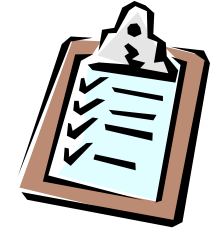# MEP design considerations
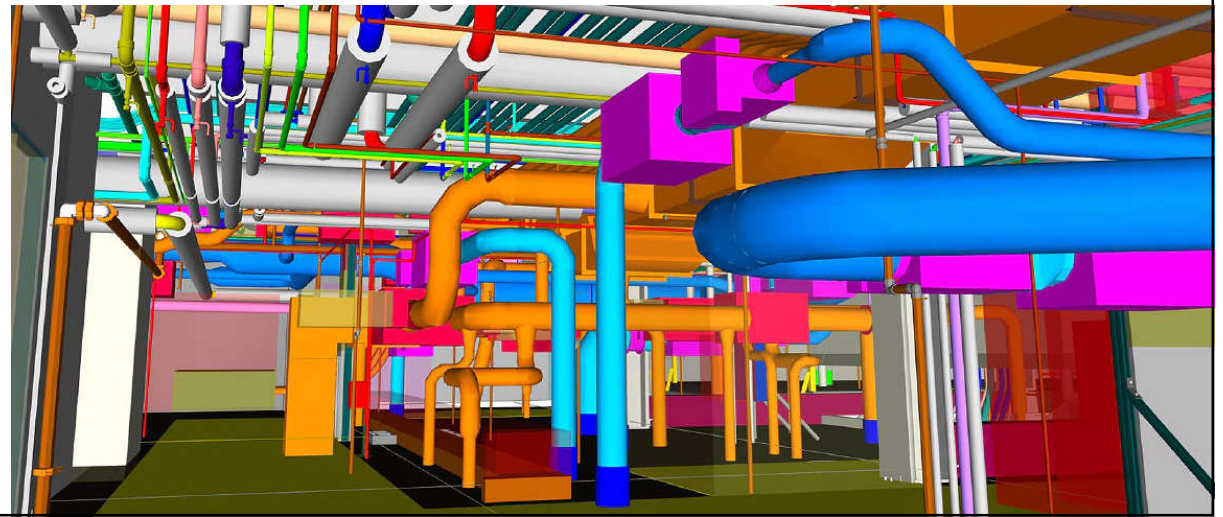
Faculty of Science and Technology
Technological and Higher Education Institute of Hong Kong

May 2019

Contents

- Introduction
- Revit MEP tips
- BIM modelling & MEP design
- Other BIM MEP applications

Introduction

- Autodesk Revit & related software*
    - Architecture, Structure, MEP: design authoring
    - BIM 360: collaboration
    - Fabrication CADmep: MEP fabrication
    - Insight: energy & building performance analysis
    - Navisworks: project review on integrated models
    - ReCap Pro: reality capture and 3D scanning
    - Revit Live: immersive visualization

Introduction

- **Revit MEP** (MEP domain)
  - Help drive accurate design, analysis, and documentation of efficient building (services) systems from concept through construction
  - Typical applications:
    - Building systems modelling and layout
      - Duct and pipe system modelling
      - Duct and pipe sizing/pressure calculations
      - HVAC and electrical system design
      - Conduit and cable tray modelling
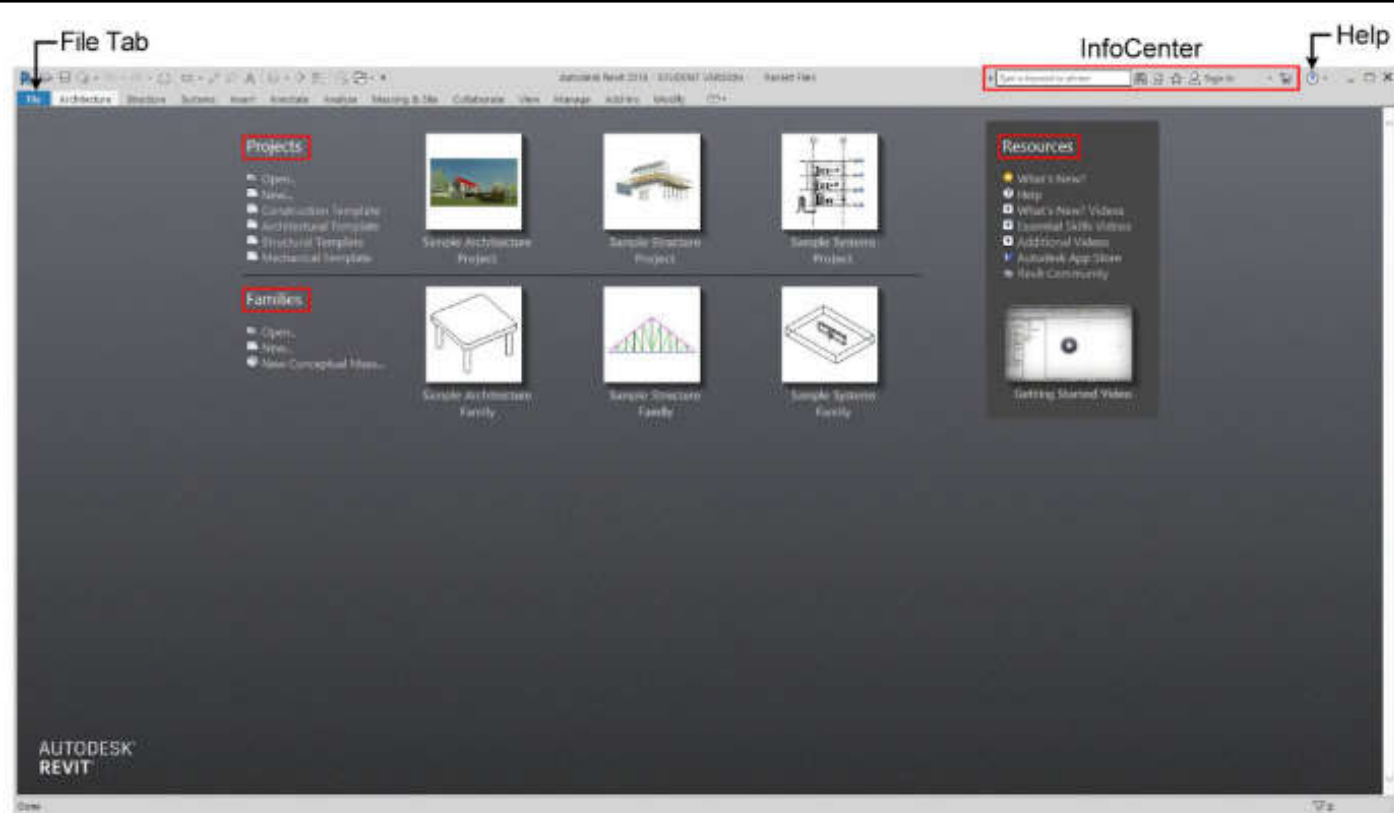   - Sustainable design with building performance analysis

Introduction

AUTODESK REVIT

- <u>General Revit techniques:</u>*

  > Please refer to your previous learning on BIM or Revit.

  - User interface

  - Revit elements & families

  - Working with views (plan, elevation, section, 3D)

  - Control object visibility/graphics

  - Setting up a project:

    - View templates, discipline settings, importing AutoCAD DWG, linking a Revit model, coordinating linked projects, adding & modifying levels & grids

(*See also: Understanding Revit Terms https://knowledge.autodesk.com/support/revit-products/learn-explore/caas/CloudHelp/cloudhelp/2014/ENU/Revit/files/GUID-2480CA33-C0B9-46FD-9BDD-FDE75B513727-htm.html)

Revit Working Environment

Projects

Open: Open a Revit related file. (or click a right icon to open a recent project file)

New: Use a Revit template file to start a new project.

Construction Template: Use default construction template to start a new project.

Architectural Template: Use default architectural template to start a new project.

Structure Template: Use default structure template to start a new project.

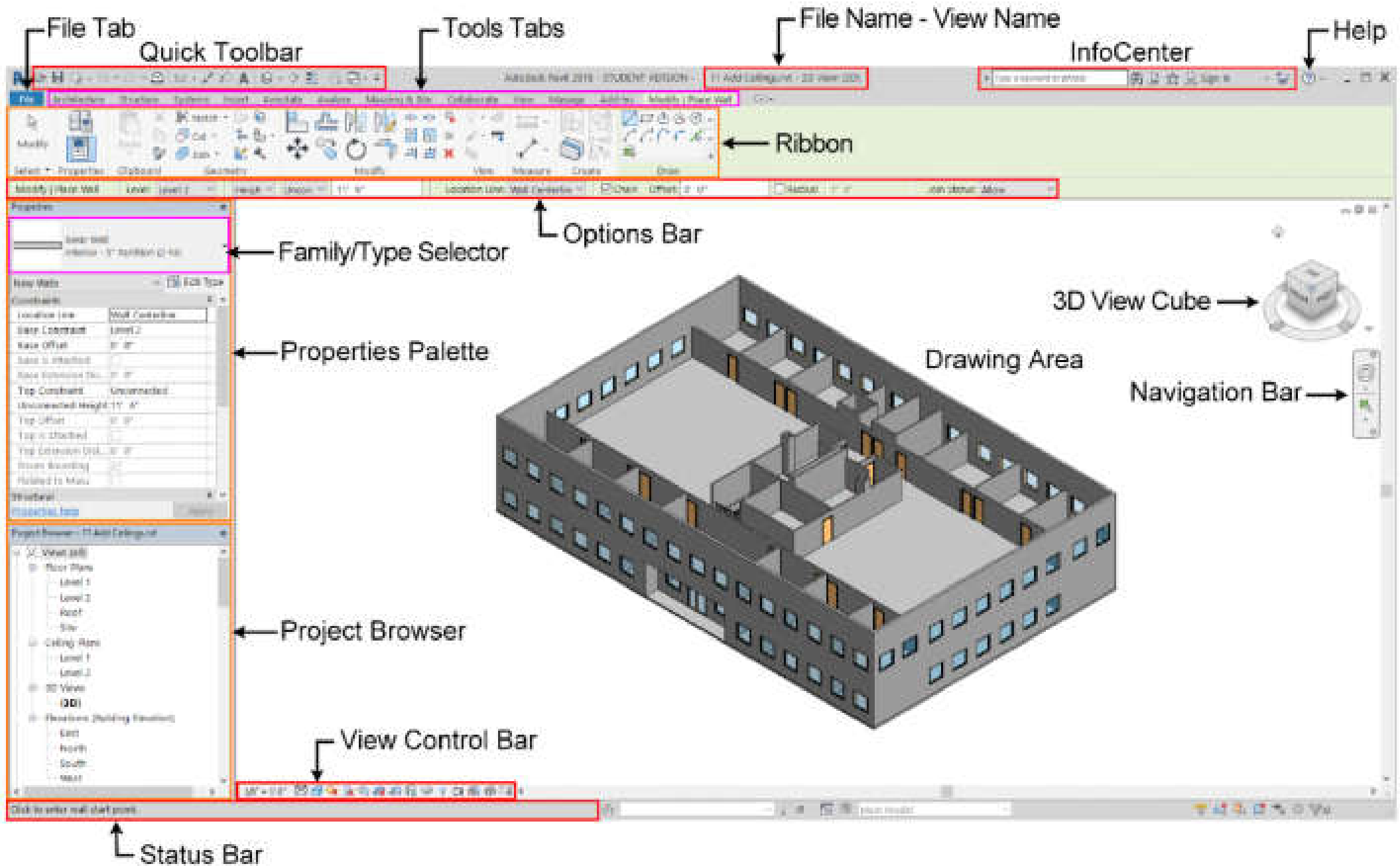**Mechanical Template**: Use default mechanical template to start a new project.

Families

Open: Open a Revit family file. (or click a right icon to open a recent family file)

**New**: Use a family template to start a new family.

New Conceptual Mass: Use default mass family template to create a conceptual massing model.

Project Editing Screen

Introduction

- Architectural modelling:
  - Floor slab, setup levels
  - Walls, partitions, doors, windows, stairs
  - Ceiling, roof & room information
- MEP systems & components:
  - Mechanical (HVAC), hydronic piping, electrical, plumbing, fire protection
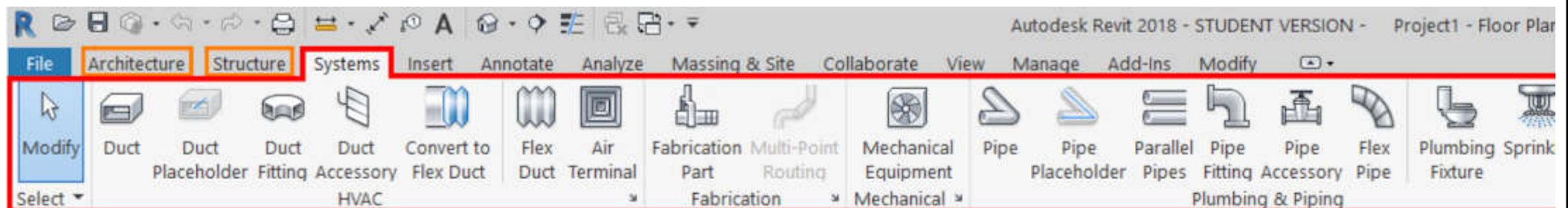
System Browser (press F9 function key):
Use it to find all components & examine the hierarchies of MEP systems

Systems	Flow	Size	Space
⊞ ❓ Unassigned (3 items)			
☐ Mechanical (0 systems)			
⊟ ☐ Piping (7 systems)			
⊟ ⟁ Domestic Cold Water			
⊞ ⟟ Domestic Cold W...	6.0 L/s		
⊟ ⟁ Domestic Hot Water			
⊟ ⟟ Domestic Hot Wa...	1.3 L/s		
⟗ M_Lavatory - ...	N/A	15 mm	
⟗ M_Lavatory - ...	N/A	15 mm	
⟗ M_Lavatory - ...	N/A	15 mm	
⟗ M_Lavatory - ...	N/A	15 mm	
⟗ M_Lavatory - ...	N/A	15 mm	
⟗ M_Lavatory - ...	N/A	15 mm	
⟗ M_Lavatory - ...	N/A	15 mm	
⟗ M_Lavatory - ...	N/A	15 mm	
⟗ M_Lavatory - ...	N/A	15 mm	
⟗ M_Lavatory - ...	N/A	15 mm	
⟗ M_Lavatory - ...	N/A	15 mm	
⟗ M_Lavatory - ...	N/A	15 mm	
⟗ M_Lavatory - ...	N/A	15 mm	
⟗ M_Lavatory - ...	N/A	15 mm	
⟗ M_Lavatory - ...	N/A	15 mm	
⟗ M_Lavatory - ...	N/A	15 mm	
⟗ M_Lavatory - ...	N/A	15 mm	
⊠ M_Water Heat...	N/A	25 mm	
⊟ ⟲ Sanitary			
⊞ ⟟ Sanitary 1	Not C...		
⊟ ⟲ Vent			
⟟ Vent 1	Not C...		
⟟ Vent 2	Not C...		
⟟ Vent 3	Not C...		
⟟ Vent 4	Not C...		
☐ Electrical (0 systems)			

Introduction

- Revit MEP techniques:
    - Starting Revit MEP projects*
        - Link architectural model
        - Copy & monitor elements
        - Set up & modify levels
    - MEP systems
        - Create systems
        - Connect components
        - Create spaces, zones and colour schemes

> You should experience & learn this in the practical training sessions.

(*See also: Revit MEP tutorial: Create a new project and link architecture model https://www.cad-notes.com/revit-mep-tutorial-create-a-new-project-and-link-architecture-model/)

Introduction

- <u>Revit MEP techniques</u>: (cont'd)
  - Energy analysis
    - Analyse heating & cooling loads
    - Secondary analysis (e.g. air-side systems)
  - Piping systems (create & routing)
  - HVAC systems
    - Create systems, add air terminals & mechanical equipment, add ductwork, create & modify duct systems, automatic ductwork layouts

Introduction

- <u>Revit MEP techniques</u>: (cont'd)

  - Electrical systems

    - Create systems, place electrical components, create electrical circuits, cable trays & conduit, electrical panel schedules

  - Annotate construction documents

    - Add detail lines & symbols

  - Tags & schedules

    - Add tags, create & modify schedules

Introduction

- ## Revit MEP techniques: (cont'd)

  - Customize Revit (to improve productivity)*

  - Customize Family & Project Templates

    - Build your own Starter Family Templates
    - Work with vendor equipment (import files)
    - Build your MEP Project Templates

  - Customize Families & Parameters

    - Know when to use family-based shared parameters versus project parameters based on shared parameters

> Good templates will facilitate efficient work.

Revit MEP tips

- MEP design considerations:
    - Start with an overall approach to your model
        - Systematic planning (integrate design & modelling)
        - Decide if work sets are required & set these up*
    - Set up standards & templates (for Revit use)
    - Use of "families" (Revit) in a project
    - Level of details & design purpose
        - Start with boxes to represent the space of an item
    - Set up main branches, pipe runs etc. first

(*See also: About Worksets http://help.autodesk.com/view/RVT/2018/ENU/?guid=GUID-86810293-6510-4F5A-8009-27B4767CA136)

Revit MEP tips

- What to model
  - Need to draw some lines as where to stop
  - Are some things not needed to be modelled?
  - Keep in mind how large your model is or will be
  - The more small detail, the slower the performance
  - Is the small detail ever going to be seen?
    - Level of details
  - Useful viewpoints, e.g. reflected ceiling plan

Revit MEP tips

- [Project Browser]* – View naming organization
  - Think about a plan of attack
  - Recommend setting a standard for view naming and sticking to it
  - Utilise the Project Browser's organisation and filters capability
  - Recommend sort by sub-discipline
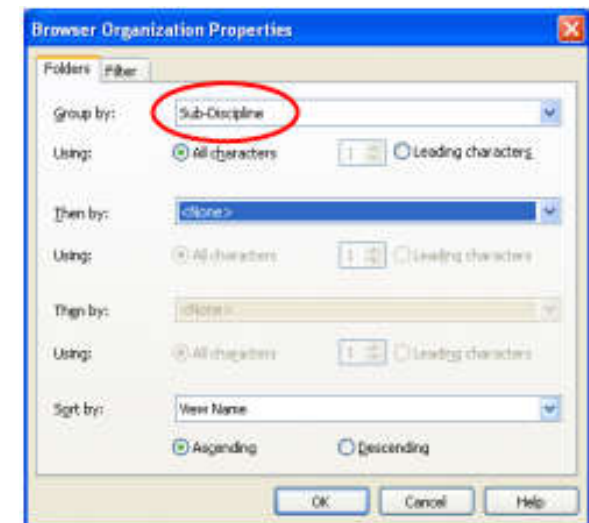
Revit MEP tips
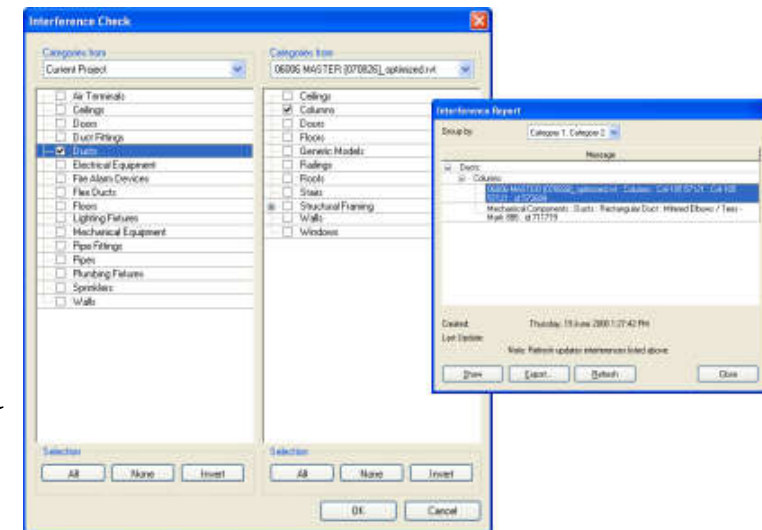
- ## Clash Detection

  - Coordination models (with Navisworks)*

  - Run an interference check**

  - To access go to:
    - Tools > Interference Check >
    - Run Check

  - All interferences will be located

  - Can sometimes be a nuisance

Revit MEP tips

- [Families](#)* – Tips & tricks
  - A family is a group of elements with a common set of properties, called parameters, and a related graphical representation
  - Use Family Editor to modify existing elements or create new ones to meet specific needs of a project
  - Be sure to start from the right family template
    - Ceiling based, wall based, floor based, face based
  - Work plane-based families:
    - Ability to place family items on any plane
  - Continually test the parameters (Flex the model)

> Revit Families is important for design productivity.

Revit MEP tips

- [Schedules](#)* (lists of any type of element in a project)
  - Will update with changes made to the elements in the model (e.g. electrical panel schedules)
  - Ability to add/remove columns, ability to format
- [Spaces](#)**
  - Create spaces to run heating & cooling load analysis (including plenums & shafts)
  - Ability to reference room names & numbers from linked model with space tags

(*See also: Schedules http://help.autodesk.com/view/RVT/2018/ENU/?guid=GUID-F50D6FF4-859E-43A2-A2F6-81C84A1BA0EB;
** Spaces http://help.autodesk.com/view/RVT/2018/ENU/?guid=GUID-48509199-F248-4B61-9DC6-CEFBE2E302F2)

Revit MEP tips

- ## [Documentation](#)

  - To communicate the design intent to team members, consultants, clients, and contractors
    - Such as project views, schedules, project phasing, annotation, detailing, construction documents

  - Prepare company standards & set up standard template you desire

  - Utilizing 2 views overlaid on each other

  - Pinning the view on a sheet (2D drawing)

(*See also: Document and Present the Design http://help.autodesk.com/view/RVT/2018/ENU/?guid=GUID-75DFA31F-1733-48C9-9856-1F323C0AE0E4)

MEP documentation (examples)
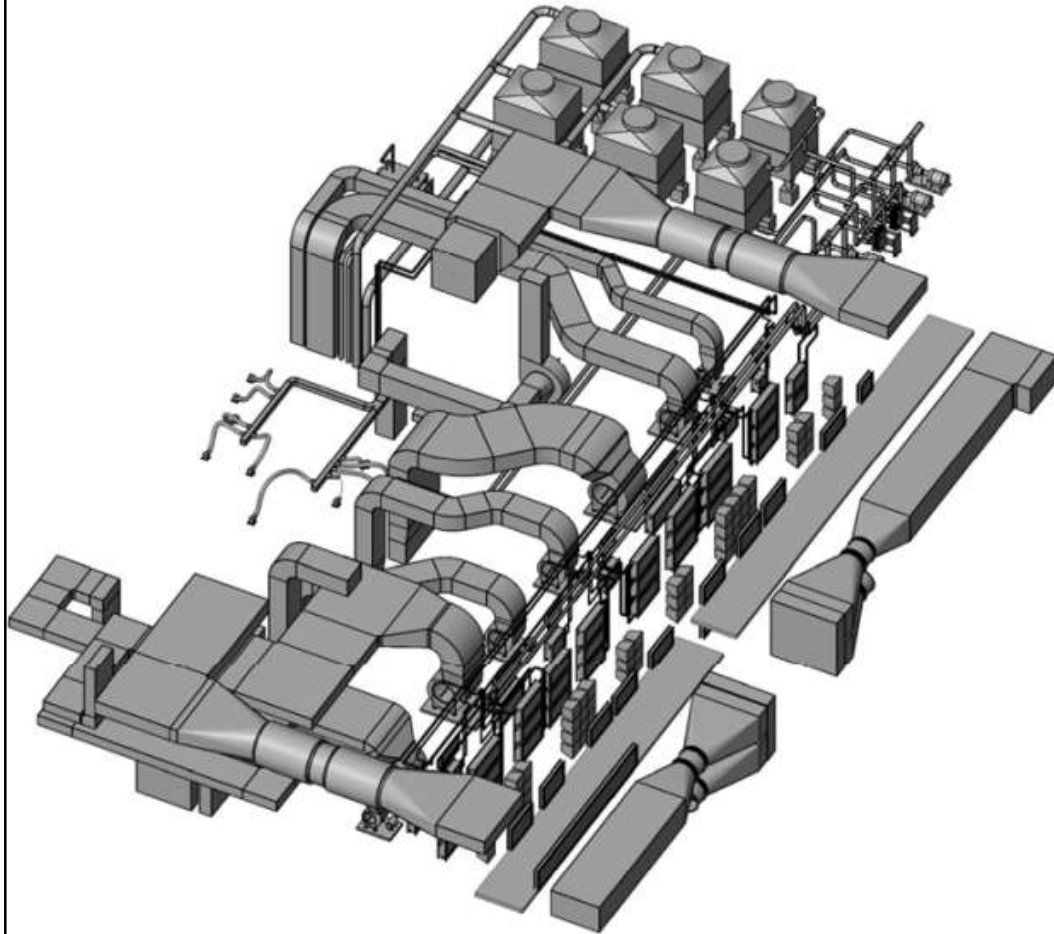
3D Model
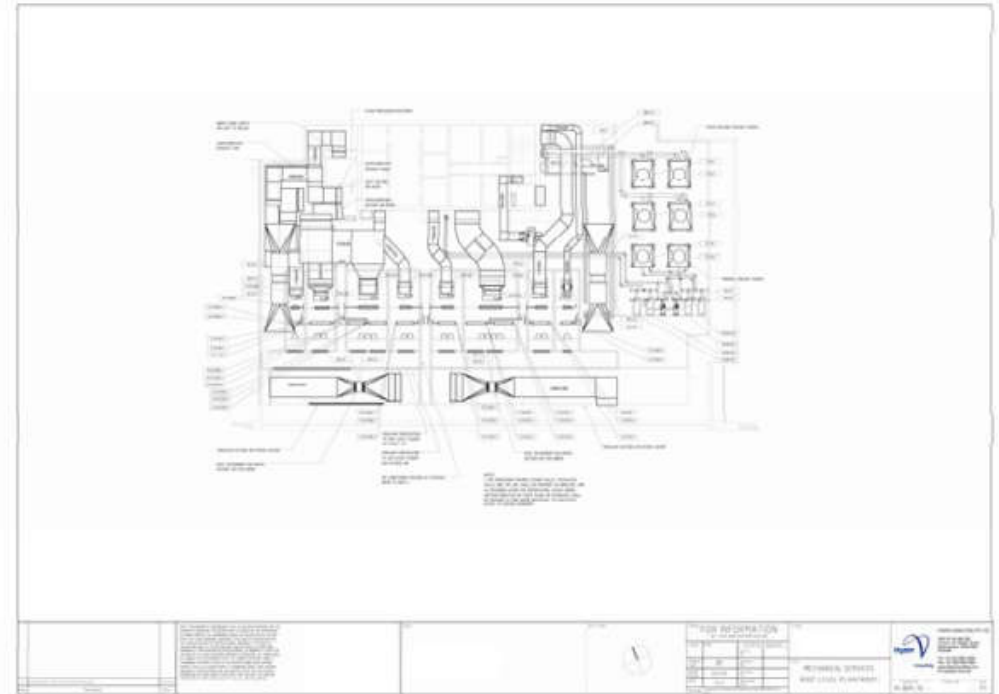
2D Documentation

2D drawing for plantroom

MEP documentation (examples)
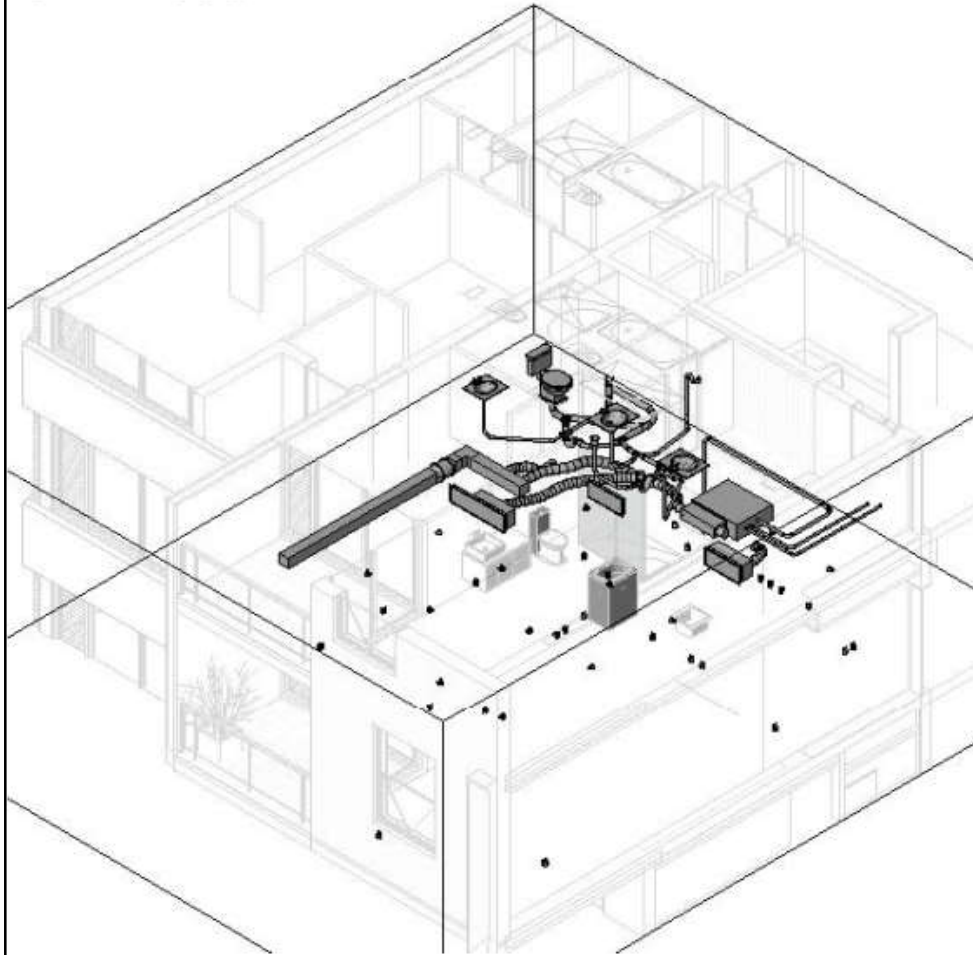
3D Model

2D Documentation
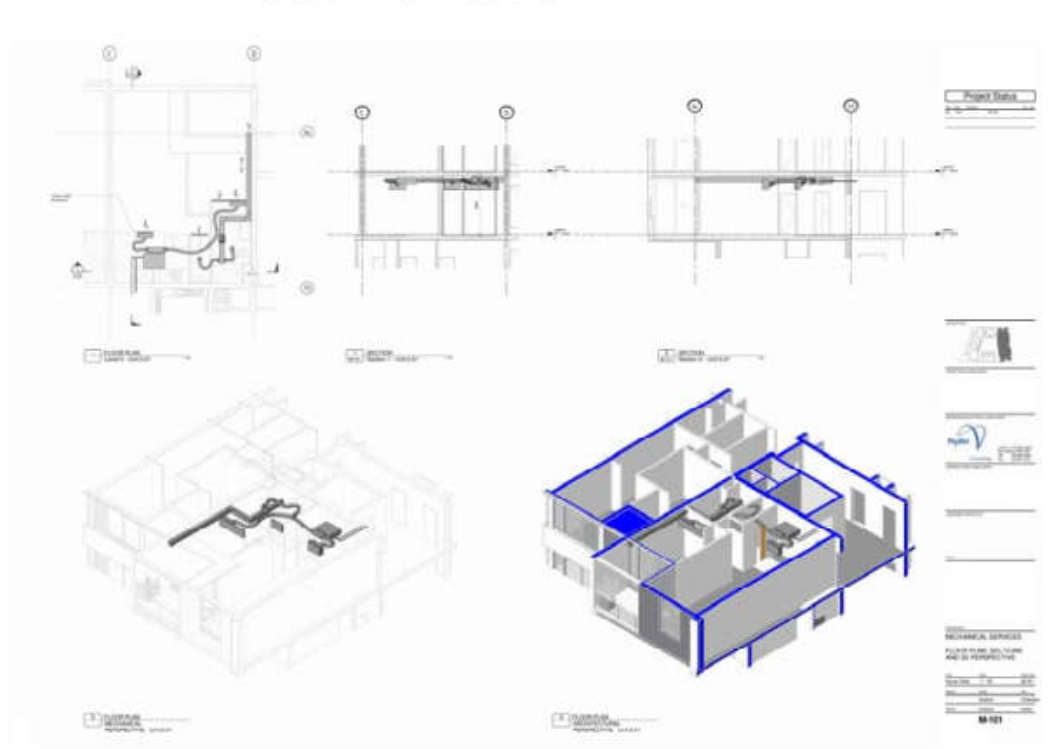
Drawings for different views

Do you know how to communicate & present your BIM MEP models?

Revit MEP tips

- Working with IFC format In/Out of Revit
  - Such as: Architect produces model in ArchiCAD & ArchiCAD model exported out to IFC format
    - Integrity of IFC model checked in Solibri model checker & file size is reduced
  - IFC model is imported into Revit and linked into MEP model; MEP main design elements produced (duct work, piping etc) in 3D
  - MEP model exported back to IFC and issued back to Architect, along with DWF

Revit MEP tips

- Working with IFC format In/Out of Revit
  - Coordination and collaboration using Navisworks
  - All details & schematics were produced in AutoCAD
  - Still a way to go for 100% integrity of IFC model geometry
    - Export/Import settings limited in both Revit & ArchiCAD
    - File size of Arch model once imported to Revit is quite large (200MB+)

Revit MEP tips

- Navisworks* & rendering**
  - Formatting schedules
  - Coordination with other file types (e.g. IFC, DWG, DXF, SAT)
  - Coordination models & clash detection
  - Quick review of models for non-CAD users
  - Rendering & animations
    - Create a photorealistic image of the building model
    - Lighting simulation & raytracing technique

Revit MEP tips

- Video tutorials:
  - Learning Revit MEP 2014
    https://www.cadtutor.net/tutorials/revit/learning-revit-mep-2014.php
    - 18 videos to teach the basics of Revit MEP
    - This video tutorial is designed for beginners, and no previous experience is necessary
    - Cover important topics such as using views, spaces and zones, running an energy analysis, HVAC, hydronic piping systems, fire protection and creating electrical systems
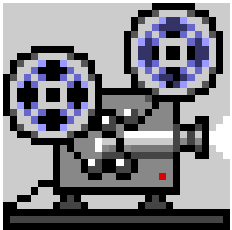
BIM modelling & MEP design

- 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

Requirements	• Creating requirements		Target consumption / Indoor air quality
Schematic	• Alternative solutions		Spatial Provisions / Energy Efficiency
Design	• Modelling chosen alternative		Network Modelling / Network calculations
Construction	• Building according the Models		Combied Models / Information content
Commissioning	• Utilization of Models		Device Validation / Information content
Maintenance	• BIM in FM		Service Area Charts / Device Database

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)

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)

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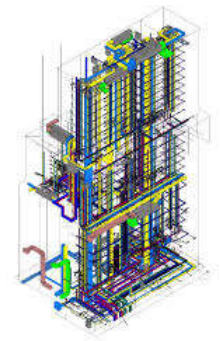
BIM modelling & MEP design
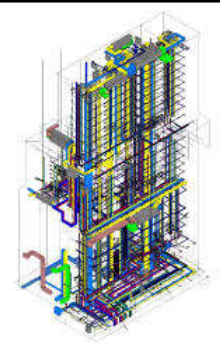
- Service area charts
  - Spaces with requirements are linked to service area charts (such as air handling unit service areas)
  - Linking is made using ifc Spaces (IfcZones are created with external software to IFC file
  - Visualization: Solibri… or some other software which understand IfcZones

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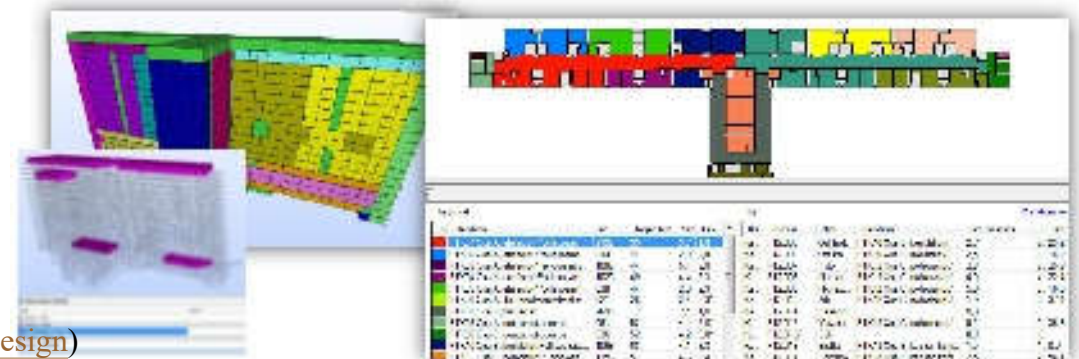
BIM modelling & MEP design

- 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

Energy analysis in different phases of building lifecycle

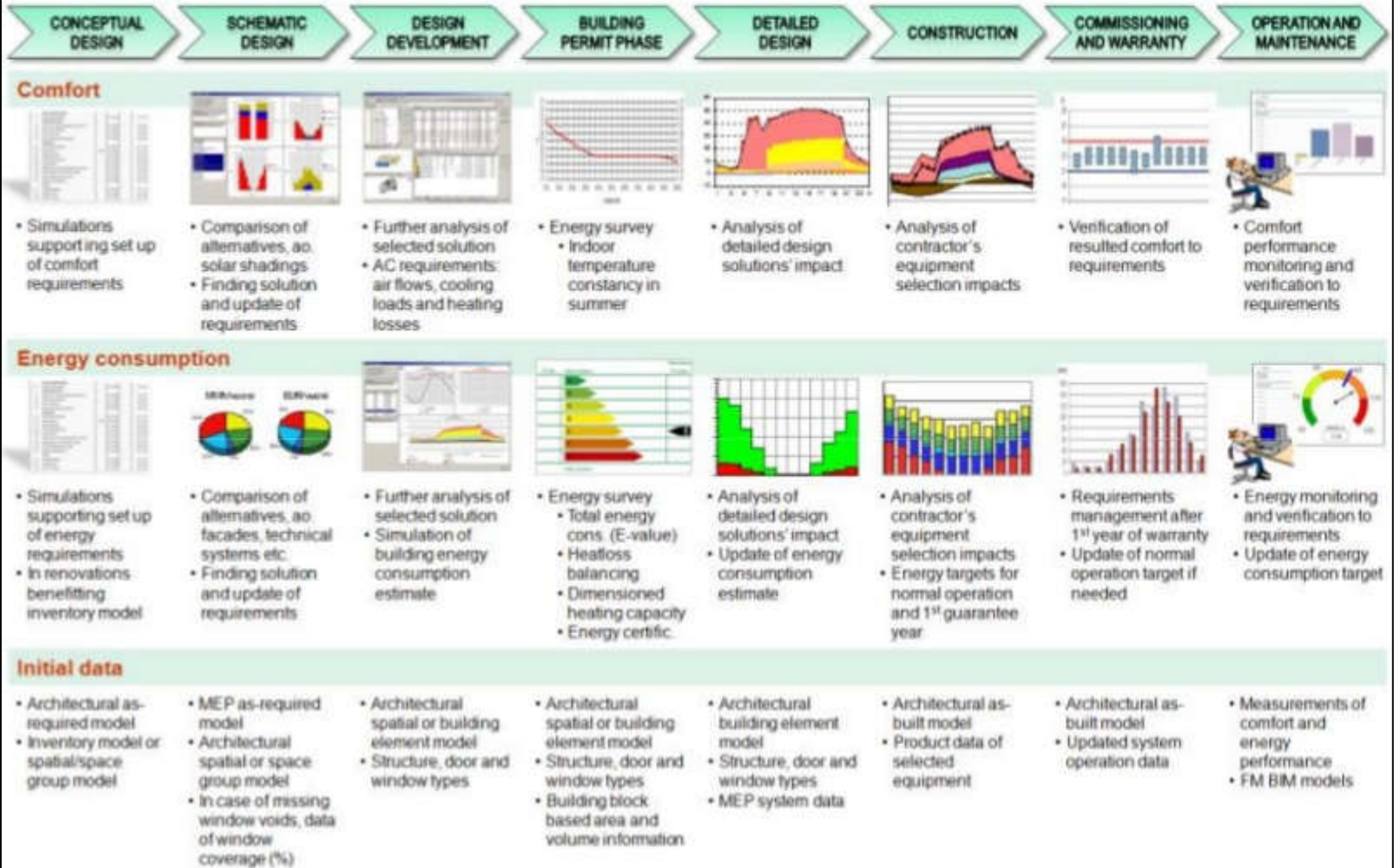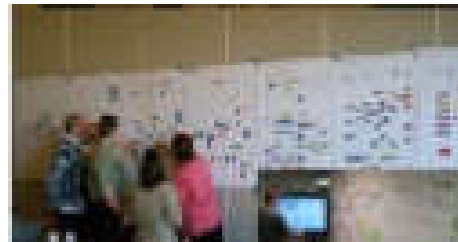| CONCEPTUAL DESIGN	SCHEMATIC DESIGN	DESIGN DEVELOPMENT	BUILDING PERMIT PHASE	DETAILED DESIGN	CONSTRUCTION	COMMISSIONING AND WARRANTY	OPERATION AND MAINTENANCE
Comfort							
• Simulations support ing set up of comfort requirements	• Comparison of alternatives, ao. solar shadings • Finding solution and 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)

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

BIM modelling & MEP design

- MEP modelling
  - Easiest thing in MEP modeling is the normal use of tools (e.g. MagiCAD) in network modelling
  - Hardest thing in MEP modelling is the iterative process & revision management
  - MEP designer is last discipline in process: changes in Arch. or Struct. models affects MEP models
  - There are quite a lot of tasks in MEP design, which is not seen in other disciplines (simulation, diagrams, system design, equipment databases… etc.)
  - **Designing is made first, modelling after that**

BIM modelling & MEP design

- How to make proper models
  - Modellers should have proper technical design skills
  - Modelling starts after schematic design
  - Continuous learning, stimulating environment
  - Passion. Be proud of your models
  - Courage to have challenges, need to take steps forward without knowing what will happen
  - Understanding your on place in big picture, other participants are also doing same building – collaborative approach

BIM modelling & MEP design

- Combined models
  - With using coordinated approach in combined models you can be sure your networks are in correct places
  - Combined models is mandatory when modelling networks in detailed design phase
  - With combined model, other disciplines have better understanding of networks (for example need of space etc.)
  - With combined model you can see all installation details you need for making networks installation possible according the design

BIM modelling & MEP design

- Combined models (cont'd)
    - When installations are made according the design, you have first step for network model usage in facility management
    - Good Practice: before assembly in certain areas is started, you should present combined model of that area to MEP contractors. This is where you can make planning of assembly schedules and contractors can see the amount of networks belonging to other contractors
    - Main use of combined models is in construction site (with contractors), e.g. 3D views are printed to paper

Important phases of MEP design

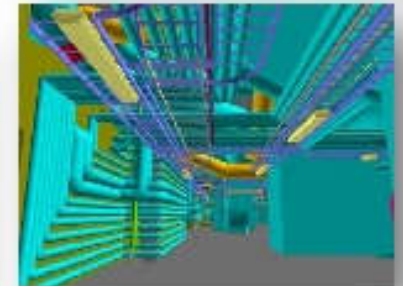| Proper Schematic design | Checking of 2D-section drawings | Modelling | Auditing | Calculations (balancing of networks pressure etc.) | Combied models to construction yard |
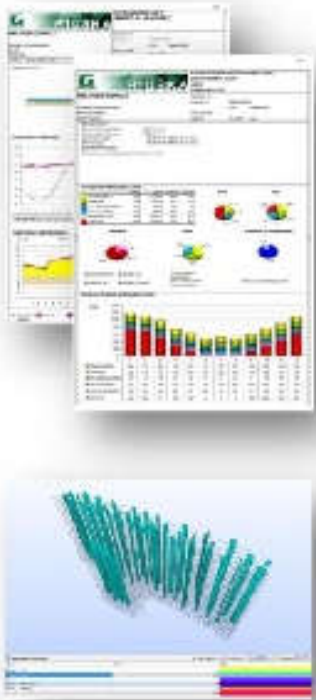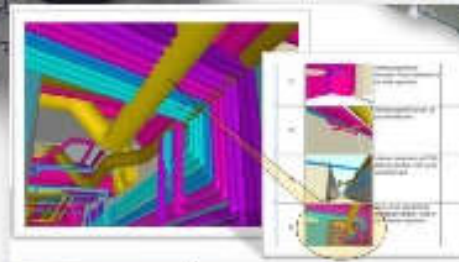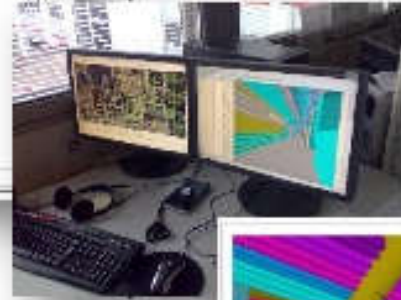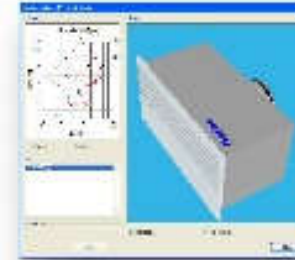
Other BIM MEP applications

- <u>BIM in construction phase</u>
  - 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

- <u>BIM in commissioning</u>
  - 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
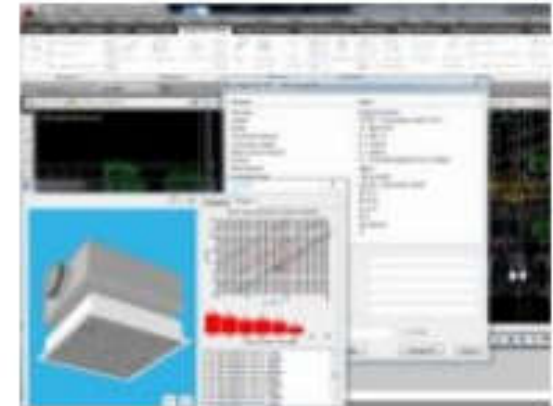
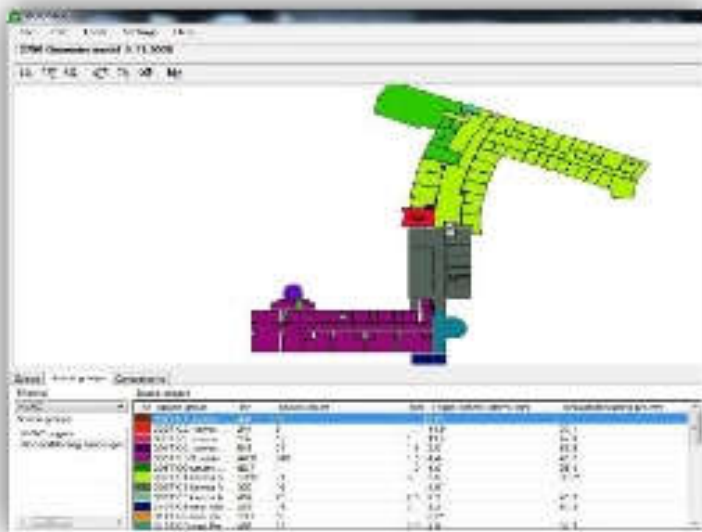# BIM to Facility Management (FM): information storage

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

BIM and MEP product lifecycle management

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