



# ALGORITHMIC DESIGN AND PERFORMANCE ANALYSIS OF ADAPTIVE FAÇADES

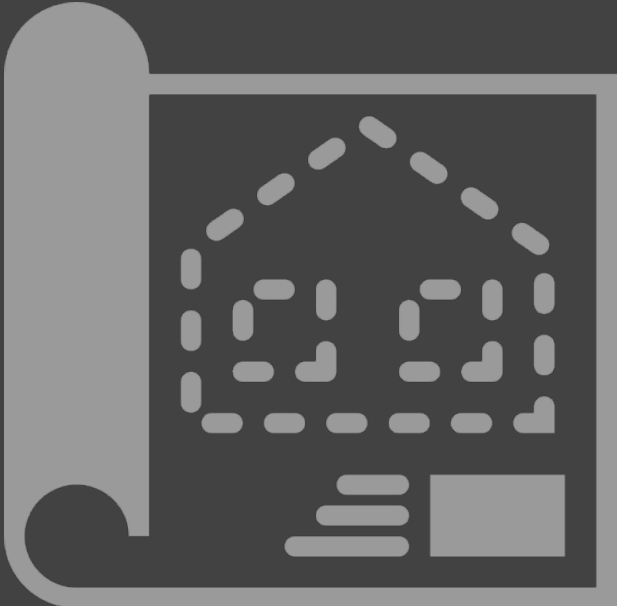


Helena Martinho  
Catarina Belém  
António Leitão  
Roel Loonen  
Maria Gomes

# PERFORMANCE CONSIDERATIONS



# PERFORMANCE CONSIDERATIONS



Aesthetics

# PERFORMANCE CONSIDERATIONS



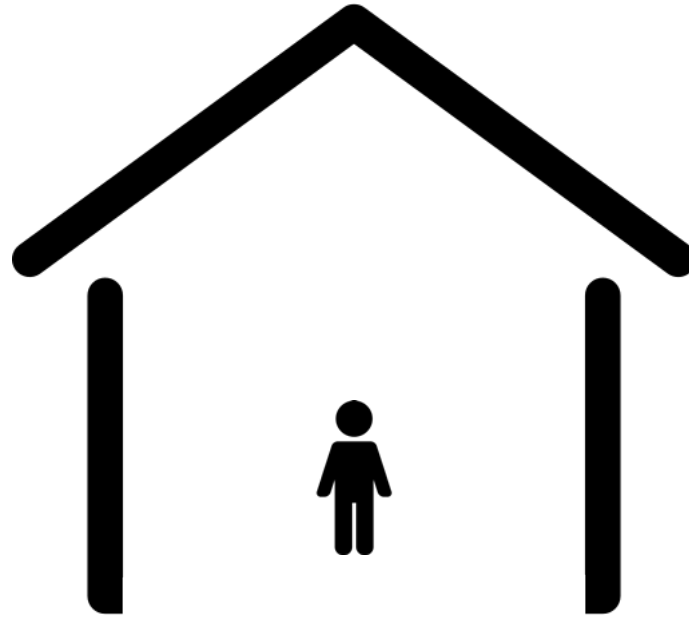
Context

# PERFORMANCE CONSIDERATIONS



Occupancy

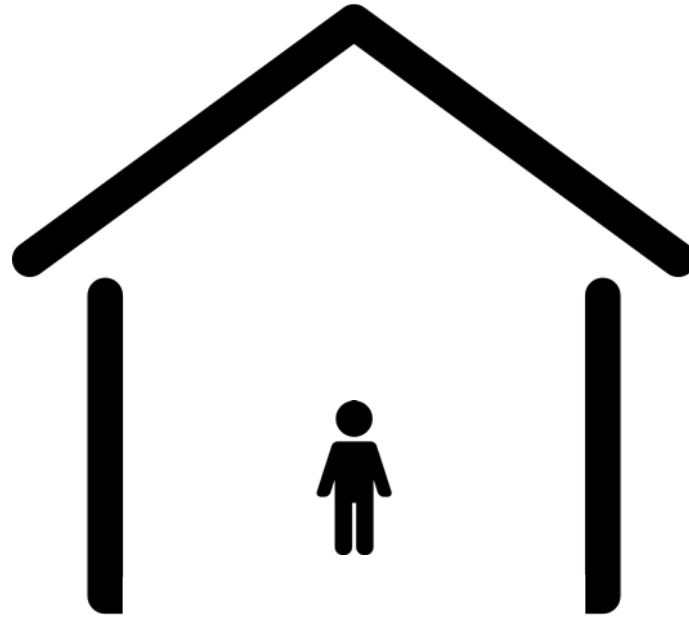
# THE BUILDING ENVELOPE



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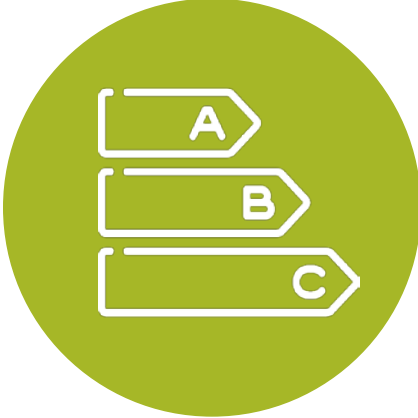
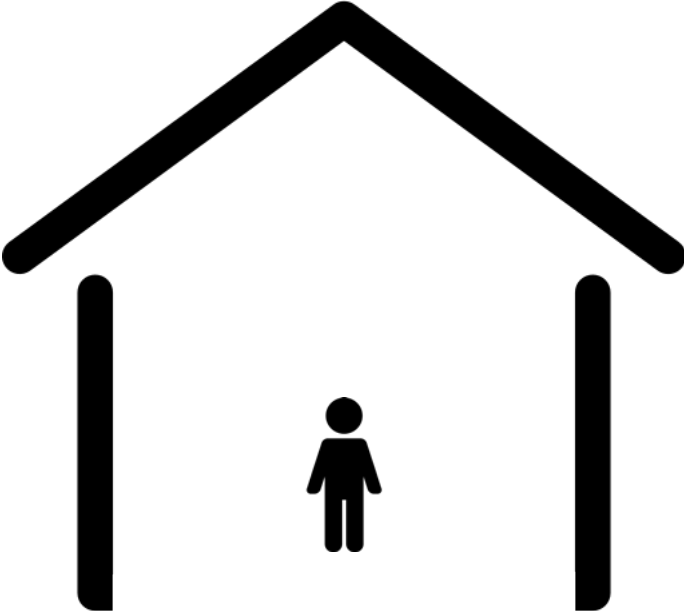
Structural



# THE BUILDING ENVELOPE



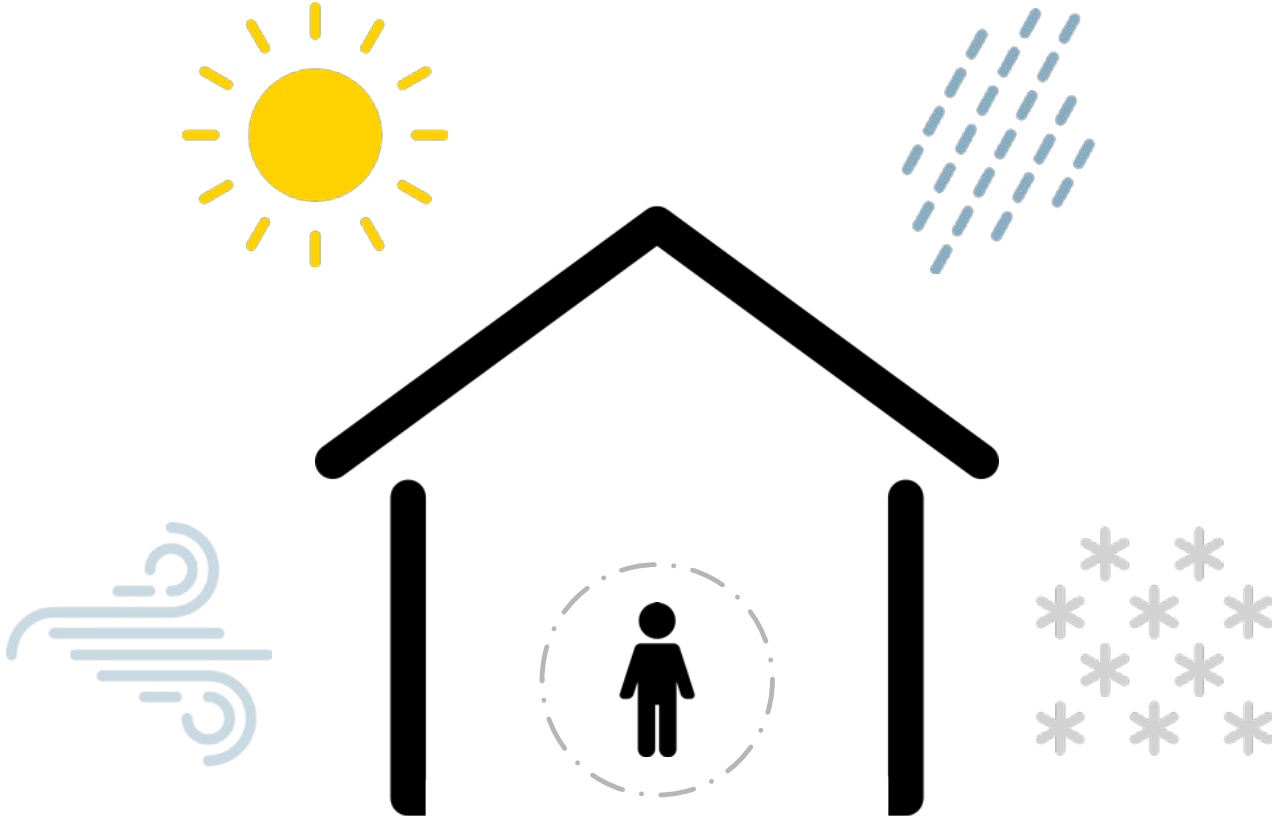
Structural



Energy efficiency



# THE BUILDING ENVELOPE

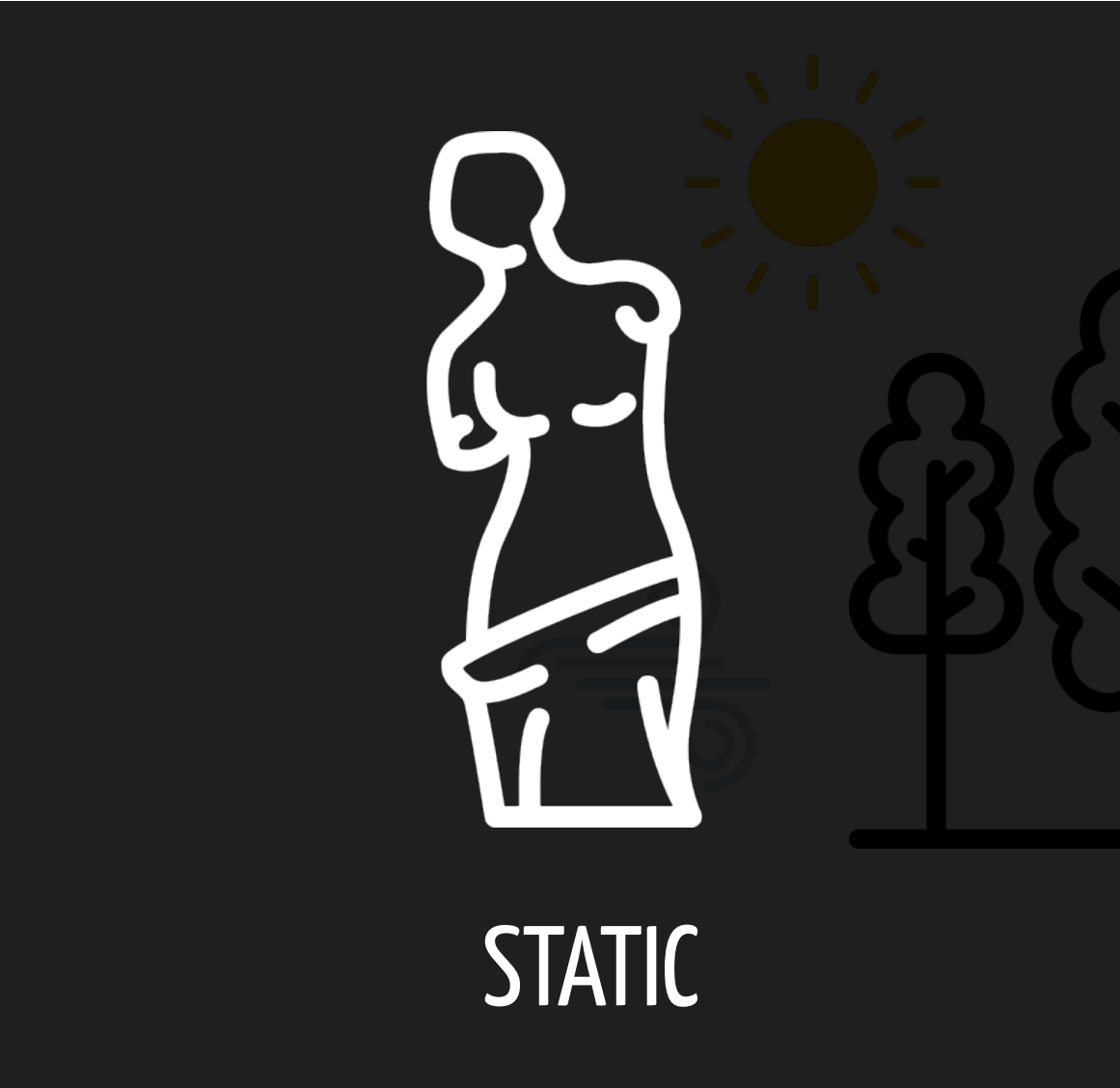


Weathertightness

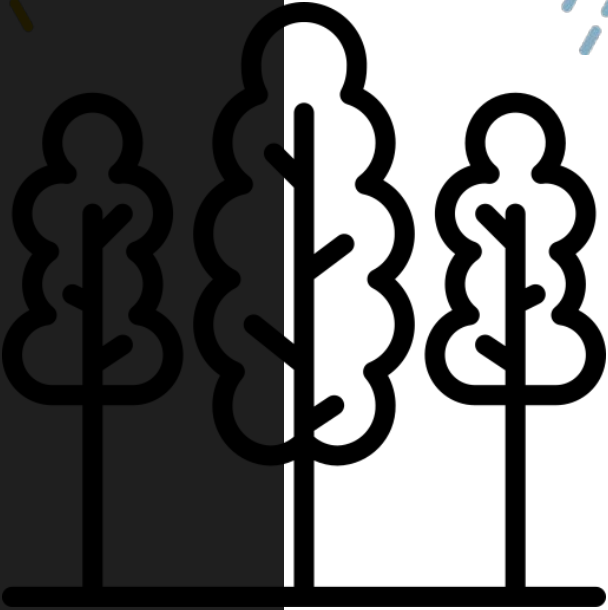
# THE BUILDING ENVELOPE



THE BUILDING ENVELOPE



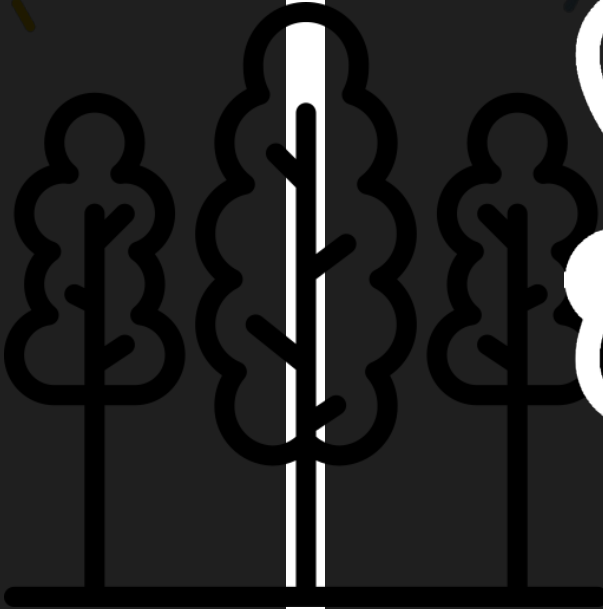
STATIC



THE BUILDING ENVELOPE

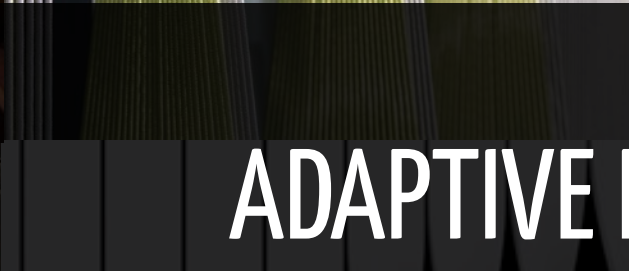
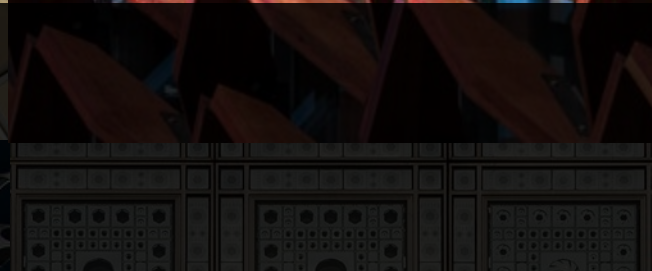
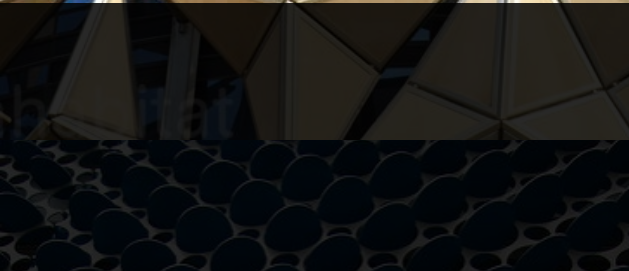


STATIC

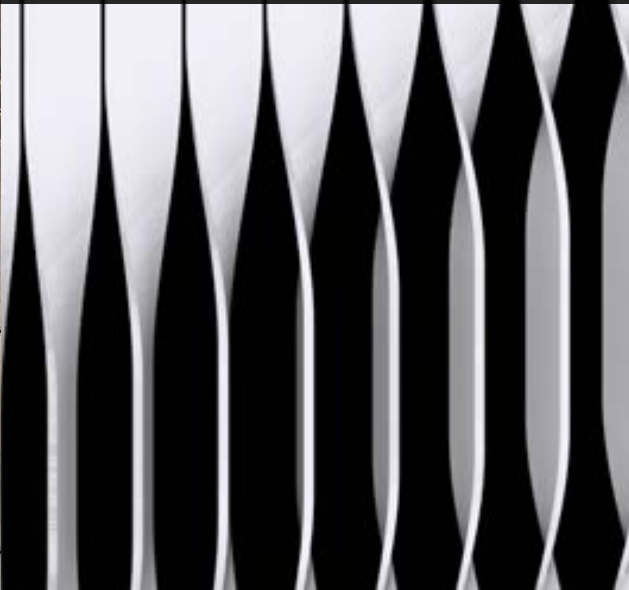
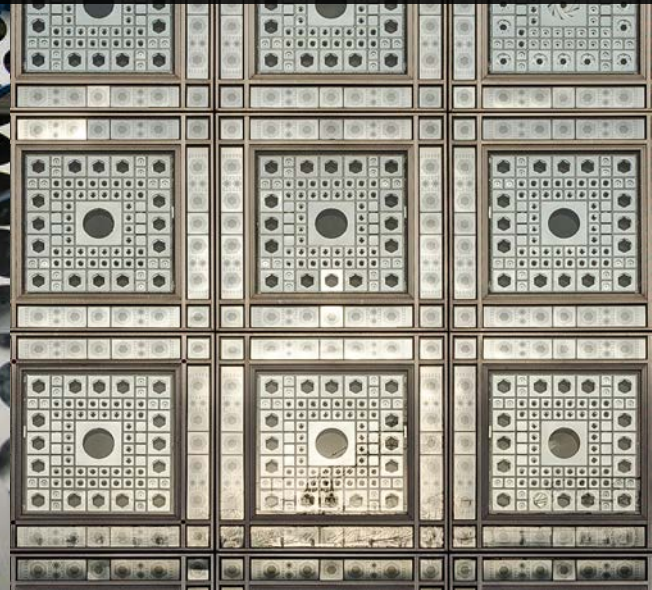


DYNAMIC





# ADAPTIVE FAÇADES









ADAPT TO



Environmental  
changes



User needs





ADAPT TO



Environmental changes



User needs

FOCUS



Increase efficiency



Reduce energy consumption



## ADAPT TO



Environmental  
changes



User needs

## FOCUS



Increase  
efficiency



Reduce energy  
consumption

## LIMITATIONS

- Increased building cost



## ADAPT TO



Environmental  
changes



User needs

## FOCUS



Increase  
efficiency

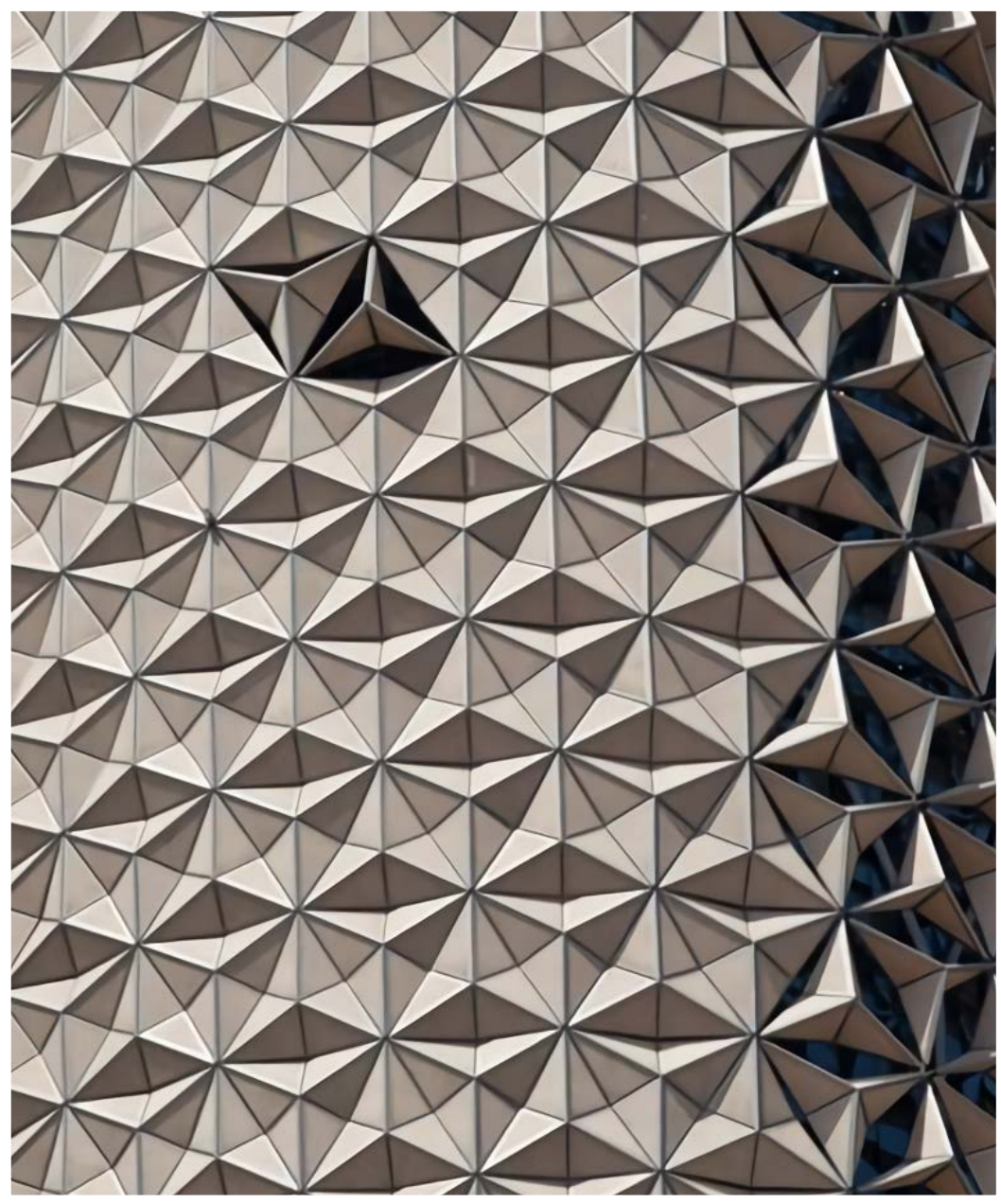


Reduce energy  
consumption

## LIMITATIONS

- Increased building cost
- Need for maintenance





## LIMITATIONS

- Increased building cost
- Need for maintenance



## ADAPT TO



Environmental  
changes

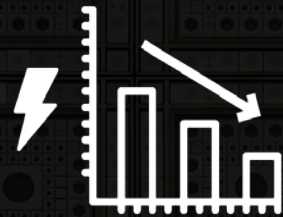


User needs

## FOCUS



Increase  
efficiency



Reduce energy  
consumption

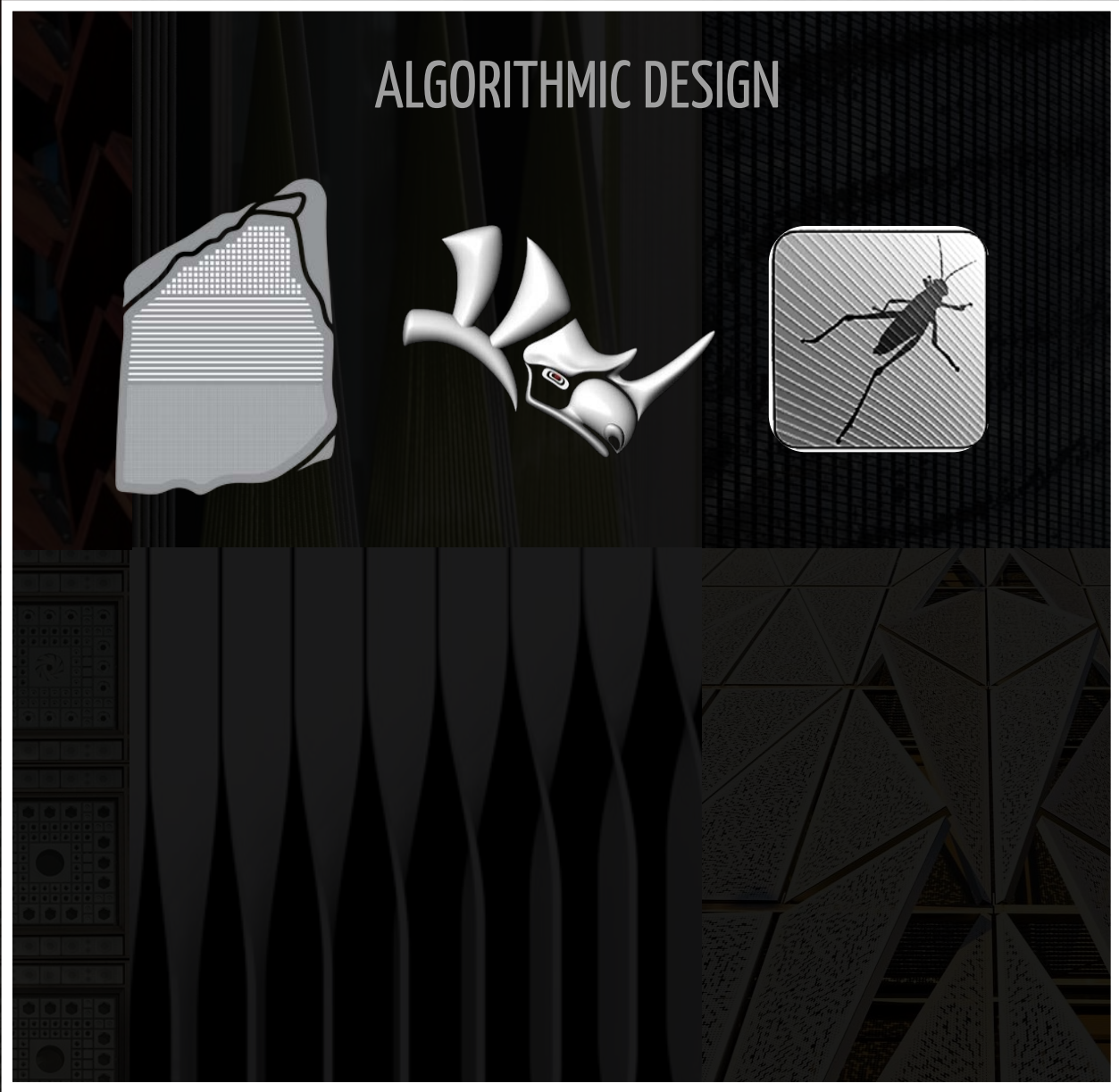
## LIMITATIONS

- Increased building cost
- Need for maintenance
- Static simulation models





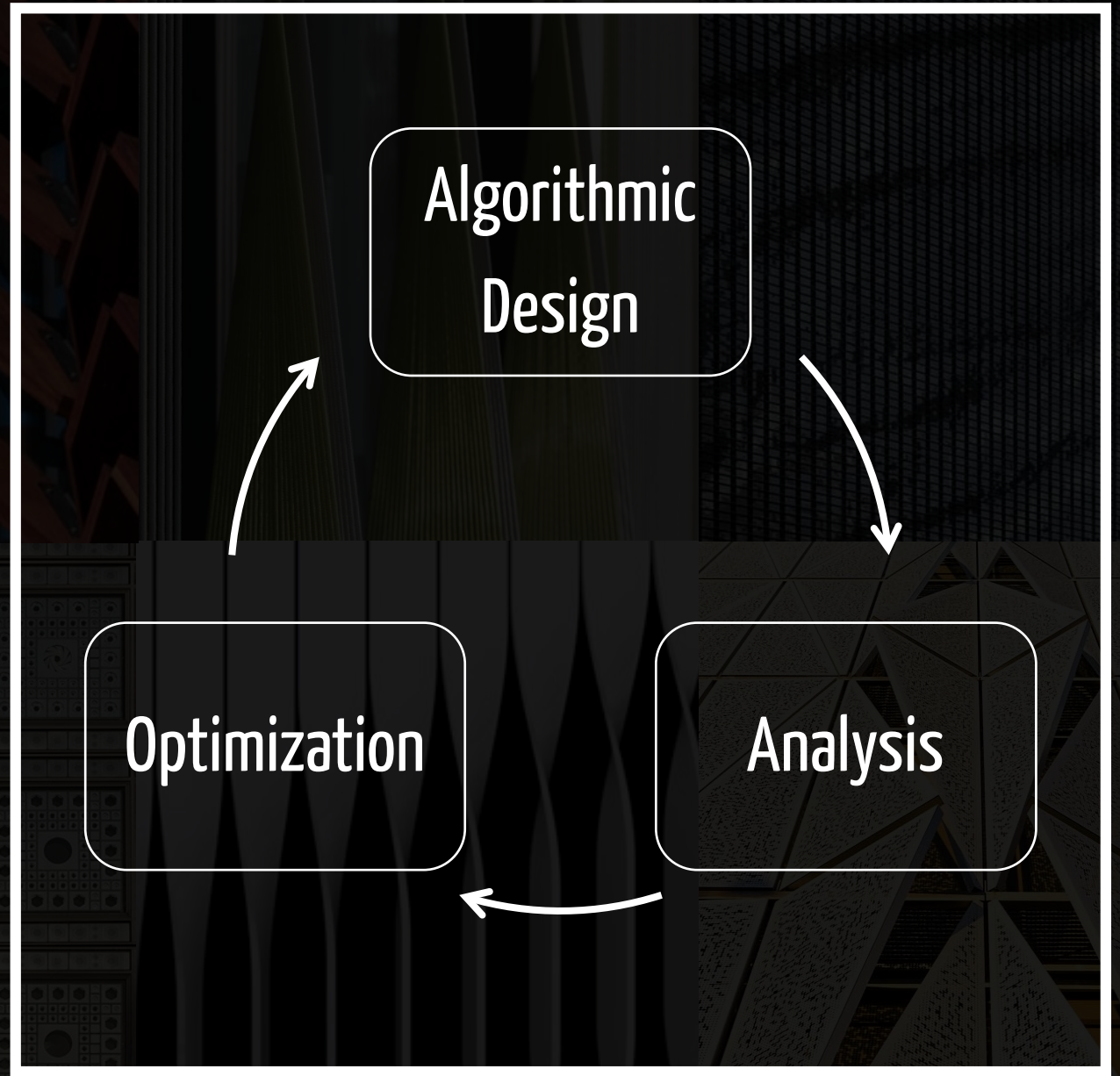




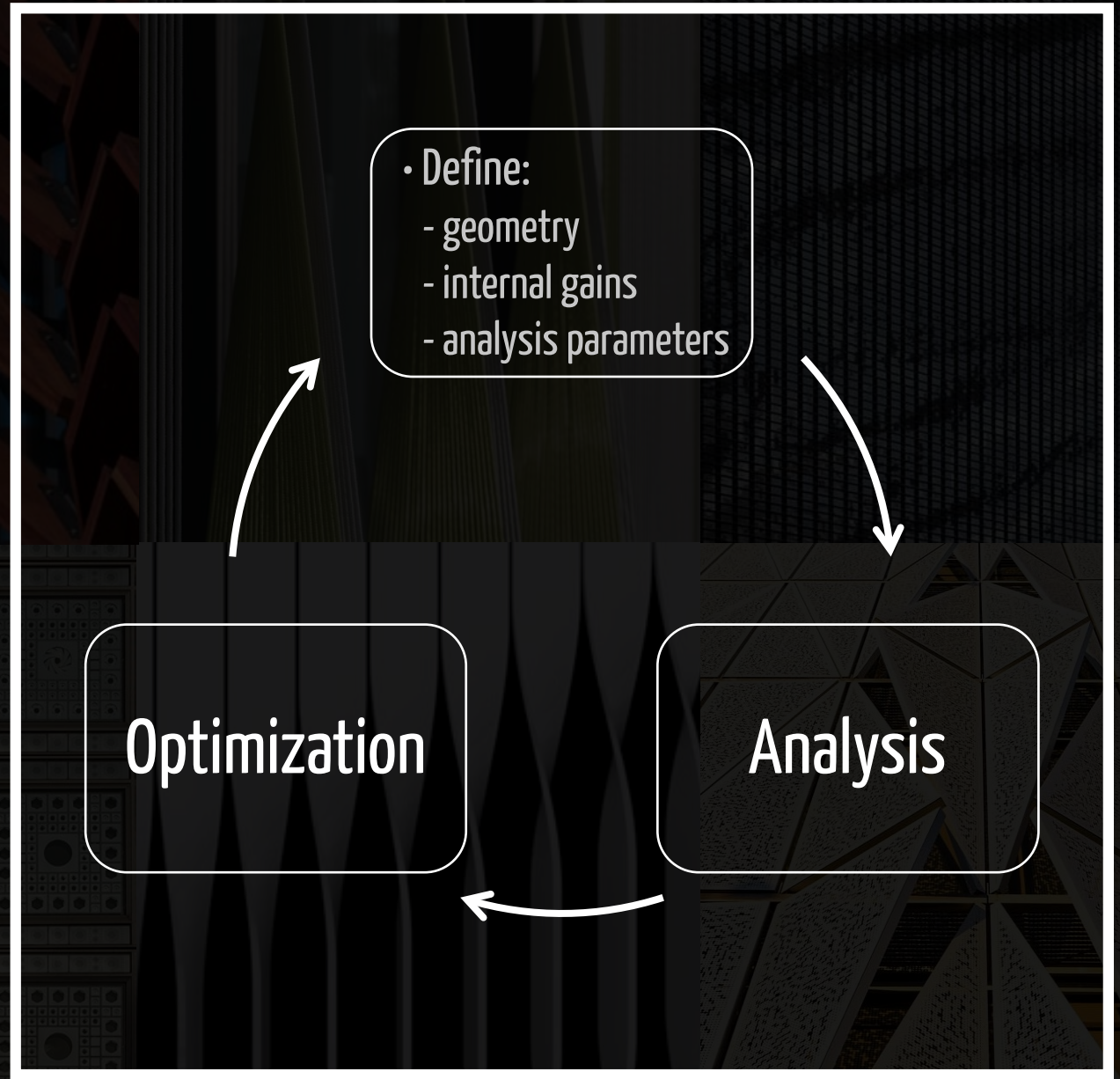




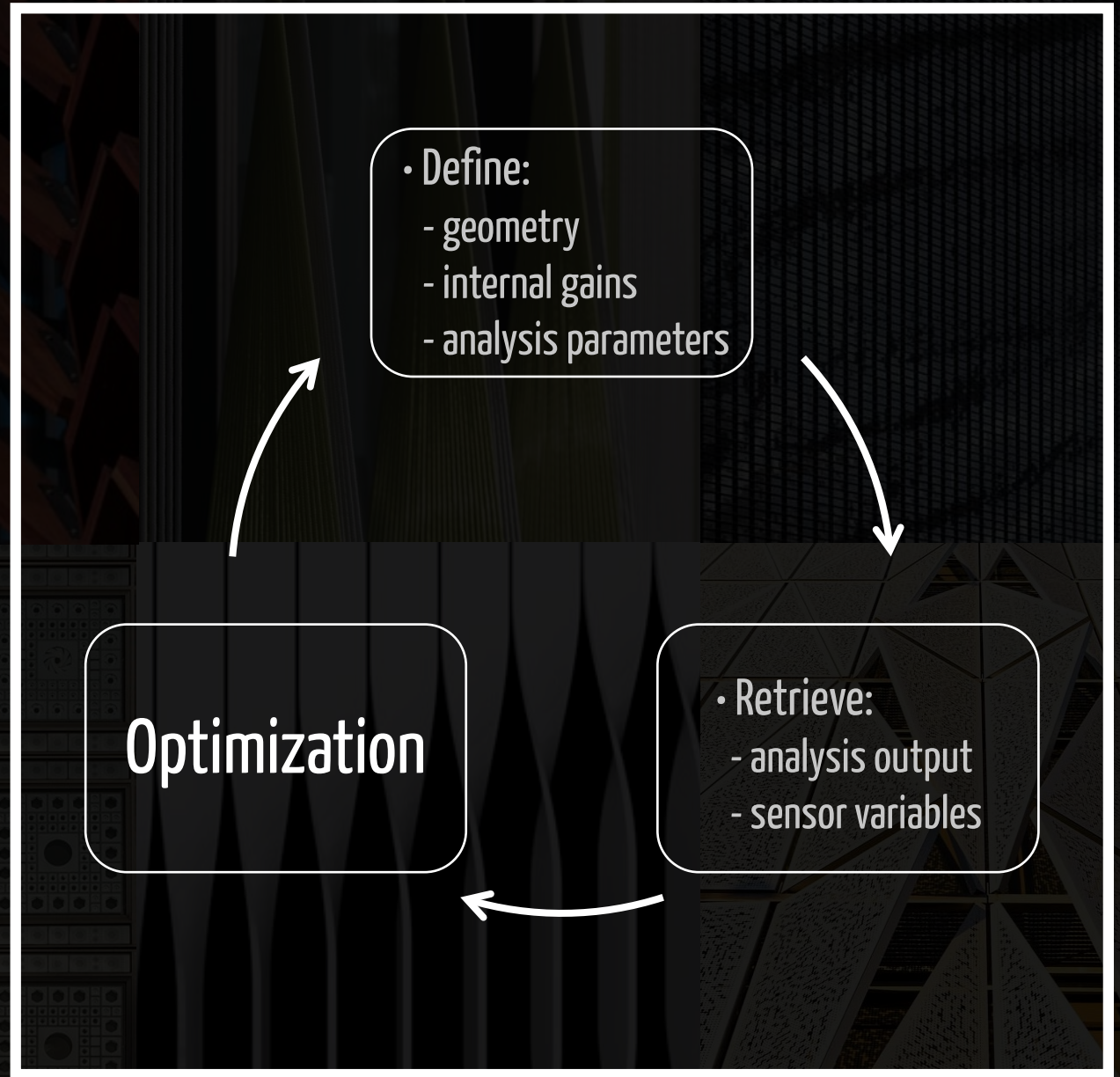




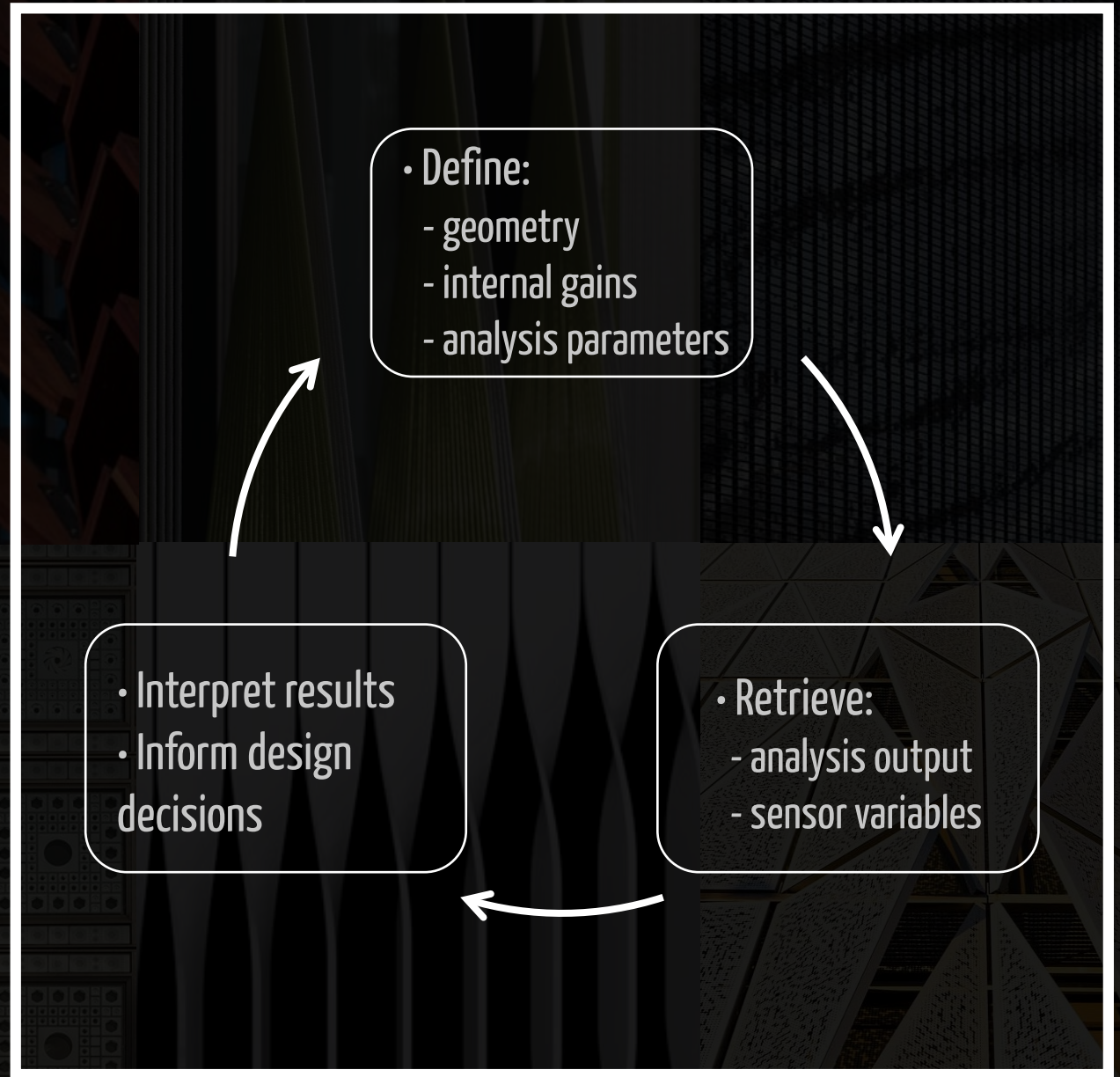








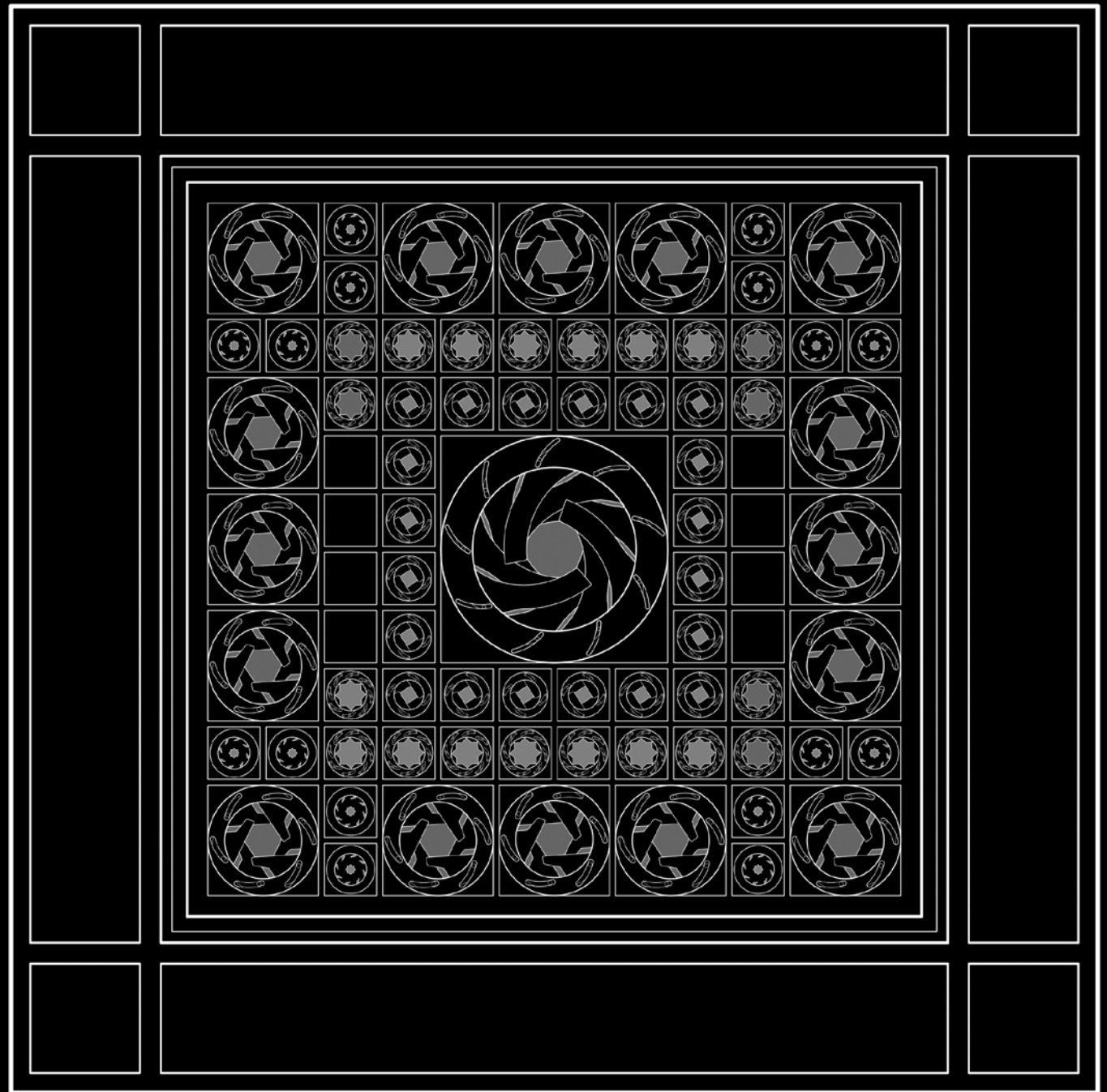
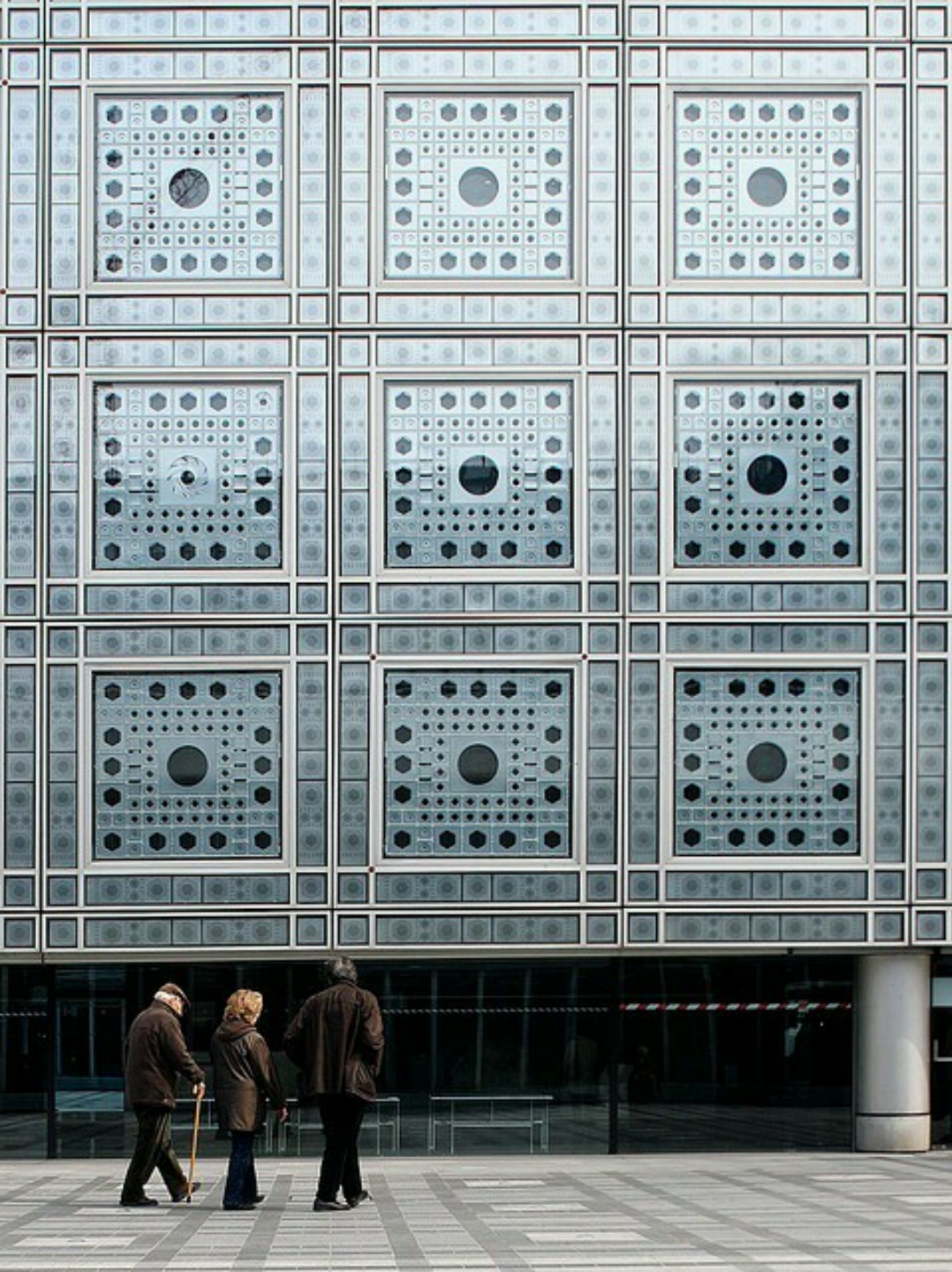




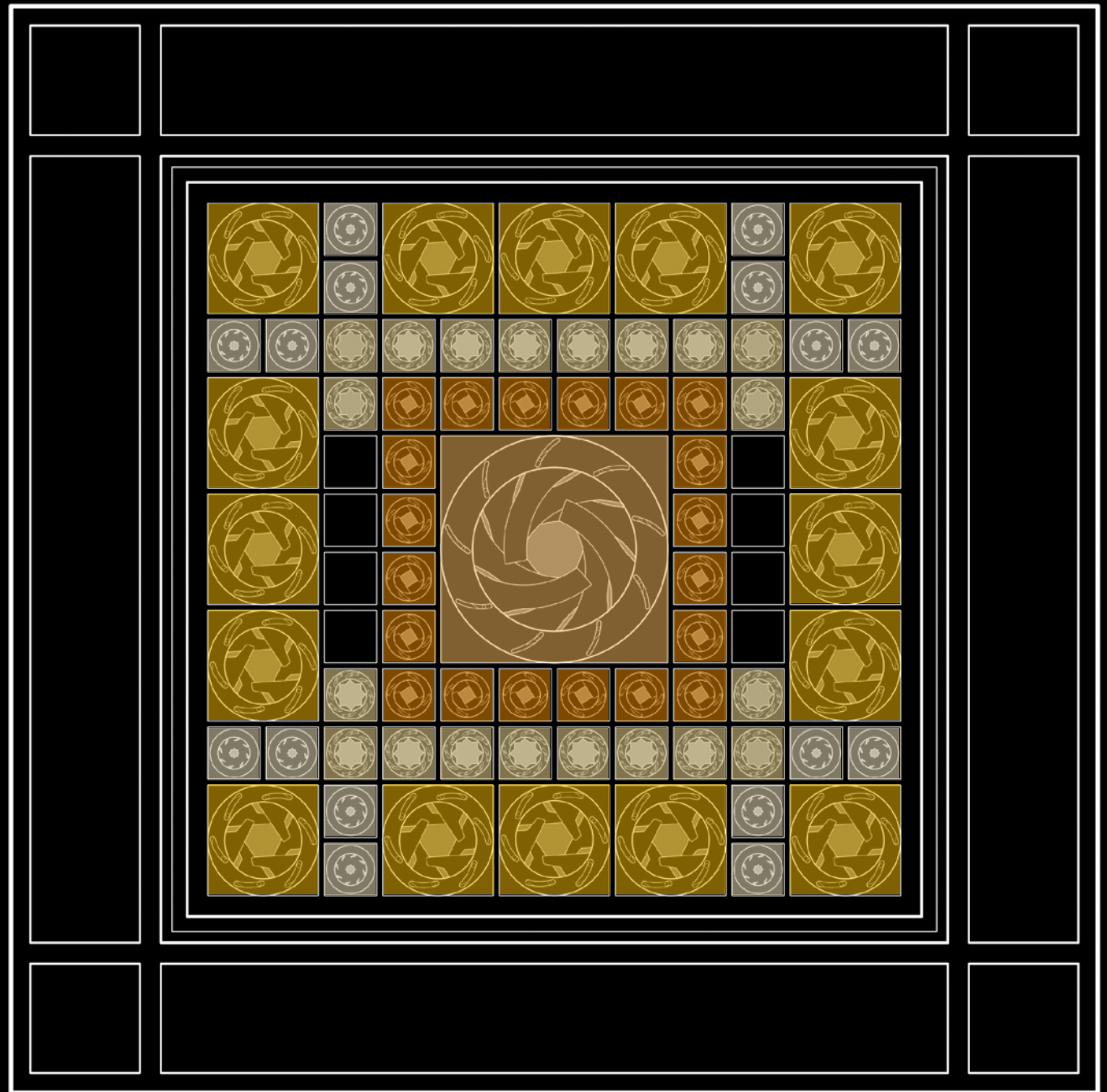
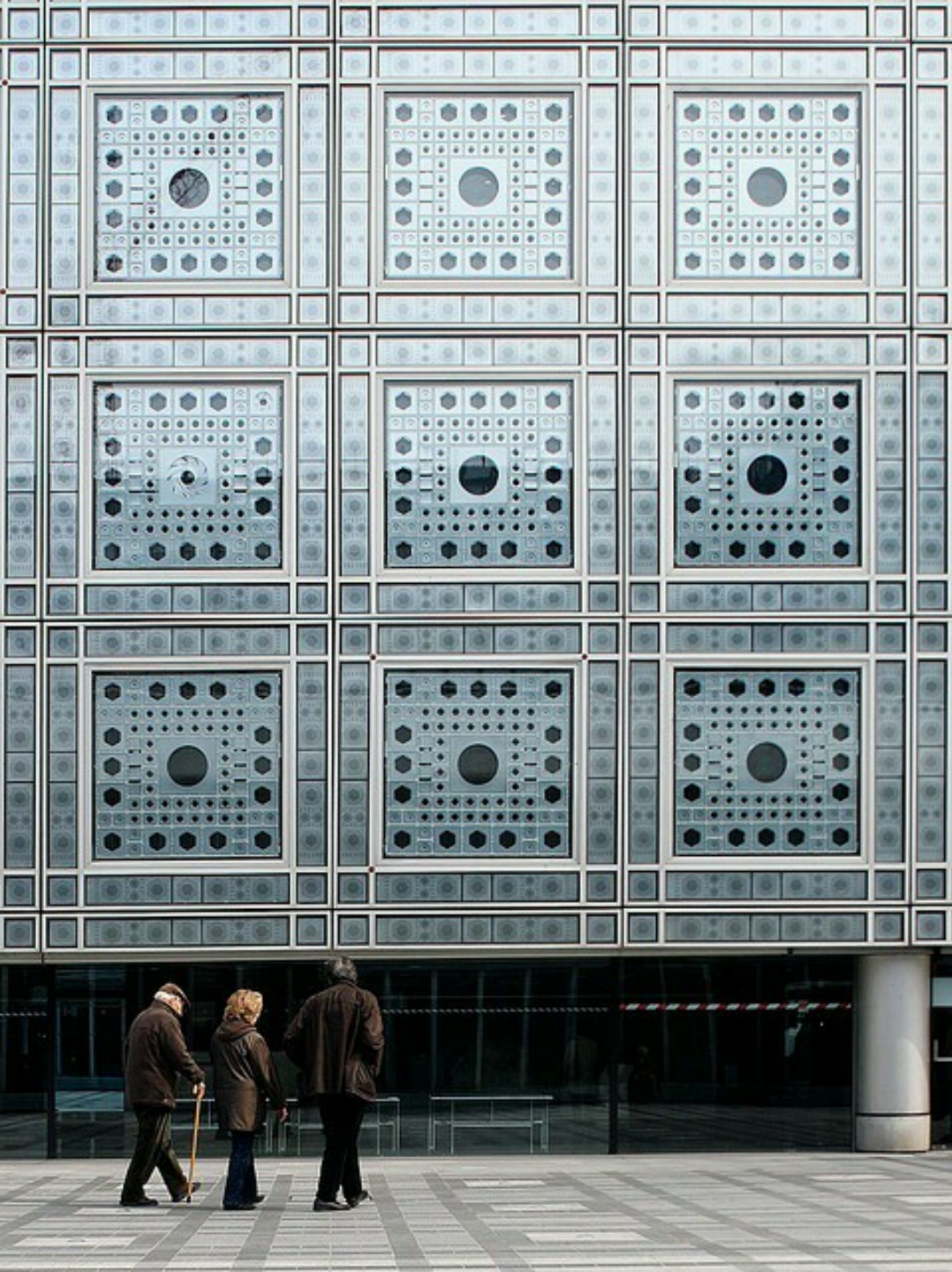


# THE ARAB WORLD INSTITUTE: A CASE STUDY



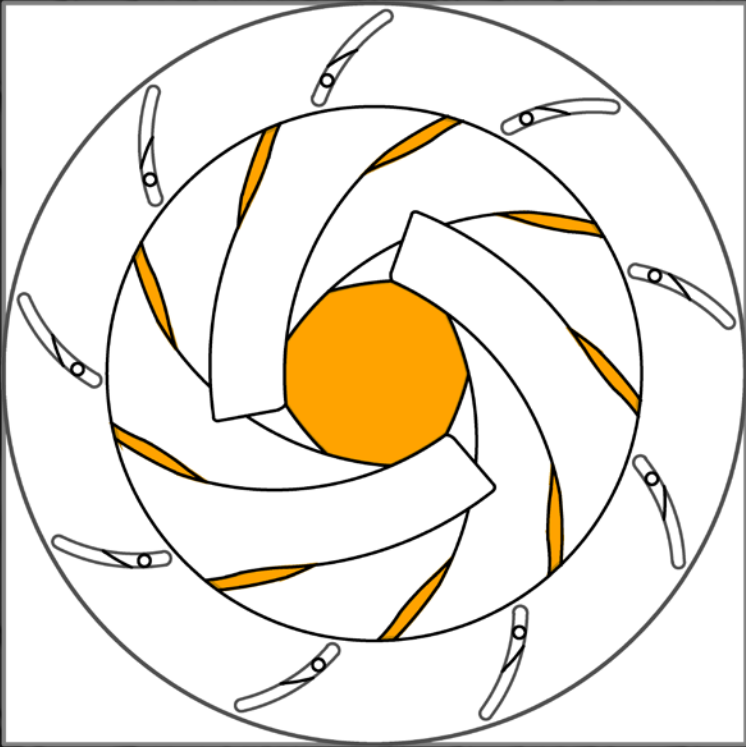
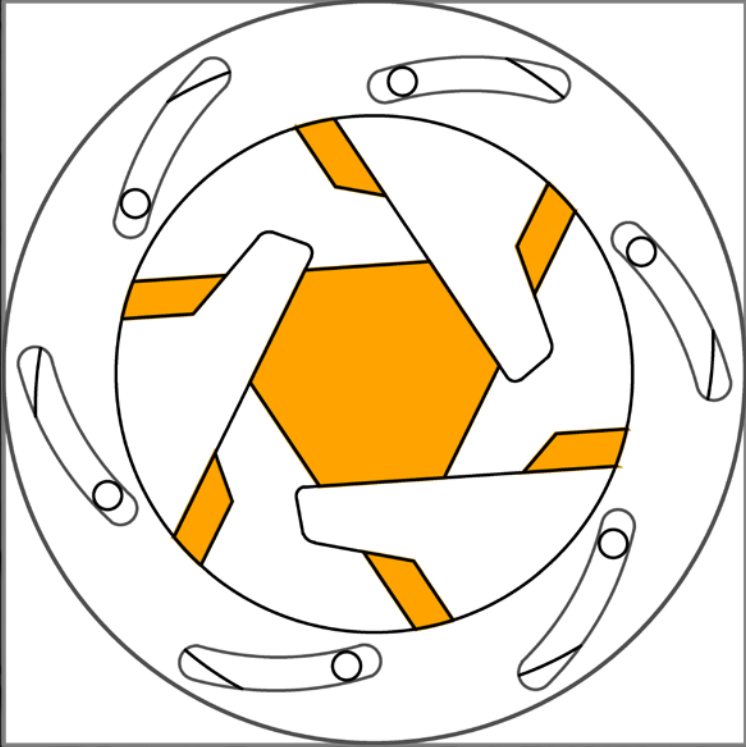




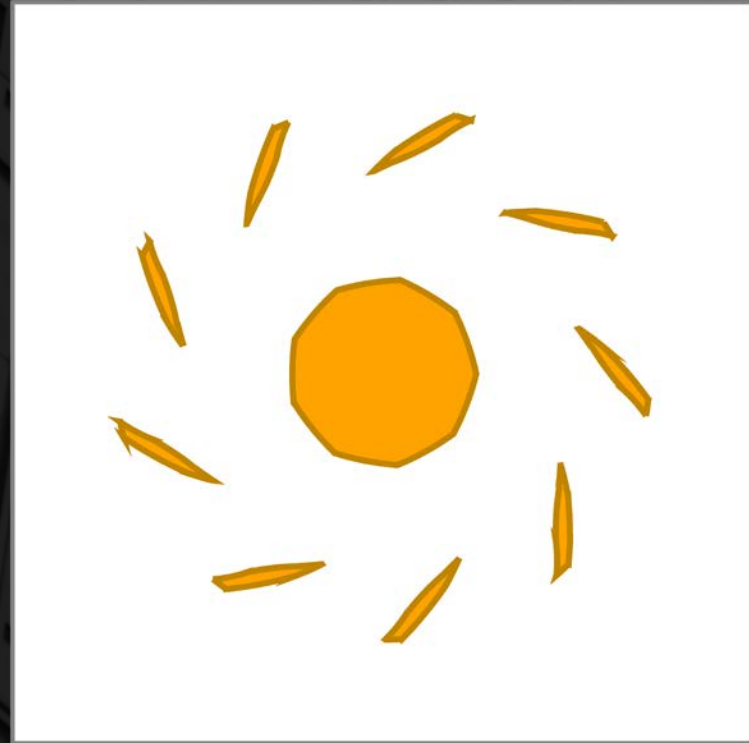
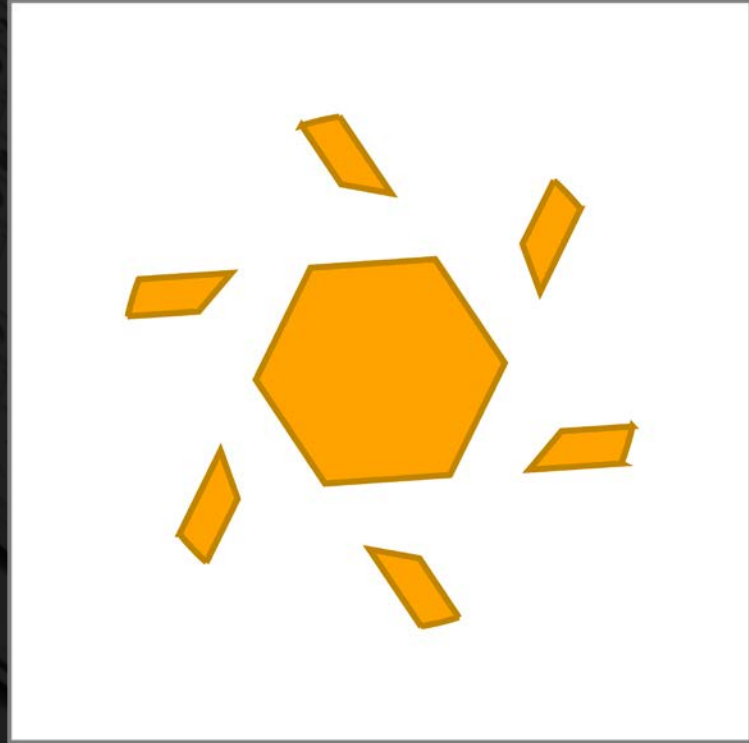




# GEOMETRY SIMPLIFICATION

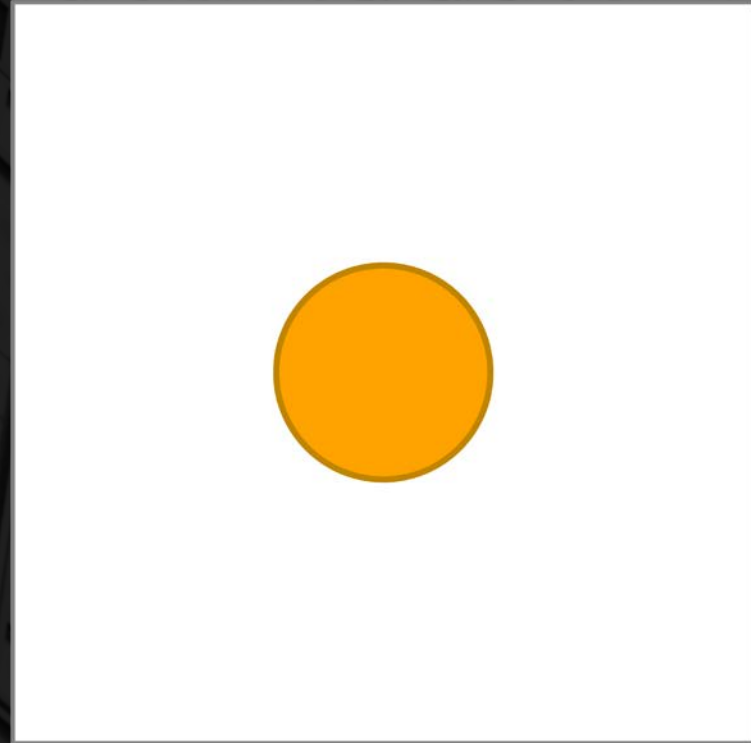
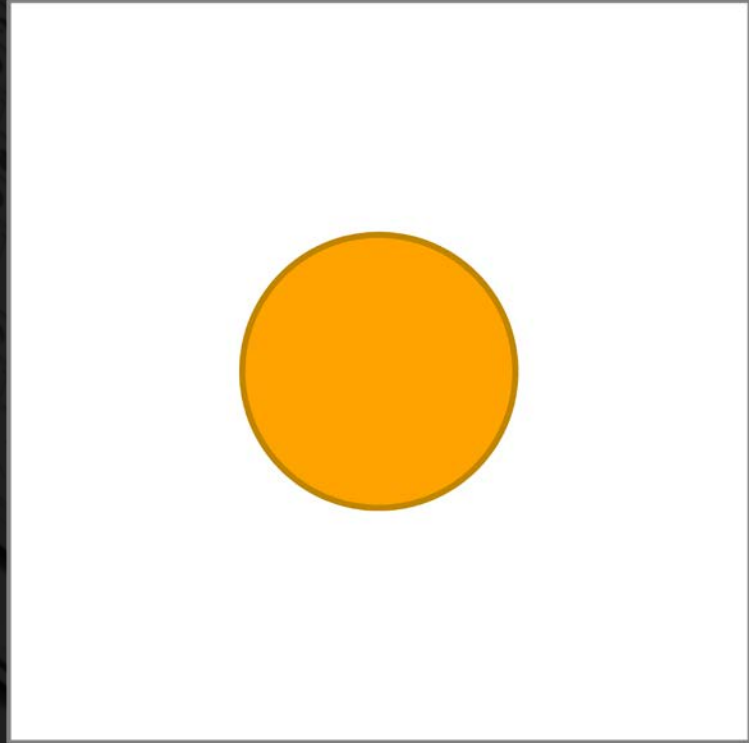


# GEOMETRY SIMPLIFICATION





# GEOMETRY SIMPLIFICATION



# SIMULATION

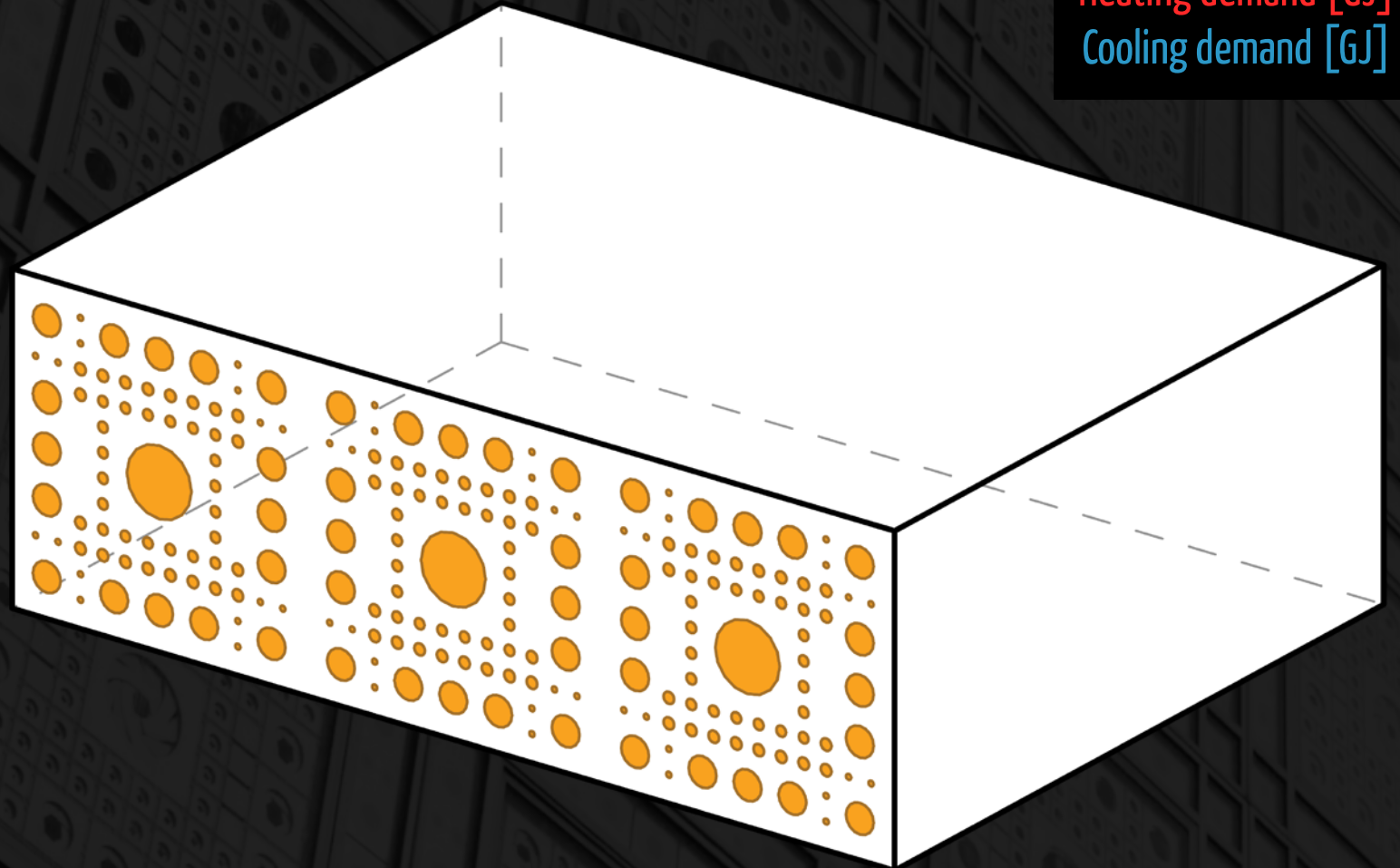
SIMULATION PERIOD

12 months

REQUESTED OUTPUT

Heating demand [GJ]

Cooling demand [GJ]



# SIMULATION TIME



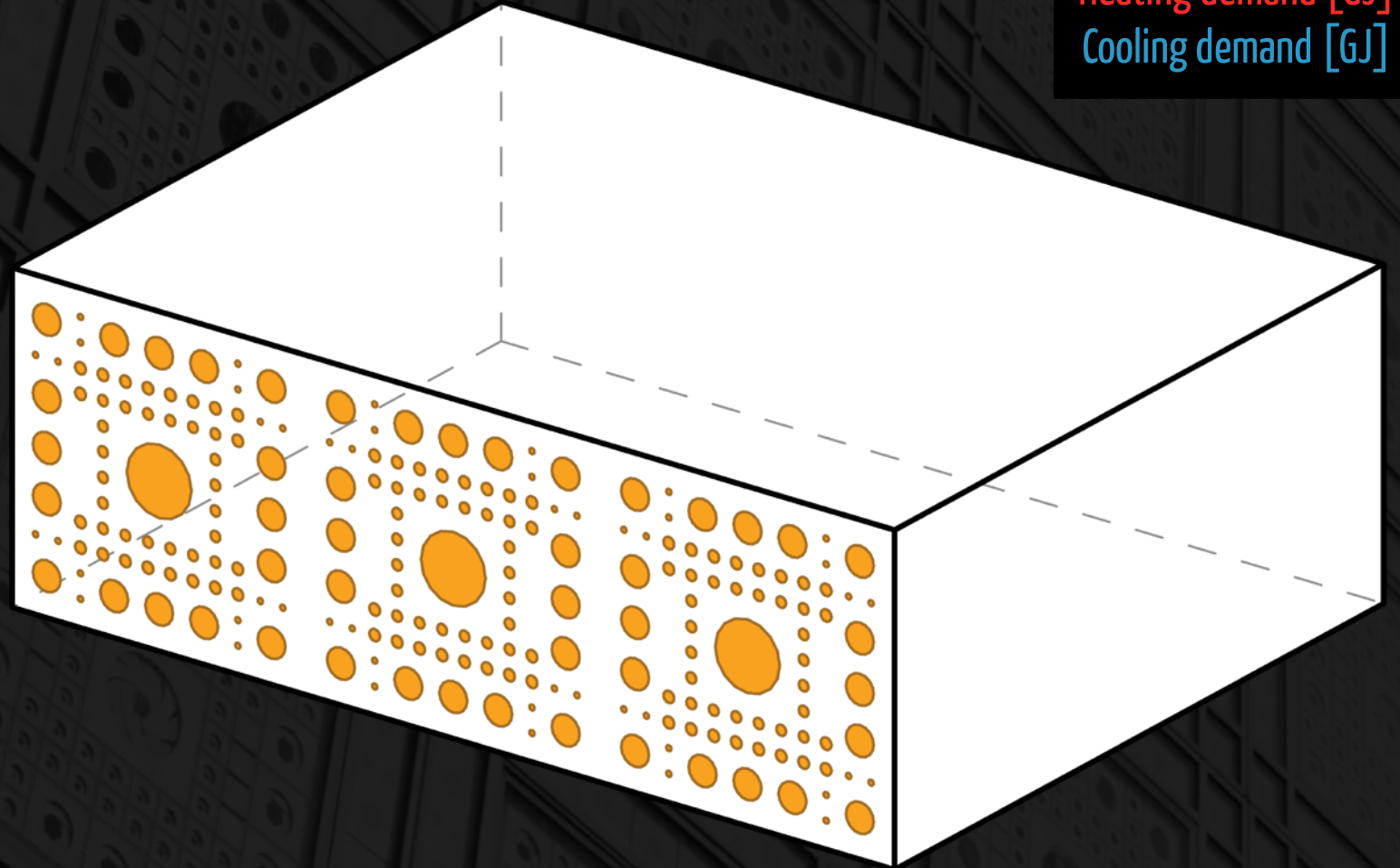
16 SIDES  
6h 30min

SIMULATION PERIOD  
12 months

REQUESTED OUTPUT

Heating demand [GJ]

Cooling demand [GJ]



## SIMULATION TIME



16 SIDES  
6h 30min



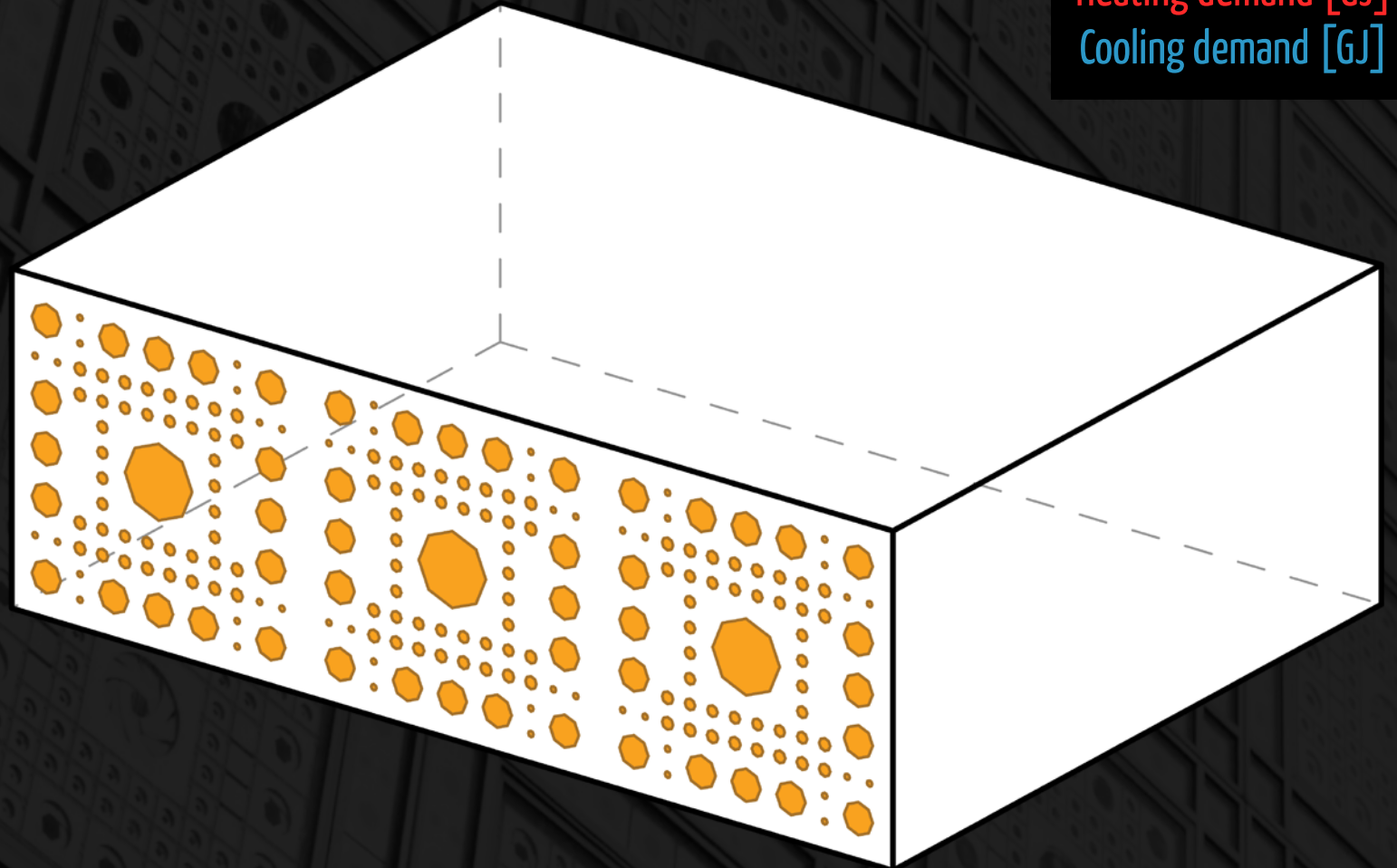
8 SIDES  
34min 30sec

SIMULATION PERIOD  
12 months

REQUESTED OUTPUT

Heating demand [GJ]

Cooling demand [GJ]





## SIMULATION TIME



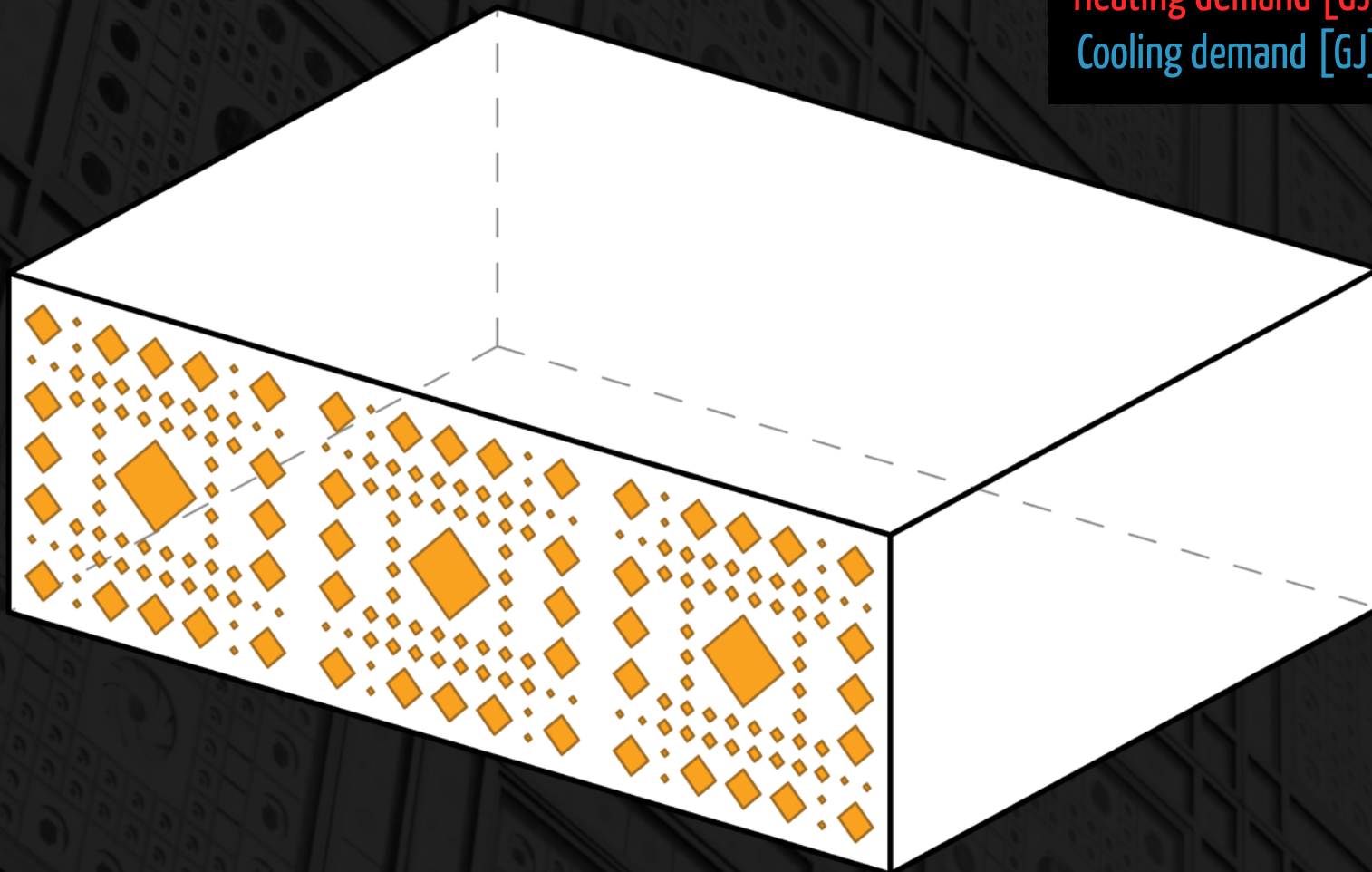
16 SIDES  
6h 30min



8 SIDES  
34min 30sec



4 SIDES  
6min 50sec



SIMULATION PERIOD  
12 months

REQUESTED OUTPUT  
Heating demand [GJ]  
Cooling demand [GJ]

# SIMULATION TIME



16 SIDES  
6h 30min



8 SIDES  
34min 30sec



4 SIDES  
6min 50sec



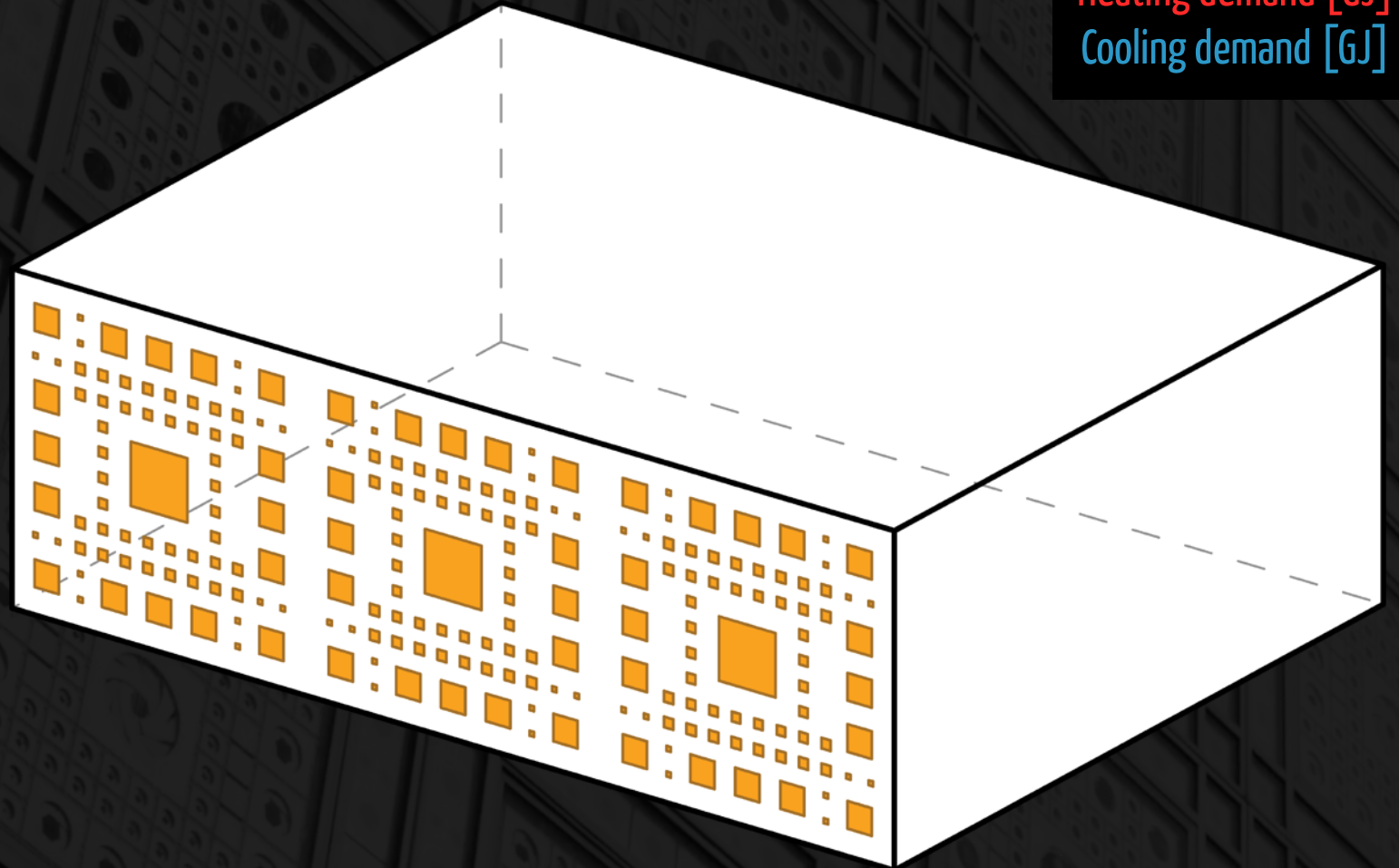
4 SIDES  
1min 30sec

SIMULATION PERIOD  
12 months

REQUESTED OUTPUT

Heating demand [GJ]

Cooling demand [GJ]

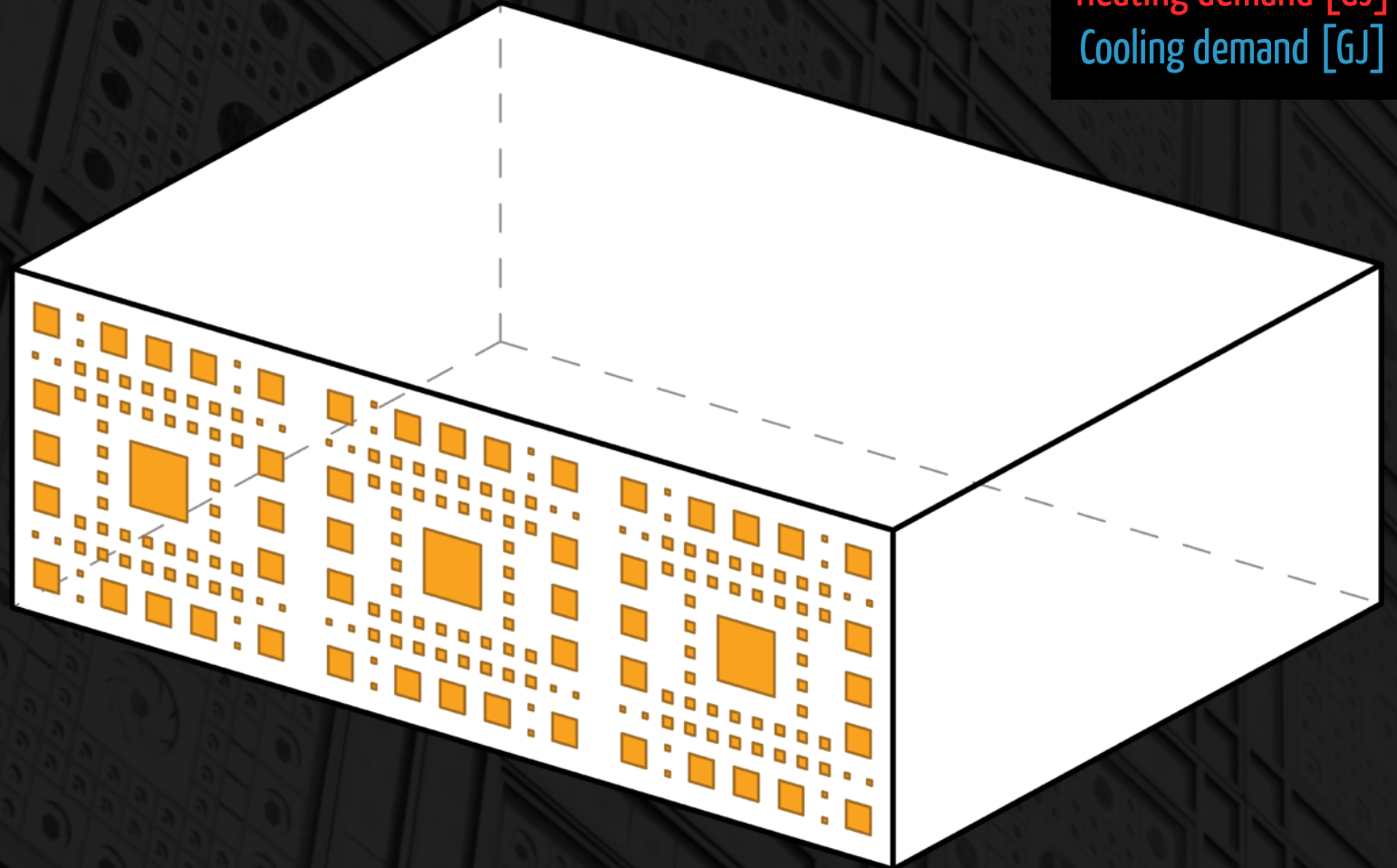


# SIMULATION OUTPUT

	16 SIDES 15.162 5.896
	8 SIDES 15.134 5.901
	4 SIDES 15.114 5.903
	4 SIDES 15.096 5.905

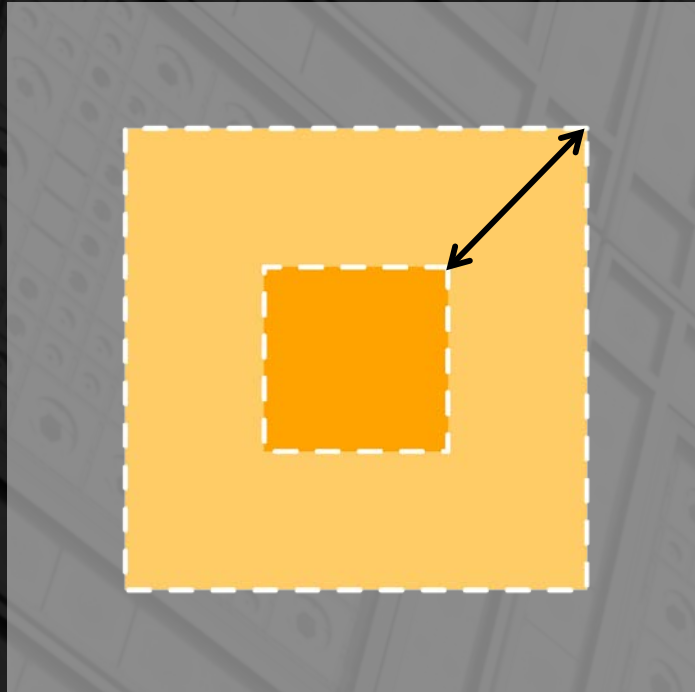
SIMULATION PERIOD  
12 months

REQUESTED OUTPUT  
Heating demand [GJ]  
Cooling demand [GJ]





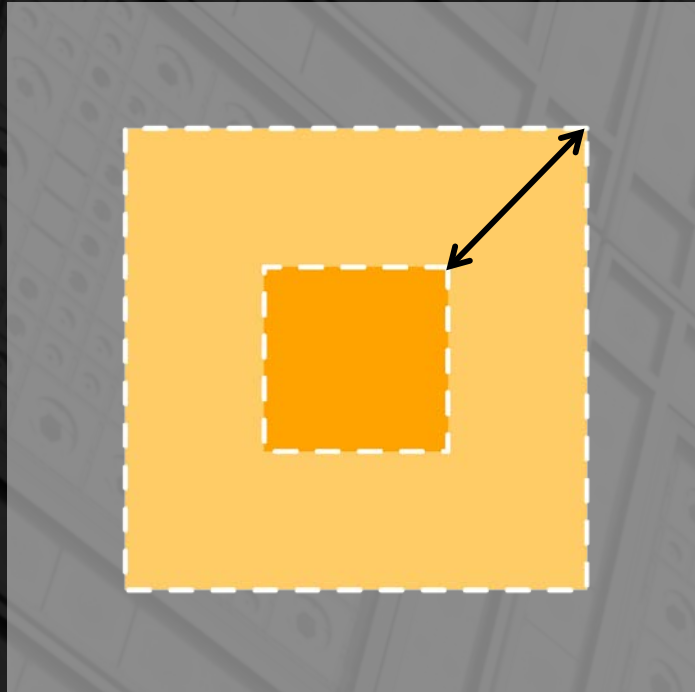
# ANALYSIS



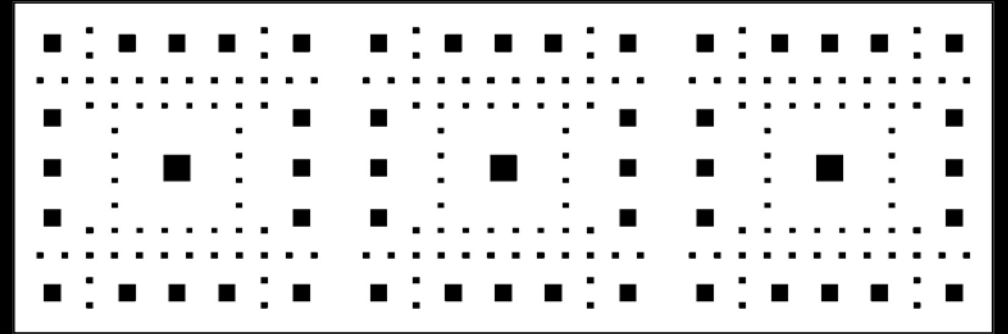
Diaphragm opening factor ( $f$ )



# ANALYSIS

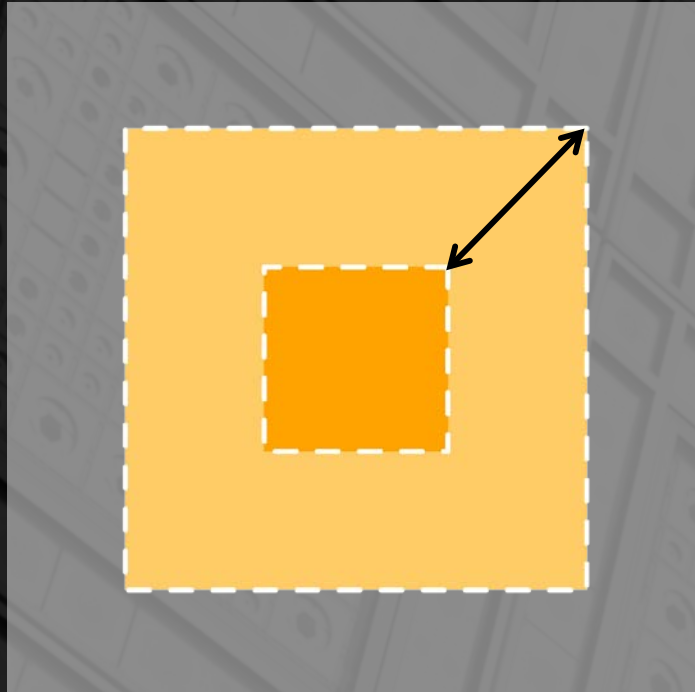


Diaphragm opening factor ( $f$ )

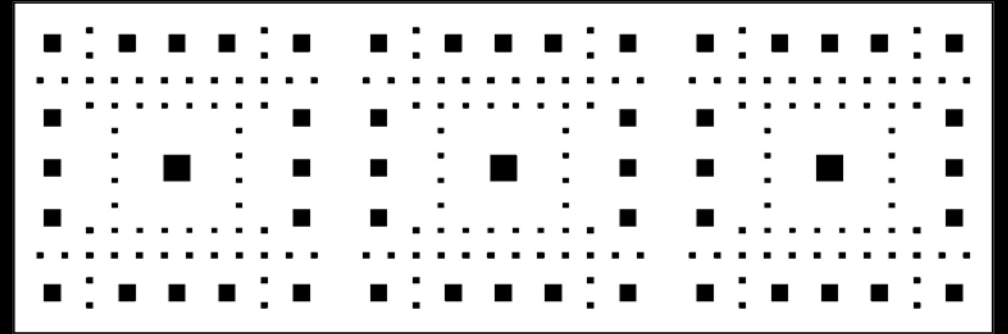


$f=0$

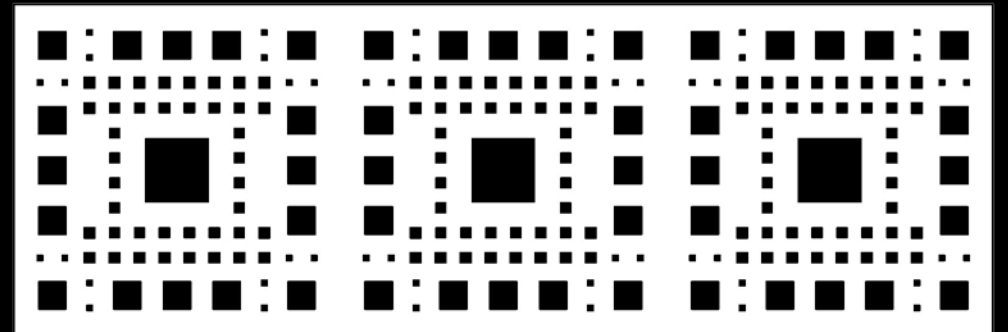
# ANALYSIS



Diaphragm opening factor ( $f$ )



$f=0$



$f=1$



# ANALYSIS

## SIMULATION PERIOD

12 months

## REQUESTED OUTPUT

Heating demand

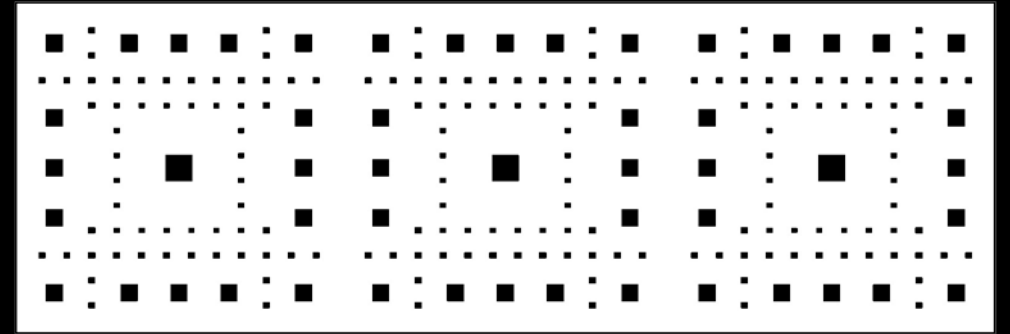
Cooling demand

Lighting demand

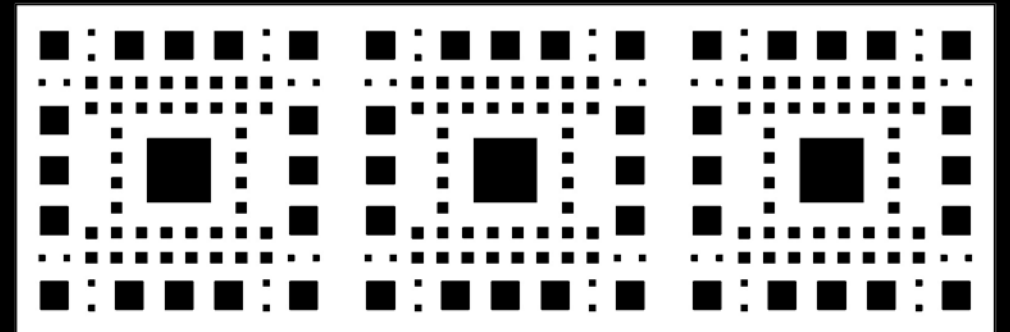
## SENSOR VARIABLES

Façade incident solar radiation

Outdoor temperature

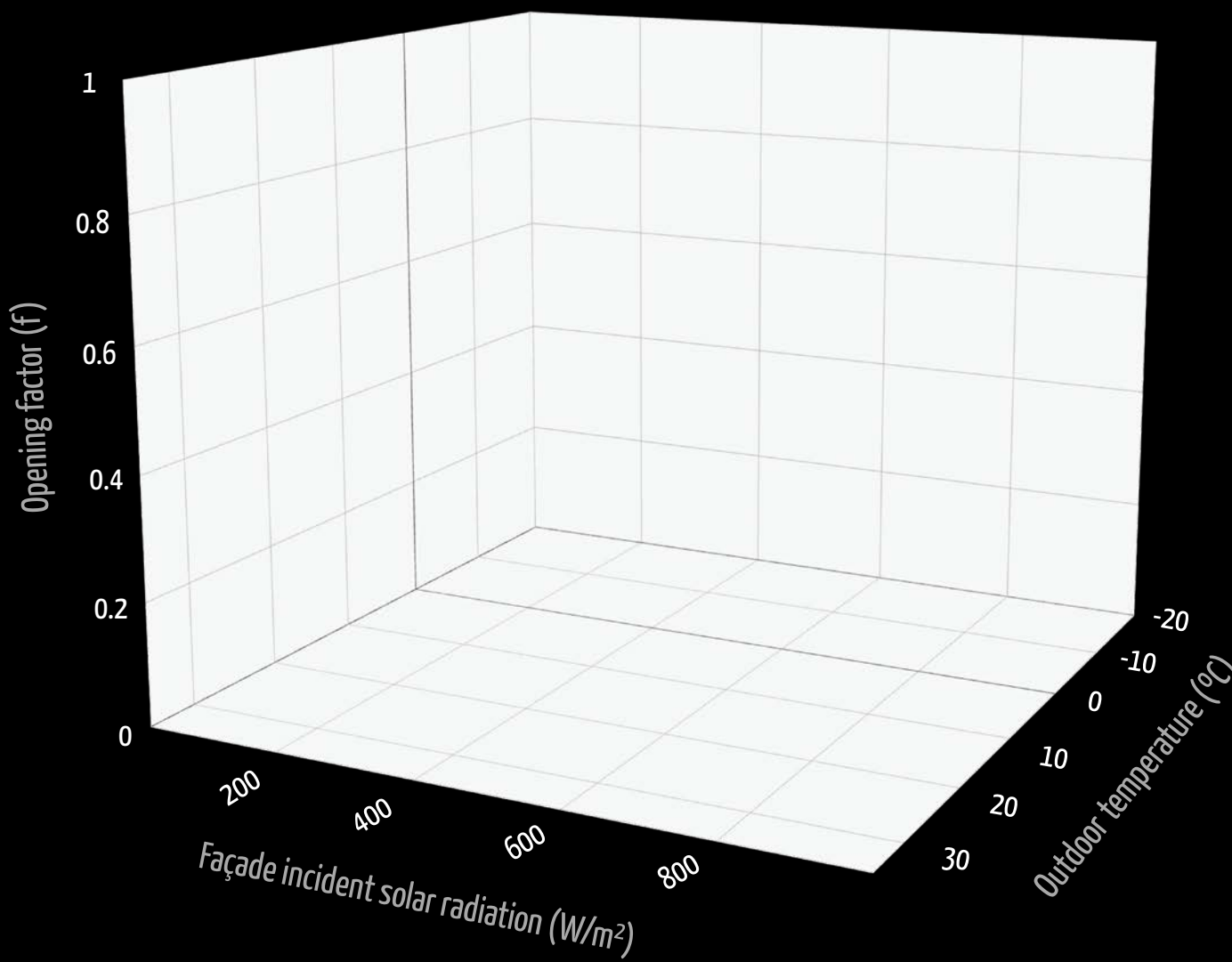


$f=0$



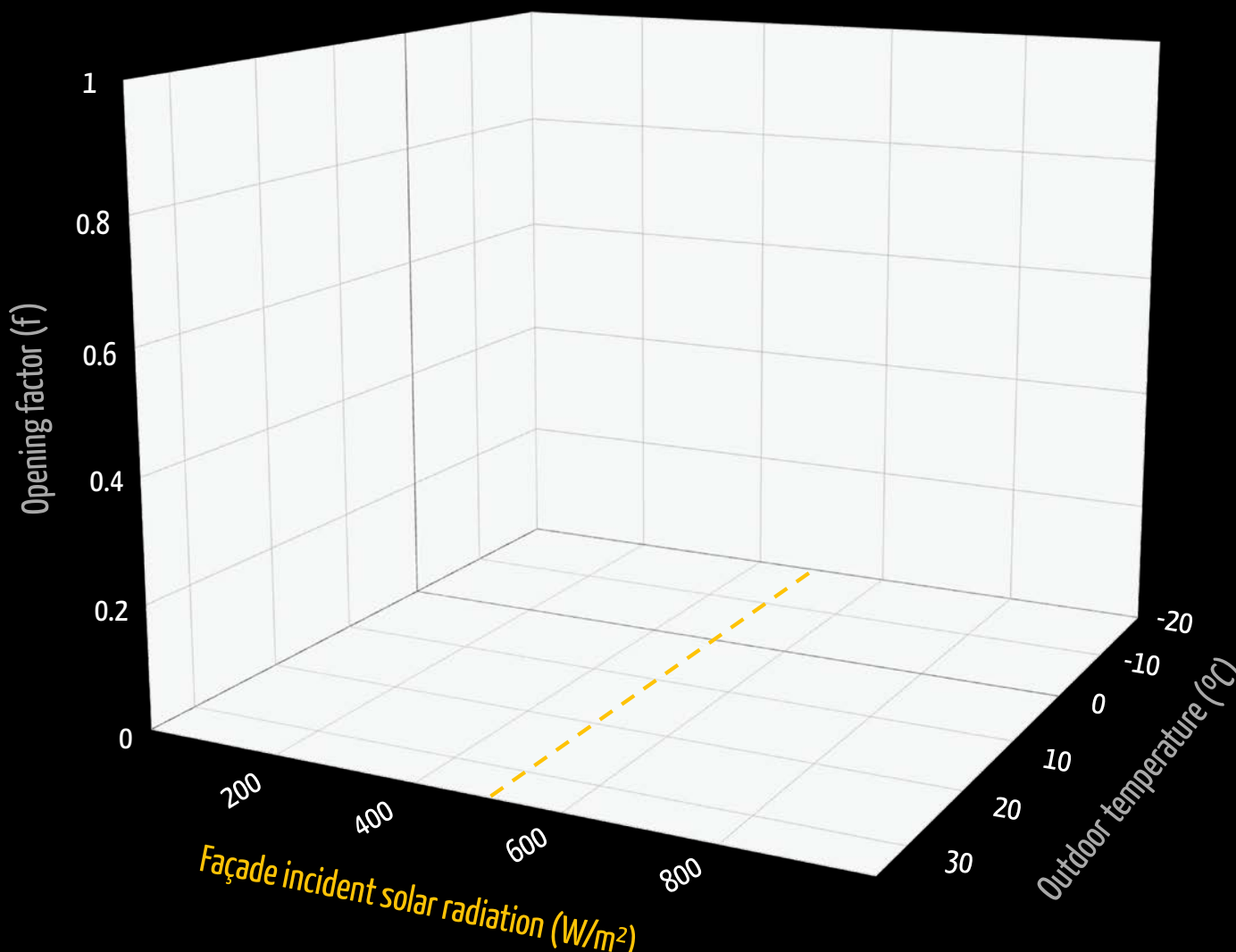
$f=1$

# OPTIMIZATION

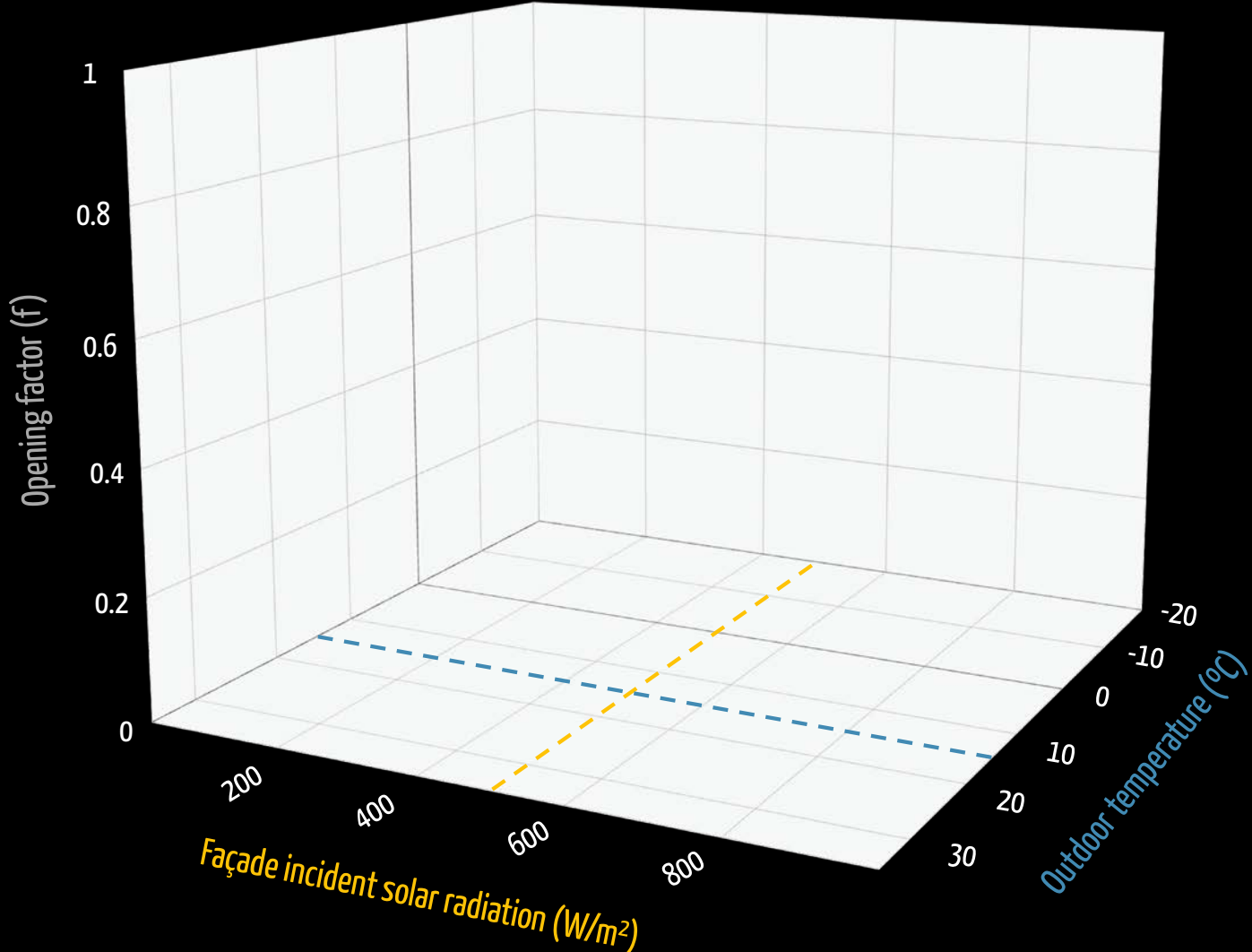




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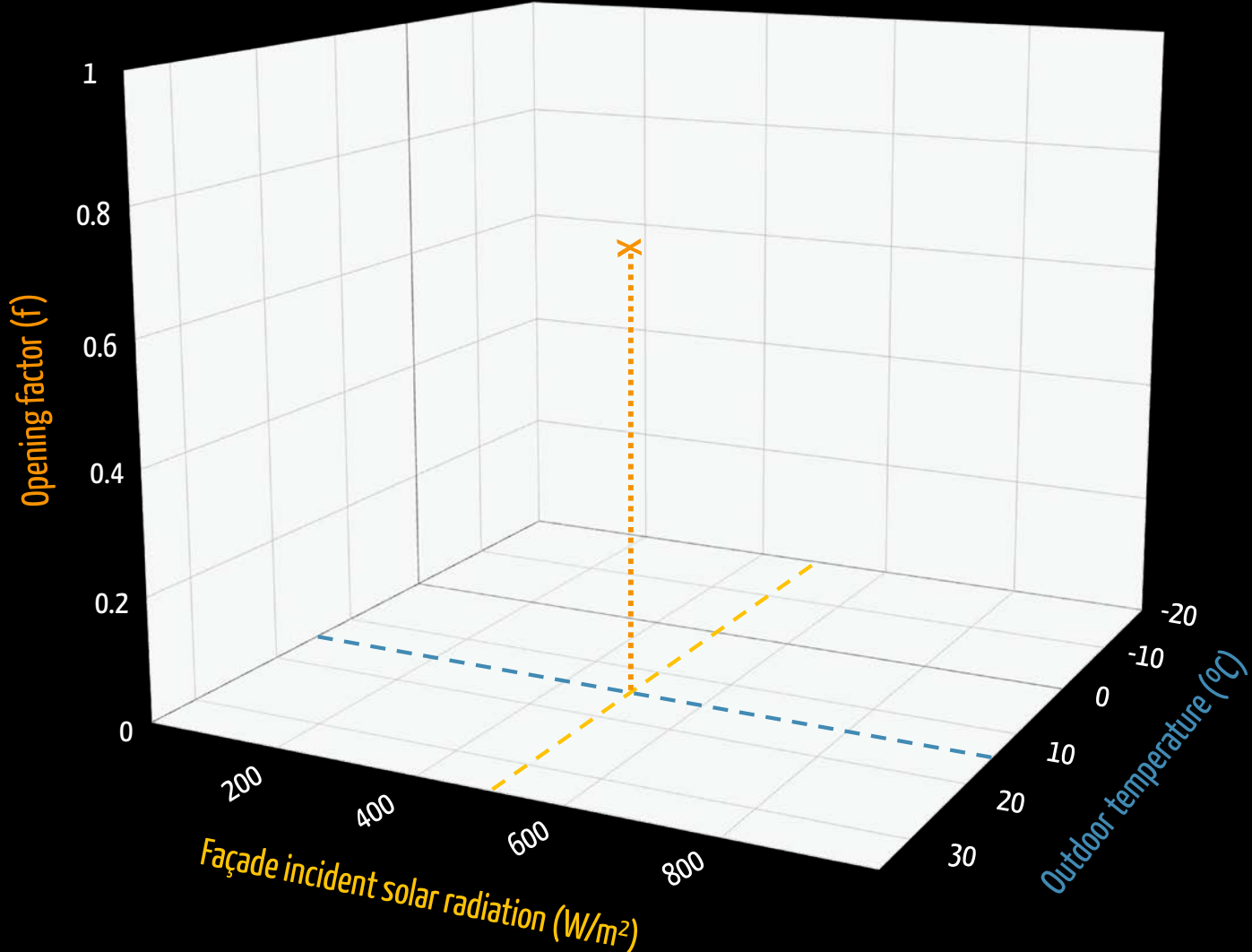


# OPTIMIZATION

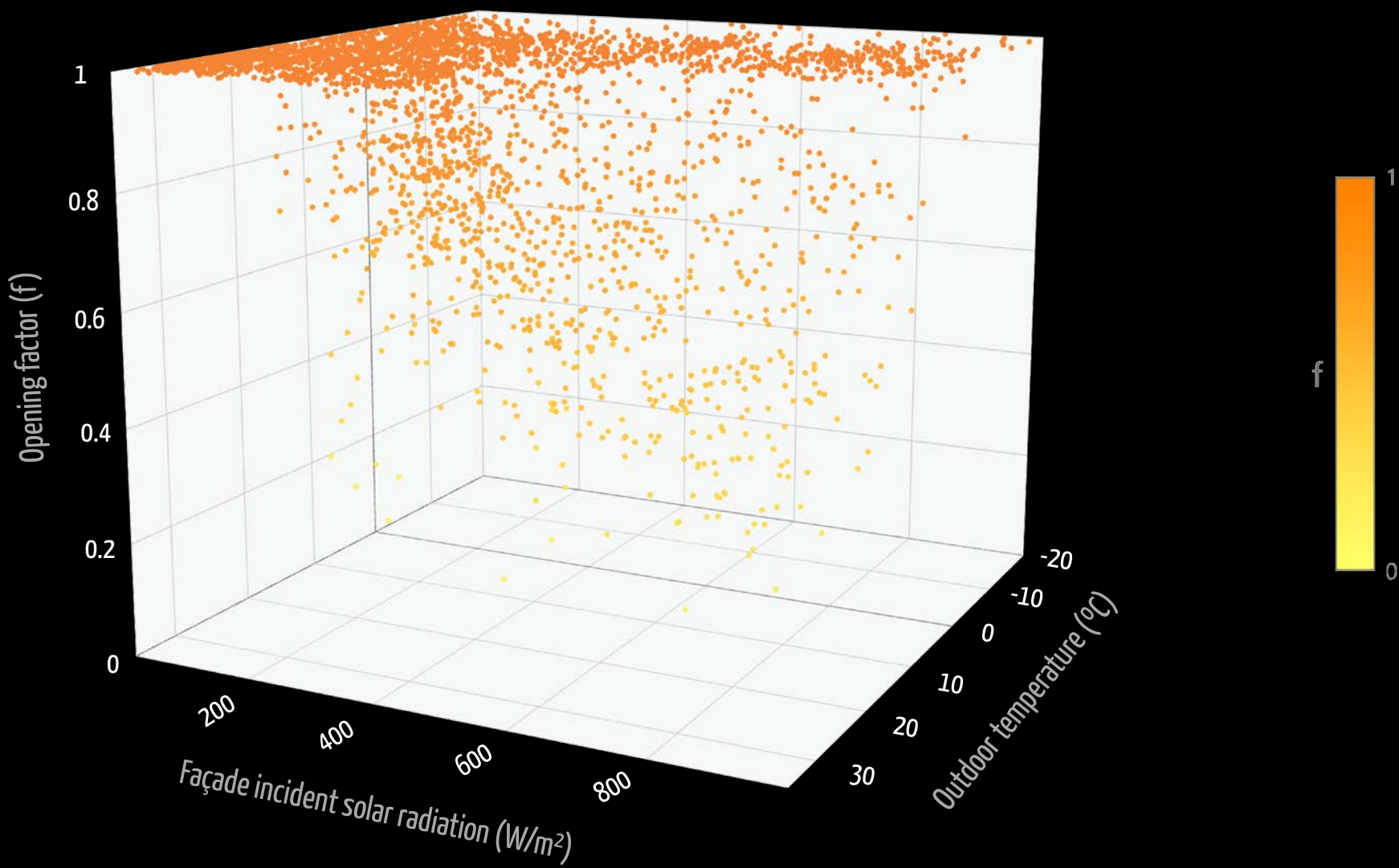




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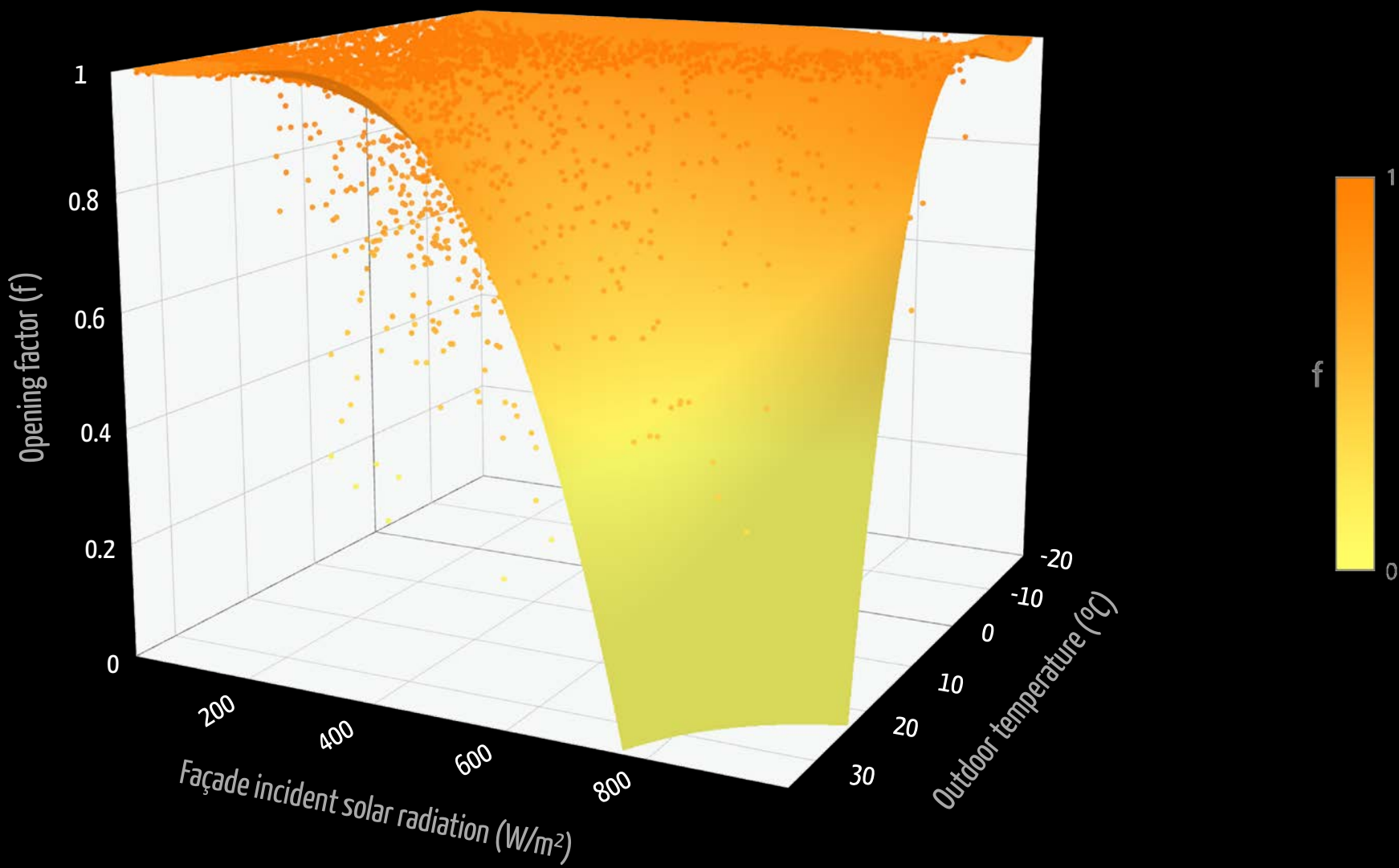


# OPTIMIZATION





# OPTIMIZATION



# CONCLUSIONS



Unified  
workflow



# CONCLUSIONS



Unified  
workflow

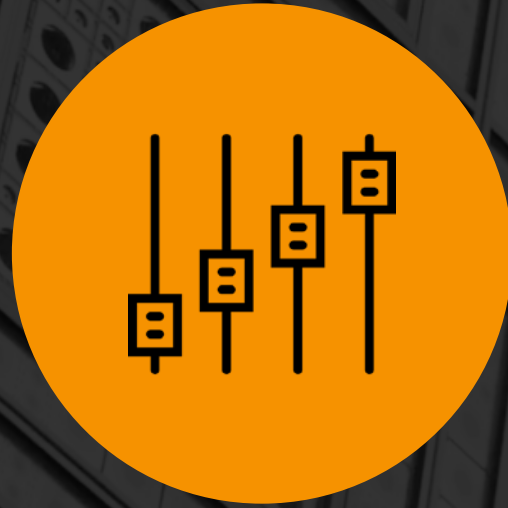


Control  
system

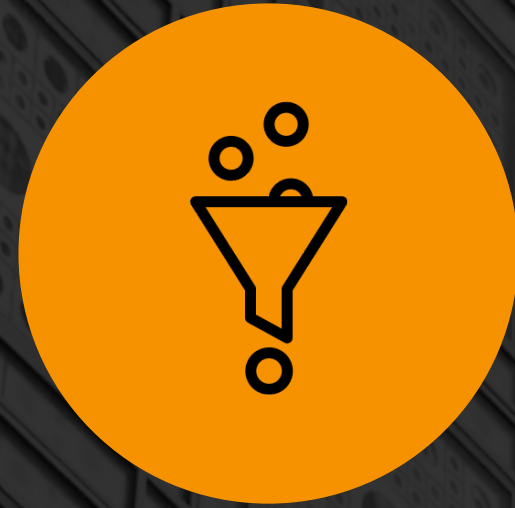
# CONCLUSIONS



Unified  
workflow



Control  
system



Filtered  
outliers



# FUTURE WORK



Iterative process

# FUTURE WORK



Iterative process



Time-delayed  
feedback



# FUTURE WORK



Iterative process



Time-delayed  
feedback



Non-planar  
geometry

# FUTURE WORK



Iterative process



Time-delayed  
feedback



Non-planar  
geometry



Maintenance





THANK YOU  
QUESTIONS?

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*maria.gloria.gomes@tecnico.ulisboa.pt*