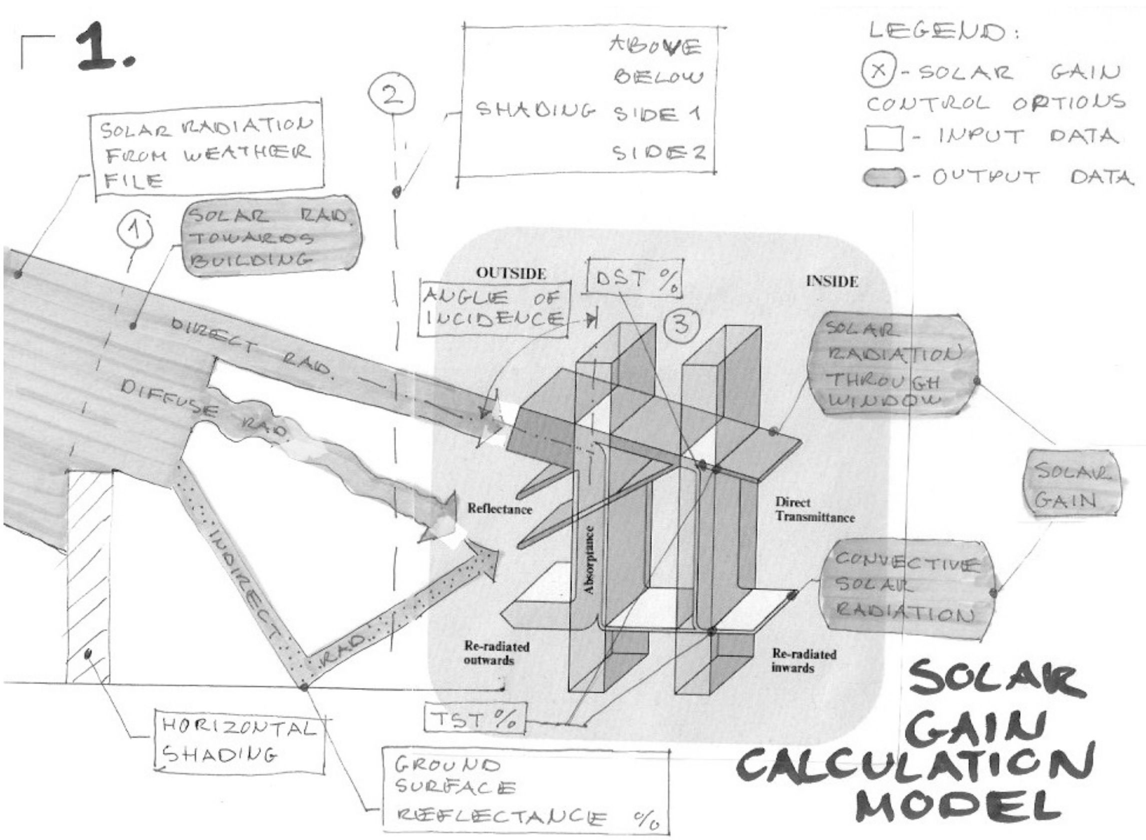
Solar Irradiation Modeling in ARCHICAD Energy Evaluation And EcoDesigner STAR

The draft picture below illustrates how the Solar Radiation data of the Climate file is processed to calculate the Solar Gain component of the modeled building’s energy balance.

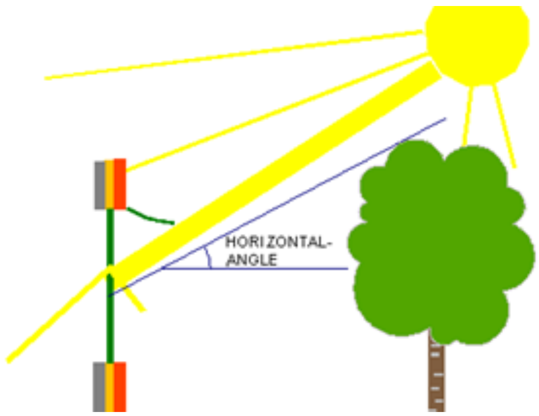


The calculation process is described step by step below:

- Hourly total solar radiation data is obtained from the weather file
- Project Location: defines the hourly sun-path
- Geometry and Orientation: together with the sun-path the hourly angle of incidence of the hourly direct solar radiation can be determined on each transparent Second Level Space Boundary
- There are two ways to model the shading effect of the surroundings in ARCHICAD. These two methods can be applied separately or in combination depending how detailed the surrounding objects are modeled within the BIM:
- Horizontal shadow mask created by distant objects can easily be

modeled with the External Shading option under the Environmental Settings. Four settings are available for each orientation. Each setting has a default horizontal angle (in degrees) assigned to it, as follows:

- None =0
- Low =10
- Medium =15
- High =30



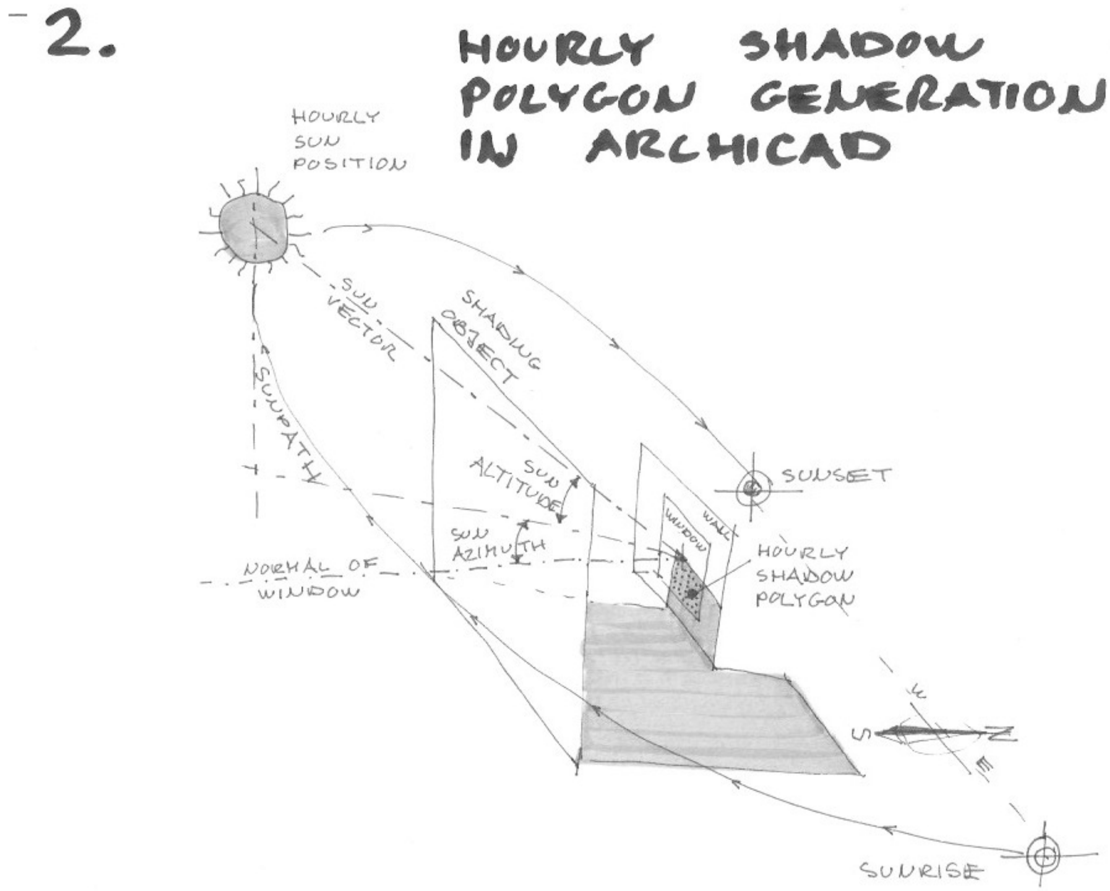
If the horizontal projection of the hourly direct solar irradiation's angle of incidence falls within the range of a certain orientation and the vertical projection of the hourly direct solar irradiation's angle of incidence falls below the threshold defined for that orientation, then the total solar radiation data is reduced accordingly.

Note: If all neighboring buildings and objects (building, trees etc.) are accurately modeled with actual 3D elements and there are no significant shadow casting objects in the distance (e.g. mountain, city skyline etc.), then it is enough to only use the model-based solar study to calculate the hourly shadow polygons on the transparent Second Level Space Boundaries. In this case External Shading can be set to None for each orientation

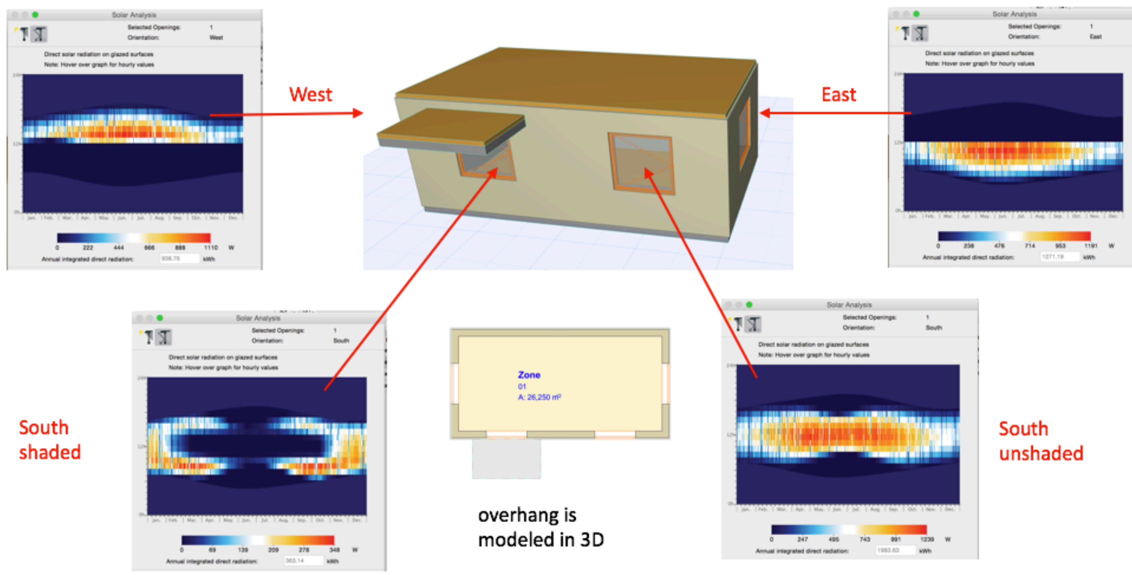
- In the next phase of the process, the diffuse, direct and indirect components of the solar radiation are determined according to the Hay-Davies-Klucher-Riendl (HDKR) standard model.
- Ground Surface Reflectance greatly depends on the general reflective properties of the surrounding environment as defined by the user via the Surroundings chapter of the Environmental Settings dialog. The following predefined options are readily available, or a custom Reflectance % value can also be entered:

- Waterfront =50%
- Garden =20%
- Paved =30%

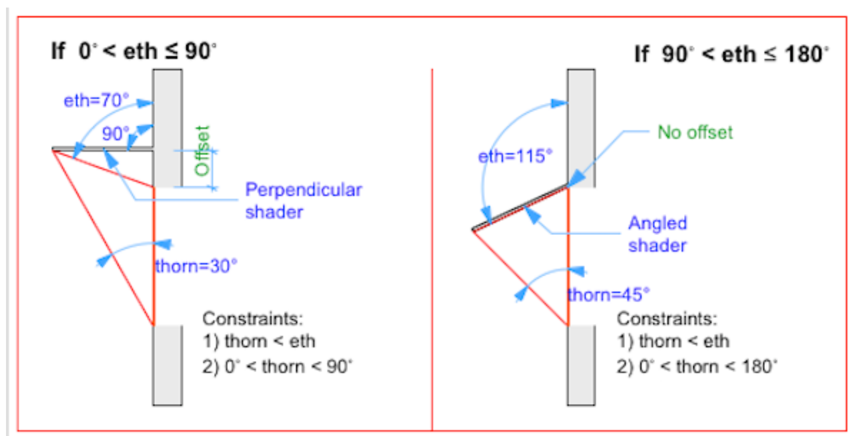
- Model-Based Solar Study
  The picture below illustrates the parallel projection applied by the program to determine the shadow polygon cast on a transparent second level space boundary for every hour of the reference year:



  Hourly solar irradiation data from the weather file is overlaid on the shadow masks to produce the model-based solar analysis diagram for each opening:



The VIP-Core calculation kernel, on the other hand, accepts angle-pair shadow mask input data exclusively, as described in the HDKR standard:



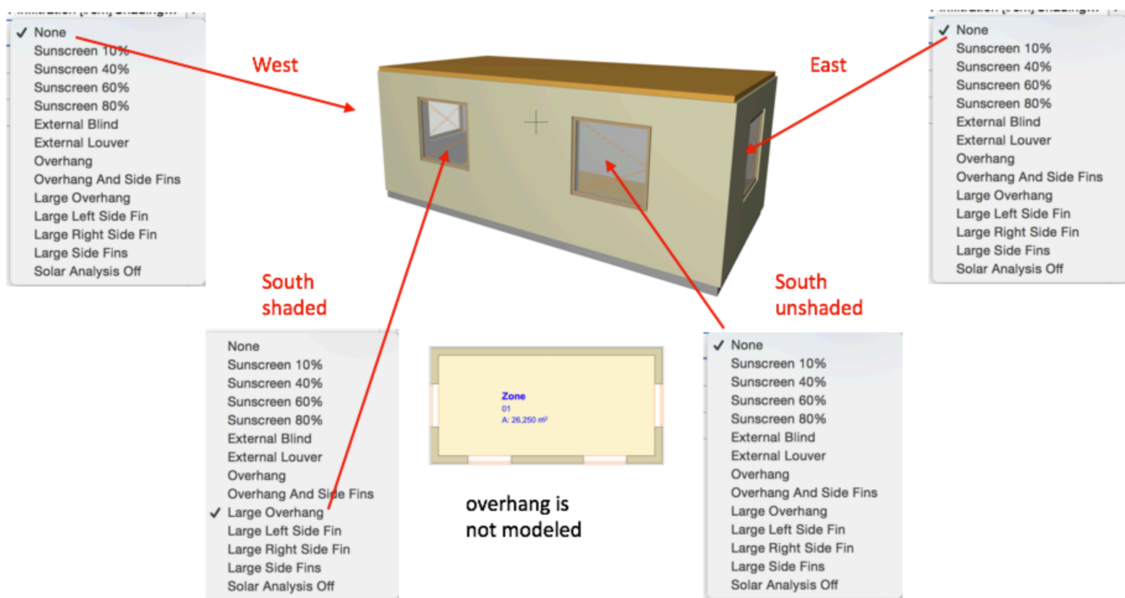
According to this protocol, thorn-eth angle pairs must be used to define:

- Vertical shadow casting fins in the horizontal 2D projection (floor plan) and
- Horizontal shadow casting overhangs/canopies in the vertical 2D projection (section)

Consequently, the hourly shadow polygons must be converted into angle pair data to facilitate the calculation. This is done automatically by the software using a proprietary algorithm developed by GRAPHISOFT.

- An alternative way to input horizontal and vertical shadow casting planes is to define analytic shadow mask angle-pair data directly by fin angles via the ShadingCatalog.xml. This method can be activated on any transparent second level space boundary by assigning one of the following Shading Devices to it:

- Overhang
- Overhang And Side Fins
- Large Overhang
- Large Left Side Fin
- Large Right Side Fin
- Solar Analysis Off



If any of the above listed Shading Devices is active on an Openings list entry, it deactivates the Automatic Solar Analysis functionality and superimposes the corresponding shadow mask as defined in the ShadingCatalog.xml.

The following excerpt from this xml illustrates the applied descriptive protocol:

<Shading Name="Large Right Side Fin" ID="116">
<LeftEth>0</LeftEth>
<LeftThorn>0</LeftThorn>
<RightEth>90</RightEth>
<RightThorn>34</RightThorn>

```xml
            <UpperEth>0</UpperEth>
            <UpperThorn>0</UpperThorn>
            <LowerEth>0</LowerEth>
            <LowerThorn>0</LowerThorn>
        </Shading>
```

The alternative analytic steady state shadow mask input method described above is recommended for use in the schematic design phase when overhangs are not yet modeled.

The preferred method to calculate the effect of any shadow mask scenario (e.g. shadow cast by a canopy on a second level space boundary) on solar gain with EcoDesigner STAR is to model the shadow casting object (e.g. overhang) using ARCHICAD.

The alternative method, when horizontal and vertical shadow masks (e.g. overhangs and/or side fins) are defined via .xml is only used in special cases such as:

- Draft design evaluation in the early architectural design phase, when small details such as canopies are not yet modeled in 3D
- For urban district scale energy models where the level of detail is low and dozens of buildings are simultaneously analyzed
- For analytic software testing (e.g. for standard compliance verification or software calibration)

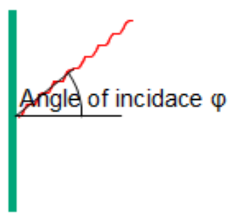
- The shading devices other than the ones listed above do not override the effect of the model-based solar study but their effect is added to each hourly shadow mask generated by the automated algorithm. These shading devices are:
    - Sunscreen 10%
    - Sunscreen 40%
    - Sunscreen 60%
    - Sunscreen 80%
    - External Blind
    - External Louver

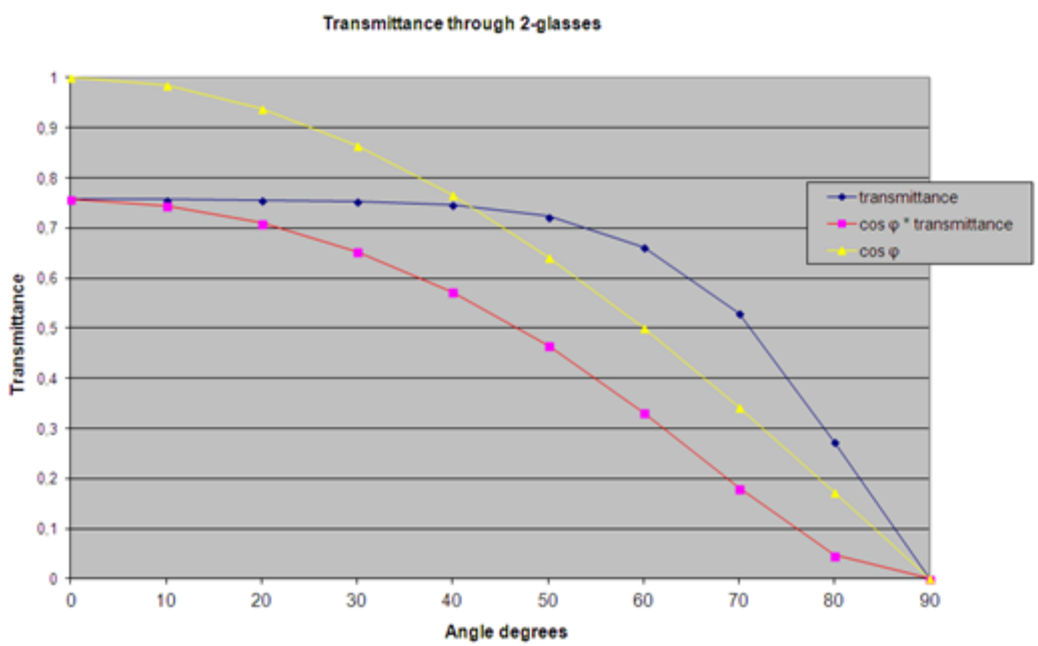
  The following excerpt from the ShadingCatalog.xml illustrates the applied descriptive protocol:

```xml
        <Shading Name="Sunscreen 60%" ID="103">
```

<TransmittanceTotal>40</TransmittanceTotal>
<TransmittanceDirect>40</TransmittanceDirect>
<TransmittanceConstrainRoom
Temperature>true</TransmittanceConstrainRoomTemperature>
<TransmittanceMinRoomTemperature>
22</TransmittanceMinRoomTemperature>
</Shading>

- Angle of incidence has a strong influence on transmittance:





- Effects of glazing properties TST and DST

The total shading coefficient (TST) is a measure of the total amount of heat passing through the glazing (known as the total solar heat transmittance) compared with that through a single clear glass. The shading coefficient (SC) is derived by comparing the solar radiant heat transmission properties of any glass with a clear float glass The shading coefficient (SC) can be separated into long-wave and short-wave components, whose values are derived by comparing with the same property of 4mm clear float glass:

  - The short wavelength shading coefficient (SWSC) is the direct solar heat transmittance (DST)
  - The long wavelength shading coefficient (LWSC) is the fraction of the absorptance released inwards via convection

The TST and DST values that can be assigned to every transparent second level space boundary act like filters that alter the magnitude of the solar radiation components according to material properties

- Eventually, hourly Solar Gain is calculated for each thermal block (see "Solar radiation through windows" column in the "Detailed Results – Hourly" table excerpt below) as the sum of the solar radiation that passes through the transparent second level space boundaries of the thermal block directly plus the energy radiated inwards by the glazing via convection (see "Convective solar radiation" column in the table below).

Energy flows		Convective solar radiation	Solar radiation through windows	Solar radiation towards building
		kWh	kWh	kWh
Annual Total [kWh]		ual Total		
Annual Absolute [kWh]		782,23	4148,02	117800,69
Annual Specific				
Date				
Day	Hour			
1/1	10	0,44	2,29	34,70
1/1	11	0,40	2,00	37,84
1/1	12	0,35	1,76	38,08
1/1	13	0,32	1,65	36,72
1/1	14	0,25	1,13	26,09
1/1	15	0,15	0,58	14,88
1/1	16	0,11	0,55	10,81
1/1	17	0,06	0,17	2,96
1/1	18	0,00	0,00	0,00