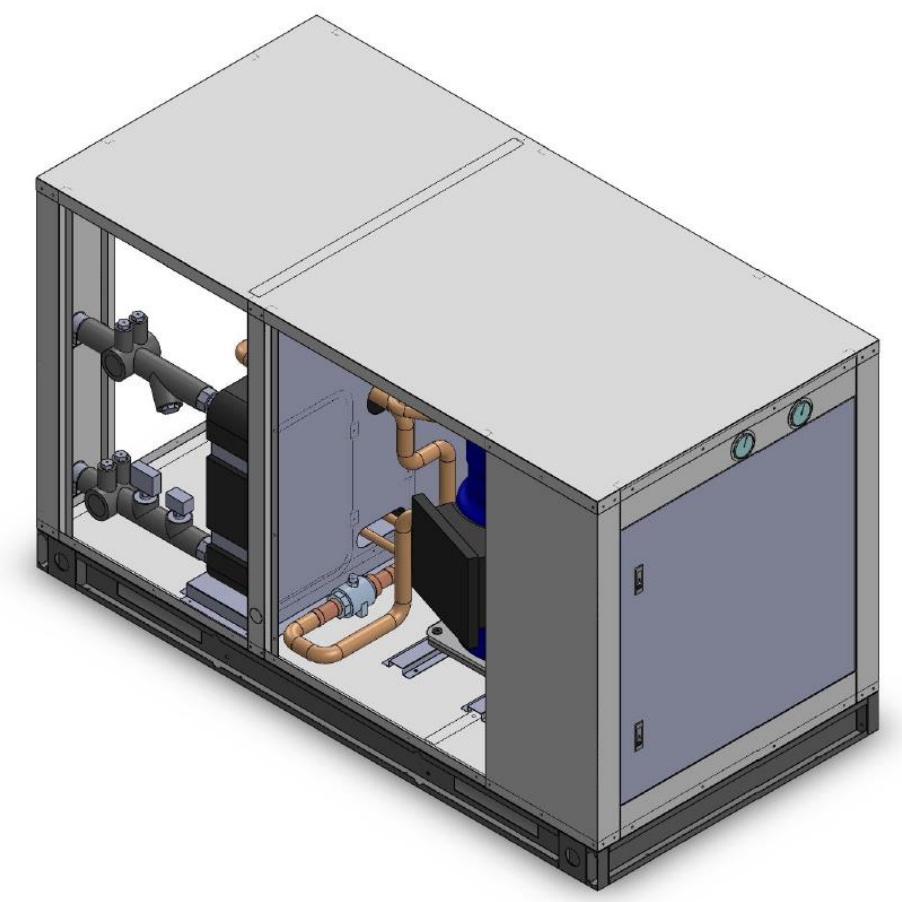

CHILLER	ตัวแปร ระบบ BAS	Required Performances	ข้อมูลทางเทคนิค	Unit
Capacity		24	24 / unit	RT
Power Supply		380 / 3 / 50	380 / 3 / 50	V / Ø / Hz
Power Consumption	Power Input	16.8	19.005	kW
Type of Compressor		Digital Scroll	Hermetic (Scroll DC Inverter)	-
HPS / Setting (Auto)	Discharge Pressure	-	440	psig
LPS / Setting (Auto)	Suction Pressure	-	130	psig
Chilled Water Flow Rate		3.63	57.6 (3.63)	gpm (L/s)
Chiller Supply Water Temperature	Tevo	45	45 (7.22)	°F (°C)
Chiller Return Water Temperature	Tevi	55	55 (12.78)	°F (°C)
Chilled Water Pressure Drop		24	23.04	kPa
Condenser Water Flow Rate		5.20	72 (4.54)	gpm (L/s)
Condenser Water Supply Temperature	Tcdo	100 (37.78)	100 (37.78)	°F (°C)
Condenser Water Return Temperature	Tcdi	90 (32.22)	90 (32.22)	°F (°C)
Condenser Water Pressure Drop		48	48.15	kPa

Chiller plant manager (CPM) and building automation system (BAS) with design information

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แบบจำลอง data information ต้นแบบ

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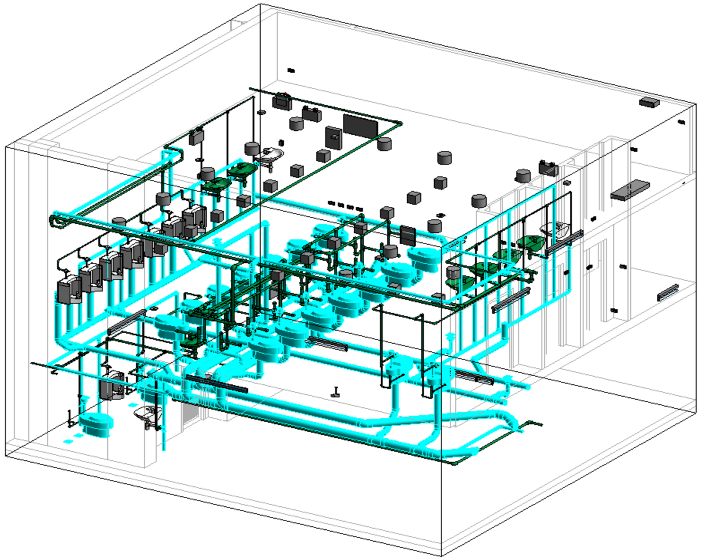
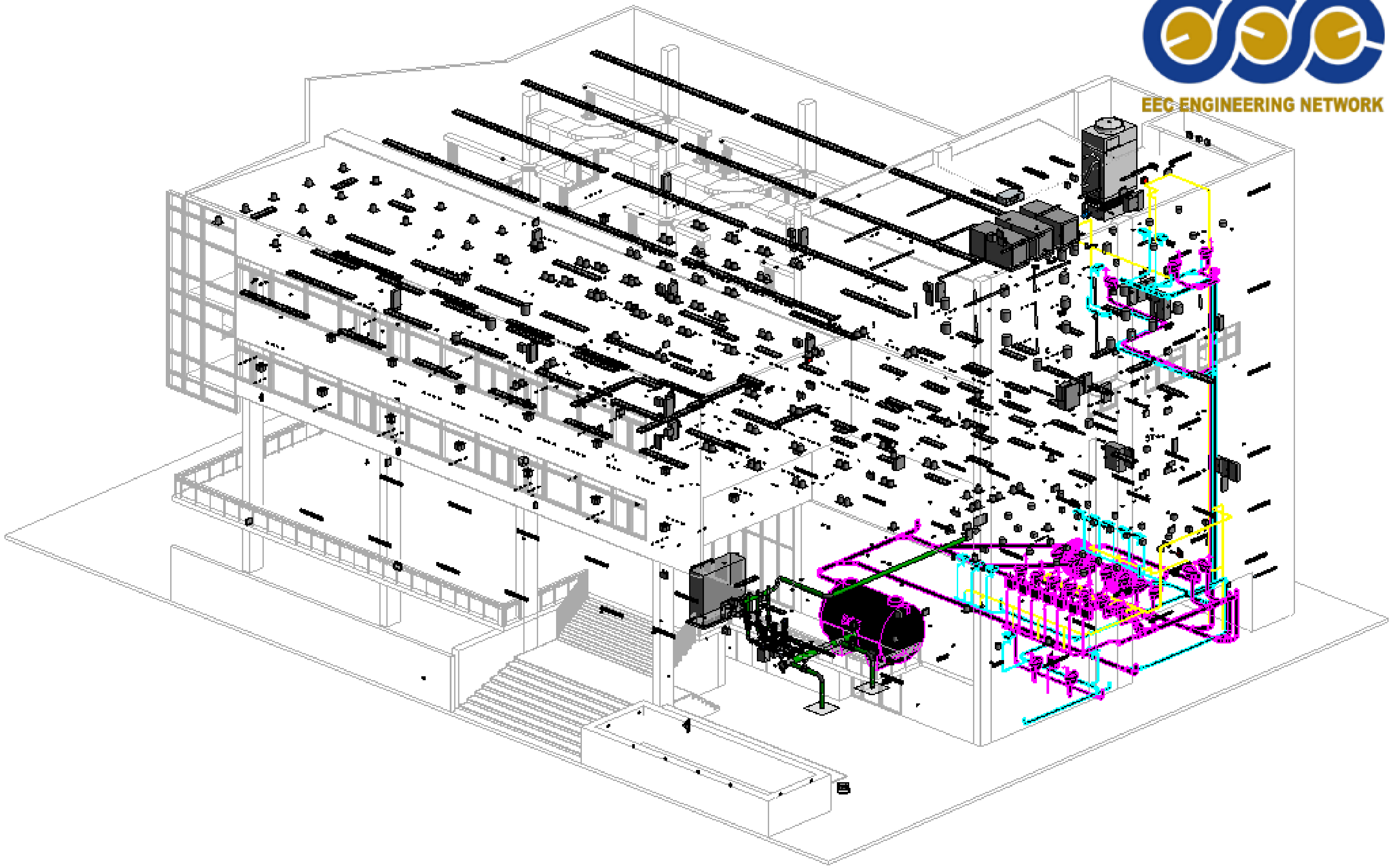


SPU
SRIPATUM UNIVERSITY

IBC
Intelligent Building Collaboration
School of Engineering @ SPU

TIE



EEC ENGINEERING NETWORK

SMART ENGINEERING AND INNOVATION FOR SOCIETY

ปัญหาในการดำเนินการ

23.75.00.00 CLIMATE CONTROL (HVAC)

23.75.10.00 Transformation and Conversion of Energy

23.75.10.11 Central Heat Generators

- 23.75.10.11.14 Hot Water Heat Generators
- 23.75.10.11.14.11 Cast-Iron Boilers
- 23.75.10.11.14.14 Condensing Boilers
- 23.75.10.11.14.17 Finned Water-Tube Boilers
- 23.75.10.11.14.21 Firebox Heating Boilers
- 23.75.10.11.14.24 Flexible Water-Tube Boilers
- 23.75.10.11.14.27 Pulse Combustion Boilers

23.75.35.00 Impelling Equipment

23.75.35.14 Air Handling Units

- 23.75.35.14.11 Built-Up Indoor Air Handling Units
- 23.75.35.14.14 Customized Rooftop Air Handling Units
- 23.75.35.14.17 Modular Indoor Air Handling Units
- 23.75.35.14.21 Modular Rooftop Air Handling Units

23.75.35.17 Fans

- 23.75.35.17.11 Fans for Air Ductwork
- 23.75.35.17.14 Fans, Single Units
- 23.75.35.17.17 Room Air Circulation Fans
- 23.75.35.17.17.11 Ceiling Fans
- 23.75.35.17.21 Air Curtains
- 23.75.35.17.24 Axial Fans
- 23.75.35.17.27 Centrifugal Fans

23.75.65.00 Monitoring and Control Equipment

23.75.65.11 Monitoring and Control of Internal Climate

- 23.75.65.11.11 Heating Controllers
- 23.75.65.11.14 Heating Programmers
- 23.75.65.11.17 Heating Optimizers/Economizers

23.75.65.14 Industrial Plant Performance Controls

- 23.75.65.14.14 Centralized Plant Controls
- 23.75.65.14.14.11 Temperature Controls
- 23.75.65.14.14.14 Pressure Controls
- 23.75.65.14.14.17 Flow Controls
- 23.75.65.14.14.21 Concentration Controls
- 23.75.65.14.17 Control and Monitoring Boards/Panels

IFC2x3 – text format

IFC4x. – API and Web information for 7D BIM

Omniclass requirement (Table 23, HVAC System 75)

BIM information exchanger

ACMV BIM ELEMENTS		
	Element	Ifc Element
ACMV Equipment	Air Handling unit	IfcEvaporativeCoolerType
	Chiller unit	IfcChillerType
	Variable refrigerant unit	IfcAirTerminalType
	Cooling Tower	IfcCoolingTowerType
	Split-type indoor & outdoor air conditioning units	IfcAirTerminalBoxType
	Exhaust or extract air fans	IfcFanType
	Fresh air fans	
	Other fans such as jet fans	
	Heat Exchanges for projects with District Cooling	IfcHeatExchangerType
ACMV Distribution	Exhaust air ducts (excluding hangars)	IfcDuctFittingType IfcDuctSegmentType IfcDuctSilencerType
	Fresh air ducts (excluding hangars)	
	Supply air ducts (excluding hangars)	
	Return air ducts (excluding hangars)	
	Transfer air ducts (excluding hangars)	
	Diffusers, air-boots, air grilles, air filters, registers	IfcFilterType
	Fire dampers, motorized dampers, volume control dampers, CO2 sensors, CO sensors	IfcDamperType

1. **Data exchange format – กำหนดอย่างไร**
2. **Designer information**
3. **Material approval**
4. **FM data (material approval)**
5. **Static data (commissioning record and design)**
6. **Dynamic data (BAS and CPM data) – IFC4**

IFC data format – with property

Catalog

Position	Qty.	Description	Single Price
	1	TP 50-190/4 A-F-B-BAQE	

Note! Product picture may differ from actual product

Product No.: 96087291

Single-stage, close-coupled, volute pump with in-line suction and discharge ports of identical diameter. The pump is of the top-pull-out design, i.e. the power head (motor, pump head and impeller) can be removed for maintenance or service while the pump housing remains in the pipework.

The pump is fitted with an unbalanced rubber bellows seal. The shaft seal is according to EN 12756. Pipework connection is via PN 16 DIN flanges (EN 1092-2 and ISO 7005-2).

The pump is fitted with a fan-cooled asynchronous motor.

Further product details

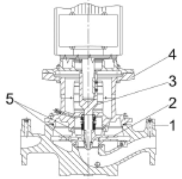
The product carries the Grundfos Blueflux® label. It represents the best from Grundfos within energy-efficient motors and frequency converters. Grundfos Blueflux® solutions either meet or exceed legislative requirements such as the EuP IE3 or IE4 grade.

The product's minimum efficiency index (MEI) is greater or equal to 0.70. This is by the Commission Regulation (EU) considered as an indicative benchmark for best-performing water pump available on the market as from 1 January 2013.

Pump

Pump housing and pump head are electrocoated to improve the corrosion resistance.

Electrocoating includes:
1) Alkaline-based cleaning.
2) Pretreatment with zinc phosphate coating.
3) Cathodic electrocoating (epoxy).
4) Curing of paint film at 200-250 °C.



1: Pump housing
2: Impeller
3: Stub shaft
4: Pump head/motor stool
5: Wear rings

BIM

Family Types

Type name: CM 50-1420 T

Search parameters

Parameter	Value	Formula	Lock
Constraints			
IFC Parameters			
IfcExportAs	IfcPumpType	=	
Data			
ENCLOSURE CLASS (IEC	55 (Protect. water jets/d	=	
MOTOR EFFICENCY AT	87.6-85.6%	=	
MOTOR EFFICENCY AT	87.7-87.2%	=	
MOTOR EFFICENCY AT	86.7%	=	
PUMPED liquid	Water	=	
LIQUID TEMPERATURE	120.00 °C	=	
LIQUID TEMPERATURE	20.00 °C	=	
DENSITY	998.2 kg/m2	=	
KINEMATIC VISCOSITY	1 mm2/s	=	
SPEED FOR PUMP DATA	1450 rpm	=	
ACTUAL CALCULATED	13.2m3/h	=	
RESULTING HEAD OF T	18.7 m	=	
ACTUAL IMPELLER DIA	240 mm	=	
SHAFT SEAL	BAQE	=	
CURVE TOLERANCE	ISO 9906:1999 ANNEX A	=	
PIPE CONNECTION	DN 50	=	
PRESSURE STAGE	PN 16	=	
RATED POWER - P2	2.2 kW	=	
POWER (P2) REQUIRED	2.2 kW	=	
RATED CURRENT	4.9 A	=	
RATED SPEED	1450 rpm	=	
Identity Data			

Manage Lookup Tables

How do I manage family types?

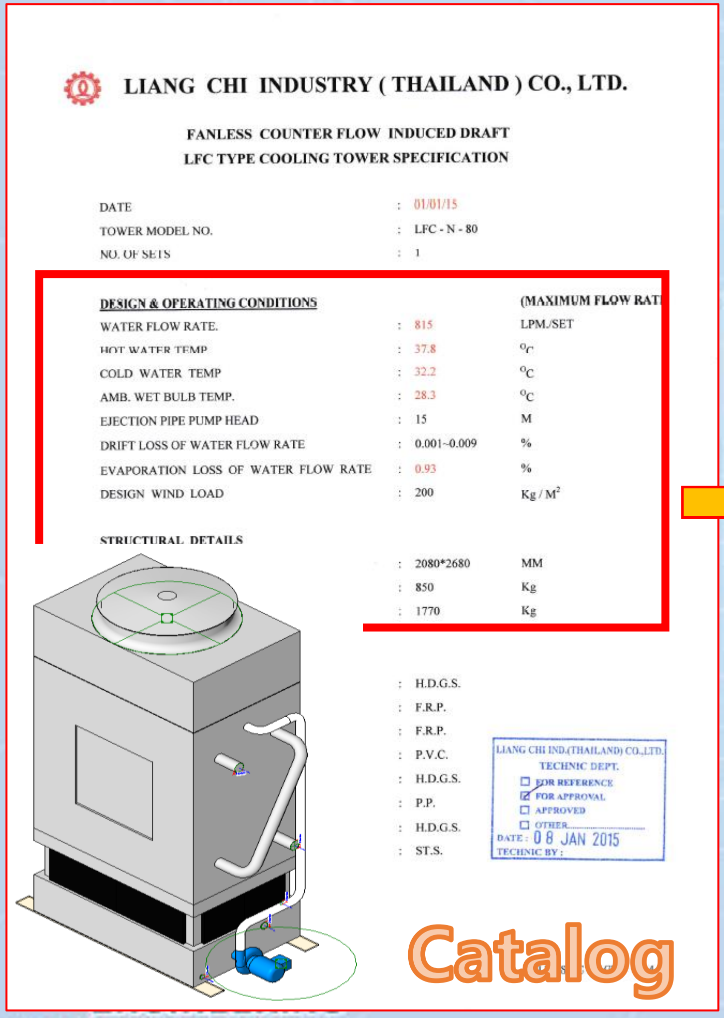
OK | Cancel | Apply

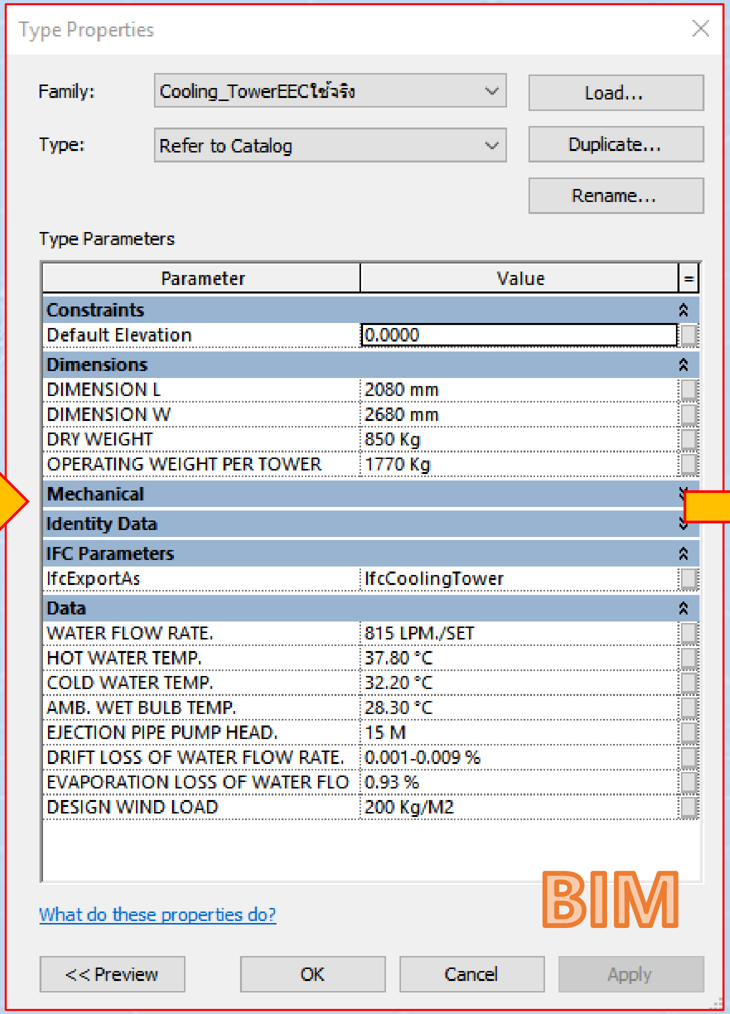
IFC

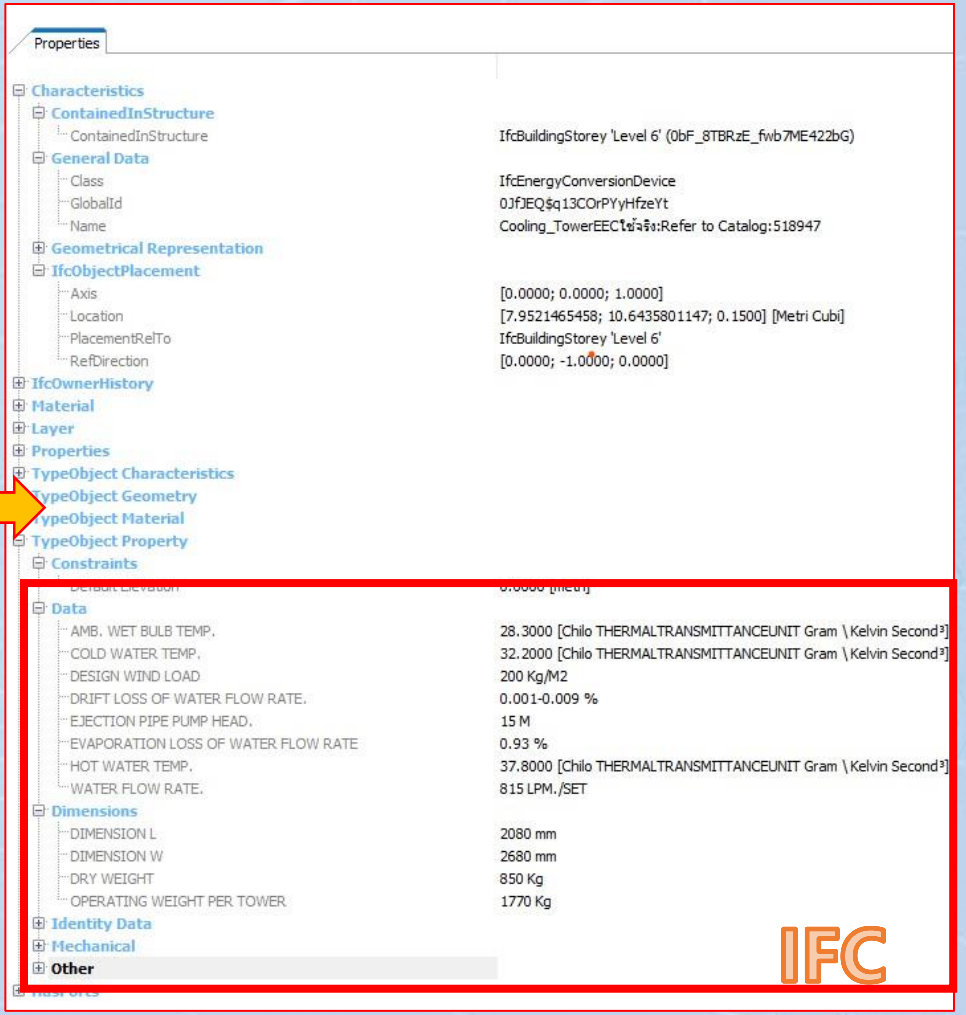
Properties

Property	Value
Characteristics	
ContainedInStructure	
ContainedInStructure	IfcBuildingStorey 'Level 6' (0bF_8TBRzE_fwb7ME422bG)
General Data	
Class	IfcFlowMovingDevice
GlobalId	0TmD2ywgP4891yFPB1H5fK
Name	Plumbing_Pumps_Dab-Pumps_CM-50:CM 50-510 T:621569
Geometrical Representation	
IfcObjectPlacement	
Axis	[0.0000; 0.0000; 1.0000]
Location	[7.352941818; 6.9065876539; 0.0000000013] [Metri Cubi]
PlacementRelTo	IfcBuildingStorey 'Level 6'
RefDirection	[1.0000; 0.0000; 0.0000]
IfcOwnerHistory	
Material	
Layer	
Properties	
TypeObject Characteristics	
TypeObject Geometry	
TypeObject Material	
TypeObject Property	
Default Elevation	0.0000 [metri]
Data	
ACTUAL CALCULATED FLOW	13.2m3/h
ACTUAL IMPELLER DIAMETER	240 mm
CURVE TOLERANCE	ISO 9906:1999 ANNEX A
DENSITY	998.2 kg/m2
ENCLOSURE CLASS (IEC34-5)	55 (Protect. water jets/duct)
KINEMATIC VISCOSITY	1 mm2/s
LIQUID TEMPERATURE	20.0000 [Chilo THERMALTRANSMITTANCEUNIT Gram \ Kelvin Second³]
LIQUID TEMPERATURE RANGE	120.0000 [Chilo THERMALTRANSMITTANCEUNIT Gram \ Kelvin Second³]
MOTOR EFFICENCY AT 1/2 LOAD	87.6-85.6%
MOTOR EFFICENCY AT 3/4 LOAD	87.7-87.2%
MOTOR EFFICENCY AT FULL LOAD	86.7%
PIPE CONNECTION	DN 50
POWER (P2) REQUIRED BY PUMP	2.2 kW
PRESSURE STAGE	PN 16
PUMPED liquid	Water
RATED CURRENT	4.9 A
RATED SPEED	1450 rpm
RESULTING HEAD OF THE PUMP	18.7 m
SHAFT SEAL	BAQE
SPEED FOR PUMP DATA	1450 rpm

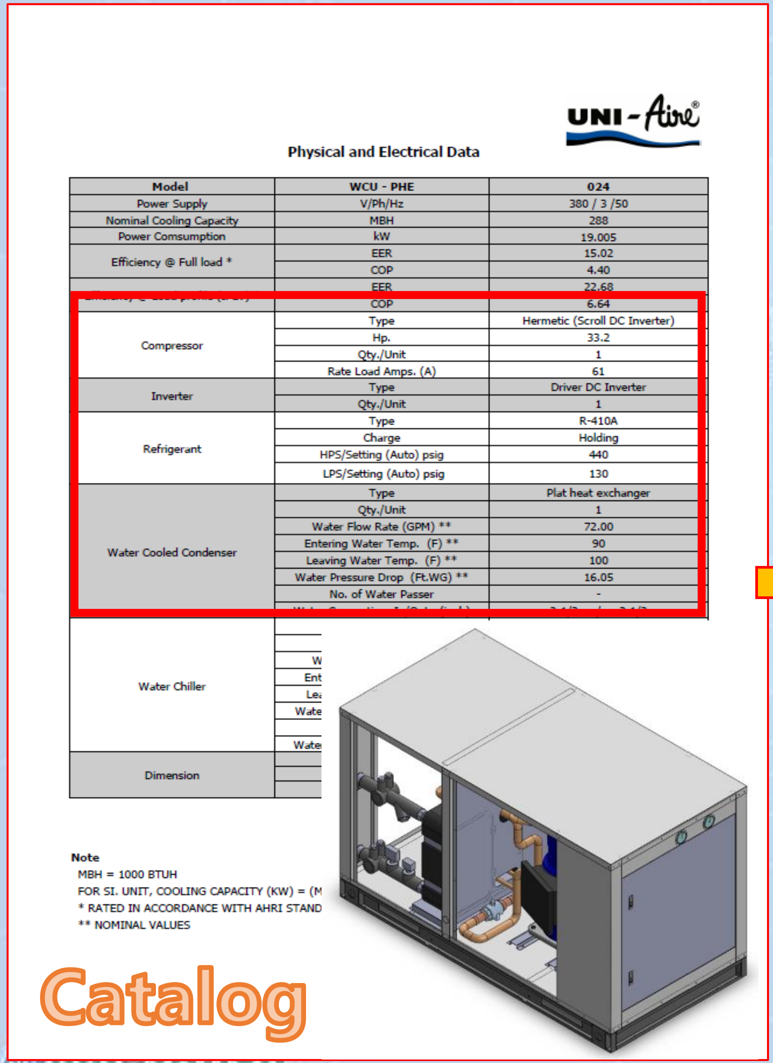
IFC data format – with property





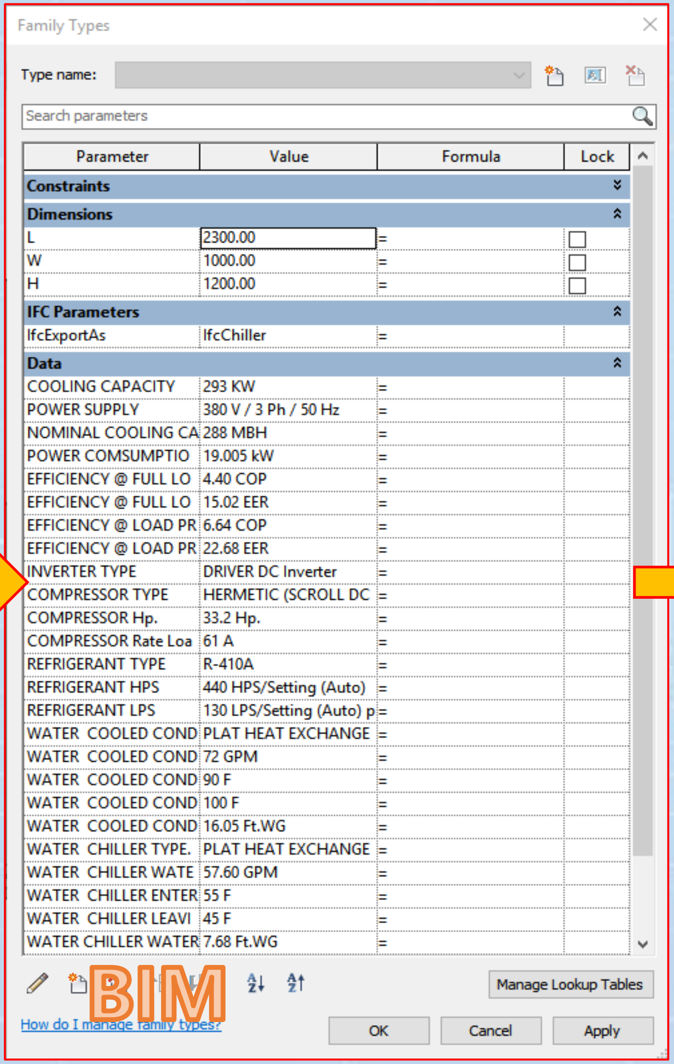


IFC data format – with property

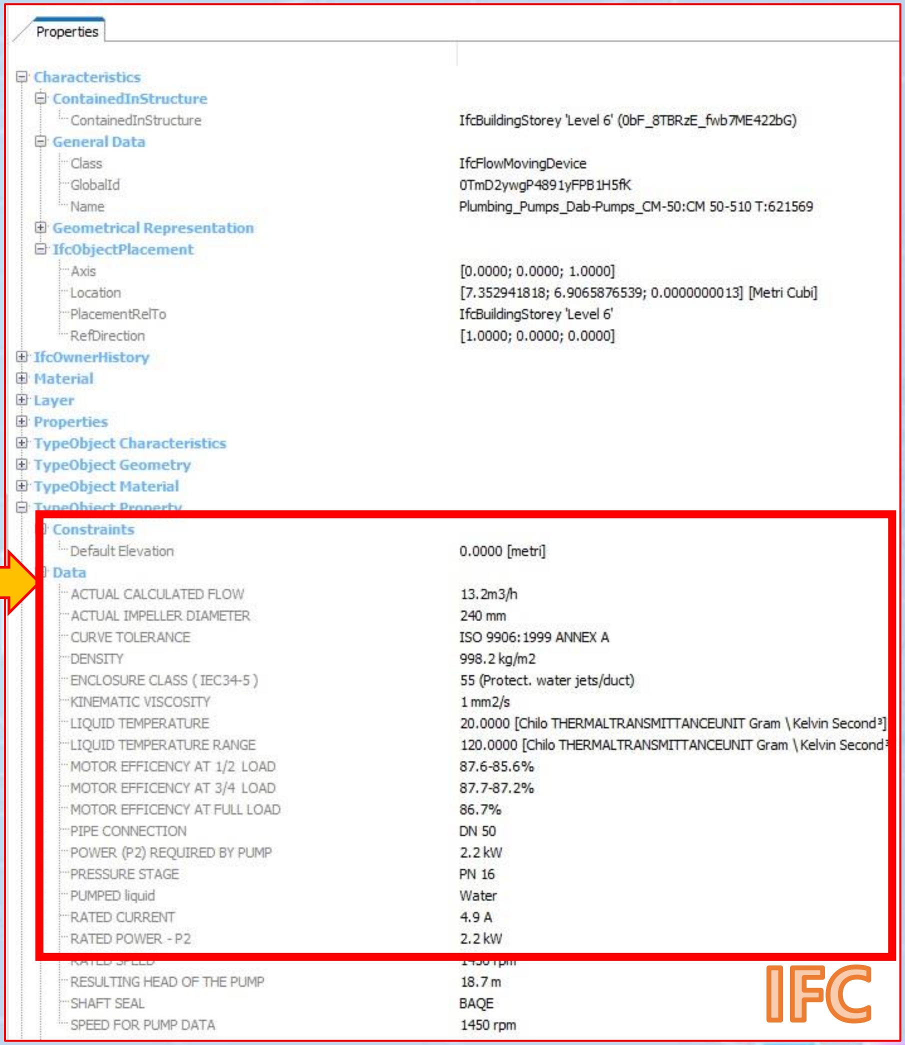


Model	WCU - PHE	024
Power Supply	V/Ph/Hz	380 / 3 /50
Nominal Cooling Capacity	MBH	288
Power Comsumption	kW	19.005
Efficiency @ Full load *	EER	15.02
	COP	4.40
	EER	22.68
	COP	6.64
Compressor	Type	Hermetic (Scroll DC Inverter)
	Hp.	33.2
	Qty./Unit	1
	Rate Load Amps. (A)	61
Inverter	Type	Driver DC Inverter
	Qty./Unit	1
Refrigerant	Type	R-410A
	Charge	Holding
	HPS/Setting (Auto) psig	440
	LPS/Setting (Auto) psig	130
Water Cooled Condenser	Type	Plat heat exchanger
	Qty./Unit	1
	Water Flow Rate (GPM) **	72.00
	Entering Water Temp. (F) **	90
	Leaving Water Temp. (F) **	100
	Water Pressure Drop (Ft.WG) **	16.05
	No. of Water Passer	-
Water Chiller		
	W	
	Ent	
	Lea	
	Wate	
	Wate	
Dimension		

Note
MBH = 1000 BTUH
FOR SI. UNIT, COOLING CAPACITY (KW) = (M
* RATED IN ACCORDANCE WITH AHRI STAND
** NOMINAL VALUES



Parameter	Value	Formula	Lock
Constraints			
Dimensions			
L	2300.00	=	
W	1000.00	=	
H	1200.00	=	
IFC Parameters			
IfcExportAs	IfcChiller	=	
Data			
COOLING CAPACITY	293 KW	=	
POWER SUPPLY	380 V / 3 Ph / 50 Hz	=	
NOMINAL COOLING CA	288 MBH	=	
POWER COMSUMPTIO	19.005 kW	=	
EFFICIENCY @ FULL LO	4.40 COP	=	
EFFICIENCY @ FULL LO	15.02 EER	=	
EFFICIENCY @ LOAD PR	6.64 COP	=	
EFFICIENCY @ LOAD PR	22.68 EER	=	
INVERTER TYPE	DRIVER DC Inverter	=	
COMPRESSOR TYPE	HERMETIC (SCROLL DC	=	
COMPRESSOR Hp.	33.2 Hp.	=	
COMPRESSOR Rate Loa	61 A	=	
REFRIGERANT TYPE	R-410A	=	
REFRIGERANT HPS	440 HPS/Setting (Auto)	=	
REFRIGERANT LPS	130 LPS/Setting (Auto) p	=	
WATER COOLED COND	PLAT HEAT EXCHANGE	=	
WATER COOLED COND	72 GPM	=	
WATER COOLED COND	90 F	=	
WATER COOLED COND	100 F	=	
WATER COOLED COND	16.05 Ft.WG	=	
WATER CHILLER TYPE.	PLAT HEAT EXCHANGE	=	
WATER CHILLER WATE	57.60 GPM	=	
WATER CHILLER ENTER	55 F	=	
WATER CHILLER LEAVI	45 F	=	
WATER CHILLER WATER	7.68 Ft.WG	=	



Characteristics	
ContainedInStructure	
ContainedInStructure	IfcBuildingStorey 'Level 6' (0bF_8TBRzE_fwb7ME422bG)
General Data	
Class	IfcFlowMovingDevice
GlobalId	0TmD2ywgP4891yFPB1H5fK
Name	Plumbing_Pumps_Dab-Pumps_CM-50:CM 50-510 T:621569
Geometrical Representation	
IfcObjectPlacement	
Axis	[0.0000; 0.0000; 1.0000]
Location	[7.352941818; 6.9065876539; 0.0000000013] [Metri Cubi]
PlacementRelTo	IfcBuildingStorey 'Level 6'
RefDirection	[1.0000; 0.0000; 0.0000]
IfcOwnerHistory	
Material	
Layer	
Properties	
TypeObject Characteristics	
TypeObject Geometry	
TypeObject Material	
TypeObject Property	
Constraints	
Default Elevation	0.0000 [metri]
Data	
ACTUAL CALCULATED FLOW	13.2m3/h
ACTUAL IMPELLER DIAMETER	240 mm
CURVE TOLERANCE	ISO 9906:1999 ANNEX A
DENSITY	998.2 kg/m2
ENCLOSURE CLASS (IEC34-5)	55 (Protect. water jets/duct)
KINEMATIC VISCOSITY	1 mm2/s
LIQUID TEMPERATURE	20.0000 [Chilo THERMALTRANSMITTANCEUNIT Gram \ Kelvin Second³]
LIQUID TEMPERATURE RANGE	120.0000 [Chilo THERMALTRANSMITTANCEUNIT Gram \ Kelvin Second³
MOTOR EFFICENCY AT 1/2 LOAD	87.6-85.6%
MOTOR EFFICENCY AT 3/4 LOAD	87.7-87.2%
MOTOR EFFICENCY AT FULL LOAD	86.7%
PIPE CONNECTION	DN 50
POWER (P2) REQUIRED BY PUMP	2.2 kW
PRESSURE STAGE	PN 16
PUMPED liquid	Water
RATED CURRENT	4.9 A
RATED POWER - P2	2.2 kW
RATED SPEED	1450 rpm
RESULTING HEAD OF THE PUMP	18.7 m
SHAFT SEAL	BAQE
SPEED FOR PUMP DATA	1450 rpm

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IFC data format – with property

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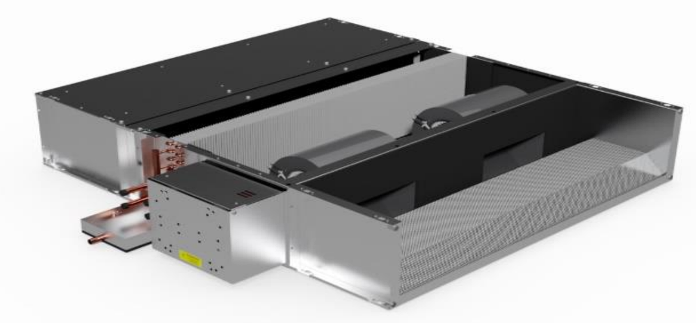
MODEL		HFCA04	HFCA06	HFCA08	HFCA10	HFCA12
RATED - Volts/Ph/Hz		220-240/1/50	220-240/1/50	220-240/1/50	220-240/1/50	220-240/1/50
SYSTEM DATA						
Nominal Airflow	cfm	400	600	800	1000	1200
Cooling Capacity	Btu/h	12000	18000	24000	30000	36000
Water Inlet Connection Size	in	5/8.	5/8.	5/8.	5/8.	5/8.
Water Outlet Connection Size	in	5/8.	5/8.	5/8.	5/8.	5/8.
Water Connection Size		Brazed	Brazed	Brazed	Brazed	Brazed
INDOOR COIL						
Fin Type		Slit	Slit	Slit	Louver	Louver
Fin per inch*						
3 - Row coil		12	12	15	18	18
4 - Row coil		14	15	16	15	15
Drain Connection Size	in	1/2.	1/2.	1/2.	1/2.	1/2.
FAN						
Fan Type		Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal
No. used		2	2	2	2	2
Drive Type		Direct	Direct	Direct	Direct	Direct
STANDARD FAN MOTOR						
Qty of Motor		1	1	1	1	1
[illegible]	[illegible]	[illegible]	47	59	162	186
No. of Speed		3	3	3	4	4



Family Types

Type name: CBY(2-Pipe EHeat)

Search parameters

Parameter	Value	Formula
Constraints		
Default Elevation	0' 0"	=
IFC Parameters		
IfcExportAs	IfcUnitaryEquipment	=
Data		
RATED - VOLTS/Ph/Hz	220-240 V / 1 Ph /50 Hz	=
NOMINAL AIRFLOW	400.00 CFM	=
COOLING CAPACITY	12000.00 Btu/h	=
FAN TYPE	CENTRIFUGAL	=
FAN (No used)	2	=
FAN (Drive Type)	Direct	=
FIN TYPE	Slit	=
3 - Row coil	12	=
4 - Row coil	14	=
MOTOR POWER	13 W	=
MOTOR-VOLTS/ Ph / Hz	220 V / 1 Ph /50 Hz	=
MOTOR-RLA/ LRA	02 / 0.35	=
Identity Data		

Manage Lookup Tables

How do I manage family types?

OK Cancel Apply

BIM

Properties

Characteristics	
ContainedInStructure	
ContainedInStructure	IfcBuildingStorey 'Level 6' (0bF_8TBRzE_fwb7ME422b
General Data	
Class	IfcEnergyConversionDevice
GlobalId	1isMSLJ4vDmBiZitAdblVW
Name	Horizontal_Telescoping_Fan_Coil_Unit_-_CBY_-_IEC_
Geometrical Representation	
IfcObjectPlacement	
IfcOwnerHistory	
Material	
Layer	
System	
Properties	
TypeObject Characteristics	
TypeObject Geometry	
TypeObject Material	
TypeObject Property	
Constraints	
Default Elevation	0.0000 [metri]
Data	
3 - Row coil	12
4 - Row coil	14
COOLING CAPACITY	37855.088941
FAN (Drive Type)	Direct
FAN (No used)	2
FAN TYPE	CENTRIFUGAL
FIN TYPE	Slit
MOTOR POWER	13 W
MOTOR-RLA/ LRA	02 / 0.35
MOTOR-VOLTS/ Ph / Hz	220 V / 1 Ph /50 Hz
NOMINAL AIRFLOW	6.666667
RATED - VOLTS/Ph/Hz	220-240 V / 1 Ph /50 Hz
Identity Data	
ARI Number	
Assembly Code	
Assembly Description	
Code Name	
Description	
Manufacturer	
Model	
OmniClass Number	23.75.70.17.27
OmniClass Title	Fan Coil Units

IFC

IFC 4.0 on 7D BIM

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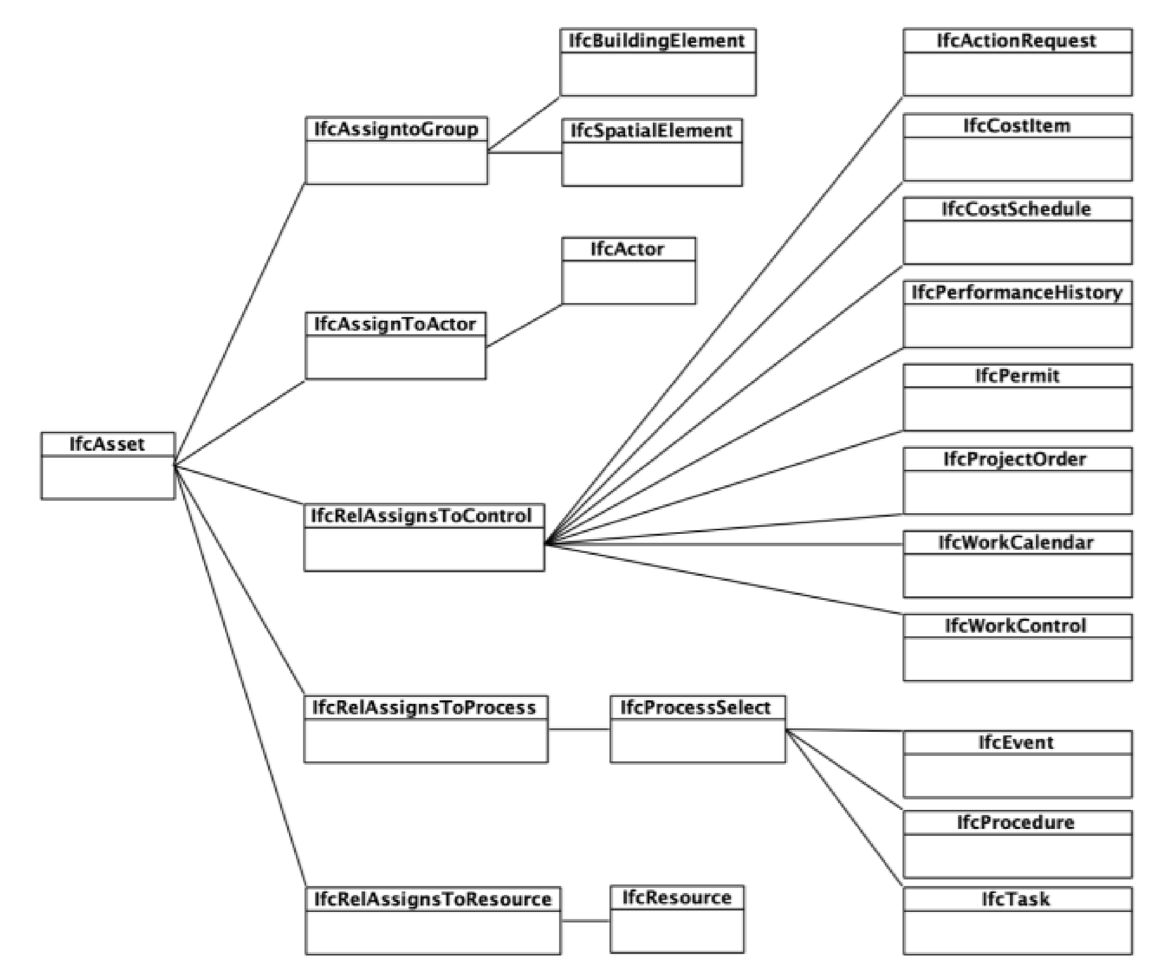
ISO

ICS > 25 > 25.040 > 25.040.40

ISO 16739-1:2018

Industry Foundation Classes (IFC) for data sharing in the construction and facility management industries — Part 1: Data schema

Code	Asset	Sensor Name	Location	Sensor Type	Unit	IFC Entities	Existing
G44	G.44 (lev.0)					IfcSpace	yes
G44_1		Monnit sensor	G.44 room	sensor unit	°C/%	IfcSensorType	no
G44_2		Temperature VRF	Air terminal at VRF 36	sensor unit	°C	IfcEnergyConversionDevice	yes
G44_3		Temperature VRF	Air terminal at VRF 37	sensor unit	°C	IfcEnergyConversionDevice	yes
G44_4		Fan speed VRF	Air terminal at VRF 36	integrated	level (1-n)	IfcFanType	no
G44_5		Fan speed VRF	Air terminal at VRF 37	integrated	level (1-n)	IfcFanType	no
AHU	AHU2					IfcAsset	no
AHU_1		AHU extract air temperature	after the air mixer	sensor unit	°C	IfcSensorType	no
AHU_2		AHU extract fan speed	AHU extract fan	integrated	ls-1/%	IfcFanType	no
AHU_3		AHU extract air filter DPS	AHU extract air filter	integrated	Pa	IfcFilterType	no
AHU_4		AHU supply air filter DPS	AHU supply air filter	integrated	Pa	IfcFilterType	no
AHU_5		AHU supply fan speed	AHU supply fan	integrated	ls-1/%	IfcFanType	no
AHU_6		AHU supply air reheat level	AHU supply air reheat	integrated	%	IfcCoilType	no
AHU_7		AHU supply air temperature	before the air splitter	sensor unit	°C / Pa	IfcSensorType	no
AHU_9		Thermowheel exchange rate	Thermowheel	integrated	% heat	IfcAirToAirHeatRecoveryType	no
WR2	WR2					IfcAsset	no
WR2_1		WR2 supply temperature	before WR2 loop	sensor unit	°C	IfcSensorType	no
WR2_2		WR2 cooling pump DPS	WR2 cooling pump	integrated	Pa	IfcPumpType	no
WR2_3		WR2 return temp	leaving WR2 loop	sensor unit	°C	IfcSensorType	no
DAC_1		Dry air cooler DPS	DAC	integrated	Pa	IfcChillerType	no
DAC_2		DAC on temp	before DAC	integrated	°C	IfcSensorType	no
DAC_3		DAC off temp	after DAC	integrated	°C	IfcSensorType	no
DIAL	1.58 (lev. 1)					IfcSpace	yes
DIAL_1		Space temp	space	sensor unit	°C	IfcSensorType	no
RAD	Radiators					IfcAsset	no
RAD_1		Radiator pump DPS	Radiator pump	integrated	Pa	IfcPumpType	no
RAD_2		VT flow supply temp	radiator inlet	sensor unit	°C	IfcSensorType	no
RAD_3		VT flow return temp	radiator outlet	sensor unit	°C	IfcSensorType	no
RAD_4		VT heat meter		sensor unit	Kwh	IfcFlowMeterType	no



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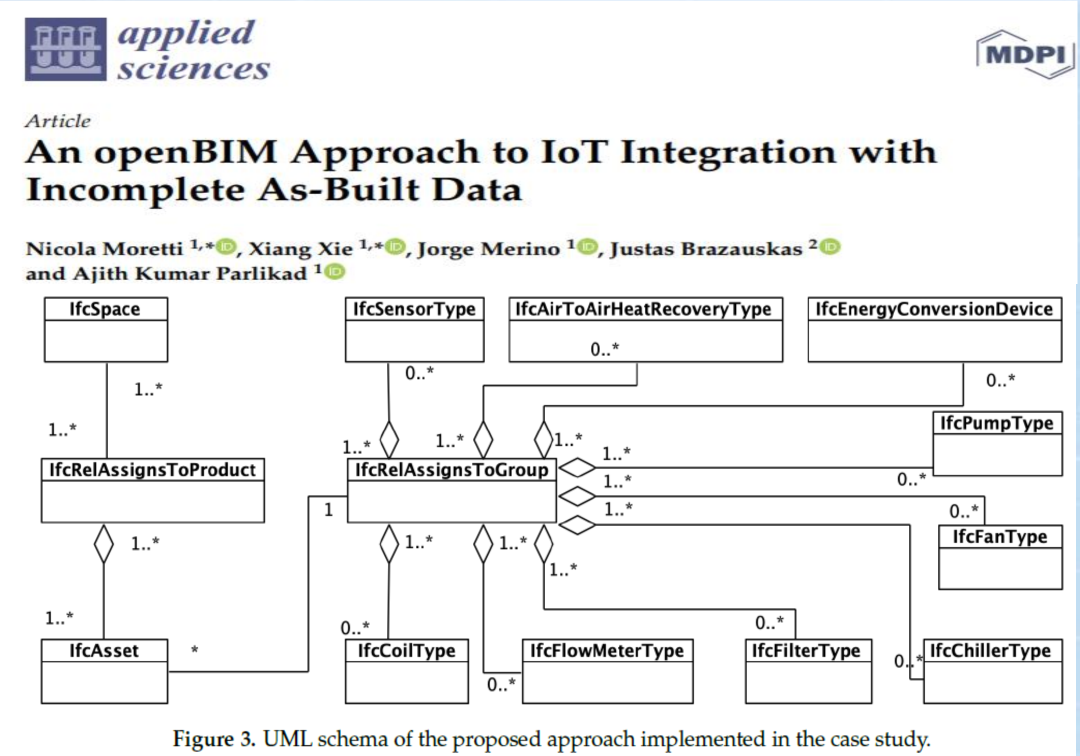

applied sciences

MDPI

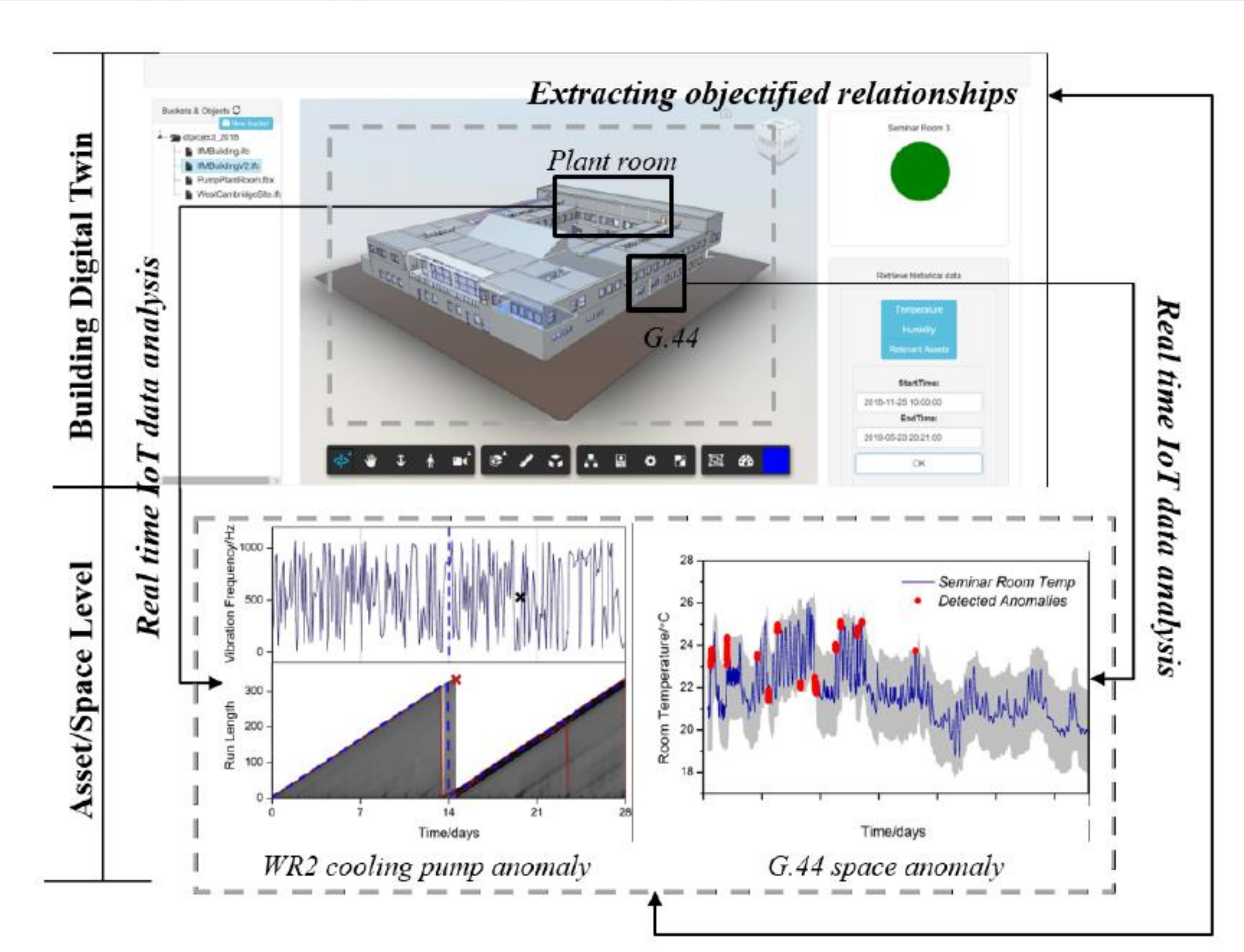
Article

An openBIM Approach to IoT Integration with Incomplete As-Built Data

Nicola Moretti [1,*], Xiang Xie [1,*], Jorge Merino [1], Justas Brazauskas [2] and Ajith Kumar Parlikad [1]

Figure 3. UML schema of the proposed approach implemented in the case study.

The Unified Modeling Language (UML) is a general-purpose, developmental, modeling language in the field of software engineering that is intended to provide a standard way to visualize the design of a system



SMART ENGINEERING AND INNOVATION FOR SOCIETY

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ปัญหาในการดำเนินการ

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IFC Export Options

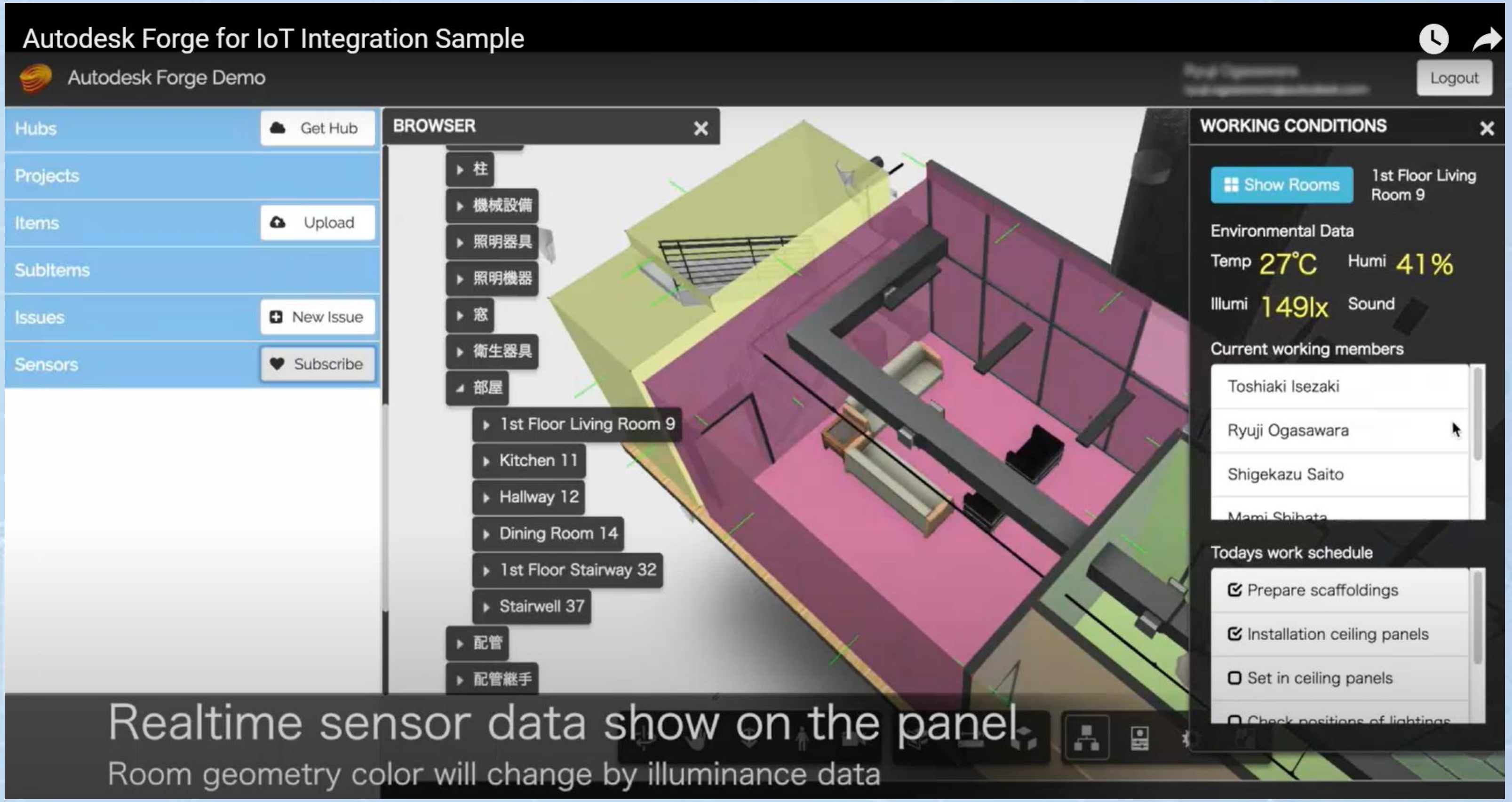
You can export SOLIDWORKS top-level assemblies or components as Industry Foundation Classes `.ifc` files. You can assign the model OmniClass™, Uniclass2015, Custom Properties, Material and Mass Properties, and Units when exporting.

To open the `.ifc` Export Options dialog box:

With a model open, click **File** > **Save As**, select **IFC 2x3** or **IFC 4.0**, and click **Options**.

Output as

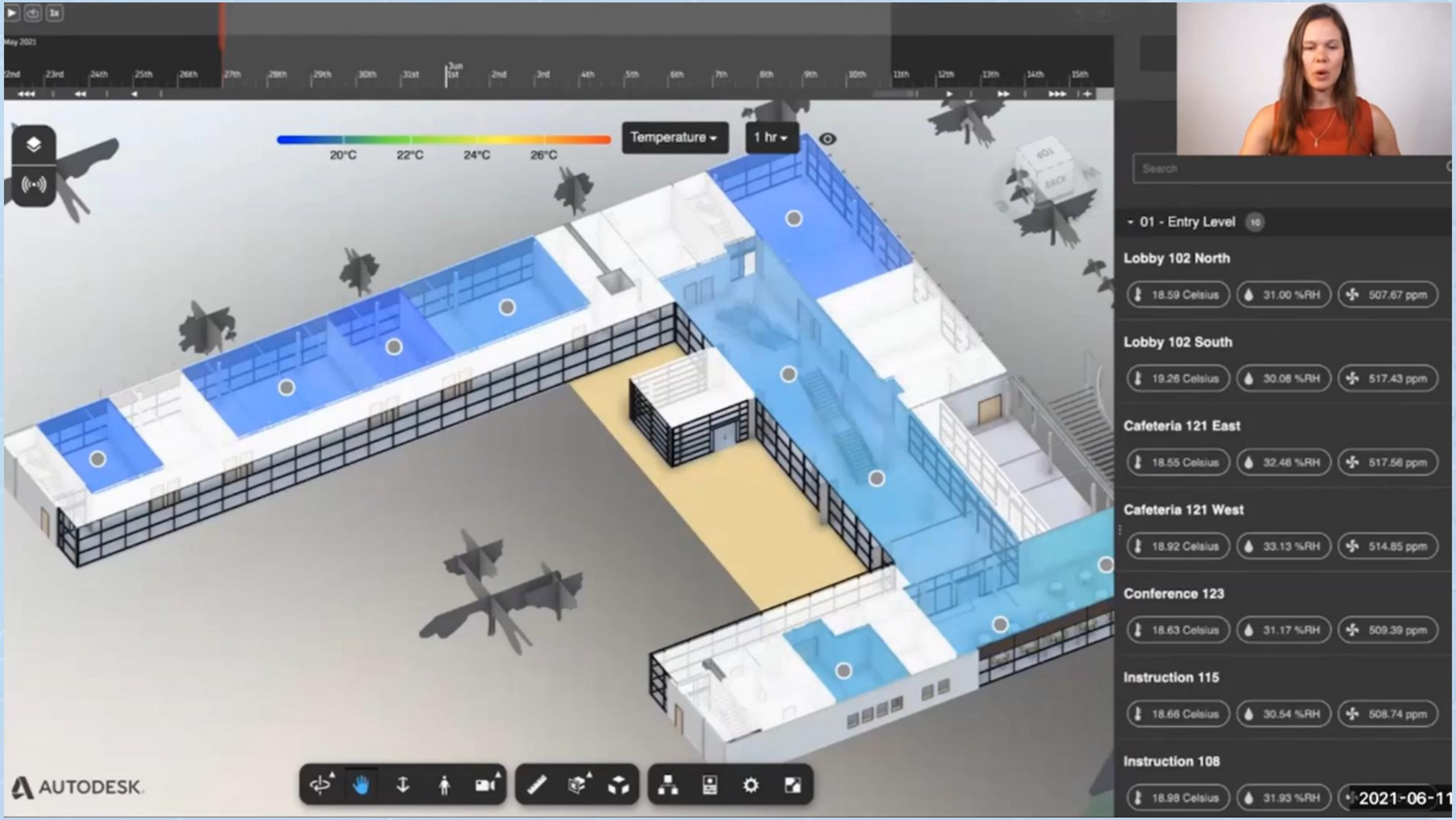
OmniClass	Specifies the OmniClass Construction Classification System class. This classification organizes components for the building supply chain or construction industry.
UniClass2015	Specifies the UniClass2015 development



IFC4 supports:

1. **multiple model view definition (MDV)**
2. **Information on XML (website)**
3. **API (application programming interface) on BIM-app**

ปัญหาในการดำเนินการ



สรุป

1. IFC2x3 for material approval data and G-sheet for use in EMIS
2. IFC4 support API on Web XML
3. How about CPM and BAS?
4. IoT should be designed for data analytics and diagnostic
5. Multi-disciplinary including: Building Eng. (data analytics expert) + IoT Eng. + IT Eng.
6. Construction ecosystem should integrate IT applications and learning
7. Construction ecosystem should know the utilizations of information and data

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