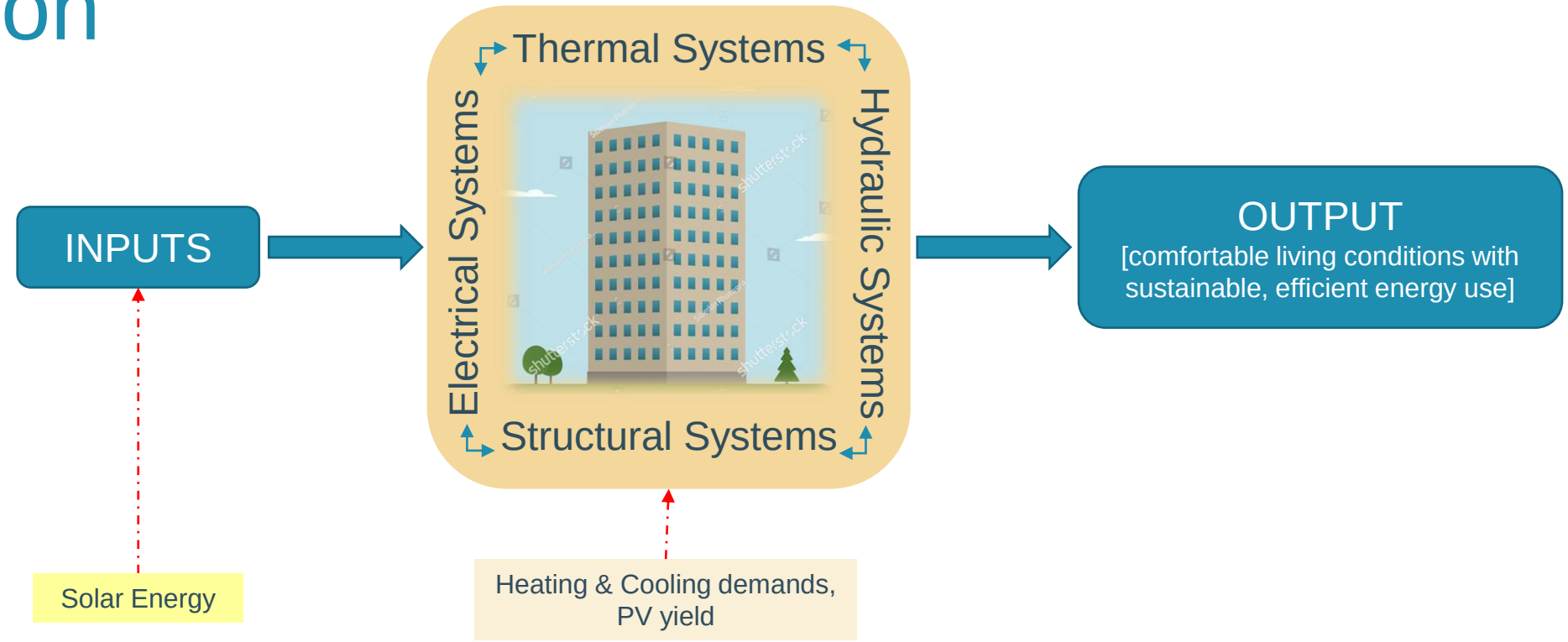
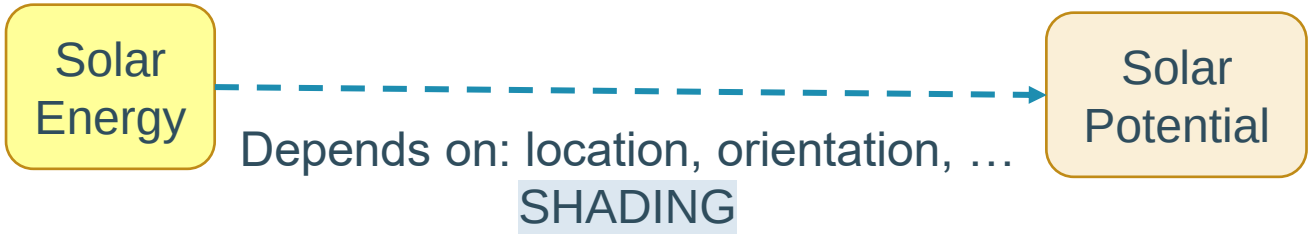
KU LEUVEN

The impact of shading on BIPV energy yield and building energy demand

Tamu Suttarwala

Introduction

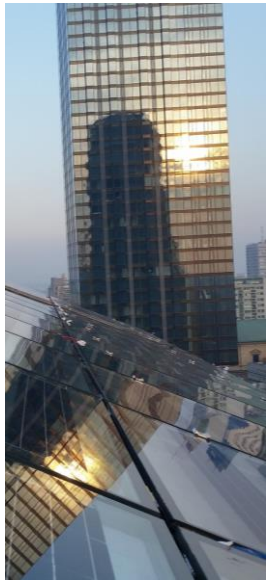




Objectives

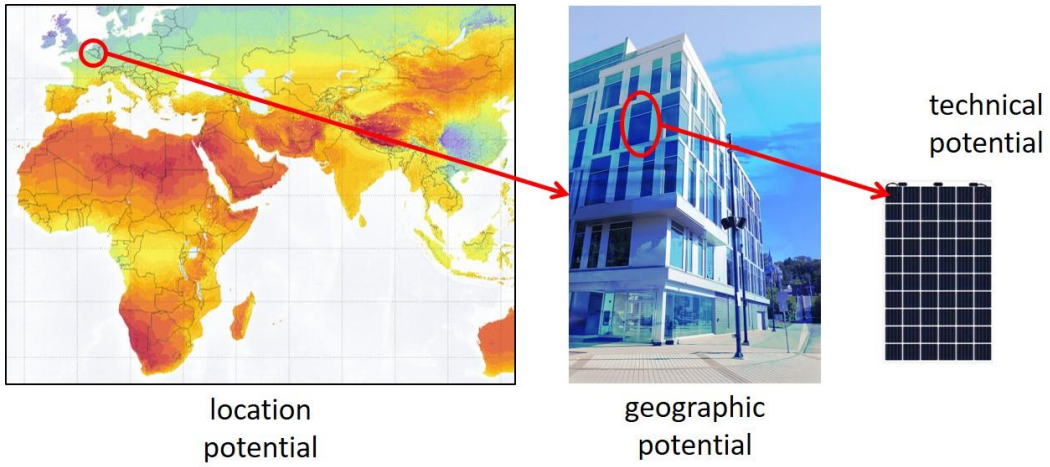
To provide a more detailed estimation of building energy demand

To identify locations with high BIPV potential for maximum yield



To predict shading impact on account of potential construction in the future

Literature study



On studies of shading in literature:

- Some algorithms too simple, some too complicated
- Smaller spatial resolution
- Either PV or BES at a time, not both

Research questions

1: What is the **effect of shading** by surrounding buildings on solar potential?

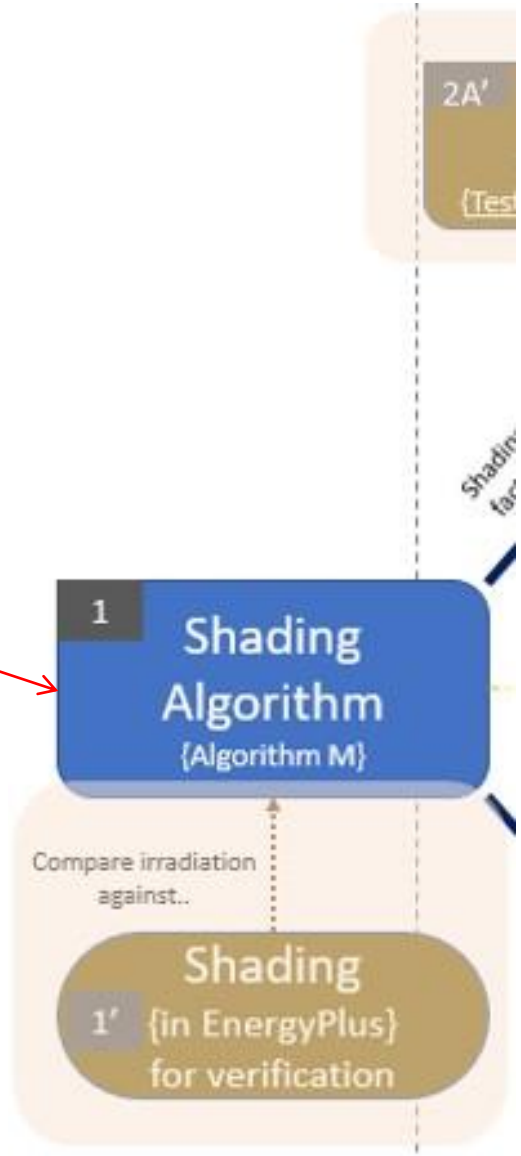
2: What is the **impact on building energy performance and BIPV output** as a result of shading?

3: How does **shading and its impact vary** with varying certain geometrical features of surrounding buildings?

Methodology

1: What is the **effect of shading** by surrounding buildings on solar potential?

2: What is the **impact on BE and BIPV output** as a result of shading?



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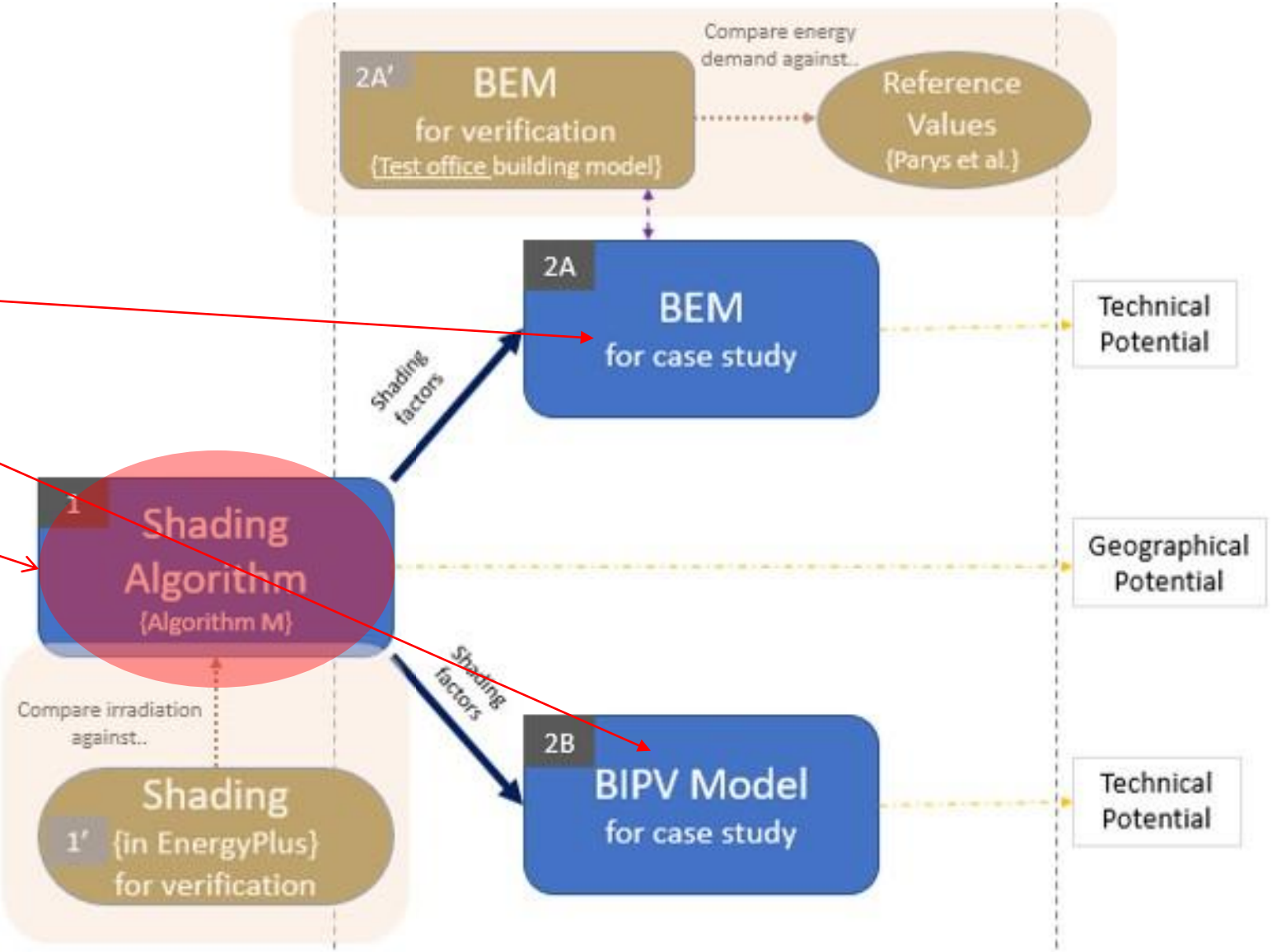
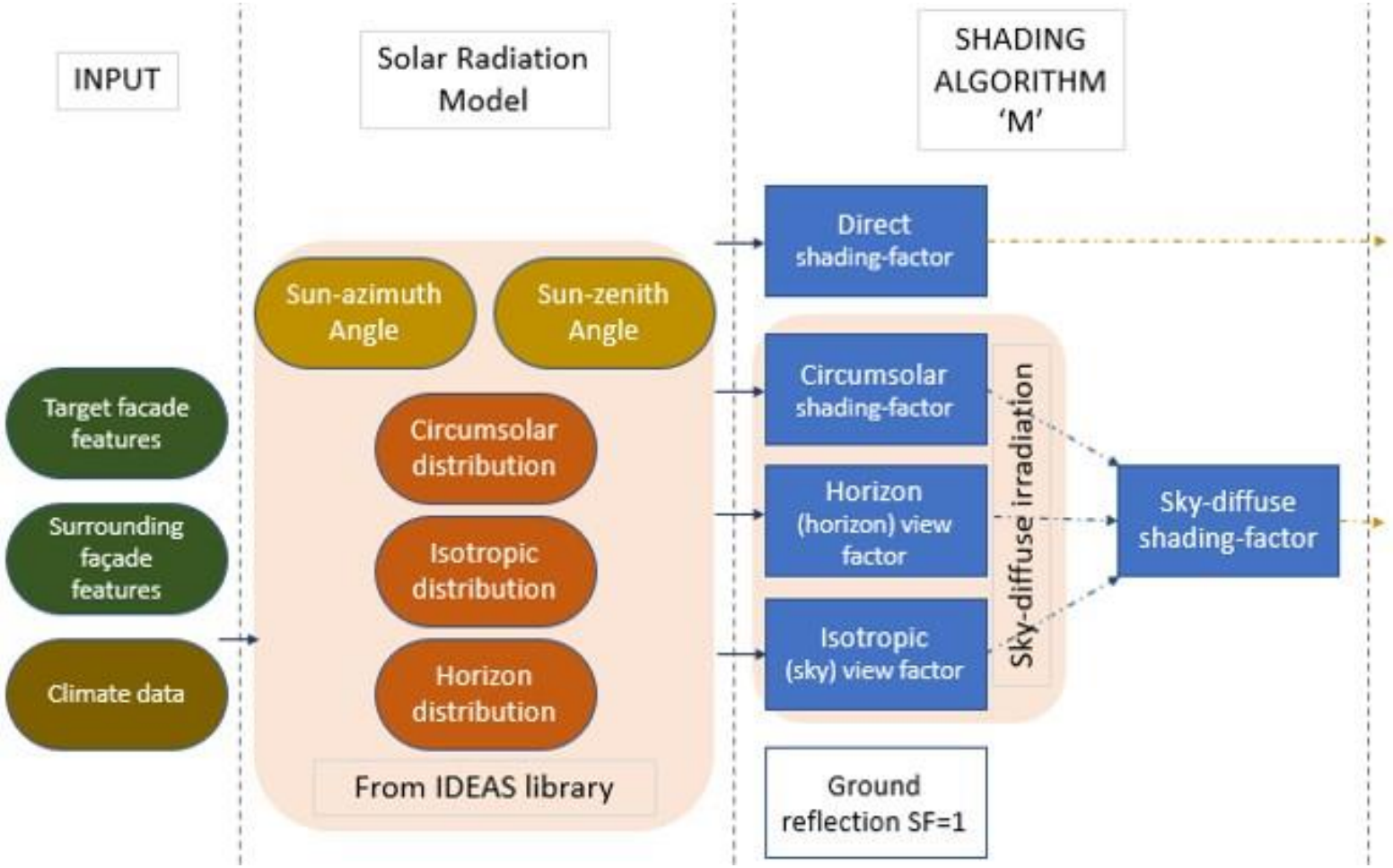
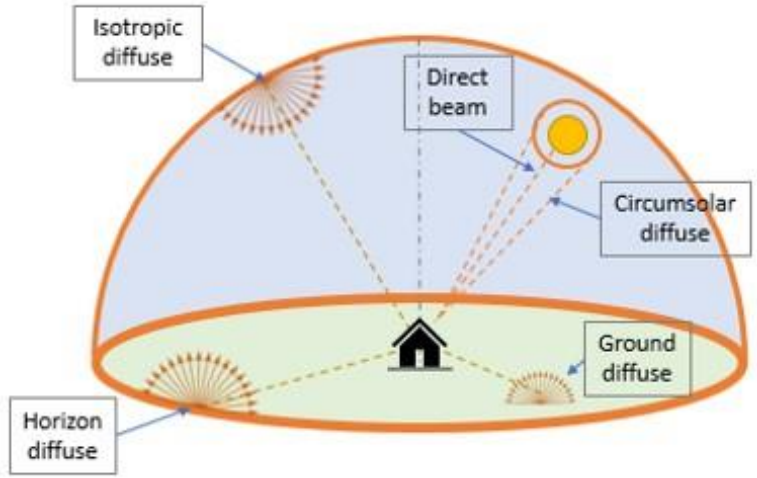


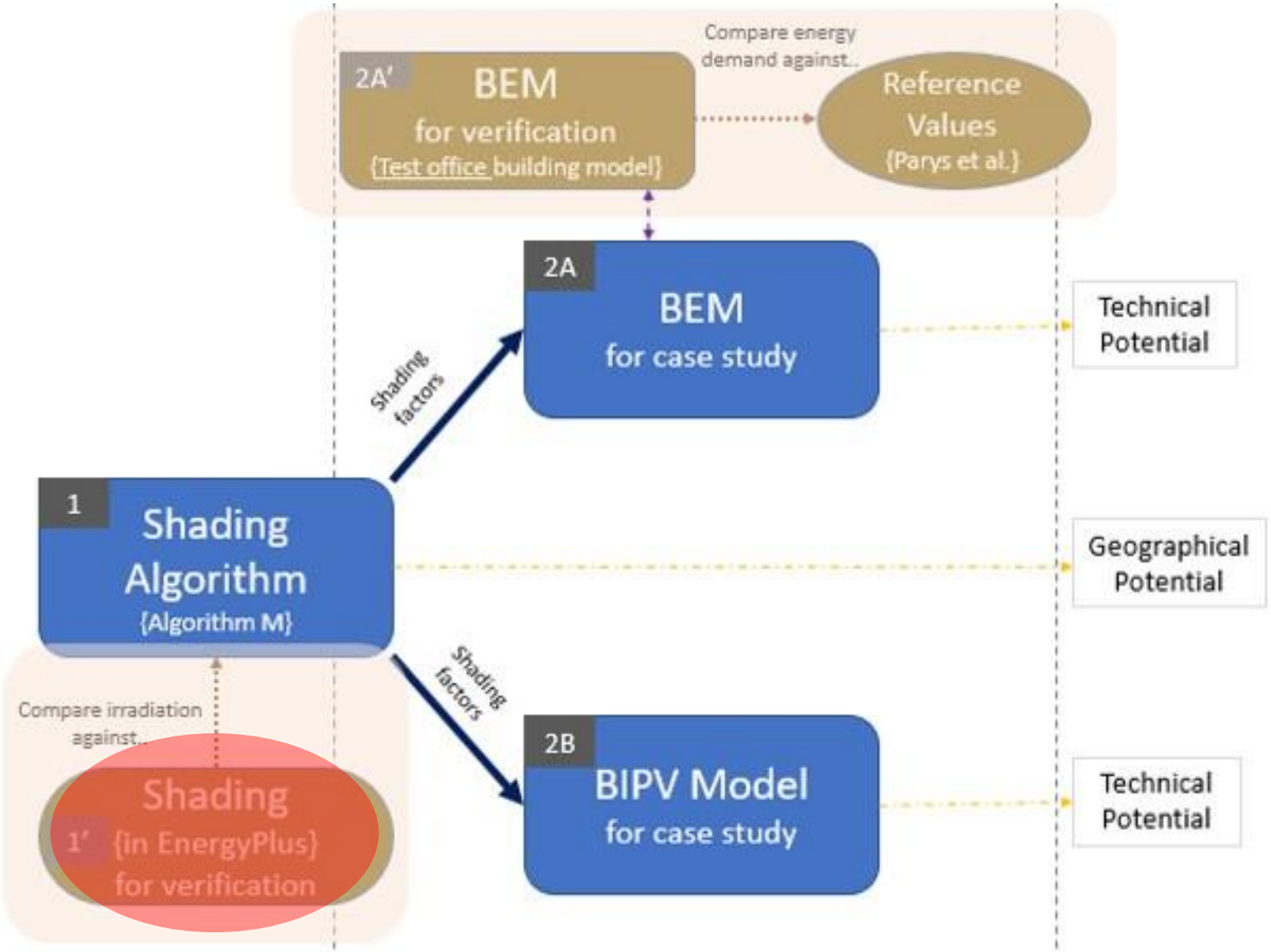
Shading Algorithm



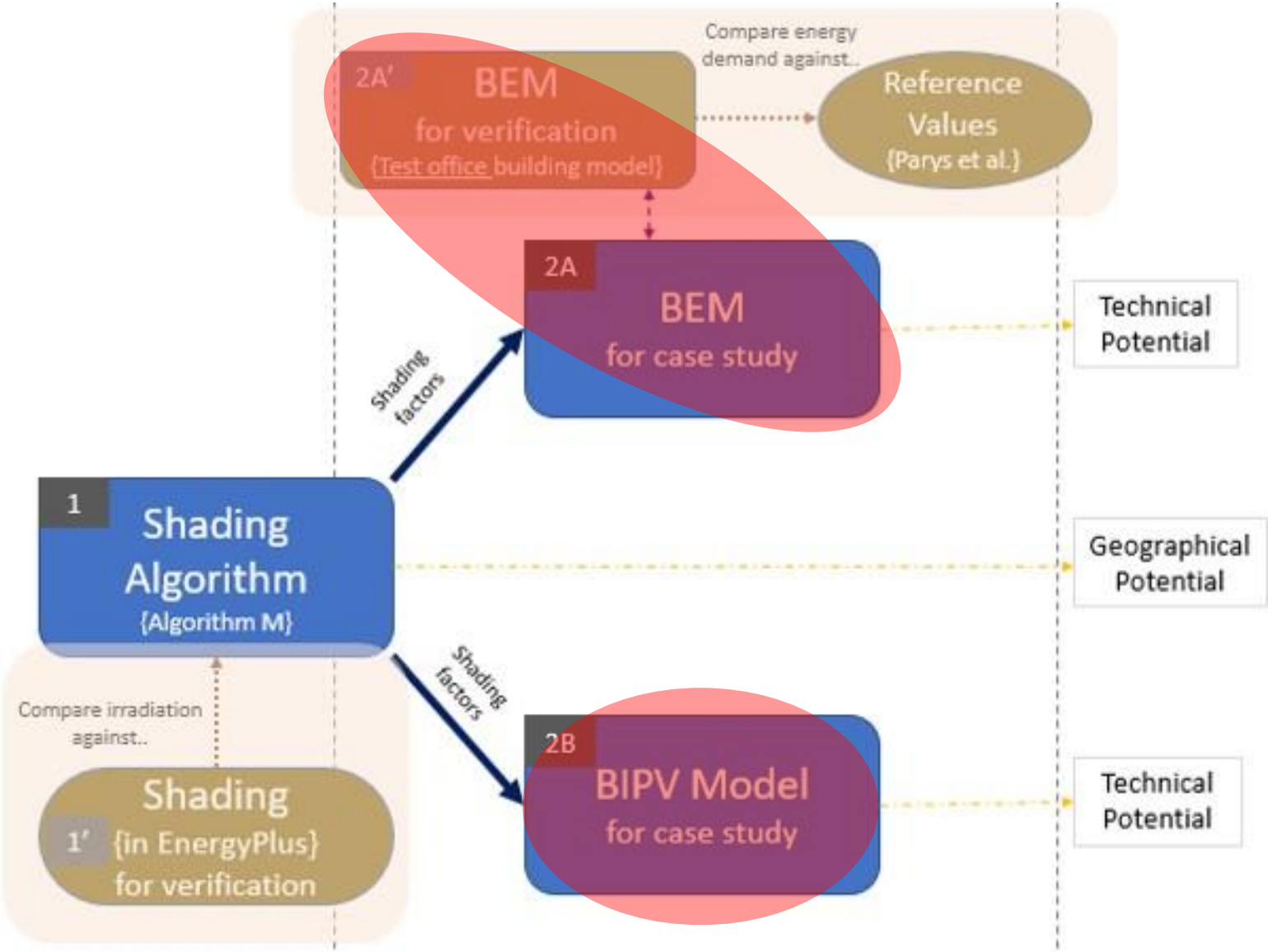


Richard Perez, Robert Seals, Pierre Ineichen, Ronald Stewart, and David Menicucci. A new simplified version of the perez diffuse irradiance model for tilted surfaces. *Solar energy*, 39(3):221–231, 1987.

Shading verification

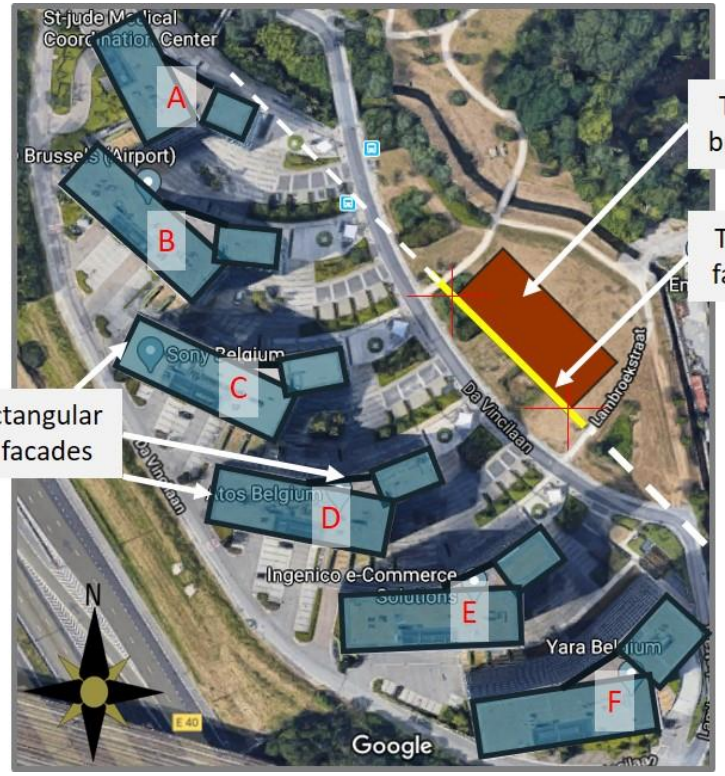


BEM & BIPV



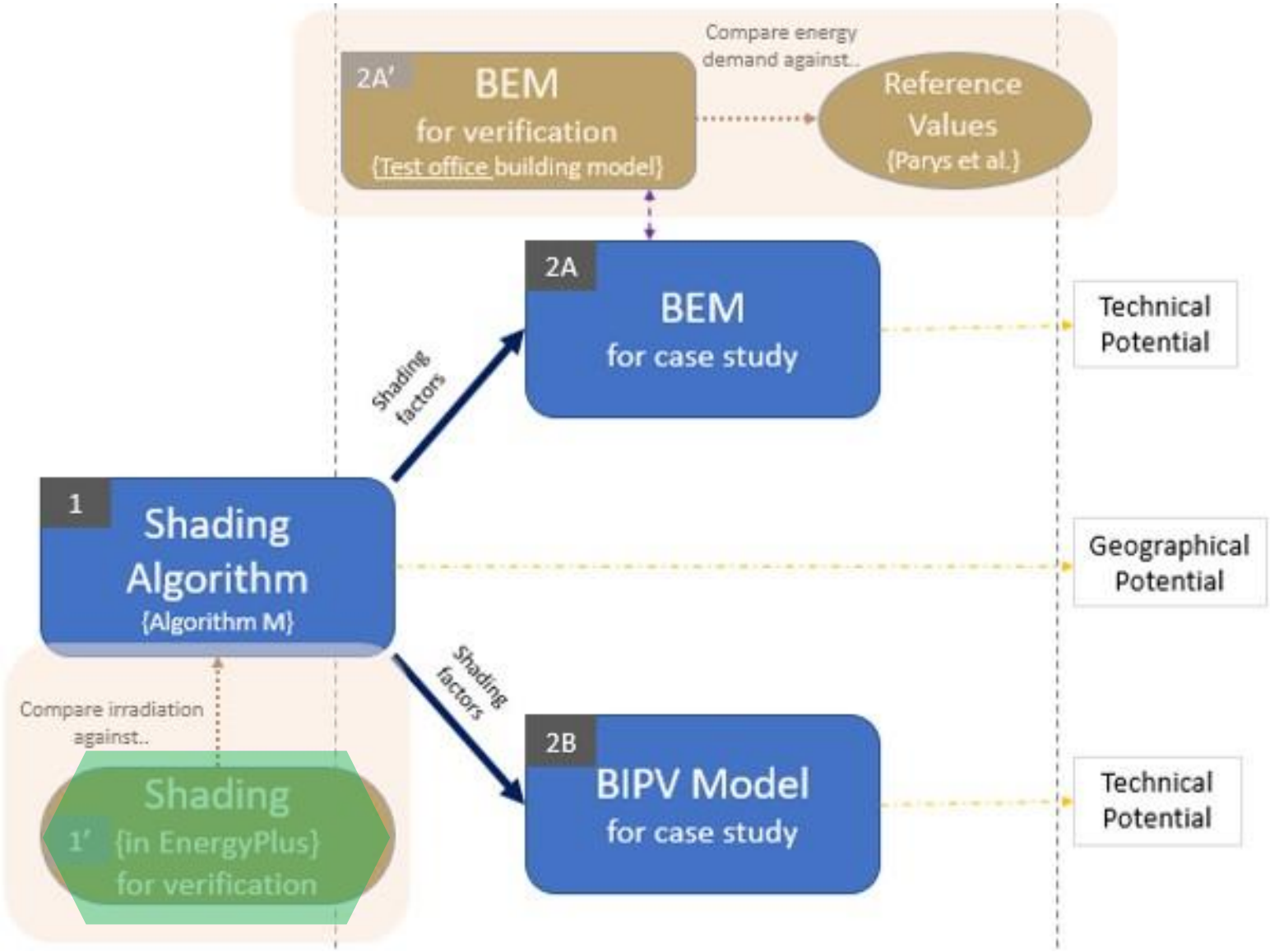
Juliana Emanuella Gonçalves, Glenn Reynders, Jonathan Lehmann, and Dirk Saelens. Modelling of a naturally ventilated bipv system for building energy simulations. In *7th International Building Physics Conference*. IBPC, 2018.

Case Study: Corporate Village



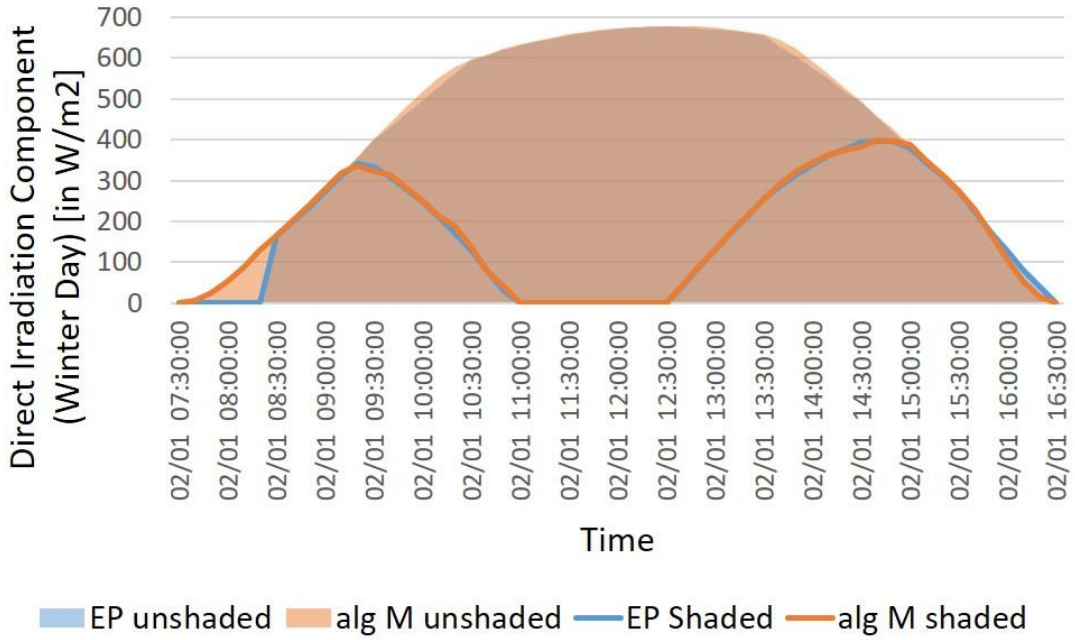
Façade height, length, distance, orientation, angular position

Results

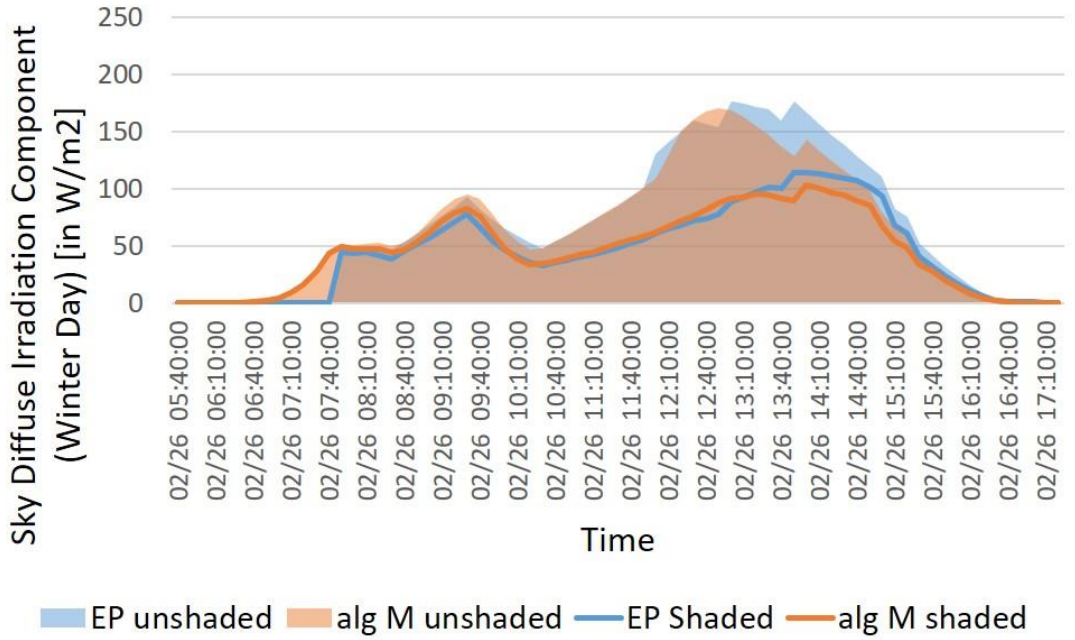

Compare energy demand against..
2A'
BEM
for verification
(Test office building model)
Reference Values
(Parys et al.)
2A
BEM
for case study
Technical Potential
Shading factors
1
Shading Algorithm
(Algorithm M)
Geographical Potential
Shading factors
Compare irradiation against..
Shading
1'
(in EnergyPlus)
for verification
2B
BIPV Model
for case study
Technical Potential

Shading verification – EnergyPlus vs Algorithm M

Difference (UNSHADED):
Direct = -0.43% | Sky-Diffuse = 2.91%



Difference (SHADED):
Direct = 0.33% | Sky-Diffuse = -3.3%



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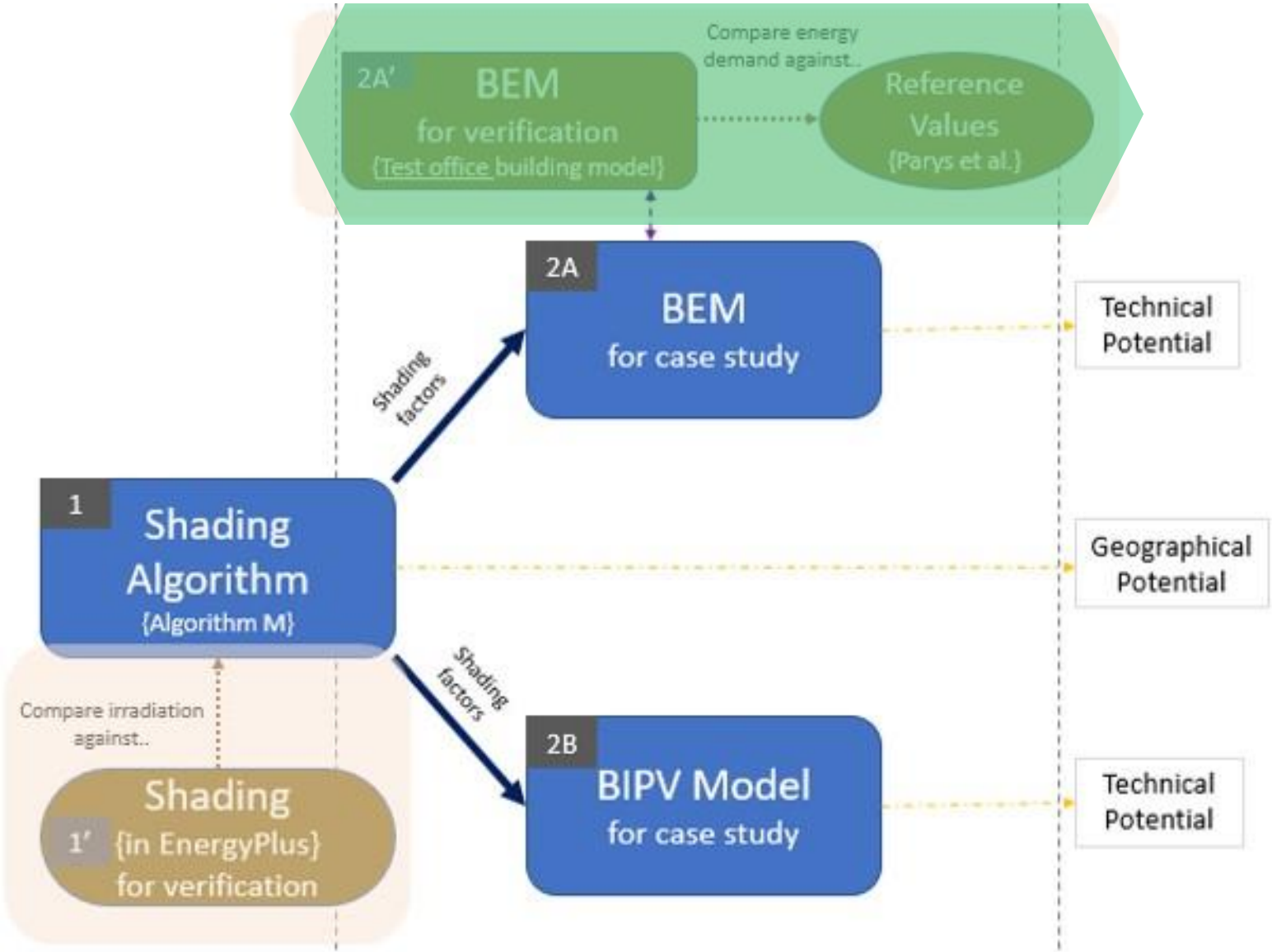
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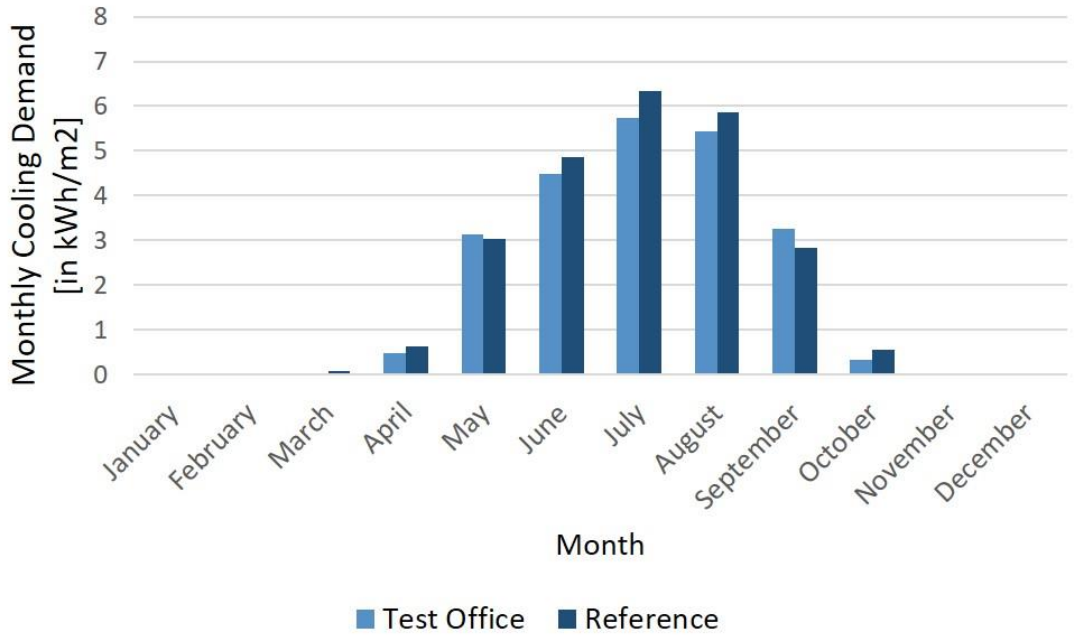
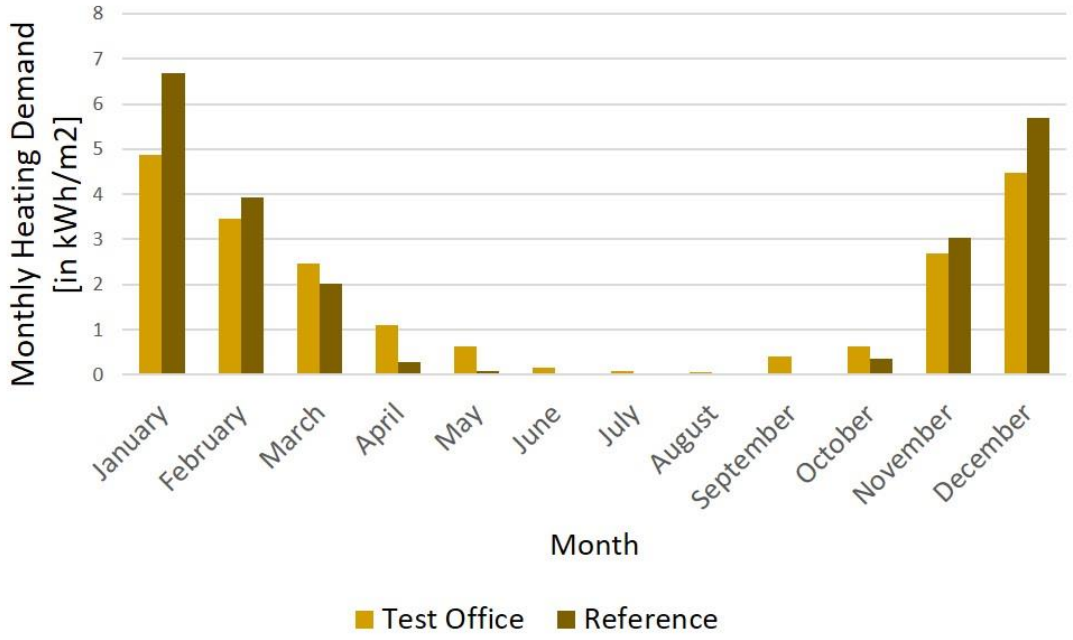
BEM verification

Difference in Annual cooling demand: 0.24%

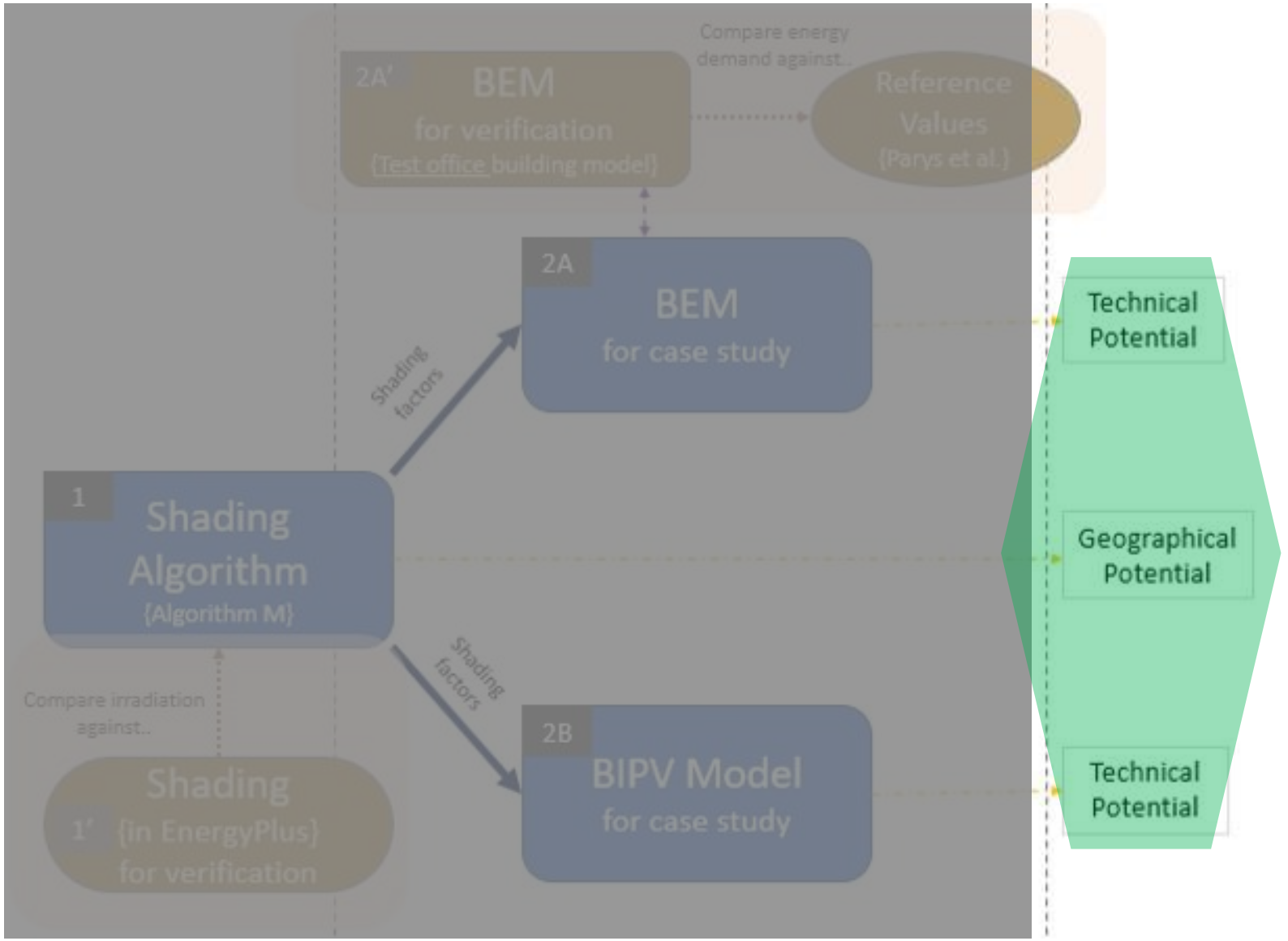
Difference in Annual heating demand: 1.68%





Wout Parys, Dirk Saelens, and Hugo Hens. Coupling of dynamic building simulation with stochastic modelling of occupant behaviour in offices - a review based integrated methodology. *Journal of Building Performance Simulation*, 4(4):339–358, 2011.

Results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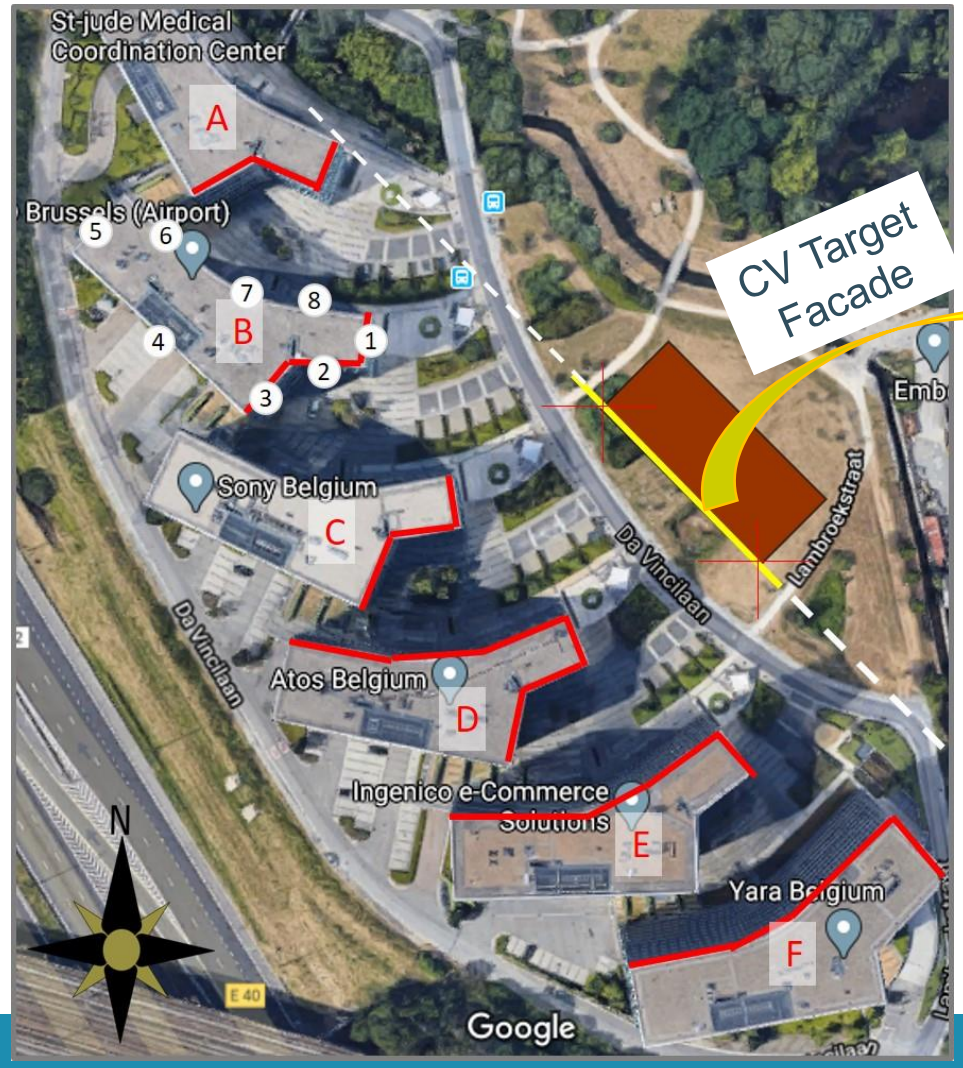
Technical Potential
Geographical Potential
Technical Potential
Energy demand
Irradiation
Electricity generated

Corporate Village - Irradiation



Height 30m	Unshaded Global Irradiation = 633.41 kWh/m2-year														
	589.4	597.4	603.8	608.5	611.9	621.5	621.4	621.3	621.2	621.1	621	621	620.9	620.9	620.8
	572.2	581.7	588.7	594.2	598.4	613.8	613.5	613.5	613.3	613.3	613.5	613.8	614	614.3	614.5
	557.2	566.2	572.3	578.2	582.8	603.6	603.3	603.5	603.8	604.4	604.6	604.2	603.3	601.8	600.9
	539.4	547.3	554.6	560.1	564.3	590.6	590.7	590.8	590.2	589.2	588.4	588.2	588.3	587.4	586.5
	520.5	527.2	532.8	537.9	544.1	574.6	573	572.7	573.4	573.1	573.1	571.7	571	569.1	567.7
	498	505.8	511.6	516.1	521.7	556.5	555.7	555.2	554.9	554.3	552.9	551	549.7	549.2	549.6
	478.9	485.6	490.5	495.4	500.8	536.7	535.8	535.2	534.2	533	531.2	531.9	532.5	533.1	534.6
	459.5	464.1	470.5	475.6	479.7	516.1	514.5	513.5	513.5	513.7	513.4	515	517	517.1	517.8
	442.1	446.3	450.5	453.6	457.5	494.6	493.8	494.2	495.2	495.9	496.6	498	499.2	499.5	499.3
	420.8	425.9	430	434.3	437.2	475.4	476.6	476.3	477.6	479	478.6	480	481.5	482	481.9
	Façade Length 45m														

29.5% reduction

Steady rise in irradiation with height

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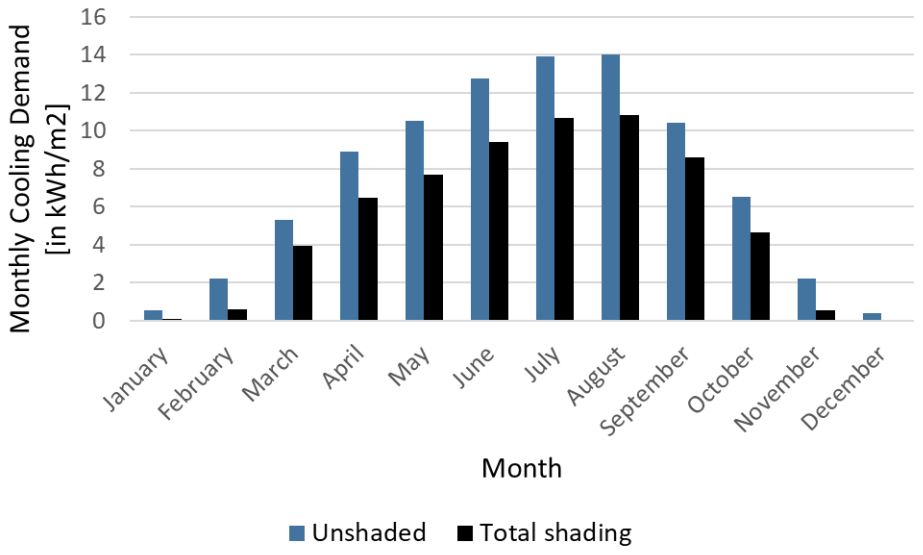
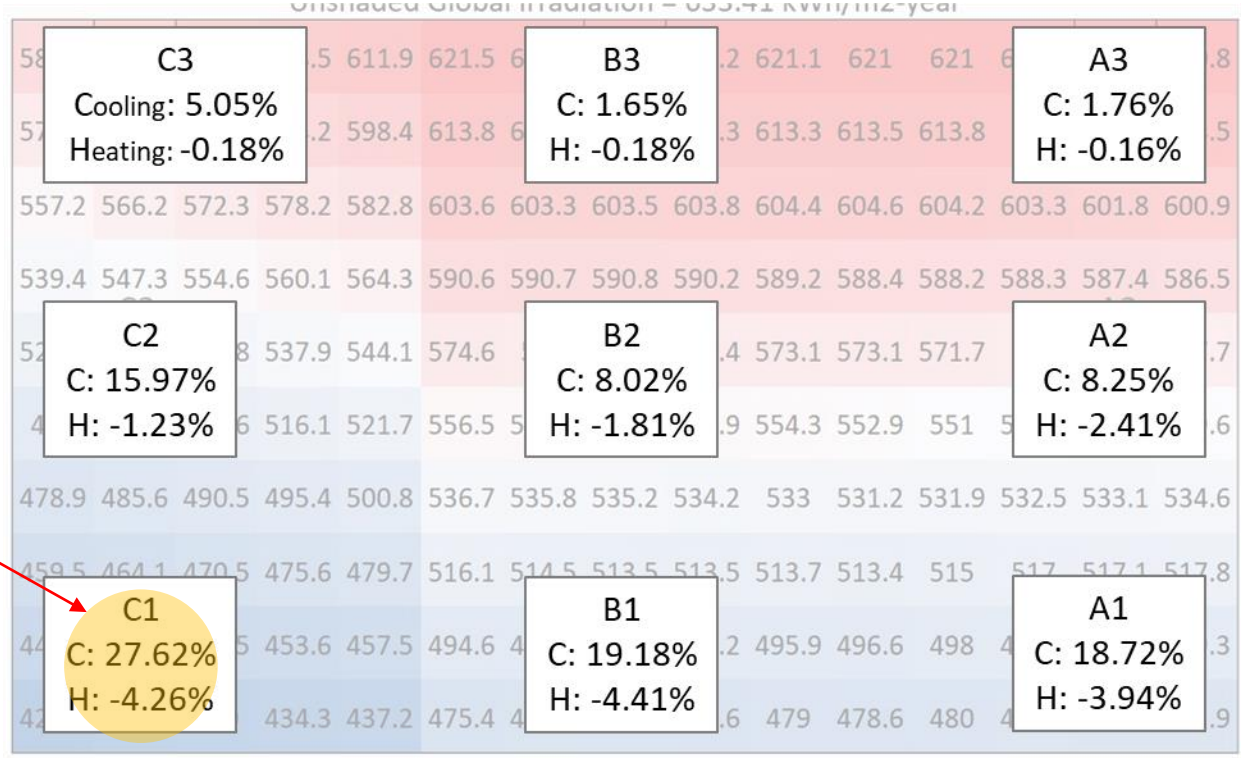
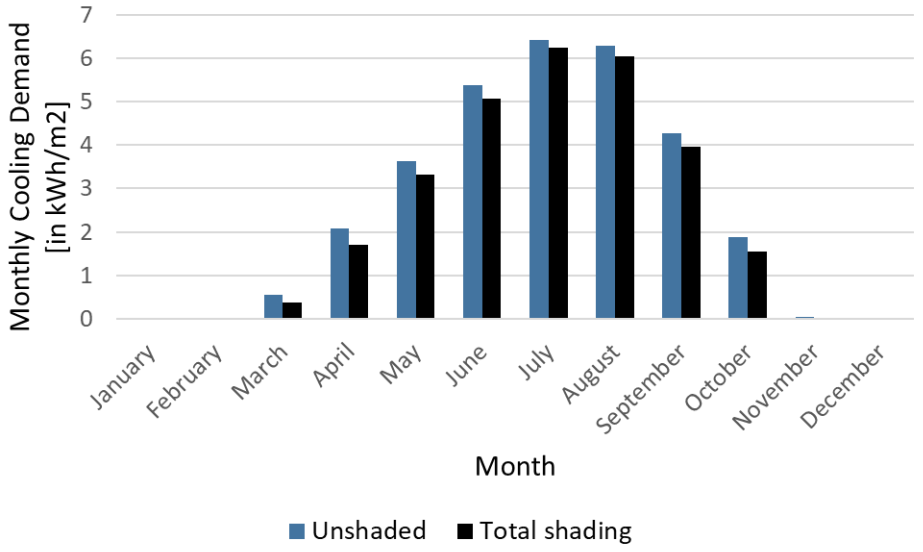
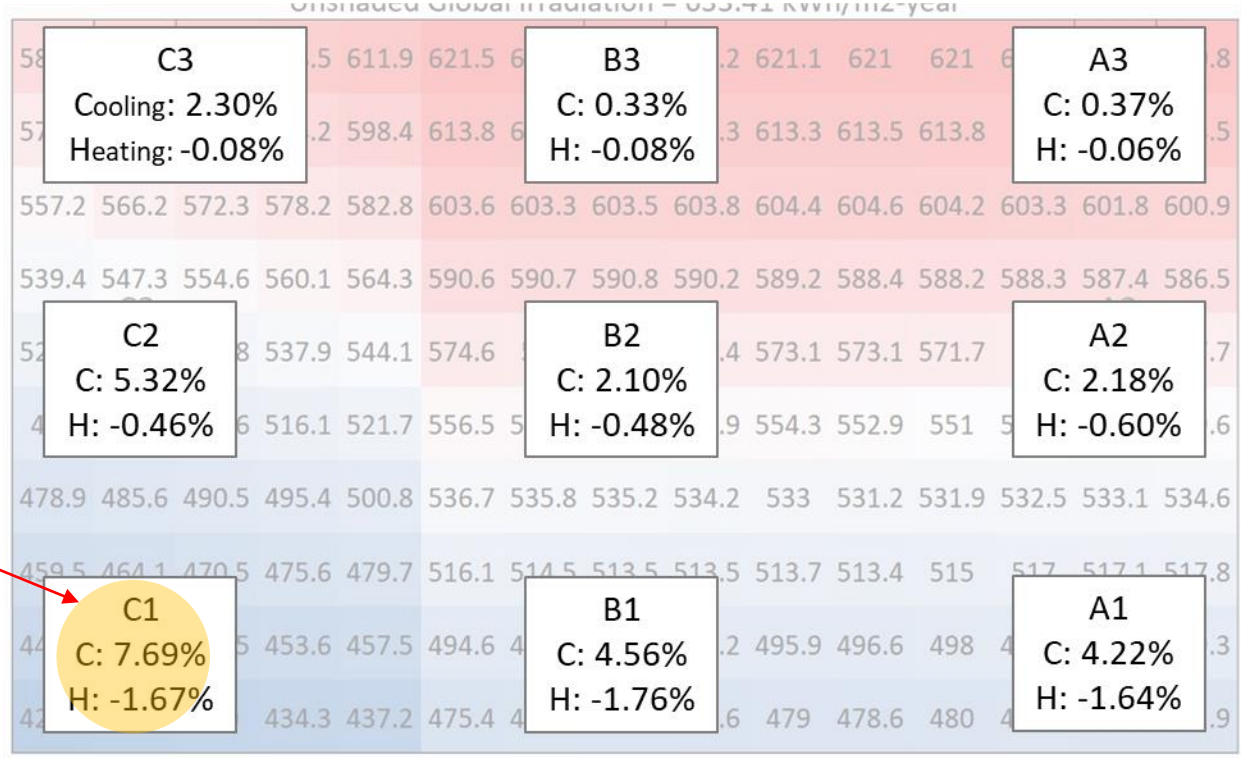
Corporate Village: BES **without** blinds



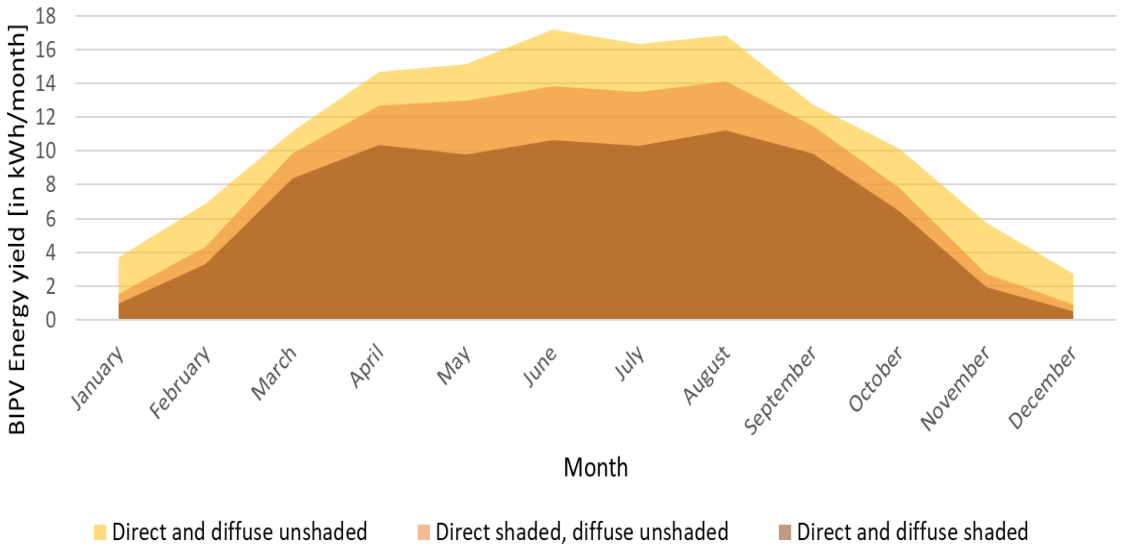


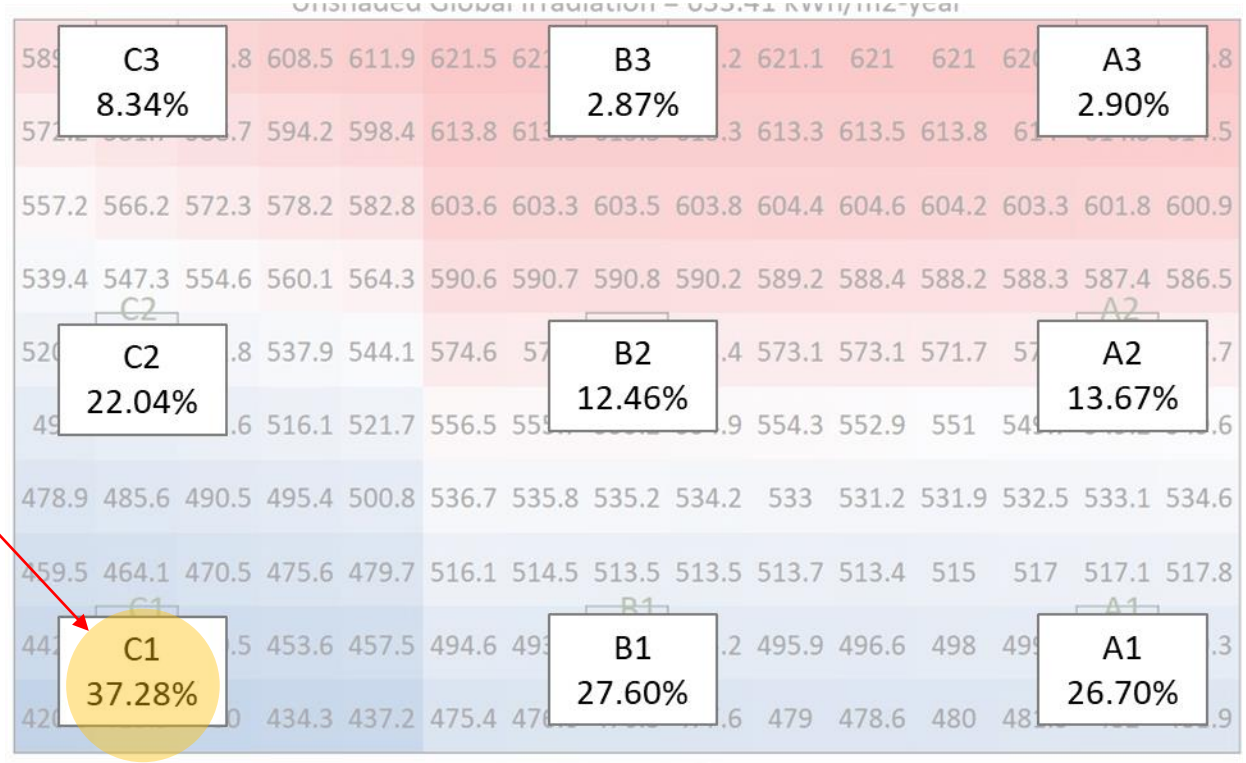
Corporate Village: BES **with** blinds



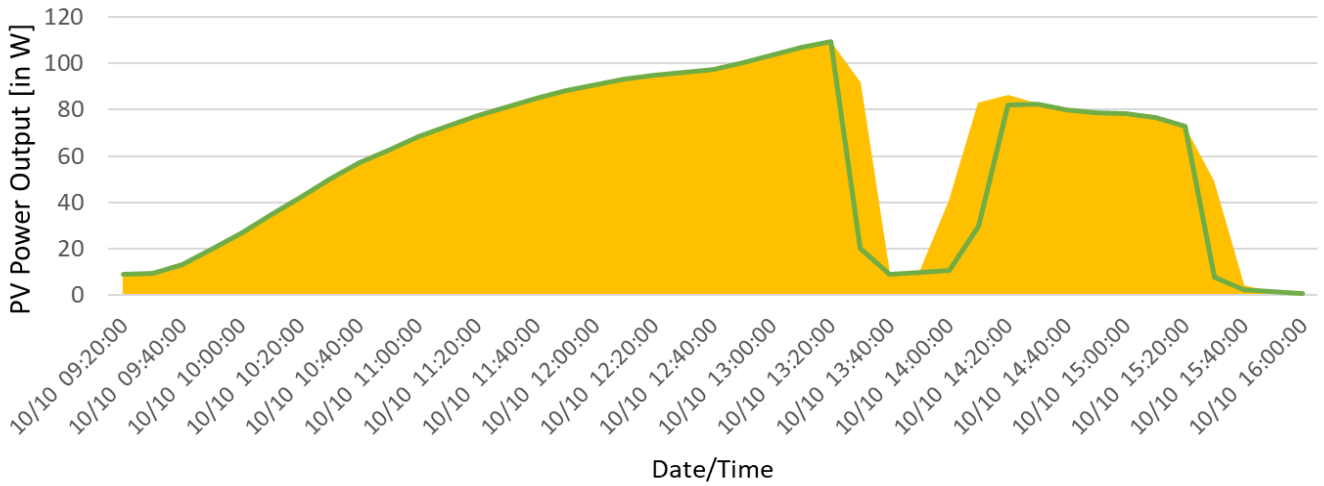


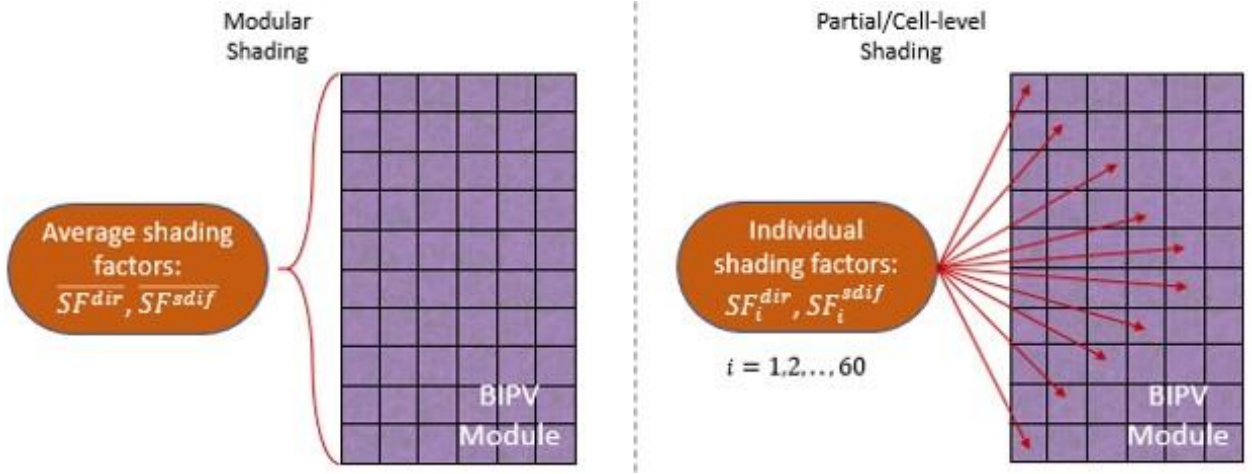
Corporate Village: BIPV





Corporate Village: BIPV partial shading

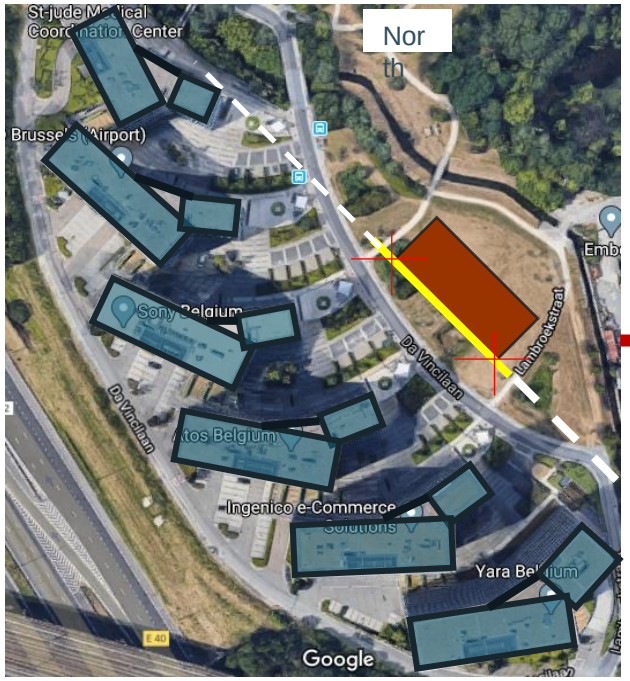




Results

3: How does **shading and its impact vary** with varying certain geometrical features of surrounding buildings?

Sensitivity Analysis



Decrease distance of surrounding buildings

Increase height of surrounding buildings

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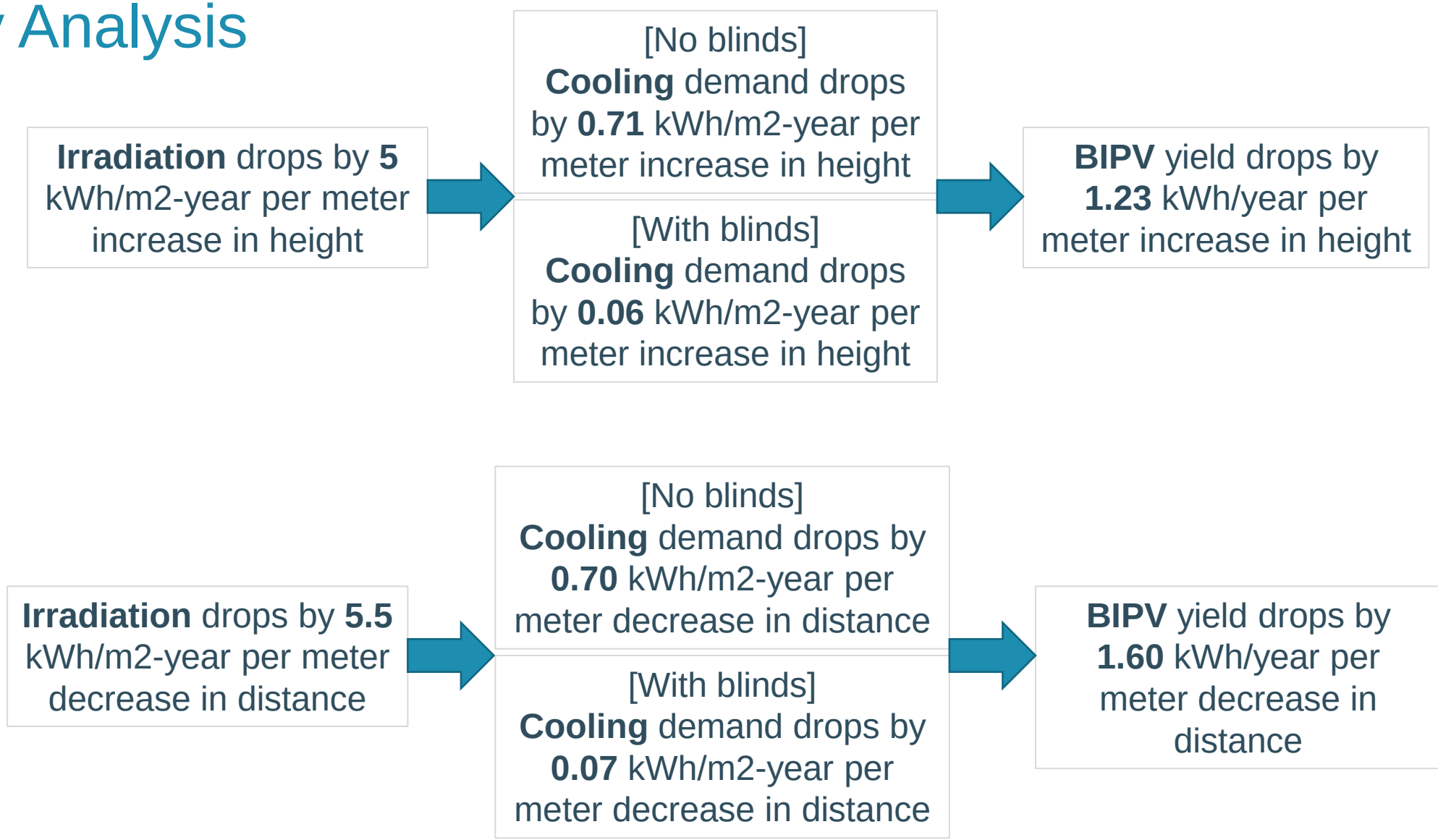
Sensitivity Analysis



Conclusion

- For office C1 close to ground: reduction in irradiation= 29.5%; reduction in cooling demand= 27.6% w/o blinds, 7.7% w/ blinds; reduction in BIPV yield= 37.3%
- For other offices too, proportionality of energy systems to irradiation holds true

Step towards a comprehensive framework for shading impact assessment on important energy systems

Select location → Collect data → Simulate!

Possibilities for Future Work:

- Automating data collection
- Improving shading algorithm (irregular shapes, reflections)
- Assessment of Economic potential

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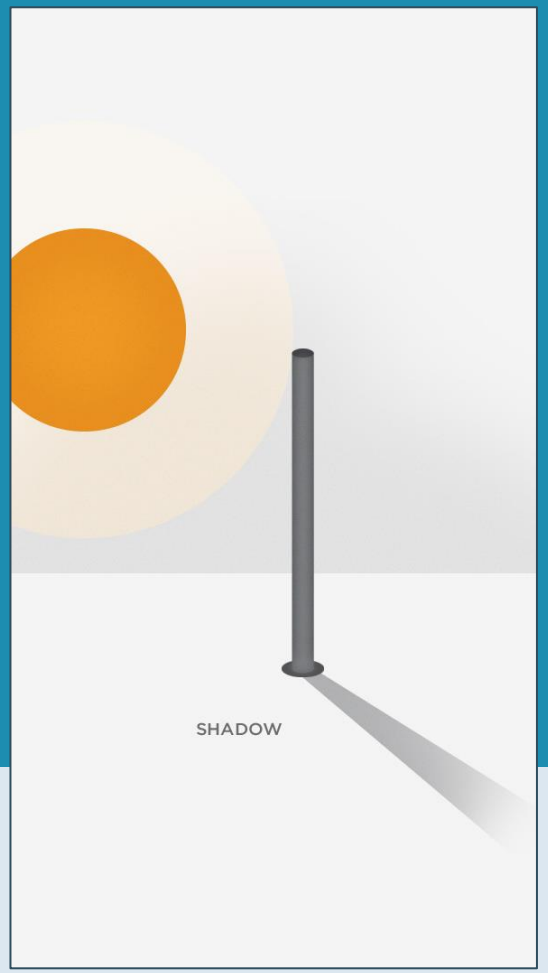
Thank You



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