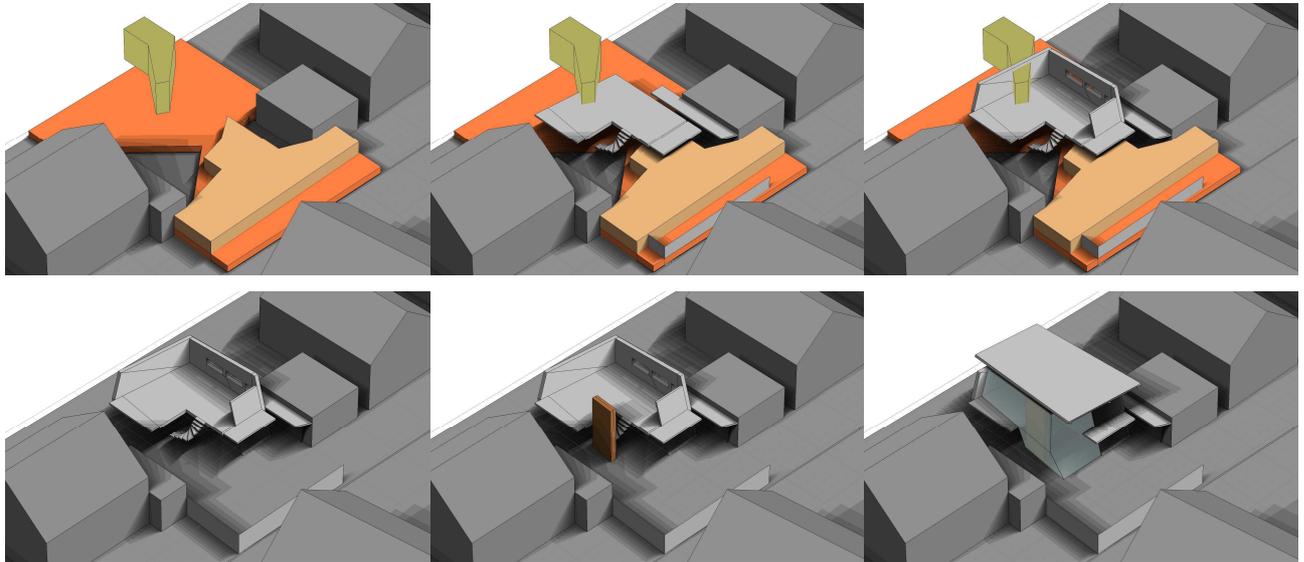


Designing with the Sun – Integrative Workflow and Solar Simulation with AutoCAD, 3D Studio MAX and EcoTect

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Adaptive building design with shadow simulation. © 2010 Wolfgang Höhl. Munich | Vienna

1 ABSTRACT

This paper examines new computer-aided tools used by architects for daylight planning. The emphasis is on integrating real-time applications for solar simulation into the design and planning process. It is demonstrated how building volumes and their placement can be optimized already during the design stage in accordance with shadow positions and sun exposure. The model of an integrative workflow shows possibilities and interfaces for integrating simulation software into the planning and design process. An actual project was used to test this integrative workflow. For this purpose, the software packages AutoCAD, 3D Studio MAX and EcoTect were utilized. Early integration of real-time simulation for daylight planning allowed for easier adaptation of the building geometry to the requirements of optimal solar planning than would have been possible using only standard planning software. EcoTect proved to be a comprehensive software package whose functions go beyond simply aiding the design process. Despite the fact that all software was developed by one manufacturer, the interfaces for data transfer and the modelling tools for this purpose can still be improved.

2 SCIENCE AND PLANNING METHODOLOGY

The aim of this research is to facilitate architectural design using computer-aided simulation methods in a meaningful manner, thereby analyzing and improving the planning process in particular. This approach is not new; Hannes Meyer also emphasized objective rationality as the foundation of construction and mentioned, among other things, planning in consideration of the sun. " ... we calculate the sun's angle of incidence over the course of a year in relation to the site's latitude and then we engineer the design so that the house's shadow range falls in the garden and sunlight streams from the windows into the bedroom ..." [HANNES MEYER: *bauen* (1928) in: CONRADS 1981, p. 110, translated by the Author with assistance of Andrea Lyman] However, in the case of all of these approaches, the question is raised as to the extent to which architectural design may be reduced to a purely objectivistic, reductionist philosophy. This paper views architectural design, in line with Popper's ideal, in a problem-solving manner and therefore aims to approach it via trial, error and critical mistake correction. Three steps derived from the standard scientific method have also been adopted: analysis, synthesis, evaluation. Kühn defines "planning as a search problem" and mentions various "generate-and-test procedures" [KÜHN 1998, pp. 87, 89 and 103] in contrast to knowledge-based systems (patterns (semantic networks = planning as a decomposition problem), frames (prototypes) and formal grammar (rule-based systems = planning as a search problem)).

The procedure for spaces of light and shadow-casting objects from my paper on “Generative Solar Design” [HÖHL 2009] was implemented to a large extent; however in this case, it was adapted in a greatly simplified manner. This paper focuses less on form generation and more on process description. The building is purposefully designed in a conventional fashion rather than in a computer-controlled manner. The actual structural form is less relevant than the design process itself, which is given more emphasis. Consequently, it merely represents one example of many possible alternatives.

3 SOLAR SIMULATION WITH ECOTECT

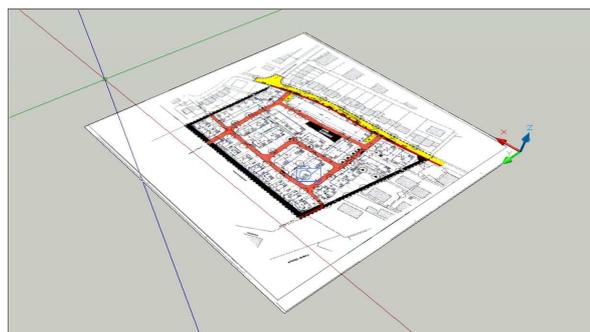
Solar simulation using AutoCAD, 3D Studio MAX and EcoTect is organized into three steps: image processing (adjustment and formatting of the original digital images), 3D modeling (creation of a 3D model of the planning area), solar simulation and reintegration of the results into the planning software.

Adjustment and formatting of the original digital images				3D modeling of the planning area				Solar simulation and reintegration of the results into the planning software	
Software	Data Exchange	GIMP or Photoshop	Data Exchange	AutoCAD	Data Exchange	3D Studio MAX	Data Exchange	EcoTect	Data Exchange
Reformatting the land development plan	PDF		JPG						
Import into AutoCAD		→	scale(px -> m)						
Construction of the 3D model and saving the AutoCAD file					DWG				
Import of the AutoCAD file into 3D Studio MAX				→	Scale 1:1 (m -> m)	Open File			
Reformatting and export of the 3D model						Export File	3DS		
Import 3D CAD Geometry and scale objects						→	Scalex 1000(m -> mm)	Scale objects by	
Loading of weather data (Weather Data)						→	WEA	Load weather data	
Conversion of triangles into quads						→		Merge coincident triangles	
Establishing the shadow range								Show shadow range	
Designation of zones with maximal sun exposure								Add zones	
Export als DXF								File / Export / To external analysis tool	DXF
Import of DXF file into AutoCAD									Scale 1:1 (m -> m)

3.1 Reformatting the land development plan

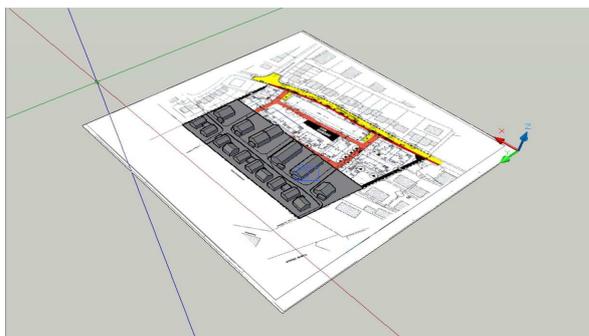
A PDF version of the land development plan may often be included with the tender documents or obtained from the responsible authorities. The PDF is opened with a suitable image editing program (e.g. GIMP or Photoshop) and then subsequently converted into JPG format so that it may be imported into the planning software (in this case: AutoCAD). Import into AutoCAD, construction of the 3D model and saving the AutoCAD file

The land development plan is imported as a JPG file into the planning software. This plan is then used as the basis for the construction of a 3D model of the planning area. The 3D model may be saved as a DWG file. Importing, reformatting and exporting the 3D model Open the DWG file in 3D Studio MAX and save the data as a 3DS file.

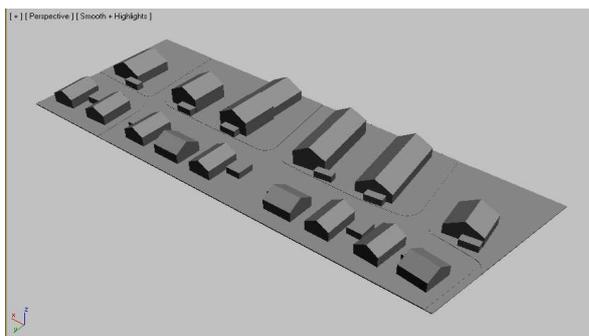


Reformatting and importing the land development plan 101121_bebauungsplan_final.tif





Creation of the 3D model of the planning area 101121_3dmodellierung_final.tif



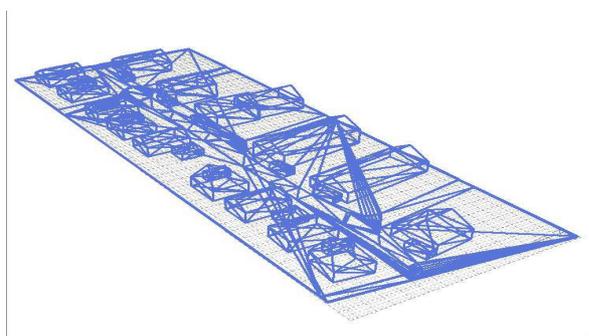
Saving and exporting the 3D model as a 3DS file 101121_3dsexport_final.tif

3.2 Import into EcoTect, loading of weather data and geometry adjustment

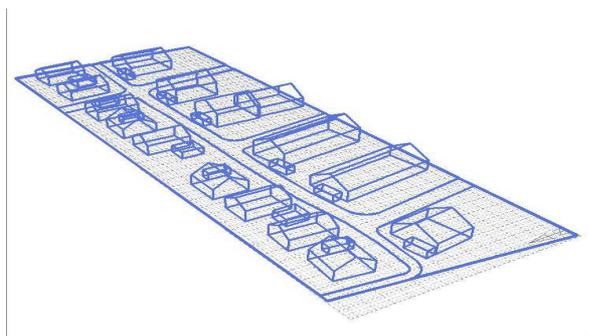
The 3DS file may now be imported into EcoTect. The appropriate weather data are loaded from external datasets (load weather data) in order to establish the correct, geographical position and the corresponding insolation. It is important that the data be scaled according to the units used. The data is then adjusted and the polygon count is reduced using the function “modify / merge coincident triangles”.

3.3 Establishing the shadow range

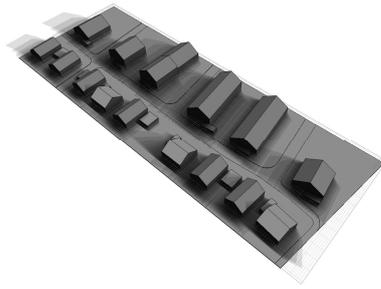
Now the shadow range (show shadow range) may be established for three different dates: 21. March 21st (Sept. 23rd), June 22nd and December 22nd.



Import of the 3D data into EcoTect and loading of weather data 101121_sonnenstandsanalyse_01.tif



Fine-tuning of the 3D model. Reduction of polygon count 101121_sonnenstandsanalyse_02.tif



Establishing the shadow range 101121_2203_B5_01.tif

3.4 Designation of zones with maximal sun exposure and export as a DXF file

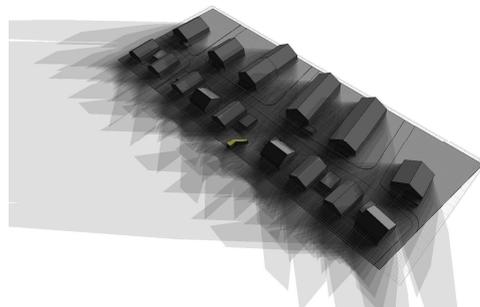
The unshaded areas are indicated with colored elements. The data is then saved in DXF format and imported into the planning tool (in this case: AutoCAD), where the unshaded parts of the structure may now be configured. As the structures are repeatedly subjected to shadow analyses, the design is continually adjusted and optimized for maximal sun exposure.



Designation of zones with maximal sun exposure. March/September 101121_2203_B5_02.tif



Designation of zones with maximal sun exposure. June 101121_2206_B5_02.tif



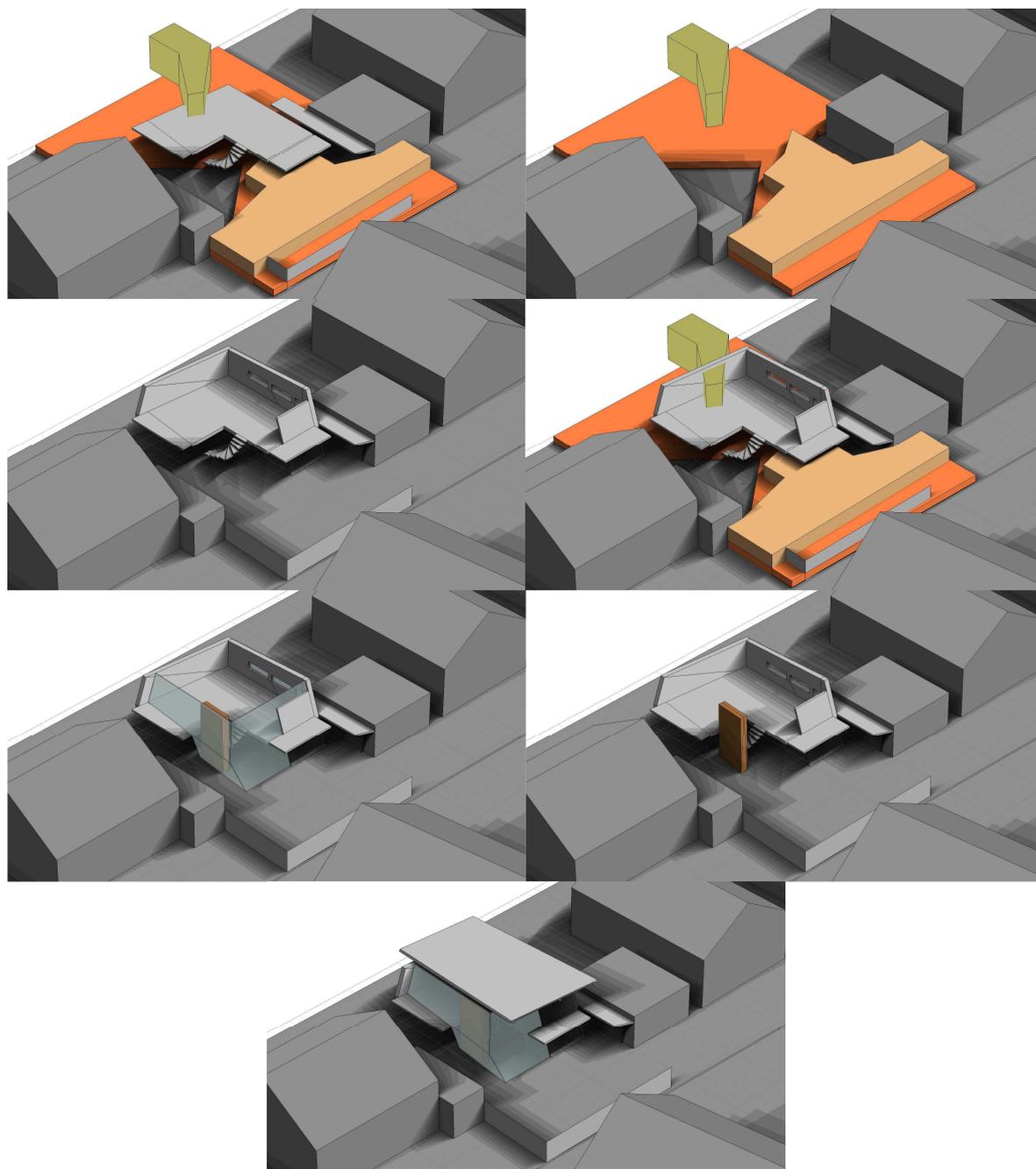
Designation of zones with maximal sun exposure. December 101121_2212_B5_02.tif

3.5 Adaptive building design coupled with shadow analysis

Various colored elements are now positioned on the physical construction site; these correspond with the building design. Due to the presence of extensive shadowing on the first floor, living areas are elevated to the



second floor. The dining area, kitchen and adjacent terrace are situated on the ground floor, within the southwestern zone that receives maximal sun exposure. A fence borders the property along the street, creating a private yard area to the south. External walls surround the building to the north and east. Changes in the current shadowing situation may be addressed with suitable modifications to the design geometry. Finalization of the solar-generated design The colored marking elements are removed and the building design is carried forward. In this case, a Trombe wall complements the solar energy concept and provides support for the building's construction. The glass façade leans to the south and west so as to absorb a maximum amount of solar heat during the winter. The roof overhang provides essential shade during the summer months.



Solar-optimized building design 101205_00_solstice_01.tif, 101205_02_aussenanlagen_01.tif, 101205_03_aussenwaende_01.tif, 101205_07_innenwaende_01.tif, 101205_08_trombewand_01.tif, 101205_09_fassade_01.tif, 101205_09_dach_01.tif

4 OPTIMIZED WORKFLOW DUE TO IMPROVED INTERFACES AND MODELING TOOLS

EcoTect offers an attractive graphical interface that is suitable for integrating solar building concepts during the design phase. Those who are well-versed in 3D modeling and simulation will quickly grasp how to use the tool. It is very advantageous to be able to see immediately what impact a design decision will have on

shadowing. This is not a plug-and-play solution, however. In order to use this software skillfully, it is necessary for one to be an experienced 3D modeler who possesses adequate expertise in the realization of solar concepts. The shadow tool only represents a small fraction of what the overall software package offers, which is so much more than just shadow simulation. It may also be used to carry out detailed thermal analyses and acoustic simulations. A direct interface between AutoCAD and EcoTect would be a great improvement. Having to go through 3D Studio MAX is cumbersome and probably not easily accessible for all users. There was a 3DSOUT command in earlier versions of AutoCAD that allowed users to create 3DS files directly. Unfortunately, this command no longer works in the current version of the software. A direct data exchange from AutoCAD to EcoTect in *.DXF format does not deliver the desired three-dimensional results but rather only 2D data. On the other hand, the transfer of data in DXF format from EcoTect back to AutoCAD works perfectly. Improved modeling tools in EcoTect would also be beneficial for architects. The tools that are currently available may only be utilized to some extent to work with free or non-Euclidian forms. They are neither intuitive to use nor easy to handle and function considerably better in conventional planning tools, such as AutoCAD and 3D Studio MAX. The recurrent data transfer to these planning tools naturally complicates the design process even more. One option would be free modeling tools (sculpting tools) that would be significantly better suited for the design phase than conventional tools.

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