Bridging BIM and BEM: the path forward to more efficient building design and operations

by Bertrand Lack and Steve Butler

Executive summary

Building Information Modeling (BIM) is increasingly being adopted worldwide to improve and accelerate productivity in the design and construction of buildings, while reducing errors and cutting costs. In support of energy-efficient design, many BIM platforms now integrate Building Energy Modeling (BEM) at the design stage, based on building geometry, location, and weather data inputs. By increasing the level of information regarding equipment energy consumption and actual measured building performance, the accuracy of BEM within the BIM environment can be further improved. This will help inform better design decisions, as well as enable a more comprehensive 'digital twin' that gives facility operations and maintenance teams a complete, unified view of all architectural and energy characteristics.

Introduction

The recent report from the Intergovernmental Panel on Climate Change confirmed that a drastic change needs to limit global warming to 1.5°C by 2050.[1] At the same time, global population is expected to grow to 10 billion by 2050. Accompanying this growth will be a massive flow of migration, with 2.5 billion people expected to move into urban areas in the next decades.[2]

To accommodate this population increase and shift in urbanization, we will need to construct 13,000 buildings per day. It will also require $3.3 trillion of investment in infrastructure annually through 2030.

This explosion in the built infrastructure will potentially have a massive impact on the environment. If we look at our existing building infrastructure, it is inefficient and responsible for:

- 40% of global energy, 25% of global water, 40% of global resources, and approximately one third of GHG emissions.[3]
- Over 30% of the waste that ends up in landfills (as part of the entire construction sector).[4]

These statistics speak to the need for the architecture, engineering, and construction (AEC) industry to radically reform existing processes. Not only must design and construction be faster and more efficient to keep up with demand, buildings must become far more energy efficient.

Figure 1

To accommodate millions of more people moving to urban centers over the next decades, building design, construction, and efficiency will need to improve dramatically.

Building Information Modeling (BIM) technology is one of the ways to achieve these goals. BIM-based design not only supports a better planning phase and more efficient construction and commissioning phases, it can also enable Building Energy Modeling (BEM) processes to be incorporated into the design stage. This provides designers with the ability to make more informed choices in building design and materials to achieve more efficient buildings.

Though great advancements have been made in integrating BEM within the BIM workflow, there are still opportunities for BIM to:

- improve the accuracy of energy-related building calculations, further increasing the efficiency of the final built asset

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[1] "Special Report: Global Warming of 1.5 º, Summary for Policymakers", IPCC, 2018

[2] "68% of the world population projected to live in urban areas by 2050, says UN", un.org, 2018

[3] "Energy Efficiency for Buildings", UNEP

[4] "Barriers to Improving…Construction Waste Management", Crawford / Mathur, Garritsen, 2017

- enrich and improve data standards – such as Industry Foundation Class (IFC) – to enable smooth and seamless interface between applications
- generate a more complete 'digital twin' that includes both architectural and energy performance characteristics that can be shared with building owners and facility management teams to maximize energy efficiency and minimize maintenance costs during day-to-day operations

These opportunities are currently facing significant, but not insurmountable, challenges.

In this white paper we will address how digitalization, standardization, and a focus on meeting the expectations and specifications of building owners and operators are all needed to drive improvements to the design and delivery of an improved built asset that is fully optimized for energy efficiency over its life cycle.

This paper is intended to help engineers, designers, manufacturers, building owners, facility management teams, and real estate professionals appreciate the possibilities for BIM and BEM. Even more importantly, this paper seeks to educate all players that this potential can only be realized through the involvement and action of all parties in driving the technical and process changes necessary.

How BIM is revolutionizing AEC

Traditionally, building design, planning, and construction is carried out by different trades with limited coordination. Very little information is shared, and much duplication of effort and repetition occurs. In fact, the World Economic Forum highlight this lack of collaboration as a major contributor to the lack of productivity in the AEC industry compared to others such as manufacturing.[5]

Each building is typically built as a prototype. Issues are anticipated as much as possible, but most of them are addressed and mitigated one-by-one during construction.

Building energy performance may often be roughly estimated, but the true performance is typically a surprise. Coupled with uncertainty as to how the final building will be constructed until ground is broken, the actual performance of purchased equipment, and the eventual occupancy patterns, it is no wonder that most buildings have under-delivered compared to expectations.

This situation is improving, largely thanks to a continuing evolution in building design tools. CAD took the AEC industries from the drawing board to the computer in 1985, digitizing the analog process and making every stage more productive. BIM was introduced in 2002.

BIM provides 3D modeling to facilitate structural design. It makes design, engineering, project, and operational information accurate, accessible, and actionable for buildings and infrastructure. A BIM model covers all aspects of a building, from the architecture to all internal systems and services – mechanical, electrical, etc. – to an exceptional level of detail. Essentially, multiple levels of data are rendered within a collaborative workflow.[6]

A BIM design can cover all stages from conception through construction and maintenance. It keeps all stakeholders on the same page by improving collaboration and control, enabling the flow of information between distributed teams.

The capabilities of BIM include capturing and sharing all information, which helps avoid duplication and conflict. Beyond the digital 3D modeling of physical and functional char-

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[5] "Shaping The Future of Construction", World Economic Forum, 2016

[6] "BIM 101: What is Building Information Modeling?", Engineering.com, 2016

acteristics, BIM can also include the dimensions of time, costs, and facility management. Time and cost dimensions relate to the BIM capability of helping sequence construction steps to improve efficiency.

Since the introduction of BIM, owner, industry and government mandates have continued to emerge, helping set goals and establishing practices to reduce waste on public projects, save construction costs, and establish strategies for mitigating climate change.

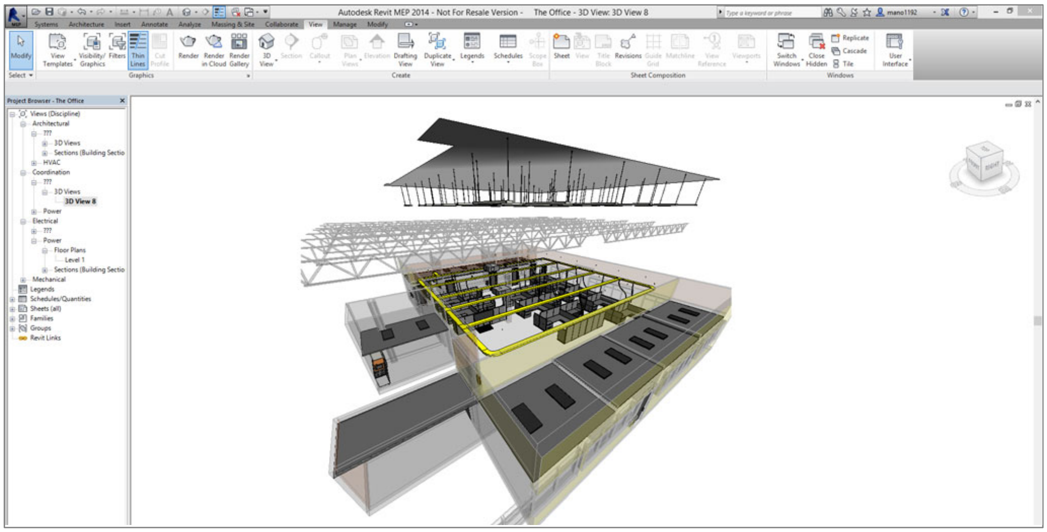

Figure 2

Building design view from a typical BIM application, showing multiple levels of architecture and internal systems.

Image courtesy Autodesk

Studies show the business value of BIM is becoming clear:

- 59% of architects and engineers say BIM improves contractor understanding of design intent, while 50% say BIM reduces errors and omissions in design documentation[7]
- 66% of owners and 64% of contractors agree that BIM improved the process and accuracy of estimating construction costs[8]

> "Modern, high-tech, intelligent buildings are complex models comprising many systems and processes which interact with each other. Most buildings have become so complex that they require a BMS (Building Management System) to collect, analyze and interpret how energy efficient a building really is. As more information regarding the performance of 'intelligent objects' is added, BIM can be used with a BMS to create a highly-accurate energy model."
> *Centrica Business Solutions*

Today, we are entering a new era of BIM that is benefiting from the processing power and ubiquity of the cloud. According to the Boston Consulting Group, implementation of a cloud-based technology solution and process can significantly reduce project lifecycle cost by 15% and cut construction time by 30%.[9]

An evolution in efficiency

BIM adoption is escalating and already helping transform the efficiency of engineering and construction in multiple dimensions. BIM technology also continues to evolve, integrating more expansive capabilities to address the AEC and facility management needs of today and tomorrow. Some examples include:

1. **Prefabrication.** Modular pre-fabrication is not a new concept, but it is slowly becoming globally prolific. It is part of the industrialization of construction, which is part of an emerging practice called 'design for manufacture and assembly' or DfMA. This is helping reform the AEC industry and drive a more efficient BIM/BEM implementation. It's an important trend, as it helps significantly improve construction productivity and quality, while reducing risk, improving safety, and saving money, materials, and time. It also means less

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[7] "Leading The Future Of Building – Connecting Design Insight", Dodge Data & Analytics

[8] "Measuring the Impact of BIM on Complex Buildings', Dodge Data & Analytics, 2015

[9] Boston Consulting Group, "The Transformative Power of Building Information Modeling", 2016

disruption and supports a strong sustainability agenda by reducing water and electricity resources at the construction site.

2. **Increased detail for more accurate energy modeling.** As noted by Facilities Net, “BIM is a platform that can provide a comprehensive and interactive assembly of the components in a building to create a new type of energy model. As more information is added to BIM for each individual part of the building, BIM becomes increasingly closer to matching the real world building itself.”[10] This additional information, in the form of equipment specifications from manufacturers, needs to be integrated into the BIM process and models. This is one of the key discussion points of this paper.
3. **Integrating real building energy performance data.** Going beyond building design, construction and commissioning, BIM promises to offer the ability to measure the actual performance of the building post-commission. The integration of BIM with the cloud and IoT-enabled power and energy management apps, meters, and sensors is becoming smoother. Including energy data inputs that reveal how a building is performing under actual operating conditions will help inform future designs to further improve energy and operational efficiencies. This will be further discussed in this paper.
4. **Generative design.** As described by Autodesk, “Generative design mimics nature’s evolutionary approach to design. Designers or engineers input design goals into generative design software, along with parameters such as materials, manufacturing methods, and cost constraints. Unlike topology optimization, the software explores all the possible permutations of a solution, quickly generating design alternatives. It tests and learns from each iteration what works and what doesn’t…–With generative design, there is no single solution; instead, there are potentially thousands of great solutions. You choose the design that best fits your needs.”[11] We can expect that BIM platforms will begin offering this exciting innovation soon to further improve the efficiency of building design workflows

As the above capabilities continue to evolve they will benefit every part of the building life cycle. We can design more efficient buildings, streamline construction, produce less waste, and reduce commissioning time. And the more accurate the building model is, the more useful and effective it becomes in supporting facility teams in managing energy, automation, and workspaces. All of this adds up to greater agility and sustainability.

Augmenting digital twins

BIM has great potential for further improving building efficiency. It might also deliver a broader, more holistic view that can support building management, as well as help in estimating total cost of ownership over the entire building lifecycle.[12] For this to happen, more work is needed to integrate even more information on energy and operating characteristics. This is where some challenges remain. To understand these challenges, let us first consider how a BIM model is constructed.

Building information modeling enables the coordination of design, simulation, and construction of buildings by focusing around the concept of a single digital model representing the complete ontology of the building. The building model produced by a BIM project culminates with the creation of a collection of coordinated ‘digital twins’, each focused on a specific purpose: energy use, digital manufacturing and construction, asset management, and facility management.

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[10] Facilities Net, “How BIM Can Improve Building Efficiency”

[11] Autodesk, “Generative Design”

[12] ISO.org, “ISO/TC 59 at the Heart of Facility and Infrastructure Industry Transformation”, 2017

Digital twins not only facilitate a better, more accurate, and more predictable design and construction delivery process, they offer the capacity to support the operation of the building after construction and commissioning. This is possible because the BIM model can include (or reference) all information on the building's structure and contents with the potential to receive all active data from sensors and any other IoT-enabled devices. A digital twin can be used to analyze the building's behavior and ultimately define new control scenarios, adjusting the performance to the target.

The BIM process, model, and digital twins are based on several concepts:

- Physical architectural modeling
- Energy analysis
- Design engineering and modeling
- Cost estimation
- Coordination modeling and detailing
- BIM objects (by manufacturers), e.g. building components, including mechanical and electrical
- Value engineering
- Procurement
- Creating the construction process
- Digital manufacturing
- Making the digital twin available for building operations

BIM objects or 'product twins'

BIM objects are the 3D and digital representations of all the items constituting a building. The primary usage today is dimensional and geometrical. Doors, walls, windows, lighting, and heating equipment are assembled to design the building. Many manufacturers are already providing this level of information for their parts and products to accommodate integration with BIM.

However, BIM objects do not only provide geometric information; they can also include the data necessary to support planning and pricing. Additional rich content can include data for electrical design, heating and cooling calculation, and energy modeling.

Characteristics for each device – for example, transformers and boilers – can include electrical consumption, energy dissipation in watts, etc. (Figure 3). However, this data is not readily available from most manufacturers. What makes this more challenging is that, currently, there are no data format standards for this information, so there is no consistency across BIM applications for importing these types of product characteristics.

The IFC standard, defined by the organization BuildingSmart,[13] is designed to support an open BIM platform. However, the industry is still waiting for an IFC definition for objects based on an undisputed international dictionary of properties. Several standardization initiatives have begun to address this, starting with work on the pr-EN ISO 23387 standard. This standard covers the process to define a dictionary.[14]

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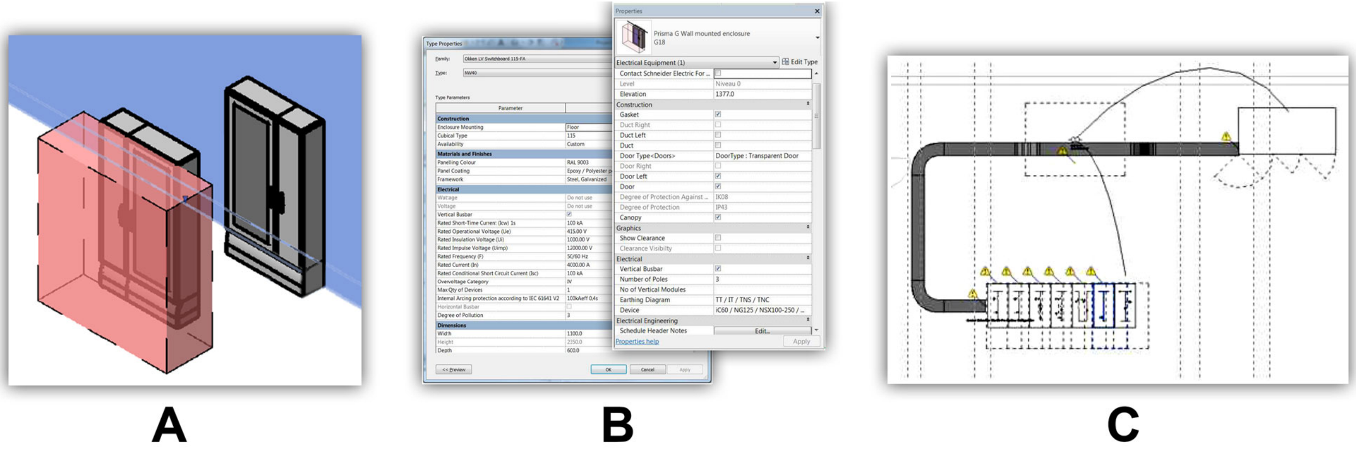
[13] "IFC Overview Summary", BuildingSmart

[14] "Is IFC equipped to structure manufacturers' data?", cobuilder, 2018



Type Properties

Family: Okken LV Switchboard 115-FA

Type: NW40

Type Parameters

Parameter	
Construction	
Enclosure Mounting	Floor
Cubical Type	115
Availability	Custom
Materials and Finishes	
Panelling Colour	RAL 9003
Panel Coating	Epoxy / Polyester p
Framework	Steel, Galvanized
Electrical	
Wattage	Do not use
Voltage	Do not use
Vertical Busbar	☑
Rated Short-Time Current (Icw) 1s	100 kA
Rated Operational Voltage (Ue)	415.00 V
Rated Insulation Voltage (Ui)	1000.00 V
Rated Impulse Voltage (Uimp)	12000.00 V
Rated Frequency (F)	50/60 Hz
Rated Current (In)	4000.00 A
Rated Conditional Short Circuit Current (Isc)	100 kA
Overvoltage Category	IV
Max Qty of Devices	1
Internal Arcing protection according to IEC 61641 V2	100kAeff 0,4s
Horizontal Busbar	☐
Degree of Pollution	3
Dimensions	
Width	1100.0
Height	2350.0
Depth	600.0

Properties

Prisma G Wall mounted enclosure
G18

Electrical Equipment (1) Edit Type

Contact Schneider Electric For ...	☐
Level	Niveau 0
Elevation	1377.0
Construction	
Gasket	☑
Duct Right	☐
Duct Left	☐
Duct	☐
Door Type<Doors>	DoorType : Transparent Door
Door Right	☐
Door Left	☑
Door	☑
Degree of Protection Against ...	IK08
Degree of Protection	IP43
Canopy	☑
Graphics	
Show Clearance	☐
Clearance Visibilty	☐
Electrical	
Vertical Busbar	☑
Number of Poles	3
No of Vertical Modules	
Earthing Diagram	TT / IT / TNS / TNC
Device	iC60 / NG125 / NSX100-250 / ...
Electrical Engineering	
Schedule Header Notes	Edit...

Figure 3

BIM objects are defined by different levels of information, for example geometry (A), operating characteristics (B), and connections (C).

Image courtesy Schneider Electric

The digital twin as a static model

The building model created by BIM is a static representation comprising the building and all assets installed within it. Every aspect of the building's external and internal architecture, and all parts of its internal systems and services, often down to the smallest bore pipework, is included during the detailing and construction phases. All electrical distribution equipment and major energy-consuming assets are included, such as electrical switchboards, control panels, boilers, fan coils, lighting, etc.

The layout of walls, doors, and windows generate rooms, spaces, and zones that are defined as other kinds of objects. These can also be assigned usages and behavioral attributes, as well as design parameters. For example, open space has different energy needs and behaviors than a kitchen.

The building model presents the global architecture, structure, and systems of the building. It can be a visual and geometric view (e.g. floors, zones, locations of space), but it can also be a logical view per domain. For example, for HVAC, the model represents the heating and cooling flow, showing which chiller feeds which equipment in what zone. For the electrical domain, the model provides the electrical architecture or diagram for the building.

In this way, a building model is essentially a multidimensional construct. A single building model will integrate several supporting models, each edited with the necessary information for each purpose. There can be:

1. An architectural model
2. A structural model
3. Mechanical models (i.e., plumbing and heating)
4. Electrical models (today, BIM platforms typically include most of this system, but often cabling is not fully complete)
5. An energy model (some BIM solutions offer some of this functionality today, but more is needed – see further discussion in this paper)
6. A space model (mainly for the use by the building owner or manager)

Issued during design phases, the different models are used by each trade to manage the coordination, procurement, and construction process. The role of the

BIM manager is to ensure the coordination of the different models along the construction process.

Ultimately, the building model needs to be updated to become the ‘as-built’ model. One of the challenges of this final stage is that many revisions are typically made during construction and services installation (e.g. repositioning of a cable tray, etc.). Updating the BIM model to reflect every subsequent change is often neglected or overlooked. Therefore, the final ‘digital twin’, though meeting the design intent, may not accurately represent the as-built asset. However, it needs to.

Currently there is no BIM protocol established to assign responsibility for these updates. However, as a good first step, the soon-to-be-published ISO 19650 standard defines the organization and digitization of information about buildings and civil engineering works, including for BIM.

The digital twin as an operating and performance model

Beyond guiding design and construction, the building model has the potential to support building operation. To enable this, the static model must be augmented with other types of information:

- Dynamic data coming from any sensor, meter, or smart equipment
- Construction and commissioning data (e.g. configuration, settings, etc.)
- Consistently updated product documentation

The different stakeholders can leverage the model specific to their usage and needs:

- **Facility manager** – Global visualization and organization to help quickly locate technical equipment. The context provided by the model (place, technical geometry) is key information for operation, diagnostics, and maintenance.
- **Maintenance manager** – In addition to static information on equipment specifications, active data on equipment status, alarms, and performance history can help reduce response time and enable predictive maintenance.
- **Asset manager** – Space organization information can complement occupation ratio and energy consumption per zone to improve asset management.
- **Energy manager** – Energy consumption per zone, floor, tenant, or equipment can help in allocating and optimizing costs.

Combining actual building performance data with the as-built model can help inform future design decisions. This can include optimizing retrofits of the same building or optimizing overall design for similar new builds.

Energy design and simulation

Many BIM solutions include performance simulation tools for mechanical, electrical, and plumbing (MEP) aspects of the building design. Only some offer equivalent integrated simulation tools for energy performance modeling. There are also vendors that offer energy simulation tools separate from BIM solutions.

Building energy performance tools can be divided in two parts:

1. **Design tools** – These are meant to size the optimal mechanical and electrical systems, taking into consideration the worst-case scenarios.
2. **Simulation tools** - These include dynamic simulation typically over a one-year duration. They will take three parameters into consideration: the building envelope, the equipment, and the control scenario. They are used to assess

> the energy demand, indoor environmental quality, carbon dioxide emission, and payback periods of energy saving measures.

Simulation tools evaluate the performance of a solution at an early design stage, checking that the global building performance will meet energy regulations or ‘green’ certifications such as LEED, BREAM or EPBD. They can also help in building a predictive control model. As reported by Navigant Research, “The results of [an energy] simulation are a valuable source of information, not only to compare alternative solutions in the conceptual and design phase, but also for modeling control of the building in the operational phase … This has the potential to save on both CAPEX and OPEX over the life of a building, ultimately adding to the building’s ROI.”[15]

As building envelope and equipment are the key elements, a natural interaction with BIM design tools is expected instead of manually creating an energy model. Today, it is possible to take the architect’s model and leverage that for energy analysis with little or no modification. This analysis can include energy and cost range, solar gains, heating and cooling loads, and lighting.

Today, most energy analysis tools are applicable only at the detailed design stage, when the design is nearing completion, as they require a lot of detailed input that may not be known until later in the process. Very often they also require a separate model from the building model – an energy model. For these reasons, these types of tools tend to be only deployed on particular projects and can require advanced specialist skills to use. However, some BIM platforms offer integrated BEM functionality. This simplifies the workflow and allows for energy analysis as early as the concept stage or as late as the design stage. This aligns with the often-referenced McLeamy Curve by enabling more informed design decisions to be made early in the project lifecycle.[16]

Figure 4

An example of integrated BEM tools within a BIM platform.

Image courtesy Autodesk

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[15] “How BIM Adds Value to Intelligent Buildings”, Navigant Research, 2018

[16] “BIM Aids Process, But Further Promise Lies in Interoperability”, The BIM Hub, 2015

Connecting BEM to BIM

Whether integrated within a BIM platform, or as an external tool, BEM tools typically use the following parameters as the basis of their calculations. Ideally, this information will come from a BIM design tool:

- The building envelope, zones, and rooms
- The building structure
- The equipment
- The control scenarios

The building structure is the core of a BIM design. You would expect that all necessary information needed for the BEM software would already natively exist. Yet, even if the amount of information available on the elements and objects (the 'Level of Development') is high in the conceptual stage, this does not necessarily mean that all these characteristics are applicable for the energy modeling purpose.

The typical examples are rooms and zones. Even if a room is the result of the walls, doors, and window placement, a room needs to be later identified and given characteristics as a room. Some BIM solutions offer the capacity to give a typology to the rooms and to define the characteristic of an office or a kitchen with information related to energy management, but this mainly addresses only the first type of energy design tools.

For comprehensive energy modeling, these characteristics require more attention. This includes the level of details and the level of definition of energy characteristics.

Equipment as BIM objects

As noted above, each piece of equipment in a building design is considered a BIM object. An object is:

- Classified in a category of equipment – e.g., architectural, mechanical, or electrical
- Composed of geometry (2D and 3D)
- And described by a set of data

The object can be generic or specific to a manufacturer. In the latter case, the description, both in terms of geometry and data, is more detailed and product specific.

Note that each BIM design tool from a different vendor requires objects to be in a format specific to that tool. Thus, object definitions are not typically cross-compatible between BIM solutions.

> "A building information model usually is abounding in data which makes it difficult to be used straight away. Which information stored in the model must minimally be handed over in order to meet the needs of the energy simulation? How can we extract these data from the model and introduce them into the analysis software?"
> *BIM in Design, Construction and Operations*

Level of information

Throughout the design process the *level of information* is increasing. The global building model, as well as each object, can be described with a different depth of information:

- LOD = the geometry (also called Level of Development) is more and more accurate.
- LOI = the level of information describing the equipment and the building model.

For an energy modeling purpose, the content and quality of data is largely dependent on the input from the designer of the model. Therefore, there is no guarantee that energy related information is present. For comprehensive energy analysis, the minimum information required is:

- The power consumption of the equipment
- The heating or cooling capacity in the case of HVAC equipment

Absence of data standardization

The biggest challenge facing BEM and BIM interaction is that there is no established standard or database to define energy-related properties, especially for energy modeling.

For sizing and design purposes, some local initiatives have attempted to unify a format and a database. For example:

- In France, EDIBATECH is proposing both a format and database of HVAC equipment suitable for HVAC system design.
- In Germany, similar initiatives are under development by organizations like BDH.
- Australia has a well-developed standard named BIM-MEPaus.

Likewise, other countries are embarking on their own standards. This is aided in part by the classification systems currently available from Omniclass and Uniclass, defining service and equipment categories.[17]

Level of integration

In a BIM design and build process a large suite of tools is needed for different purposes:

- The building model is generally created with BIM tools
- Structural and MEP models are produced using similar tools
- Other tools are used for clash detection

As each tool is proprietary, integration between them is typically enabled by industry-standard protocols, such as IFC.

Similarly, data needs to be transferred from a BIM tool to a BEM tool. When the BEM tool is integrated within the BIM tool, this transfer is simplified. When the BEM and BIM tools are separate and from different vendors, this is more challenging.

BIM software packages offer several possibilities for extracting model data. One option is to generate 'lists' or 'schedules', then create an output file in one of the industry-standard protocol formats:

- **IFC** = Industry Foundation Classes. IFC is "the open and neutral data format for openBIM." It is an output format for sharing with different applications and groups. The limitation of this format is that it cannot be edited. Therefore, any required changes must be done at the source (i.e. within the BIM software).
- **gbXML** = Green Building XML.[18] "An industry supported schema for sharing building information between disparate building design software tools…Allows disparate 3D building information models (BIM) and architectural / engineering analysis software to share information with each other."

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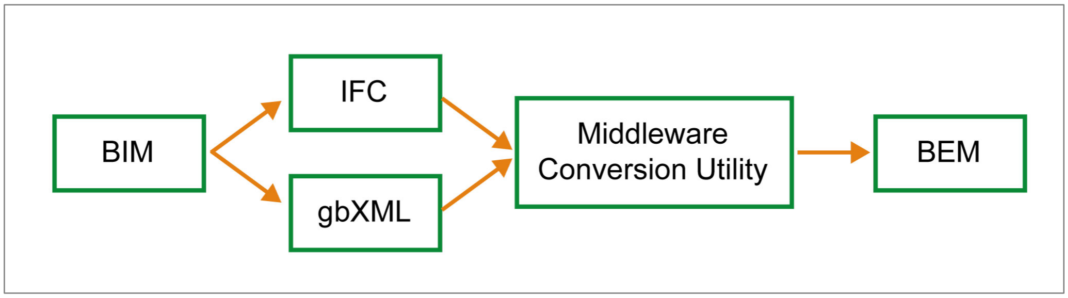
[17] "BIM Classification: giving your models some class", AREO blog, 2016

[18] gbXML.org

Errors may occur for various reasons in this process. Geometry model errors can occur due to the BIM modeler and the differences between the geometry expression methods of BIM and that of the gbXML protocol in the process of exporting BIM data to gbXML. Errors may even occur due to the energy modeler’s mistake(s) or their lack of relevant information or proficiency in the energy simulation process.

Figure 5

Middleware conversion tools can provide a data link between BIM and external energy simulation tools, enabled by protocols such as IFC or gbXML.



Building energy performance modeling based on a BIM model saves considerable amount of time. This time savings can be used to address the above-mentioned issues, ensuring the overall accuracy of results.

Need for active control scenarios

So far, the energy modeling process in most BEM applications only takes into consideration ‘passive’ elements. But energy efficiency also relies on the implementation of an active control scenario.

A building model with room and zone definitions can be complemented by an energy usage and control scenario. This is not currently modeled with BIM or integrated BEM design tools, but some external BEM solutions may offer this extended capability.

> “Although BIM is more expensive in cost and effort at the beginning of a project, the long-term benefits significantly outweigh these additional costs … The extra expenditure necessary to perform additional design effort can be returned multiple times over the life of the asset in the form of a more efficient construction process and operational cost savings in areas such as energy consumption, equipment integration and operation, maintenance process efficiencies, and scoping and implementation of retrofit projects..”
> *Navigant Research*

CASE STUDY: Technopole

As part of its GreenOValley project to bring together Schneider Electric Grenoble-based teams on 5 sites, the recently completed Technopole building showcases the company’s capabilities. The company partnered with Autodesk to use BIM as ‘the operating tools for tomorrow's building.’

Built using the Autodesk Revit platform, the building's digital model is a true mirror of the 'as built' construction. It helped coordinate all professions as the project was carried out. The model was used and updated throughout the construction process until delivery, resulting in a digital reflection of the exact building. The BIM process helped Technopole achieve LEED Platinum green building certification.

But the digital model is also intended to be an energy model, reproducing the energy behavior of the real building. This vision was initiated from the BIM design phase. This digital model will soon be connected to the operating data of the building to be used to support daily operation. As such, it will be at the service of all players in the building (occupants, technical services, site manager, etc.).

Specifically, the model will be used to execute augmented virtual tours, manage spaces, perform scheduling in connection with the building management system (BMS), monitor and manage energy, and perform predictive maintenance.

Conclusion

It has been said that 80% of how a building will perform is decided within the first 20% of design. Now, more than ever before, there is a global need for us to design buildings with the highest possible energy performance. BIM solutions are supporting this goal through support for building energy modeling capabilities.

However, to achieve greater levels of accuracy in energy performance simulation requires BIM solutions to input greater levels of energy-relevant specifications from equipment manufacturers. It also requires a bridge between BIM and actual energy performance once a building is in operation. This will inform better design decisions for subsequent retrofits or new builds, as well as giving facility teams an accurate 'digital twin' they can use to more effectively manage operational sustainability.

These initiatives will require a more standardized approach to BIM energy data integration, which requires the active participation and support of all stakeholders, from BIM developers and equipment manufacturers to architects, engineers, designers, building owners, and managers.

Resources

Standards, specifications, and guidelines

EDIBATECH, France – BIM standard for HVAC objects
http://www.edibatec.org/tag/bim/

BDH, Germany – BIM standard for HVAC objects
https://www.bdh-koeln.de/en/association

BIM-MEP^{aus}, Australia – BIM standard for HVAC objects
https://www.bimmepaus.com.au

Case studies

"Autodesk @ MaRS" - example of generative design
https://www.autodeskresearch.com/projects/autodesk-mars

Example BIM solutions

Autodesk Revit
https://www.autodesk.com/products/revit/overview

Graphisoft ArchiCAD
https://www.graphisoft.com/archicad/

Bentley AECOSim
https://www.bentley.com/en/products/brands/aecosim

StabiPlan Stabicad (for MEP design)
https://www.stabiplan.com/en-us/products/bim-software/

Trimble Electrical Design Software
http://mep.trimble.co.uk/products/design

Example BEM solutions

Autodesk Insight
https://insight.autodesk.com/oneenergy

U.S. Department of Energy, EnergyPlus
https://energyplus.net

EQUA IDA Indoor Climate and Energy (IDA ICE)
https://www.equa.se/en/ida-ice

IESVE (IES Virtual Environment)
https://www.iesve.com

Example power and energy management solutions

Schneider Electric EcoStruxure Power
https://www.schneider-electric.com/en/work/campaign/innovation/power-distribution.jsp

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