Daylighting performance assessment of shading devices concerning building's aesthetic

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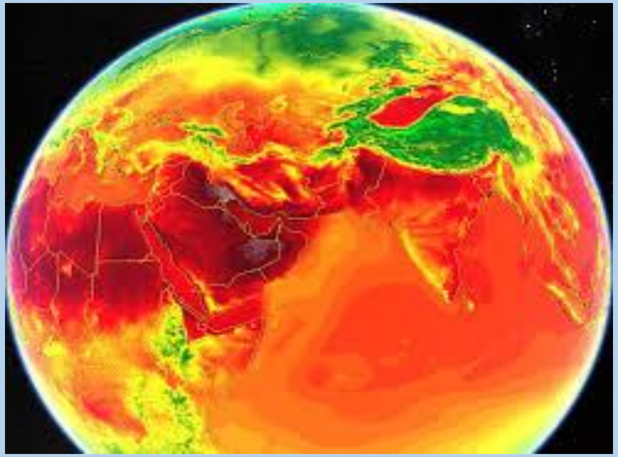
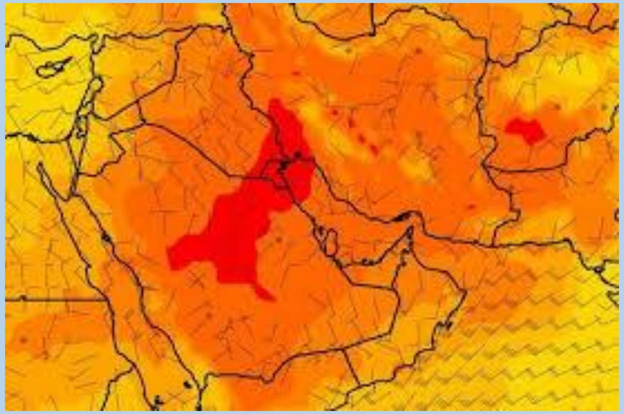
Outline

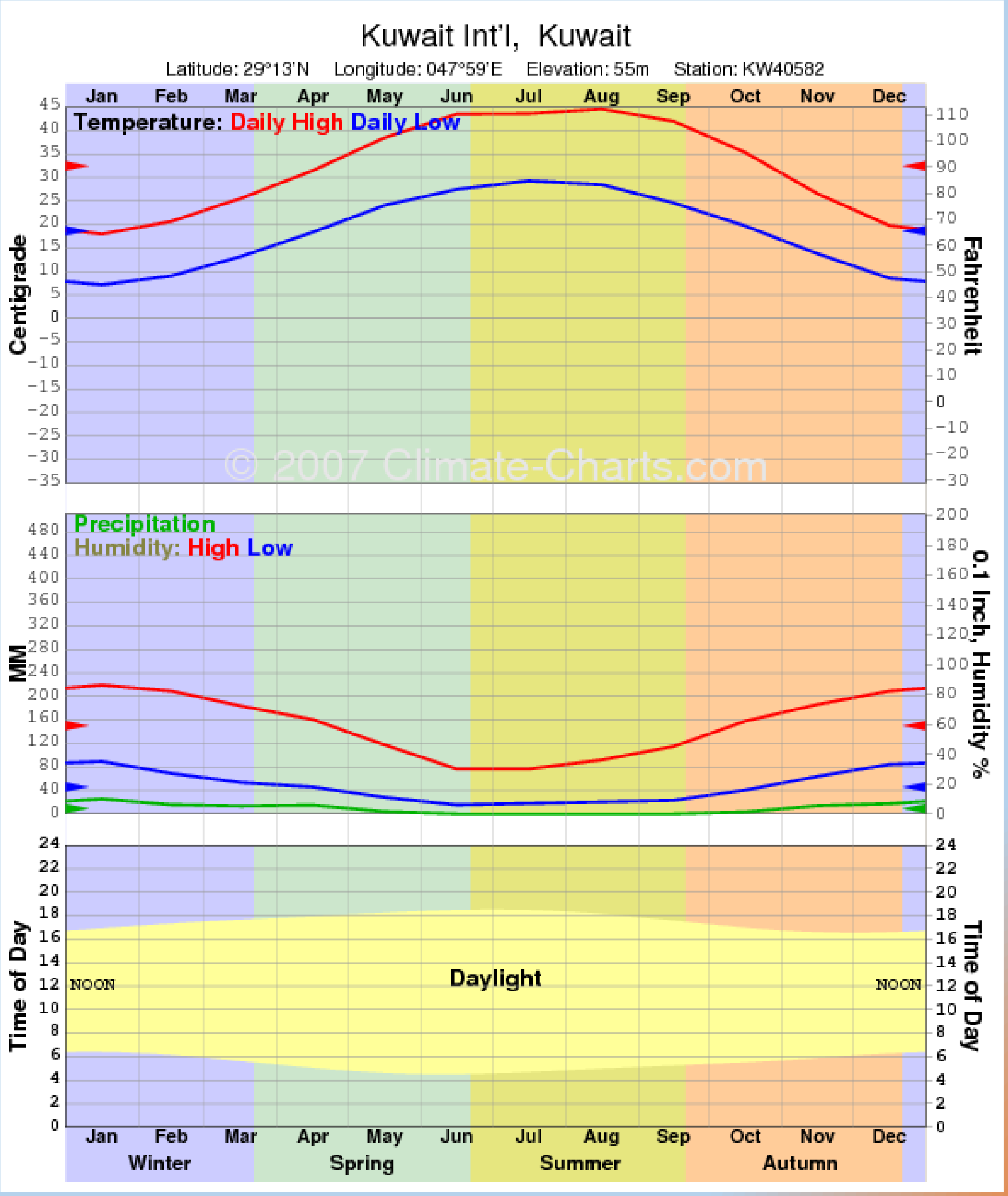
- Background
- Introduction
- Objectives
- Methodolgy
- Results
- Conclusion
- Future work

Background

- Climate
- Weather







Introduction

- Buildings consume the majority of generated power more than 40%.

- Windows and its attachment play a major role in heat gain or loss from a building.

Introduction

- Buildings/Windows designed to be more sustainable.

70-80s

80-90s

Now

- Building owners are fascinated by the appearance of their buildings.

Objectives

- Optimum selection of window elements that:
  - Reducing heat gain
  - Provide an aesthetic façade
  - Ensure visual comfort

Objective Function and Constraints

Objectives

$$f(x) = \left[Q_c(x) + Q_h(x)\right] / 3.6 \times 10^6 \qquad (1)$$

$$f(y) = \left\lfloor E_{Daylighting}(x) \right\rfloor \qquad (2)$$

$$f(xy) = f_{\min}(x) + f_{\max}(y) \qquad (3)$$

Constraints

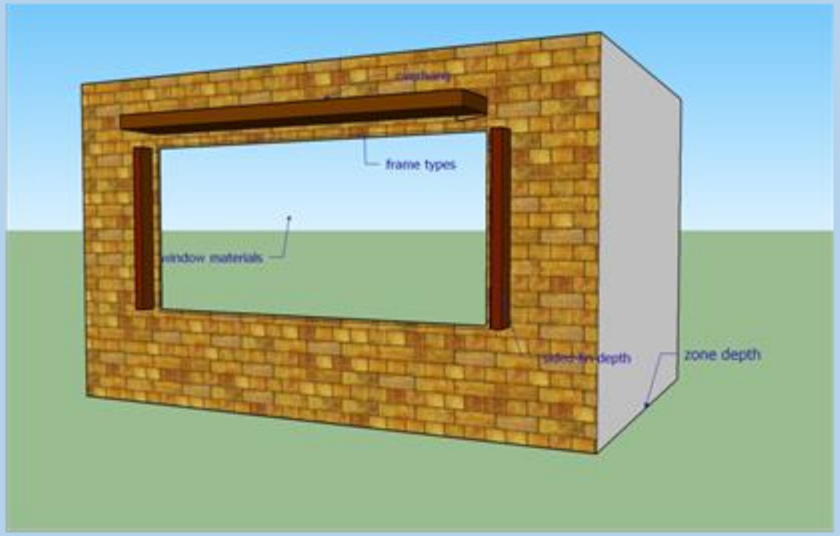
$$c_{1,2}(x) = \sum_{i=1}^{n} z_i / n \qquad (4)$$

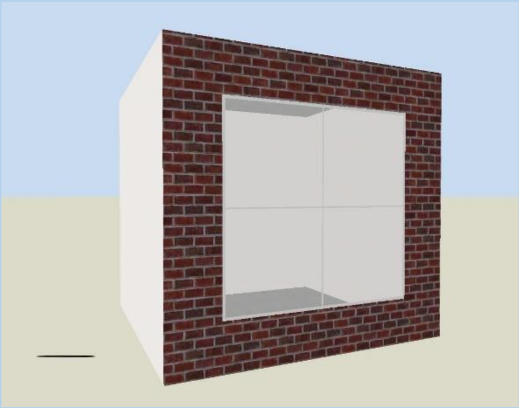
$$z_i = \begin{cases} NH_{lux}, & \text{if } \left(NH_{lux} > 500\right) \\ NH_{glare}, & \text{if } \left(NH_{glare} > 22\right) \end{cases}$$

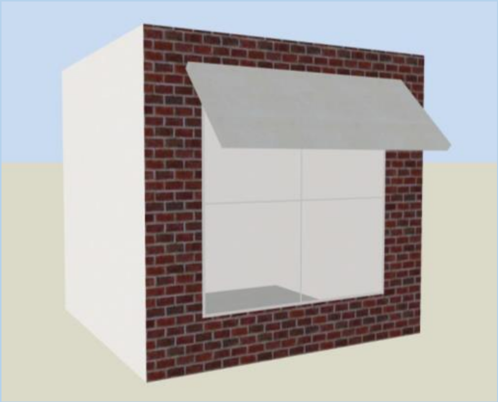
Design Parameters

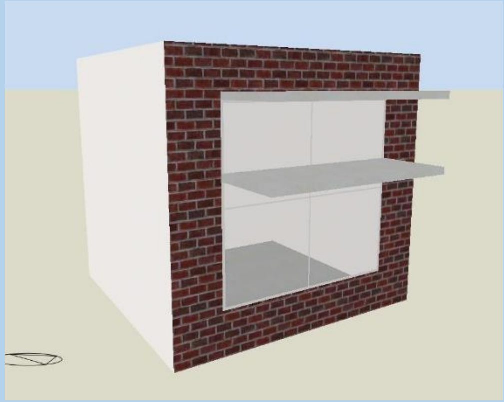
Table 1: Design parameters values.

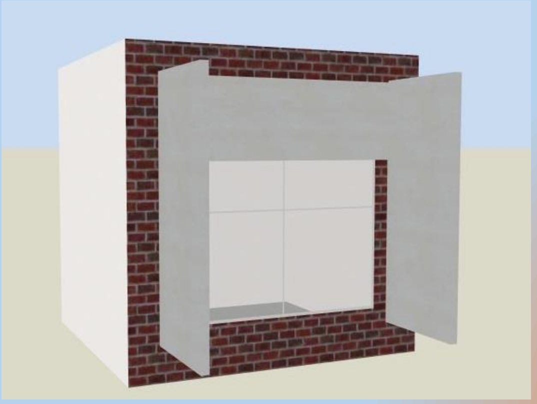
Index	Variable	LB	UB	Increment
1	Overhang tilt (°)	90	135	5
2	overhang projection (%)	0	H/2	5
3	side-fins projection (%)	0	W/2	5



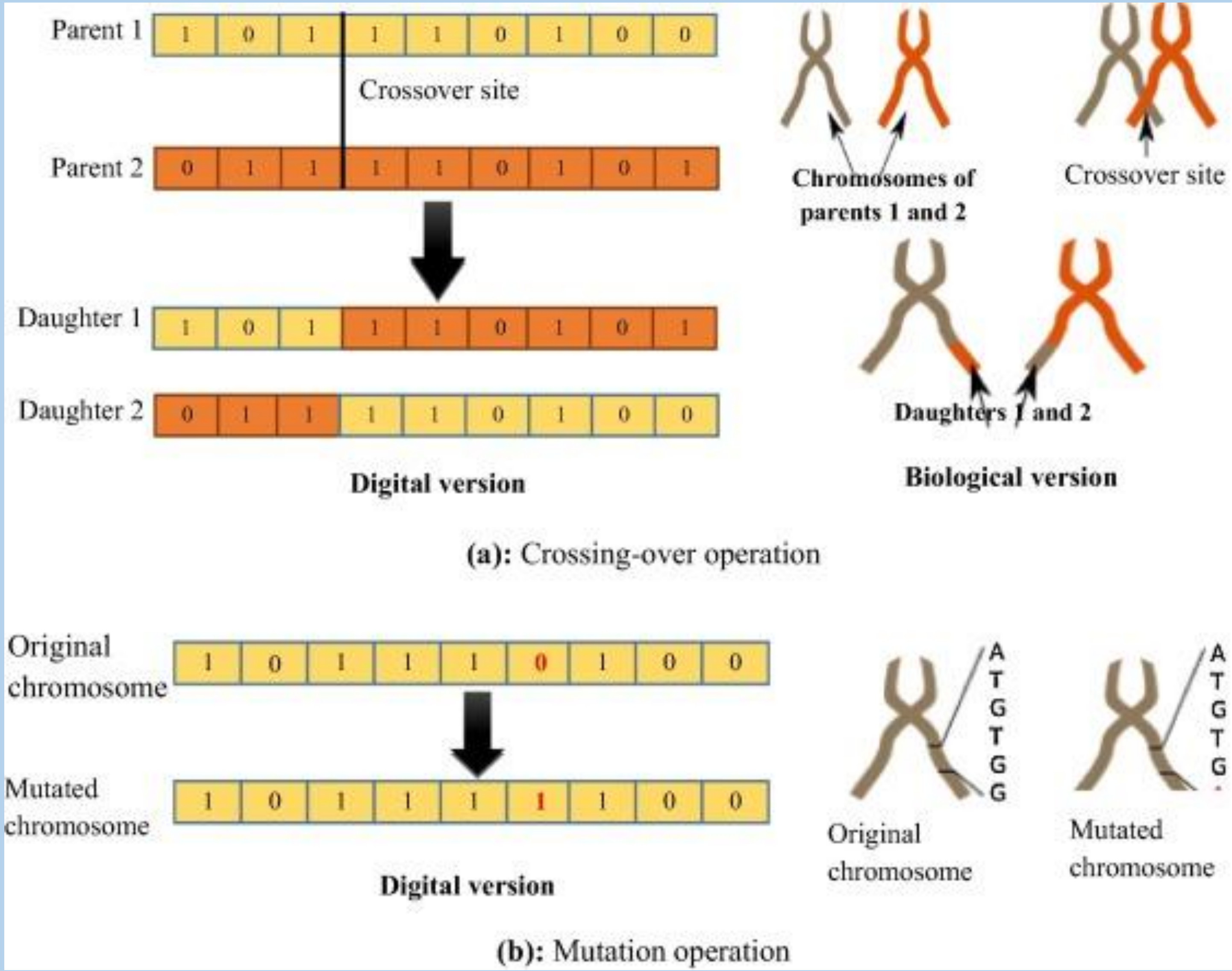








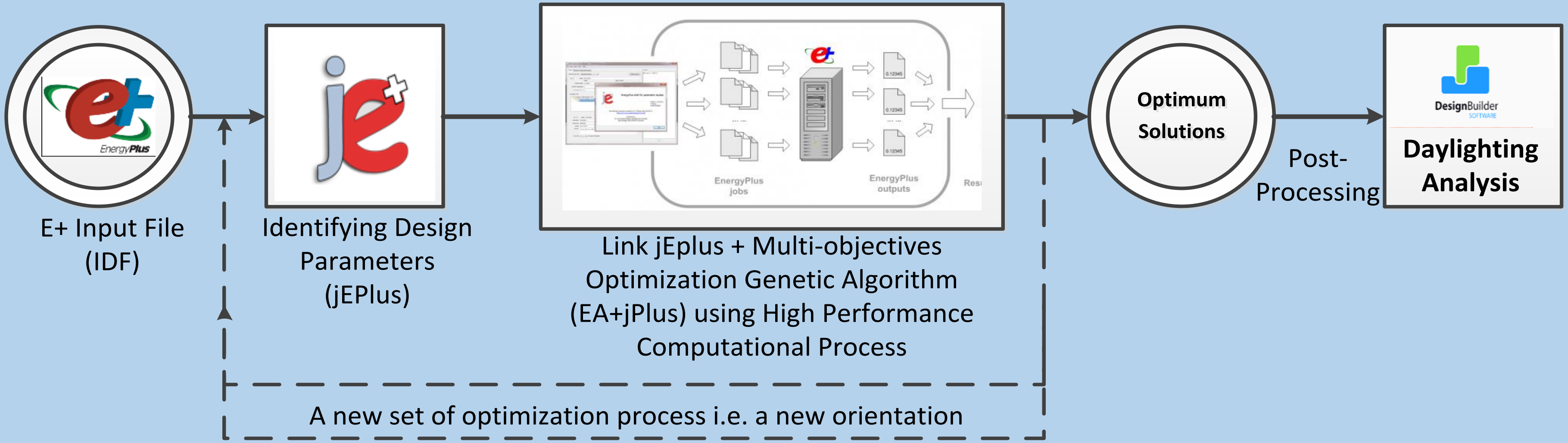
Genetic Algorithm Concept



Methodology

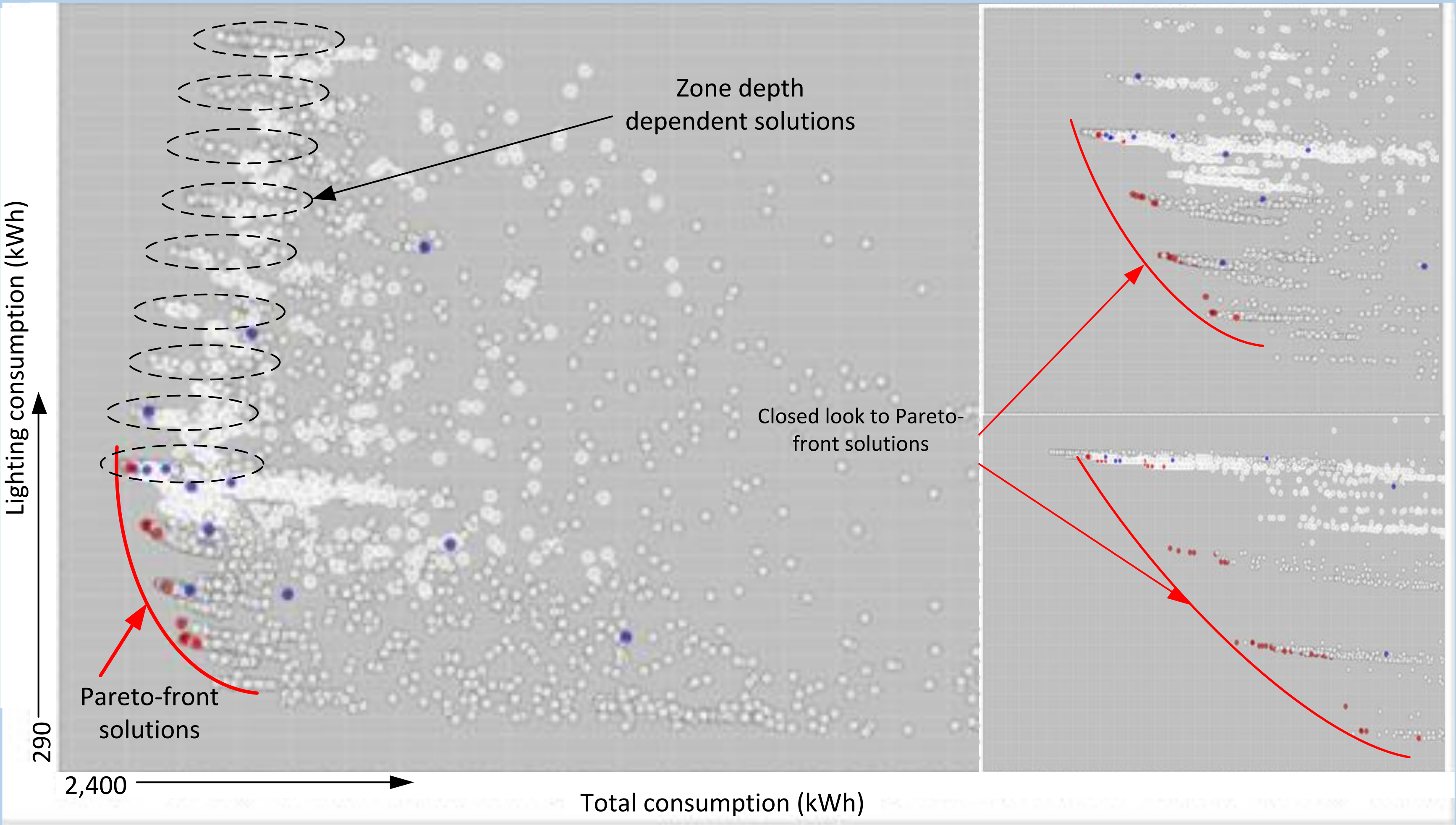
Simulation-based Optimization

Genetic algorithm (GA) coupled with a building simulation program (EnergyPlus)



A workstation of 48 threads (ENSIMS X3200) powered by 2x Intel Xeon 2.5GHz with a memory size of 64GB RDIMM was allocated to accomplish the computation (up to 56 at a time).

Results



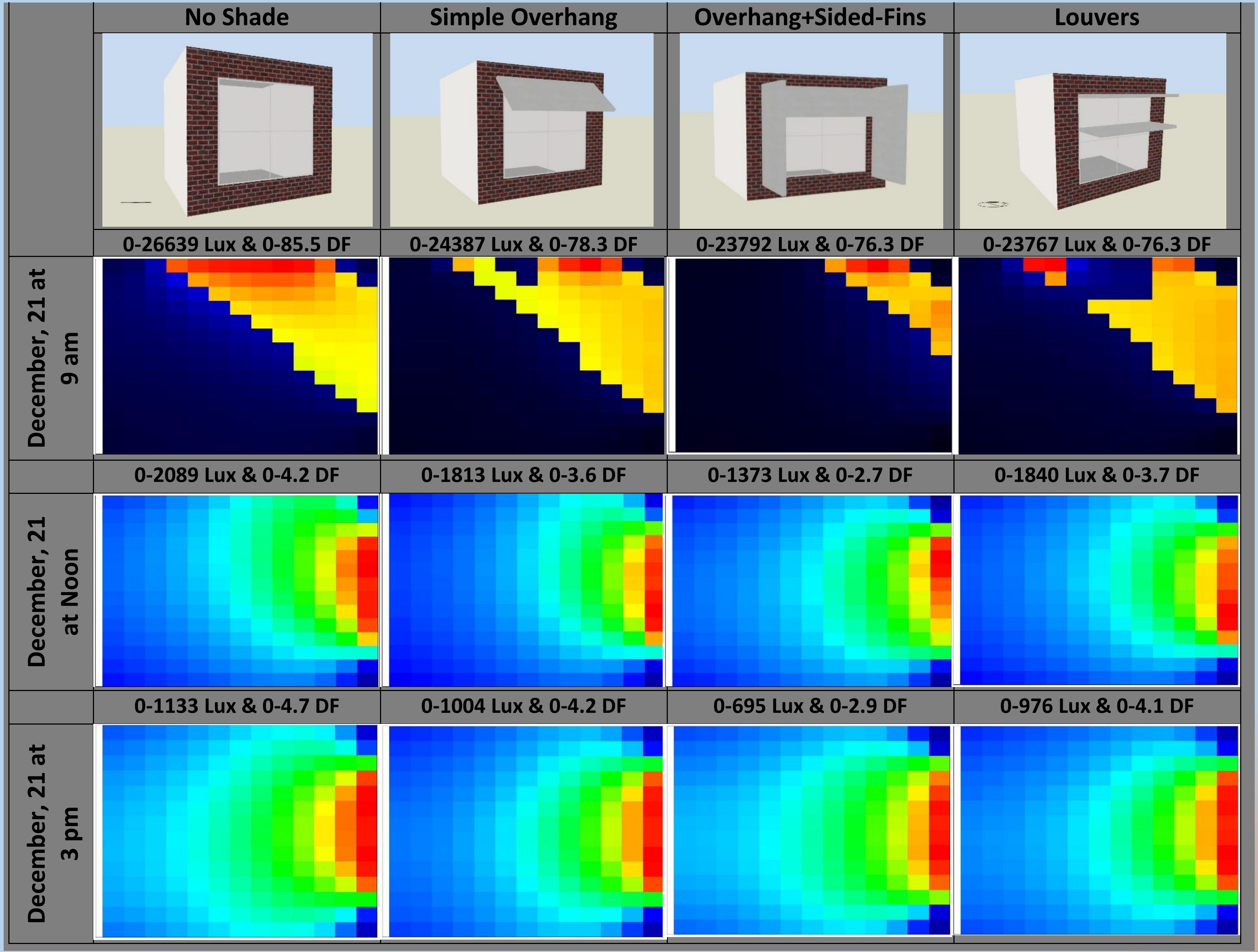
Zone depth
dependent solutions
Closed look to Pareto-
front solutions
Pareto-front
solutions
Lighting consumption (kWh)
290
2,400
Total consumption (kWh)

Results

	Overhang (m)	Projection Telt (°)	Fins (m)	Glazing Mat	Air Gap	WWR	W	H	Lighting (kWh)	Heating (kWh)	Cooling (kWh)	Total	Saving
base	N/A	N/A	N/A	Low-e 6mm	12	50	2.8	2.7	43.3	26.4	3846.0	3872	0%
Overhang/ Sided-fins	**1.2**	**130**	**1.0**	**Low-e 6mm**	**12**	**50**	**2.8**	**2.7**	**49.9**	**97.5**	**2738.4**	**2836**	**-27%**
	0.9	115	1.1	Low-e 6mm	12	50	2.8	2.7	46.2	86.8	2899.4	2986	-23%
	1.1	110	0.7	Low-e 6mm	12	50	2.8	2.7	45.4	74.1	2976.1	3050	-21%
Simple Overhang	**1.3**	**135**	**N/A**	**Low-e 6mm**	**12**	**50**	**2.8**	**2.7**	**46.7**	**74.1**	**2847.9**	**2922**	**-25%**
	1.2	125	N/A	Low-e 6mm	12	50	2.8	2.7	44.9	63.8	2983.2	3047	-21%
	1.2	110	N/A	Low-e 6mm	12	50	2.8	2.7	44.7	54.9	3099.2	3154	-19%
Louvers	**1**	**90**	**N/A**	**Low-e 6mm**	**12**	**50**	**2.8**	**2.7**	**44.1**	**69.0**	**2891.5**	**2960**	**-24%**
	0.75	90	N/A	Low-e 6mm	12	50	2.8	2.7	44.0	60.0	3050.0	3110	-20%
	0.5	90	N/A	Low-e 6mm	12	50	2.8	2.7	43.5	51.0	3232.2	3283	-15%

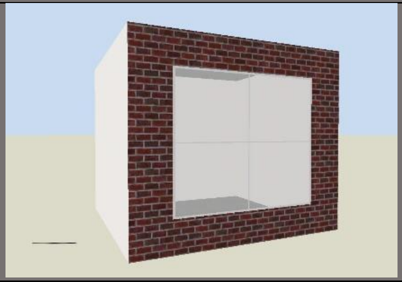
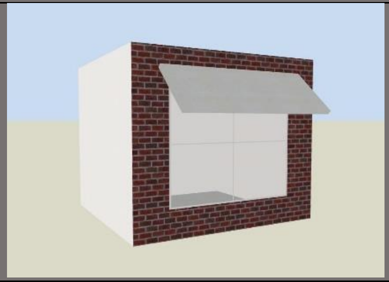
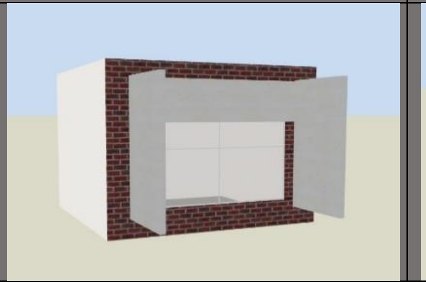
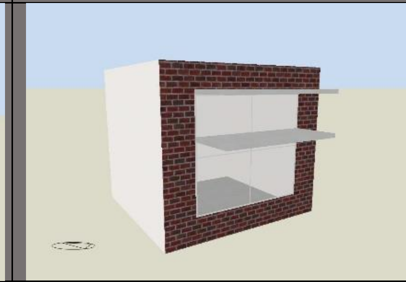
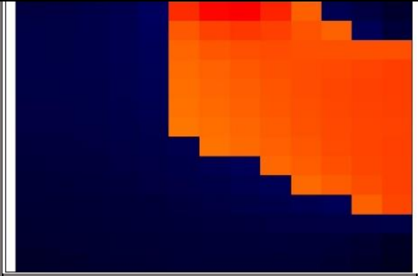
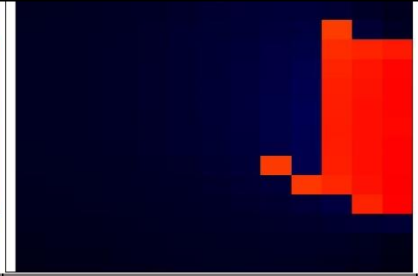
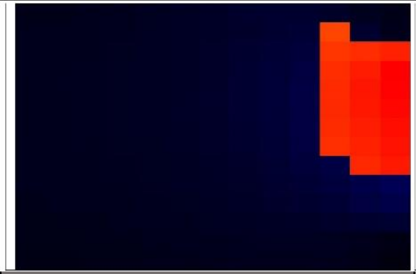
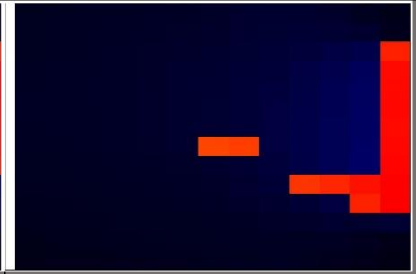
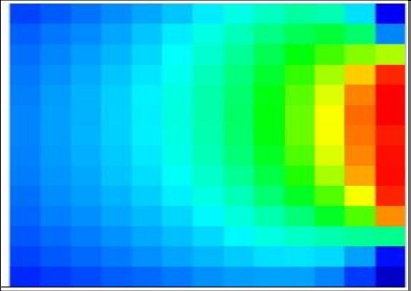
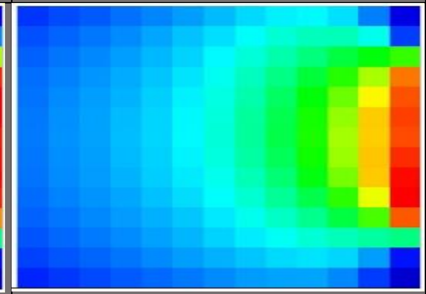
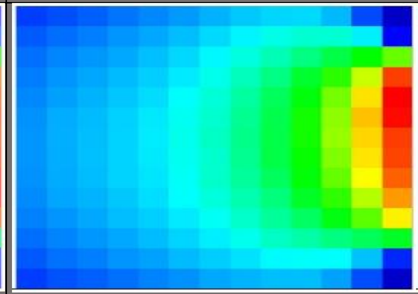
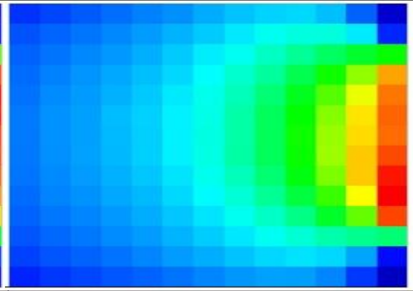
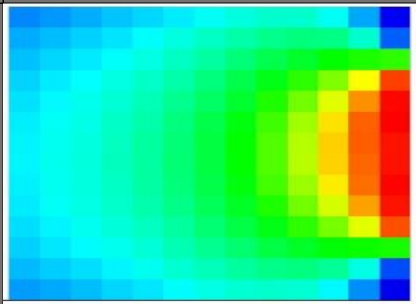
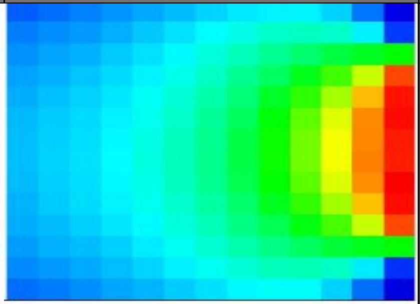
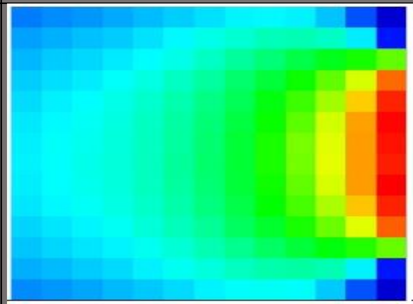
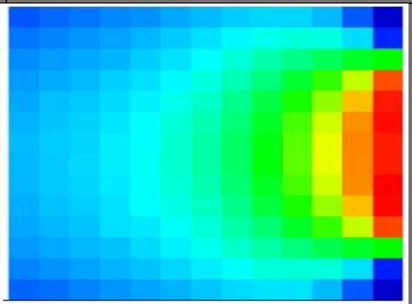
Results

Illuminance



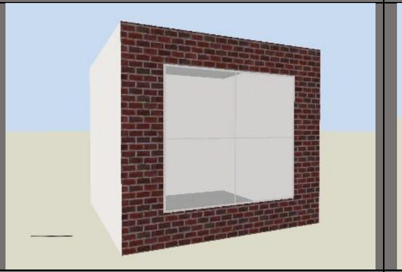
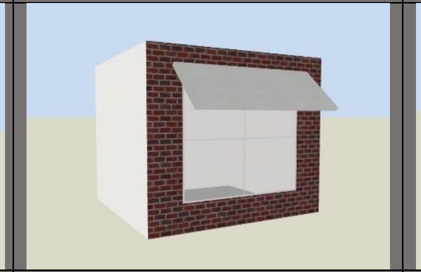
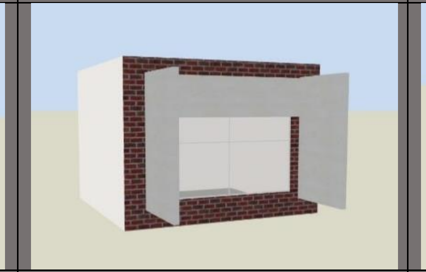
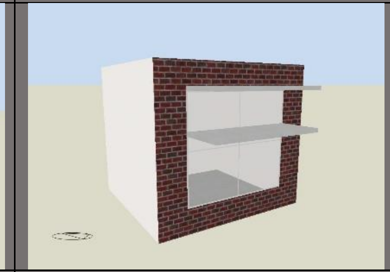
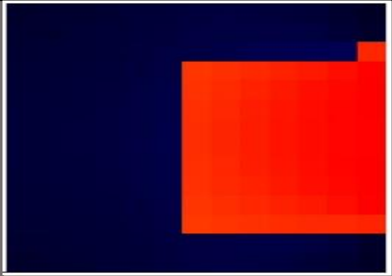
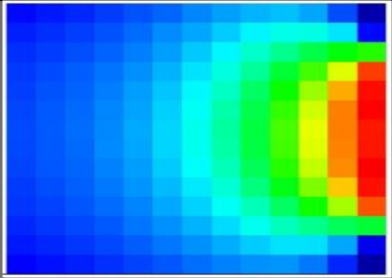
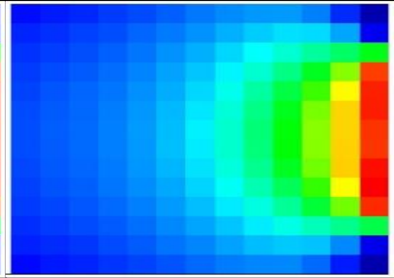
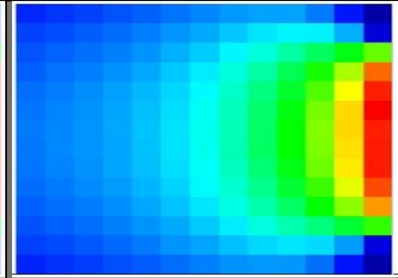
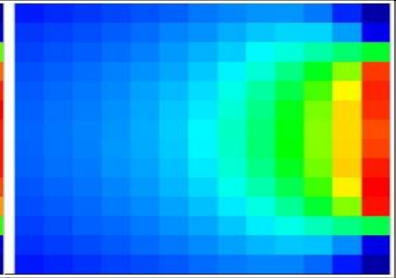
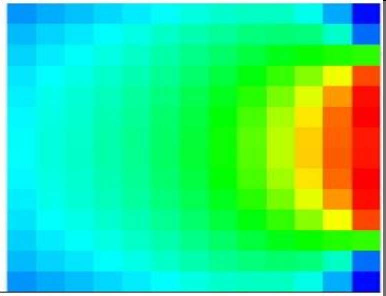
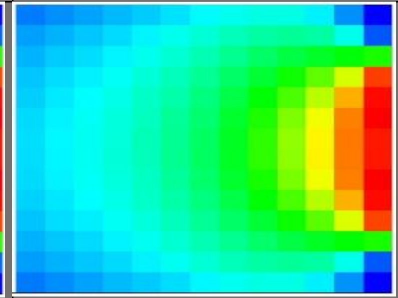
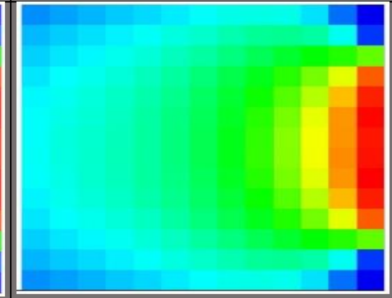
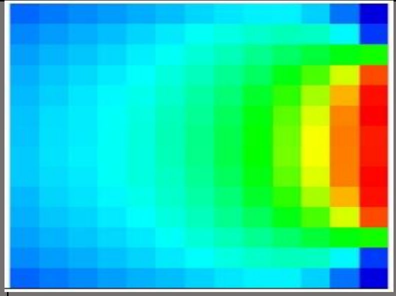
Results

Illuminance

	No Shade	Simple Overhang	Overhang+Sided-Fins	Louvers
				
	0-41269 Lux & 0-73.6 DF	0-38445 Lux & 0-68.6 DF	0-38446 Lux & 0-68.6 DF	0-38307 Lux & 0-68.3 DF
September, 21 at 9 am				
	0-2296 Lux & 0-3.1 DF	0-1927 Lux & 0-2.6 DF	0-1515 Lux & 0-2.0 DF	0-1964 Lux & 0-2.6 DF
September, 21 at Noon				
	0-1374 Lux & 0-3.0 DF	0-1227 Lux & 0-2.6 DF	0-916 Lux & 0-2.0 DF	0-1251 Lux & 0-2.7 DF
September, 21 at 3 pm				

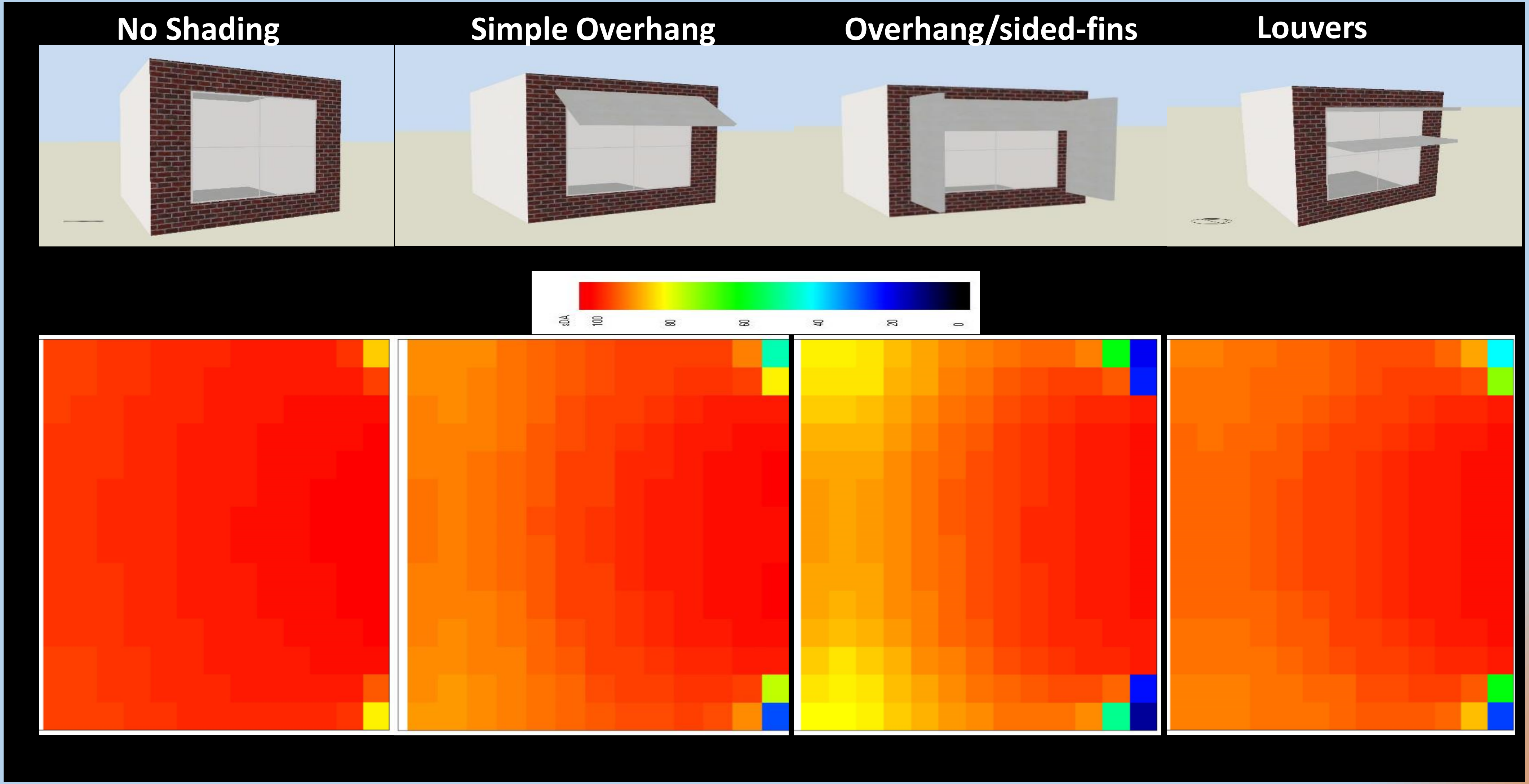
Results

Illuminance

	No Shade	Simple Overhang	Overhang+Sided-Fins	Louvers
				
	0-46427 Lux & 0-69.6 DF	0-45404 Lux & 0-68.1 DF	0-44840 Lux & 0-67.2 DF	0-45070 Lux & 0-67.6 DF
June , 21 at 9 am				
	0-4310 Lux & 0-4.6 DF	0-3209 Lux & 0-3.4 DF	0-2359 Lux & 0-2.5 DF	0-3061 Lux & 0-3.3 DF
June, 21 at Noon				
	0-1509 Lux & 0-2.4 DF	0-1341 Lux & 0-2.2 DF	0-1024 Lux & 0-1.6 DF	0-1395 Lux & 0-2.6 DF
June, 21 at 3 pm				

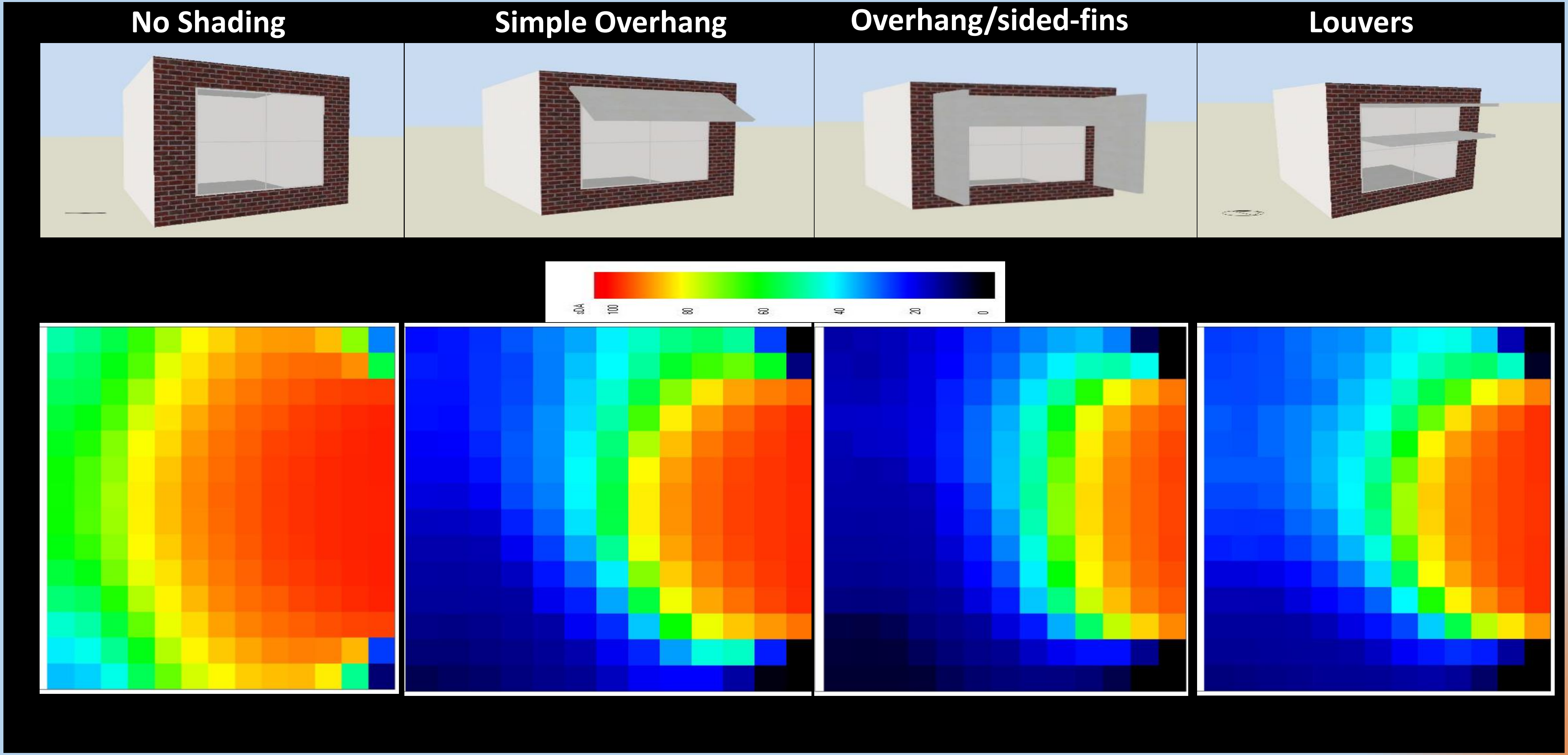
Results

Annual - sDA



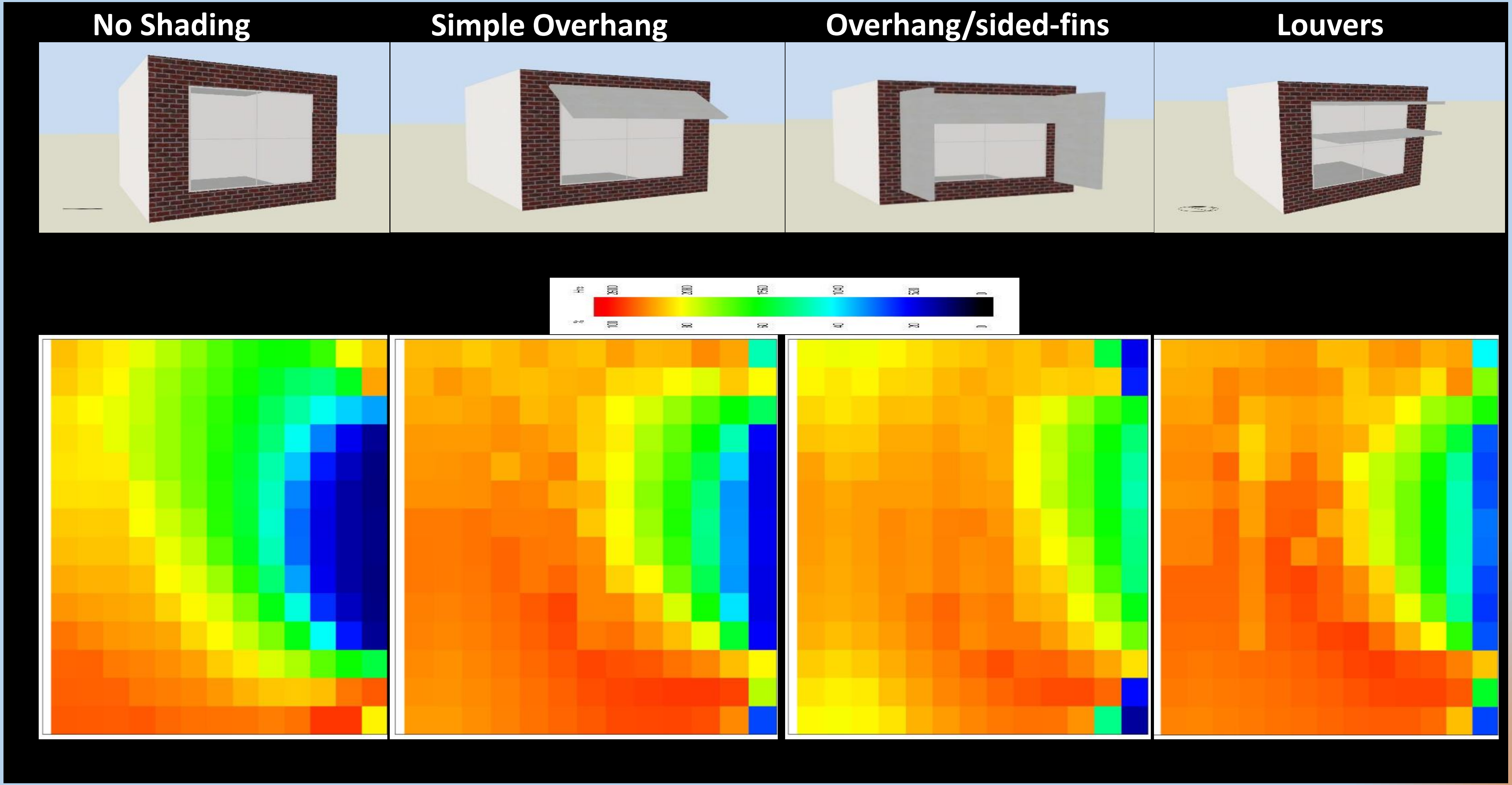
Results

Annual - ASE



Results

Annual-UDI



Conclusions

- Shading devices, overhang/sided-fins, louvers, and simple overhang, in East orientation saved 27, 25, and 24% respectively.
- It is only 3% different between the optimum solutions.
- Illuminance and annual daylighting proved that the louvers shadings performed the best.
- Louvers shading was less risk to visual discomfort as interpreted by the ASE assessment.
- Consequently louvers shading has a better UDI.

The architect can select optimum efficient shading devices that keep the building's aesthetic to their preferences without prejudicing the energy efficiency.

Future Work

- The effect of including INTERIOR BLINDS might enrich the analysis.
- Optimum shading devices of OTHER orientations.
- LIFE-CYCLE COST ANALYSIS of optimum solutions.

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