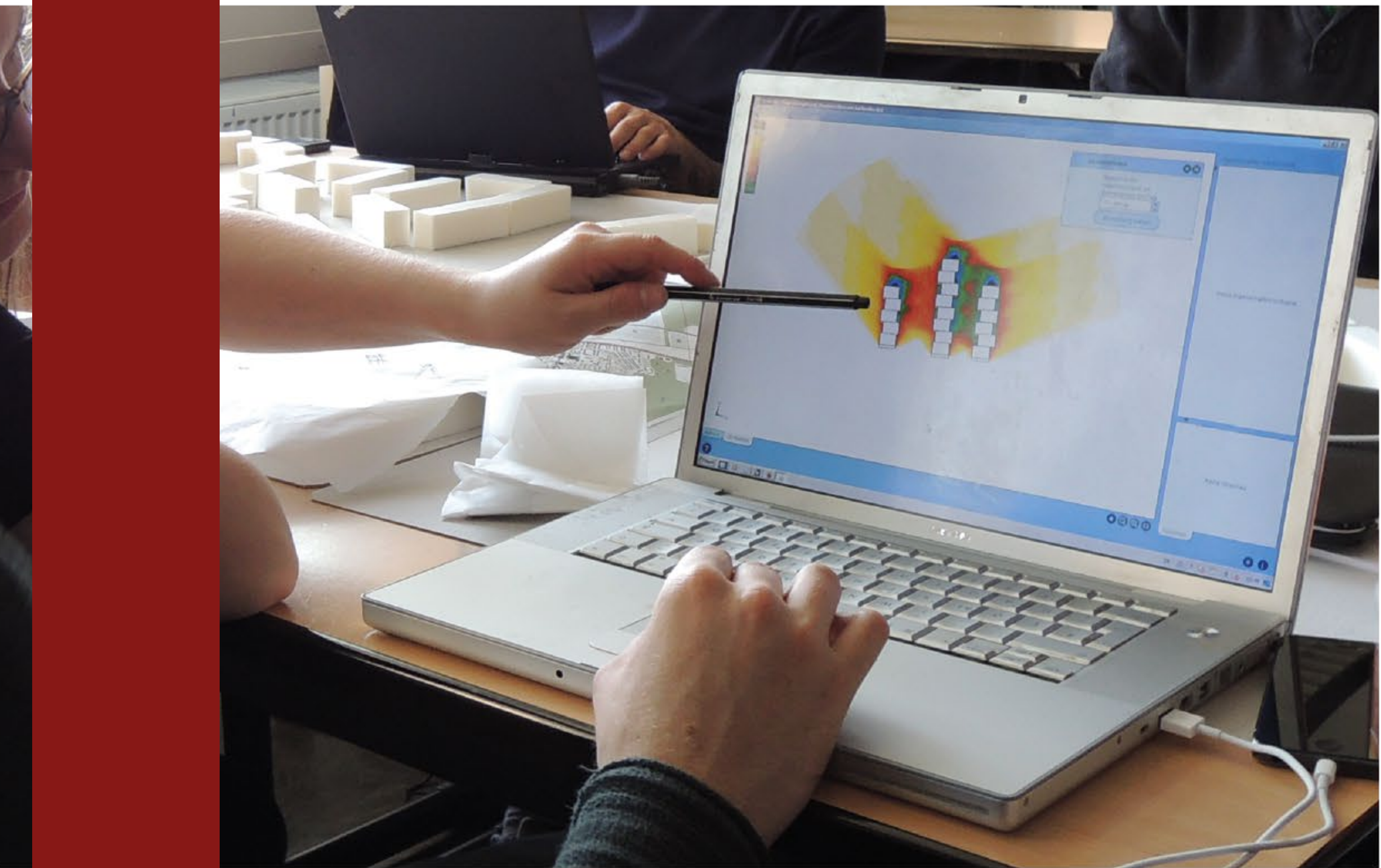

Urban-based solar potential analysis – A teaching and learning tool for determining the solar energy use at the district scale

User Manual

IEA SHC Task 51 Solar Energy in Urban Planning

Task 51/User Manual

Urban-based solar potential analysis – A teaching and learning tool for determining the solar energy use at the district scale

User manual

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Preliminary remarks

The tool is currently available as a usable beta version that is aimed at providing urban-based solar potential analyses with a didactic focus. Some functions, such as importing project data or the ability to share projects with other group partners in the Project Editor, have been created but are not yet operable.
The Webstart Java Applet software version described here can be reliably used on all Windows and Mac operating systems that support the latest version of Java.

Last amended: January 2017

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Urban-based solar potential analysis

As part of the "Lernnetz Bauphysik" (Building Physics Learning Network), an independent tool for urban-based solar potential analyses has been specially developed for use in education and training. This is available free of charge and can be obtained under the link *http://solarpotential-fbta.ieb.kit.edu*. The user interface can be activated and used in both German and English.

Based on a simplified 3D model created in the integrated Project Editor, EnOB Solar Potential Analysis enables the simulation of solar irradiation totals in freely defined time periods together with the shading and solar hours, in each case on the district scale. Unlike solar registers, which exclusively display solar irradiation totals for roof surfaces of existing buildings, the vertical and inclined surfaces are also taken into account in the EnOB Solar Potential Analysis system and included in the calculations. The simulations are therefore suitable for investigating structural changes in existing urban districts or parameter studies with new-build schemes.

The EnOB Solar Potential Analysis functions are currently limited to urban-based solar potential analyses on flat sites without horizon shading. Projector editors for individual buildings and rooms as well as calculation modules for the indoor environment and lighting of interior spaces have been created but are not yet available for the application because of their development status.

A detailed comparison with different solar tools is available in the Report: State-of-the-art of Education on Solar Energy in Urban Planning- Part II: Solar Irradiation Potential Tools in Education.

Glossary

Webstart
Webstart is the online-accessible web page from which the current Project Editor package can be downloaded in English and German. Webstart can be accessed at *http://solarpotential-fbta.ieb.kit.edu*.

Project Editor
The Project Editor is the CAD-based integrated editor for creating the urban model that forms the basis for all simulations.

Background image
In the Project Editor you can load a background image and scale it to provide a drawing basis for the further work.

Configuration wizard
The configuration wizard is a pop-up window for configuring new buildings.

Program start

The urban-based EnOB Solar Potential Analysis software is a simulation tool that is run as a Java applet independently of the respective operating system. The software is programmed as a Java applet and is therefore fully functional in all operating systems that support Java. The latest version can be downloaded and run via the lernnetz.fbta.uni-karlsruhe.de/enob-webstart/ web link. The EnOB Solar Potential Analysis software and the weather database necessary for the calculations are being continually developed. We therefore recommend that you download a new software package before each program starts. The weather data is located on the ILIAS learning platform and is downloaded in a calculation module from the server when selecting the weather data.
The latest Java version – Java 111 (or newer) – is required to ensure that the software fully functions. The software runs independently of the browser and, after the package has been downloaded, it also runs independently from any network connection. Without a network connection at the start of calculations, only the weather data from Mannheim is used, which is contained as a standard weather dataset in the software package.
The downloaded software package can be started by double-clicking and shows a Java startup window (see Figure 1: Run Java), which must be confirmed.

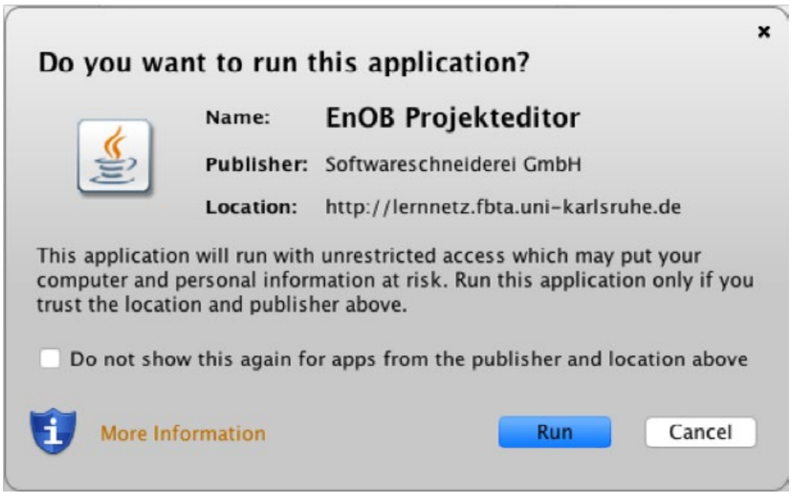


Figure 1: Java applet startup window

Functionality

In the EnOB Solar Potential Analysis system, the solar hours, shading and solar irradiation can be simulated on the basis of a simplified 3D model. The 3D model is created directly in EnOB Solar Potential Analysis using predefined elements and can be used for all three simulations. Direct and diffuse radiation is taken into account in the calculations. However, only the shading from direct radiation is taken into account for simplification purposes. The reflections from surfaces are ignored. The solar irradiation on inclined, randomly oriented surfaces is calculated using the same algorithm deployed by the Therakles thermal simulation tool, see *http://bauklimatik-dresden.de/therakles/index.php?aLa=en*.

Project Editor

Project Editor functions

The Project Editor for creating urban 3D models is highly simplified and consists of just a few buttons (see Figure 2). A district model is assembled from preconfigured buildings. The model can only be used for flat terrains. In order to correctly depict the horizon shading caused by surrounding hills, this shading needs to be recreated with the aid of added buildings.

The Edit Window is located in the centre.

The menu bar above the Edit Window contains the buttons for editing the project. The Project Editor enables you to import a template graphic – see Site Plan, insert buildings using a wizard, calculate the solar hours, shading and solar irradiation, as well as save and export projects. Currently, projects within the loaded Project Editor are stored on the local file system and loaded from there. Below the Edit Window are buttons to change the view of the model. The two buttons at the lower left edge can be used to toggle the display in the Edit Window between the 2D view (Site Plan) and the 3D perspective (Site 3D). The five buttons in the right-hand corner below the Edit Window – Zoom out, Zoom in, Pan view, Zoom window and Zoom to fit – enable you to change the display view.

The right column next to the Edit Window displays additional information about the project or a selected item.

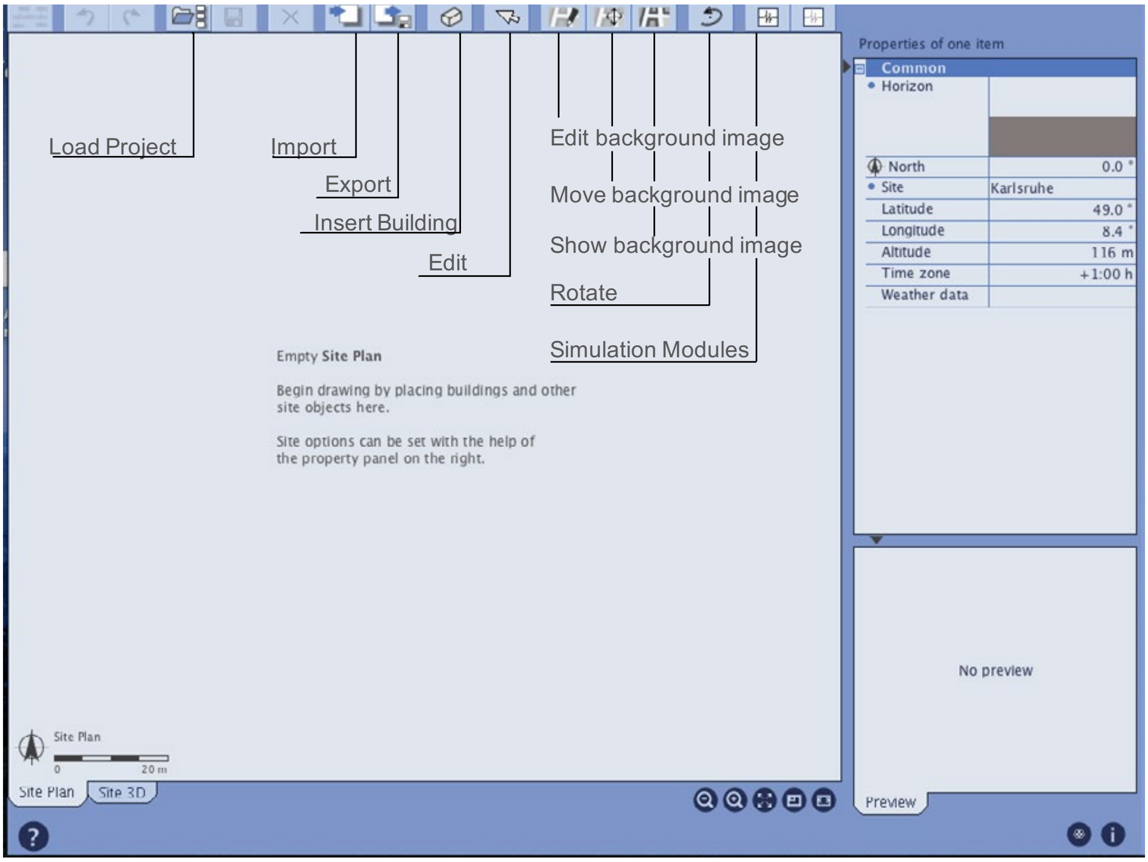


Figure 2: Buttons and basic functions in the German-language EnOB Solar Potential Analysis Project Editor.

Site Plan

Using the Edit background image button you can import and scale a site plan that can then be subsequently used as a basis for drawings. The imported image can be moved at any time using Move background image or replaced using Edit background image. In the 2D view, the site plan is always located on the upper level and hides the calculation results. However, you can hide the background image using the Show background image button.

The background image needs to be scaled to enable it to be used as a basis for drawings. You can scale it using a reference length. For setting the reference length you will need to mark a distance with a known length on the imported background image. As shown in Figure 3, the reference length was set on the side of a house that is known to be 15 metres long. After setting the reference length by simply clicking it with the mouse, it needs to be assigned a length in metres in the menu below.

The Project Editor automatically and equally scales the stored image based on the details provided for the reference length. The imported template can be changed at any time using the Edit background image button and moved using the Move background image button.

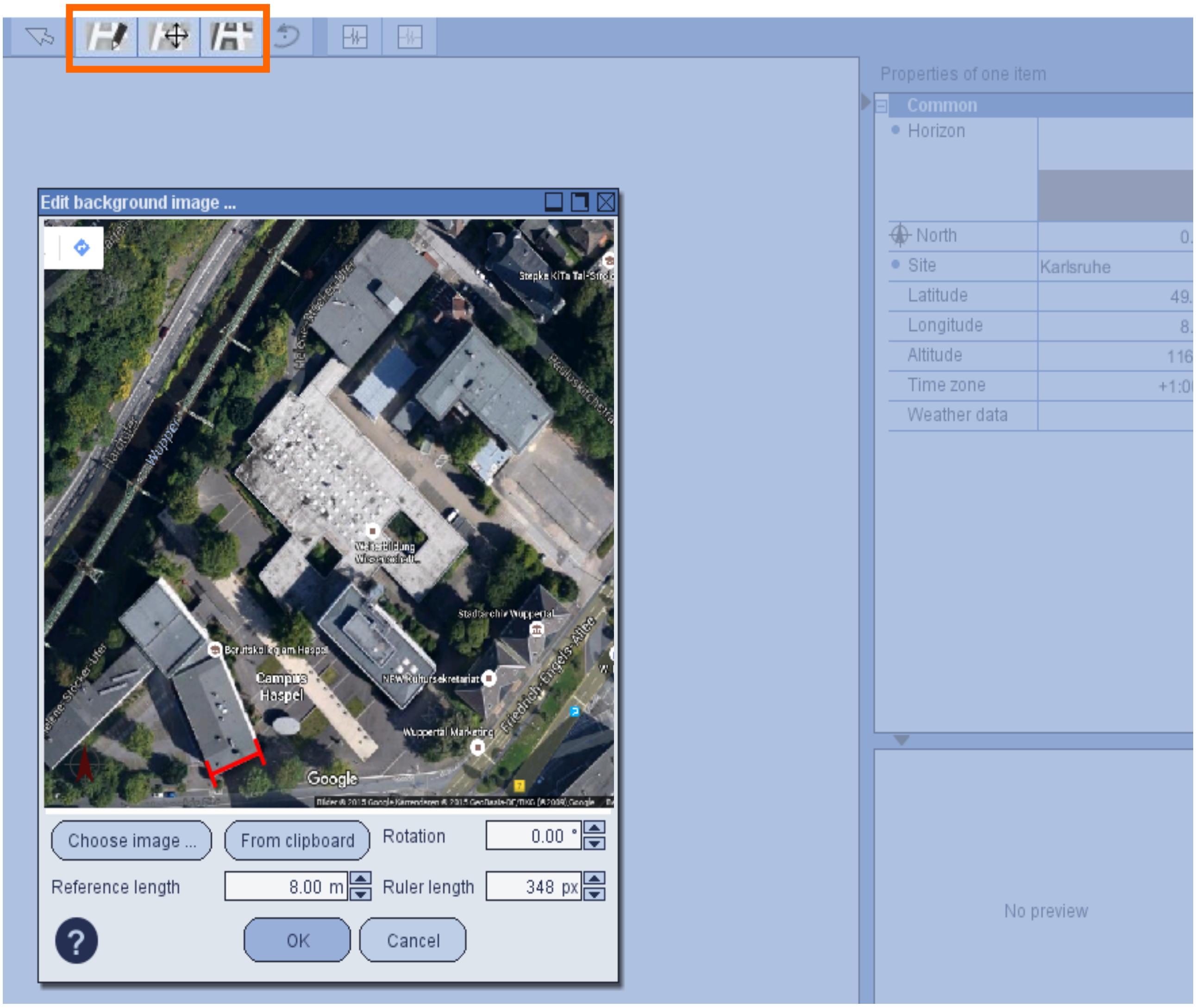


Figure 3: Scaling an imported background image using a reference length.

Inserting buildings

The 3D model of a district is not drawn in the Project Editor as in standard CAD programs, but is composed by assembling pre-defined buildings. Clicking the Insert building button opens the wizard for creating a new building.

As shown in Figure 4, four different buildings types can be configured.
The different building types are defined by the following information:

Basic building:
- Building width
- Building length

Block building:
- Building width
- Building length
- Main building depth
- Lateral building depth
- Lateral building count
- Lateral building spacing
- Lateral building length

Linear building
- Here you can draw L-shaped lines with the correct width and length on the floor plan or
- Set any number of points (outer corners of a block) on the plan (after completing the configuration wizard)

Free form building
- Set as many points as required (external corners of the building) on the plan (after completing the configuration wizard)

After selecting a building form, the building dimensions are queried in the configuration wizard for basic and block buildings. This step is skipped when creating linear and free form buildings since the basic form of the buildings is drawn on the floor plan after the additional configuration.

With the exception of basic buildings, all building types can only be configured with a flat roof. Basic buildings can be created with flat, monopitch, hipped or pitched (gable) roofs.

Step 3 of the configuration wizard, which is shown in Figure 5, is the same for all four building types and queries additional building properties. Here you can give the building a name, which is essential for clarifying the later calculation results.

If building properties need to be changed in the course of the project, we recommend that you delete the building and re-draw it.

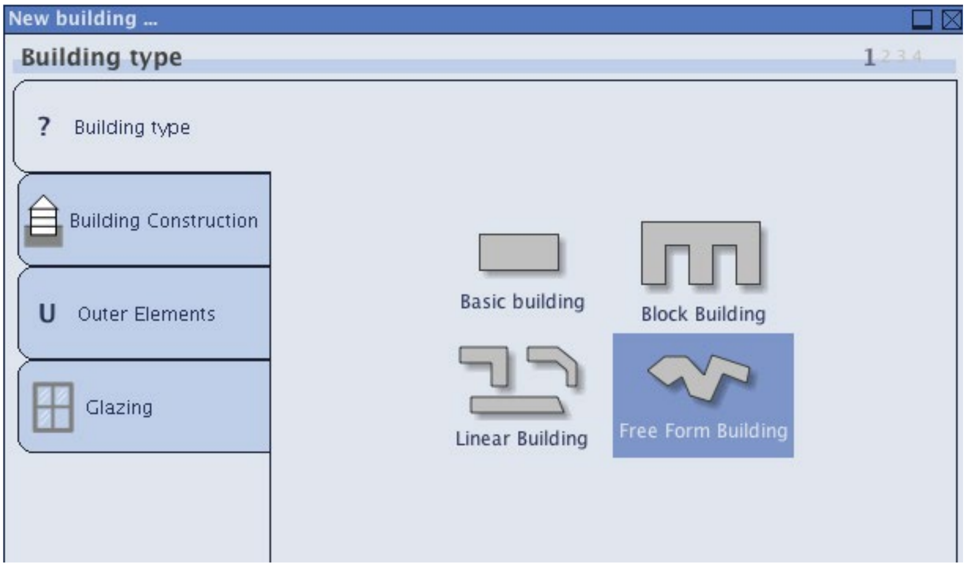


Figure 4: Wizard for configuring new buildings. This window opens by clicking the Insert building button.

Depending on the type of building, the building dimensions on the floor plan can be defined on the floor plan or by entering the dimensions in the configuration wizard. The building height for all buildings is determined from the Number of levels, Level height, Slab thickness and the Roof height. The various information relating to the building height is queried in the third step of the configuration wizard (see Figure 5). No other properties need to be processed for urban-based calculations. These are aimed at possible other calculation modules.

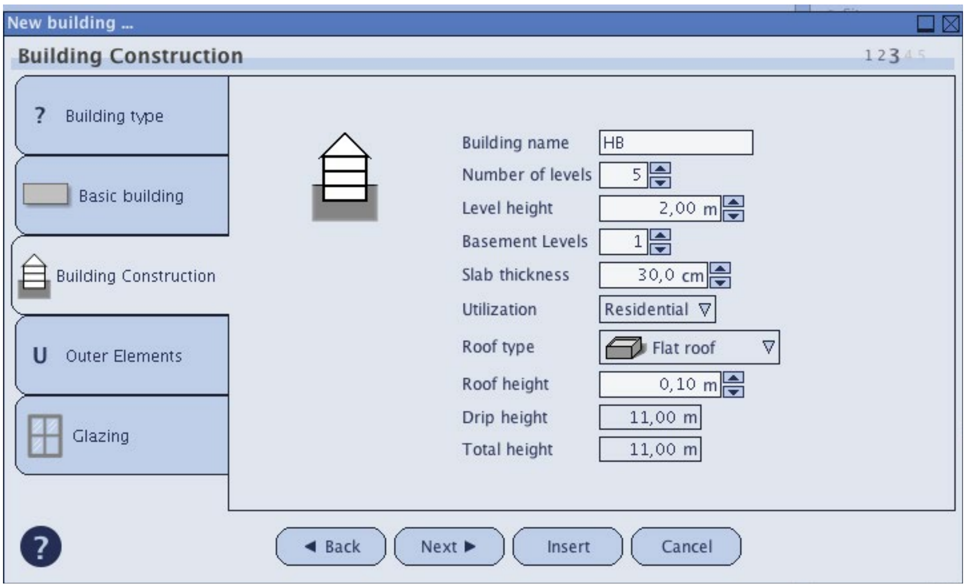


Figure 5: Step 3 of the configuration wizard for inserting new buildings

Saving and loading models

Projects can be saved in EnOB Solar Potential Analysis in the Project Editor or can be exported in the software's own .lnb file format or as an .xml file.

In the current project development stage, it is possible to export the created project but it is not yet possible to re-import the exported file. A project can only be saved in the Project Editor. Here you can also create new folders to organise the saved project files. The My Projects, Public, Developer and Share levels have been created for storing projects. This structure stems from an EnOB Solar Potential Analysis development stage that was still linked to an online learning platform and was aimed at facilitating the exchange of project data within working groups or seminars. Because it is planned to re-integrate EnOB Solar Potential Analysis into an online learning platform in future, the organisational structure has been retained here but without the ability to exchange project data. It is currently not possible to exchange project data.
A calculated false colour image can be exported as a .png, .jpeg, .svg, .pdf or .eps file by clicking the "Export – Export current image" button.

Simulations

The EnOB Solar Potential Analysis system enables you to simulate the shading, daily solar hours and solar irradiation on an urban scale.
For all calculations, only the shading from direct radiation is taken into account and reflections from surfaces have no influence on the result. The underlying calculation algorithm is explained in more detail under the Functionality heading. The program creates a calculation grid for all surfaces with a 1x1 metre grid.

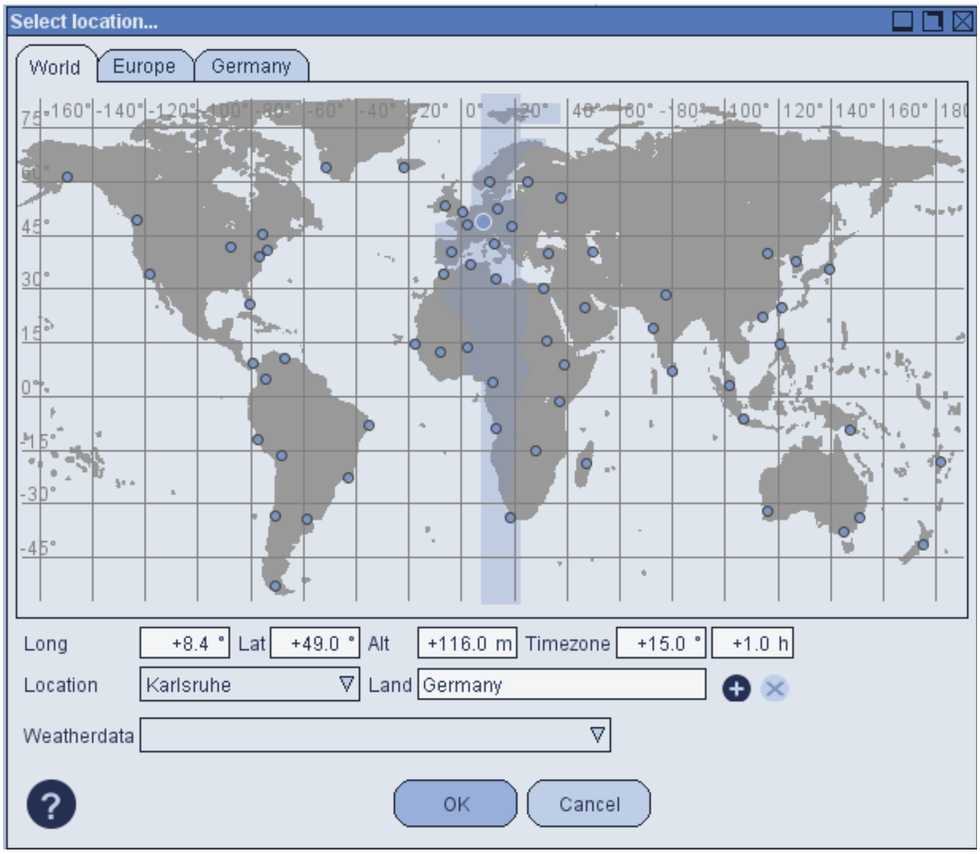


Figure 6: Selecting weather data.

The simulations are location-based and refer to an online weather database from the US Department of Energy at https://energyplus.net/weather. For further information on selecting weather data, see Solar hours, Solar irradiation, Shading and Figure 6. The weather data is located on ILIAS and is downloaded in a calculation module from the server when selecting the weather data. They cover locations in Germany (10), Europe (40) and worldwide (65) that are sufficiently densely spread for teaching purposes. The standard weather dataset in offline mode is Mannheim.

Based on a previously created, true-to-scale 3D model, the simulations can be started by clicking the Calculation modules button in the 2D view.

Solar hours

The daily hours with direct solar irradiation can be determined with the Solar hours simulation tool. The simulation result is displayed as a false colour image with a scale (h/d).

Clicking the Calculation modules button opens a menu window where you can select the desired simulation. Clicking the Play button starts the Solar hours module.

The hours of sunshine are always calculated for one specific day, which can be selected via a displayed menu window. The location of the model is set by clicking the Weather data button.

The calculated false colour image can be exported (see Save and Load).

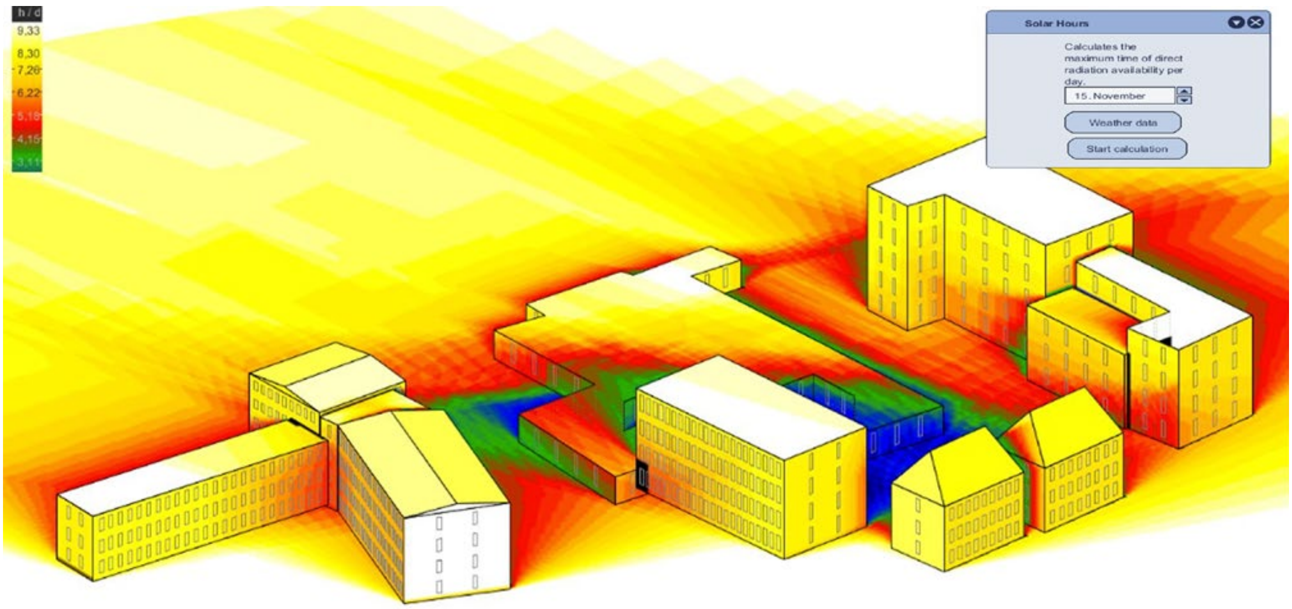


Figure 7: Simulation result for “Solar hours” as a false colour image.

Shading/ Solarization

In the Shading/Solarization calculation module, shading created by direct solar radiation can be depicted as single images for selected time points or additively as superimposed individual images (see Figure 9). The module enables you to calculate the shading either in 1-, 2-, 5-, 10- or 20-minute intervals during the course of a specific day (daily) or during the course of the year at a specific time in 1-, 2-, 5-, 10- or 20-day intervals (annually).

The time period and calculation interval are defined in the selection menu for the simulation module (see Figure 9).

The shading cannot only be depicted as a still image but also played as an animated sequence.
The greyscale images generated here can be exported (see Save and Load).

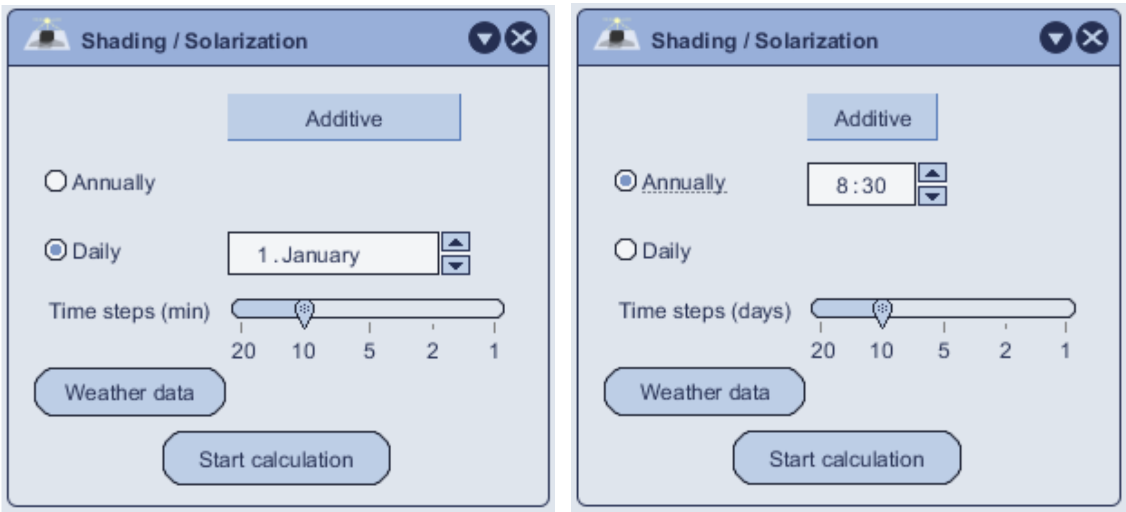


Figure 8: Selection menu for the Shading/Solarization calculation module

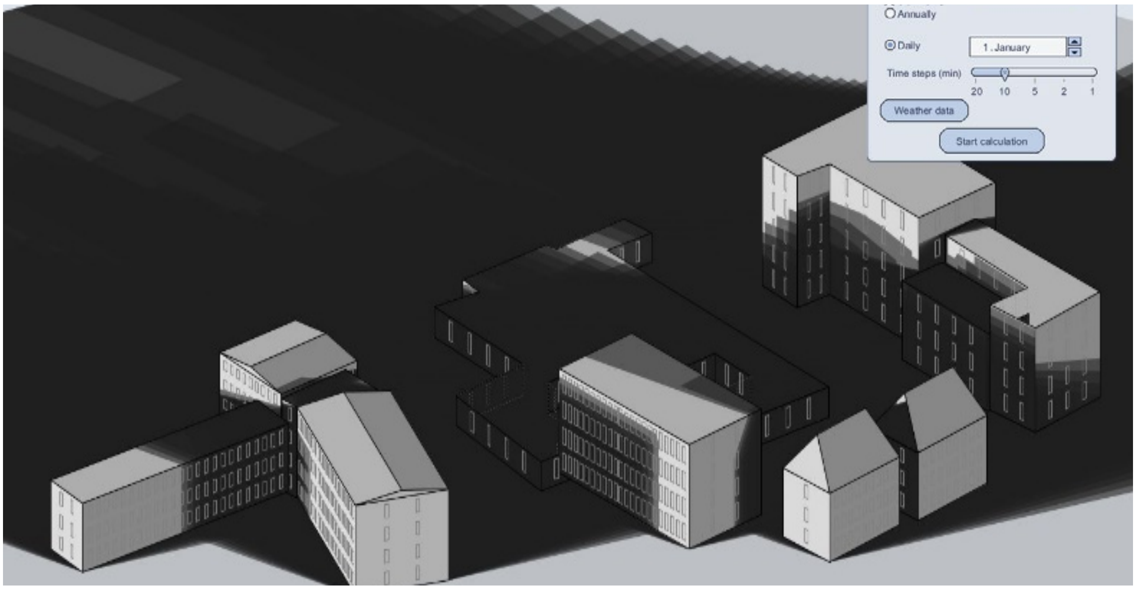


Figure 9: Simulation result for Shading/Solarization with the additive depiction with grey-scaling

Solar irradiation

In addition to simulating the solar hours and shading, the solar irradiation on all surfaces built in the model can be determined as total values for selected periods.

Clicking Calculation modules – Solar irradiation opens a menu window in which the calculation can be modified.

Here you can select a single day with an exact date for the calculation period or a single week, a typical week or an extreme week in spring, summer, autumn or winter. In addition, it is also possible to calculate the solar irradiation for one year.

Before the calculation can be made by clicking Start calculation, you will first of all need to specify the location of the model by clicking the Weather data button. For the selected location, the corresponding radiation data from the climate database will then be automatically loaded for the calculation. If the weather data is not manually selected, a pop-up window will ask if the standard weather dataset should be used when starting the calculation. The result is displayed as a false colour image and as a numeric value in the .csv format. The simulation result can be downloaded as a .csv file by clicking the Export button in the calculation menu window.

In the exported file, all surfaces of all modelled buildings are listed according to their orientation and plane with their size and the irradiation averaged over the respective grid listed as total or area-specific values (the calculation grid is 1x1 m).

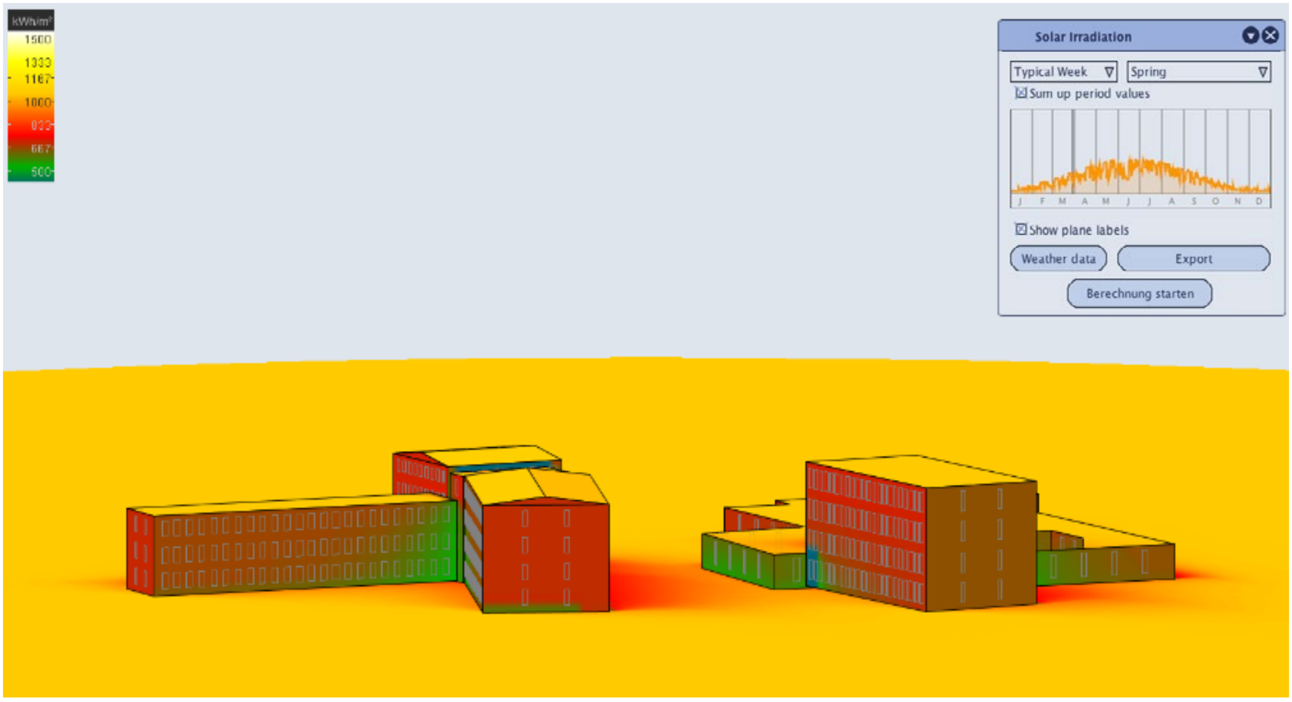
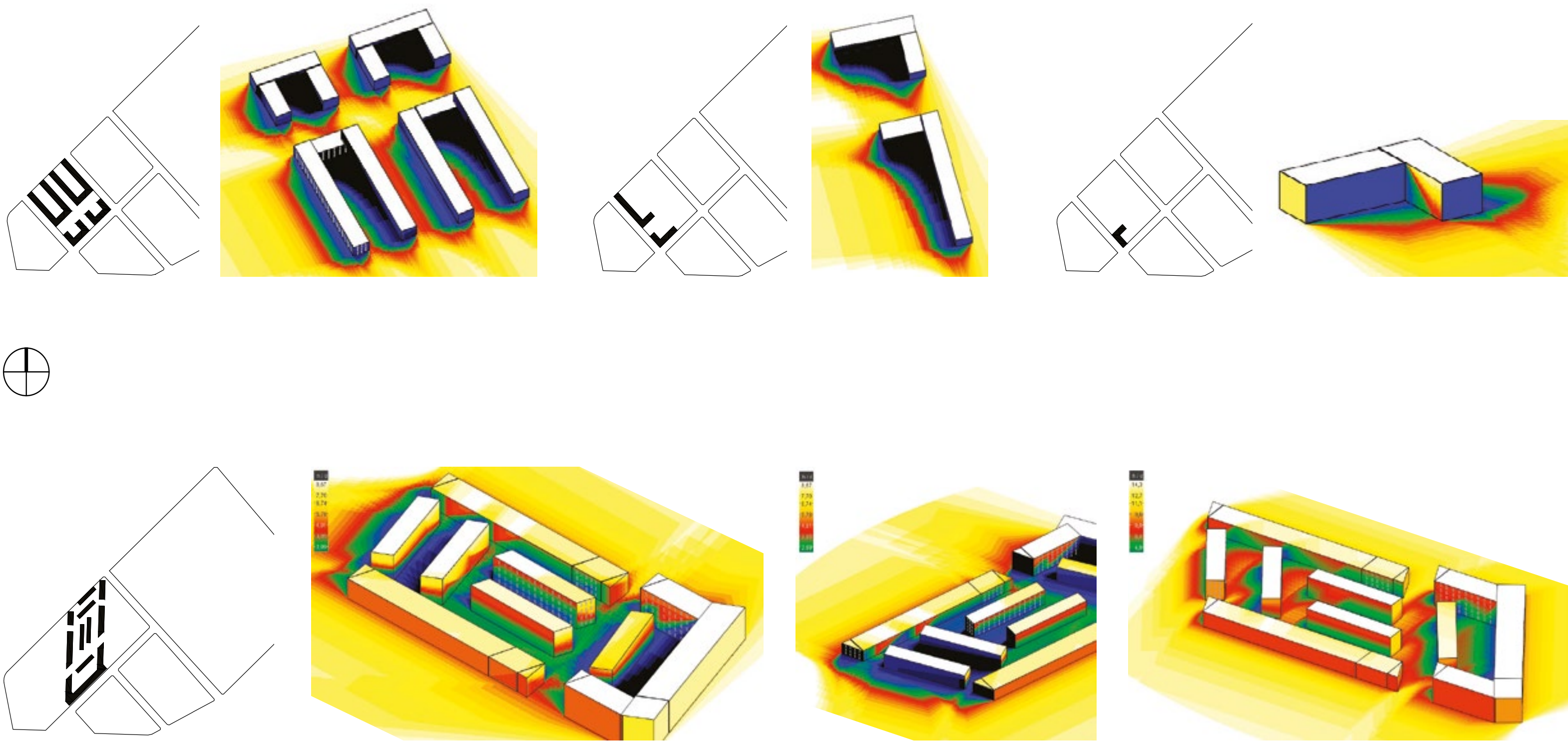


Figure 10: Simulation result for the solar irradiation depicted as a false colour image for a one-year calculation period

Table 1: Exported result of the Solar irradiation calculation module for one year and for Düsseldorf as the location

EnOB	Lernnetz					
Project:	<unsaved>					
Measured	time:	one	year			
Location	Düsseldorf	(DE)	[lat=51	20°	lon=6	70°
Building	Plane	Orientation	Average irradiation kWh/m^{2}a	Irradiation kWh/a	Area m^2	
b1	1	north	375	23658	63	52
	2	east	389	12844	33	21
	3	south	419	26412	63	24
	4	west	531	17523	33	0
	5	flat	837	193528	231	78
b2	1	north	374	94487	252	95
	2	east	414	79600	192	58
	3	south	643	162175	252	55
	4	west	531	101952	192	0
	5	north	904	151997	168	74
	6	south	943	158555	168	78
	7	east	421	6739	16	19
	8	west	531	8496	16	0
b3	1	north	376	181608	483	0
	2	east	485	390798	805	46
	3	south	644	311514	483	96
	4	west	506	407704	805	46
	5	north	934	686490	735	0
	6	south	645	13545	21	0
	7	east	486	17010	35	0
	8	west	531	18585	35	0



Variation study during the summer school, Berlin 2016

For further information see *Task 51/Report D2: Summer Schools on Solar Energy in Urban Planning- Teaching Methodologies and Results*

More about the tool

This platform for urban-based solar potential analysis combines simulation tools for calculating solar hours, shading and solar irradiation in a Java-based and platform-independent application. It is freely available as a web application. Standard solar registers document the total irradiation values on roof surfaces of existing buildings and districts but are not suitable for investigating structural changes in existing buildings or new-build districts. Standard CAD tools enable shading studies, but do not quantify the results. However, a range of planning tools are now available that enable more detailed investigations. As part of the "Lernnetz Bauphysik & Architektur" (Building Physics & Architecture Learning Network), a tool has been developed specifically for use in education and training.

Project context

The EnOB Solar Potential Analysis – EnOB Lernnetz project was based on the idea of enabling the simple application of simulations for teaching purposes with a minimum of software requirements. The tool is suitable for basic urban planning teaching and for supporting solar potential analyses for planning tasks at the district level. It is primarily aimed at students. Advantageous are the low system requirements, the platform-independent work and the ability to quickly achieve conceptual findings based on the calculations. Good experiences have been made in the context of compact courses, such as summer academies, since the software is quick to learn and a dedicated building editor is available. Exemplary is EnEff:Stadt's interdisciplinary "City in Transformation" summer school, which was held in Berlin in 2016, see *IEA SHC Task 51/Report D2*.

Research focus

The urban-based solar potential analysis combines simulation tools for calculating solar hours, shading and solar irradiation in a Java-based and platform-independent application. All calculation tools use a central CAD model and access a common database that provides the additional data required for the calculations. The CAD model is generated in 3D via a Project Editor on the EnOB Solar Potential Analysis. The Project Editor is principally designed so that models can be created at different scales. This enables different urban situations, buildings, rooms and structures to be investigated more closely. A possible further development requires the definition of suitable data exchange formats. A number of activities are being conducted in this regard in the "Planning Tools" working group in the Energy in Buildings and Districts research network. EnOB Solar Potential Analysis has previously used its own data exchange format.

Milestones and successes

The foundations for the EnOB Solar Potential Analysis system stem from the German Federal Ministry of Education and Research's "Multimedia-Based Learning Network Building Physics" eLearning initiative (2001 and 2004). The core work stems from Karlsruhe Institute of Technology (KIT) and was developed as part of a doctorate project (Arne Abromeit). Project partners at the time were the departments for building physics at Darmstadt, Karlsruhe, Kassel, Stuttgart and Weimar universities as well as at Biberach University of Applied Sciences. The project's main objective was to provide example building physics and calculation methods on the Internet in order to be able to use the new possibilities of this medium in teaching. Since 2007, the work within the EnOB research initiative has been funded within various projects. The "Solar Energy in Urban Planning" project (2015-2017) completed and stabilised the Project Editor as well as the calculation module for the urban-based analyses. For more information, see:
https://projektinfos.energiewendebauen.de/projekt/werkzeug-fuer-die-staedtebauliche-solarpotenzialanalyse/

Annex - IEA Solar Heating and Cooling Programme

The Solar Heating and Cooling Technology Collaboration Programme was founded in 1977 as one of the first multilateral technology initiatives ("Implementing Agreements") of the International Energy Agency. Its mission is to enhance collective knowledge and application of solar heating and cooling through international collaboration to reach the goal set in the vision of solar thermal energy meeting 50% of low temperature heating and cooling demand by 2050.

The members of the IEA SHC collaborate on projects (referred to as "Tasks") in the field of research, development, demonstration (RD&D), and test methods for solar thermal energy and solar buildings.

A total of 59 projects have been initiated, 50 of which have been completed. Research topics include:

- Solar Space Heating and Water Heating (Tasks 14, 19, 26, 44, 54)
- Solar Cooling (Tasks 25, 38, 48, 53)
- Solar Heat or Industrial or Agricultural Processes (Tasks 29, 33, 49)
- Solar District Heating (Tasks 7, 45, 55)
- Solar Buildings/Architecture/Urban Planning (Tasks 8, 11, 12, 13, 20, 22, 23, 28, 37, 40, 41, 47, 51, 52, 56, 59)
- Solar Thermal & PV (Tasks 16, 35)
- Daylighting/Lighting (Tasks 21, 31, 50)
- Materials/Components for Solar Heating and Cooling (Tasks 2, 3, 6, 10, 18, 27, 39)
- Standards, Certification, and Test Methods (Tasks 14, 24, 34, 43, 57)
- Resource Assessment (Tasks 1, 4, 5, 9, 17, 36, 46)
- Storage of Solar Heat (Tasks 7, 32, 42, 58)

In addition to the project work, there are special activities:

- SHC International Conference on Solar Heating and Cooling for Buildings and Industry
- Solar Heat Worldwide – annual statistics publication
- Memorandum of Understanding – working agreement with solar thermal trade organizations
- Workshops and seminars

Country Members

Australia	France	South Africa
Austria	Germany	Spain
Belgium	Italy	Sweden
Canada	Mexico	Switzerland
China	Netherlands	Turkey
Denmark	Norway	Portugal
European Commission	Slovakia	United Kingdom

Sponsor Members

European Copper Institute	International Solar Energy Society
ECREEE	RCREEE
Gulf Organization for Research and Development	

For more information on the IEA SHC work, including many free publications, please visit www.iea-shc.org