Shading Calculation for Passive House Certification – Discussion and Development of a New Method

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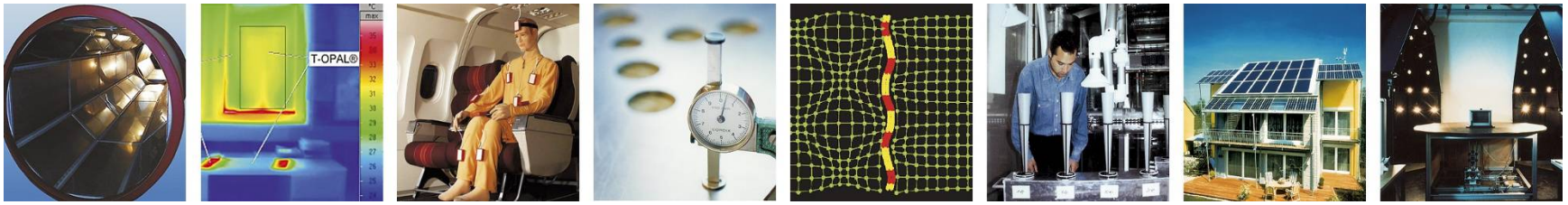
11th North American Passive House Conference (NAPHC) 2016 - Philadelphia

Auf Wissen bauen



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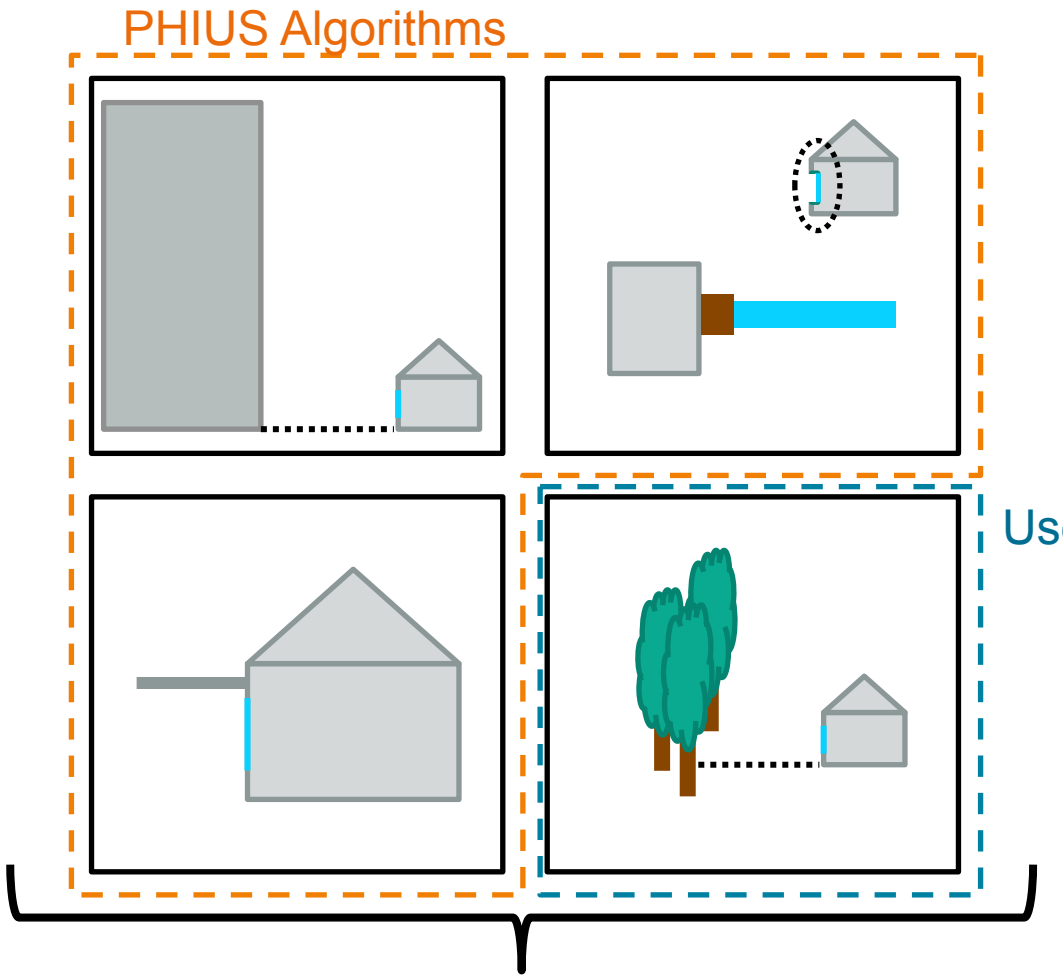
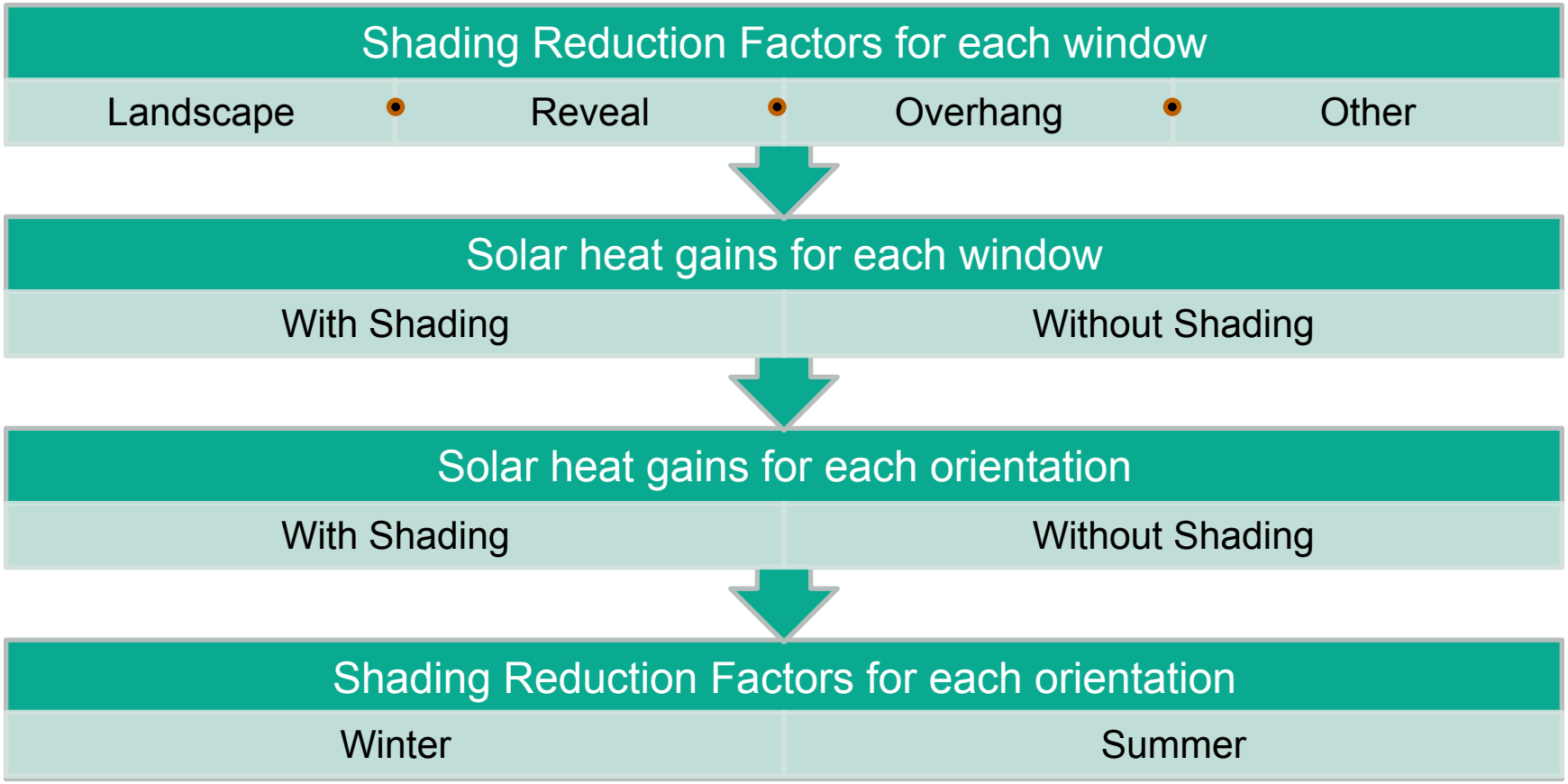
AGENDA

- The current PHIUS method
- Discussion/Application of the current method
- Test of the current method
- New method development
- Application to a real case
- Outlook and required next steps

Current PHIUS calculation method



Current PHIUS calculation method



Current PHIUS calculation method

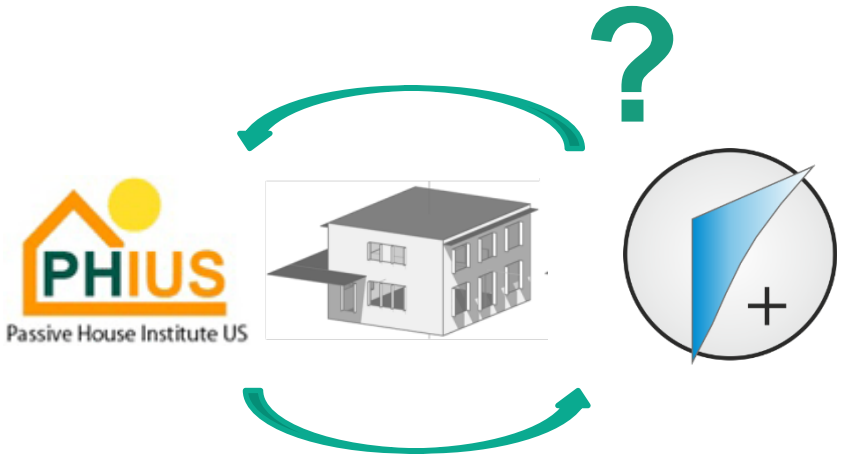
Shading Reduction Factors for each orientation	
Winter	Summer
Used for calculation of solar heat gains in: ▪ Heating demand ▪ Heating load	Used for calculation of solar heat gains in: ▪ Cooling demand ▪ Cooling load ▪ Overheating frequency

→ Shading reduction factors are of high importance for calculation of solar heat gains and passive house design

Test-Methodology

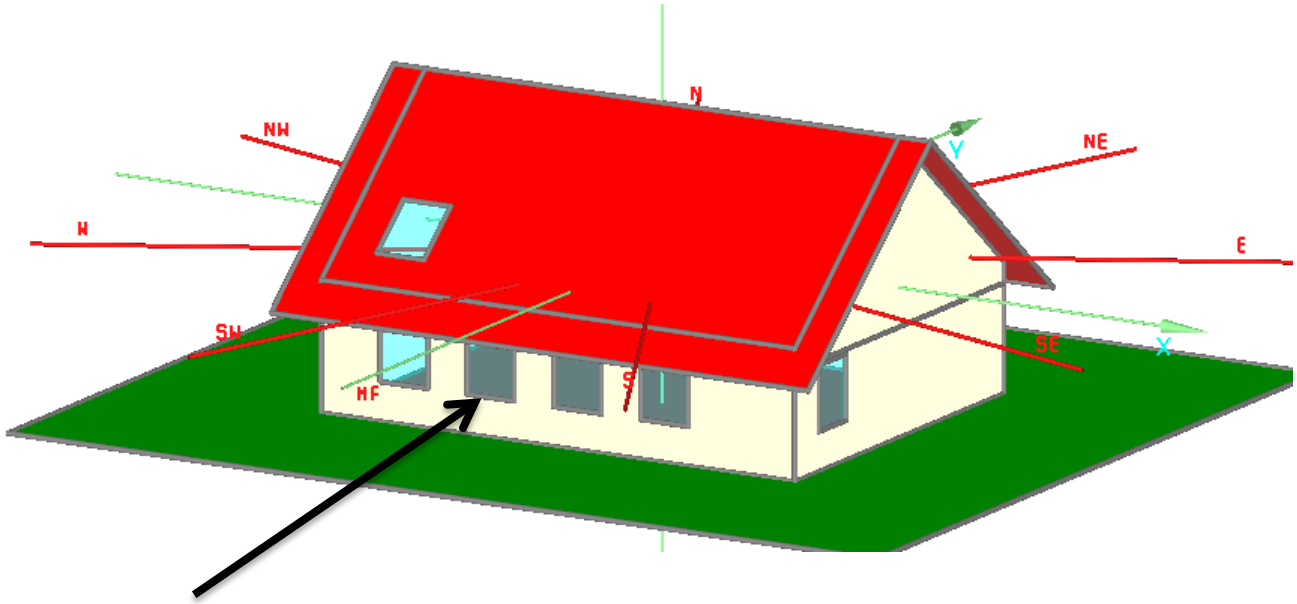
- Formulae for current PHIUS calculation method for shading were derived from dynamic building simulations, but no reference to their source available

- Testing their validity by cross-validation with results of dynamic building simulation software WUFI® Plus



Orientation and Inclination

Example: vertical windows facing south with roof overhang



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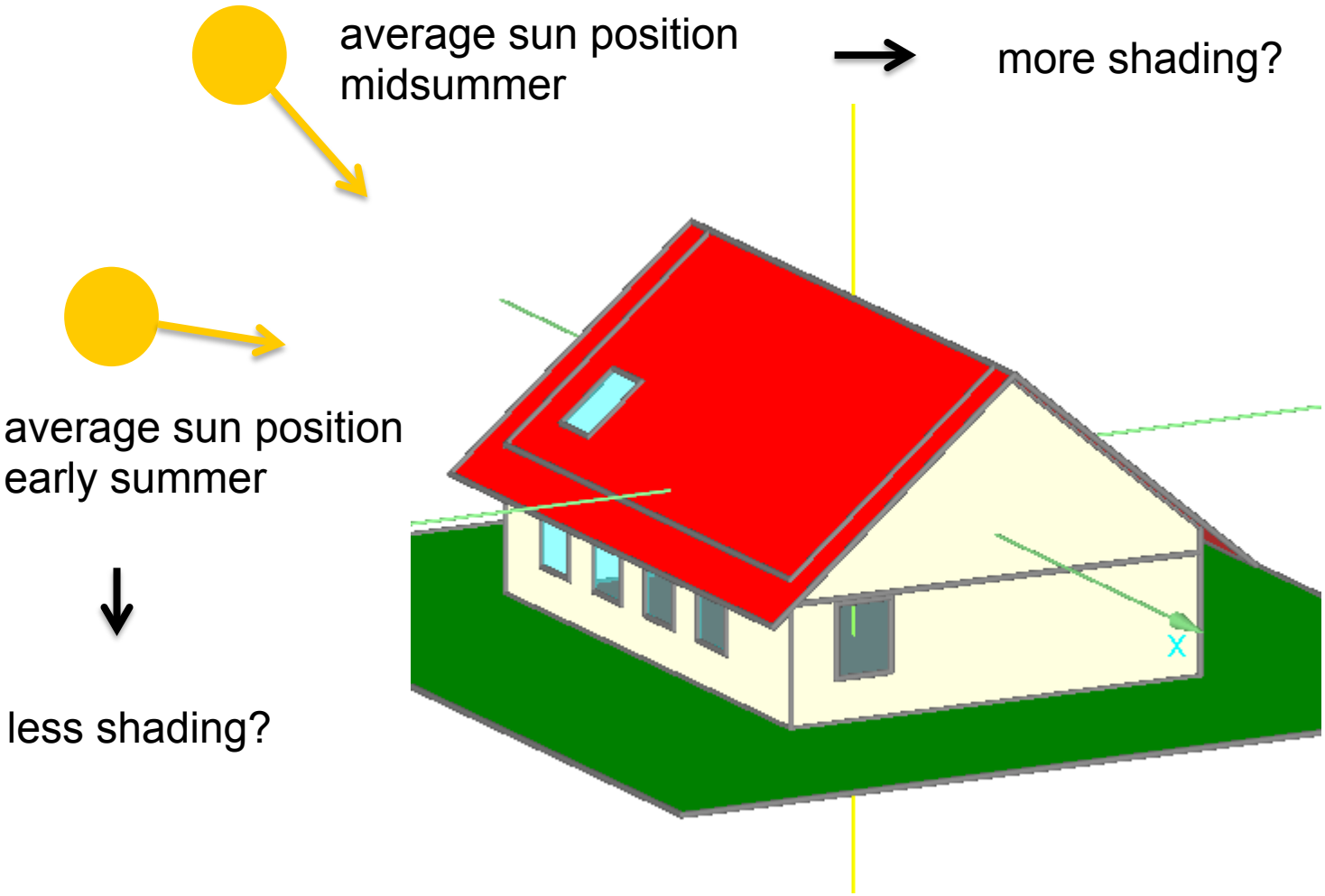

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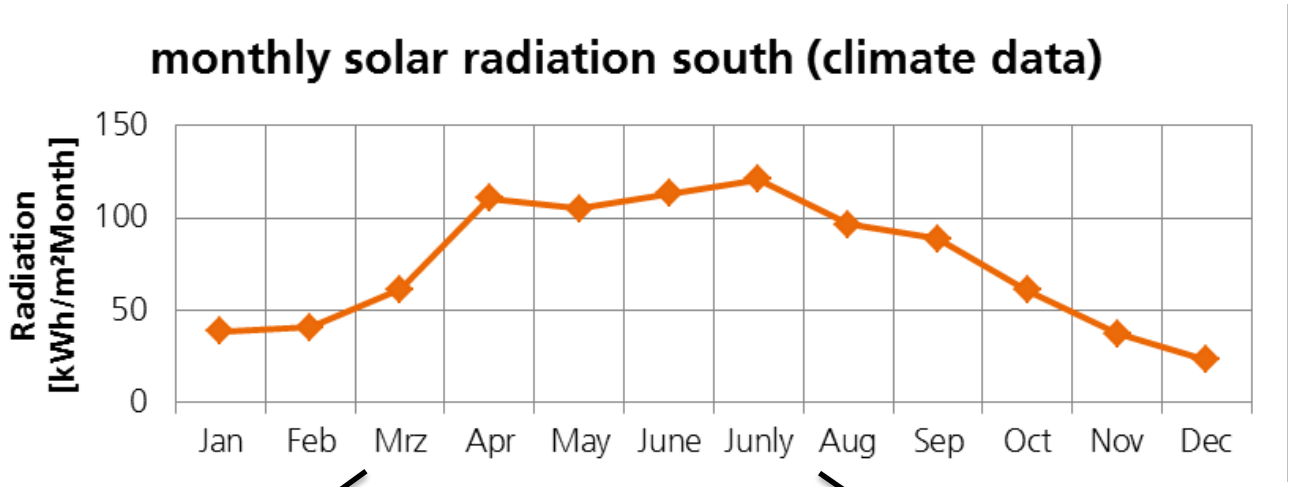

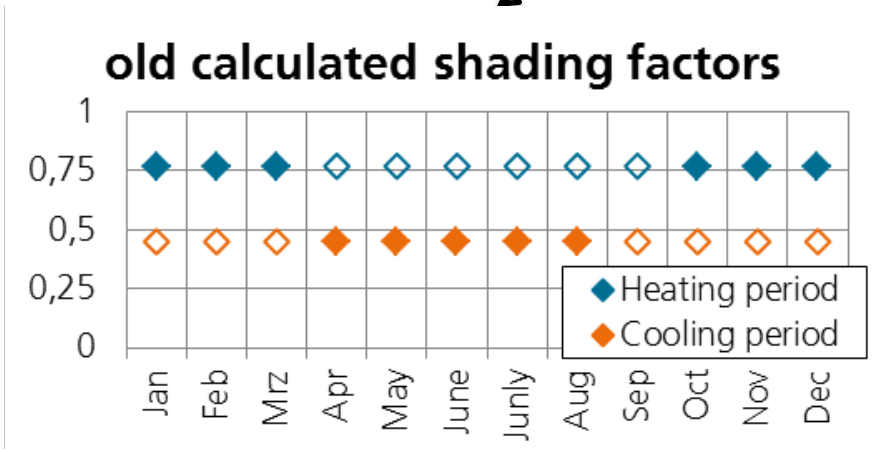

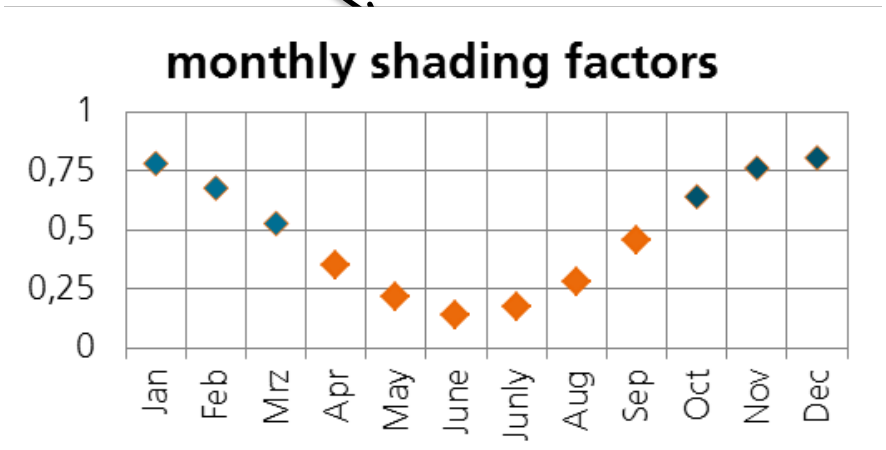

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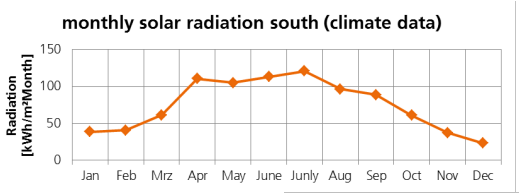
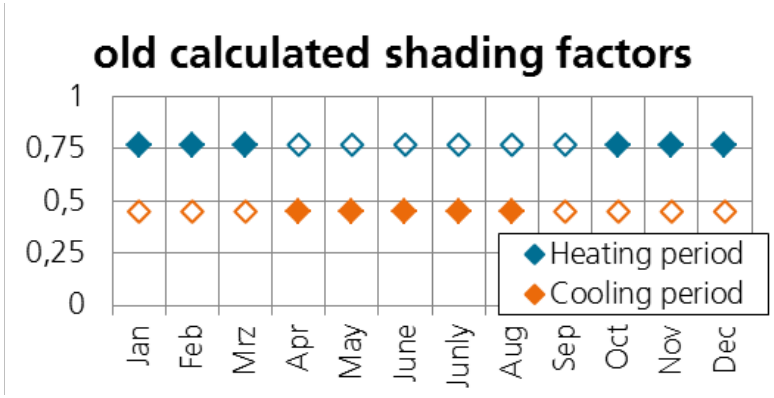
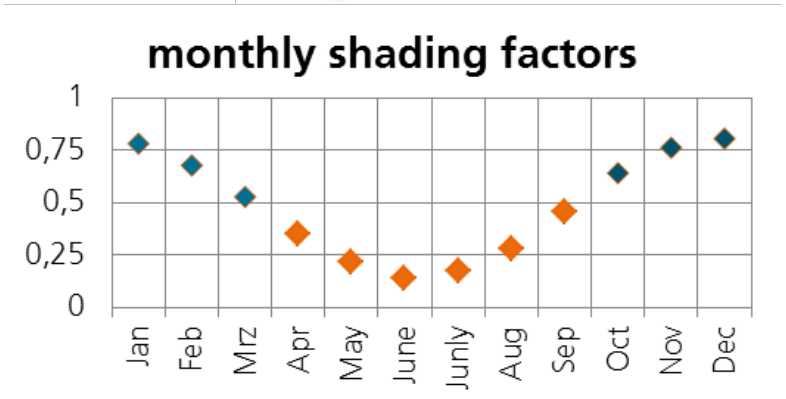
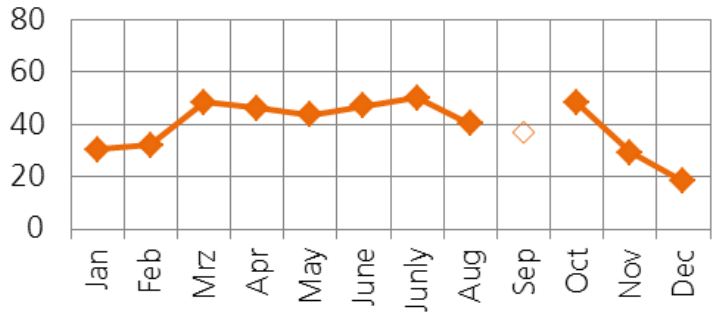
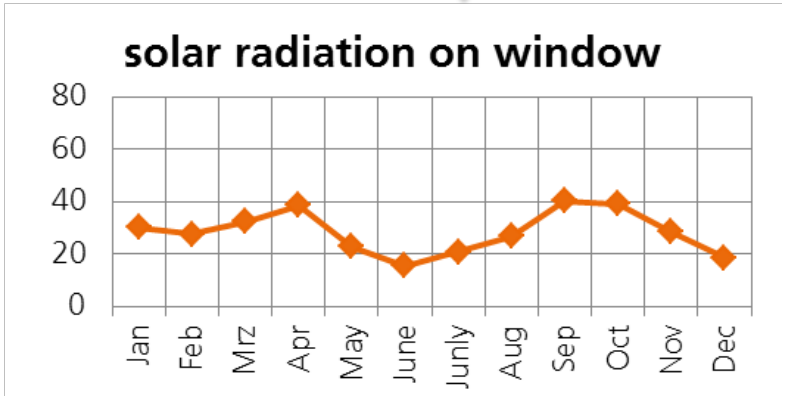
Orientation and Inclination











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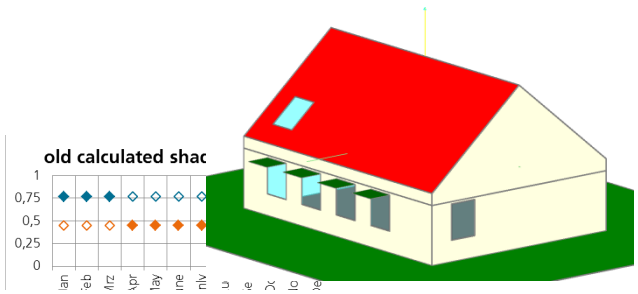
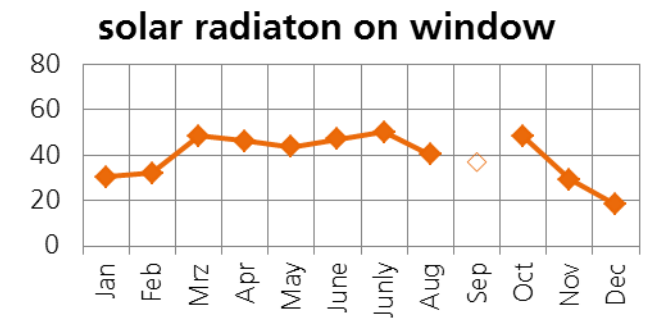
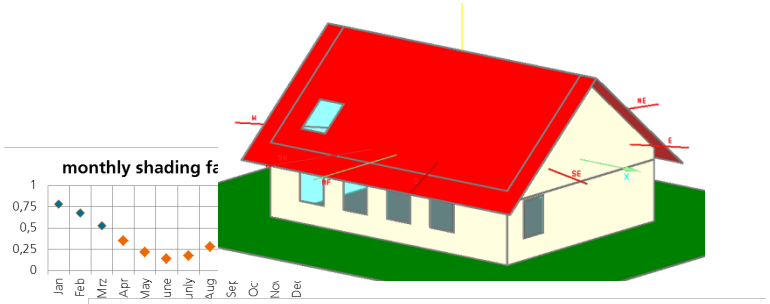
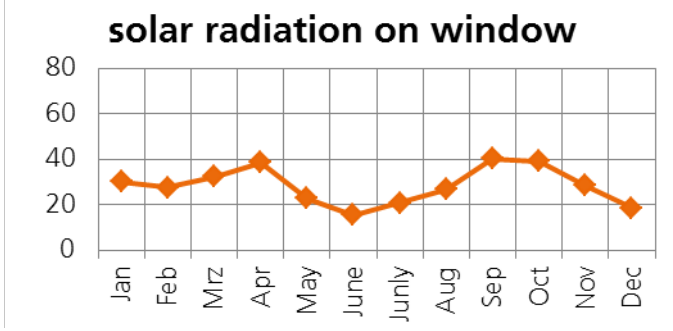
Orientation and Inclination





- „averaged“ solar radiation
- to high radiation in midsummer?





- „detailed“ shading for each month
- higher radiation in early summer
- quite lower radiation in midsummer

Different cooling demand?

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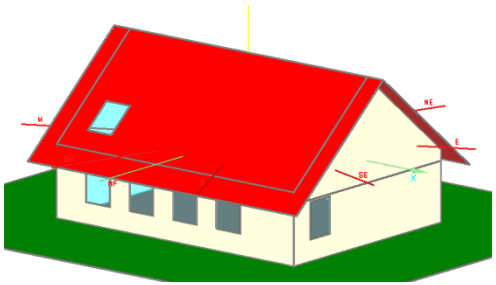
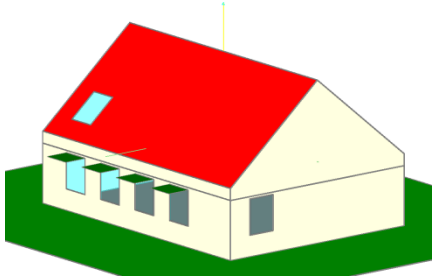
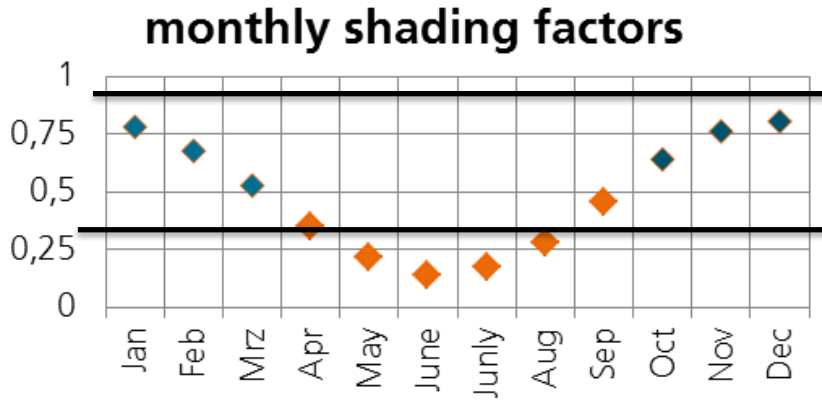
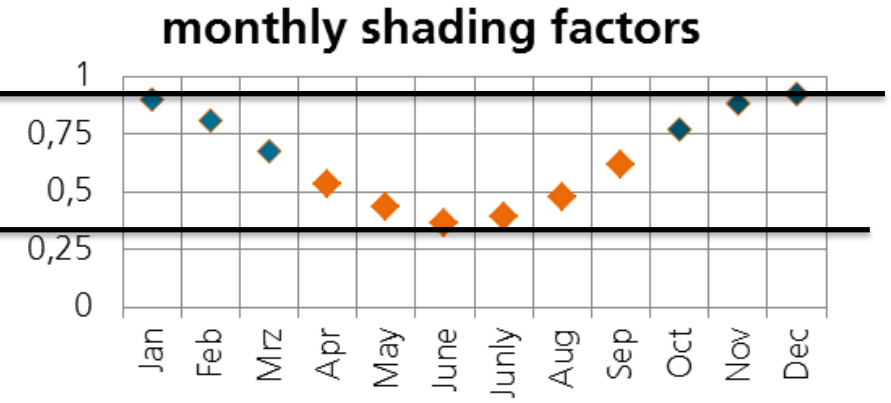
Orientation and Inclination





influence roof overhang - with monthly shading factors





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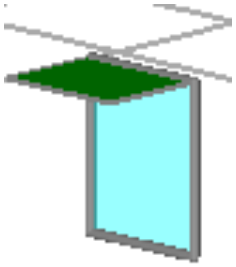
Orientation and Inclination

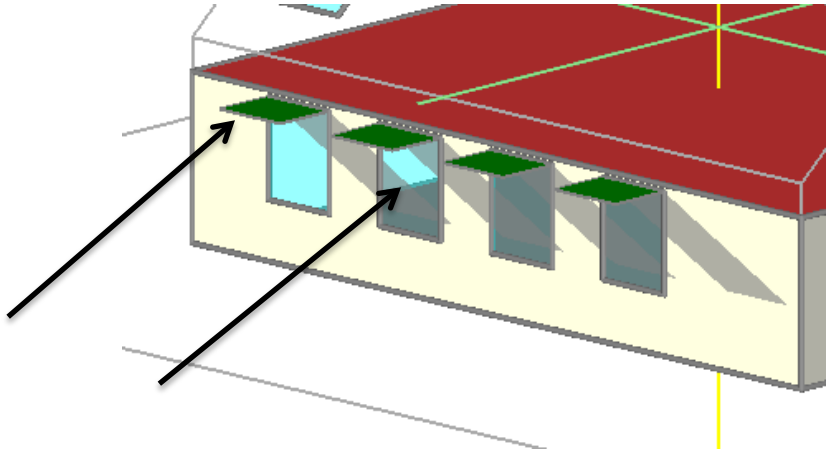
Current Method

→ not regarding the interaction of different shading components



Detailed 3D shading

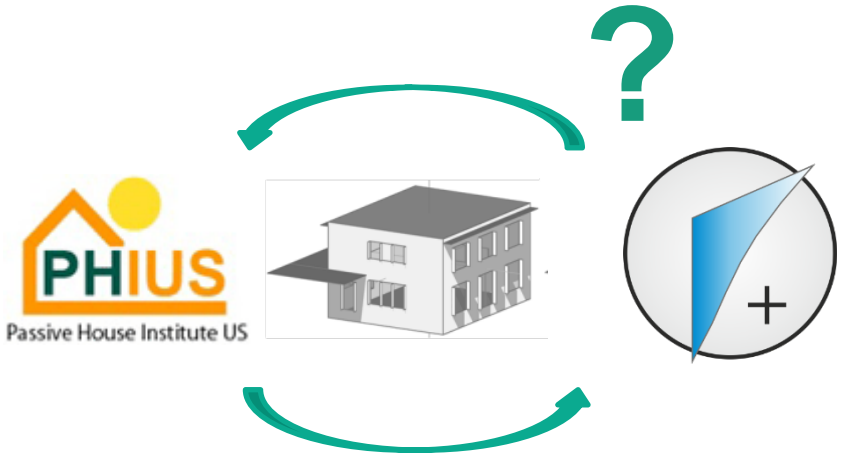
→ Takes into account all shading interactions



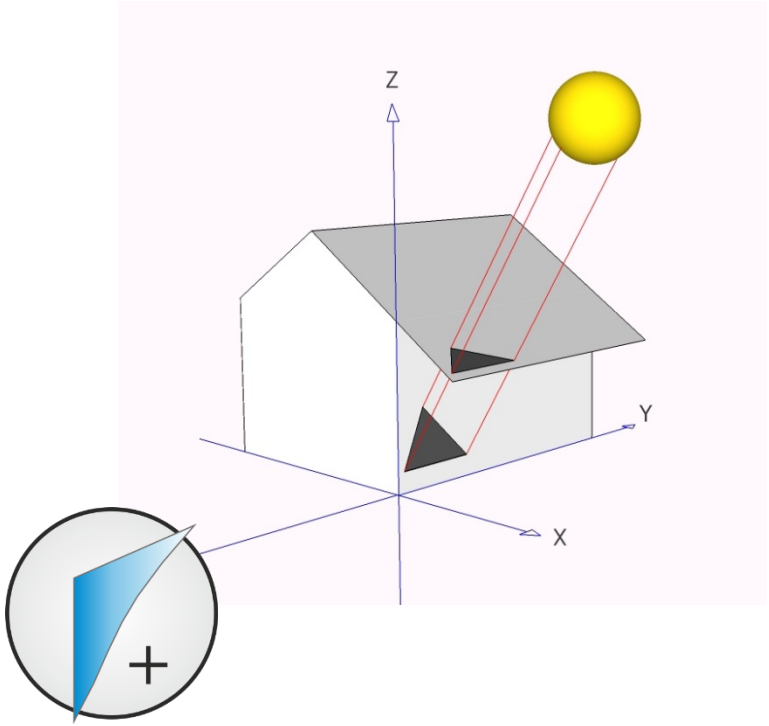
Why did we question this methodology?

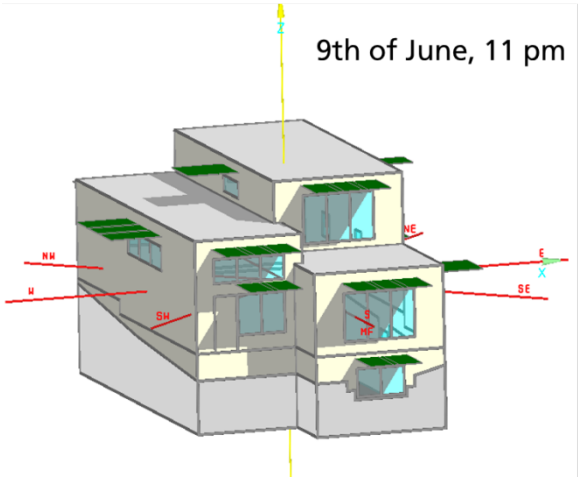
- Huge impact on final results
- No scientifically sound methodology development
- No verification of applicability and accuracy
- Indicators of problems

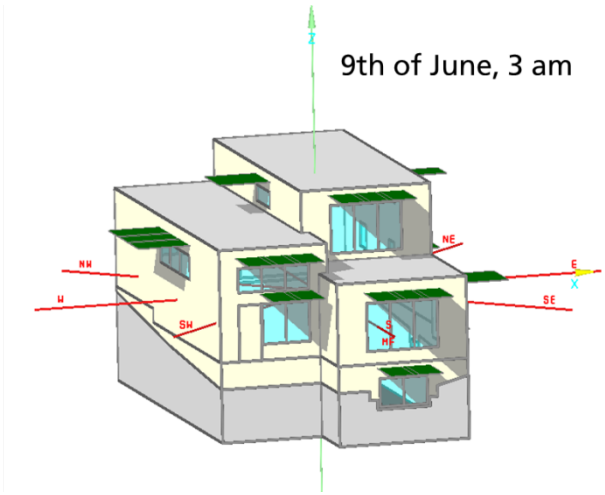
→ Cross-validation with dynamic building simulation software WUFI® Plus



Dynamic building simulation with WUFI® Plus







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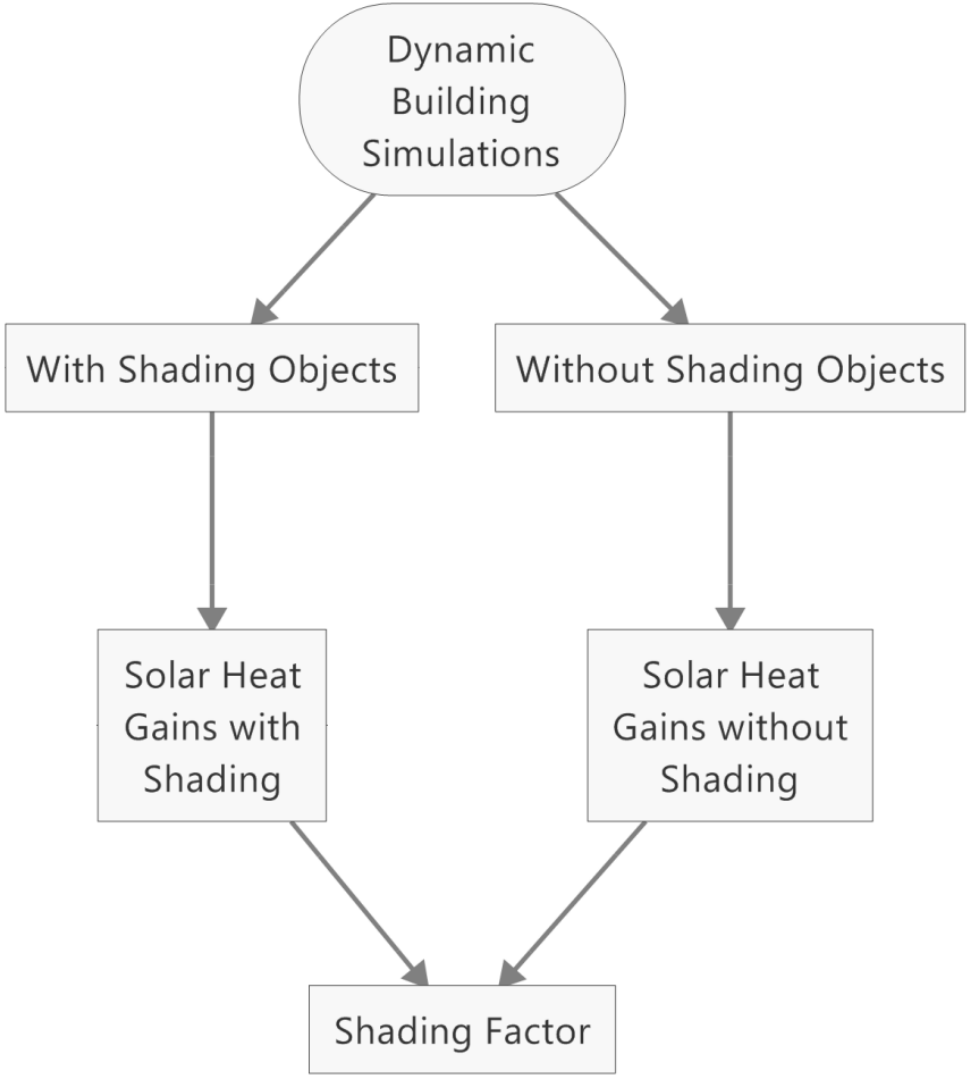
Test-Methodology

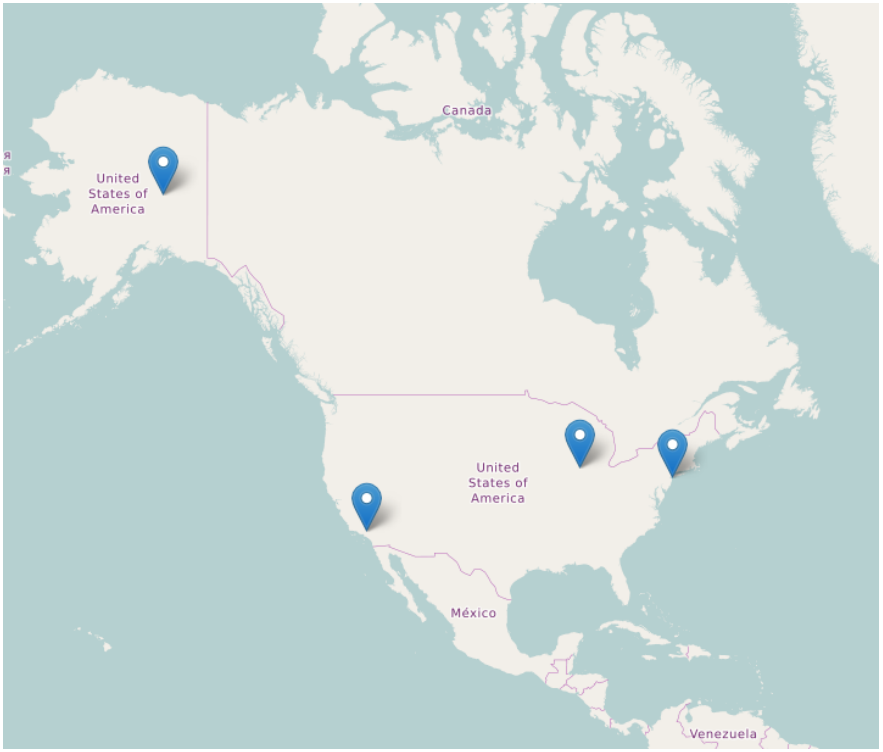
- Following the same methodology as in static mode
- Compute Shading factor as the difference between shaded and unshaded case



Solar radiation data from Meteonrom

- Meteonorm climate data was used for the comparison
- Allows the creation of monthly and hourly data sets which represent the same radiation characteristics

- Tests were performed for various locations in the USA, including:
  - Chicago (IL)
  - Fairbanks (AK)
  - Los Angeles (CA)
  - New York City (NY)

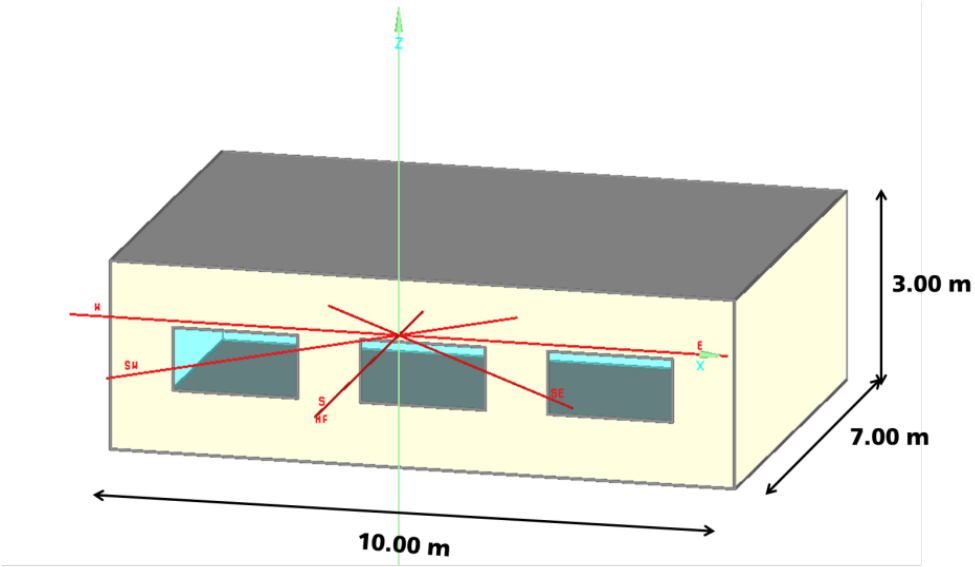


© OpenStreetMap

Test-Methodology: Example building

Four typical shading scenarios were tested using an exemplary building

- High rise object
- Reveals
- Adjacent Wall
- Window Overhang



Central questions:

- Do the more granular simulations confirm the current PHIUS method‘s shading factors?
- Are there limitations in the current PHIUS method?

U_w	0.795 W/m²K
SHGC (direct + diffuse)	0.510
Frame Factor	0.658
Orientation	South

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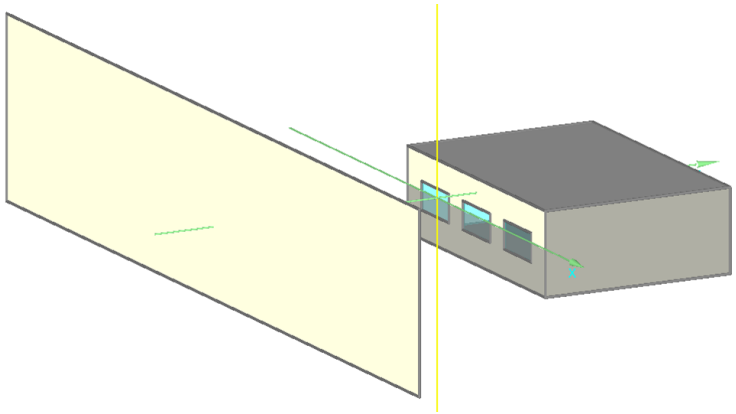
Shading from a high-rise object

- Mostly for summer good accordance of shading factors
- For winter the solar heat gains are underestimated slightly in the current PHIUS method
- Highest deviations between both methods in most northern location „Fairbanks“

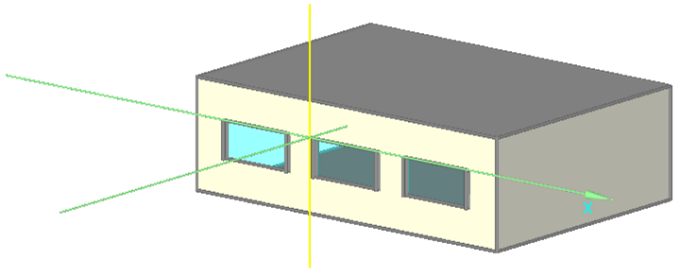


Height of landscape obstruction	6.00 m
Distance of landscape obstruction	10.00 m

Shading from window reveals

- Good accordance for typical reveal geometries of 0.10 m

- At large reveal depths of 1.00 m the solar heat gains are underestimated in the current PHIUS method

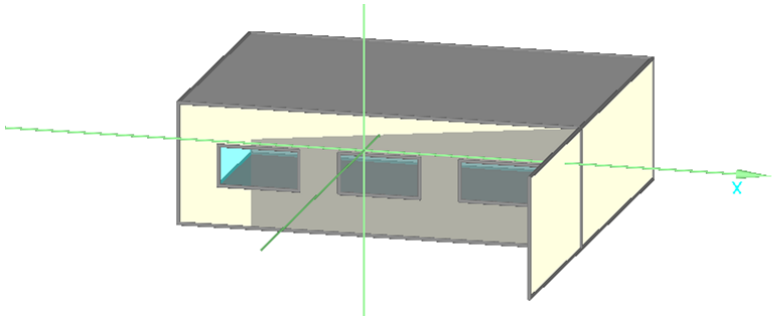


Reveal depth	0.10 m
Distance from daylight opening	0.05 m

Shading from an adjacent wall

- The PHIUS algorithms for window reveals can also be applied to calculate shading from adjacent walls
- High deviations between both methods. PHIUS method underestimates solar heat gains greatly
- Deviations increase with distance from adjacent wall

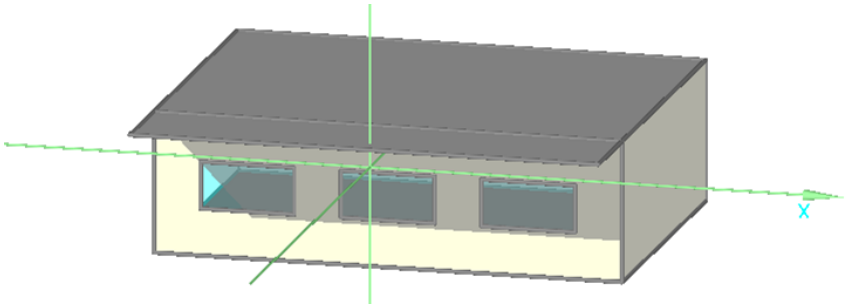
→ The current PHIUS method cannot be considered as correct!



Wall length	5.00 m
Distance from windows	1.00 m / 4.00 m / 7.00 m

Shading from a window overhang

- The PHIUS method calculates up to 23% higher solar heat gains for winter and
- Up to 41% lower heat gains for summer
- The PHIUS method calculates shading factors larger than 1.00 for latitudes of 64.3° or more northern

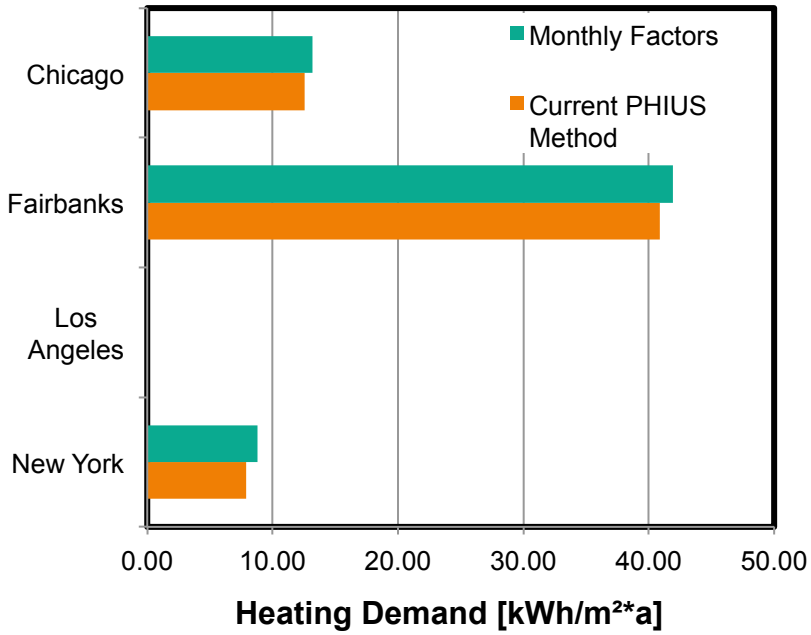


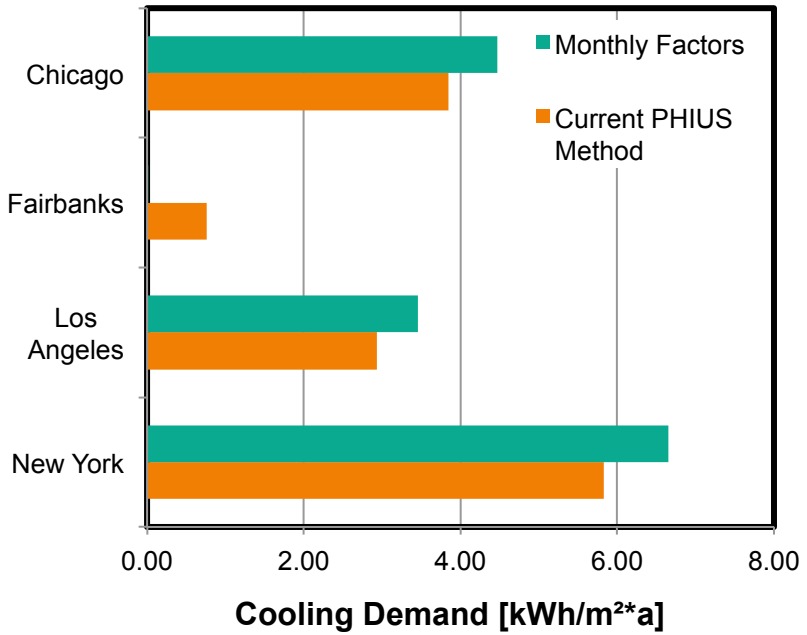
→ The current PHIUS method cannot be considered as correct!

Overhang depth	2.00 m
Distance from daylight opening	1.00 m

Implications on energy demand

Test case: Shading from a window overhang





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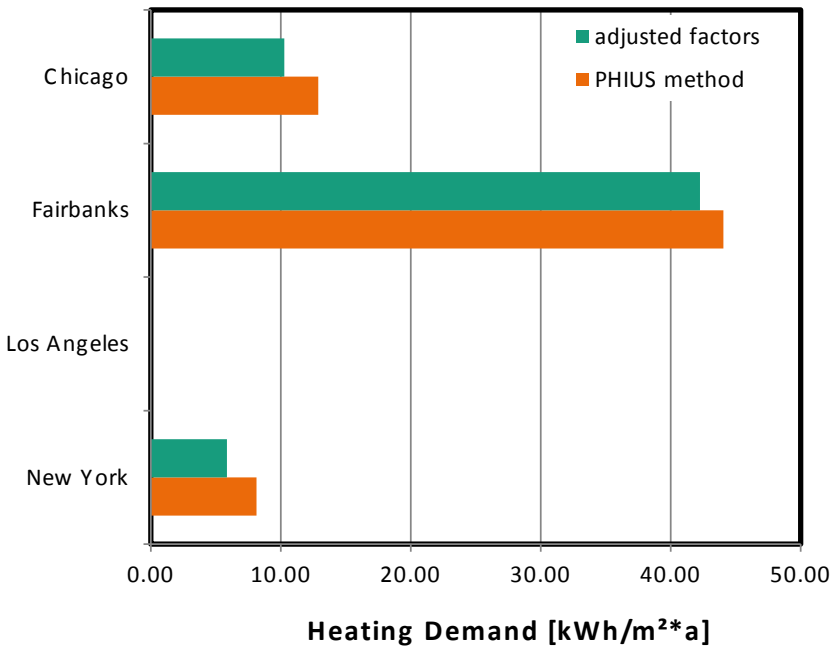
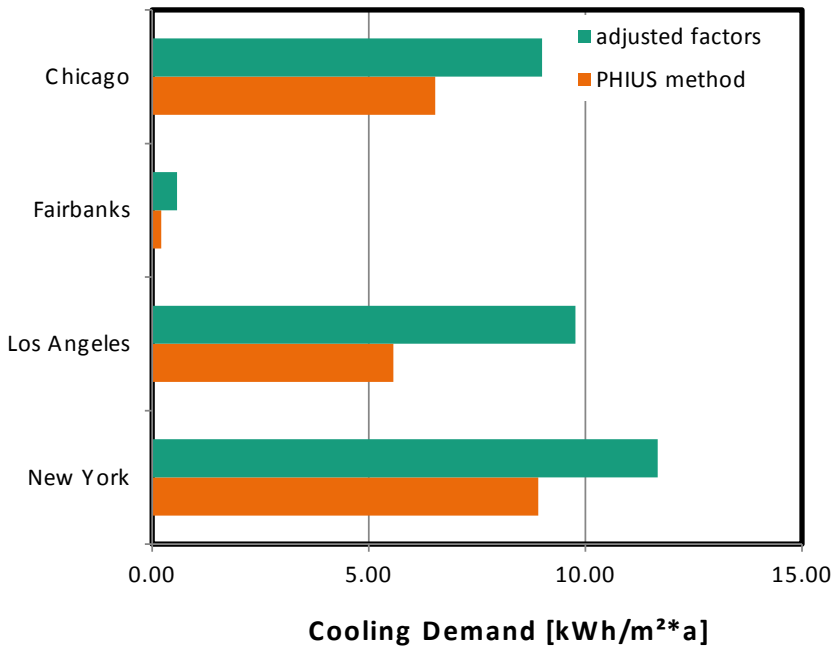
Implications on energy demand

Test case: Shading from an adjacent wall





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Conclusion from tests

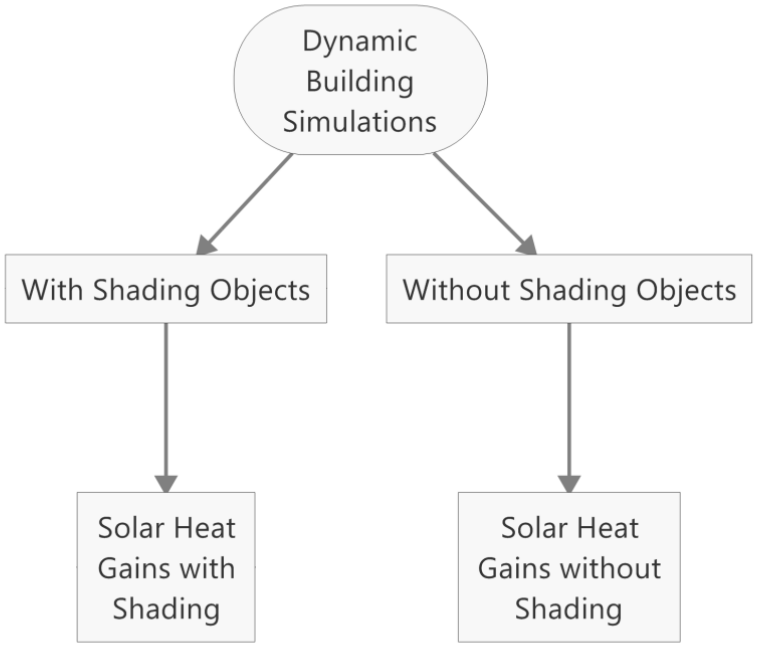
- Current algorithms for static shading calculation can give erroneous & unreliable results
- Not all shading scenarios are included

→ Room for improvement of the current PHIUS method

→ Replacement of current PHIUS method with new and more generally usable method

Proposed new methods

New methods were developed which combine results of dynamic building simulations with the current PHIUS method

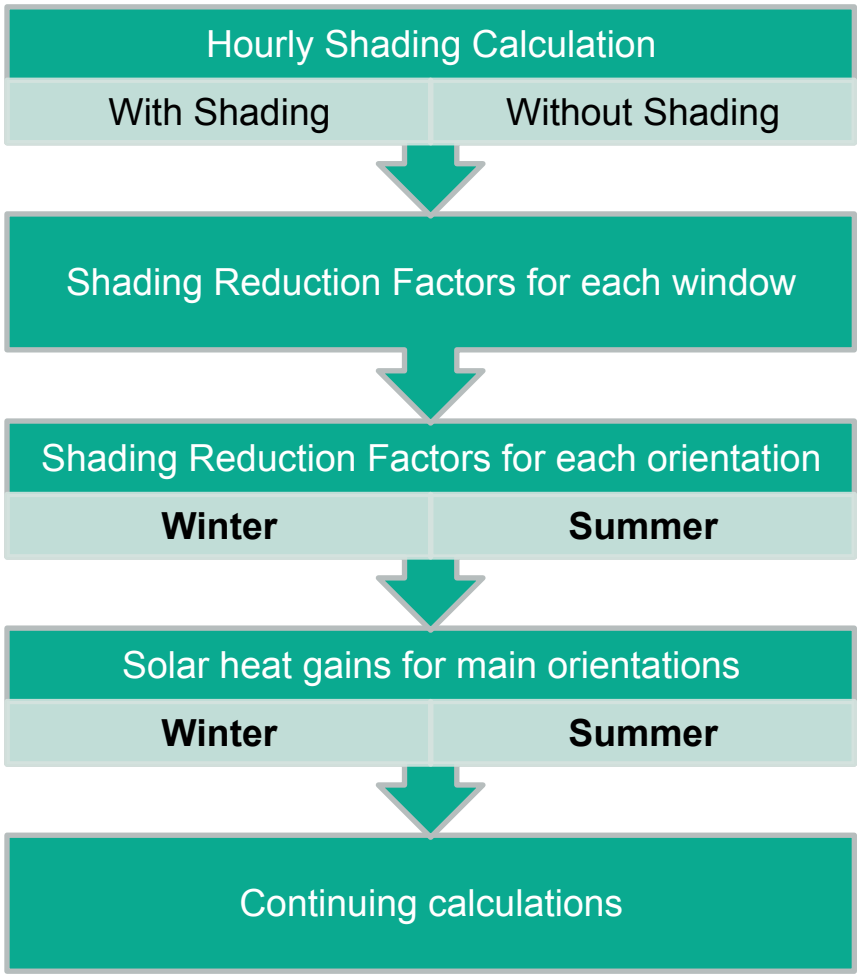


+ More flexible
+ More accurate
+ More realistic results
− Increased calculation time

Proposed new methods

Method 1:

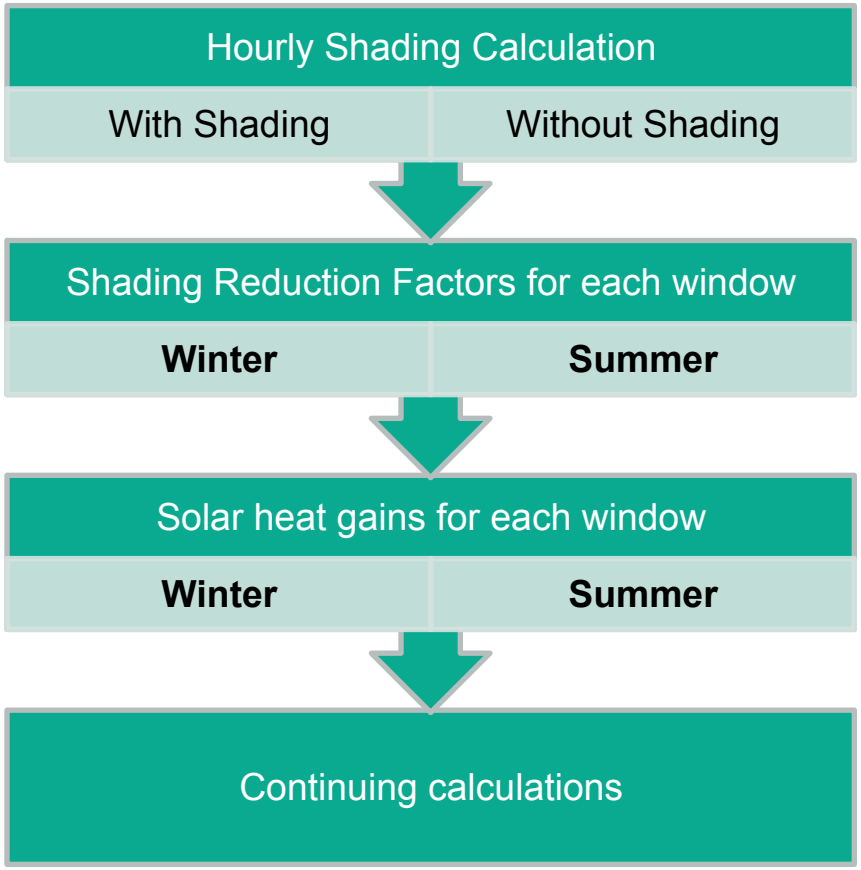
- Replacement of current PHIUS algorithms with results of dynamic building simulations
- Seasonal shading reduction factors from winter- and summer-half-year for each orientation
- All further calculations remain untouched



Proposed new methods

Method 2:

- Replacement of current PHIUS algorithms with results of dynamic building simulations
- Seasonal shading reduction factors from winter- and summer-half-year
- Individual shading reduction factors for each window
- All further calculations remain untouched

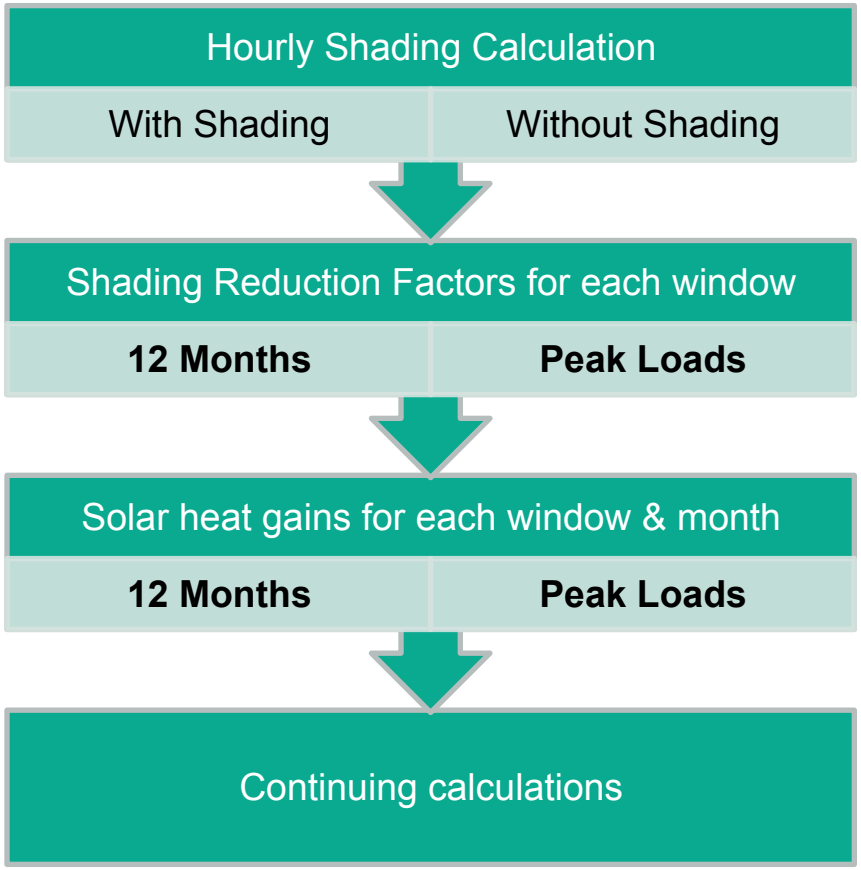


Proposed new methods

Method 3:

- Replacement of current PHIUS algorithms with results of dynamic building simulations
- Individual shading reduction factors for each window
- Individual shading reduction factors for each month and peak load calculation

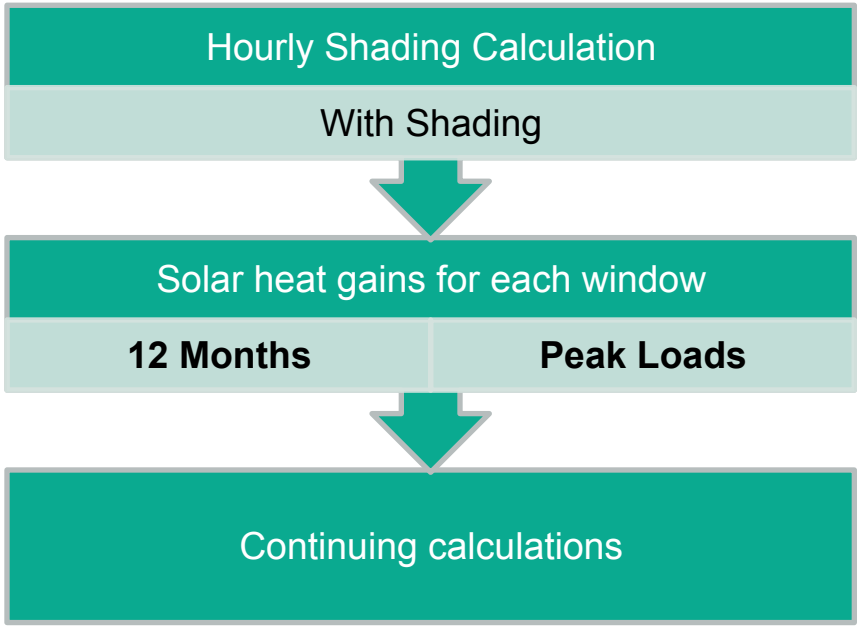
- All further calculations remain untouched



Proposed new methods

Method 4:

- Complete replacement of solar heat gain calculations with results of dynamic simulations
- All further calculations use the solar heat gains calculated with dynamic simulations

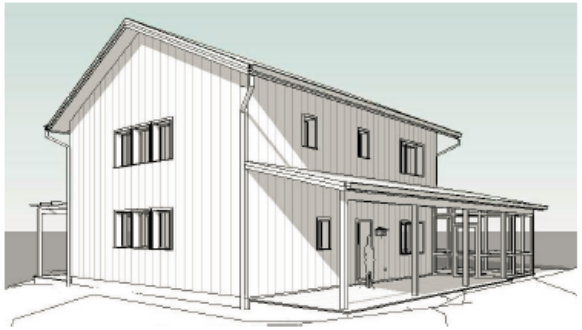


Proposed new method

Method 1	Method 2	Method 3	Method 4
Simple integration in current PHIUS method	Window specifc solar heat gains	More realistic results than proposed methods 1 & 2	Most accurate results
Carries on existing disadvantages of current PHIUS method	Dependence on fixed Winter/ Summer periods	Independent of fixed Winter/ Summer periods	Requires high-resolution climate data
Neglects existing results from simulations	Neglects existing results from simulations	Adjustments to current PHIUS method	Increased complexity for the user

Example Project: Application of the new method

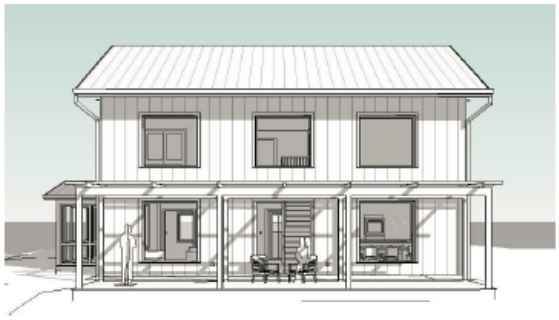
PHIUS Sample Project: Single Family Building



Exterior view from the northeast

Exterior view from the southwest

Exterior view from the northwest

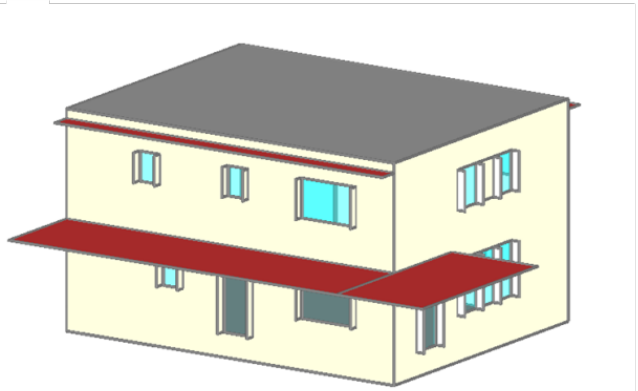


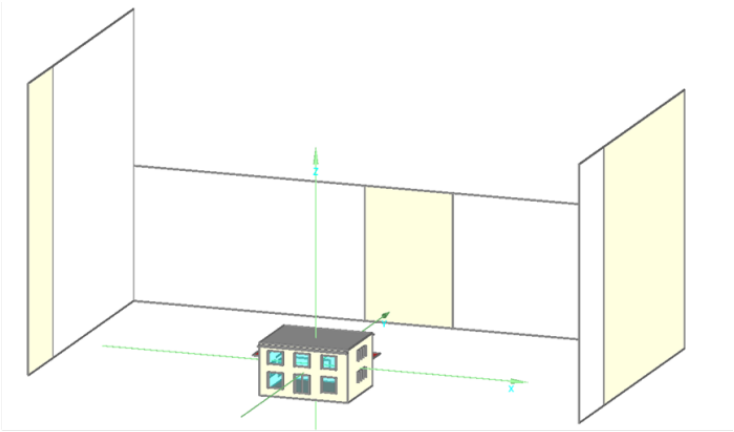
Exterior view from the southeast

Example Project: Adjustments

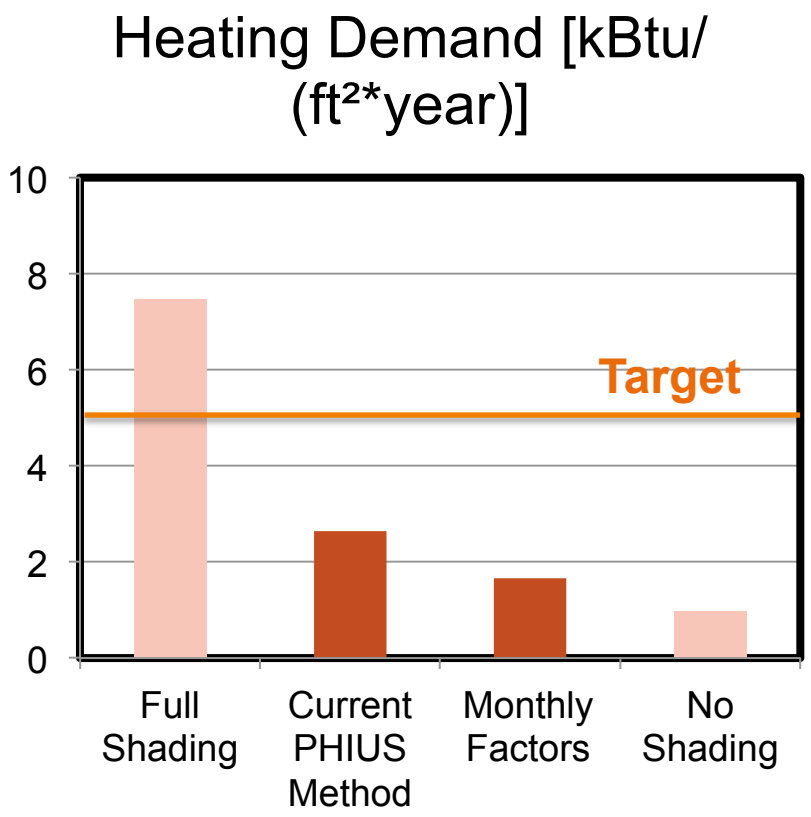
Adjustments to the original PHIUS model:

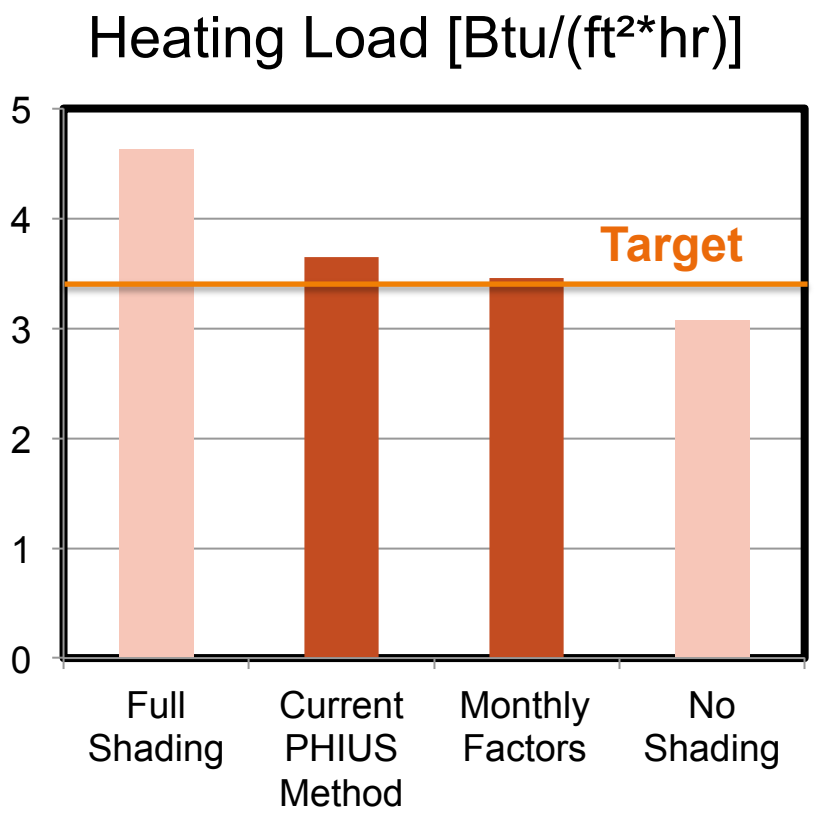
- Location was moved to New York City (LaGuardia)
- The window reveals were unified for the whole building
- The input for landscape obstructions was unified for each main orientation





Example Project: Results Heating





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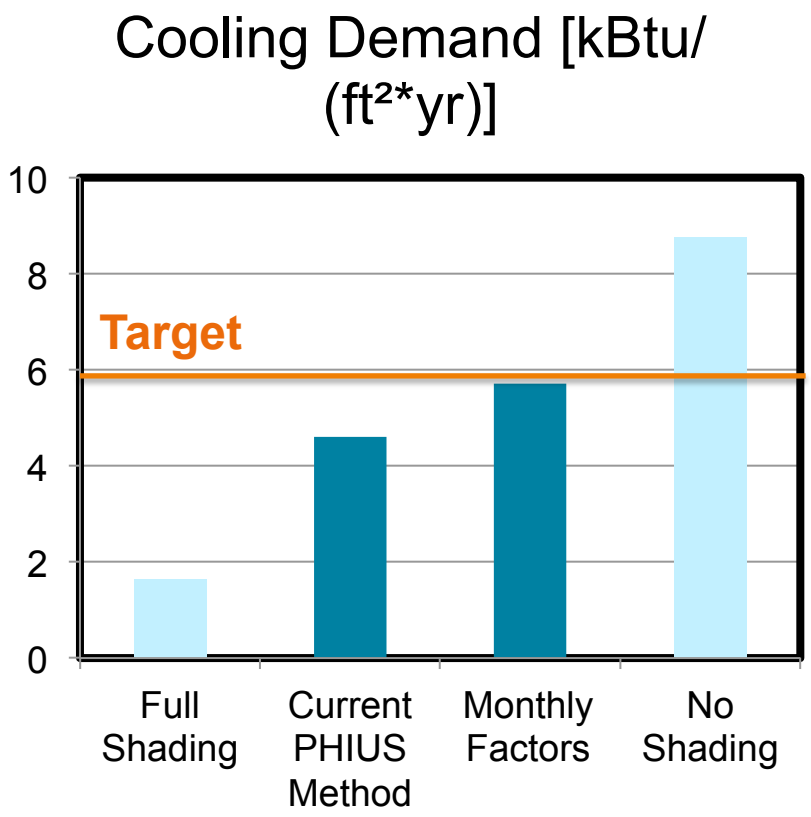
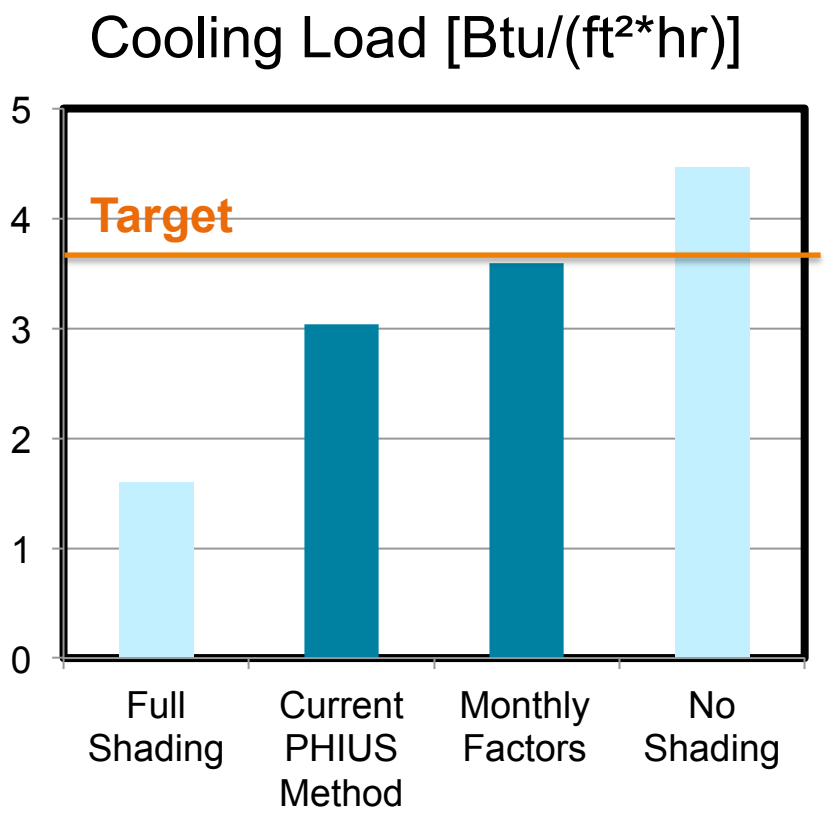
Example Project: Results Cooling





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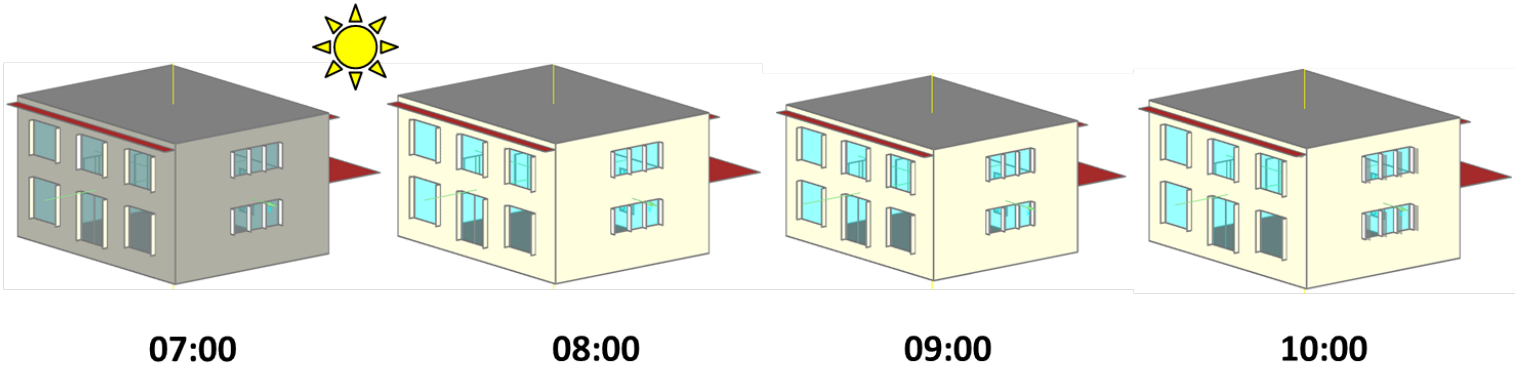
Example Project: Shading Factors

- Highest deviations for eastern & western windows with up to 2.5x higher solar heat gains predicted by dynamic simulations
- Current PHIUS method indicates high impact from landscape obstruction
- Simulations show only minor effect of landscape obstruction:
  - Shading occurs only in early or late parts of morning or evening hours with comparatively low incident solar radiation
  - Solar heat gains from diffuse radiation throughout the day

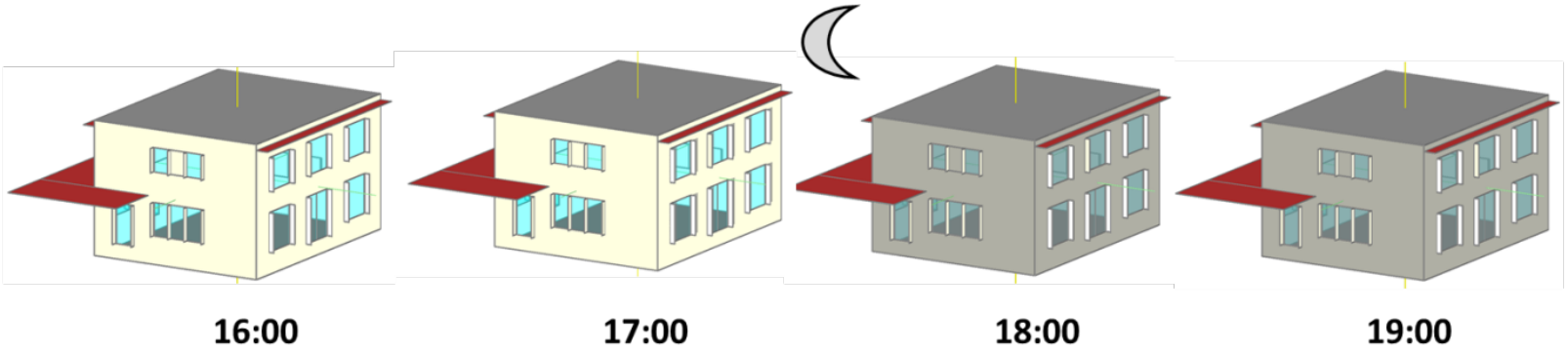
Example Project: Shading Factors

January, 8th:

East:



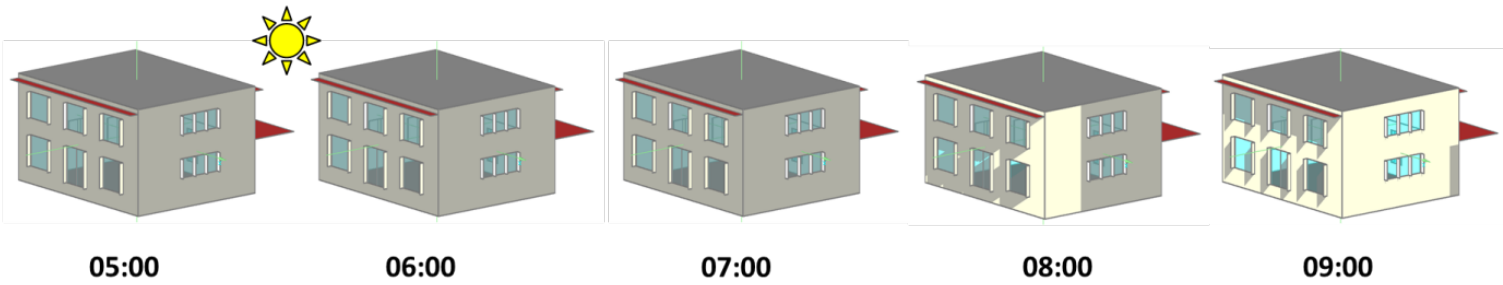
West:



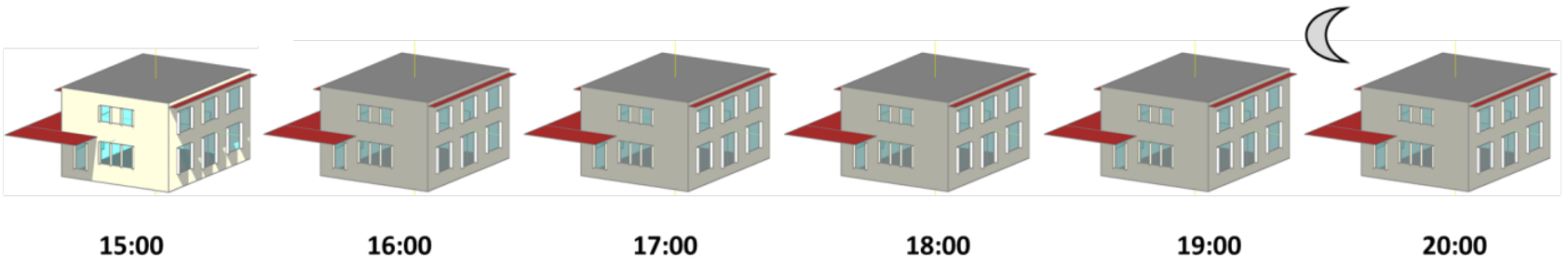
Example Project: Shading Factors

June, 2nd:

East:



West:



Example Project: Conclusion

- High impact of shading on building‘s energy performance & comfort conditions
- New method indicates increased solar heat gains

  → Reduced heating demand & increased cooling demand
- Direct influence on building design

  → Reduction of thermal insulation possible

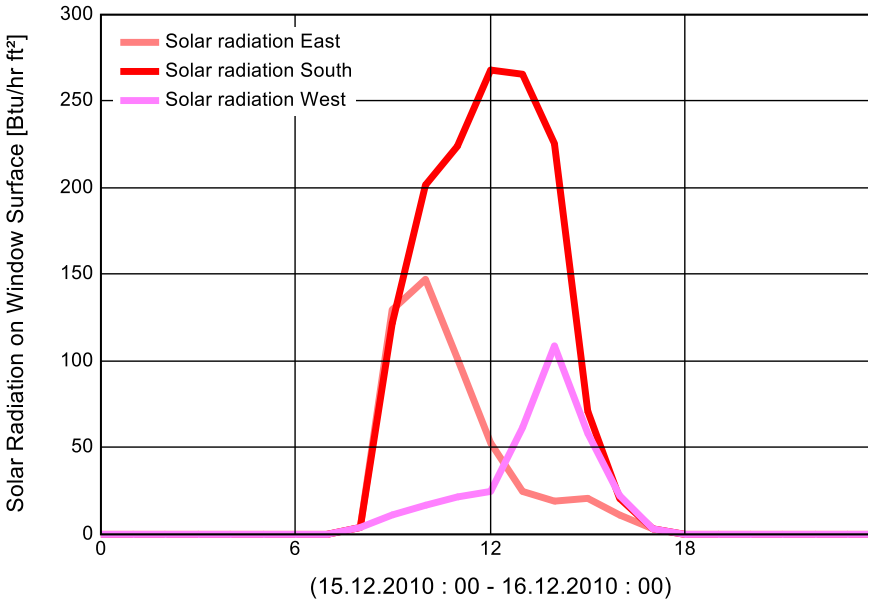
  → Additional shading measures necessary

→ Emphasis on shading in future passivehouse-design provides opportunities for higher cost-efficiency and comfort conditions

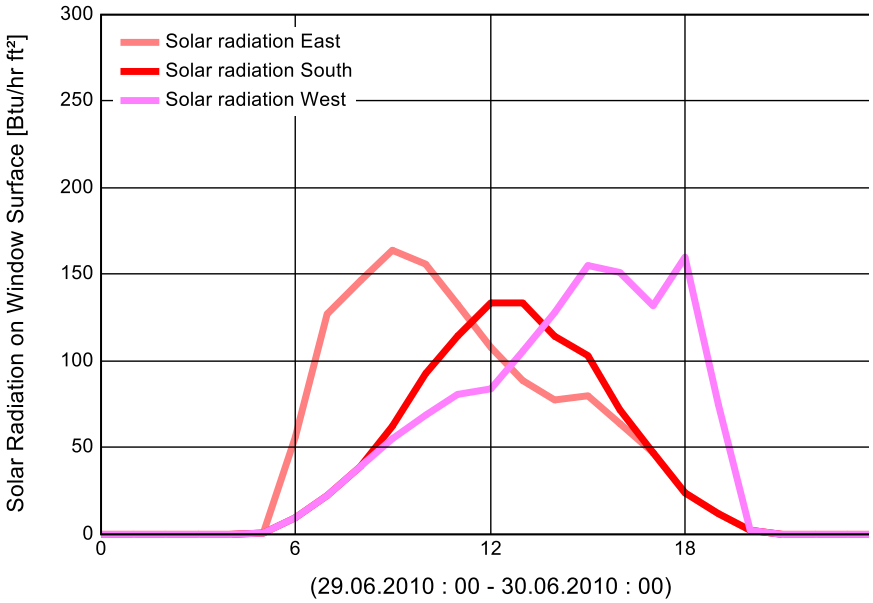
Outlook – Day Profile from Monthly Climate Data Set

- Determine Peak Day(s) (Peak Load Calculation, Overheating)
- Determine Average Day (Demand Calculation)

Winter



Summer



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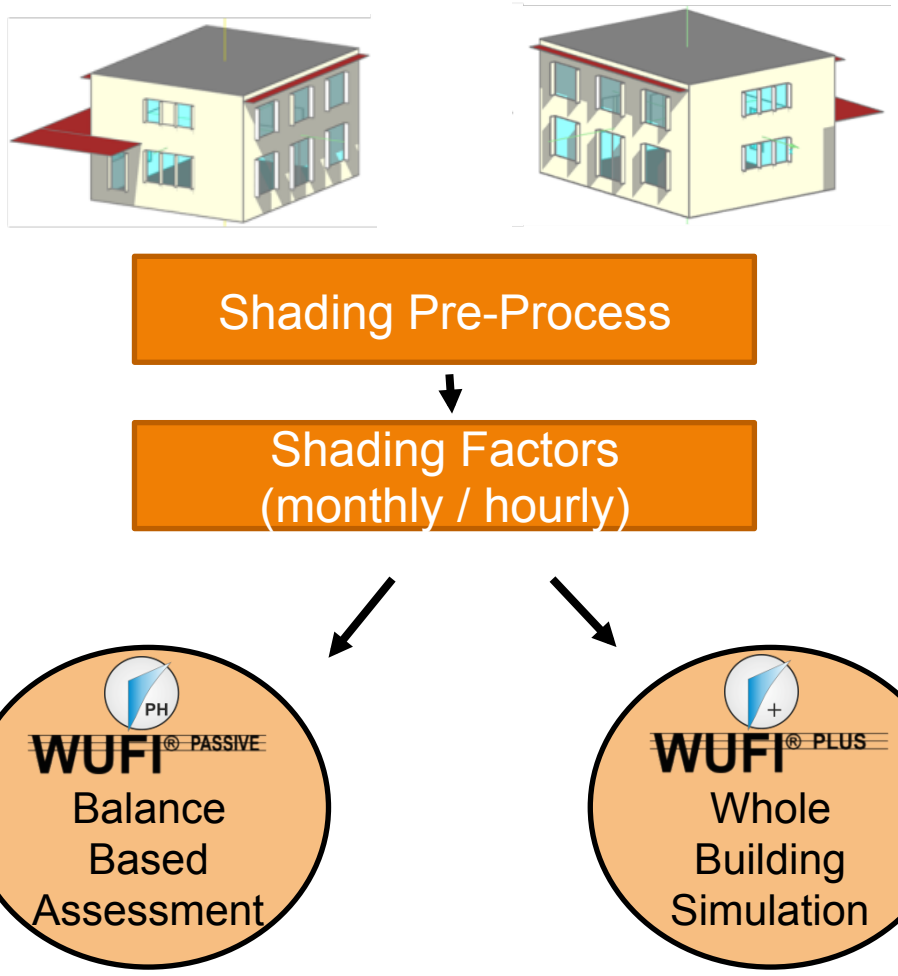
Outlook – Implementation in WUFI Passive



Outlook

- Current method uses two Meteonorm-datasets for solar radiation.
  - Further research to derive solar radiation profiles from existing monthly climate data to reduce complexity for the user
- Optimization of simulation performance to reduce calculation time
- Discussion & testing of the proposed method
- Implementation of new shading method into the WUFI® Passive software to verify compliance with the PHIUS+ standard

Shading Calculation for Passive House Certification – Discussion and Development of a New Method

11th North American Passive House Conference (NAPHC) 2016 - Philadelphia

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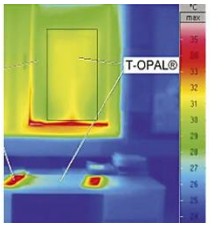
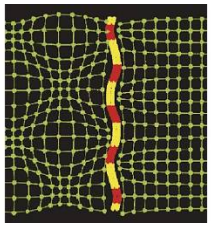
Auf Wissen bauen



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