Using Simulations in development of comfortable urban spaces and sustainable building design

Daniel Nielsen

Companies: *aDN and EcoBIM*
Academic: *The Royal Danish Academy of Fine Art, School of Architecture and Technical University of Denmark*

Class id: AB6585

With the new functionalities and plug-ins for Revit software-such as Light Analysis for Revit software, Green Building Studio web-based energy analysis service, the Tally app, and the Dynamo visual programming language extension—new potentials have emerged during the last year. These developments have not only led to much easier work-flows, but also to a more holistic analysis of the building performance and urban comfort studies. In this lecture, these new potentials, work-flows, and methods for visualizing simulations are shown based on various consultancy tasks and a research project that seeks to add knowledge to architects' design processes as supported with simulation tools. The research project also included a workshop where participants tested methods on unskilled architectural students. We will wrap this all up in the lecture and relate it to model detail levels, instead of the typical schematic design process related to design phases. In many cases, this does not reflect the actual design process. Design development is done in various detail levels at the same time, especially in the early design phases.

Learning Objectives

At the end of this class, you will be able to:

1. Get started with the newest simulation functionalities in Revit software from early conceptual design to detail design
2. Recognize possibilities and limitations within the different simulations related to model detail levels
3. Learn how to choose simulations and visualization methods to analyze urban spaces, indoor environment, and operational and embodied energy
4. Discover more effective use of simulations to minimize time consumption in the process of creating sustainable designs

About the Speaker

Danish architect Daniel Nielsen became interested in sustainability in 2001, and he now has both a broad understanding and practical experience in creating architectural sustainability. Daniel works on projects of various scales—from buildings to planning—with the aim of creating high-quality architectural designs that take comfort, climate conditions, and resources into account. He integrates Green Building Information Modeling (BIM) into his work, using digital 3D BIM modeling and simulation tools to visualize and validate his designs. At the moment Daniel is involved in various research projects and education programs as external researcher and lecture at The Royal Danish Academy of Fine Arts, School of Architecture and Technical University of Denmark. Daniel also consults about architectural design at architecture firms.

Email: *ark.daniel.nielsen@gmail.com*
LinkedIn: *https://www.linkedin.com/in/arkdanielnielsen*
YouTube: *https://www.youtube.com/user/arkdanielnielsen/*
Twitter: *https://twitter.com/greenBIMdesign*

Content

Part 0 | Introduction
The structure of this Handout is not based on the Learning Objectives, as recommended, because the presentation is structured in three+one main parts. Therefore it makes more sense to use the same structure in both the Presentation and this Handout.

Part 1 | Educational Context
The achieved knowledge and experiences, from research-based teaching and design practice as greenBIM analyst and consultant, with the simulation outputs, its limitations, the use of the output and how it could be communicated and visualized, will be summarized in this section.

1.1. Introduction to Autodesk environmental simulation tools
1.2. How to read and understand simulation outputs
1.3. Case-studies from Student Courses and Design Practice
1.4. Learning from Educational Context

Part 2 | Design Analyses
Taking it to the next level by understanding the interrelation between Scales of Design, design questions, possible design strategies and choice of supporting simulations.

2.1. Strategy-driven Design Studies
2.2. Mapping Design Strategies, Scale of Design and Simulations
2.3. Mapping Simulations with Model Detail Levels
2.4. Learning from Design Analyses

Part 3 | Parametric Possibilities
By introducing Parametric Possibilities and full parametrically controlled and informed models, design variation studies and and performance and environmental studies becomes easier to perform because geometry and properties can rapidly be changed.

3.1. Parametric Methodology
3.2. Parametric Models
3.3. Parametric Simulations
3.4 Learning from Parametric Possibilities

Part 4 | Efficient Process
The overall aim is to present a more Efficient Process based on the knowledge strategies and possibilities presented in previous sections.

4.1. Opportunities and limitations of Pre-, Parallel and Post Design Analyses
4.2. Conceptual vs Reference vs Contextual Studies
4.3. The Analytical Design Process
4.4. Learning from Efficient Process

The presentation at Autodesk University will contain many illustrations and examples from students, consultancy and design from the past years.

Many of the Tips and Tricks that is mentioned as best-practice, is shown in the video tutorials on the above linked YouTube Channel.

Part 1 | Educational Context

In this first section The Educational Context is unfolded as a result of research-based teaching, consultancy and design practice as a part of the framework for a Efficient Process. The theme should be seen broadly, both learnings from different student courses, design projects and consultancy tasks. Besides this, available Autodesk tools is structured in relation to its simulation results with its limitations and best practice use.

1.1. Introduction to Autodesk environmental simulation tools

The selecting and use of the tools presented should be seen from an designers/architects need. Further, in this handout/presentation the focus are on Autodesk tools or plug-ins related to the primary modeling tools Revit/Vasari.

The simulation tools and plug-ins could be grouped in similar and/or interrelated analysis:

1. Tools and functionalities for Weather data Visualization/Analysis
2. Tools and functionalities for Exterior Analysis
3. Tools and functionalities for Interior Analysis
4. Tools and functionalities for Constructions and Area Analysis
5. Tools and functionalities for Visualization of Simulations

Table of Autodesk Tool related to different types of analysis and visualization

Tools for Weather data visualization /analysis	Tools for Exterior Analysis	Tools for Interior Analysis	Tools for Constructions and Area Analysis	Tools for Visualization of simulations/calculations
Revit+GBS - Climate studies (through Results & Compare or GBS) Revit+Project Solon - Climate studies	Revit - Shadow studies Revit - Solar Radiation studies	Revit - Shadow studies Revit - Conceptual Energy studies Revit - Detailed Energy studies Revit - Daylight and light Levels (with Render in cloud) Revit+Light Analysis - Light Levels	Revit - Studies of surface areas and floor areas Revit - U-value studies of detailed constructions Revit - Conceptual LCA studies Revit+Tally - Detailed Object-based LCA	Revit - Sheets, model Views, Images etc. Revit+Project Solon - energy and climate data viz
Vasari - Climate studies (through Results & Compare or GBS) Vasari - Wind rose studies (speed and direction) Vasari+Project Solon - Climate studies	Vasari - Shadow studies Vasari - Wind Pattern Vasari - Solar Radiation	Vasari - Shadow studies Vasari - Conceptual Energy studies Vasari - Solar Radiation Vasari - Wind Pattern	Vasari - Conceptual LCA studies Vasari - Studies of surface areas and floor areas	
GBS+Project Salon - Climate studies		GBS - Conceptual Energy studies and Detailed Energy studies		GBS+Project Salon - energy and climate data viz
	Flow Design - Wind Pattern Flow Design - Wind Pressure	Flow Design - Wind Pattern Flow Design - Wind Pressure		
Dynamo - Simulation Results	Dynamo - Solar Radiation	Dynamo - Energy studies Dynamo - Daylight and Light Levels (with Render in cloud) Dynamo - Solar Radiation		

*(In **red** - in between interior and exterior or something that affect the interior)*

1.2. How to read and understand simulation outputs

In this section it is introduced how the author reads and understand the simulation results, and which limitations have been discovered with different tools. This is something the user should be aware before getting started with simulations, to avoid asking the wrong questions.

Applicable for all simulations, the value of simulate concepts/designs is to compare different options, and to compare concepts/designs it is important that they have the same settings, conditions, square-meter etc. Single simulations is not as valuable as comparing different options.

Analysing Shadow Simulations

Using Shadows for analysing concepts/designs is a fast method to understand shadow patterns. But it does not give a holistic answer to whether the concept/design is good in relation to light levels or thermal comfort. Only a raw analysis of where there are shadows or not.

Limitations with Shadow Simulations

- It is not possible to create Shadow Range / Butterfly Diagram automatically, similar to what is possible within Ecotect.

Summary / best-practices Shadow Simulations

- By using setup on Sheets with Views for each hour (or wished time-step) it is possible to create a Butterfly Diagram in a Plan View by layering Views (without e.g. Floors and Toposurface). The method is limited, but possible. Further, the Butterfly Diagram updating real-time if geometry is moved or changed.
- Another way of making Shadow studies is in Plan or Section views, where it is possible to look inside the model without cutting the above model/geometry away. This means the above model/geometry is taken into account when showing shadows.

Analysing Wind Simulations

The Wind Tunnel in Vasari and Flow Design simulate in similar ways. Mainly it shows how the wind pattern could be around or in-between some objects. The simulation could be read in different ways, the one that have been explained in teaching and used in practice is an analyze of the wind pattern, instead of looking at wind speed. The wind speed is in a way a result of the input wind speed, therefor a reading of the simulation could be a more visual reading like the below color legend Fig 1.01.



Fig. 1.01 Color Scale Legend for reading wind pattern and speed.

Limitations with Wind Simulations

- One of the limitations in Vasari is that it does not effect the result pattern if it is a high or low wind speed. The pattern is the same just with a other wind speed for the same colors. The pattern should be different and react differently with a higher or lower wind speed in relation for spots with turbulence etc.
- In the Flow Design Stand-alone version is it not possible to change the Color Scale Legend. This makes it difficult to compare different concepts/designs. This is possible when using Flow Design within Revit (do not support Revit 2015).

Summary / best-practices Wind pattern simulations

- As written above, the reading of the color scale makes a more visual understanding of meaning of the colors by relating it to the above color scale.
- If the project is located in a undulating terrain, then is it difficult to use the 2D horizontal section for visualising the wind pattern, because it will slice in the terrain. In this case the 3D Iso-surface with different thresholds gives a better visualization and understanding of the wind pattern in the model.

Analysing Solar Radiation Simulations

Analysing the Solar Radiation does not only tell something about the amount of energy (kW) received on a given surface during a given time. There is a direct relation between Radiation levels and Illuminance levels, as seen in the diagram Fig. 1.02, it could be argued that when simulating Radiation it also tells something about if there is good or poor daylight conditions, or if there could appear glare issues, if there where placed a lot of glazing on those surfaces that had high Radiation levels.

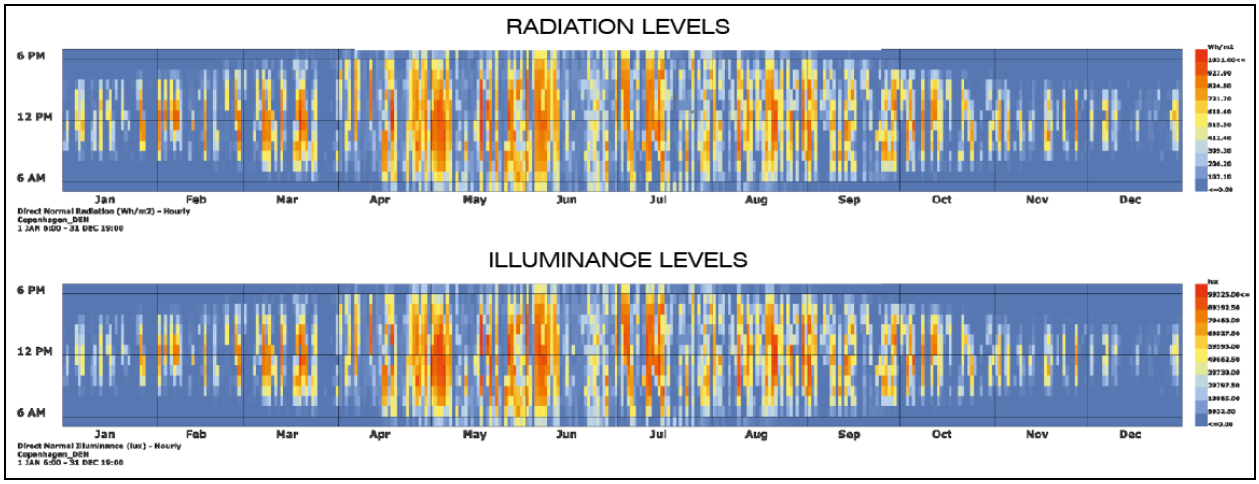


Fig. 1.02 Relation between the amount of Radiation and Illuminance (light levels) during a year from 6am to 6pm.

Limitations with Solar Radiation Simulations

- To read the total amount of Radiation it is needed to export/save the results to a .cvs file and then import data into Excel or read results through Dynamo.
- Simulating other Categories than Mass. To simulate a more detailed model is possible by exporting the model as .dwg file and then import the model or part of the model (to limit the amount of surfaces) into a new Mass.
- The editing of the Color Legend is limited, e.g. it is not possible to set the minimum and maximum value, but it is possible to change number color steps. With the right nodes in Dynamo it is possible to control min/max color value.
- There is a limitation of x-amount of surfaces. Typically this is not a huge problem, but when importing models either context models or detailed models this can be a problem.
- The Solar Radiation does not account for reflected Radiation. It is not necessarily a limitation with early studies, but for more detailed analysis it is a limitation .Because typically the design question is about material properties as well, which material absorb or reflect radiation/light better.

Summary / best-practices Solar Radiation

- There are different ways of visualize results. Typical the colored surfaces is fine in the early stage of a design. Later the point with values method could be more useful.
- In general this tool is best for visual feedback. It is possible to calculate a average Radiation by exporting data and post-process data in Excel or similar tool.

Analysing Daylight Simulations

There is two ways of simulating Day-/light (illuminance levels) with Revit. One method is using the Render i Cloud function, with this method it is possible to run any date and time, and sky type as wanted. The other method is with the plug-in Light Analysis, and this one is limited to only run the 21. of September at 9am and 3pm with a Clear Sky. By having placed Rooms in the model extended feedback is given with the Light Analysis. This is not the case with the illuminance simulation with the Cloud method.



Fig 1.03 Spacial visualizations and daylight simulation.

Limitations with Daylight Simulations

- At the moment it is only possible to simulate light levels (Illuminance), and not Luminance that is useful for Glare studies.
- It is only possible to simulate Object-based Revit models, not Mass models. This is relevant to simulate at a early stage to get the “full” picture on how the concept/design could perform.
- Only by using the Light Analysis plug-in it is possible to get average values or similar numeric feedback from the simulation. Further, as is it now, it is only possible to run date and time in relation to LEED certification (21. Sep. 9am and 3pm).

Summary / best-practices Daylight Simulations

- There are some interesting possibilities to compare and analyze daylight levels both in spacial views, as shown in Fig 1.cc, in combination with the same kind of visualization/simulations in plan views. The best part is how easy it is to simulate a detailed object-based model.

Analysing Energy Simulations

One thing that is important to mention with energy simulation in general, also really detailed ones, they can never predict the actually energy need, mainly because of the users. Therefor the results should be seen as a average energy need that could both be less or higher in reality.
Beside the Energy Use simulation it comes also with a Life Cycle Energy Use/Cost, this calculation is based on a average energy cost (fuel and Electricity) for whole countries/states. Therefor it is a very rough calculation because, e.g. in Denmark the energy cost is very different from regions.

Limitations with Energy Simulations

- With Conceptual Energy Analysis (CEA) it is a huge limitation that it is only possible to select pre-defined construction types. That mainly is based on the North-American market. This is the same limitation when choosing HVAC Systems.
- Regarding the Object-based (detailed constructions/elements) Energy Analysis (BEA) there is the same limitation regarding the selection of HVAC Systems. Further, it is only possible to apply the same function (e.g. office) to the whole building or all buildings. This is opposite the possibilities by analysing Conceptual Mass models, where it is possible to apply different function for each zones/buildings.
- Generating Energy Models based on object-based models have problems in different situations. E.g. with air gabs when the geometry/objects is not joining in a very simple way. Second there is a limitations related to the thickness of the construction. This is a huge problem in cold climate where construction is typical quite thick (400mm or thicker).
- The energy use for lighting is based on the square-meter. This means even though if the glazing percent is change the energy use for lighting is still the same. If it is instead done from Green Building Studio (GBS) it have an effect on the result, but the unfriendliness of GBS could have been better.

Summary / best-practices Energy Simulations

- Typical it is needed to do some post-processing with the results to communicate results more clearly with only key values.
- The must useful result in the overwhelming Results & Compare window is:
    - Energy use for heating, Cooling and Lighting.
    - Surface and floor areas.
- Second, after the energy and areas numbers is the Monthly Loads, to get a understanding of losses and gains.
- With Project Solon there is new and better ways of interact with the results, as well as for exporting data and graphs, e.g. vector graphic.
- The energy use for Fuel and Electricity are not the same unit, therefor by converting the results in MJ to kW makes it easier to compare and communicate results.

Layout and Visualization in Revit

Revit is probably not meant to be a tool for layout setup or presentation of simulations, but there is workarounds that makes it possible.

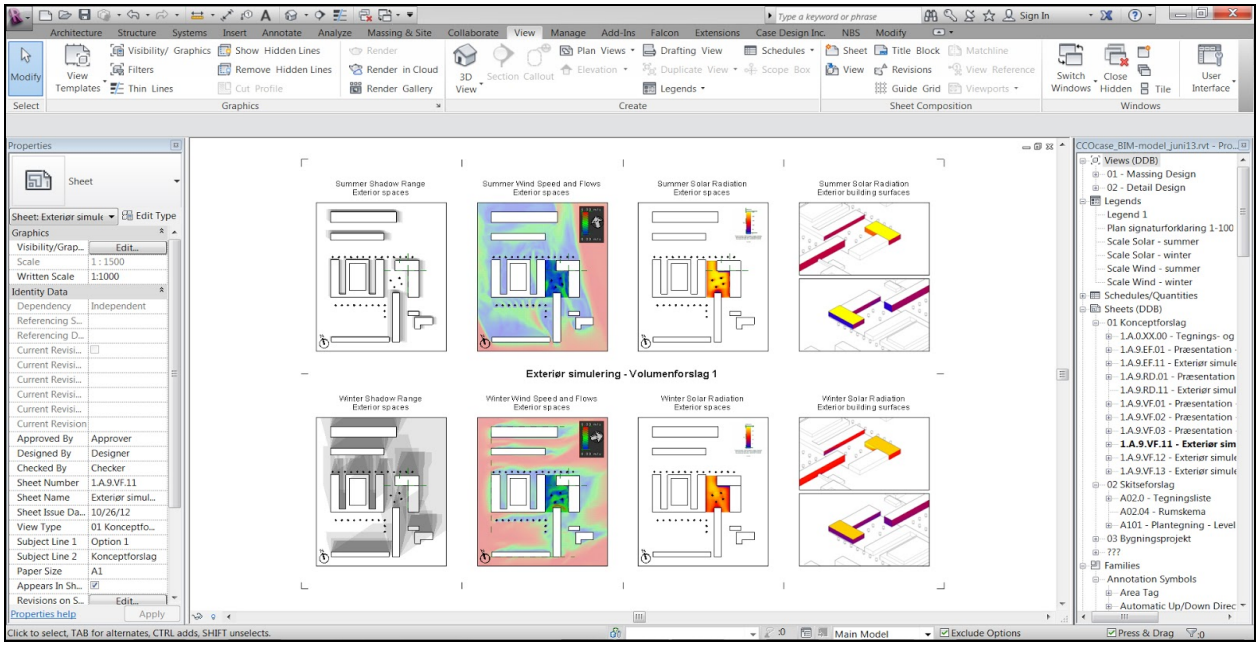


Fig 1.04 Example of setup of Simulations in Revit.

Summary / best-practices Layout and Visualization in Revit

- In general for all kind of results that suppose to be read only visually it gives the best reading if model view orientation and zoom is the exactly the same. In this way it is very easy to visually see differences.
- A workaround for not having functionalities for cropping images, is having the images places on a Drafting View and placing a Masking Region on top of the Image to hide parts that is undesirable.
- By adding small explaining comments to the simulations, the simulations goes from just a raw simulation to a analyzed simulation.

1.3. Case-studies from Student Courses and Design Practice

This part of the presentation is mainly illustration-based to show good student and own project examples is illustrated and communicated and how Autodesk tools have been used to simulate and analyze concepts and designs.

Some courses have only had few simple simulation integrated in the design assignment. Other courses have had introduced simulations from the very first beginning with Massing studies to the end studies of detailed object-based models. These courses have gained high quality feedback on suggested work-flows, model and simulations issues that would have not been possible in the same time-frame on your own. Besides this, seen how students develop there own visual style of communication based on some important guidelines for communicating simulations in general, and how important this part is.

A typical first task have been to challenge there intuitive perceptions by predicting there concepts/designs urban comfort, daylight etc. performance.

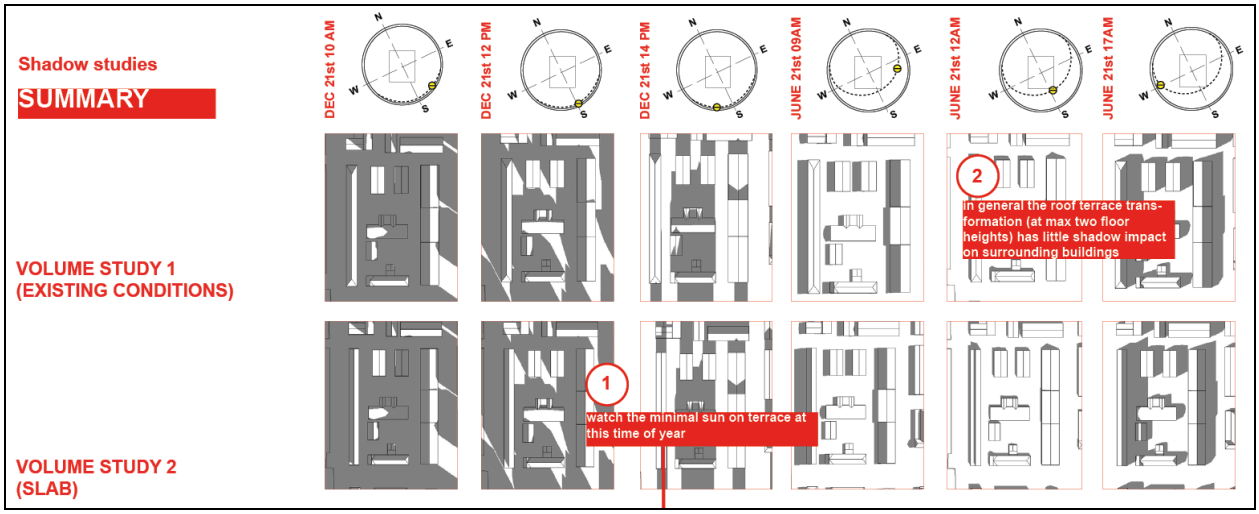


Fig. 1.06 Student project example from KADK. This layout could have been done i Revit on Sheets.

Regarding consultancy and design jobs, there is other learnings, e.g. how to deal with quickly changing design process with valuable feedback. Most of the consultancy jobs, have been analysing design during the design development. During the Presentation more examples will be shown.

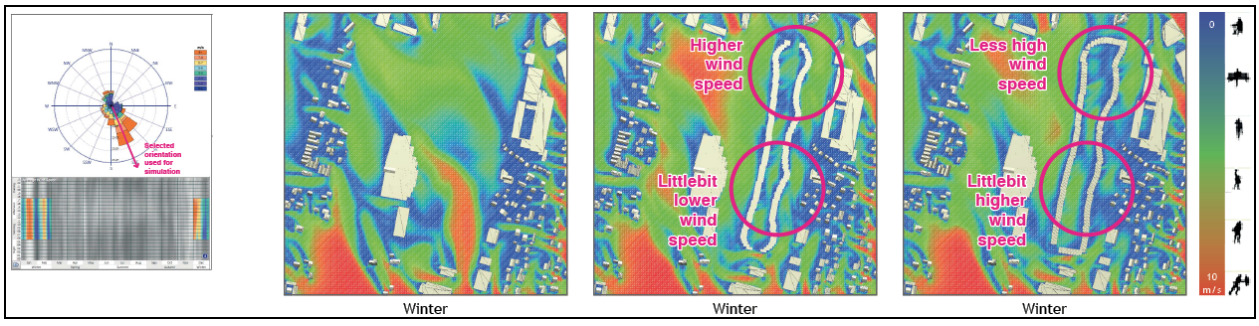


Fig. 1.07 Urban Wind studies, together with EcoBIM.

1.4. Learning from Educational Context

Many of the key-points in this section creates the basis understanding for efficient and useful simulation output. As mention earlier the key-points are based on both research-based teaching and analysis tasks from practice, which gives different views on efficiency and learnings.

General/process orientated issues

- Often the communication takes more time than the simulation it self.
- Setup models is also a time consuming task when working as specialist or consultant
- Due to late involvement in the design process as a specialist or consultant it is typical a challenge to follow up with feedback to the designers.
- The importance of clearly and describing illustrations for communicating results from simulations. Simulations cannot stand alone without any after-processing or comments to describe the output and result of the analysis.

Technical issues

- Designers and modelers lack of knowledge about good models for simulations. There is limitations, and some specific ways of creating models, due to both how Revit is programmed and how it transform the model into a energy model.
- Due to the focus on the North-American market there is a need of customized thermal properties for window and door elements.

Part 2 | Design Analyses

The relation between Scale of Design and relevant analysis question, What to study? Why study? Which studies are relevant at this Scale?

Further, introducing a re-defined model for mapping model detail levels with relevant simulation tools. A model that original was based on a rigid phase work-flow, Nielsen (2011), is now linked to model detail levels.

2.1. Strategy-driven Design Studies

Previous literature used to relate Design Studies to Design Phases, e.g. Conceptual Design, Design Development and Detail Design. In practices studies is not necessarily related to a specific phase - because where does a phase begin or end before a new phase starts!?

This handout/presentation present another model, a Strategy-driven. This model is more related to the creative design process, where design maybe is developed in different scales with various design questions at the same time.

- It is fundamental to understand that an architect needs answers for all kind of design questions to keep a progressive process that strives for a higher synthesis - a ongoing interactive process.
- When facing a complex design questions or simple one, it could be divided into smaller questions that could, as a starting point be analyzed isolated, but in the end all possible analysis should be done.

2.2. Mapping Design Questions, Scale of Design and Simulations

Defining a model for Scale of Design

A schematic model for Scale of Design could be described based on the “Integrated Building design System” (IBDS) by Steemers (2006) with extension by Andresen (2009) Fig. 2.01.

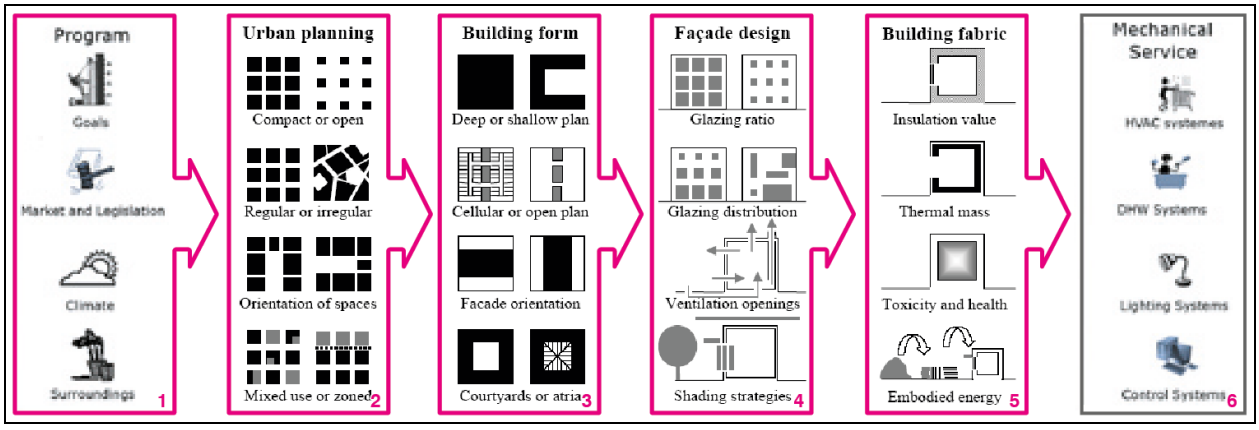


Fig. 2.01 A schematic model for Scale of Design

A modified model is created to correspond better to this handout/presentation, with following headlines and content used:

1. Program and Climate studies.
2. Urban Planning and outdoor spaces studies.
3. Building Form and Typology studies.

4. Facade and Room studies.
5. BuildingRelate Fabric, Construction and material studies.
6. *Mechanical Service Studies (not included in this framework).*

Defining Design Questions related to Scale of Design with Simulations

A Relation Matrix based on Steemers (2006) is modified to integrate the use of simulations.

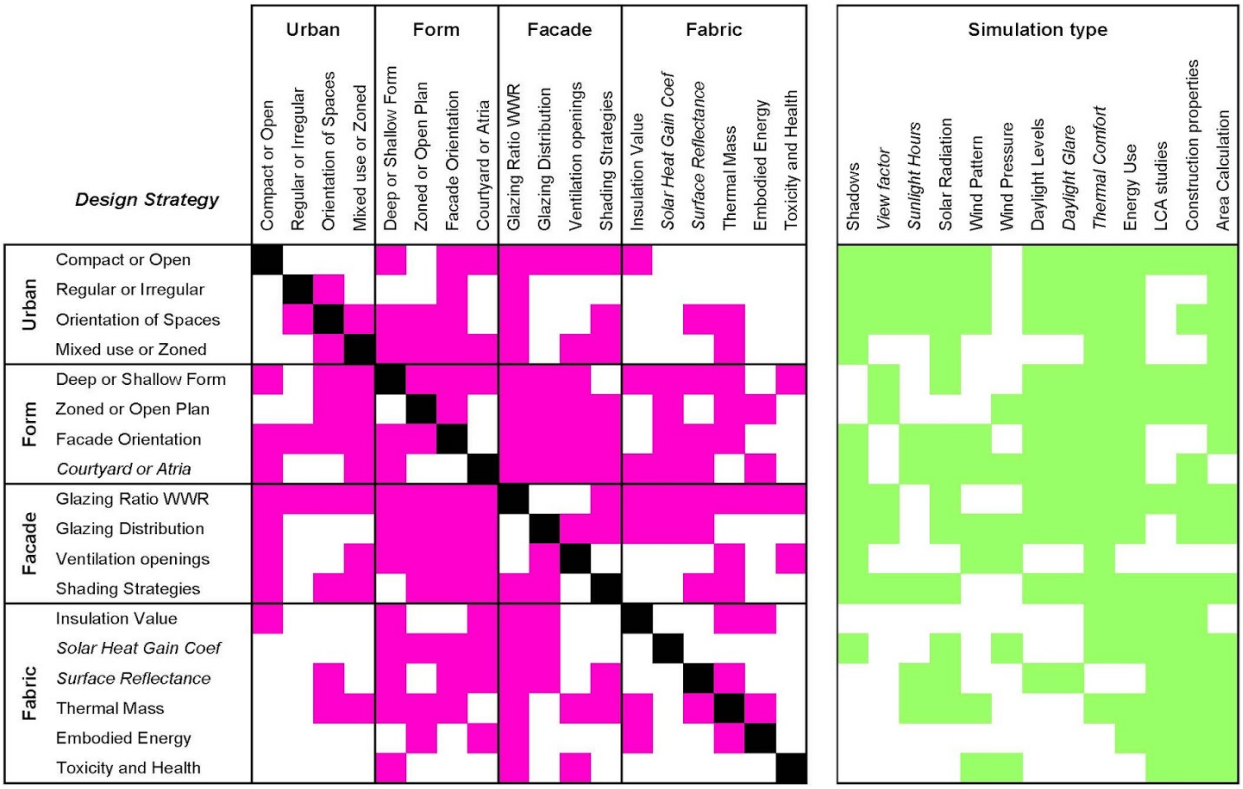


Fig. 2.02 An example of a Relation Matrix between Scale of Design and Design Strategies, and finally relevant simulations based on

2.3. Mapping Simulations with Model Detail Levels

The relation between Scale of Design, model detail level and possible simulations are typically a confusing consideration or choice. When to select a tool or try simulate something?

The aim of Fig. 2.03 have been to define a schematic diagram with a model progress from simple Context Models to Detailed Object Models with possible simulations specific for that model detail level. It should not be seen as a rigid work-flow starting from left to right but more as a way of getting a overview of possible simulations for a specific model detail level (vertical reading). This model structure is developed based on the model progression that is possible with traditional Revit modeling, and especially parametric models built from scratch (see the section “Parametric Possibilities”).

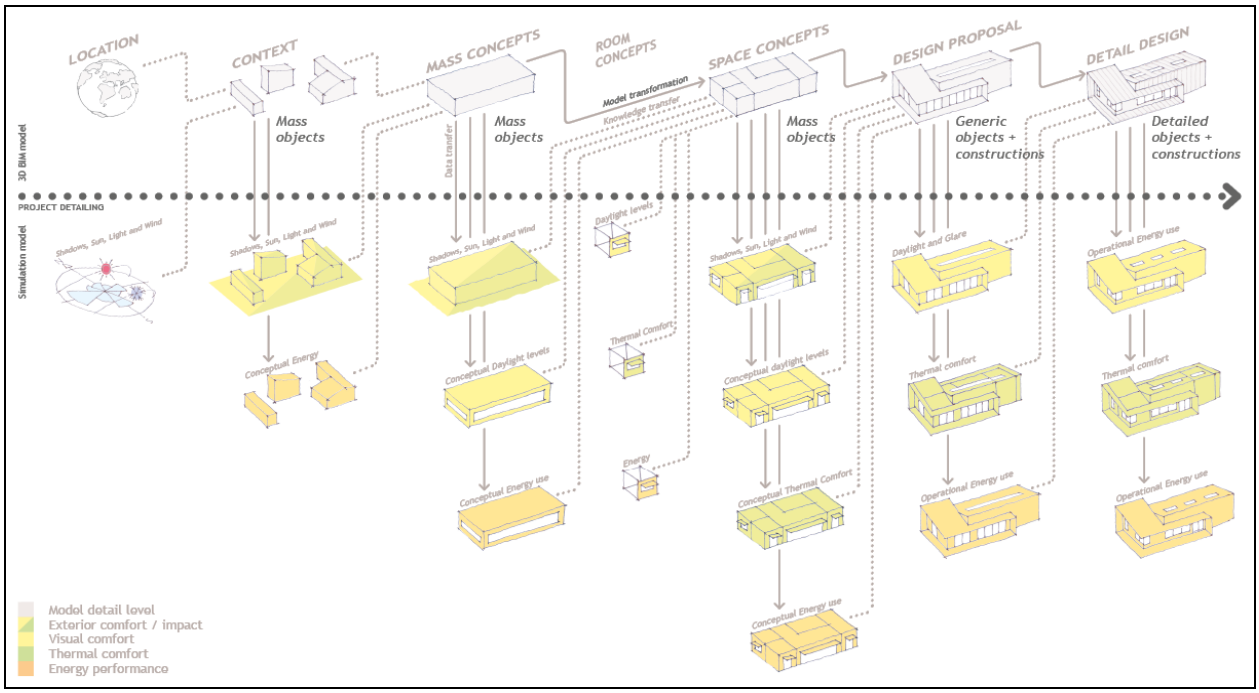


Fig. 2.03 Schematic diagram of mapping simulations with model detail levels.

The included studies and simulations in Fig. 2.03, are not all supported by Autodesk products:

- Visual Comfort studies in general (i.a. Daylight):
  - There is no tools or plug-ins support daylight studies of Mass models. Except Ecotect, but Ecotect is not considered as a future choice anymore. Because of its uncertain accuracy, and the simulation speed is slow. Further, it no longer maintained with updates.
  - It is possible to simulate Illuminance Levels, but not Luminance that is used for analysing Glare issues.
- Thermal Comfort studies in general:
  - No Autodesk tools or plug-ins support simulations of thermal comfort. Note, heating and cooling loads, e.g. kWh, is not a analysis of thermal comfort.
  - Maybe in the future this will be possible based on the initiative of re-written the EnergyPlus engine/code!? Because this is possible with EnergyPlus.
- Studies of Rooms and Facade Concepts/Designs:
  - There is no immediate tools or plug-ins to support these studies. Daylight studies of illuminance as mention above could be done as the only simulation.
  - The studies could be done with Ecotect, but is no longer considered as a rational choice.

2.4. Learning from Design Analysis

- Simulation tool does not necessary need to be highly accurate but it should be a accurate enough to indicate the path to follow. This doesn't mean a more accurate feedback is not necessary, but it could wait to later in the process.
- It is also important to underline that designs should not be seen as a sum of individual optimized parts, but as a holistic environmental design.

General Summary about Autodesk Simulations

The next step into environmental analysis is combining and/or over-layering different types of data input, e.g. when simulating Radiation this does not say anything about if it is need or not. By combing data input and create a threshold for when Radiation is wanted or not this kind of simulation gets more valuable (Fig WW see right image).

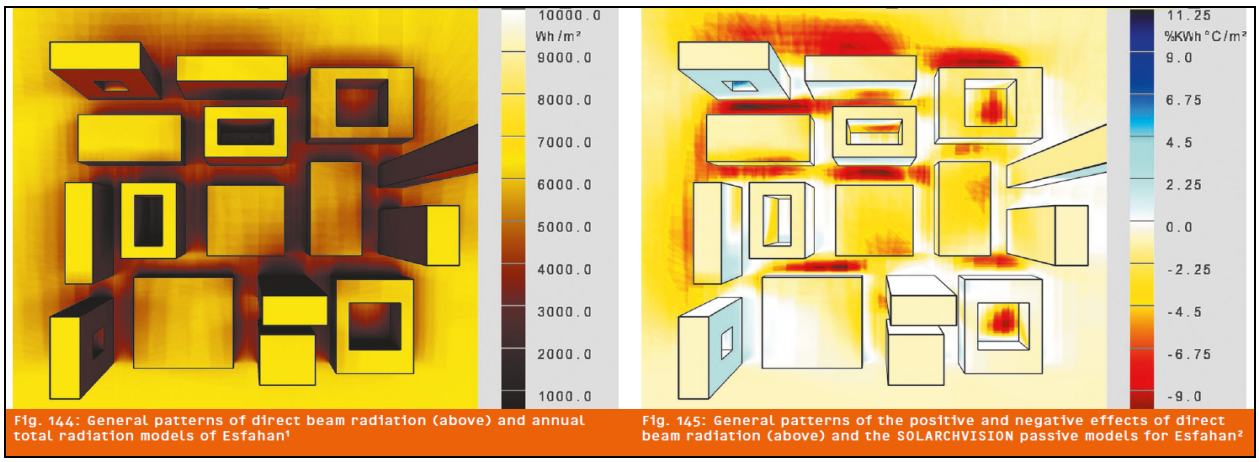


Fig 2.04 Left: Radiation simulation. Right: A combined simulation of Radiation and Temperature.

Part 3 | Parametric Possibilities

When working with digital models and simulations there is some great benefits if models are applied with parametric relations or objectives. It makes things more valuable if it is possible to change concepts or designs easily. By having the geometry parametric or the properties parametric, it get possible to simulate parametric variations in relation to environmental objectives. This is also possible with structural objectives, but that is not the focus in this handout/presentation.

3.1. Parametric Methodology

The term/buzzword Parametric Design have been around for a while. But what does it mean? And can "Parametric Design" be used for other things that just crazy organic shapes with a applied even-more crazy surface elements? This is the typical search result when searching on Parametric Design - crazy shapes!.

To often Parametric Design is linked to these crazy shapes, but it is also possible to parametrize concepts or design in a more clever/useful way.

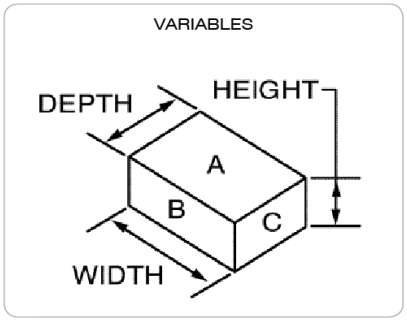


Fig 3.01 This case project is an example of parametric controlled architectural and structural design done in collaboration with ag5 Architects and Rambøll UK, 2014.

Intro to Design Constraints, Variables and Objectives

When working with parametric design and simulations in general it is needed to define constraints, variables and objectives for which the design should or could be controlled/changes or analysed. Without it would be difficult to analyze or validate the design.







Design Constraints

- Constraints are a set of criteria which impose a limitation on e.g. the design of the building i.e. the height of the building must not exceed 80m.
- It could be related to specific legislation's.

Design Variables

- Design Variables are parameters that could change the form of the building i.e. building height, width, depth etc. The variables should relate to the constraints i.e. if the building height have a constrain there should be a parameter to control the constrain of the building height.
- The variables appear as data which can be interrogated on an individual design basis to assess its performance. Again e.g. the height of the building could be controlled by a number input between 20 and 80 m. While parametric variation studies each concept/design could in the same time be simulated and saved, and at the end, the variations could be analyzed and inspected.
- The designer/specialist/consultant defines the solution space, i.e. the boundary conditions.

Design Objectives

- Last, defining the Objectives, or goals. A specific result that should be achieved. It could be client wish of getting Certification Credit e.g maximum Energy Use or minimum Daylight Levels.
- In many cases there is conflicting Objectives, therefor a weighting system typically needed. It could be based on its importance or a desired performance goal.
- More likely the desires of the client/designer could/would be a combination of different desires. Recording these ambitions and weighting them in terms of importance allows the client or design team to see exactly how their decisions influence the building design and performance. It could also acts as a record of the decision making process.

3.2. Parametric Models

With the introduction of Dynamo a couple of year ago, a new era emerged. Dynamo is visual programming plug-in for Revit that makes it possible to create cross related relations and parameters that is nearly not possible in Revit. With Dynamo as the tool that connect all kind of parameters have the potential of create fully controlled parametric models.

Highlights of possibilities when build/apply models with parametric Variables:

- Parametric models (geometrically) do not necessarily have any limits it could be done at all Scales of a Design, e.g. Urban Layout, overall building form, room proportions, facade design etc.
- Everything is more or less possible to parametrize.

A parametric case "Urban Haven"

The case is an example of parametric controlled architectural and structural design (Fig. 3.01):

- Starting with points that makes the whole basis for the rest of the building shape and structure.
- Using the simple building shape for early energy analysis, as well as daylight studies.
- The core shape as basis for the main structural design concept.
- When developing a parametric model typical one step is a simple massing model, where surfaces later is subdivided to add parametric surface elements. At this stage, with a simple mass, it is easy to use that shape for early conceptual energy analysis (CEA).

3.3. Parametric Simulations

In similar ways explained about Parametric Models, simulations can also be build with parametric objectives. Example of parametric simulation properties:

- Material properties of building parts (constructions) these can also be parametric, as well as glazing properties, e.g. u-value, transparency, solar heat gain coefficient etc.
- It is also possible to parametrize building system properties, e.g. set-points, efficiency etc.
- This means it is possible to run a lot of variation studies or more quantitative optimizations runs of the properties.
- That is why it is interesting to set-up parametric design, models, properties and/or relations. It just makes things, much easier to change, test, analyze design.

Environmental performance-based extensions for Dynamo:

- Solar Radiation Nodes, not limited to only Mass faces
- Sun Path orientating Nodes
- Nodes for Daylight Simulations, both Illuminance and Daylight Factor results
- Parametric Energy Simulation Nodes by Thornton Tomasetti CORE studio
- Nodes for importing/moving simulation data, Mantis Shrimp for Dynamo by Konrad Sobon
    - E.g. simulations done with Grasshopper+Ladybug/Honeybee moved/visulized in Revit with Dynamo.

3.4. Learning from Parametric Possibilities

In general

- Before building a parametric model, develop a robust and strong concept that is not limited in variation. If the concept is limited, why build parametric models?
- Start sketching the parametric relation on paper by hand.

Technical

- Define Objectives, Constrains and Variables before analyzing variation studies. If one is missing it is difficult to analyse and decide the "best" variation.

Part 4 | Efficient Process

An initial questions - what is a efficient process?

- Fast and visual feedback.
- Useful and valuable feedback or guidance.

4.1. Opportunities and limitations of Pre-, Parallel and Post Design Analyses

Why is this important to know?

- To be aware of opportunities and limitations, when doing or considering environmental simulations and analyses and to align expectations of the result benefits between all involved, because the benefit of the analyses is very dependent on when simulations are done:
    - Internally (in the company - designers, specialist etc.)
    - Externally (consultant, other designer, client etc.)

Performance and Environmental Analyses can be grouped as Pre, Parallel and Post Analyses.

Pre-Analyses - analyses before getting started with designing

- Analysis done before the actually design development by analysing conceptual concepts or reference projects.
- The advantage of doing analysis before the design get started is the time aspect, because it takes time to setup and do the analysis and communicate the results clearly to the designer or the team.
- Further, at this point there is the greatest design freedom/possibilities to make more sustainable and robust designs.

Parallel Analyses - analyses during the design development

- The simulations during design development is the most challenging one, because of the constantly changing design at this stage of the creative design process.
- To get success with analysis during or beside the creative design process it is needed to have a very structured work-flow, where the designers are taught in god modelling routines/methods that support easier simulations of the models for the analyst or consultant to give fast feedback to the designer. Ideally the designer should have the skills to do design analysis, but that is almost never the case.

Post Analyses - analyses after design

- These kind of analysis is more documentation than analysing. Why? because of the design is finish (or probably close to be). Therefor there is no probably no time for changing or design freedom to change anything, at least not the geometrical design.
- There could be small properties or system adjustment related to glazing type, surface reflectance and HVAC. As mention earlier, HVAC optimizing is not the focus in this handout/presentation, but it should be stressed there is some optimizing possibilities in this area.

4.2. Conceptual vs Reference vs Contextual Studies

Design studies can be divided into three different types/focus areas. The selecting of words could be discussed, but in this handout/presentation they are defined conceptual, reference and contextual studies.

Conceptual studies

- Studies of a not defined design, an idea or possible options, like a typology study of urban layout or a overall building design.
- Models of conceptual Concepts that is not related to a specific site with a existing urban structure or building shapes, heights etc.
- The advantage with these studies is, they can be done fast by just changing the location (weather file), and get a result on how the Conceptual Concept perform in that specific climate, and compare the concept with other concepts or/and climate. To get a better understanding of the both the concept but also the climate, instead of looking at weather data. This could be easier for the designer to understand - climate understanding through models!
- These conceptual model studies could either be done on a “standard” of an Urban Layout with a fixed Floor area ratio (FAR) and street width, building heights etc, or changing the Conceptual model to the project program demand, to have same comparable Design Constraints. This is one of the reasons parametric design is described in this handout/presentation, because of its great possibilities in relation to these kind of studies, by combining Conceptual Studies with parametric modeling.

Reference Studies

- Reference studies is referring to studies of build reference projects. It could be a urban area, a whole building, a part of a building or just a single room.
- The aim of these studies is to bring the “good” reference into the same (digital) environment as the proposed concepts or designs. In this way it get possible to analyze the references digital and second compare and analyze the reference against proposed concepts or designs, and the opposite.
- Typical it is difficult to find the right properties for the constructions, surface reflectance, glazing transparency etc. Studies can also be done with the same settings as the design. In this way the analysis is based on the geometrical condition rather than the properties. Especially for designing new buildings the construction setup etc needs to fulfill current legislation. Therefor it can be difficult to analyze an old building with a design of a new building because of the different construction setup. A result of having the same setup could lead to the old “good” reference is not that good when it have applied current legislation setup. The outcome in this case, the performance and experience of the building/room is totally different with current setup.

Contextual studies

- Contextual Studies are studies of concepts or designs of urban areas and/or buildings that are depended or related to the context. The context consist of the site with its surrounding landscape, buildings, trees, etc.
- Before starting the contextual studies everything should be ready, e.g. a simple model of the context and landscape, how to summaries and communicate the results etc. Especially with these studies this is very important, because these are typically done during the creative design process, which means concepts/designs are changing rapidly.

4.3. The Analytical Design Process

Taking a closer look at the individual process during an analysis “The analytical design process” is describing the basic steps (Fig.). First of all, there need to be a model before it is possible to simulate it digital. After simulating, how to visualize it? To make it easier to analyze? When analysing the output should be analyzed against the performance objectives. If the design is full filling the objectives, a decision can be taken on which design should be used, if not, a optimizing need to be done, or other action need to be taking. And last communicate the decisions, or recommended designs to be used. Visualization and Communication is similar, it is about present result clearly and visually to the designers, clients or other involved internally or externally.

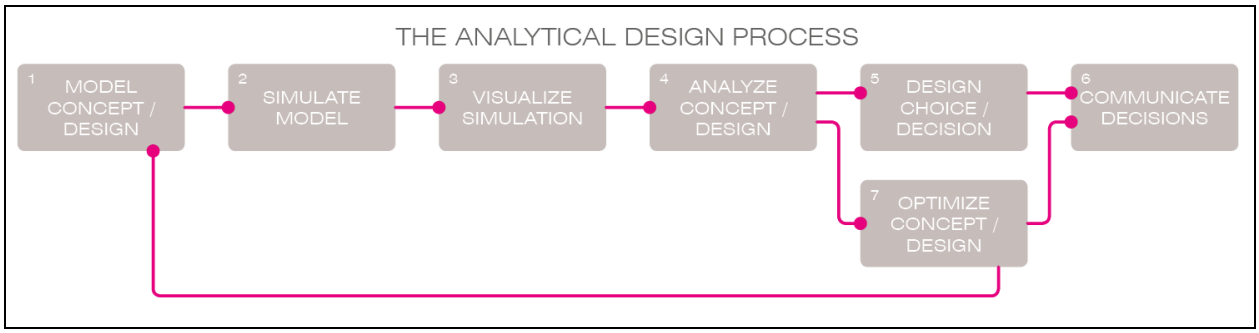


Fig. 4.01 Schematic diagram of the proposed “The Analytical Design Process”.

4.4. Learning from Efficient Process

Process-oriented

One of the major learnings to create better Comfortable Urban Spaces and/or Sustainable Building Design is during Conceptual studies before and under design at all Scale of Design. As shown in Fig. 4.02, Design with knowledge gives a better foundation and more knowledge-based and qualified decisions during design.

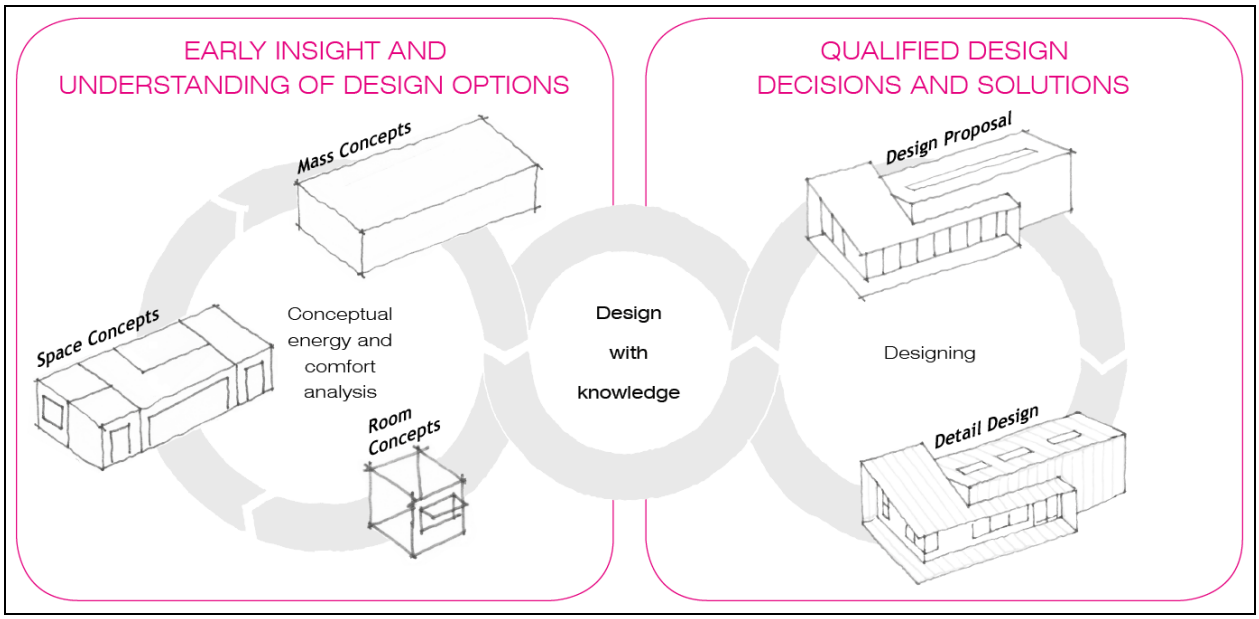


Fig 4.02 Diagram of "Design with knowledge".

Combing this section with previous key-points

- Be aware of the limitations in the tools/simulations/functionalities!
- Don't waste time on following a rigid simulation process - use a Strategy-driven method with a holistic analysis review!!
- Use your commonsense for a basic critical review of the simulations results/output!
- Use time on planning the process and how to communicate results/guidelines!
- Make variation studies easier - think parametric and in relation-based design!
- Don't try to simulate something the tool cannot give feedback on!

Technical

- For all of the different types of studies there are some common things there need to be done or setup before doing the different simulations and analysis, so time during the process was on doing the simulations and analysis, and not prepare models, setup layout for communicating results etc.

Acknowledgements

Louise Thuren Jørgensen, Emanuele Naboni, Francesco Zaccardo, Michael Curtis, Mostapha Sadeghipour Roudsari, Chris Mackey, Konrad Sobon, Elian Hirsch, Erik Falck Jørgensen, Morten Myrup, Brian Hurup-Felby, Santiago Velez, Adam Menter, John Harding, Rambøll UK, ag5 Architects … and probably more people.

Bibliography

Andresen, Inger et al (2009); IED - A guide to integrated energy design; Web Publication

Naboni, Emanuele (2013); A unified tool to design and define Architectural Sustainability 2.0.; 11th EAEA Conference, Milan, Italy

Naboni, Emanuele (2014); Sustainable design teams, methods and tools in international practice; DETAILGreen 2014 no. 1

Steemers, Koen (2006); Environmental Design of Urban Buildings - an Integrated Approach; Cambridge University

Sattrup, Peter Andreas and Beim, Anne (2012); Sustainability - Energy Optimization - Daylight and Solar Gains; Ph.D. thesis

Samimi, Mojtaba and Nasrollahi, Farshad (2014); Intelligent Design using Solar-Climatic Vision; Universitätsverlag der TU Berlin

Nielsen, Daniel and Levring, Asbjørn (2011); Schematic strategies and work-flows for sustainable Design development; Autodesk University 2011; Presentation: http://sustainabilityworkshop.autodesk.com/buildings/au-preso-holistic-bpa-workflows