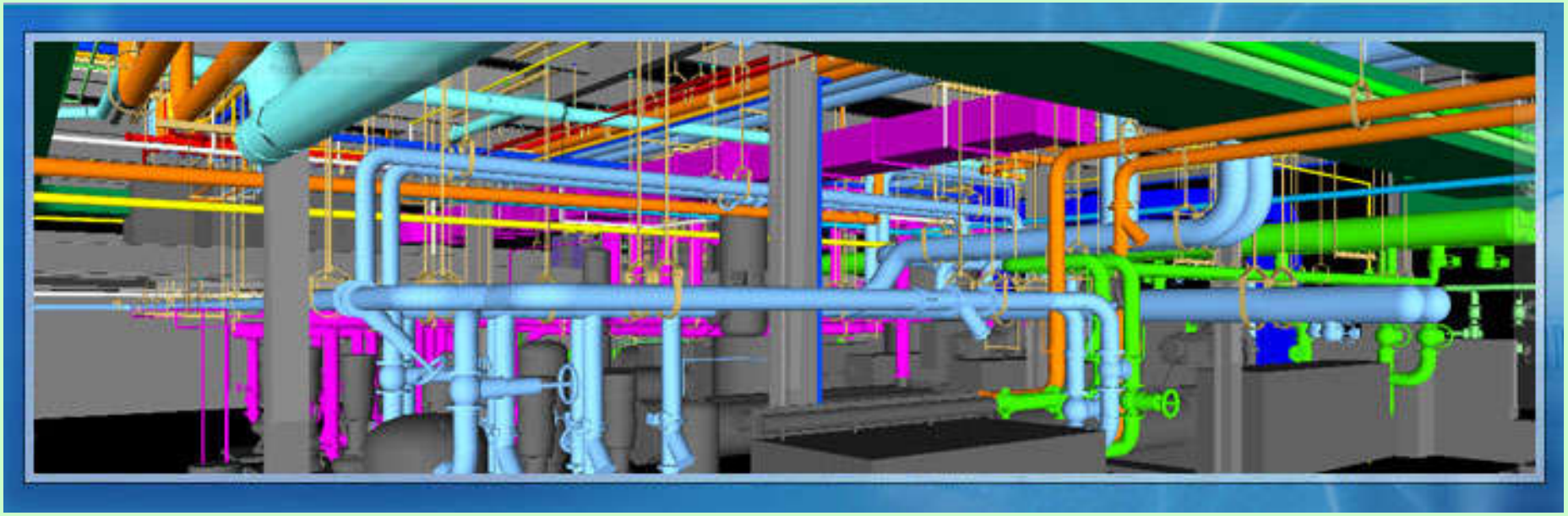
Building Information Modelling (BIM) Training

https://ibse.hk/BIM-Training/



4.1 BIM for MEP

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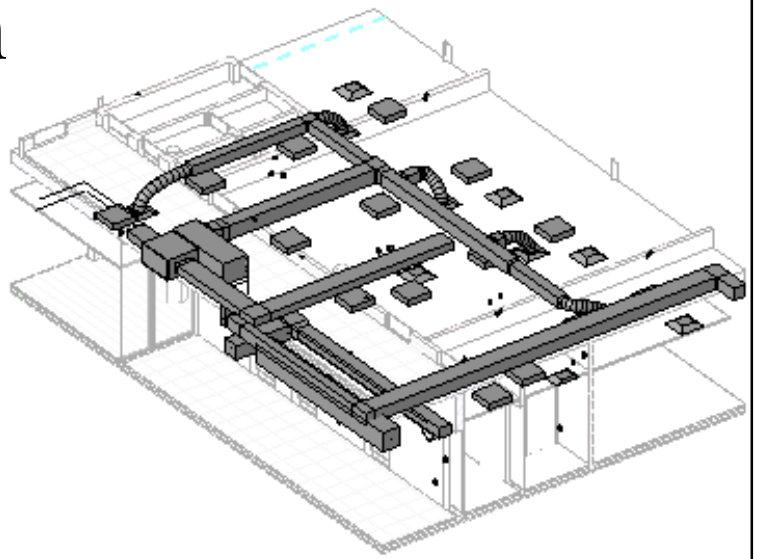
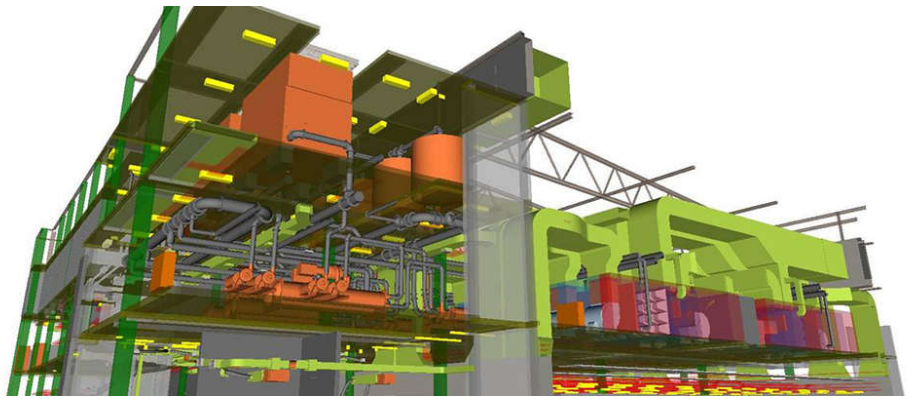
Contents

- Basic concepts
- Potential benefits
- MEP model coordination
- Sustainable design with BIM
- BIM modelling & MEP design
- Other BIM MEP applications

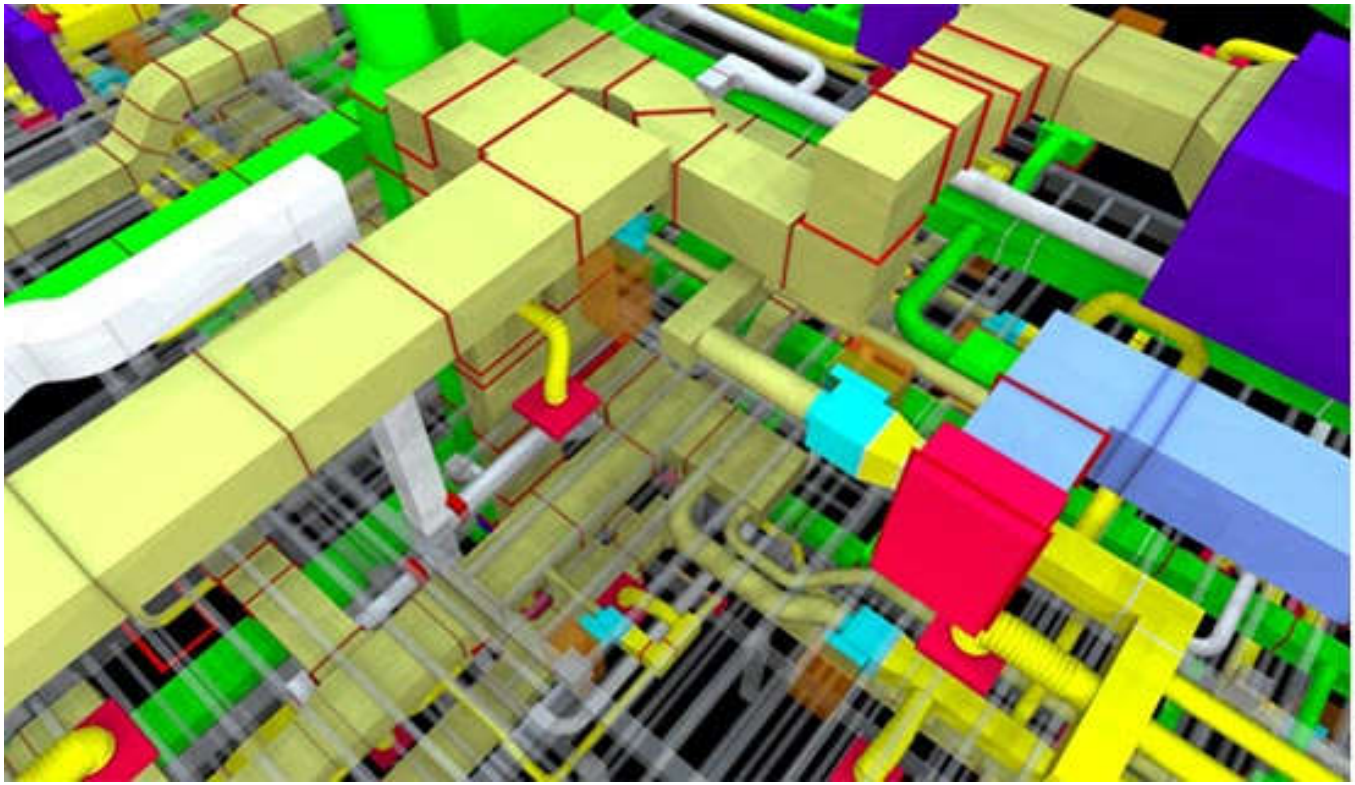


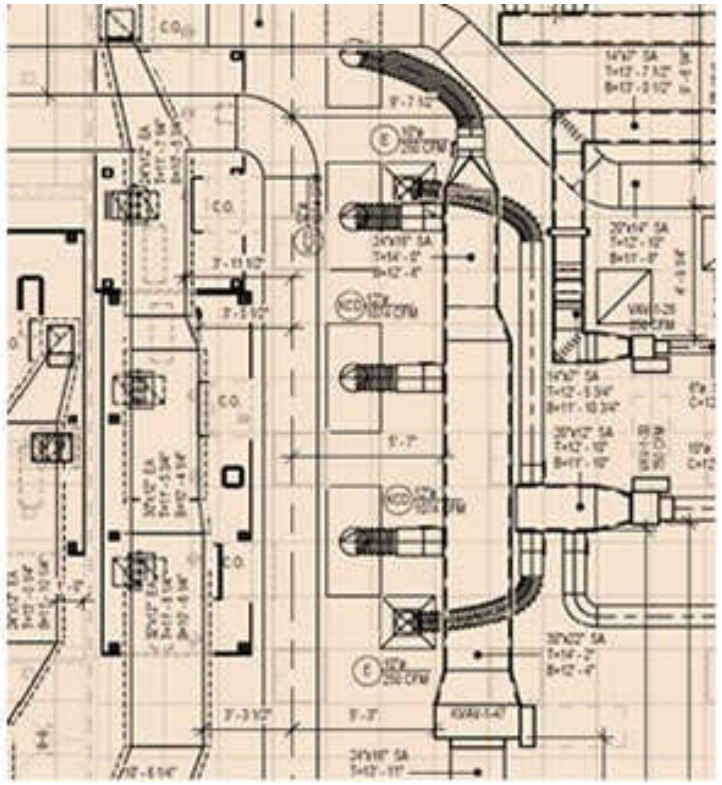
Basic concepts

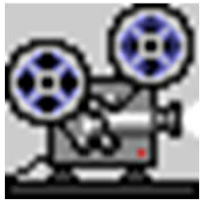
- How BIM can help BSE/MEP engineers?
  - BIM (建築資訊模型) 技術如何持續協助MEP工程人員？ http://itacademia.com/bim-mep-workflow/
  - Early conceptual design 前期概念設計
  - Detailed design and modeling 詳細設計
  - Energy analysis 能量分析
  - Collaboration 協同設計
  - Visualization 可視化



BIM: integrated tools for connection workflows for MEP engineering and design; use tools for conceptual design, analysis, and detailing coordination of building systems.







Video: What can MEP engineers do with the Autodesk AEC Collection? (3:20)
https://youtu.be/V6CiZzG5Qsk

Basic concepts

- Using BIM to improve BSE/MEP design
  - 1. Computable building model
    - A (virtual) model in software that can be operated on by a computer as a building
  - 2. Holistic BSE/MEP design
    - Such as automatically configure electrical load requirements to dynamically change in mechanical equipment specifications
  - 3. Parametric change management
    - Schedule, cost, building performance, and so forth
  - 4. Avoiding interferences
    - To overcome the challenges of fitting the components into tight spaces, and then provides interference checking to detect collisions

Basic concepts

- Computable building model
  - Test the performance of their design, eliminating the time-consuming task of transferring data manually
  - Support performance-based design (to meet certain codes/standards)
- BIM for MEP design
  - The data centric design
  - Increase design insight
  - Increase coordination
  - Enhance communication
  - Parametric change management

Basic concepts

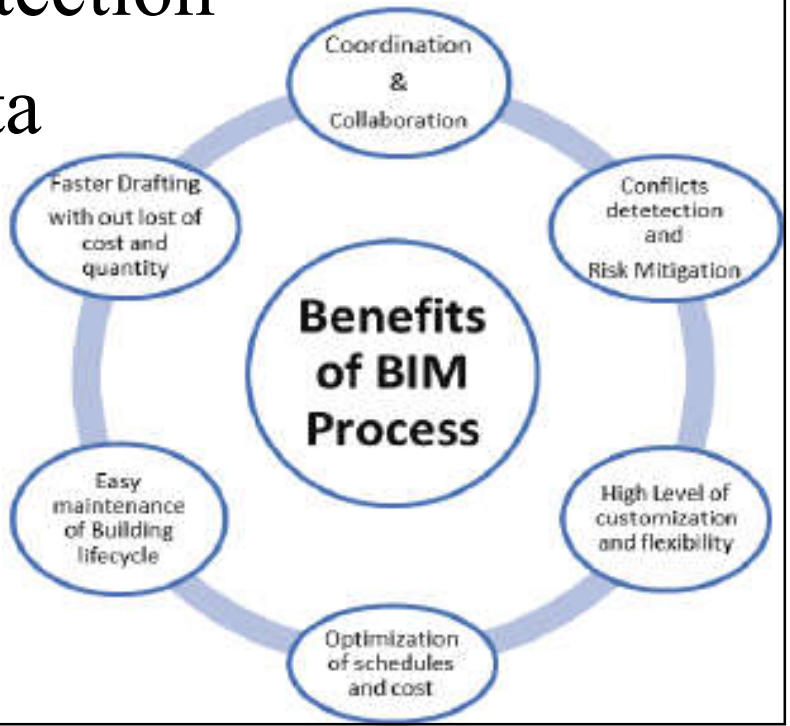
- BIM in the design process
  - The BIM approach offers access to critical design, schedule, and budget information as well as the integrated automatic updates, that create savings in time and money
- BIM in construction
  - With easy retrieval of information using BIM, contractors are able to quickly produce estimates, propose value-engineer items for projects, produce construction planning details, understand and coordinate construction documents, increase in speed of delivery and improve visualization of the project

Basic concepts

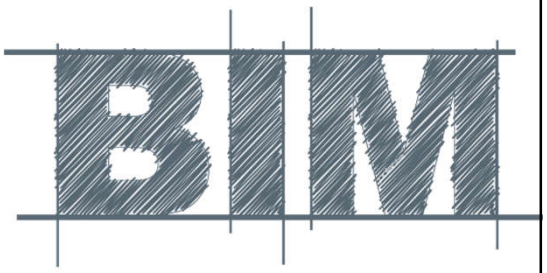
- BIM in building management
  - BIM can be used to collect information on the use and performance of the actual building once it is built
  - It provides a digital record of renovations and any changes to the building
  - The access to this information improves both revenue and cost management of the building management phase
  - By ensuring that all of the information about the building is available, the amount of time and money spent on managing the building is decreased considerably

Potential benefits

- Benefits of BIM for MEP or BSE:
  - Video: Benefits of BIM for MEP Engineers (3:31) https://youtu.be/C8j4uYF0I-g
  - 1. 3D modelling & collision detection
  - 2. Rich repository of design data
  - 3. Sustainable design processes
  - 4. Competitive advantages

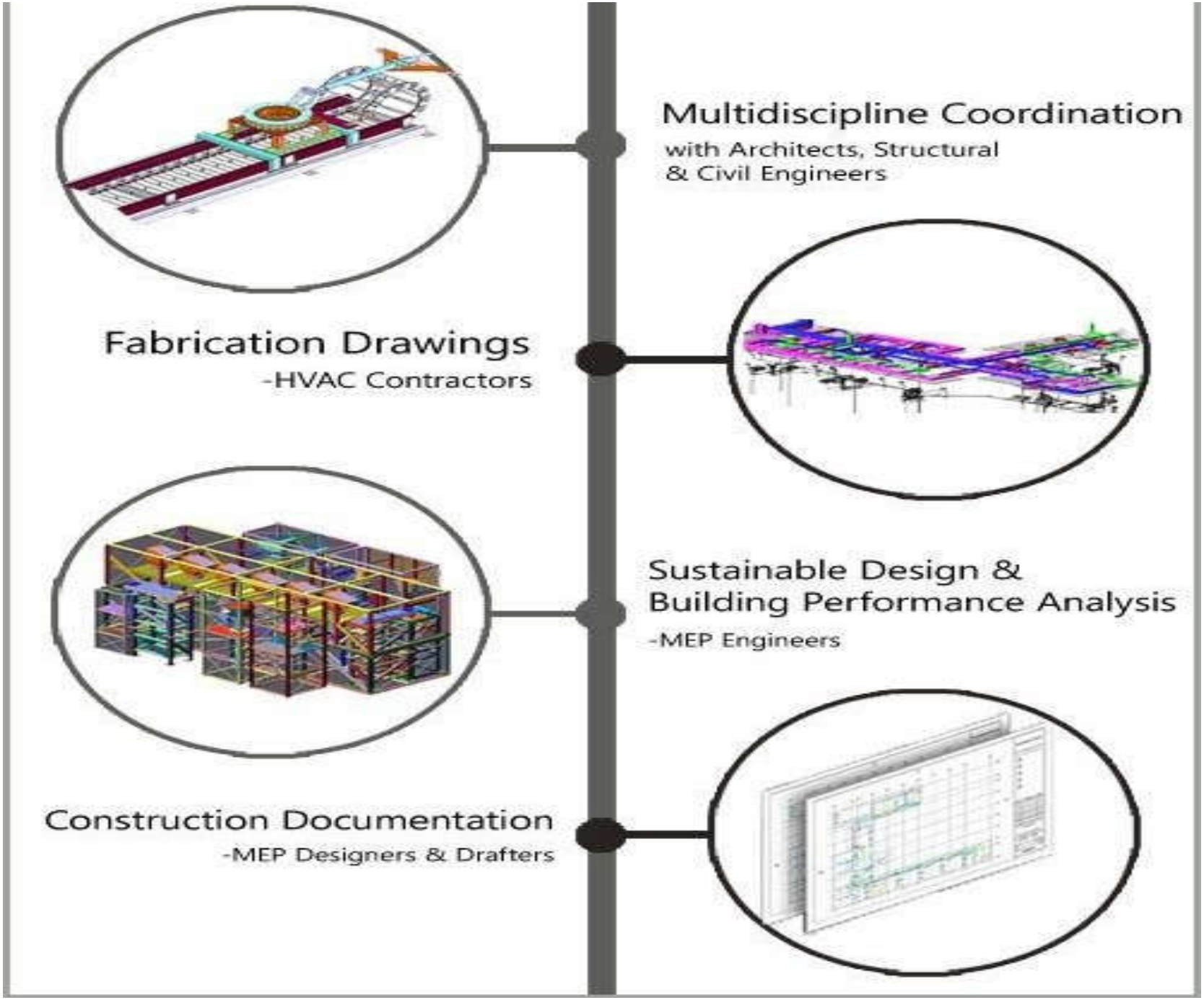


Potential benefits



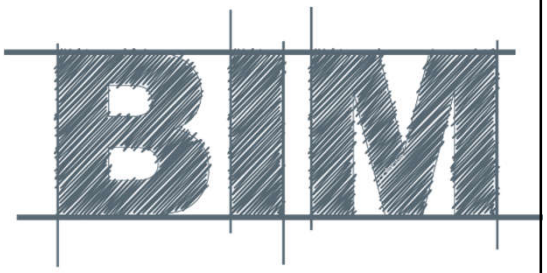
- How BIM can help MEP engineers:
  - 1. Modelling & design: 2D/3D models that helps in identifying loopholes to minimize the cost of reworks
  - 2. Fabrication drawings: by contractors to fabricate building systems & components
  - 3. Construction documentation
  - 4. Sustainable design and building performance analysis

How BIM can help MEP engineers?



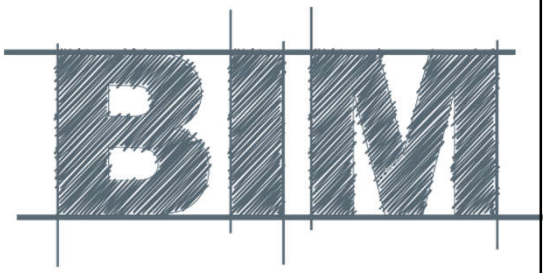
(Source: Is BIM (building information modeling) actually useful for MEP projects? https://www.quora.com/Is-BIM-building-information-modeling-actually-useful-for-MEP-projects)

Potential benefits



- BIM can be used for sustainable design:
  - Optimize design (using analysis software/tools)
  - Daylighting (analyze & promote natural light)
  - Energy analysis (such as solar/sun study, HVAC systems, building energy simulation)
  - Computation of materials (reduce waste of materials & environmental impacts)
  - Reducing waste and inefficiency (at the construction site or during building in use)

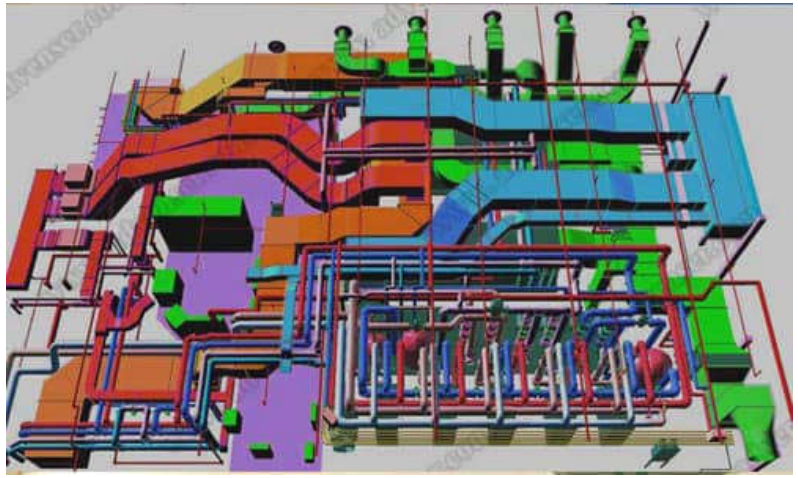
Potential benefits



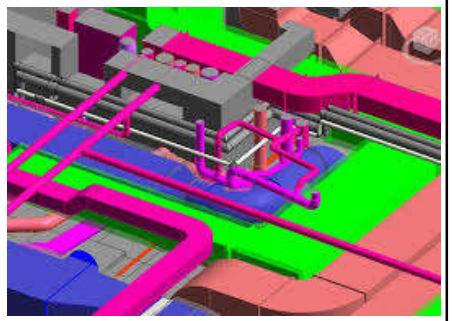
- Sustainable design support:
  - Provides integrated cooling and heating load analysis tools to help you perform
    - Energy analysis, green building assessment (e.g. LEED, BEAM+)
    - Evaluate system loads
    - Produce heating and cooling load reports
- Duct and pipe sizing/pressure loss calculations:
  - Built-in tools to perform sizing & pressure calculations
- HVAC/Electrical space design:
  - 3D modeling of ductwork and piping
  - Electrical color schemes for power loads & lighting

Potential benefits

- Examples of MEP engineering services using BIM
  - https://www.advenser.com/mep-engineering/
  - MEP BIM coordination
  - MEP shop drawings
  - MEP 3D modelling
  - Mechanical room modelling
  - Builders work drawing
  - As-built drafting
  - Piping spooling drawing (pipe assembly)
  - MEP quantity take off

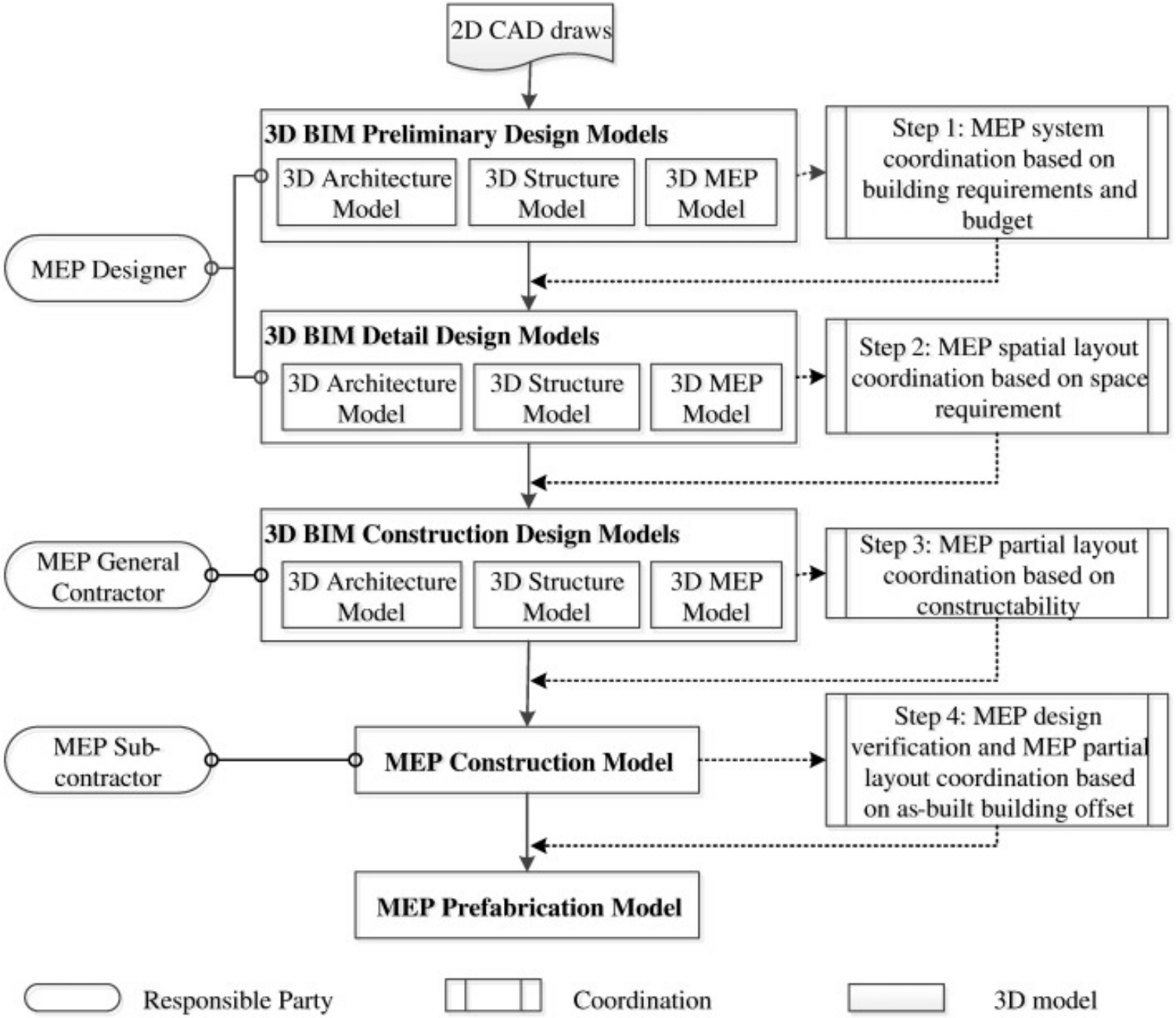


MEP model coordination



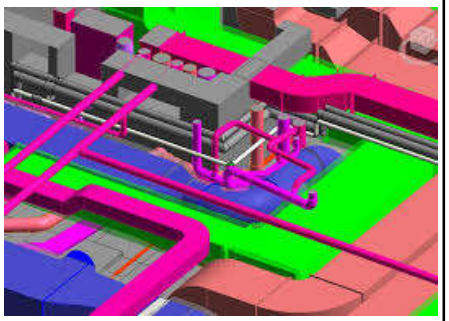
- Models of three major disciplines:
  - Architecture, Structure, MEP
- Five types of MEP models:
  - 3D MEP preliminary design model
  - 3D MEP detailed design model
  - 3D MEP construction design model
  - MEP construction model
  - MEP prefabrication model

Framework for BIM-based MEP layout design and constructability



(Source: Wang J, Wang X, Shou W, Chong H.-Y. and Guo J., 2016. Building information modeling-based integration of MEP layout designs and constructability, *Automation in Construction*, 61 (2016): 134-146.)

MEP model coordination



- Four steps of MEP coordination:
  - 1. MEP system coordination based on building requirements and budget
  - 2. MEP spatial layout coordination based on space requirements
  - 3. MEP partial layout coordination based on constructability
  - 4. MEP design verification and MEP partial layout coordination based on as-built building offset

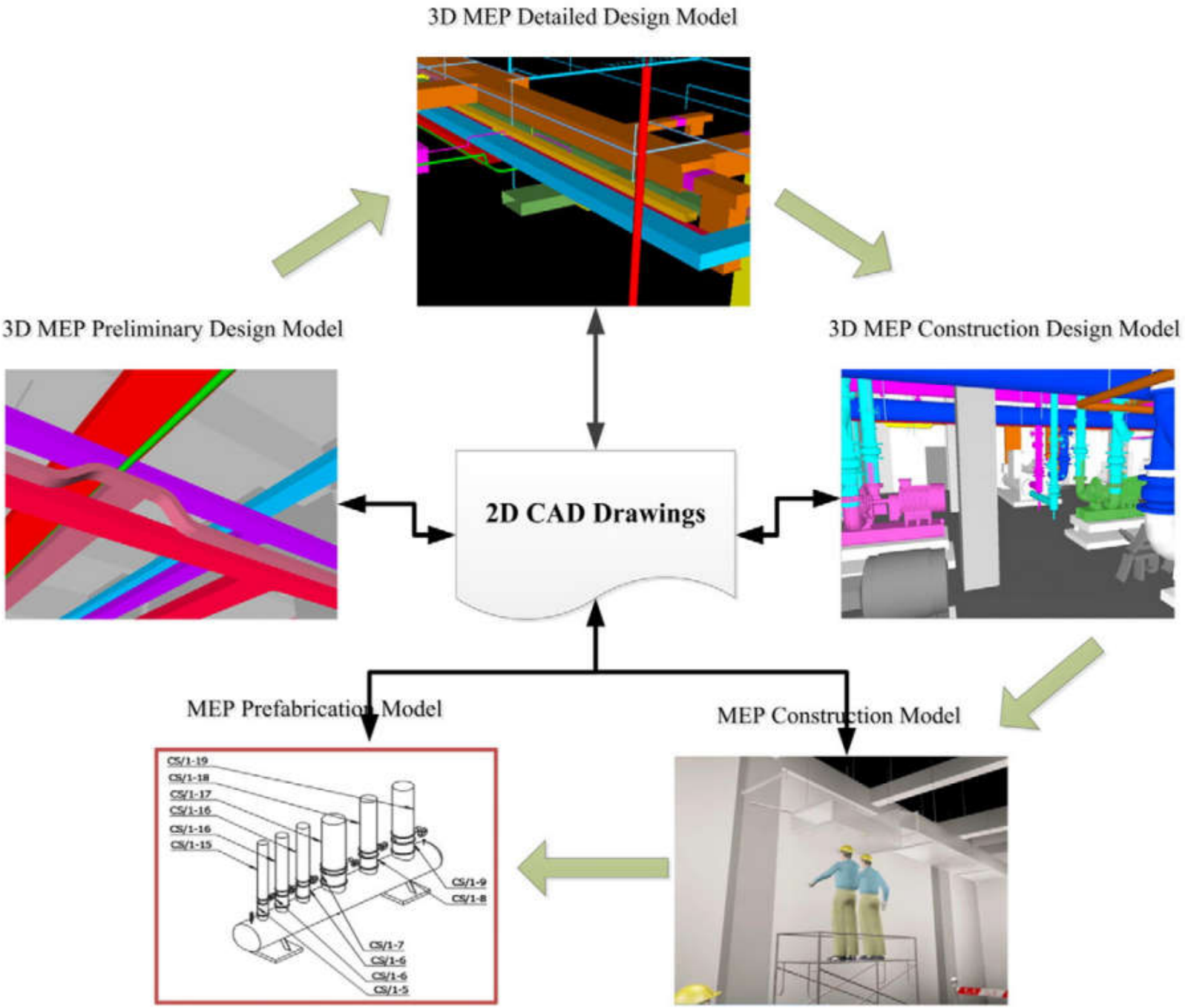
(Source: Wang J, Wang X, Shou W, Chong H.-Y. and Guo J., 2016. Building information modeling-based integration of MEP layout designs and constructability, *Automation in Construction*, 61 (2016): 134-146.)

Level of details (LOD) of model elements in the MEP models

Type of models					
Model elements	3D MEP preliminary design model	3D MEP detailed design model	3D MEP construction design model	MEP construction model	MEP prefabrication model
Architecture (wall and ceiling)	LOD 200	LOD 200	LOD 300	LOD 300	-
Structure (wall, column, beam, floor and steel)	LOD 200	LOD 200	LOD 300	LOD 300	-
Cable tray	-	LOD 200	LOD 300	LOD 300	LOD 400
Conduit	-	-	LOD 200	LOD 300	-
Device	-	-	LOD 200	LOD 300	-
Lighting fixture	-	-	LOD 300	LOD 300	-
Pipe	LOD 200	LOD 200	LOD 300	LOD 300	LOD 400
Valve	-	-	LOD 200	LOD 300	-
Plumbing fixture	LOD 200	LOD 200	LOD 300	LOD 300	-
Sprinkler	-	-	LOD 200	LOD 300	-
Duct	LOD 200	LOD 200	LOD 300	LOD 300	LOD 400
Air terminal	LOD 200	LOD 200	LOD 300	LOD 300	-
Mechanical equipment	-	LOD 200	LOD 200	LOD 300	-

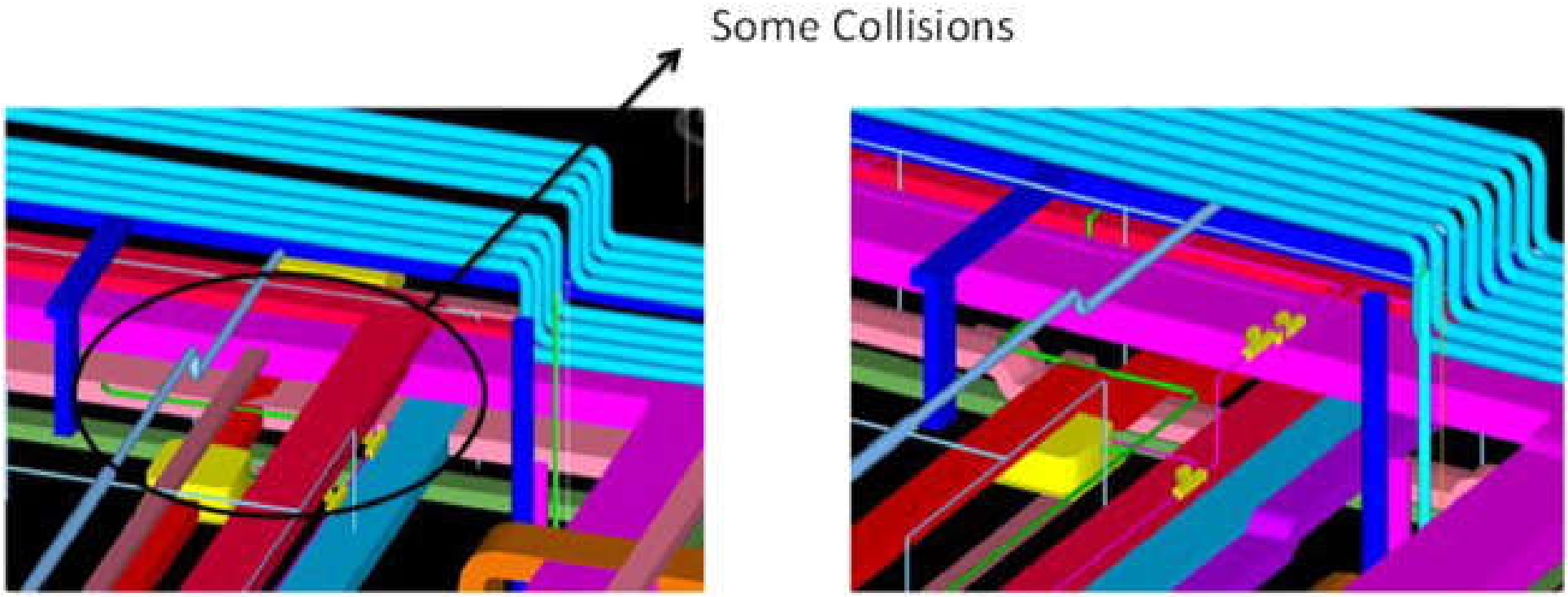
(Source: Wang J, Wang X, Shou W, Chong H.-Y. and Guo J., 2016. Building information modeling-based integration of MEP layout designs and constructability, *Automation in Construction*, 61 (2016): 134-146.)

MEP model development process



(Source: Wang J, Wang X, Shou W, Chong H.-Y. and Guo J., 2016. Building information modeling-based integration of MEP layout designs and constructability, *Automation in Construction*, 61 (2016): 134-146.)

MEP spatial layout coordination for eliminating collisions



(a) Original Design

(b) After coordination

The design experience of the designers was mainly applied to solve the clashes:
(1) Gravity driven plumbing system was firstly considered because of limited space to adjust;
(2) HVAC system usually was secondly to be considered due to the large size of components and high price;
(3) Electrical system with large cables was thirdly considered due to inflexible routing and high price;
(4) Pressure driven plumbing system, fire protection, control system and other small systems were finally considered because of flexible routing; and
(5) Any other rules, such as a small pipe gave way to a big pipe and a cheap component gave way to an expensive component.

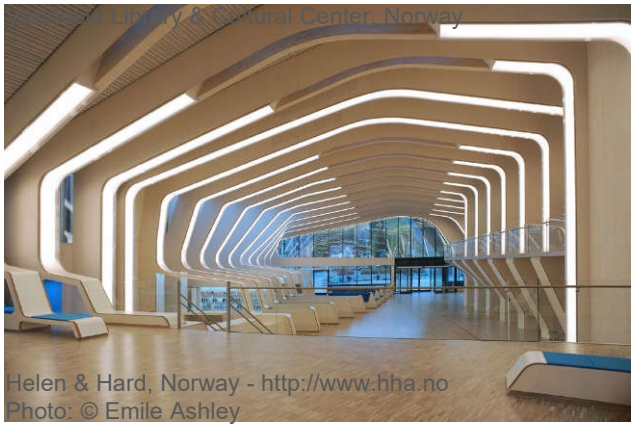
(Source: Wang J, Wang X, Shou W, Chong H.-Y. and Guo J., 2016. Building information modeling-based integration of MEP layout designs and constructability, *Automation in Construction*, 61 (2016): 134-146.)

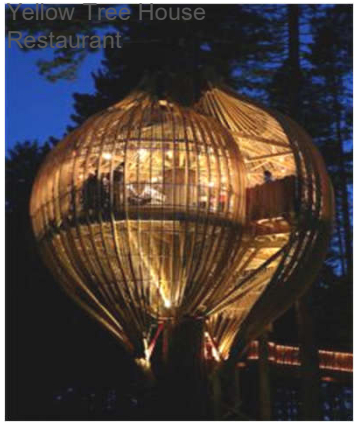
Sustainable design with BIM

- Sustainable design considerations:
  - Understand climate, culture and place
  - Understand the building typology
  - Reduce the resource consumption need
  - Use free local resources and natural systems
  - Use efficient man made systems
  - Apply renewable energy generation systems
  - Offset negative impacts

(Source: Krygiel, E. and Nies, B., 2008. *Green BIM: Successful Sustainable Design with Building Information Modelling*, Wiley Publishing Inc., Indianapolis.)

Sustainable Design Disciplines





Pacific Environment

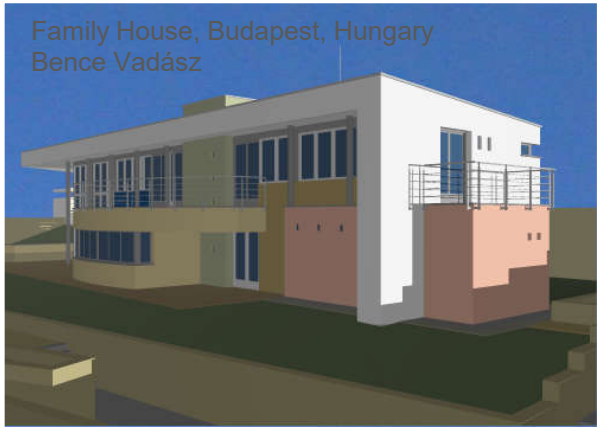
- Sustainable sites
- Water efficiency
- Energy and atmosphere
- Materials and resources
- Indoor environment
- Innovation in design
- Regional priority

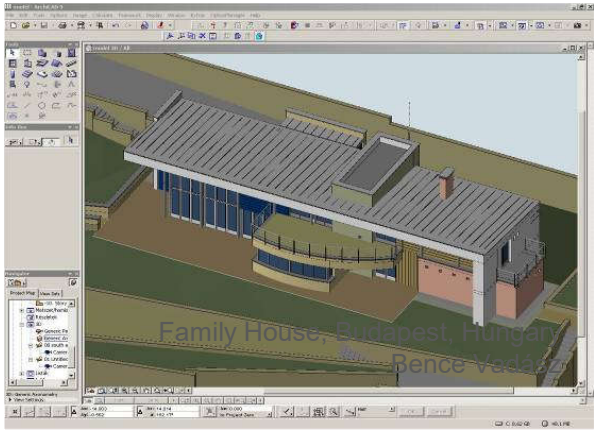
(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

Sustainable Design with BIM

Building Information Modeling

Intelligent building model (virtual building)





(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

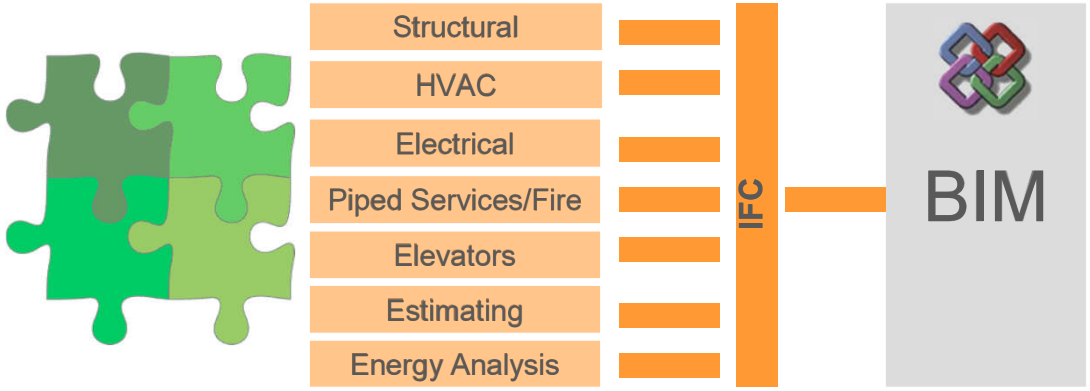
Sustainable design with BIM

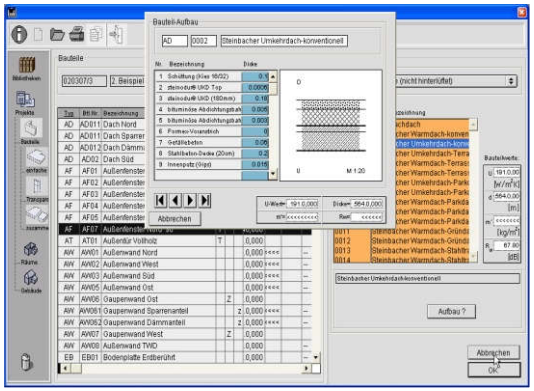
- BIM advantages include:
  - Ability to analyze
  - Ability to evaluate green buildings
  - Access to info to make sustainable decisions
- Performance analysis & evaluation
  - Merge of design & analysis = optimize building performance
  - Better quality of data = minimum errors and miscalculations

Sustainable Design with BIM

BIM as Collaborative Foundation

- Sharing and exchange of BIM information
  e.g. to execute simulations
- Strategic cooperation between software vendors



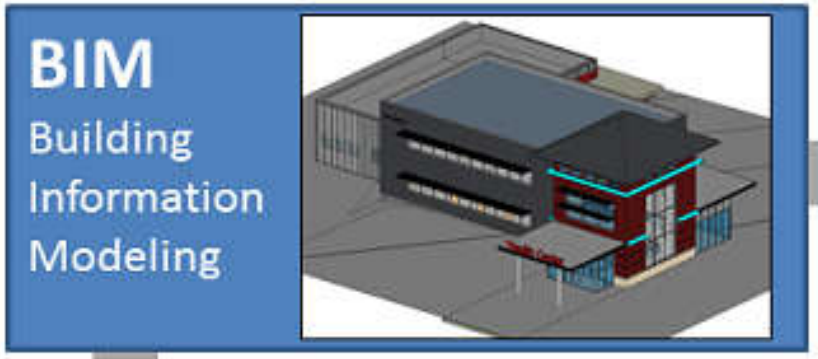


BIM

- Structural Engineering
- Collision Detection
- Code Checking
- Building Performance and energy simulations

(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

BIM and Building Performance Analysis (BPA)

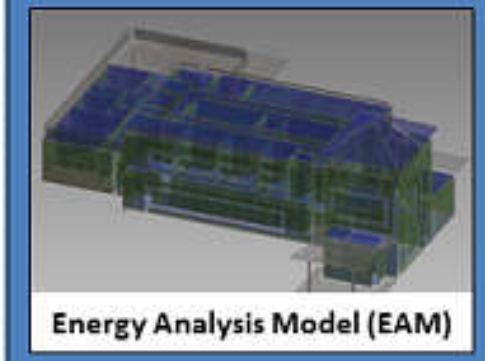


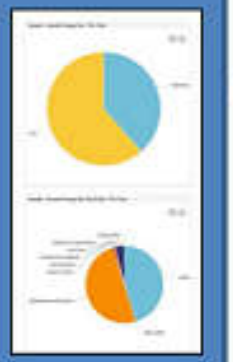
- Visualization
- Structural analysis
- Cost
- Documentation
- Fabrication/ Construction
- Etc...

Building Performance Analysis (BPA)

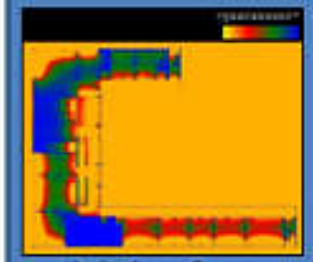
Whole Building Energy Analysis

- Conceptual Models
- Detailed Models

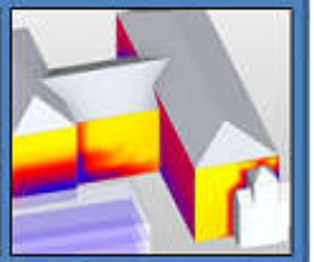


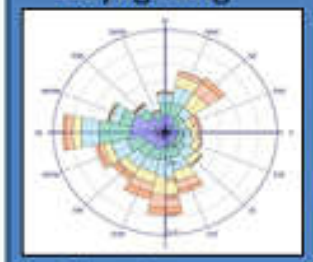


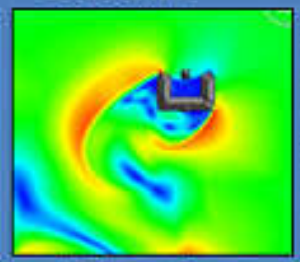
Other Performance Studies


Lighting & Daylighting


Sun & Shadows


Solar Radiation


Climate Analysis

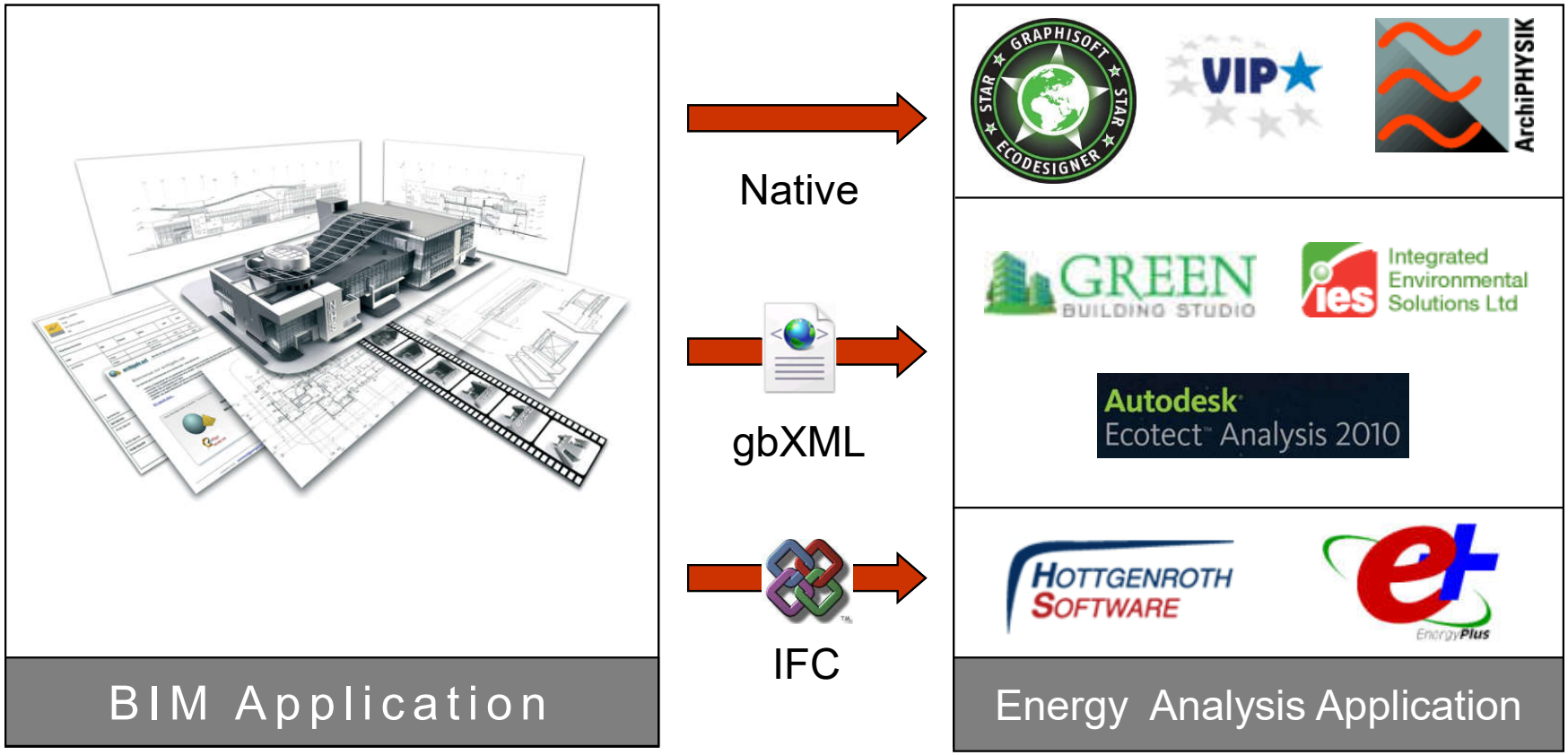

Airflow & Ventilation


Lifecycle Analysis

(Source: Building Performance Analysis (BPA) https://sustainabilityworkshop.autodesk.com/buildings/building-performance-analysis-bpa)

Sustainable Design with BIM

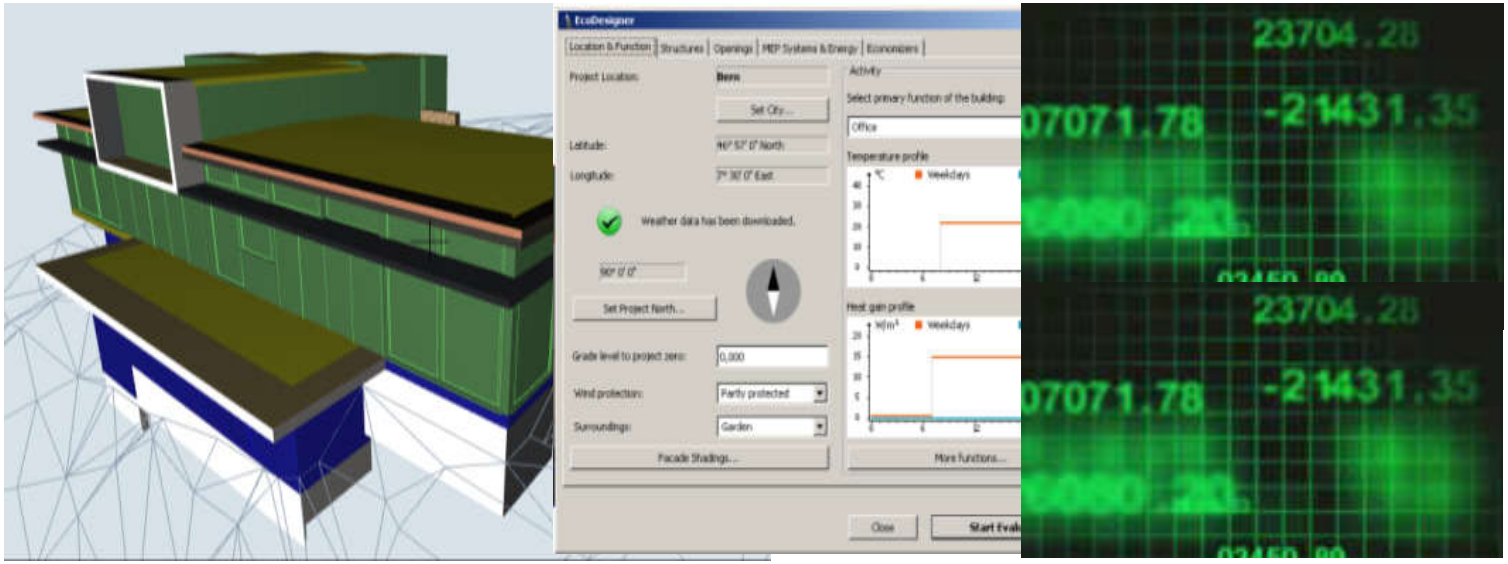
BIM and Energy Software Collaboration



(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

Sustainable Design with BIM

BIM-Integrated Energy Simulation



- Model geometry analysis
- Additional data input
- Annual hourly energy simulation
- Results

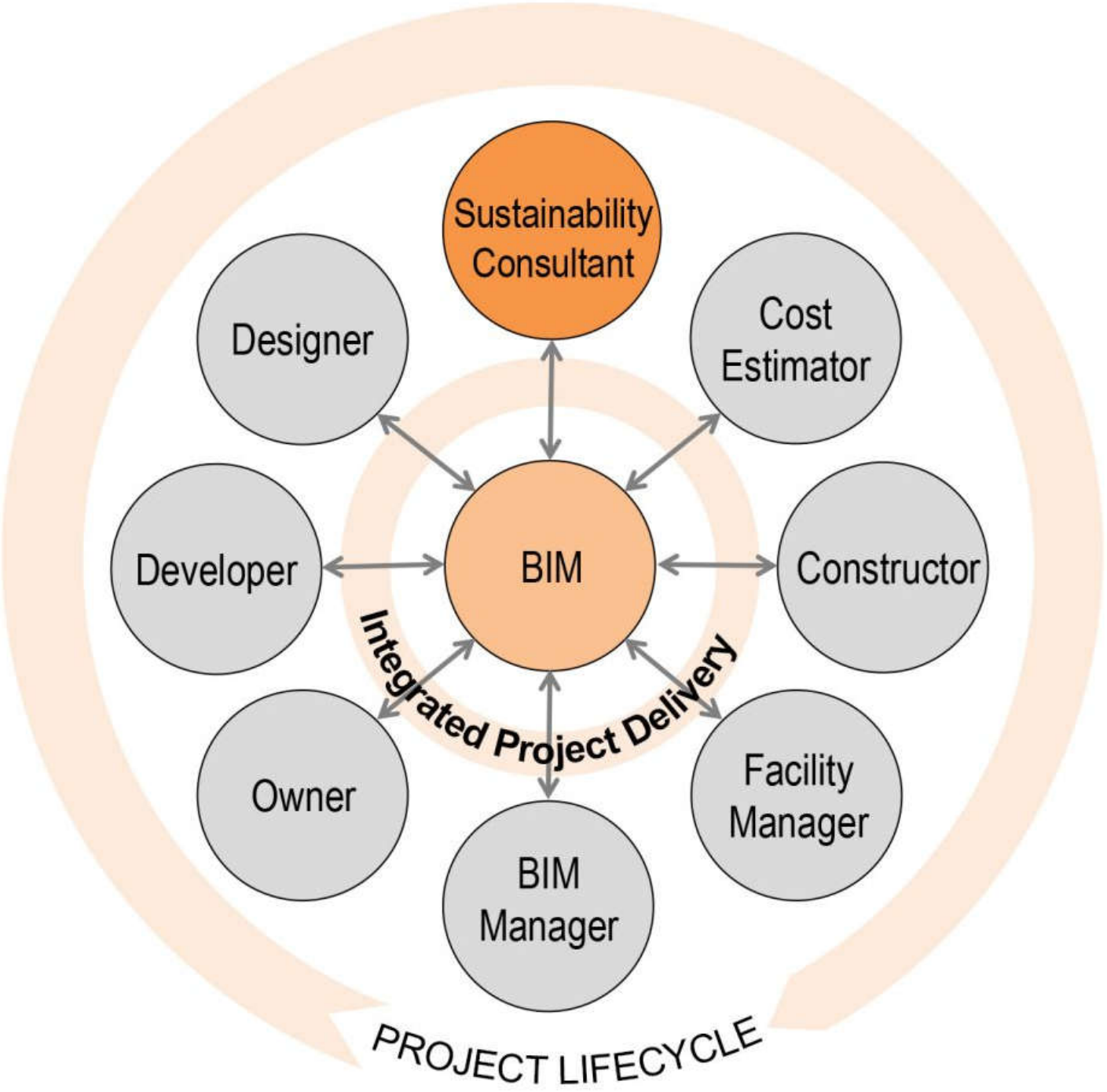
(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

Sustainable design with BIM

- Green BIM in sustainable infrastructure
  - Planning site location and analysis
  - Planning building design and analysis
    - The use of natural ventilation, natural lighting and shading effective measures
    - The use of solar energy
    - Rainwater recycling and waste recycling
    - The use of permeable ground & green materials
    - Focusing on ecological maintenance
    - Energy-efficiency and performance analysis

(Source: Bonenberg, W. Wei, X., 2015. Green BIM in sustainable infrastructure, *Procedia Manufacturing*, 3: 1654-1659.)

Sustainability consultant and BIM for integrated project delivery



(Source: https://www.macrodesignstudio.it/2017/02/14/the-potential-of-bim-as-a-sustainable-design-tool/?lang=en)

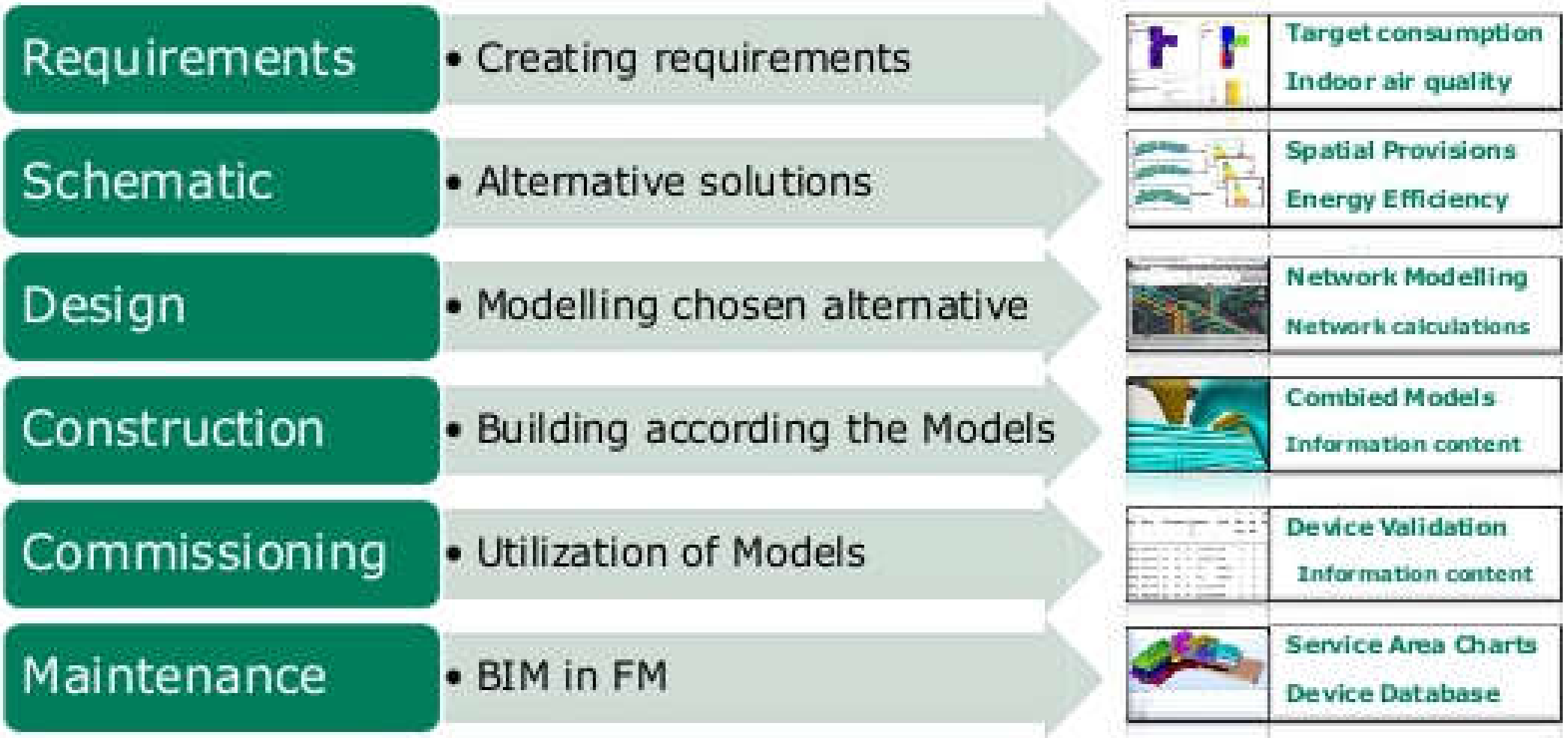
BIM modelling & MEP design

- Need for BIM modelling?
  - There has to be need for models from client
  - Different companies have different opinions about what modelling is
  - Common language is missing without “BIM Execution Plan”
  - BIM modelling is a different way to make design
  - BIM is a tool for designers, contractors & building owners

BIM modelling & MEP design

- BIM modelling requires:
  - Professionalism from every participants
  - Common vision, where to aim in project
  - Wider collaboration then “normal” project
  - Understanding what other participants are doing
  - Mental or cultural change

MEP BIM design process



(Source: MEP BIM design https://www.slideshare.net/TeroJrvinen/mep-bim-design)

BIM modelling & MEP design

- Two major phases of MEP design:
  - 1. Schematic design
    - Gathering requirements from client
    - Develop & evaluate the design concepts & options
    - Simulations & visual information for decision makers
  - 2. Detailed design
    - Modelling building according to the decisions made in schematic design phase
    - Design development to produce detailed design information (for tendering & construction)

(Source: MEP BIM design https://www.slideshare.net/TeroJrvinen/mep-bim-design)

BIM modelling & MEP design

- Schematic design tasks:

Tasks	Methods/Tools
Requirements -> Targets	(Excel / BIM)
Service area charts	(CAD / BIM)
Technical spaces	(discussion with architect)
2D-section drawings	(CAD)
3D-mock-up rooms / spaces	(CAD + combined models)
Main network routes	(CAD + combined models)

(Source: MEP BIM design https://www.slideshare.net/TeroJrvinen/mep-bim-design)

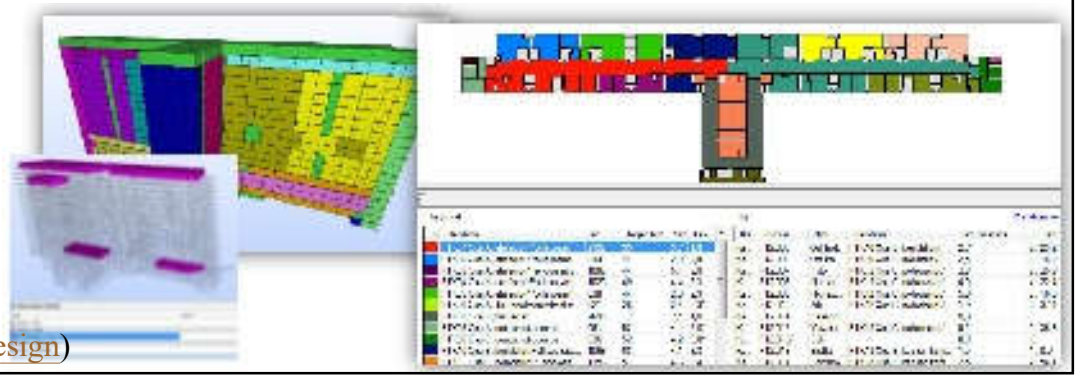
BIM modelling & MEP design

- Space types & requirements -> Targets
  - From the space type, the maximum temperature is decided; then the MEP designer makes comfort & energy simulations for fulfilling the requirements. End result is a target value for each space which MEP designer has to fulfill, such as:
  - Requirement max. 26 ˚C -> simulation -> target value 1.2 kW cooling

(Source: MEP BIM design https://www.slideshare.net/TeroJrvinen/mep-bim-design)

BIM modelling & MEP design

- Service area charts
  - Spaces with requirements are linked to service area charts (such as air handling unit service areas)
  - Linking is made using ifc Spaces (IfcZones are created with external software to IFC file
  - Visualization: Solibri… or some other software which understand IfcZones



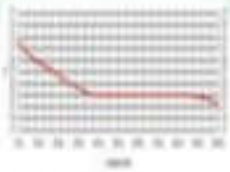
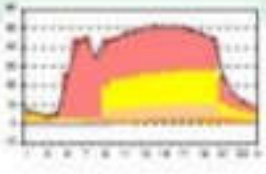
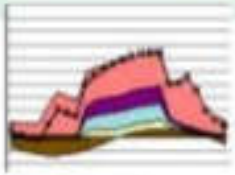
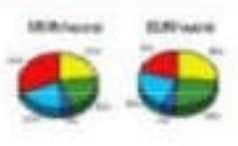
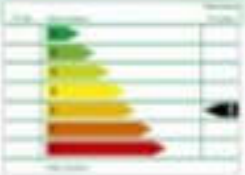
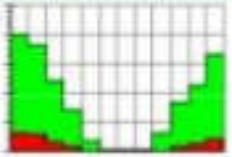
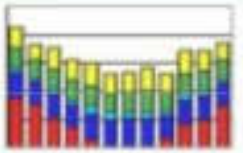
(Source: MEP BIM design https://www.slideshare.net/TeroJrvinen/mep-bim-design)

BIM modelling & MEP design

- Energy and comfort simulations
  - Dynamic simulation of energy and comfort is made according to the requirements, building model and service area charts
  - Every space is simulated
  - Alternative simulations and comparison for different envelopes, windows etc.
    - -> Beginning of LCC (life cycle cost) calculations

(Source: MEP BIM design https://www.slideshare.net/TeroJrvinen/mep-bim-design)

Energy analysis in different phases of building lifecycle

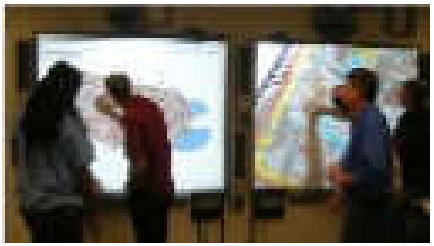
	CONCEPTUAL DESIGN	SCHEMATIC DESIGN	DESIGN DEVELOPMENT	BUILDING PERMIT PHASE	DETAILED DESIGN	CONSTRUCTION	COMMISSIONING AND WARRANTY	OPERATION AND MAINTENANCE
Comfort	• Simulations supporting set up of comfort requirements	 • Comparison of alternatives, ao. solar shadings • Finding solution and update of requirements	 • Further analysis of selected solution • AC requirements: air flows, cooling loads and heating losses	 • Energy survey • Indoor temperature constancy in summer	 • Analysis of detailed design solutions' impact	 • Analysis of contractor's equipment selection impacts	 • Verification of resulted comfort to requirements	 • Comfort performance monitoring and verification to requirements
Energy consumption	 • Simulations supporting set up of energy requirements • In renovations benefitting inventory model	 • Comparison of alternatives, ao. facades, technical systems etc. • Finding solution and update of requirements	 • Further analysis of selected solution • Simulation of building energy consumption estimate	 • Energy survey • Total energy cons. (E-value) • Heatloss balancing • Dimensioned heating capacity • Energy certific.	 • Analysis of detailed design solutions' impact • Update of energy consumption estimate	 • Analysis of contractor's equipment selection impacts • Energy targets for normal operation and 1st guarantee year	 • Requirements management after 1st year of warranty • Update of normal operation target if needed	 • Energy monitoring and verification to requirements • Update of energy consumption target
Initial data	• Architectural as-required model • Inventory model or spatial/space group model	• MEP as-required model • Architectural spatial or space group model • In case of missing window voids, data of window coverage (%)	• Architectural spatial or building element model • Structure, door and window types	• Architectural spatial or building element model • Structure, door and window types • Building block based area and volume information	• Architectural building element model • Structure, door and window types • MEP system data	• Architectural as-built model • Product data of selected equipment	• Architectural as-built model • Updated system operation data	• Measurements of comfort and energy performance • FM BIM models

(Source: MEP BIM design https://www.slideshare.net/TeroJrvinen/mep-bim-design)

BIM modelling & MEP design

- Detailed design tasks:

Tasks	Methods/Tools
2D-section drawings	(CAD)
Network modeling	(CAD + combined models)
Auditing	(combined models)
Visualizations	(combined models)



(Source: MEP BIM design https://www.slideshare.net/TeroJrvinen/mep-bim-design)

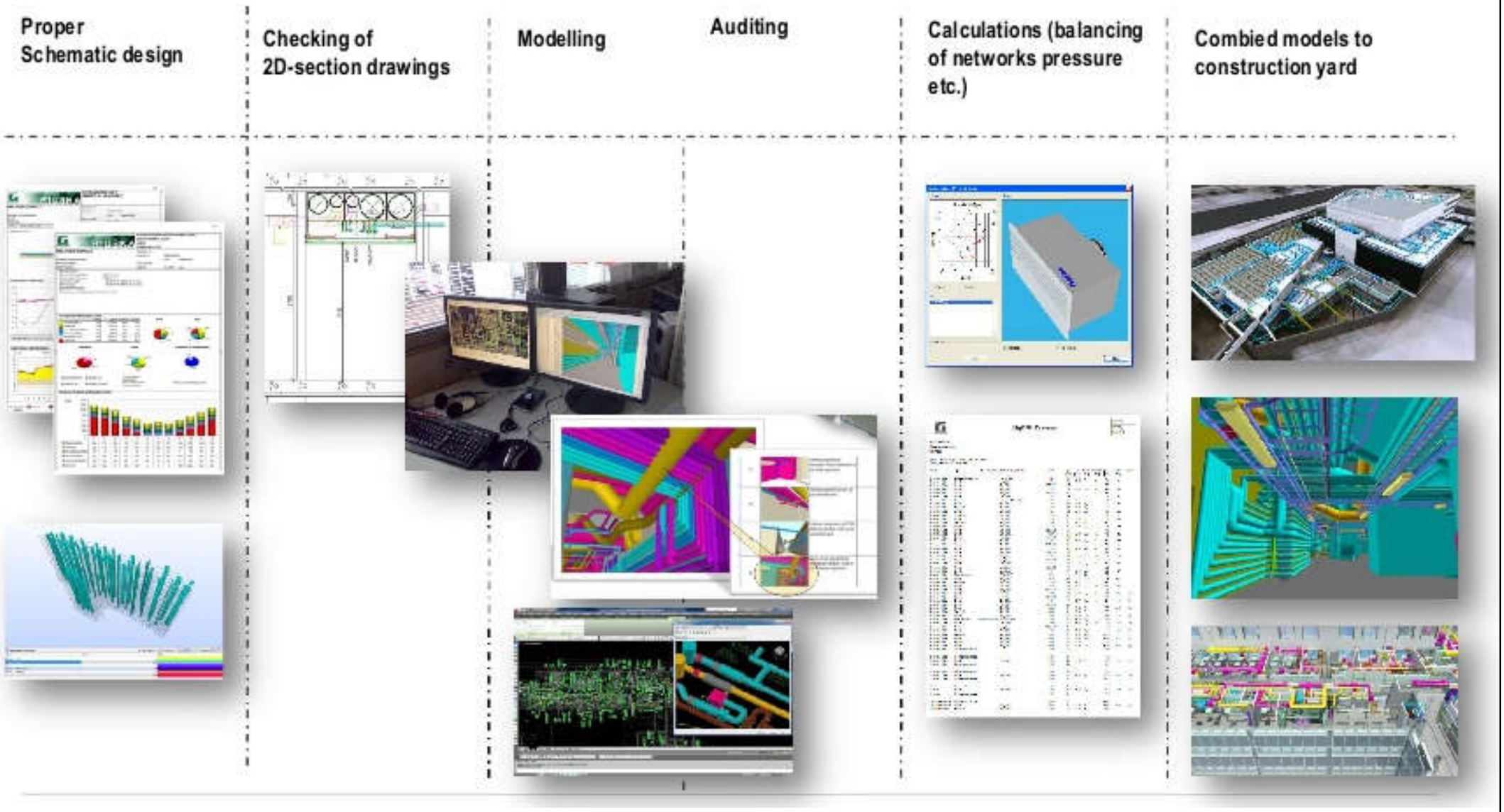
BIM modelling & MEP design

- BIM in design development phase
  - Specify the investment costs, energy consumption, indoor air quality levels & life cycle costs
  - Typical design & analysis tasks:
    - Alternative solutions comparison, sustainability, life cycle analysis, energy and comfort simulations
    - Diagrams and equipment databases, spatial provisions & service area zones
    - Lighting simulations, technical visualizations, 3D-mockups, CFD simulations

BIM modelling & MEP design

- BIM in detailed design phase
  - Detailed design is made according to the design development
  - Combined models, modelling of MEP networks, model auditing
  - Common BIM requirements
  - Route design, BIM-based provision of voids
  - Equipment database, information export from models

Important phases of MEP design



(Source: MEP BIM design https://www.slideshare.net/TeroJrvinen/mep-bim-design)

Other BIM MEP applications

- BIM in construction phase
  - Installations are made according to the detailed design model
  - Combined models
  - Information export from models
  - Model based assembly inspection
  - Revision handling of models, documents and equipment data
  - Equipment validation

Other BIM MEP applications

- BIM in commissioning
  - Information of BIM is used in commissioning
  - Information export from models
  - Target values of energy consumption for facility management
  - As-built model
  - Assembly inspections

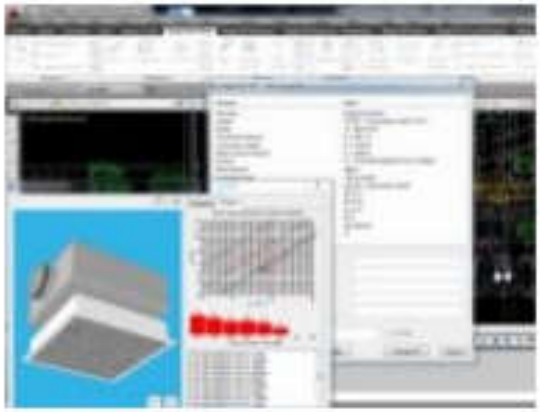
Other BIM MEP applications

- BIM in facility management & maintenance
  - BIM is helping facility management
  - Use of models in facility management
  - Service area zones
  - Equipment database
  - BIM management process during building life cycle
  - Monitoring energy efficiency

BIM to Facility Management (FM): information storage

BIM2FM, 3D-view

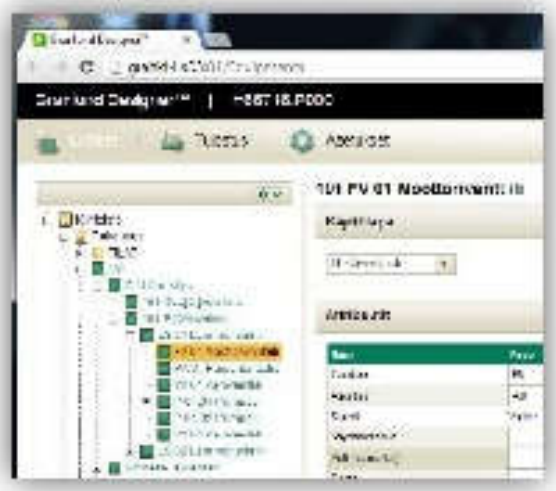
Bim software

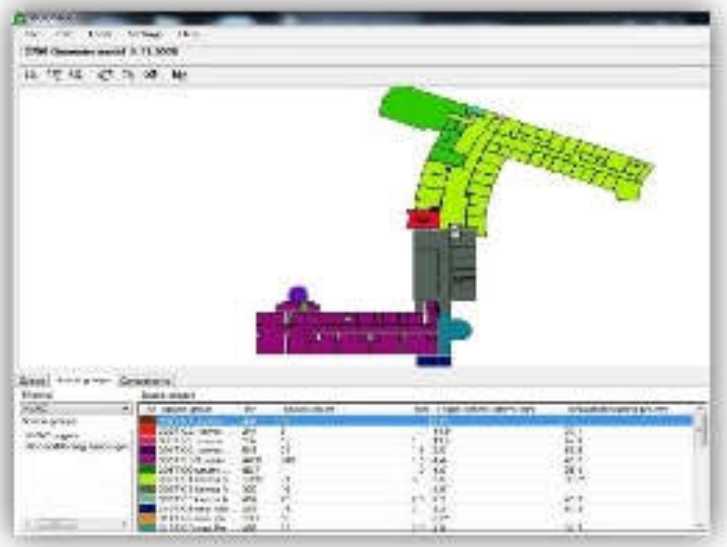


Partial information from Graphical BIM

Partial daily updated information from Equipment database

Equipment Database





Above information also linked To IFC-spaces

BIM2FM: Intelligent 2D IFC-spaceview

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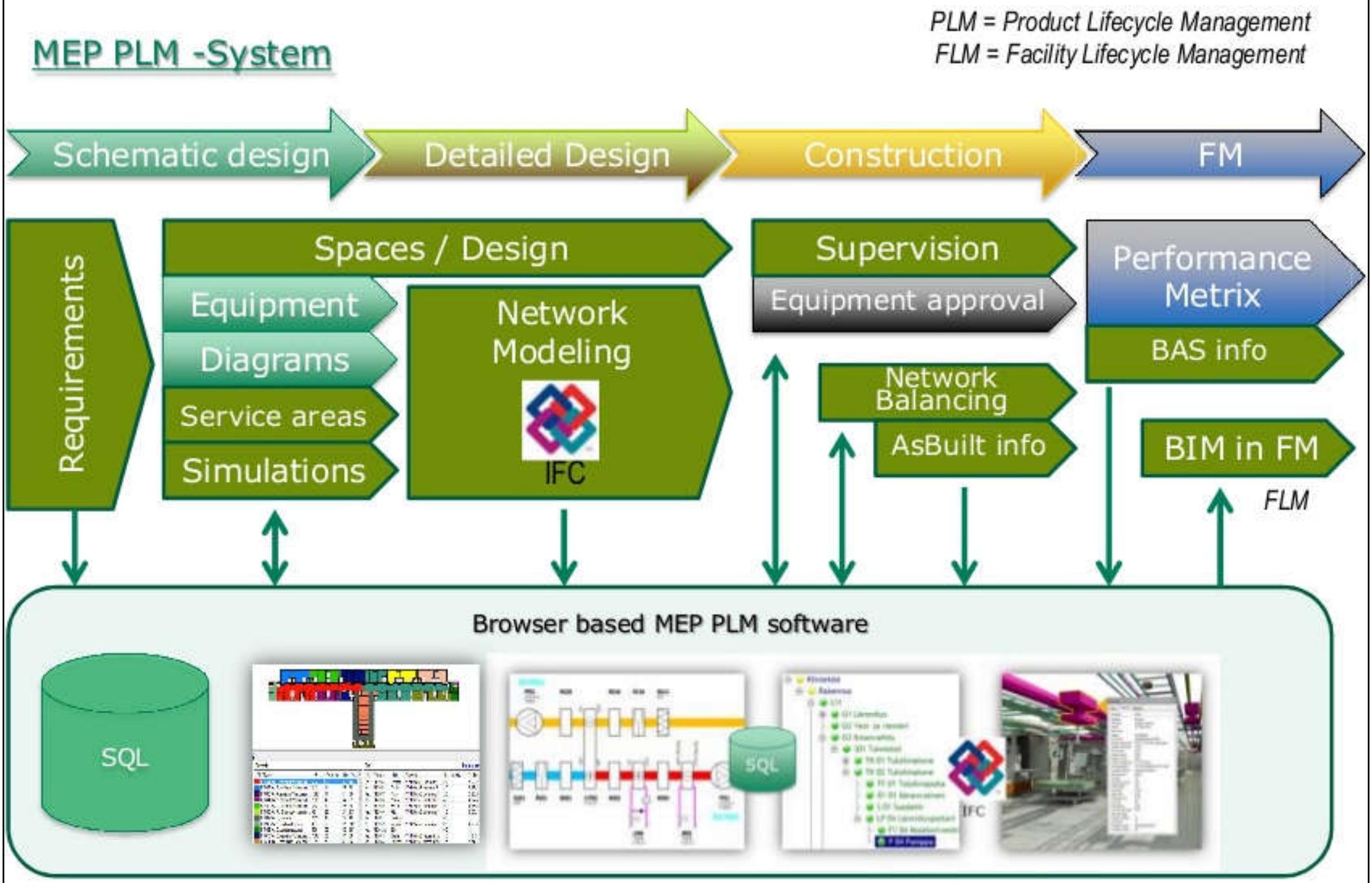
BIM and MEP product lifecycle management



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