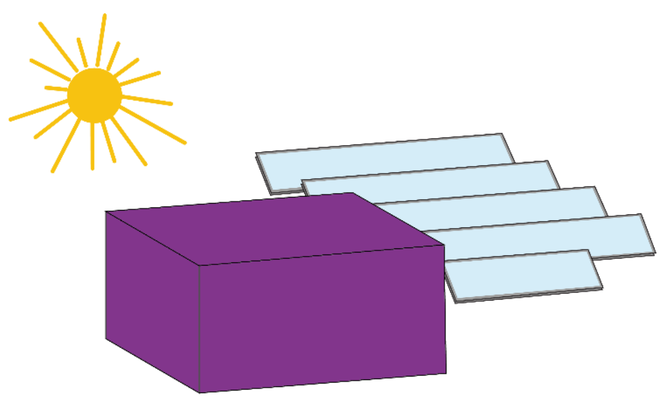
Trnsys User Manual
TYPE 390
Solar Collector Array Shading
Version 1.0, Jun 2022



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1. Nomenclature

A_{sunlit}	m²	Sunlit area
A_{total}	m²	Total surface area
$f_{s,dir}$	-	Sunlit factor of surface
$f_{s,dir,intpol}$	-	Interpolated sunlit factor of surface
$f_{s,dif,iso}$	-	Isotropic diffuse sunlit factor of surface
$I_{s,dir}$	kJ/hm²	Incident unshaded direct radiation on surface
$I_{s,dir,shd}$	kJ/hm²	Direct shaded radiation on surface
$I_{s,dif,iso,shd}$	kJ/hm²	Diffuse radiation on surface with isotropic sky
$I_{s,dif,circumsolar,shd}$	kJ/hm²	Circumsolar diffuse radiation on surface
$I_{s,dif,horizon,shd}$	kJ/hm²	Diffuse radiation on surface for horizon brightening
α_k	°	Angle between surface normal and sun vector of sky patch k
$\Delta\gamma_k$	°	Increment of solar azimuth angle of sky patch k
$\Theta_{Z,k}$	°	Zenith angle of sky patch k
$\Delta\Theta_Z$	°	Increment of solar zenith angle of sky patch k
$\Delta\omega_k$	°	Increment of solid angle of sky patch k

2. Introduction

Type 390 calculates the radiation (direct and sky diffuse) on planar collector fields under the influence of self-shading and shading through external obstructions like surrounding buildings. The implemented algorithms are based on routines implemented in the multi-zone building model (Type56) and thus, a similar preprocessing is required:

For using Type 390 in a project, the following steps have to be performed:

Step 1: Draw 3D geometry information of the scene with the SketchUp plugin *Trnsys3D* as for the multi-zone building model (Type56).

Step 2: Generate shading matrix file with TRNbuild

Step 3: Check defined geometry and resulting shading matrix

Step 4: Assign shading matrix as external file to Type 390 in your TRNSYS simulation project and define parameters, input and outputs

This TRNSYS Type was developed within the research project „SWD.SOL2 – Decentralized Solar Feed-in into the District Heating Network of the Stadtwerke Düsseldorf AG“, funded by the German Federal Ministry for Economic Affairs and Energy.

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Federal Ministry for Economic Affairs and Energy

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2.1. License Agreement

Transsolar Energietechnik GmbH has developed the component Type 390 for the simulation program TRNSYS 18. The development was carried out within the research project „SWD.SOL2 – Decentralized Solar Feed-in into the District Heating Network of the Stadtwerke Düsseldorf AG“, funded by the German Federal Ministry for Economic Affairs and Energy. The use of TRNSYS Type 390 is exclusively based on the following conditions. The sole responsibility for the content lies with the authors. It does not necessarily reflect the opinion of the funding organization. Neither the funding organization nor the client of the author are responsible for any use that may be made of the information contained therein.

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Transsolar Energietechnik GmbH points out that the use of software always depends on the hardware and software used by the user. The use of a suitable hardware and software environment is the sole responsibility of the user. Data backup in the sense of proper data processing and/or in order to comply with any existing legal storage or documentation obligations shall be the sole responsibility of the user.

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2.2. Installation

For using Type390 the recent 64-bit TRNSYS Version (TRNSYS 18.04 or higher) has to be installed first. The provided installation copies files in the appropriate TRNSYS directories:

%TRNSYS18%\Documentation\Nostand

%TRNSYS18%\Examples\Nostand

%TRNSYS18%\SourceCode\Nostand

%TRNSYS18%\Studio\Proformas\Nostand

%TRNSYS18%\Tools

%TRNSYS18%\Userlib

(where *%TRNSYS18%* is your TRNSYS installation directory)

In addition, the template file (*%TRNSYS18%\Tools\Type390\NewFileTemplateType390.idf)* should be located in the templates folder of the TRNSYS SketchUp plugin Trnsys3d after the installation:

%Trnsys3d%\templates\Type390\NewFileTemplateType390.idf

(where *%Trnsys3d%* is your Trnsys3d installation directory, e.g. *c:\ProgramData\SketchUp\SketchUp 2022\Plugins\Trnsys3d*).

If this file wasn't copied successfully by the installation, please copy the file manually. For older SketchUp version this step may require administrator rights.

NOTE: This installation doesn't contain the required preprocessing tools like Trnsys3d and TRNBuild for generating the shading mask. These routines are part of the standard package of TRNSYS 18.

2.3. Citation

To cite this document and the associated software, please use:

Hiller, Marion. 2022. TRNSYS TYPE 390 - Solar Collector Array Shading. Transsolar Energietechnik GmbH.

3. Trnsys Component Configuration

3.1. Description of Parameters

Par. no.	Symbol	Description	Unit
1	lu_file	**logical unit (*.shm file)**	-
2	rot_angle	**scene rotation angle** The parameter can be used to rotate the scene given by the SHM matrix: for northern hemisphere -> positive value for rotating west for southern hemisphere -> negative value for rotating west	degrees
3	n_ori_inp	**number of orientations** for internal radiation calculation mode -> set this parameter to 0 for external radiation calculation mode -> set this parameter to the number of orientations This number has to match the number of different surface orientations provided by the shading matrix file.	-
4	n_surfout	**number of surface outputs** Define the number of surfaces for which surface specific output data is desired.	-
5 + i	surf_id	**Surface ID** Optional parameter depending on parameter 4. Par(4) > 0 , i = 1 … n_surfout	-

3.2. Description of Inputs

Input no	Symbol	Description	Unit
1	sol_zenith	**solar zenith angle** for internal radiation calculation (parameter 3 = 0) -> the solar zenith angle has to be connected to Type 15, Type 16 or Type 99 for external radiation calculation (parameter 3 > 0) -> no restrictions	degrees
2	sol_azimuth	**solar azimuth angle** (0=facing equator, 90=facing west, -90=270=facing east) for internal radiation calculation (parameter 3 = 0) -> the solar azimuth angle has to be connected to Type 15, Type 16 or Type 99 for external radiation calculation (parameter 3 > 0) -> no restrictions	degrees
3	grd_reflec or latitude	for internal radiation calculation (parameter 3 = 0): **ground reflection for solar radiation** for external radiation calculation (parameter 3 > 0) **latitude of weather data station**	- or degrees
		The following inputs are required for external radiation calculation only (parameter 3 > 0) They are required for each orientation in the same order	
4 + j	I_beam_Oj	**beam radiation of orientation j**	kJ/(h m²)
5 + j	I_dif_Oj	**sky diffuse radiation of orientation j**	kJ/(h m²)

6 + j	I_grd_Oj	**ground reflected radiation of orientation j**	kJ/(h m²)
7 + j	inc_angle_Oj	**incident angle of orientation j**	degrees
8 + j	surf _slope_Oj	**slope angle of orientation j**	degrees
9 + j	surf_azimuth_Oj	**azimuth angle of orientation j**	degrees

3.3. Description of Outputs

Out. no	Symbol	Description	Unit
1	Ishd_tot_all	**shaded total radiation of all surfaces**	kJ/(h m²)
2	Ishd_beam_all	**shaded beam radiation of all surfaces**	kJ/(h m²)
3	Ishd_dif_all	**shaded diffuse radiation of all surfaces**	kJ/(h m²)
4	Ishd_sky_all	**shaded sky diffuse radiation of all surfaces**	kJ/(h m²)
5	Ishd_grd_all	**shaded diffuse ground reflected radiation of all surfaces**	kJ/(h m²)
6	inc_angle_all	**angle of incidence**	degrees
		The following outputs are created for each surface group	
7 + k	Ishd_tot_Gk	**shaded total radiation of group k**	kJ/(h m²)
8 + k	Ishd_beam_Gk	**shaded beam radiation of group k**	kJ/(h m²)
9 + k	Ishd_dif_Gk	**shaded diffuse radiation of group k**	kJ/(h m²)
10 + k	Ishd_sky_Gk	**shaded sky diffuse radiation of group k**	kJ/(h m²)
11 + k	Ishd_grd_Gk	**shaded diffuse ground reflected radiation of group k**	kJ/(h m²)
12 + k	inc_angle_Gk	**angle of incidence of group k**	degrees
		The following outputs are created for each selected surface from input 4 and 5	
13 + m	Ishd_tot_Sm	**shaded total radiation of surface m**	kJ/(h m²)
14 + m	Ishd_beam_Sm	**shaded beam radiation of surface m**	kJ/(h m²)
15 + m	Ishd_dif_Sm	**shaded diffuse radiation of surface m**	kJ/(h m²)
16 + m	Ishd_sky_Sm	**shaded sky diffuse radiation of surface m**	kJ/(h m²)
17 + m	Ishd_grd_Sm	**shaded diffuse ground reflected radiation of surface m**	kJ/(h m²)
18 + m	inc_angle_Sm	**angle of incidence of surface m**	degrees

4. General Description

The shading calculation with Type 390 is based on the interpolation of an existing shading matrix file. In general, the user can generate the shading matrix file by any tool, provided the file has the correct syntax (see section 5.4). In Section 6.1, the preprocessing steps using tools from the TRNSYS package are described.

Type 390 has two solar radiation data modes implemented; internal and external calculation. The outputs of Type 390 are solar radiation data aggregated for all receiver surfaces and for the different groups of receiver surfaces. In addition, solar radiation outputs for individual receiver surfaces can be defined. These outputs can be used as input to other TRNSYS components e.g. solar collector models.

5. Mathematical Description

5.1. Incident solar radiation (without shading)

Type 390 has two modes implemented for providing solar radiation data on tilted surfaces: internal and external calculation.

The “**internal calculation mode**” is very user-friendly because it requires only 3 inputs and allows to apply a more detailed diffuse sky radiation shading based on an anisotropic sky model. The additional required data is obtained through an internal data exchange with the linked weather data component and the surface information (slope and azimuth) provided by the shading matrix file. Therefore, it is mandatory that the 1st input (solar zenith angle) is linked to one of the following weather data components:

- Type 15
- Type 16
- Type 99

Note that the ground reflectance is provided through an input for this mode and is not automatically retrieved from the weather data component.

The surface orientation (slope and azimuth) is included in the shading matrix file (*.shm) and therefore is not obtained from the weather data component either.

In a first step, the weather data provided by the weather data component is converted to match the simulation time step. Afterwards, the direct and diffuse radiation of tilted surfaces are determined based on the horizontal radiation data. For diffuse radiation it is recommended to select an anisotropic sky model e.g. the Perez model in the weather data component. With these models, the diffuse sky radiation may consist of up to three parts:

- Isotropic part of the sky hemisphere
- Circumsolar part near the current sun position
- Horizon brightening

Therefore, the following kernel functions of TRNSYS 18 are used:

- `call GetRadiationData`
- `call GetHorizontalRadiation`
- `call GetTiltedRadiation`

(Further information on these functions can be found in the TRNSYS documentation, section 7.4.4.5 of *%TRNSYS18% \Documentation\07-ProgrammersGuide.pdf*).

The “**external calculation mode**” allows the user to define the incident radiation on the receiver surfaces manually (e.g. constant boundary conditions). The given slope and azimuth angels of the orientations have to match the surface orientations provided by the additional surface information included in the shading matrix file (*.shm).

5.2. Geometric surface shading

The geometric shading calculation of incident solar radiation on a receiver surface is based on a previously generated shading matrix.

For the shading matrix, the celestial hemisphere is divided into patches. The Tregenza-based sky division scheme divides the hemisphere vertically into 7 superimposed horizontal rows, each representing a differential altitude of 12°, with the hemisphere topped at its zenith by a circular segment with a half-cone angle of 6°. Each horizontal row is then divided into rectangular segments based on the Tregenza convention for a total of 144 rectangular and 1 circular segment. A scaling factor is used to increase the number of direct solar positions. (Bourgeois, 2008). Besides a medium resolution of 577 patches, there is also a high resolution of 2305 patches available. The matrix contains solar sunlit factors of all sky patches for each receiver surface as well as a diffuse shading factor.

The sunlit factor is defined as

$$f_{s,dir} = \frac{A_{sunlit}}{A_{total}} \qquad (5\text{-}1)$$

where A_{sunlit} is the sunlit area and A_{total} is the total area of a receiver surface. A sunlit factor of 0 represents a completely shaded surface whereas a sunlit factor of 1 indicates a completely sunlit surface. If the sun is behind the surface the factor is set to 99.

For solving the diffuse radiation shading, it is assumed that the patches are rather small and far away. Thus, the diffuse radiation leaving each patch can be considered parallel to the direction connecting the patch's center to the center of the hemisphere. In the current version, the diffuse radiation is assumed to be isotropic. Therefore, the diffuse fraction of an external window can be determined by:

$$f_{s,dif,iso} = \frac{\sum_{k=1}^{n} \cos\alpha_k \cdot \Delta\omega_k \cdot f_{s,dir,k}}{\sum_{k=1}^{n} \cos\alpha_k \cdot \Delta\omega_k} \qquad (5\text{-}2)$$

$$\Delta\omega_k = sin\Theta_{Z,k} \cdot \Delta\Theta_Z \cdot \Delta\gamma_k \qquad (5\text{-}3)$$

where n is the number of sky patches where the receiver surface is sunlit, α_k is the angle between the surface normal vector and the sun vector of sky patch k, $\Theta_{Z,k}$ is the zenith angle of sky patch k, $f_{s,dir,k}$ is the direct sunlit fraction of patch k, $\Delta\omega_k$ is the increment of the solid angle of patch k, $\Delta\gamma_k$ is the increment of the solar azimuth angle, $\Delta\Theta_Z$ is the increment of the solar zenith angle of the patch.

5.3. Incident solar radiation including shading effects

Type 390 reads the direct and diffuse sunlit factors for each receiver surface at the beginning of the simulation. For each time step, the current sunlit fraction of the surface is determined by a bilinear interpolation of the four nearest center points with respect to the sun's actual position. The resulting direct radiation on the surface $I_{s,dir,shd}$ is determined by

$$I_{s,dir,shd} = f_{s,dir,intpol} \cdot I_{s,dir} \qquad (5\text{-}4)$$

where $f_{s,dir,intpol}$ is the interpolated sunlit factor and $I_{s,dir}$ is the incident unshaded direct radiation.

The parts of the diffuse sky radiation are calculated in a similar way:

$$I_{s,dif,iso,shd} = f_{s,dif,iso} \cdot I_{s,dif,iso} \quad (5\text{-}5)$$

$$I_{s,dif,circumsolar,shd} = f_{s,dir,intpol} \cdot I_{s,dif,circumsolar} \quad (5\text{-}6)$$

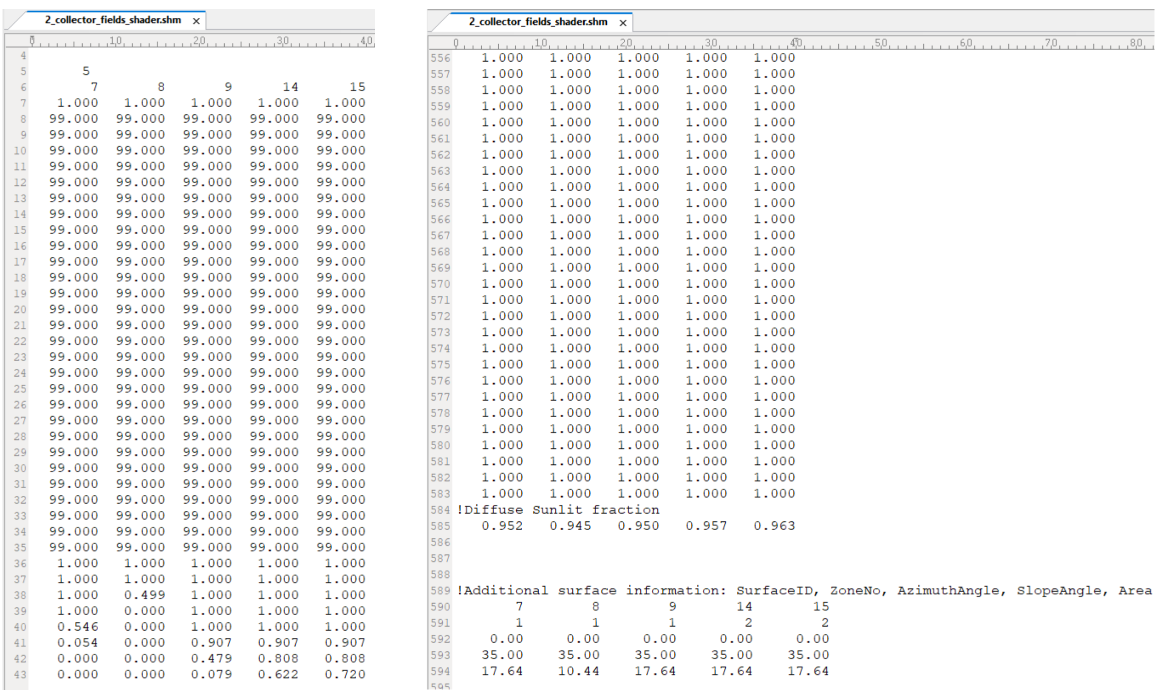
$$I_{s,dif,horizon,shd} = f_{s,dif,horizon} \cdot I_{s,dif,horizon} \quad (5\text{-}7)$$

The isotropic sunlit factor, $f_{s,dif,iso}$, is given by the shading matrix file. For circumsolar radiation, the interpolated sunlit factor for direct radiation, $f_{s,dir,intpol}$, is applied. For horizon brightening, the shading factor of the last row is used for positive values, whereas for negative values the isotropic sunlit factor is given.

5.4. Format of the shading matrix

The shading matrix file (see Figure 5-1) has a fixed format which is described in the following:

- 1st line: -1 (577 sky patches) or -2 (2305 sky patches)
- 4 blank lines
- 5th line: Total number of the receiver surfaces
- 6th line: ID numbers of the (receiver) surfaces
- Starting line7th : Direct sunlit fraction for sky patches with 3 decimal places
  (0…completely shaded; 1…completely sunlit; 99…sky patch behind the surface)
- Comment line: !Diffuse Sunlit fraction
- Next line: Sunlit patches for diffuse isotropic sky (only sky patches in front of the surface
- 3 blank lines
- Comment line: !Additional surface information: SurfaceID, ZoneNo, AzimuthAngle, ….
- Next line: ID numbers of the (receiver) surfaces
- Next line: Group number for Type 390 (= ZoneNo)
- Next line: Azimuth angle of surface
- Next line: Slope angle of surface
- Next line: Surface area




```

     5
        7        8        9       14       15
    1.000    1.000    1.000    1.000    1.000
   99.000   99.000   99.000   99.000   99.000
   99.000   99.000   99.000   99.000   99.000
   99.000   99.000   99.000   99.000   99.000
   99.000   99.000   99.000   99.000   99.000
   99.000   99.000   99.000   99.000   99.000
   99.000   99.000   99.000   99.000   99.000
   99.000   99.000   99.000   99.000   99.000
   99.000   99.000   99.000   99.000   99.000
   99.000   99.000   99.000   99.000   99.000
   99.000   99.000   99.000   99.000   99.000
   99.000   99.000   99.000   99.000   99.000
   99.000   99.000   99.000   99.000   99.000
   99.000   99.000   99.000   99.000   99.000
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   99.000   99.000   99.000   99.000   99.000
   99.000   99.000   99.000   99.000   99.000
    1.000    1.000    1.000    1.000    1.000
    1.000    1.000    1.000    1.000    1.000
    1.000    0.499    1.000    1.000    1.000
    1.000    0.000    1.000    1.000    1.000
    0.546    0.000    1.000    1.000    1.000
    0.054    0.000    0.907    0.907    0.907
    0.000    0.000    0.479    0.808    0.808
    0.000    0.000    0.079    0.622    0.720
```

```
    1.000    1.000    1.000    1.000    1.000
    1.000    1.000    1.000    1.000    1.000
    1.000    1.000    1.000    1.000    1.000
    1.000    1.000    1.000    1.000    1.000
    1.000    1.000    1.000    1.000    1.000
    1.000    1.000    1.000    1.000    1.000
    1.000    1.000    1.000    1.000    1.000
    1.000    1.000    1.000    1.000    1.000
    1.000    1.000    1.000    1.000    1.000
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    1.000    1.000    1.000    1.000    1.000
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    1.000    1.000    1.000    1.000    1.000
    1.000    1.000    1.000    1.000    1.000
    1.000    1.000    1.000    1.000    1.000
    1.000    1.000    1.000    1.000    1.000
    1.000    1.000    1.000    1.000    1.000
    1.000    1.000    1.000    1.000    1.000
    1.000    1.000    1.000    1.000    1.000
    1.000    1.000    1.000    1.000    1.000
    1.000    1.000    1.000    1.000    1.000
    1.000    1.000    1.000    1.000    1.000
    1.000    1.000    1.000    1.000    1.000
    1.000    1.000    1.000    1.000    1.000
    1.000    1.000    1.000    1.000    1.000
!Diffuse Sunlit fraction
    0.952    0.945    0.950    0.957    0.963



!Additional surface information: SurfaceID, ZoneNo, AzimuthAngle, SlopeAngle, Area
        7          8          9         14         15
        1          1          1          2          2
     0.00       0.00       0.00       0.00       0.00
    35.00      35.00      35.00      35.00      35.00
    17.64      10.44      17.64      17.64      17.64
```

Figure 5-1: Example of a Shading Matrix File

6. Example of a collector array modeled in TYPE 390

In the following sections, an example for the application of Type 390 is described. This includes a brief description of the preprocessing steps using tools of the TRNSYS standard package.

6.1. PreProcessing

6.1.1. Step 1: Generating 3D geometry information of the scene by Trnsys3D

For generating the 3D geometric information of the collector modules as well as shading objects, the SketchUp plugin Trnsys3D of TRNSYS can be used. The plugin is designed originally for the multi-zone building model of TRNSYS (Type 56) and a general introduction is given by section *9.3.2.2.* of the TRNSYS tutorial (*%TRNSYS18%\Documentation\09-Tutorials.pdf*).

For Type 390, it is important that a new project is started based on the template for Type 390, *NewFileTemplateType390.idf*, because it includes the required settings for generating the necessary shading matrix mode (shm_mode = 390). This setting ensures that completely sunlit receiver surfaces as well as additional surface information are included in the shading matrix file.

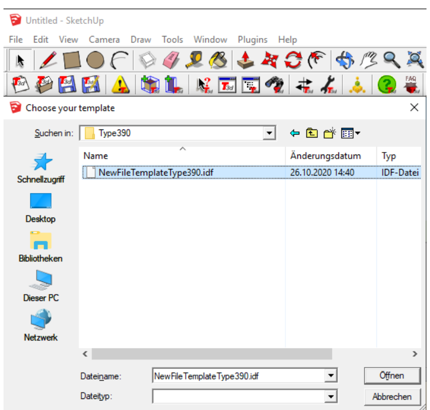

Figure 6-1: Sketchup User-Interface for Choosing a template

Now, the scene can be generated by adding zones and shading groups, respectively. The building components are used by Type390 as follows:

- collector receiver surfaces are represented by the surface type “*window*”.
- several collector receiver surfaces can be aggregated to a group by being associated to one “*zone*”
- other objects like trees or buildings are represented by shading groups as usual
- Note: Potential shadow casting surfaces are limited to:
  - external (!) surfaces of zones
    (Be aware that the orientation matters: At each point in time, only shaded external surfaces cast shadows on “receiver surfaces”, not the sunlit ones.)
  - surfaces of a shading group
    (in contrast to external surfaces, both sides (shaded and sunlit) may cast shadows)

General recommendations for drawing geometry:

- reduce complexity by considering relevant surfaces only
- avoid small surfaces relative to other surfaces
  (e.g. collectors shouldn’t be drawn as closed 3D volumes, but as two parallel surfaces, one containing the receiver and one for casting shadows.)

The following general geometric restrictions of Trnsys3D apply:

- all surfaces are considered planar non-self-intersecting polygons without holes.
- "*windows*" are subsurfaces of "*walls*".
- the edges of a polygon are restricted to straight lines.

For this example, a scene of 5 collector rows including a shading box is modeled (see Figure 6-2). The collector rows are assigned to two fields.

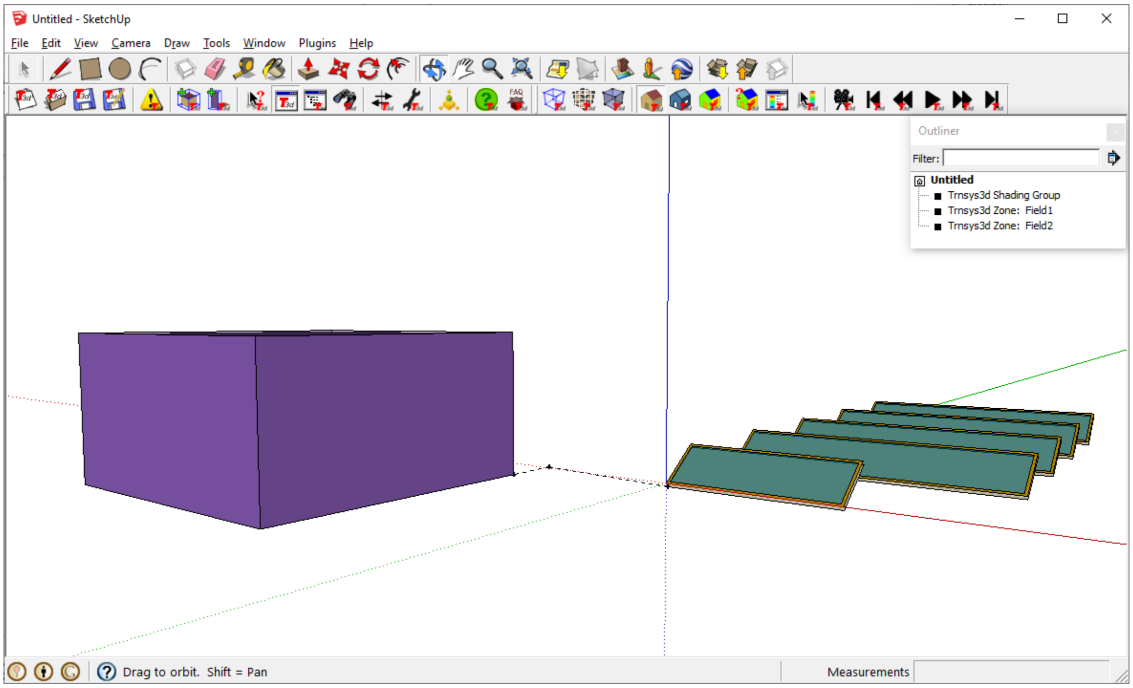

Figure 6-2: Example collector field in Sketchup

The geometric scene information is saved in a so-called *.idf-file by Trnsys3D. (**Caution: Never save the scene as a SketchUp project -> this leads to model inconsistency and may corrupt your model!**)

6.1.2. Step 2: Generating the shading matrix file by TRNBuild

The **.idf* file from Trnsys3D can then be imported with TRNBuild, the GUI for the multi-zone building model. For this, open TRNBuild and select *"File -> Import TRNSYS3d file"*.

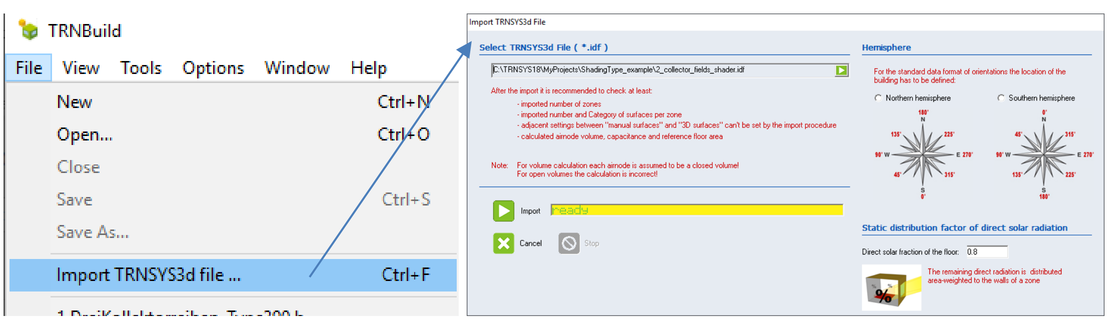

Figure 6-3: Importing geometry in TRNBuild

It is recommended to check the imported scene by selecting *"View 3d building geometry"* (Further information regarding the viewer can be found in *%TRNSYS18%\Documentation\A4_trnViewBUI.pdf*). Afterwards, the viewer window can be closed.

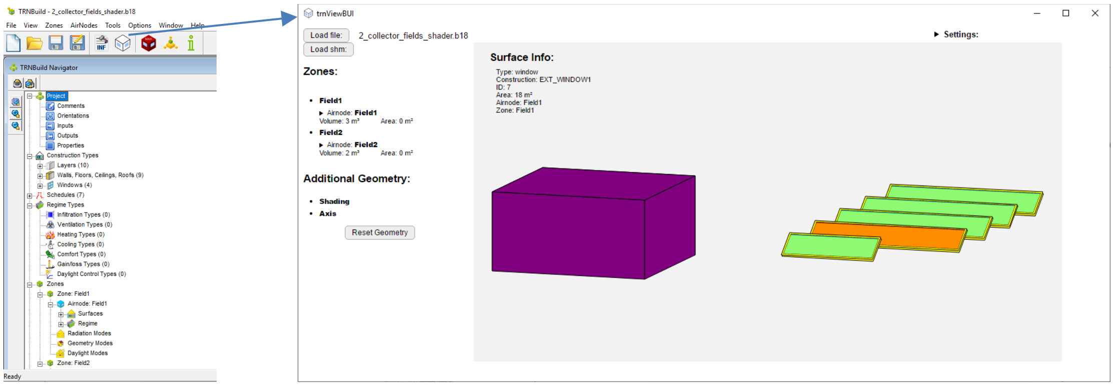

Figure 6-4: Visualization of the imported geometry

To generate the shading/ insolation matrices select the menu *"Tools -> Generate Shading/Insolation matrix*". In doing so, TRNBuild calls an auxiliary tool based on TRNSHD. TRNSHD divides the celestial hemisphere into patches based on the aforementioned Tregenza model. Under properties in the project branch, the resolution of the sky division can be set to either medium (577 patches) or high (2305 patches). For most cases, the medium resolution is sufficient. The generated shading matrix file has the same file name as the current **.B18* file, and the file extension *.shm and is located in the same directory. If an error occurs, no file is generated. Additional information can be found in the log file **_shd.log*.

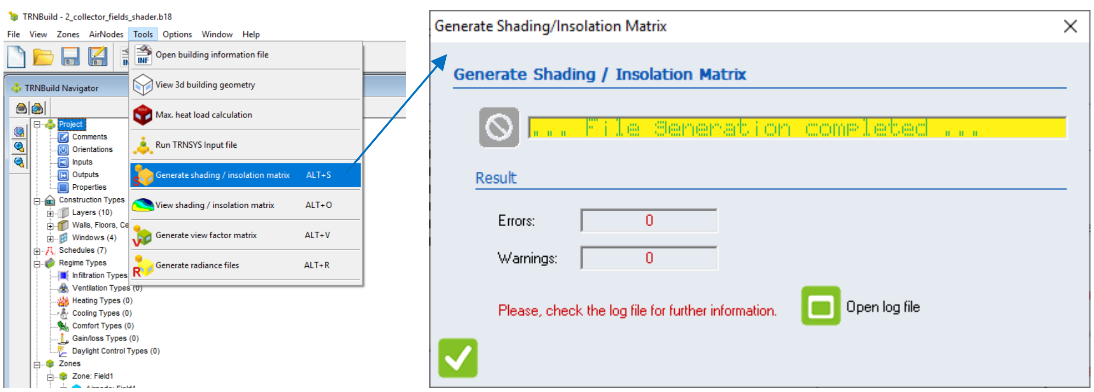

Figure 6-5: Generate Shading/ Insolation Matrix

6.1.3. Step 3: Checking the resulting shading matrix

It is recommended to check the generated shading matrices by selecting *"View 3d building geometry"* in TRNBuild again. If the shading matrix file exists, it is automatically loaded in addition to the geometry. Select a *"window"* and enable *"view SHM"*. For each patch of the celestial hemisphere, the sunlit fraction is displayed (0… completely shaded, 1…completely sunlit).

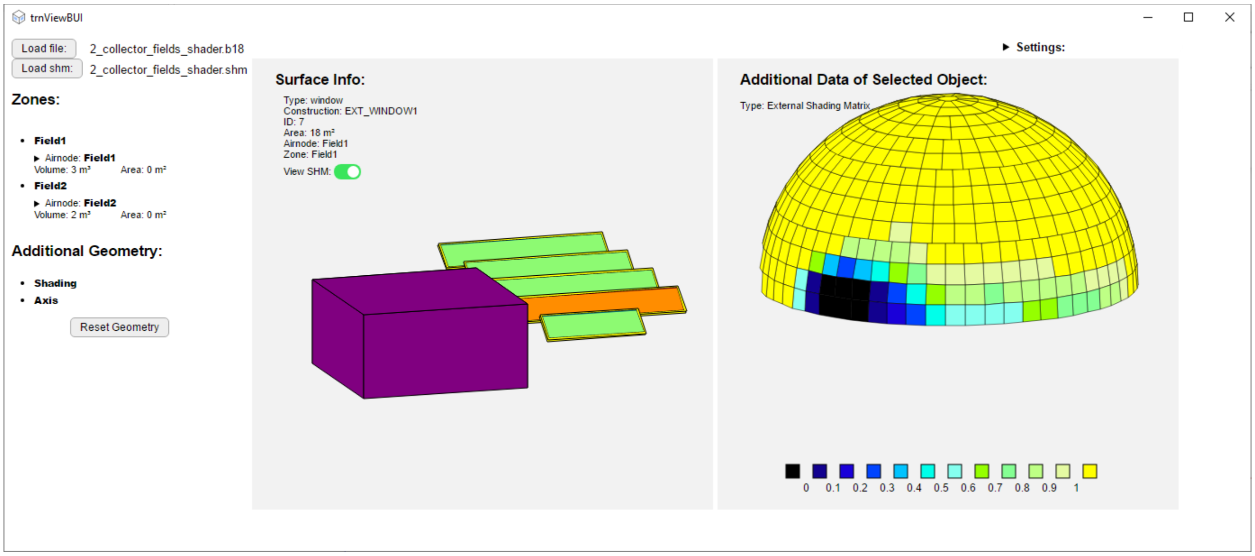

Figure 6-6: Checking generated shading matrices

Finally, the generated shading mask (*.shm) has to be assigned to Type 390 as external file in TRNSYS Studio.

6.1.4. Automated shading matrix generation by TRNSYS Studio plugin

Although it is highly recommended to generate the shading mask as previously described with steps 2 and 3, the TRNSYS Studio plugin of Type 390 can also be used to execute step 2 and 3 automatically.

In this case, the resulting *.idf file from step 1 is initially assigned as the external file to Type390. By clicking on the plugin, the automated import and generation process is started. Afterwards, the 3d building geometry viewer opens to allow the user to check the results. The external file of Type 390 then has to be reassigned to the generated shading matrix file *.shm. In addition, the number of groups in the tab *"Outputs"* is set automatically according to the data of the shading matrix file.

If the plugin is executed and the assigned external file of Type 390 is already a shading matrix file *.shm the 3d building geometry viewer opens. Also, the number of groups in the tab *"Outputs"* is updated automatically according to the data of the shading matrix file.

6.2. Studio Project

The shading Type 390 can be retrieved form the direct access tool. The following example consists of a weather component (Type 15), the shading component (Type 390) and an online plotter (type 65). In the Tab *"External files"*, the previously generated shading matrix file is assigned (see section 6.1).

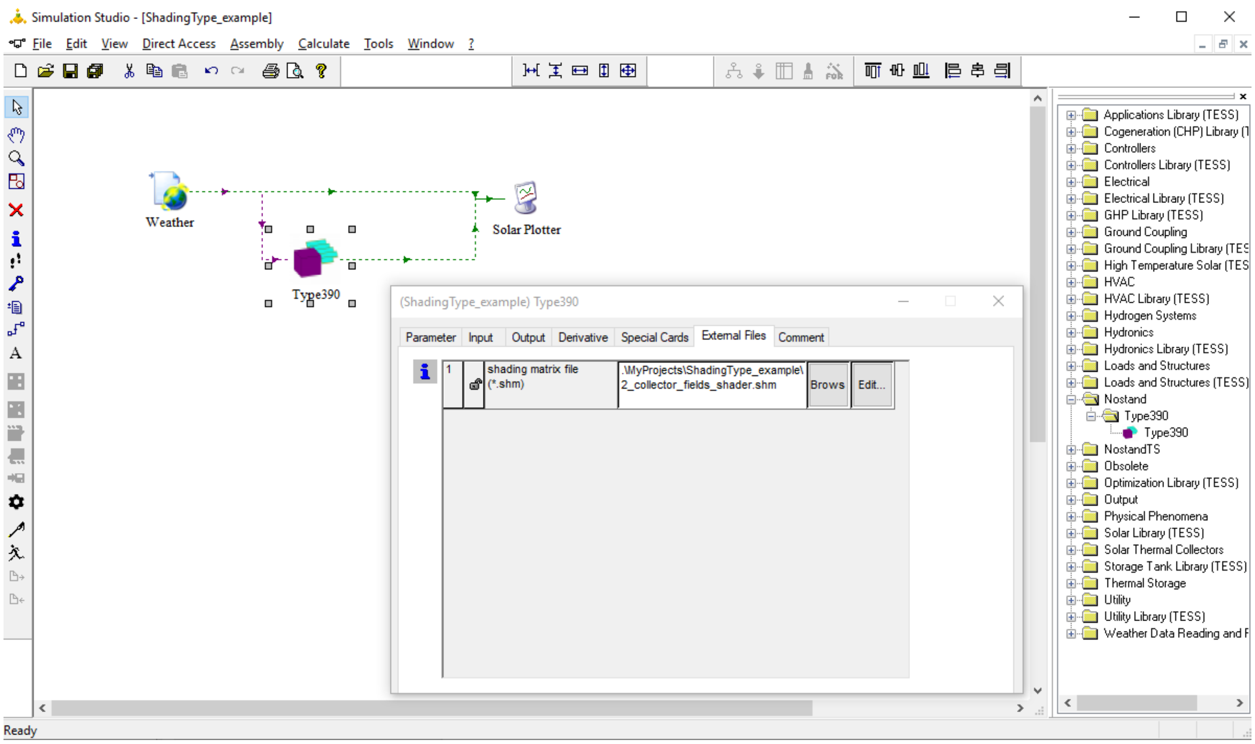

Figure 6-7: Interface in Trnsys Studio

6.2.1. Parameters

By clicking on the tab *"Parameter"* a plugin icon is shown in the lower left corner. If the plugin is executed the 3d building geometry viewer opens. Also, the number of groups in the tab *"Output"* is updated automatically according to the data of the shading matrix file. In addition, some information about the surfaces contained in the shading matrix file is written to the tab *"Comment"*. For reasons of convenience, the internal radiation calculation mode is being used (parameter 3 equals 0). For the first two collector rows, surface 7 and 8, individual surface outputs are set.

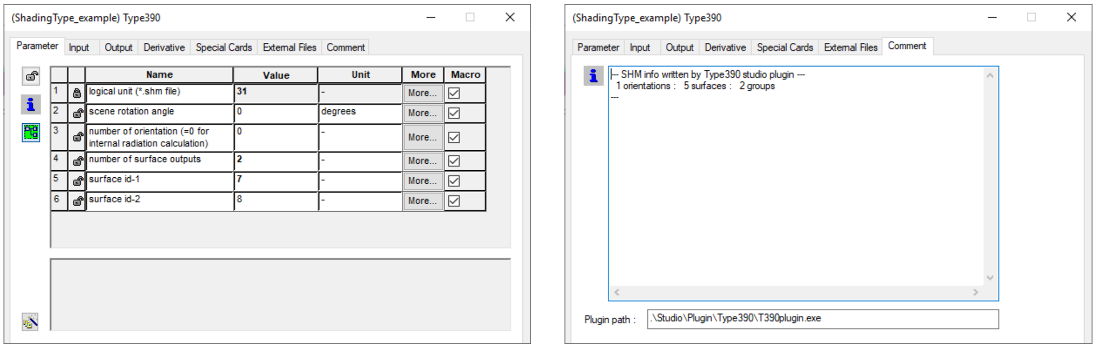

Figure 6-8: Parameters

6.2.2. Inputs

All the required inputs are connected to outputs from the weather component.

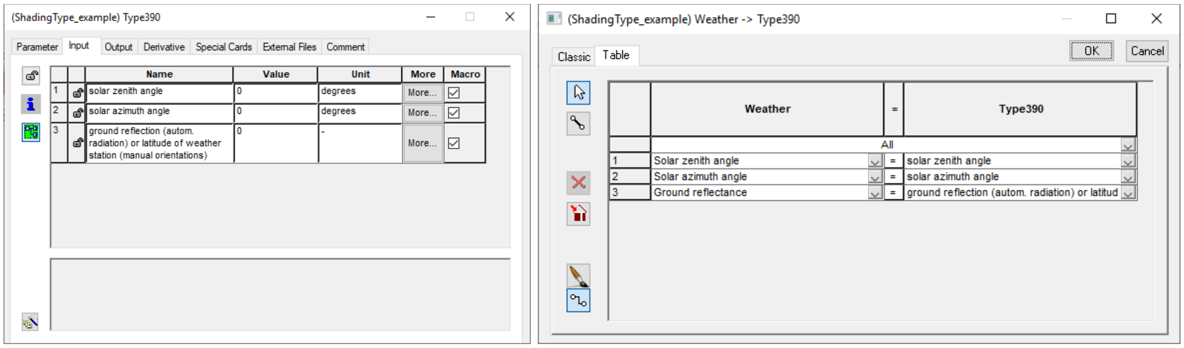

Figure 6-9: Inputs

6.2.3. Outputs

The number of outputs depends on the number of surface groups defined in the shading matrix file. If the plugin is executed, the number of groups in the tab *"Outputs"* is updated automatically. Otherwise, the number has to be entered manually.

It is recommended to check the outputs by connecting them to an online plotter. Figure 6-10 shows the simulation results for the first week in January. As expected, there aren't large shading effects. In the morning hours self-shading occurs. Collector group 1 (first three rows) is less shaded than group 2. In the afternoon the "box" casts shadows on the collector surfaces. Group 1 is more affected by this than group 2.

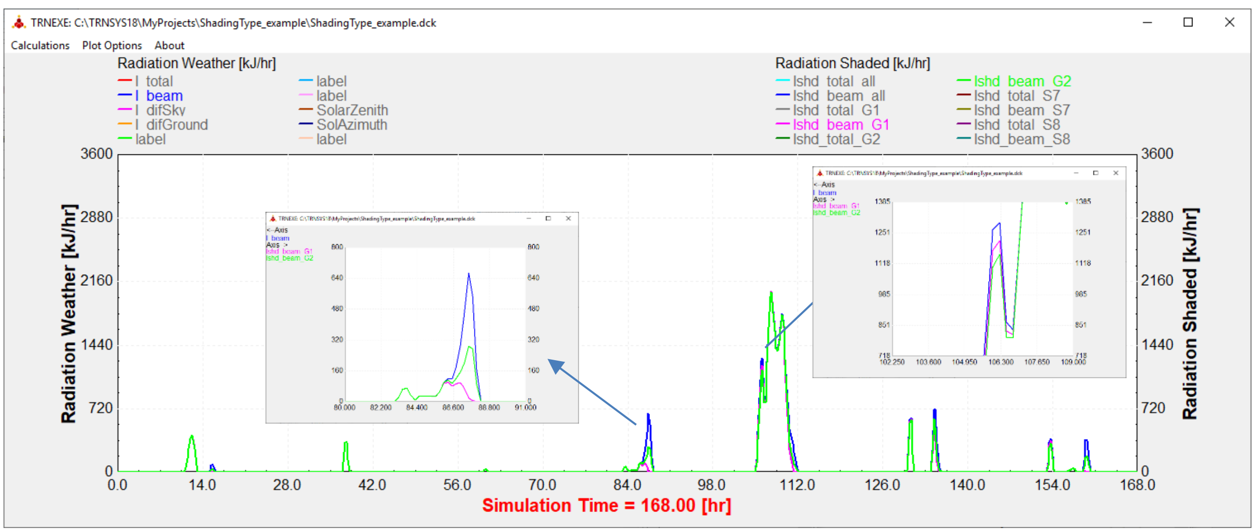

Figure 6-10: Simulation results

Type 390 was developed to be used in combination with solar collector components as an external solar shading component. Nevertheless, it could be used in combination with any other component that requires input of incident radiation on planar surfaces.

7. References

Bourgeois D, Reinhart CF, Ward G, “A Standard Daylight Coefficient Model for DynamicDaylighting Simulations” Building Research & Information 36:1 pp. 68 – 82, 2008

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