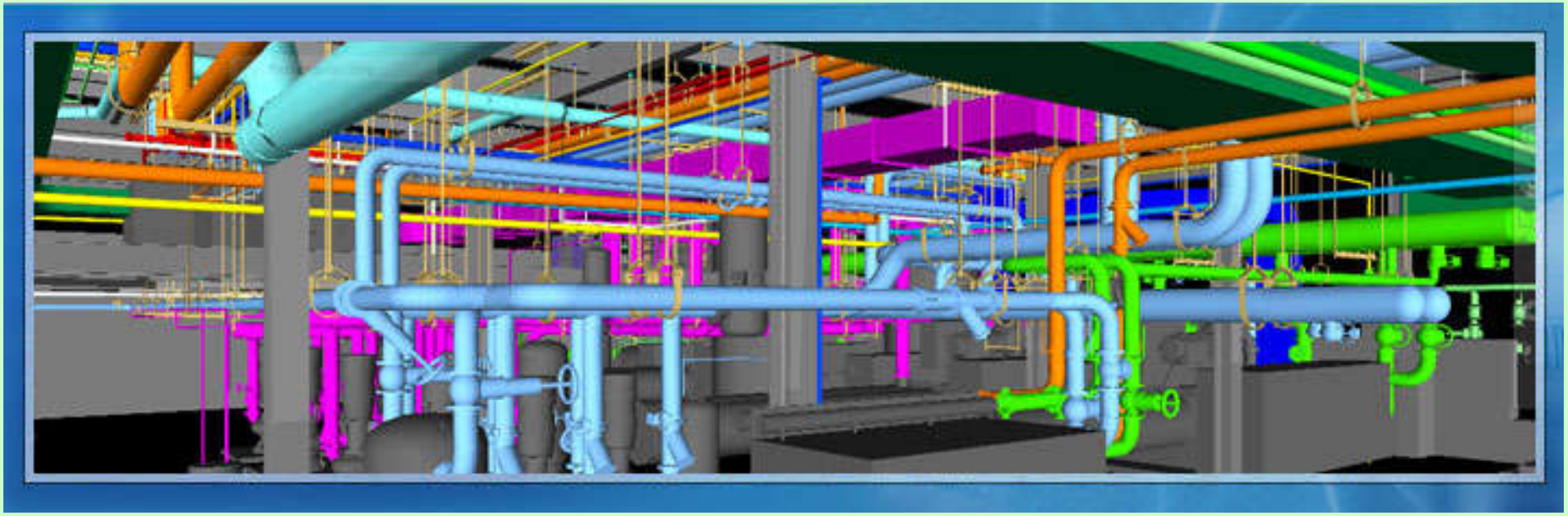
SBM5106 BIM for MEP & Sustainable Building

http://ibse.hk/SBM5106/



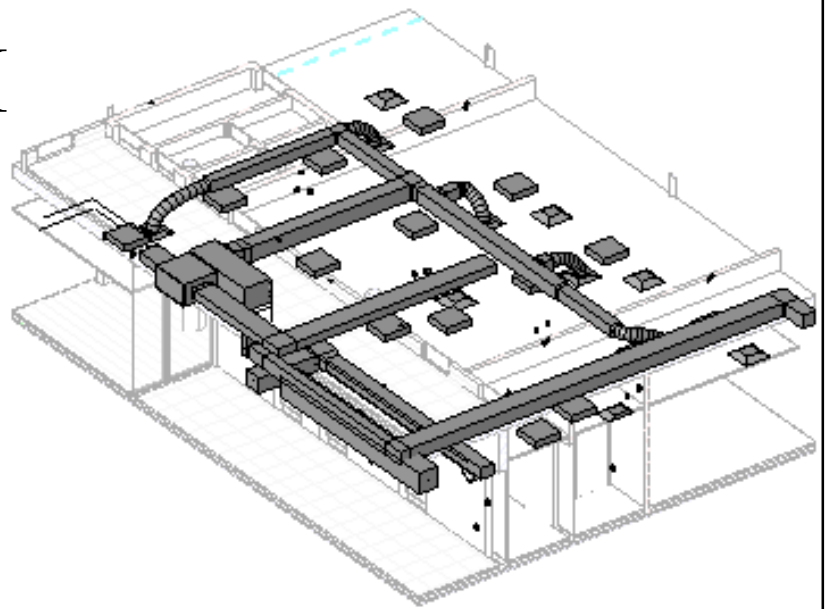
Introduction

Faculty of Science and Technology
Technological and Higher Education Institute of Hong Kong

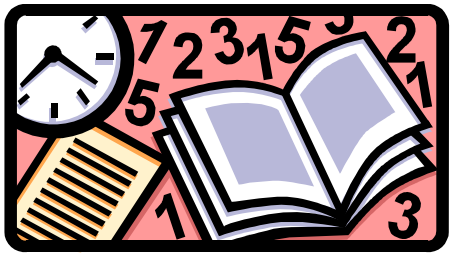
May 2019

Contents

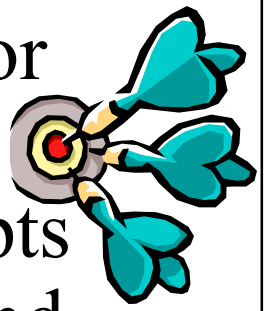
- Background
- BIM for MEP
- Potential benefits
- MEP model coordination
- Sustainable design with BIM



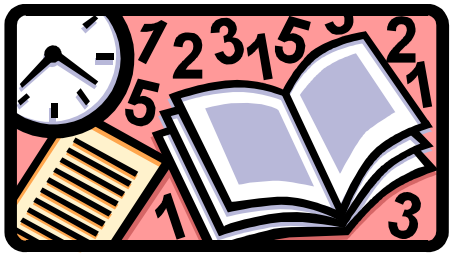
Background



- Module Aim(s):
  - This module examines the critical techniques for using BIM in MEP (mechanical, electrical and plumbing) design and presents the basic concepts of green BIM for sustainable building design and building performance analysis. It will discuss the importance of BIM for MEP coordination and design management. It will also explain the importance of sustainability in building & construction projects and highlight the common techniques and key considerations for achieving sustainable buildings using BIM technology.

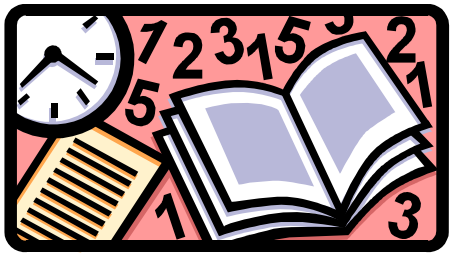


Background

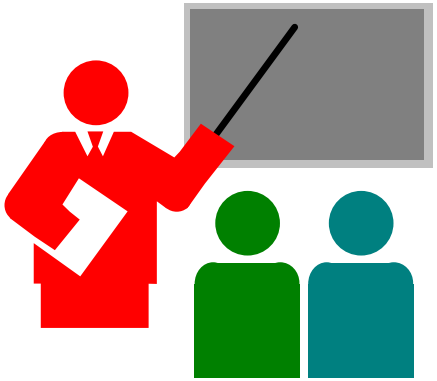


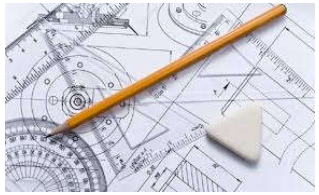
- Learning Outcomes:
  - 1. explain the critical techniques for using BIM in MEP design;
  - 2. apply BIM in MEP coordination and design management;
  - 3. explain the basic concepts of green BIM for sustainable building design and building performance analysis; and
  - 4. apply the common techniques and tools for building performance analysis and environmental design.

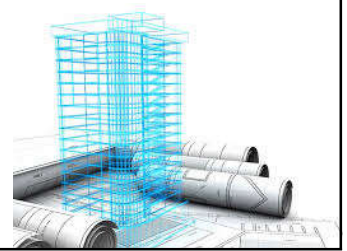
Background



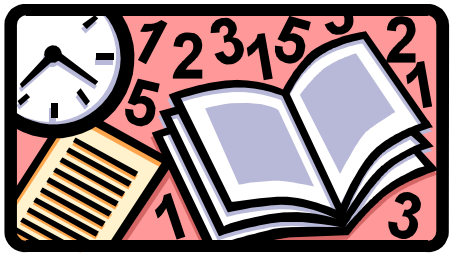
- Module Leader:
  - Dr. PAN Yan, Penny (pennypan@vtc.edu.hk)
- Lecturers:
  - To be confirmed…
- Course Website: (with links and resources)
  - http://ibse.hk/SBM5106/
- Moodle system
  - http://moodle.thei.edu.hk/







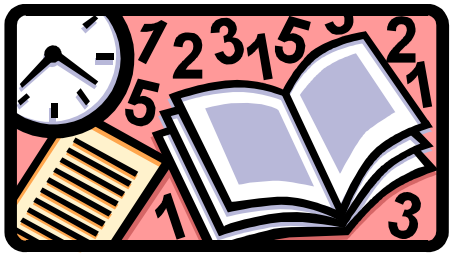
Background



- Assessment Components:
- Assignment (20%):- Week 01-04
- Mini-project (30%):- Week 05-13
- Examination (50%) (3 hours)
  - Details to be confirmed

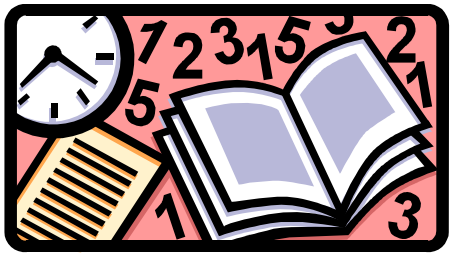
- (*** Attendance to lectures, tutorials & practical sessions is important.)

Background



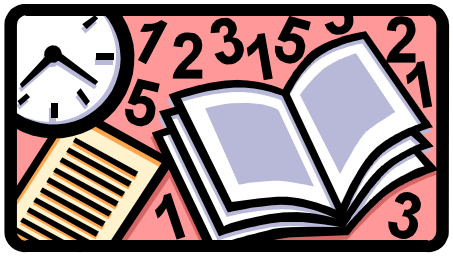
- Study topics:
  - 1. Introduction
  - 2. MEP design considerations
  - 3. MEP design management
  - 4. MEP design coordination
  - 5. Basic concepts of sustainable building
  - 6. Sustainable building design principles
  - 7. Sustainable design with BIM
  - 8. Sustainable design analysis
  - 9. Green operation and maintenance

Background



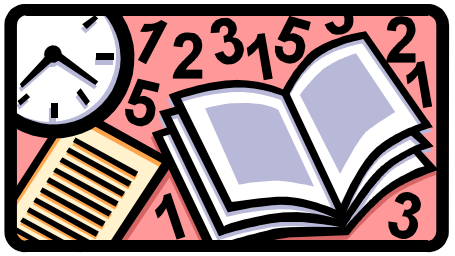
- Learning Methods:
  - Lectures + Further reading
  - Individual assignments
  - Mini-project
  - Group discussions
- Resources:
  - Videos + ebooks
  - Web links + References

Background



- Useful References:
  - Bernstein, H. M., Jones, S. A. and Russo, M. A., 2010. *Green BIM: How Building Information Modeling is Contributing to Green Design and Construction*, Smart Market Report, McGraw-Hill Construction, Bedford.
  - Churcher, D., Ronceray, M. and Sands, J., 2018. *Design Framework for Building Services*, 5th ed., BG 6/2018, Building Services Research and Information Association, Bracknell, Berkshire, England.
  - Krygiel, E. and Nies, B., 2008. *Green BIM: Successful Sustainable Design with Building Information Modelling*, Wiley Publishing Inc., Indianapolis.
  - Lévy, F., 2012. *BIM in Small-scale Sustainable Design*, Wiley, Hoboken, NJ.

Background



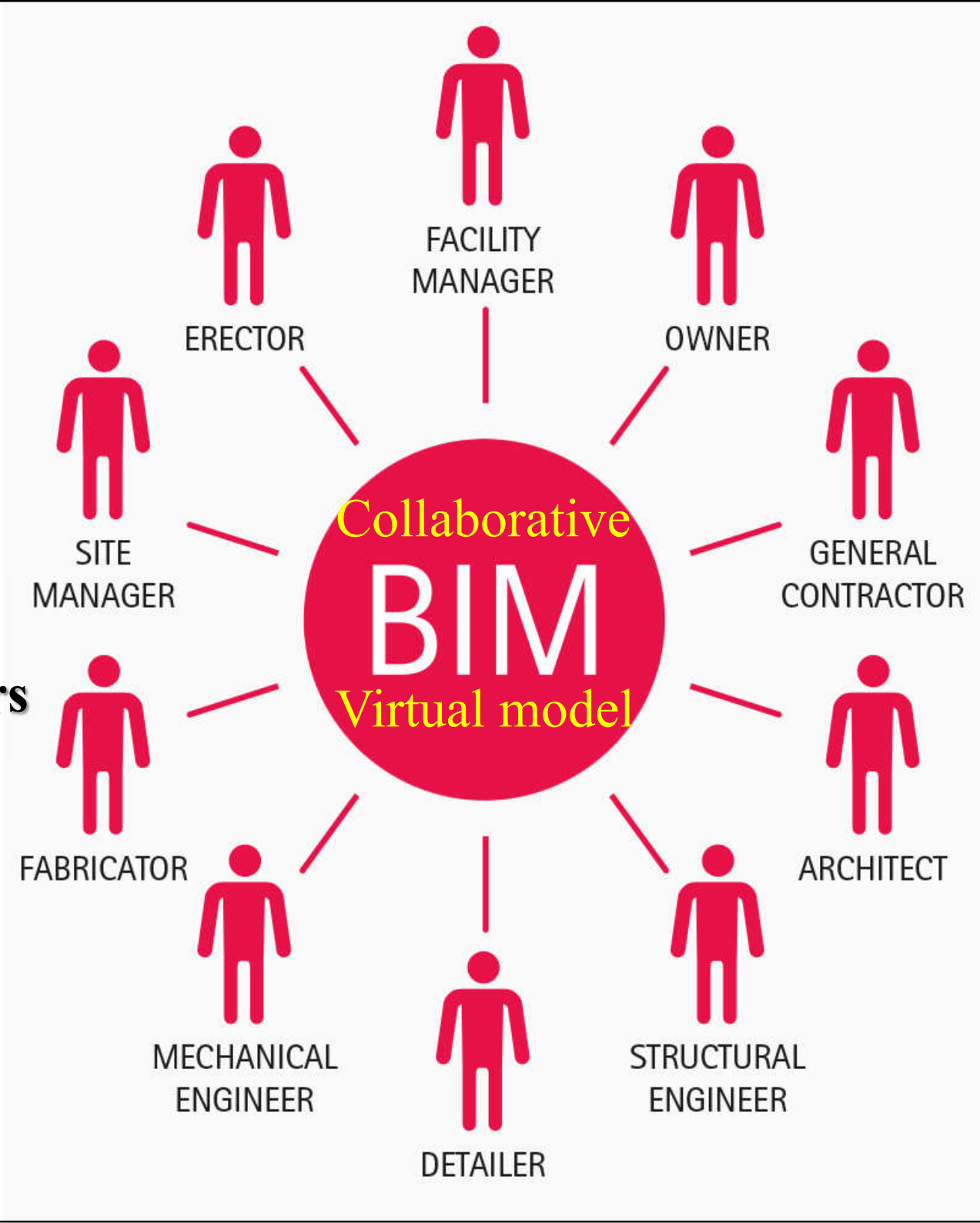
- Useful Websites:
  - Autodesk Sustainability Workshop
    - https://sustainabilityworkshop.autodesk.com/
  - Designing Buildings Wiki
    - https://www.designingbuildings.co.uk/wiki/
  - Whole Building Design Guide
    - http://www.wbdg.org/design/engage_process.php

BIM for MEP

- Building Information Modelling (BIM)
  - It is a model-based technology linked with a database of project information
  - BIM builds a virtual model of the building so that architects, engineers, and contractors can all access at anytime (enhance collaboration)
  - With BIM, architects and engineers are able to efficiently generate and exchange information, create digital representations of all stages of the building process, and simulate real-world performance
    - Many errors are eliminated in the field which increases productivity and improves quality

Facility Manager

Building Owner



Contractors

Suppliers/ Manufacturers

Architect

Engineers

BIM offers automatic coordination of changes to eliminate mistakes and improve the overall quality

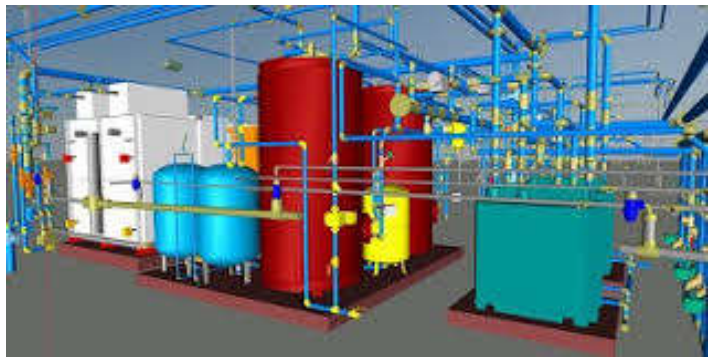
BIM Virtual Model

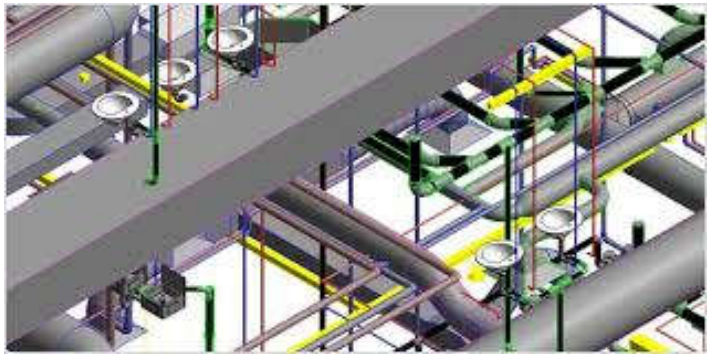
Excel Spread-sheet

Similar to the Excel spreadsheet (with automatic recalculation), whenever a change is made to the project, all the consequences of that change are updated throughout the entire project. This means that the design and documentation are captured at the point of creation and embedded throughout the project.

BIM for MEP

- BIM for BSE or MEP Engineering
  - It is the purpose-built building information modelling (BIM) developed to incorporate non-conflicting design of Mechanical, Electrical, and Plumbing (MEP) engineering in an architectural design of building and to identify the material requirements for complete construction

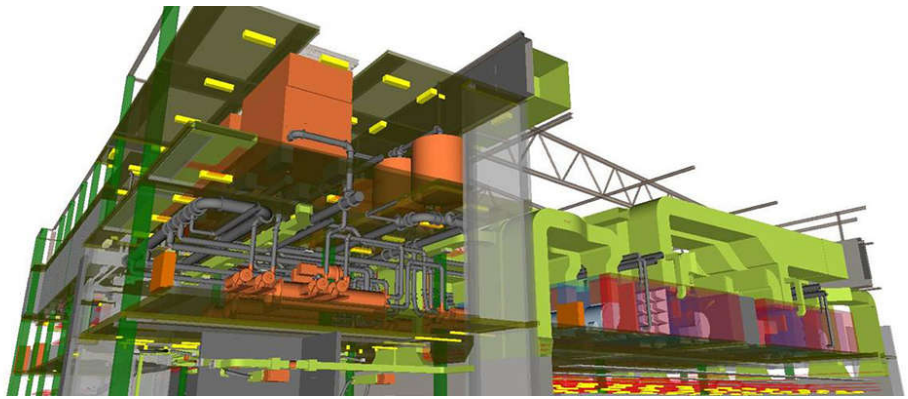




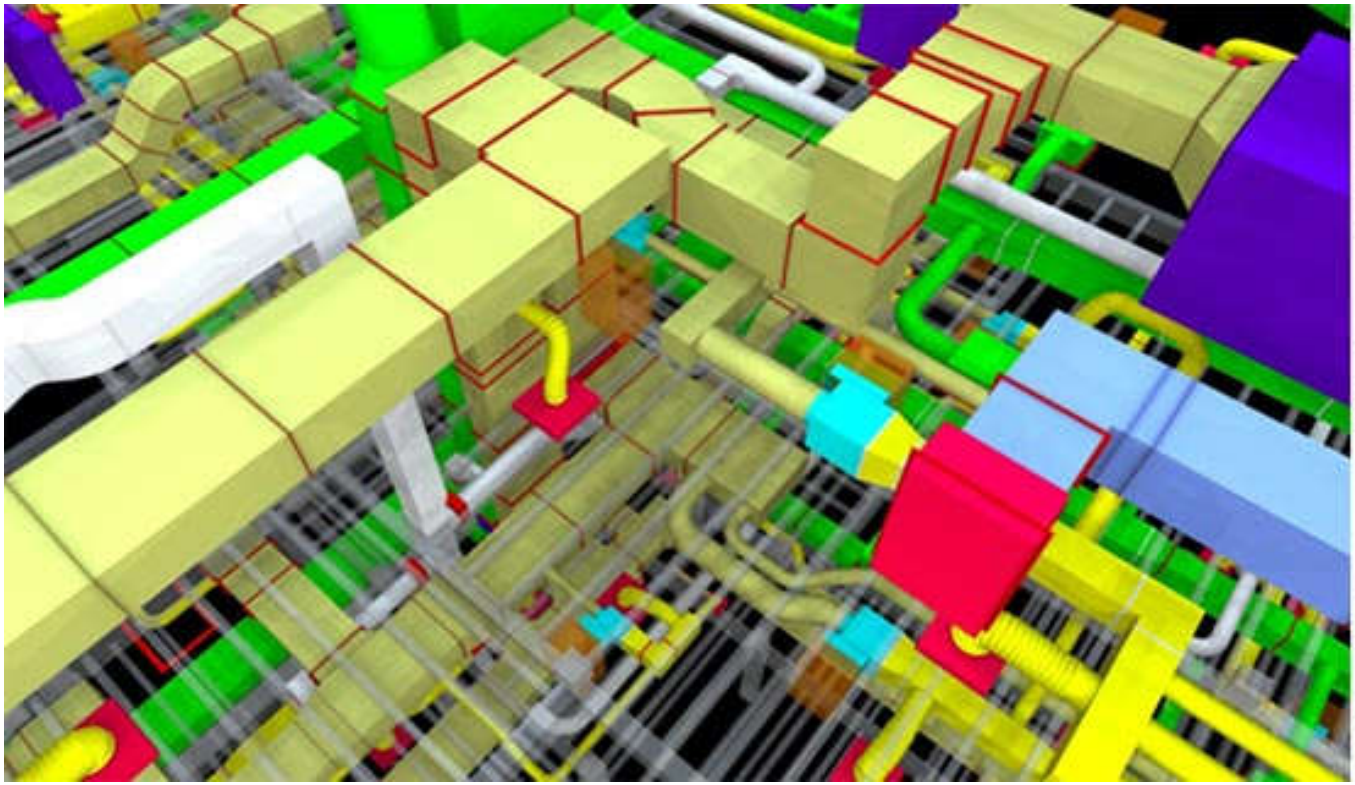
(Source: Autodesk Revit MEP https://www.slideshare.net/imrankhattak5/autodesk-revit-mep-48876296)

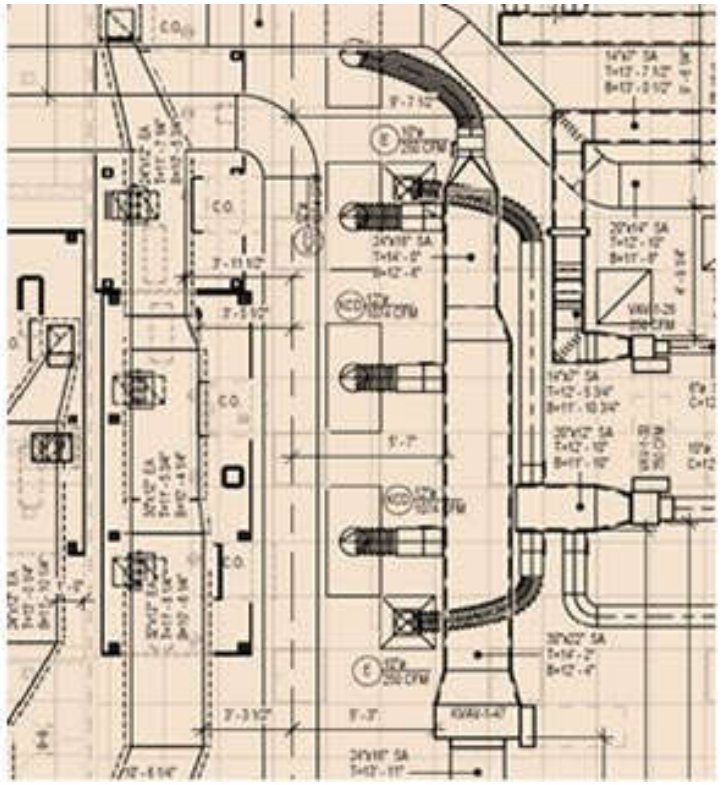
BIM for MEP

- 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

BIM for MEP

- 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

BIM for MEP

- 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

BIM for MEP

- 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

BIM for MEP

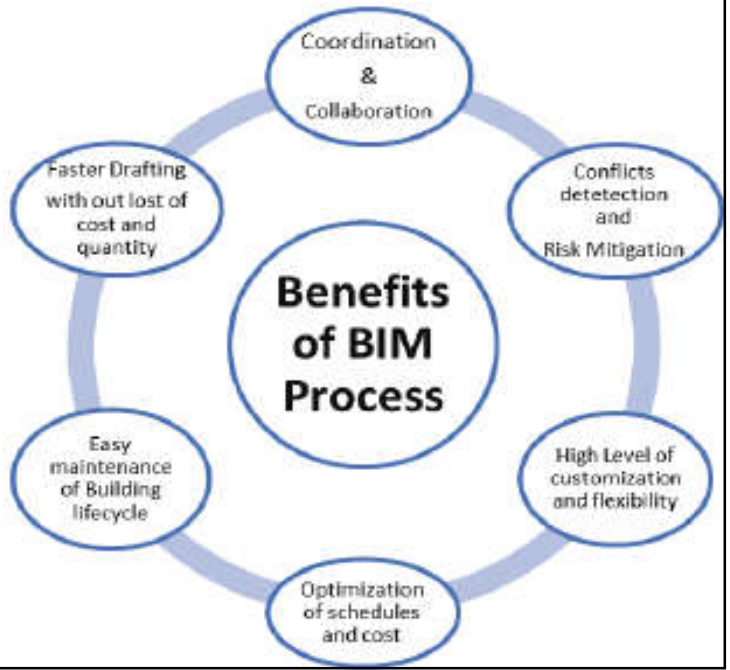
- BIM in building management
  - BIM can be used to collect information on the use and performance of the actual building once it is built
  - It provides a digital record of renovations and any changes to the building
  - The access to this information improves both revenue and cost management of the 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

BIM for MEP

- 10 BIM Trends in the MEP Industry for 2018
  - https://constructible.trimble.com/construction-industry/10-bim-trends-in-the-mep-industry-for-2018
  - 1. Modular construction & prefabrication
  - 2. Internet of Things (IoT)
  - 3. Augmented/VR Reality
  - 4. Order directly from the model
  - 5. Mobile cloud applications
  - 6. BIM to the building site: 3D laser scans and drones
  - 7. Mix and match or all-in-one solutions
  - 8. BIM Goes Green
  - 9. 3D Printing
  - 10. 4D, 5D, and 6D-BIM

Potential benefits

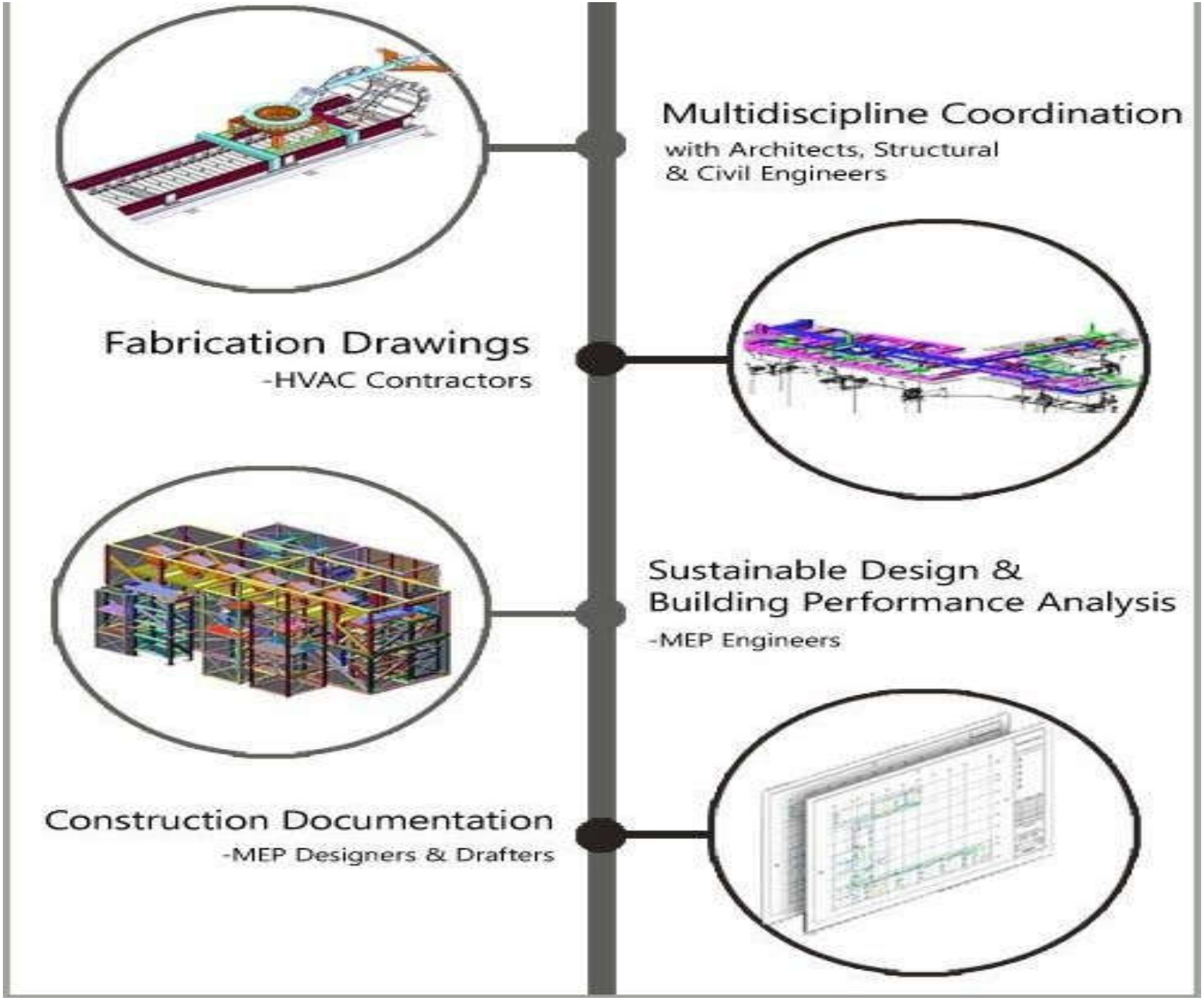
- Benefits of BIM for MEP or BSE:
  - Video: Benefits of BIM for MEP Engineers (3:31) https://youtu.be/C8j4uYF0I-g
  - 1. 3D modelling & collision detection
  - 2. Rich repository of design data
  - 3. Sustainable design processes
  - 4. Competitive advantages



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

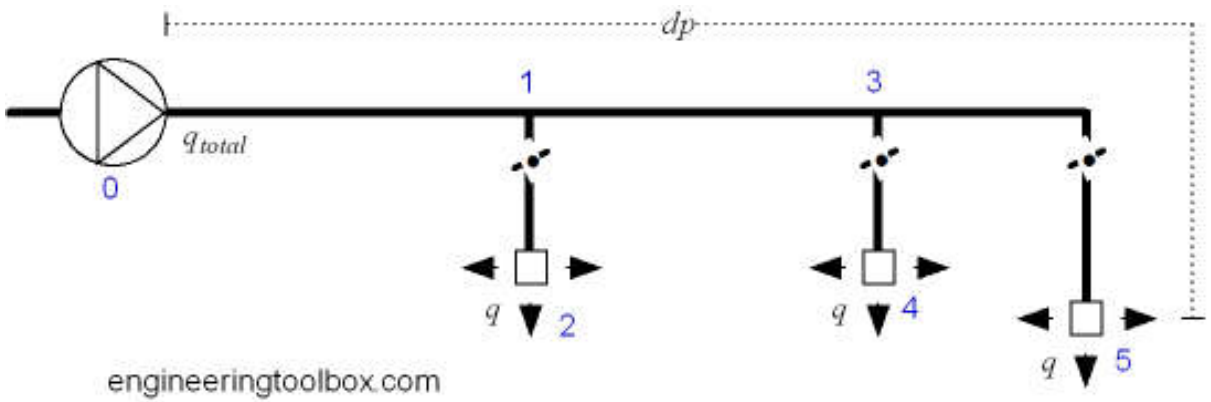
- BIM can be used for sustainable design:
  - Optimize design (using analysis software/tools)
  - Daylighting (analyze & promote natural light)
  - Energy analysis (such as solar/sun study, HVAC systems, building energy simulation)
  - Computation of materials (reduce waste of materials & environmental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

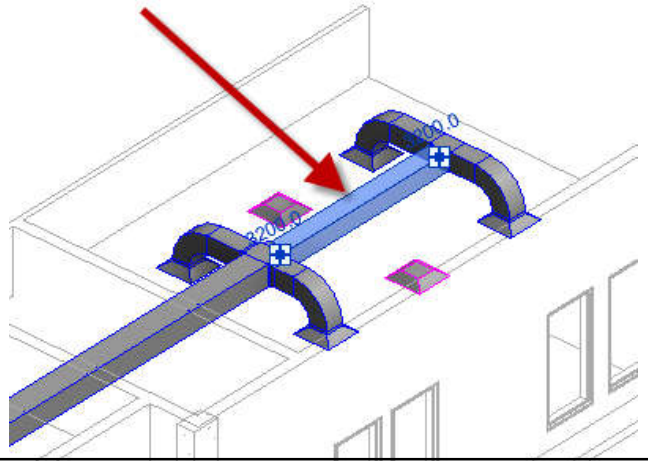
Potential benefits

- 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

- Example (1):
  - System inspector (critical path): Identify and adjust high pressure loss areas in your system, enhancing economy and efficiency
  - The software displays critical flow path for branches, main trunks or entire systems



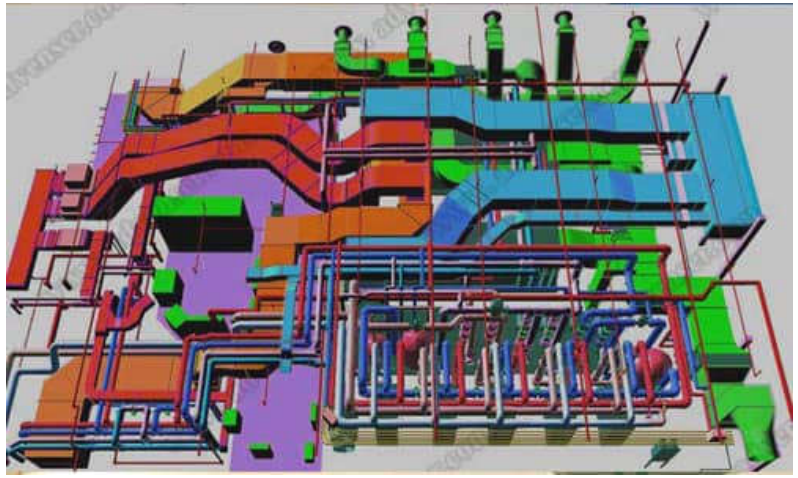


Potential benefits

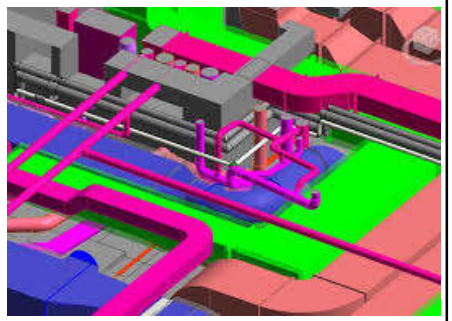
- Example (2):
  - The basic requirement of the project is the material calculations for the best estimated costing
  - Normally due to uncertainties in design safe material estimate requires 20% to 25% increased material which can be exactly calculated here
  - By the development of 3D modeling incorporated with the MEP, more exact estimation of the cost is possible
  - Through this, the project cost could be reduced up to some extent by adding it at the rate of even less then 0.5%

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

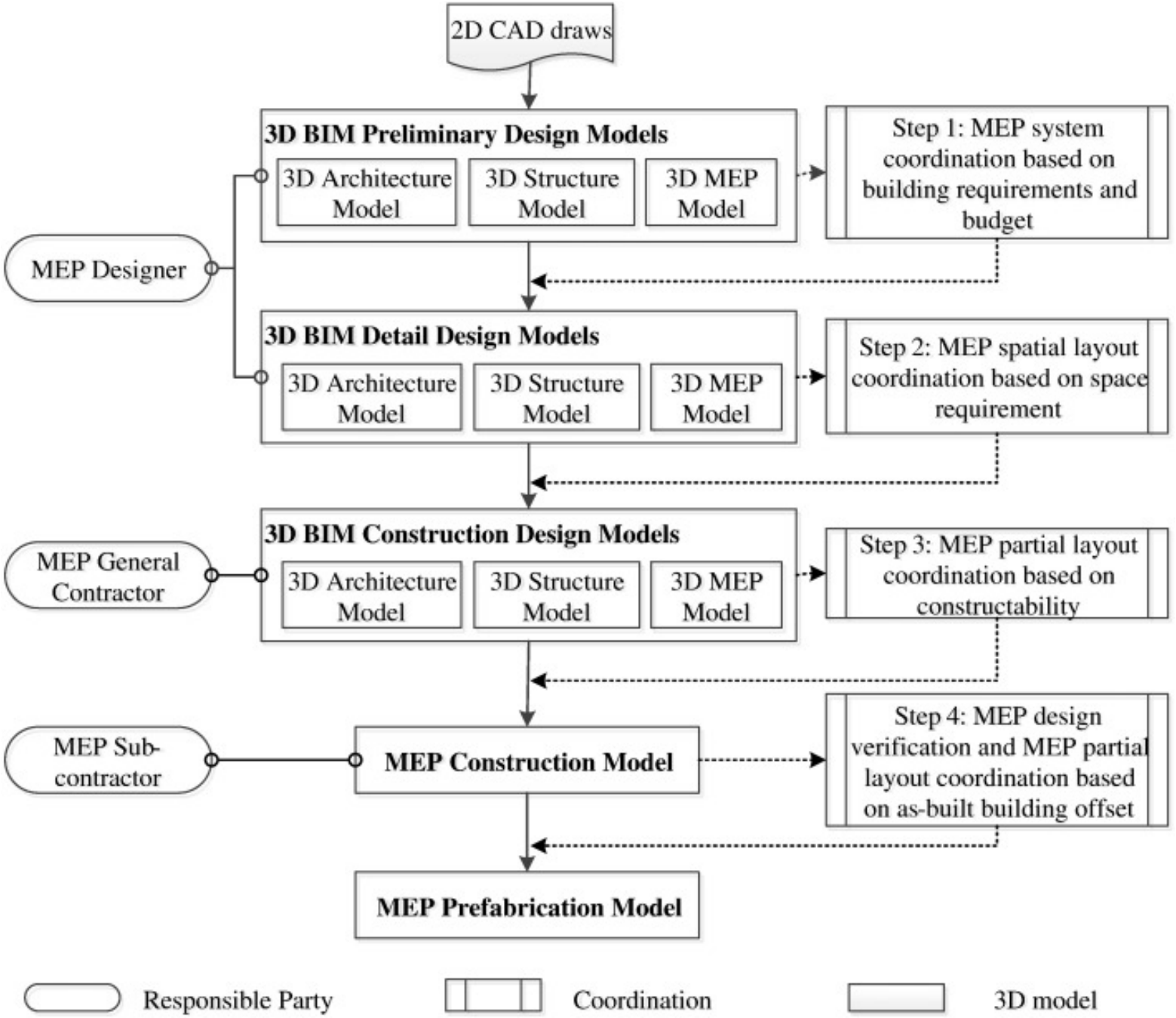


MEP model coordination



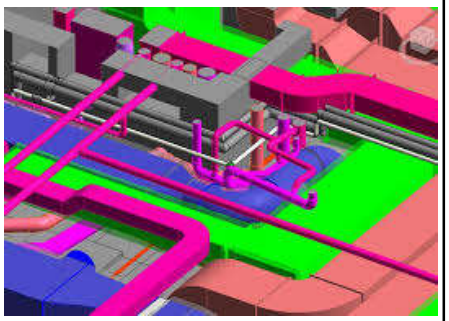
- Models of three major disciplines:
  - Architecture, Structure, MEP
- Five types of MEP models:
  - 3D MEP preliminary design model
  - 3D MEP detailed design model
  - 3D MEP construction design model
  - MEP construction model
  - MEP prefabrication model

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

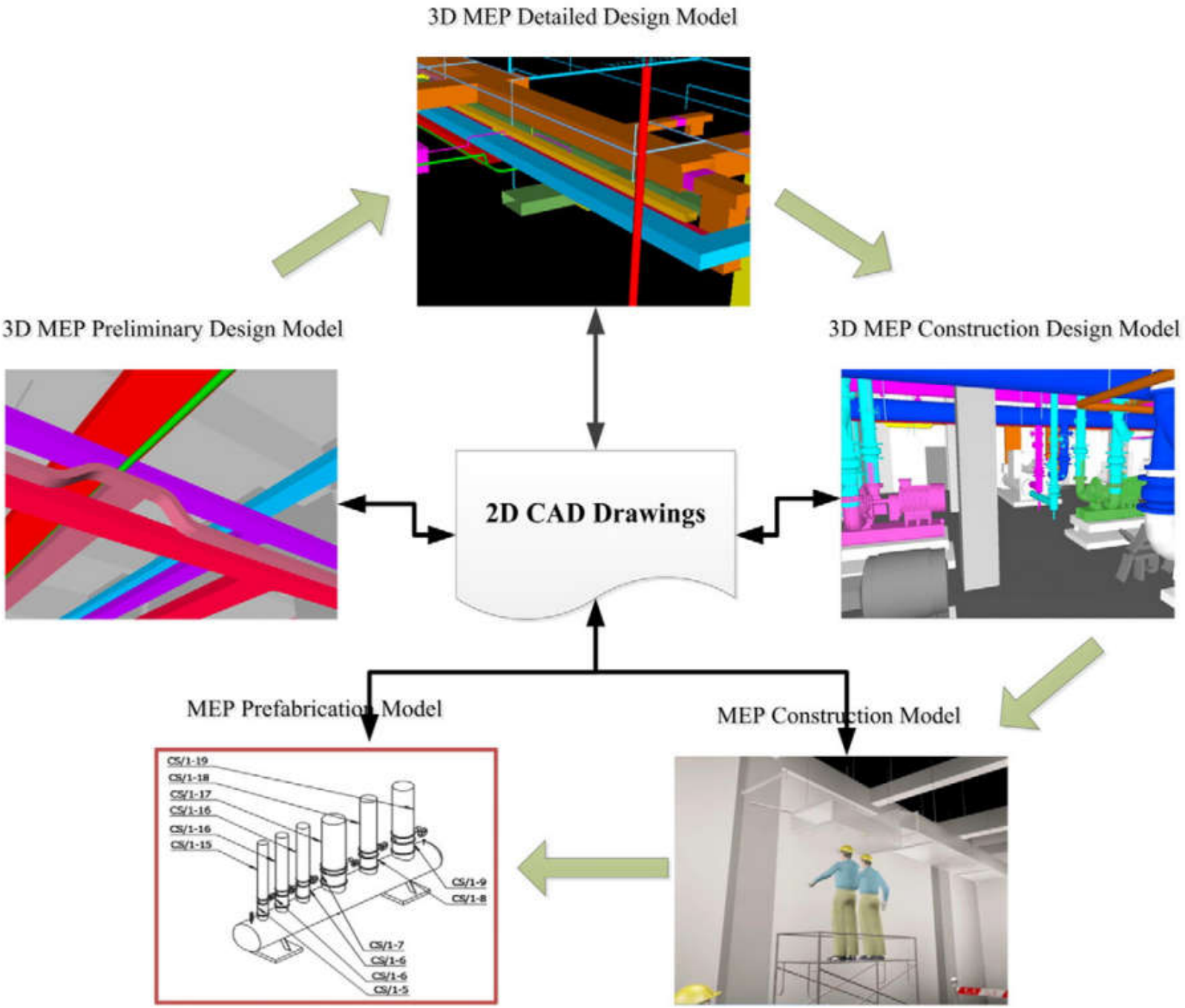
(Source: Wang J, Wang X, Shou W, Chong H.-Y. and Guo J., 2016. Building information modeling-based integration of MEP layout designs and constructability, *Automation in Construction*, 61 (2016): 134-146.)

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	-

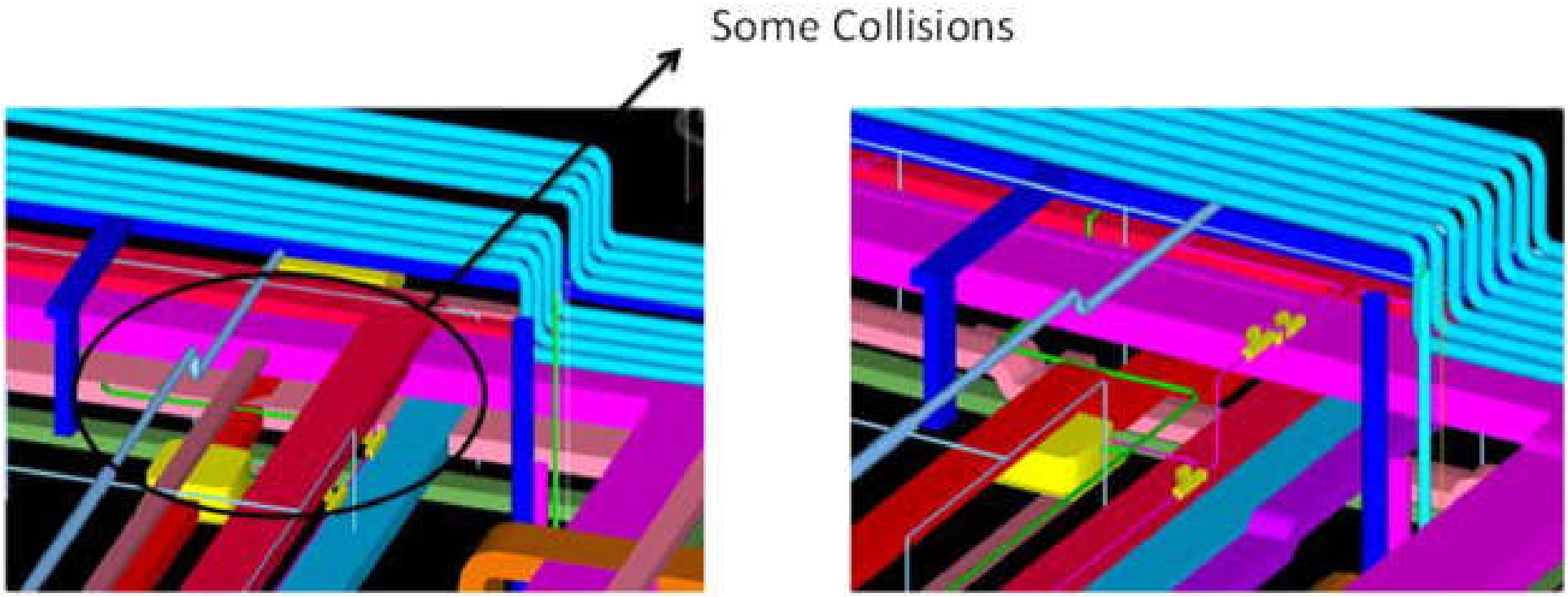
(Source: Wang J, Wang X, Shou W, Chong H.-Y. and Guo J., 2016. Building information modeling-based integration of MEP layout designs and constructability, *Automation in Construction*, 61 (2016): 134-146.)

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.

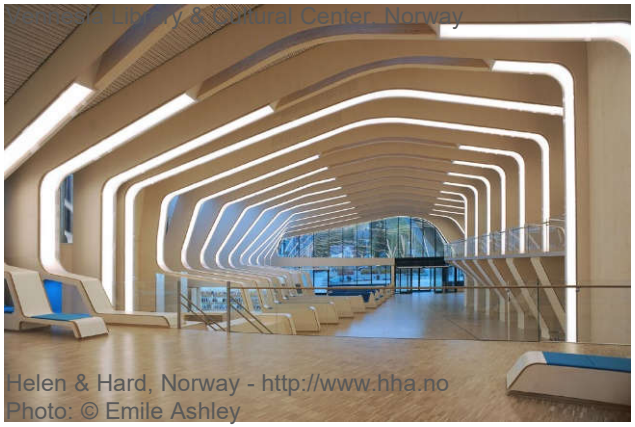
(Source: Wang J, Wang X, Shou W, Chong H.-Y. and Guo J., 2016. Building information modeling-based integration of MEP layout designs and constructability, *Automation in Construction*, 61 (2016): 134-146.)

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

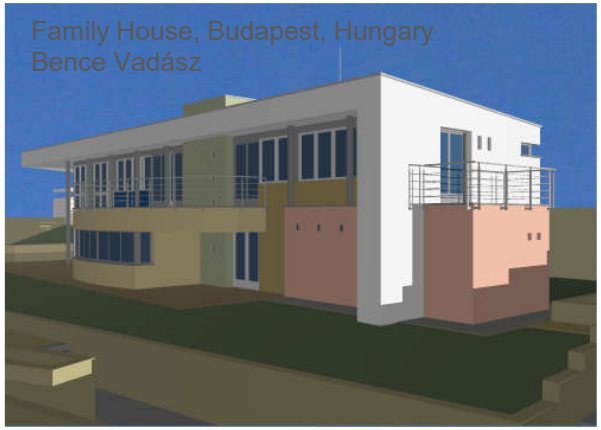
- Sustainable sites
- Water efficiency
- Energy and atmosphere
- Materials and resources
- Indoor environment
- Innovation in design
- Regional priority

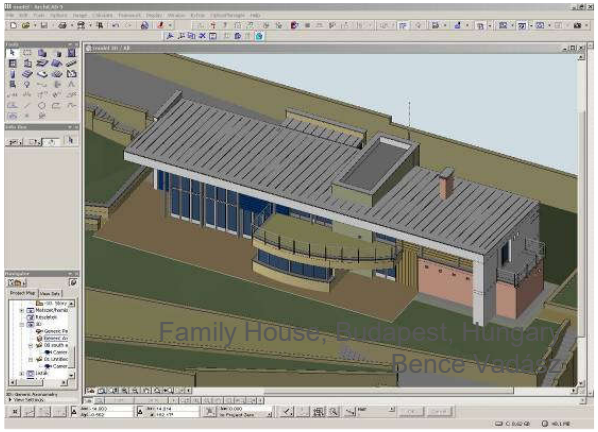
(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

Sustainable Design with BIM

Building Information Modeling

Intelligent building model (virtual building)





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

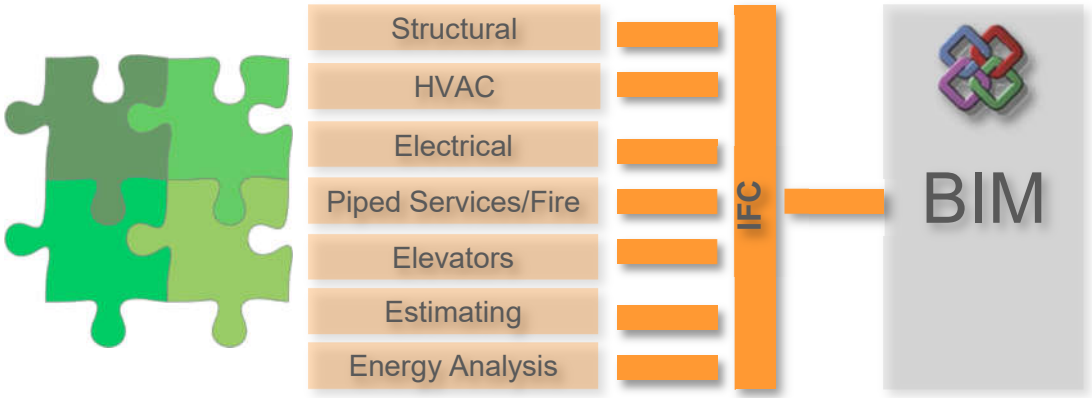
Sustainable design with BIM

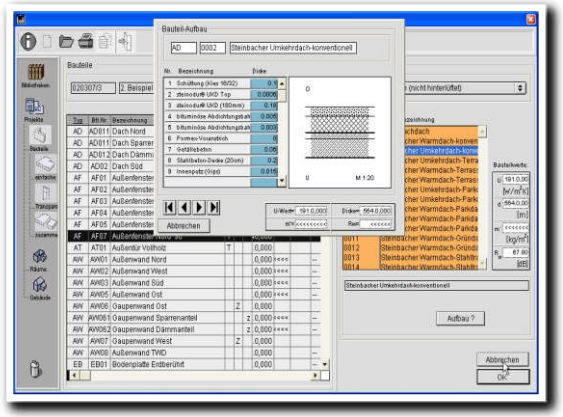
- BIM advantages include:
  - Ability to analyze
  - Ability to evaluate green buildings
  - Access to info to make sustainable decisions
- Performance analysis & evaluation
  - Merge of design & analysis = optimize building performance
  - Better quality of data = minimum errors and miscalculations

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

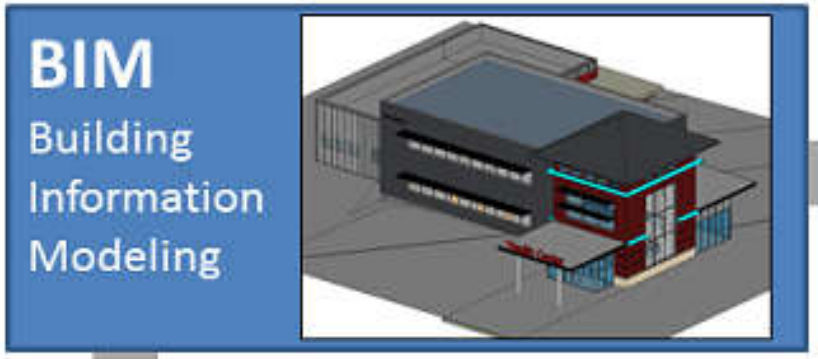
- Structural Engineering
- Collision Detection
- Code Checking
- Building Performance and energy simulations

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

Sustainable design with BIM

- BIM enables sustainable design analysis
  - BIM provides important data and information for design projects and also encompasses several important functions for building performance and sustainable design analysis
  - Common software tools:
    - Autodesk Ecotect
    - Autodesk Green Building Studio (GBS)
    - Integrated Environmental Solutions (IES) Virtual Environment (VE)

BIM and Building Performance Analysis (BPA)

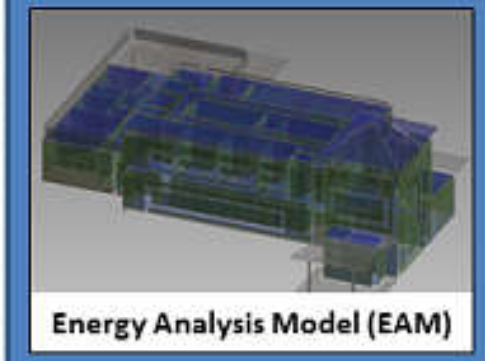


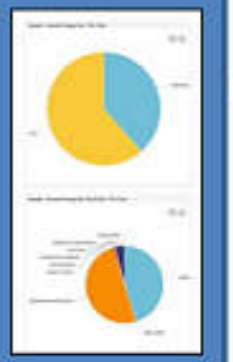
- Visualization
- Structural analysis
- Cost
- Documentation
- Fabrication/ Construction
- Etc...

Building Performance Analysis (BPA)

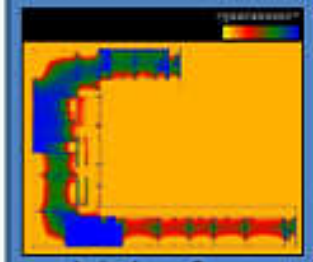
Whole Building Energy Analysis

- Conceptual Models
- Detailed Models

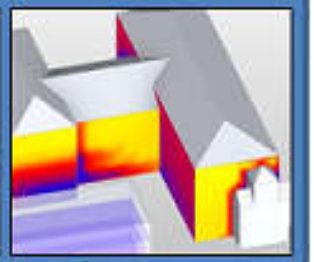


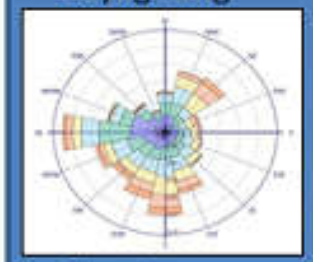


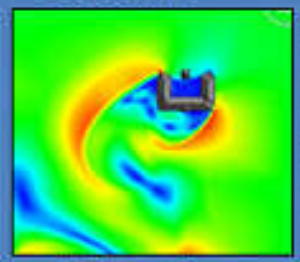
Other Performance Studies


Lighting & Daylighting


Sun & Shadows


Solar Radiation


Climate Analysis

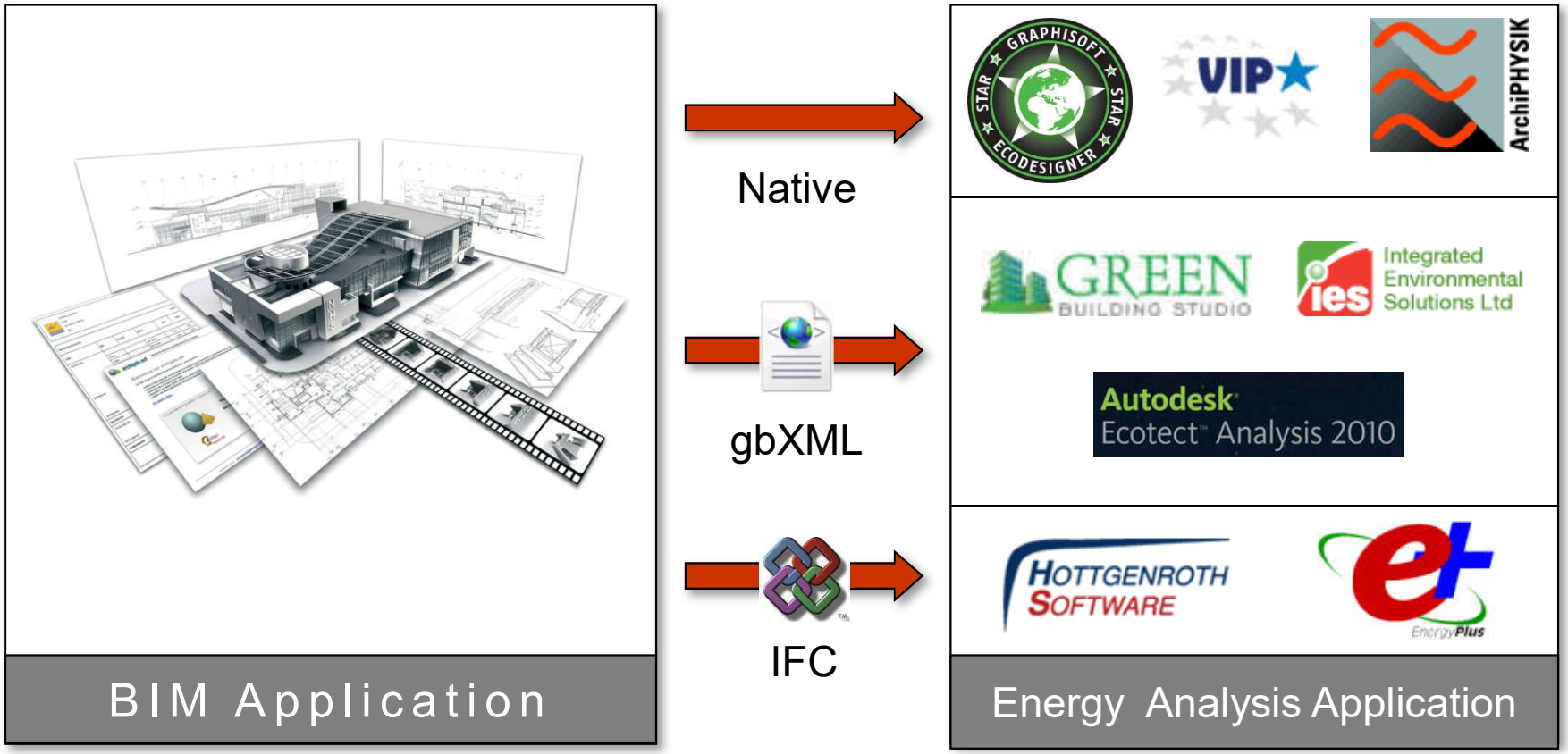

Airflow & Ventilation


Lifecycle Analysis

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

Sustainable Design with BIM

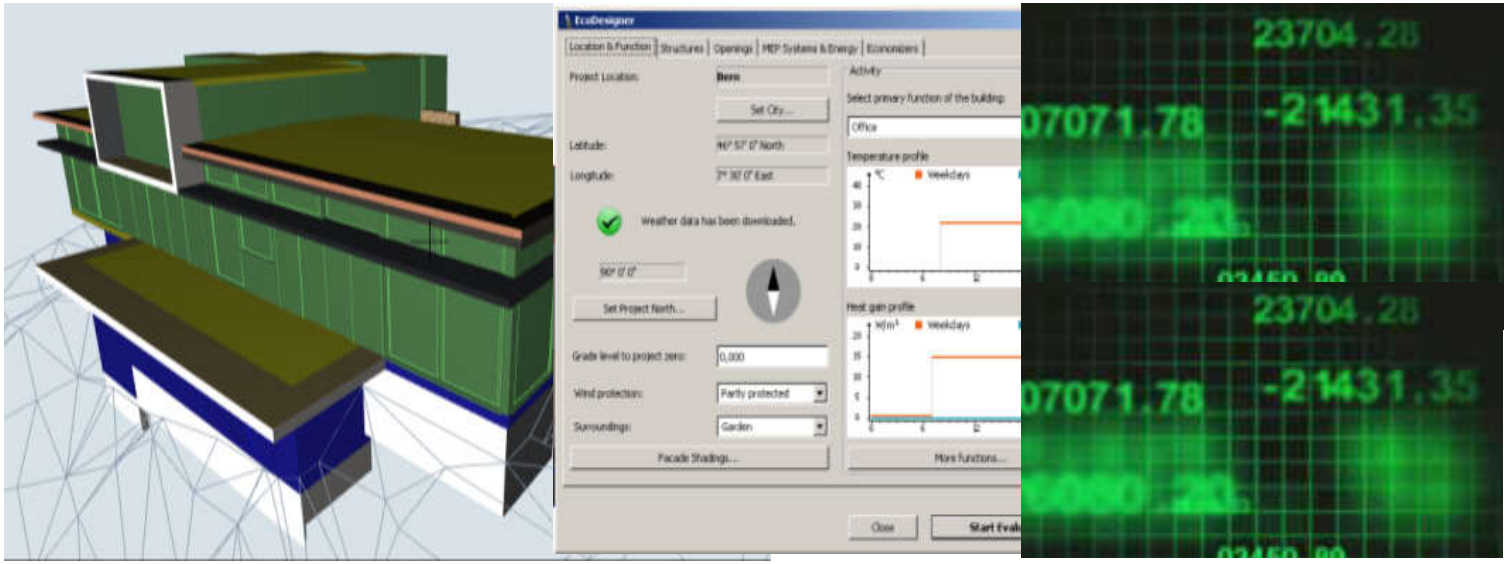
BIM and Energy Software Collaboration



(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

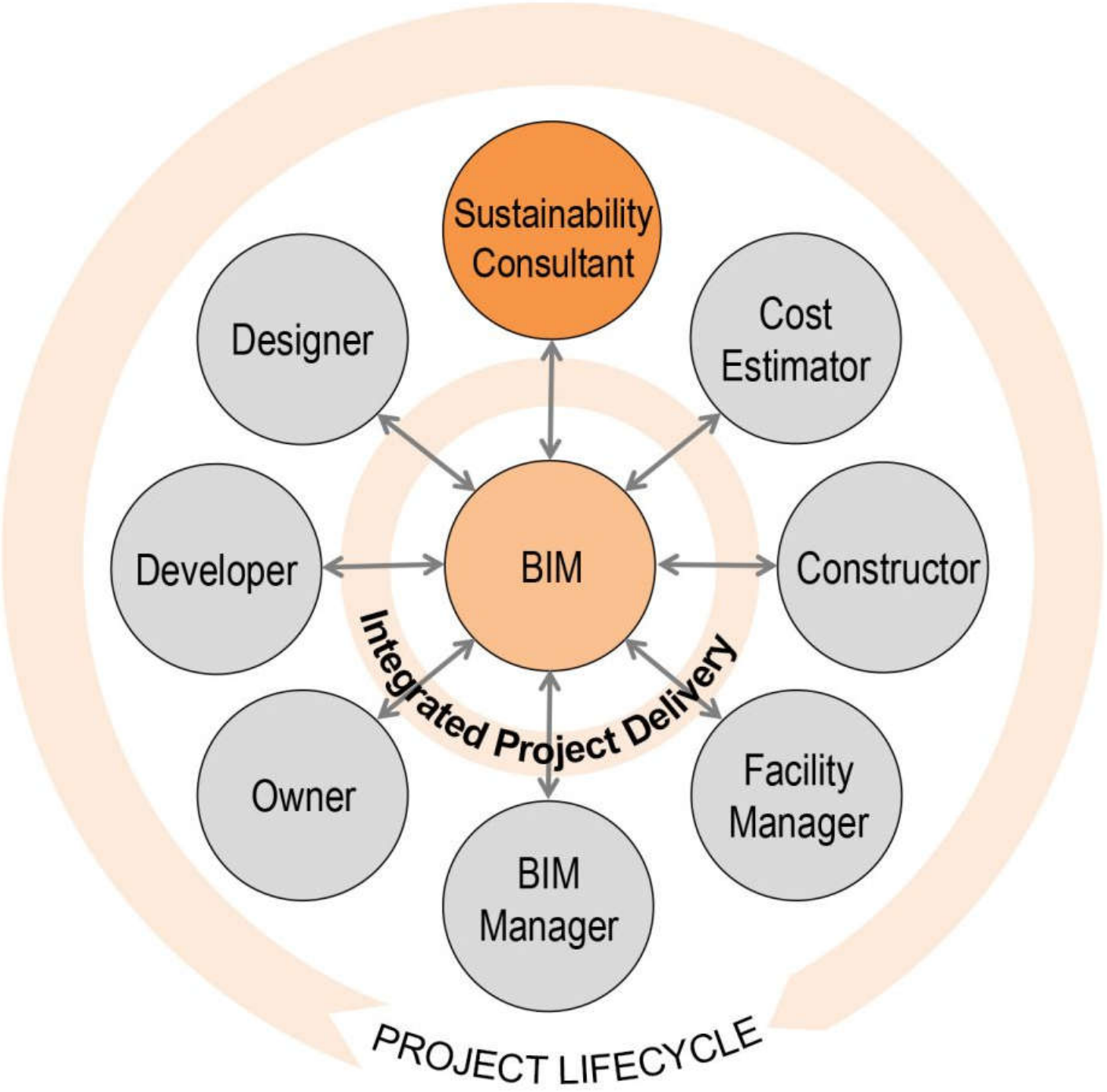
(Source: Graphisoft BIM Curriculum http://www.graphisoft.com/learning/bim-curriculum/)

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

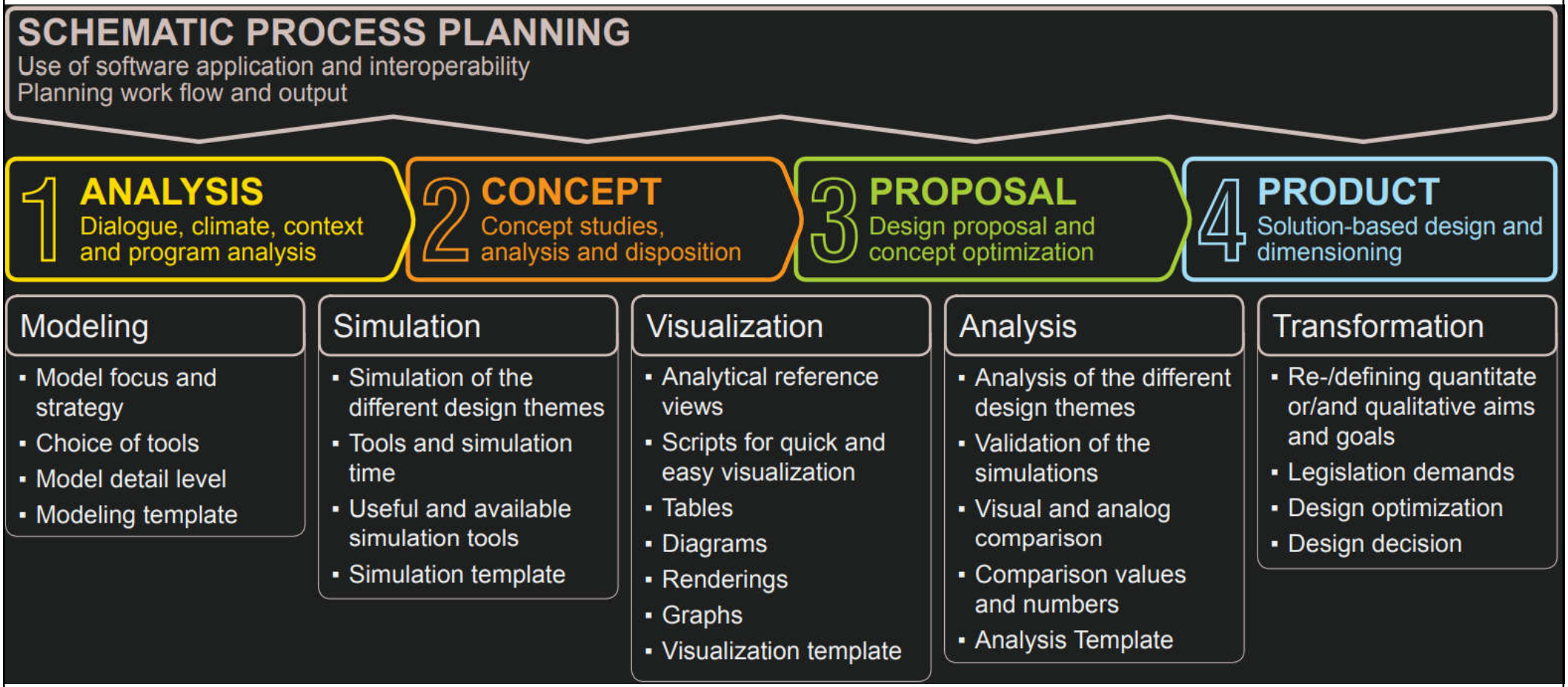
(Source: Bonenberg, W. Wei, X., 2015. Green BIM in sustainable infrastructure, *Procedia Manufacturing*, 3: 1654-1659.)

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)

General process and workflow for sustainable building design



Inside:

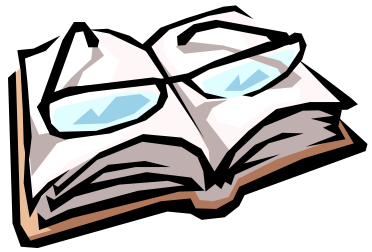
- Modelling
- Simulation
- Visualization
- Analysis
- Transformation

Outside:

- Communication
- Collaboration
- Holistic analysis
- Design optimization

(Source: AU Preso: Holistic BPA Workflows https://sustainabilityworkshop.autodesk.com/buildings/au-preso-holistic-bpa-workflows)

Further reading



- BIM as a Framework for Sustainable Design
  - http://www.susted.com/wordpress/content/bim-as-a-framework-for-sustainable-design_2012_03/
- Autodesk Sustainability Workshop
  - https://sustainabilityworkshop.autodesk.com/
  - Building Design https://sustainabilityworkshop.autodesk.com/building-design
  - BPA Software Workflows https://sustainabilityworkshop.autodesk.com/buildings/bpa-software-workflows
  - Revit tools for BPA https://sustainabilityworkshop.autodesk.com/buildings/revit-tools-bpa