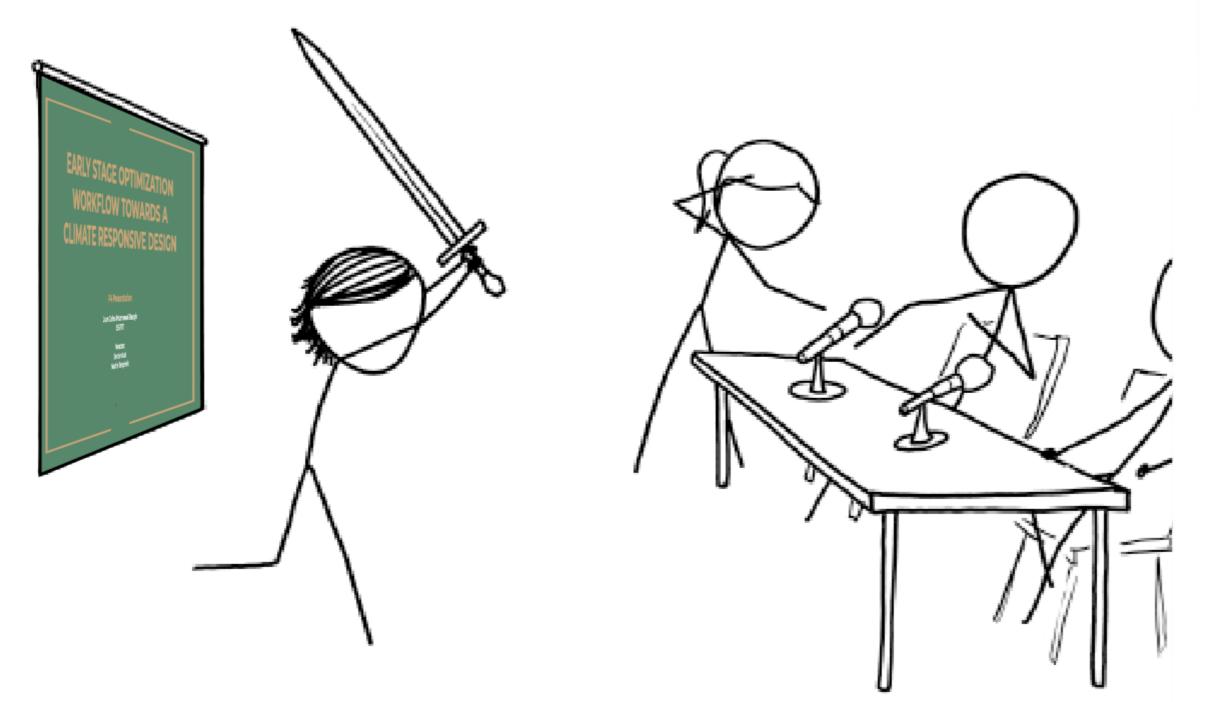


### THE BEST THESIS DEFENSE IS A GOOD THESIS OFFENSE.



## EARLY STAGE OPTIMIZATION WORKFLOW TOWARDS A CLIMATE RESPONSIVE DESIGN

### **P5** Presentation

Juan Carlos Prazmowski Baczyk 5557771

> Mentors: Serdar Asut Martin Tenpierik





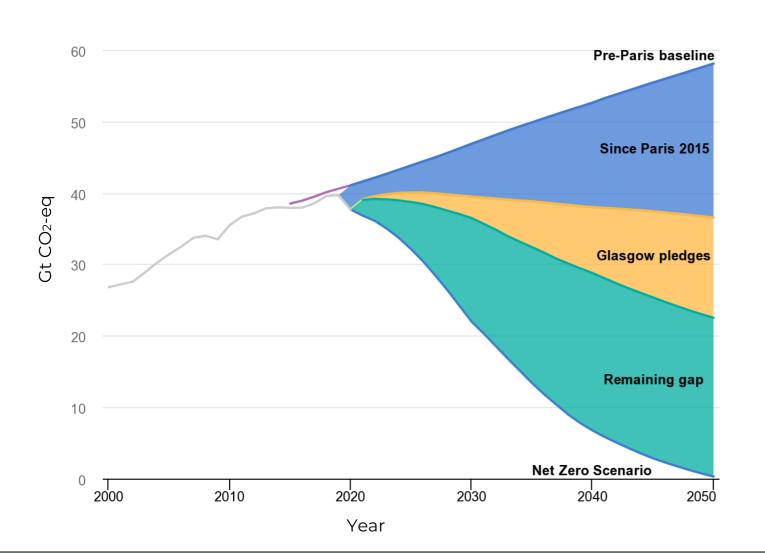






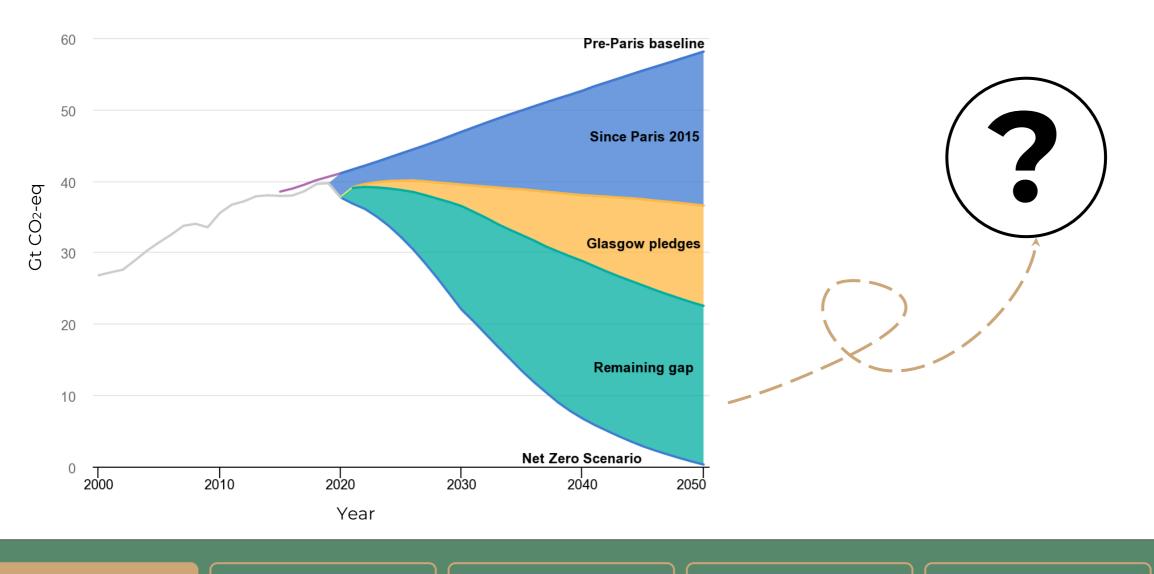
ONLY ≈ 5% of world energy produced by Renewable Resources

### **CO<sub>2</sub> Global Emissions**



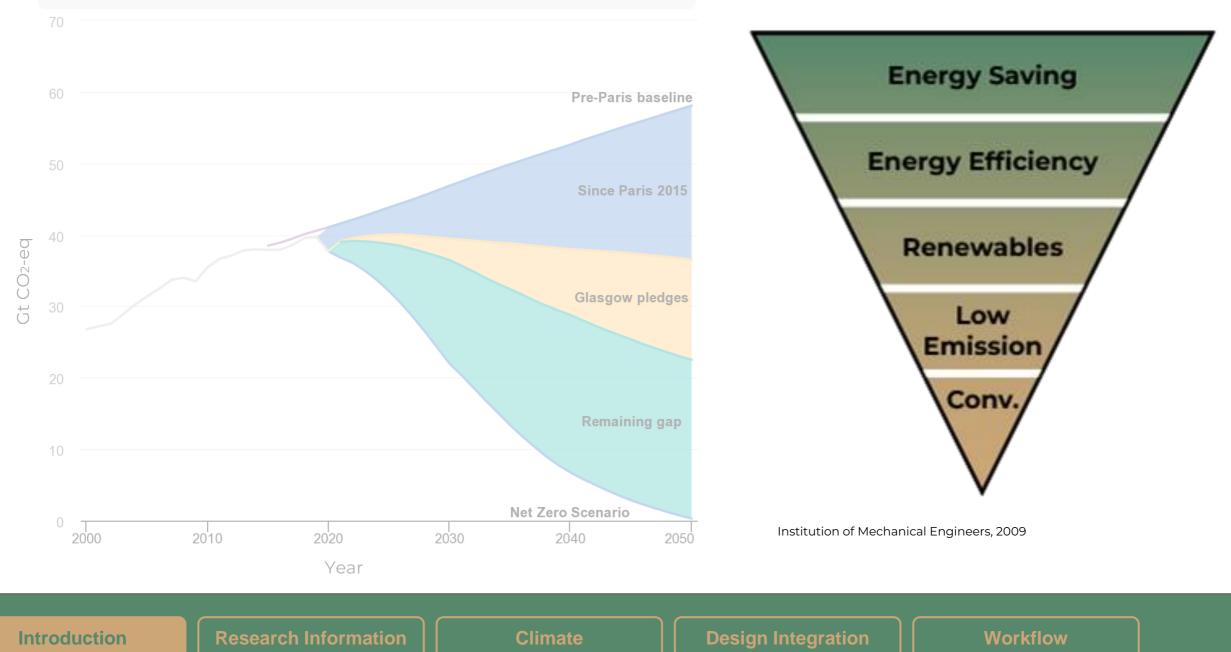
70

### **CO<sub>2</sub> Global Emissions**

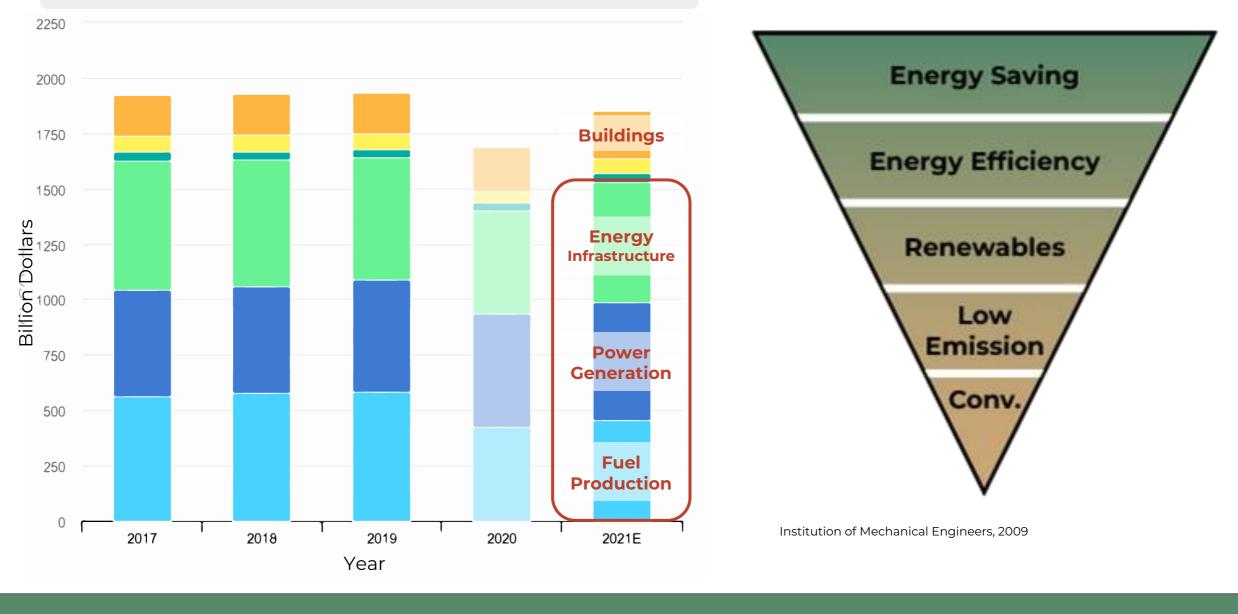


70

### **CO<sub>2</sub> Global Emissions**



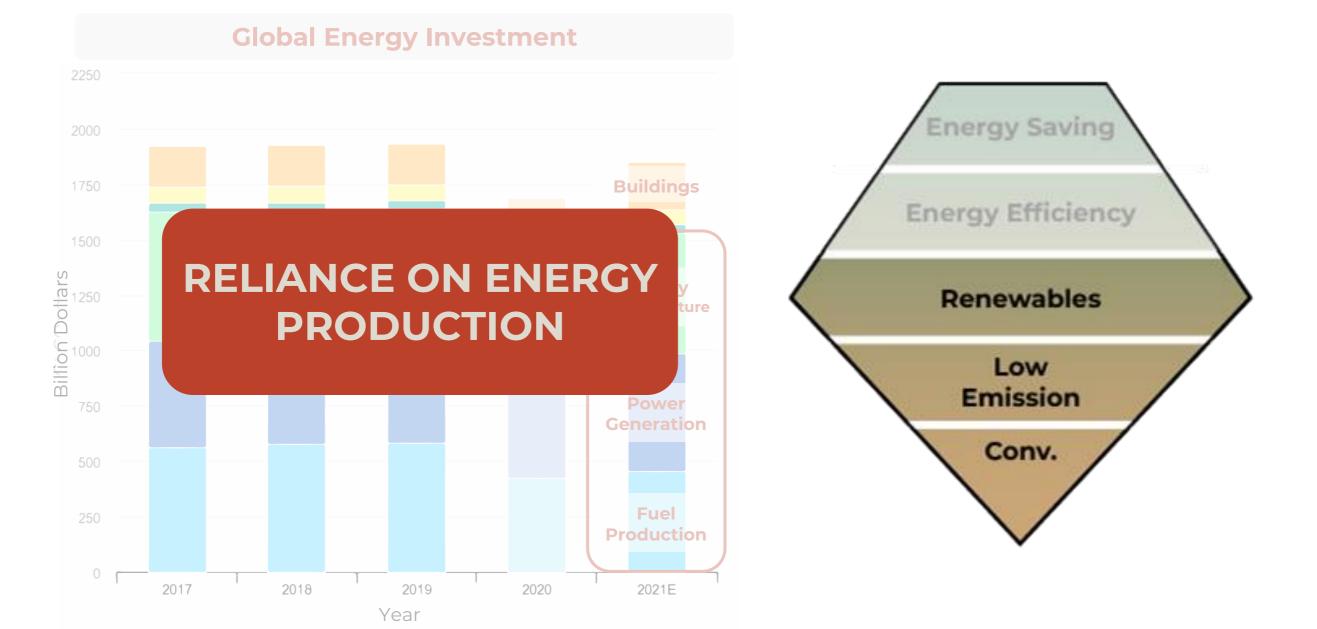
#### **Global Energy Investment**



Introduction

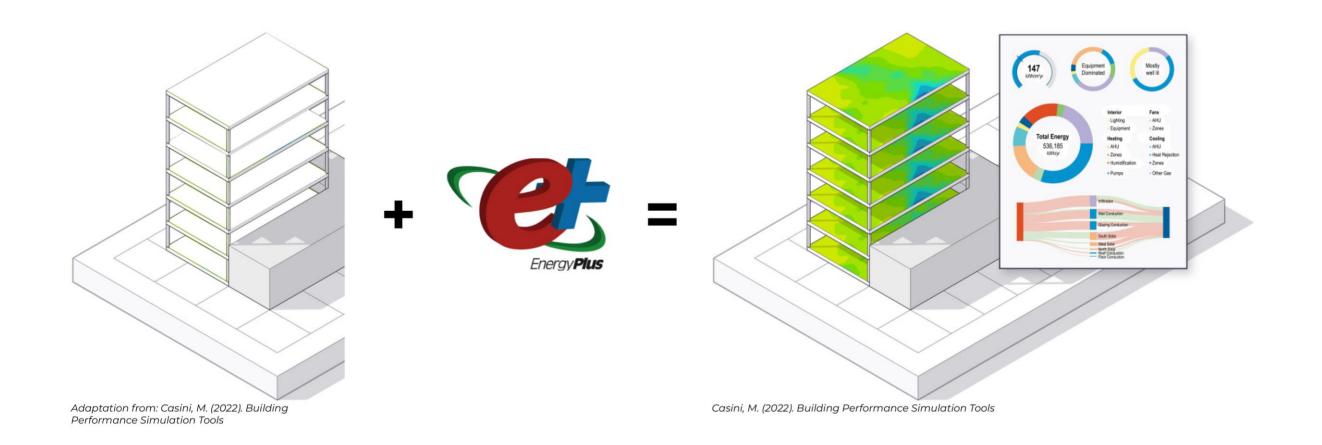
Climate

**Design Integration** 



**Design Integration** 

#### There are methods...

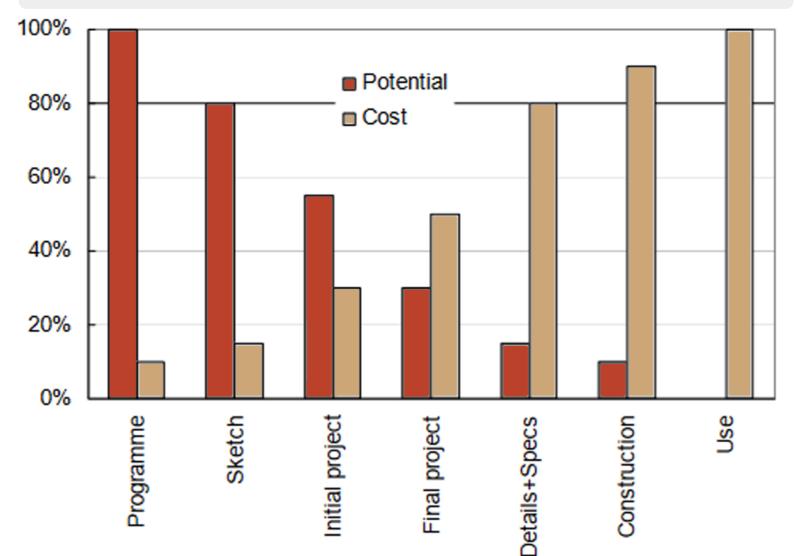


**Design Integration** 

# TSTOULTE

## FOR THAT, SAM\_

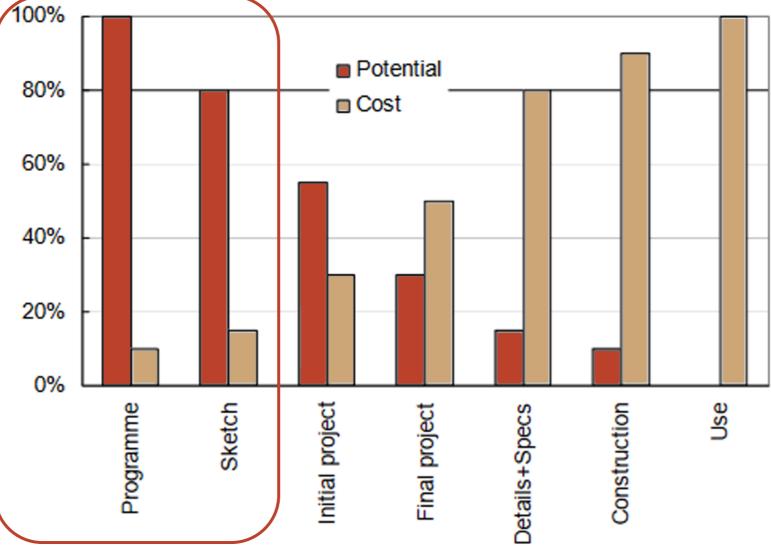
### **Design Stage & Potential / Cost Impact**



Evans, J.M. (2007). The Comfort Triangles: A New Tool For Bioclimatic Design



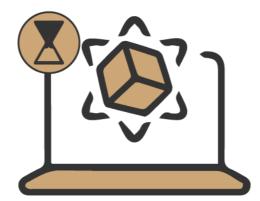
### **Design Stage & Potential / Cost Impact**



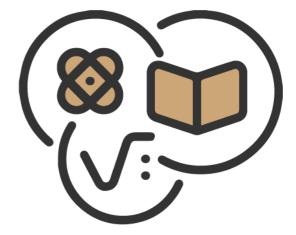
Evans, J.M. (2007). The Comfort Triangles: A New Tool For Bioclimatic Design



Energy consumption on the rise

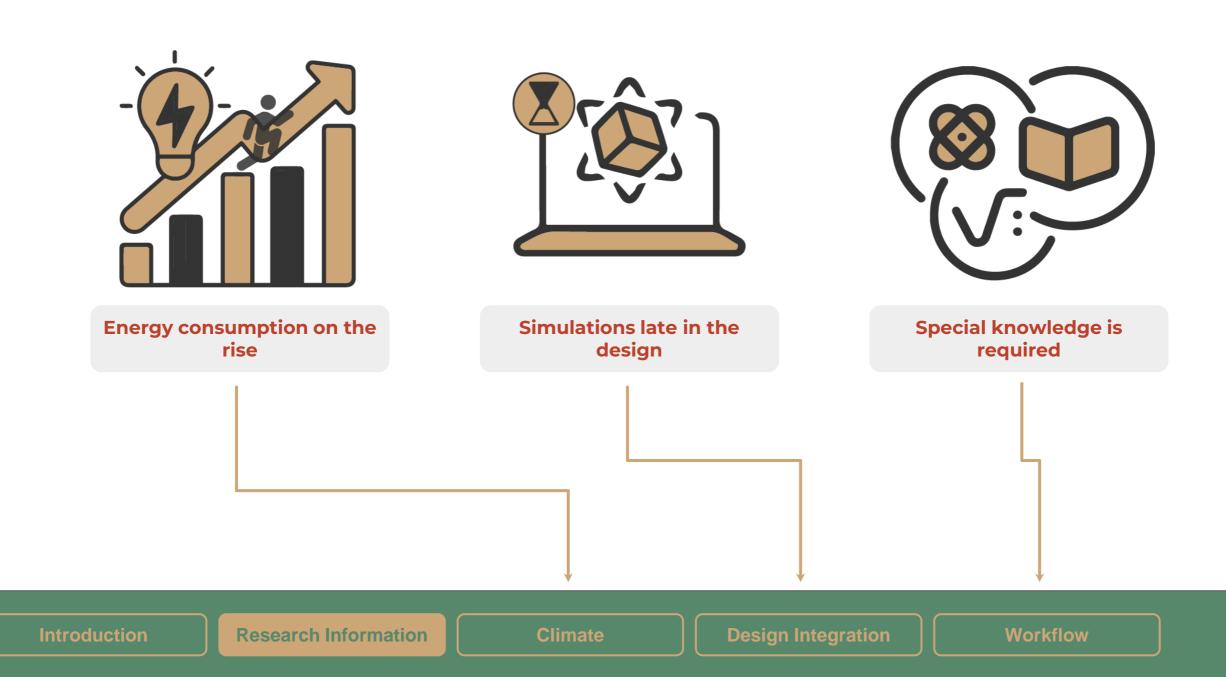


Simulations late in the design



Special knowledge is required

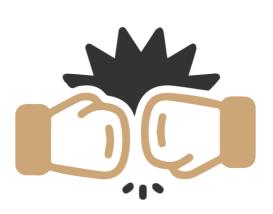
**Design Integration** 



How can a multi-objective optimization **workflow** assist in **early design stages** towards a **climate responsive design**? How can a multi-objective optimization **workflow** assist in **early design stages** towards a **climate responsive design**?







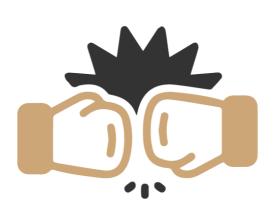


Insensitive

Combative

Responsive







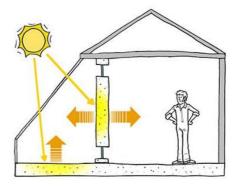
Insensitive

Combative

Responsive







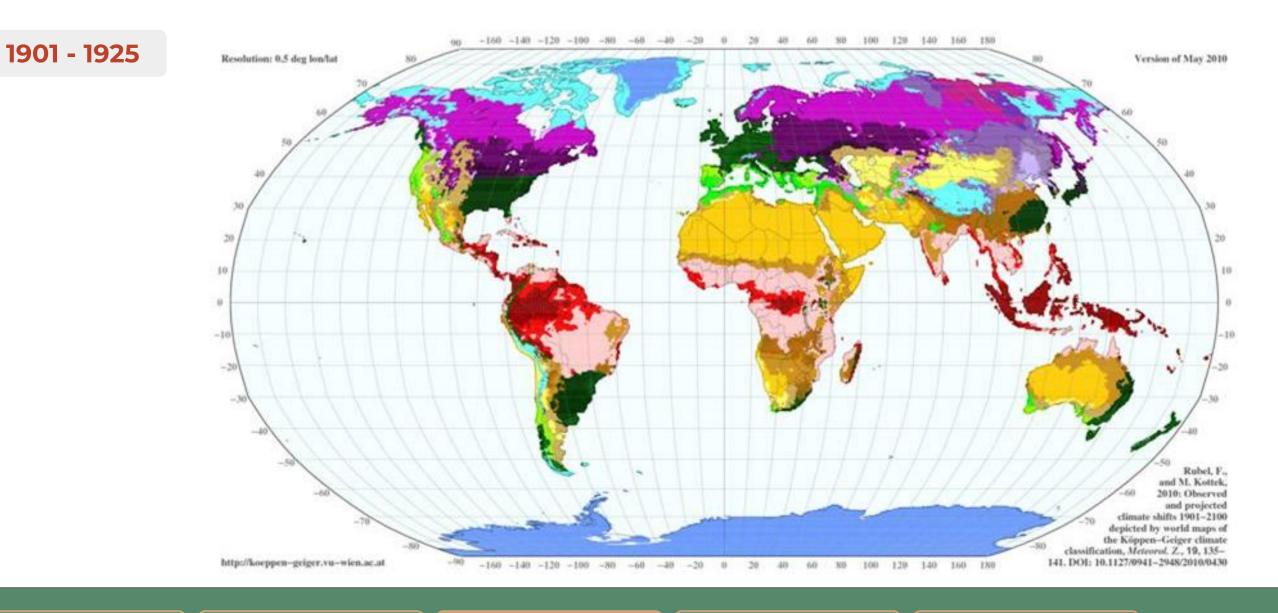
Introduction

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Climate

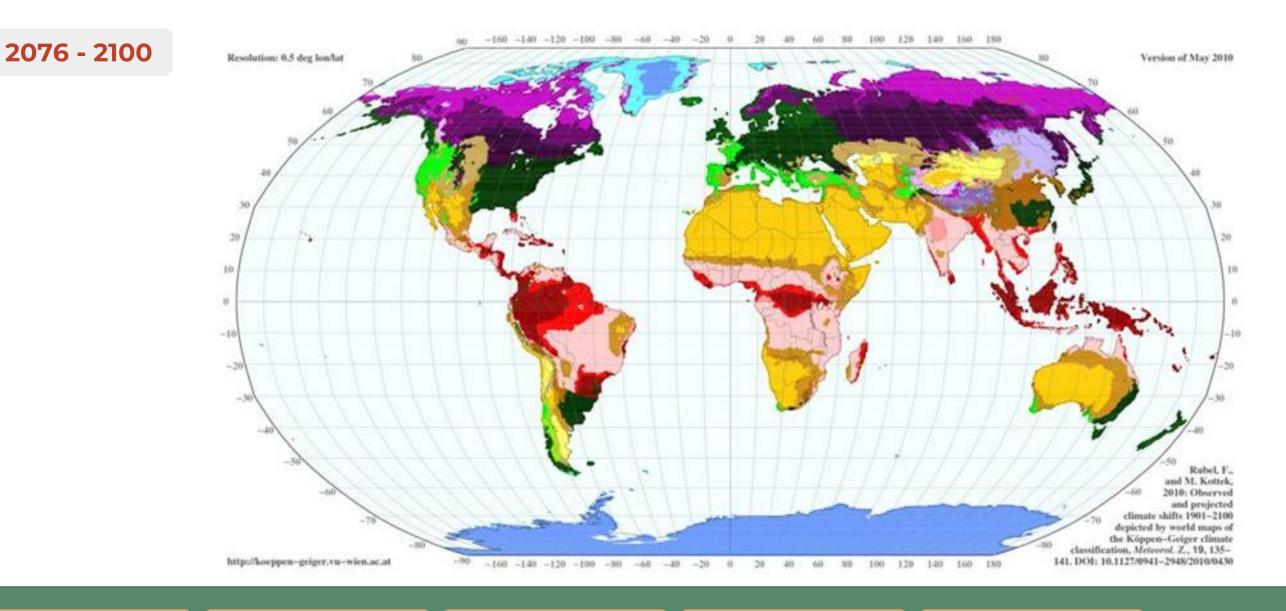
**Design Integration** 

### **Köppen-Geiger Climate Classification**

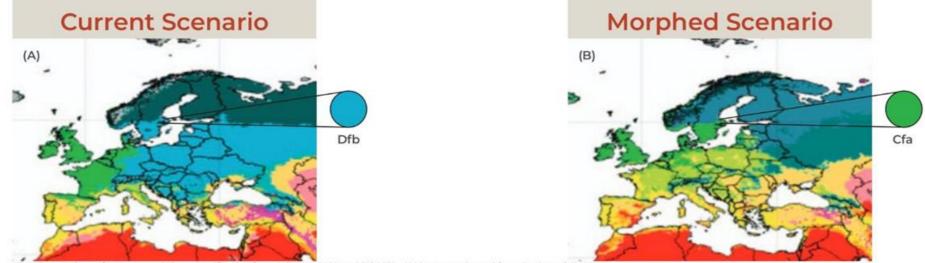


**Research Information** 

### **Köppen-Geiger Climate Classification**



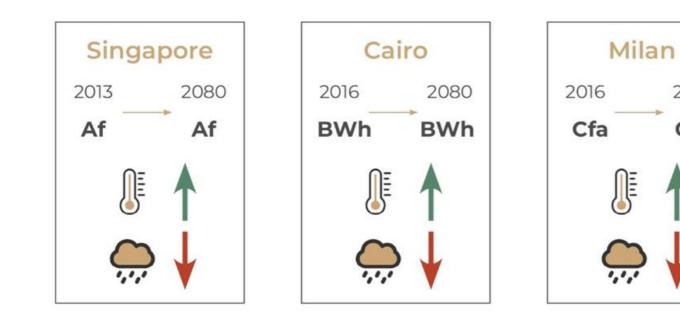
**Research Information** 

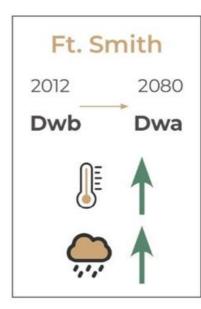


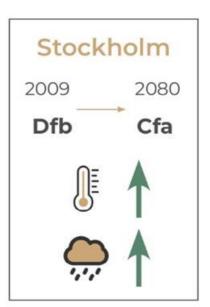
2080

Cfa

Fig 1: Comparison of a Koppen - Geiger classification from (A)1980 - 2016 and (B) 2071 - 2100. Maps adapted from Beck et al. (2018)

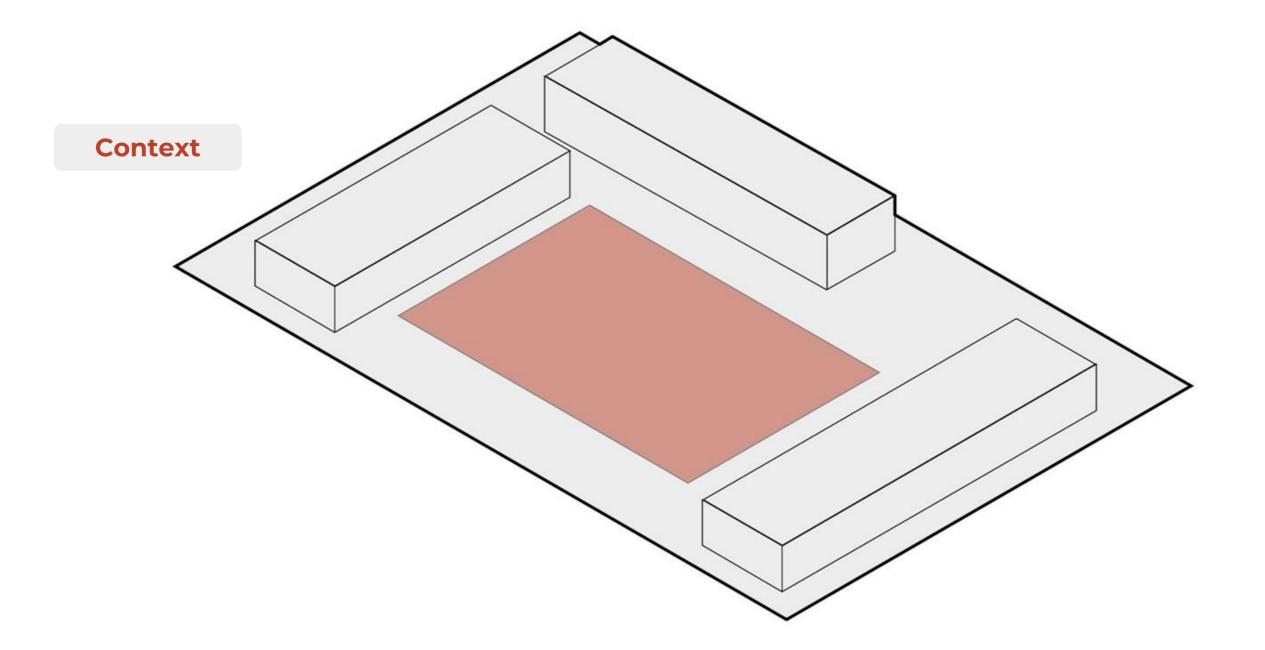




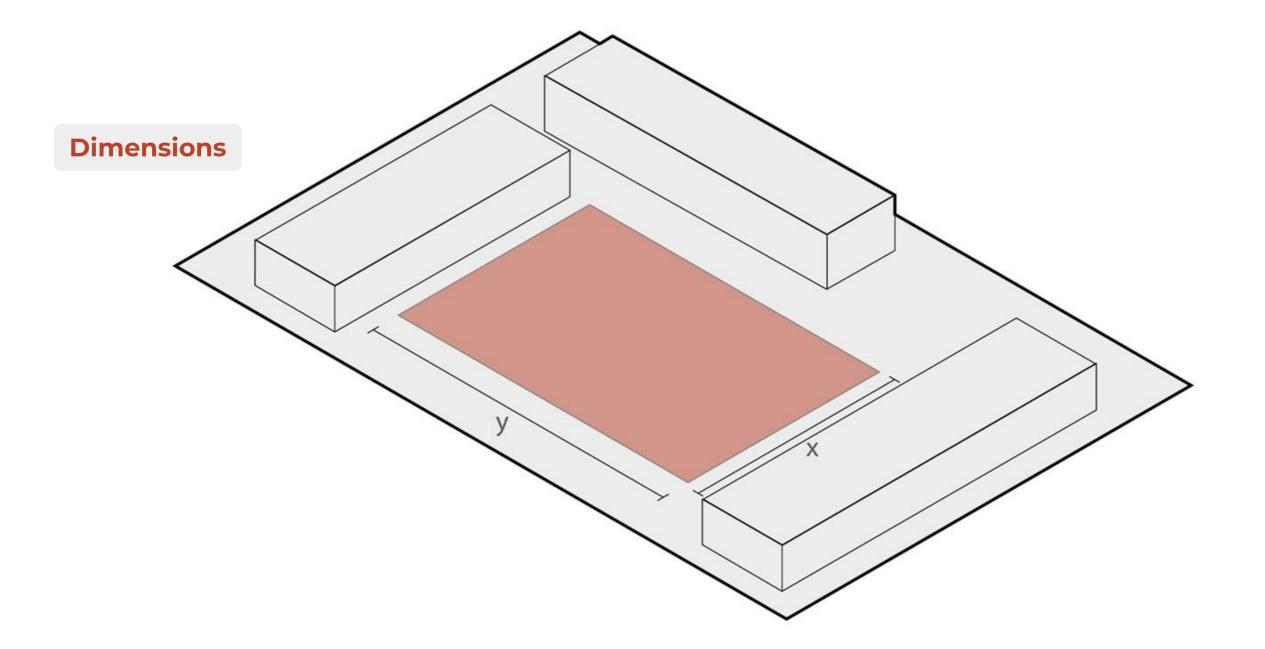




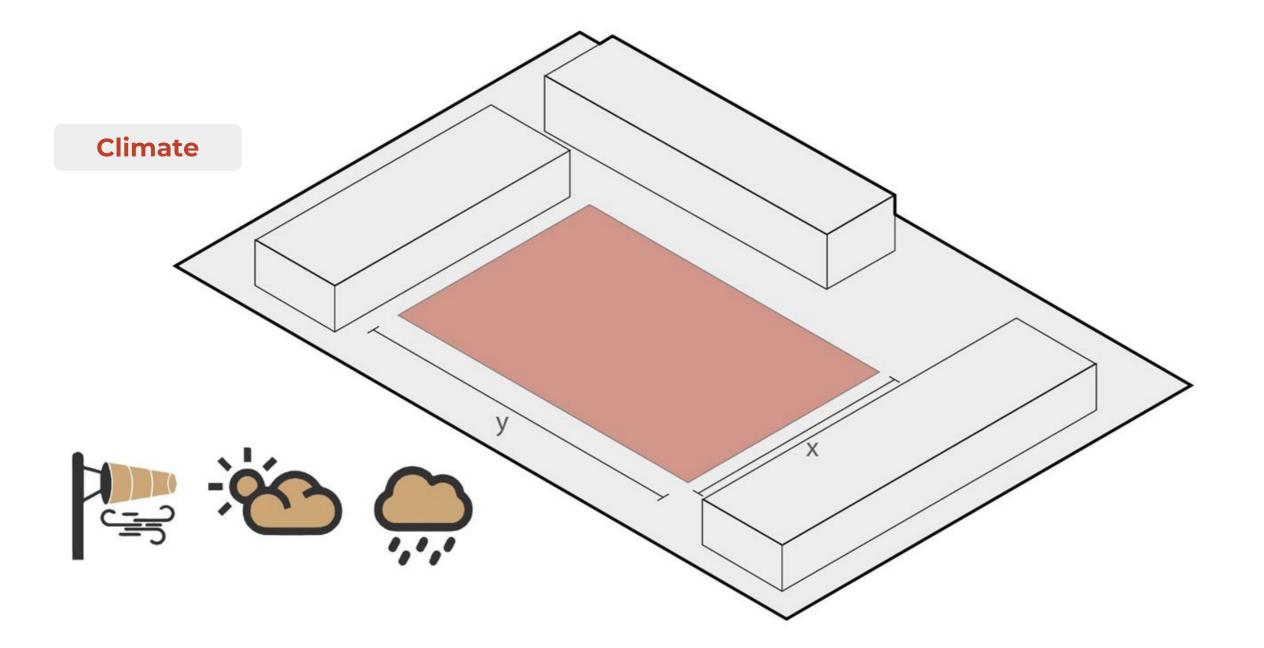
### DESIGN INTEGRATION







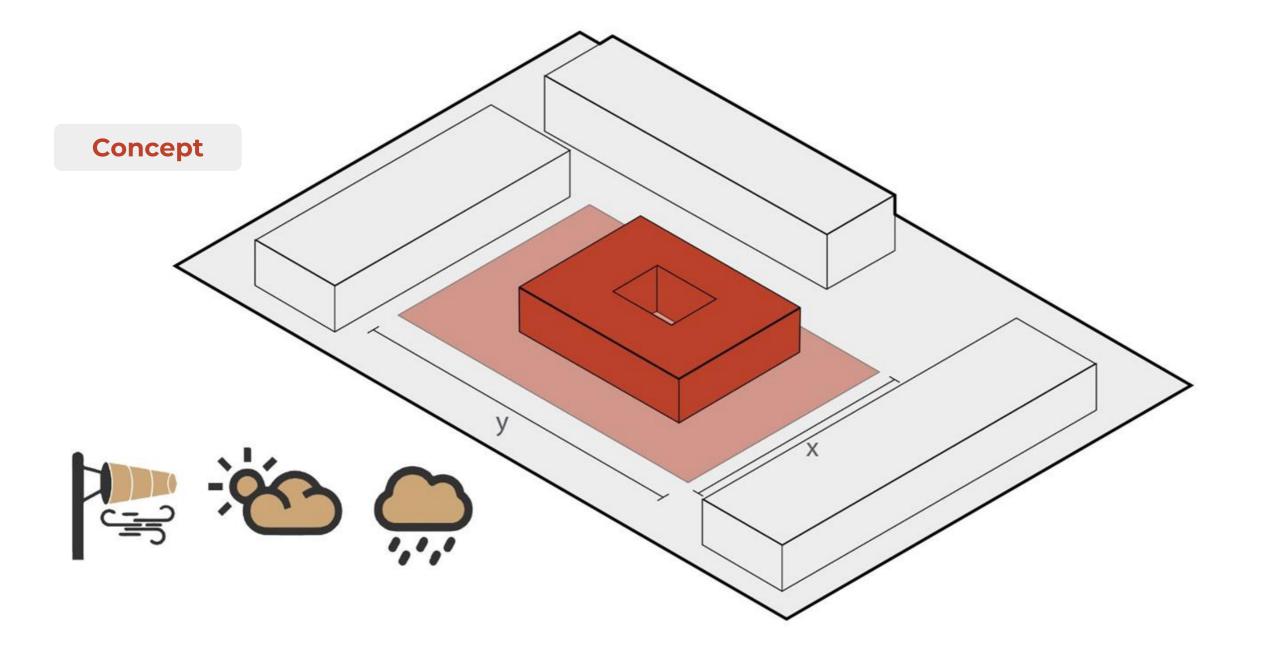


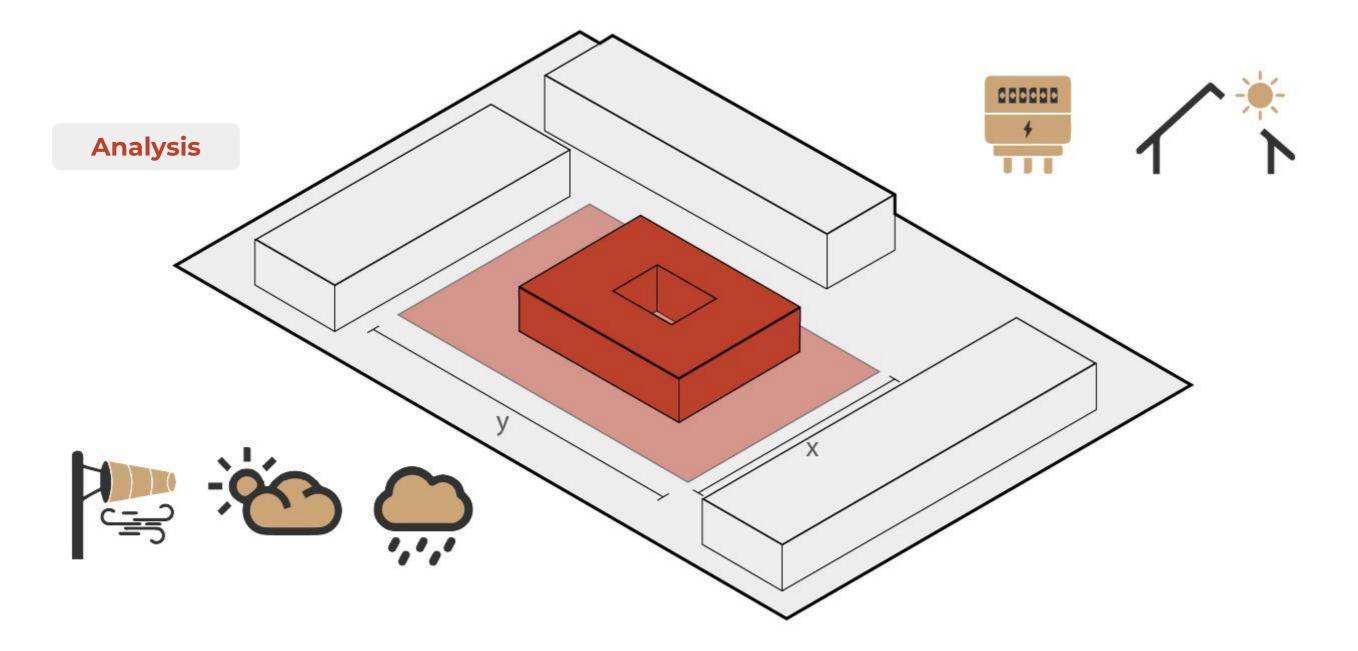


Research Informati

Climate

**Design Integration** 



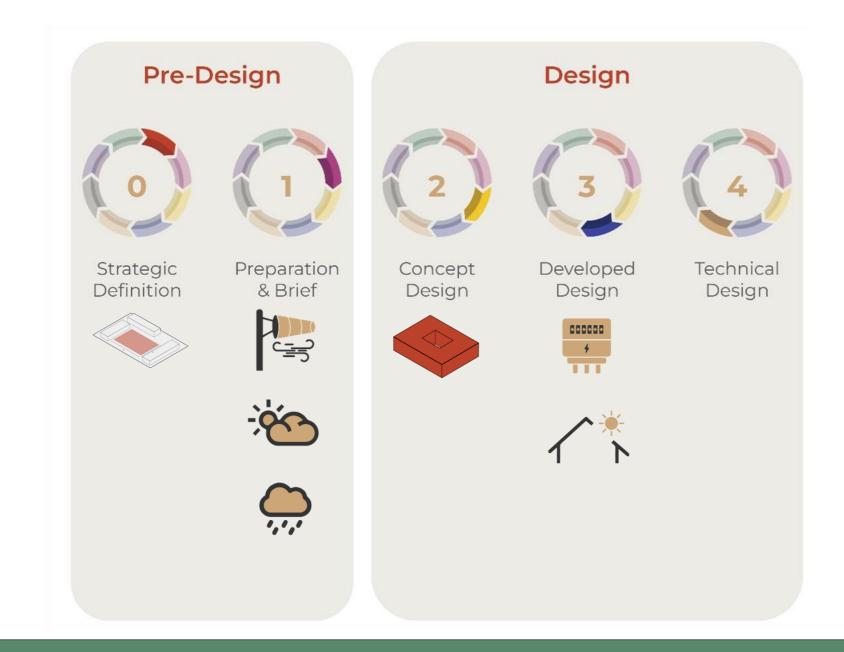






Climate

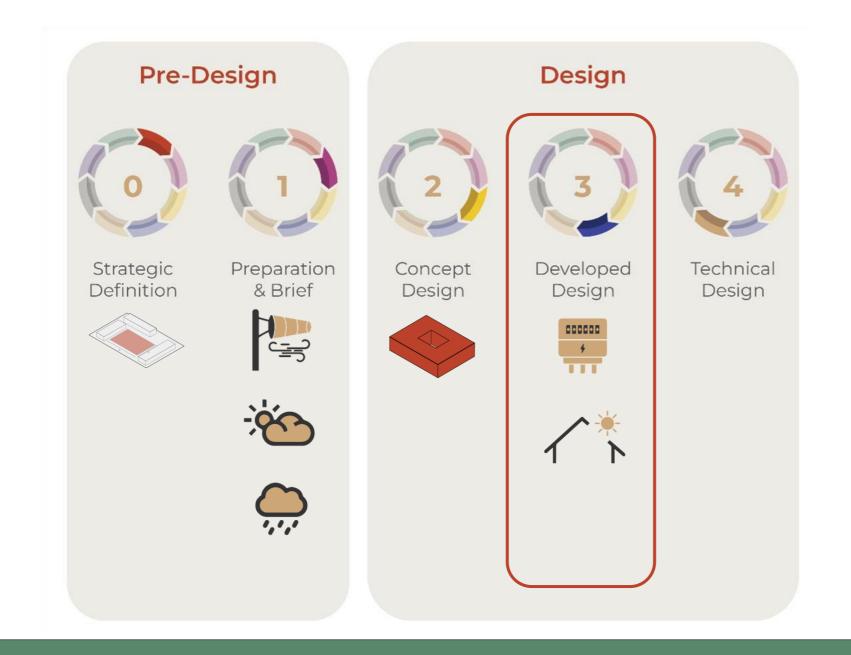
**Design Integration** 

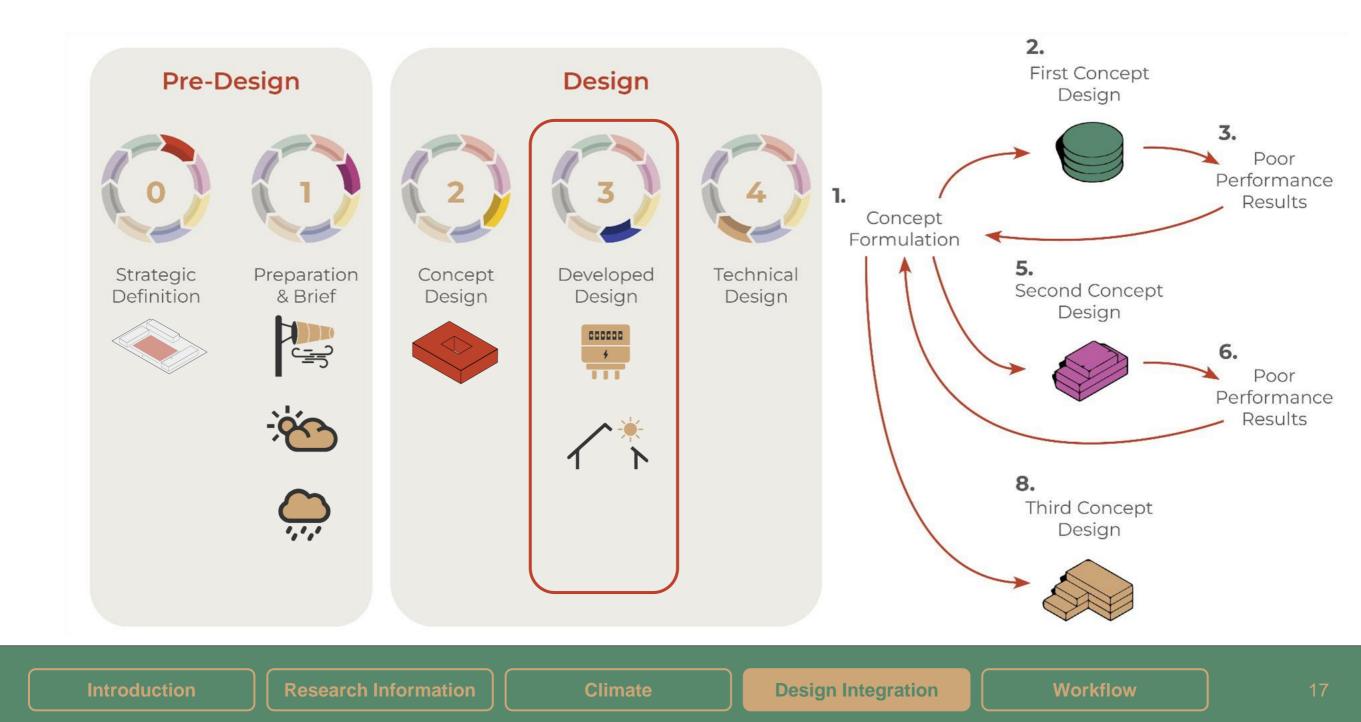


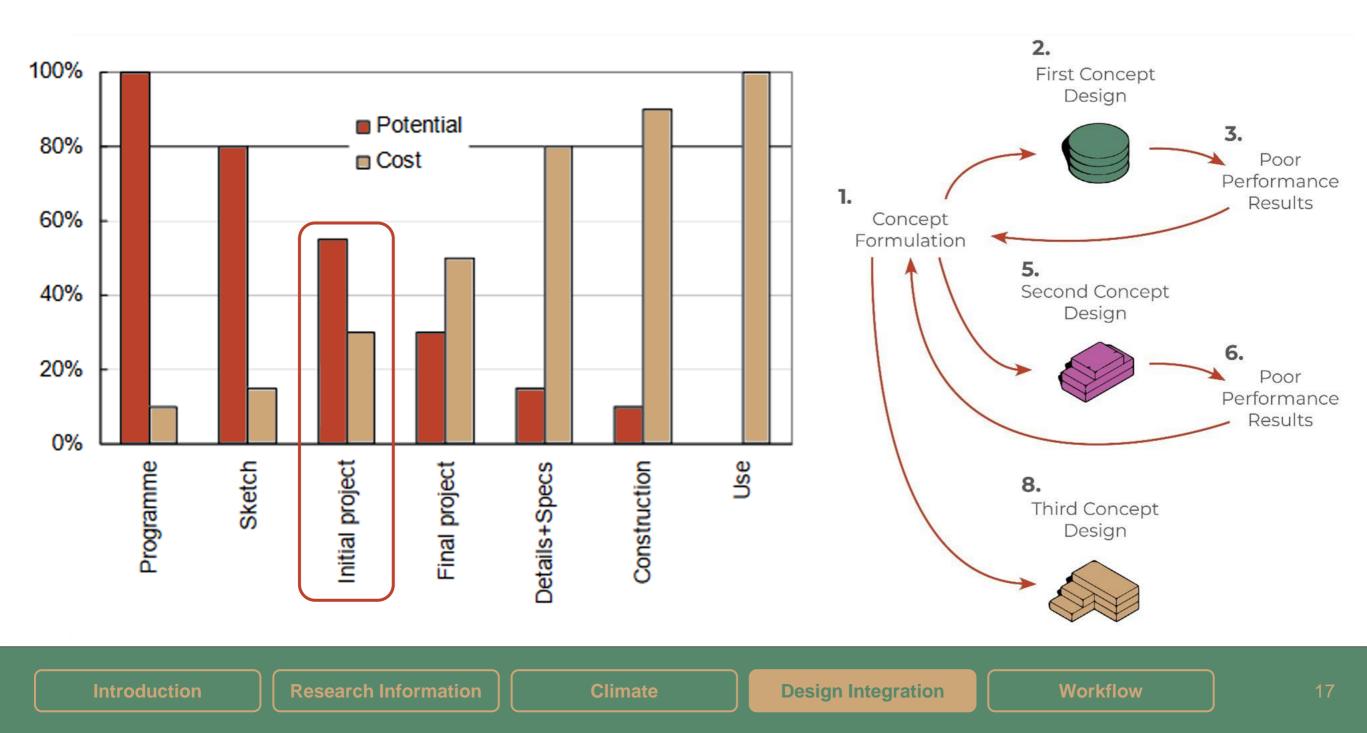
**Research Information** 

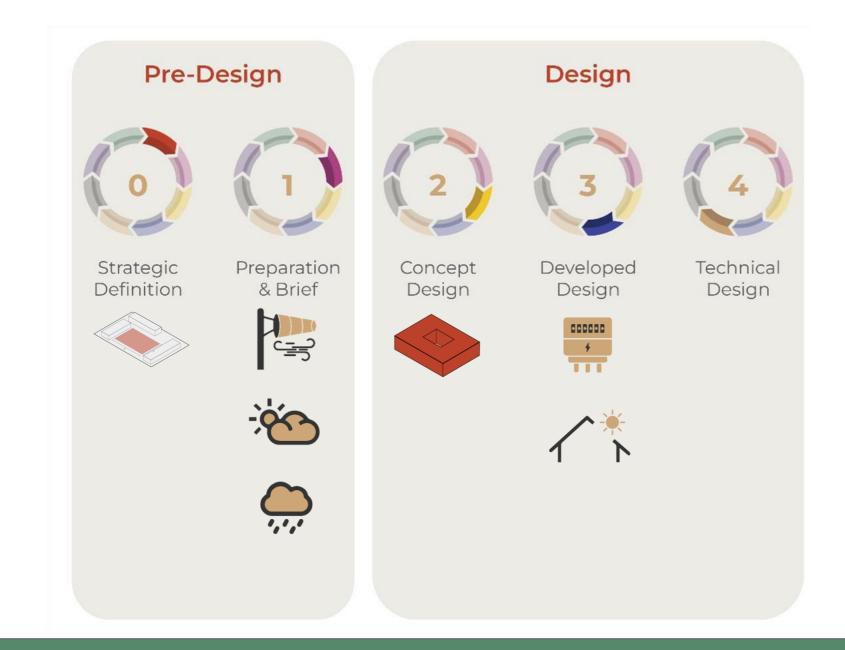
Climate

**Design Integration** 





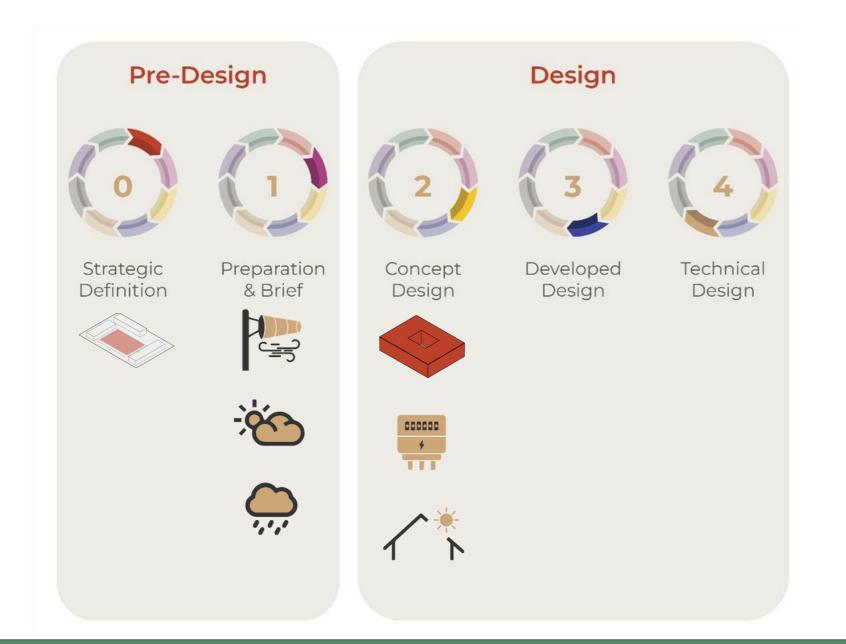


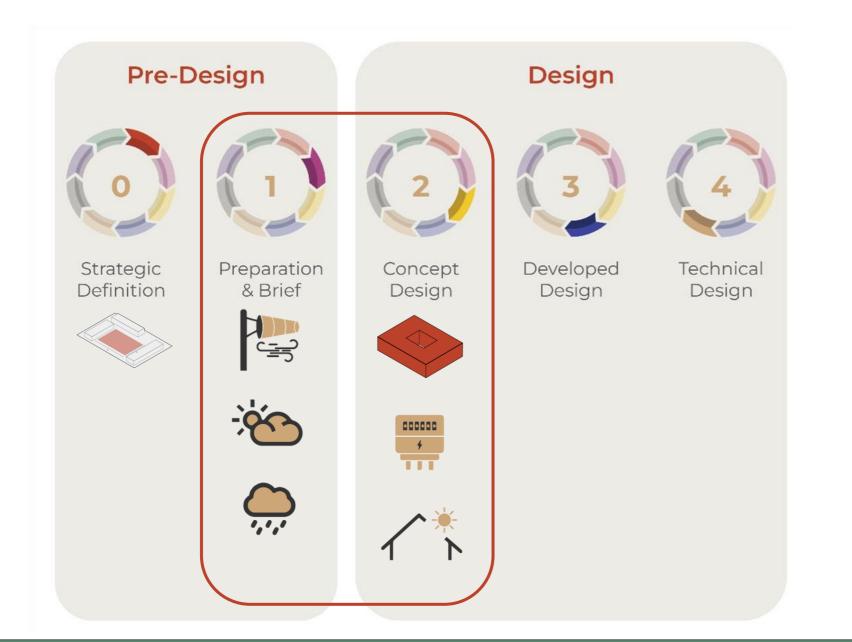


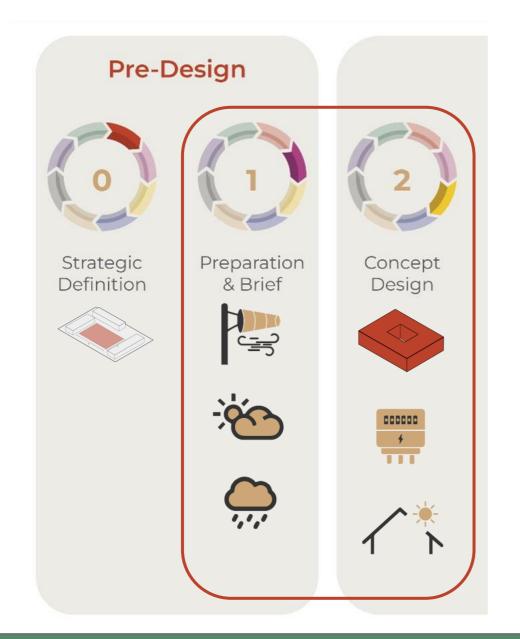
**Research Information** 

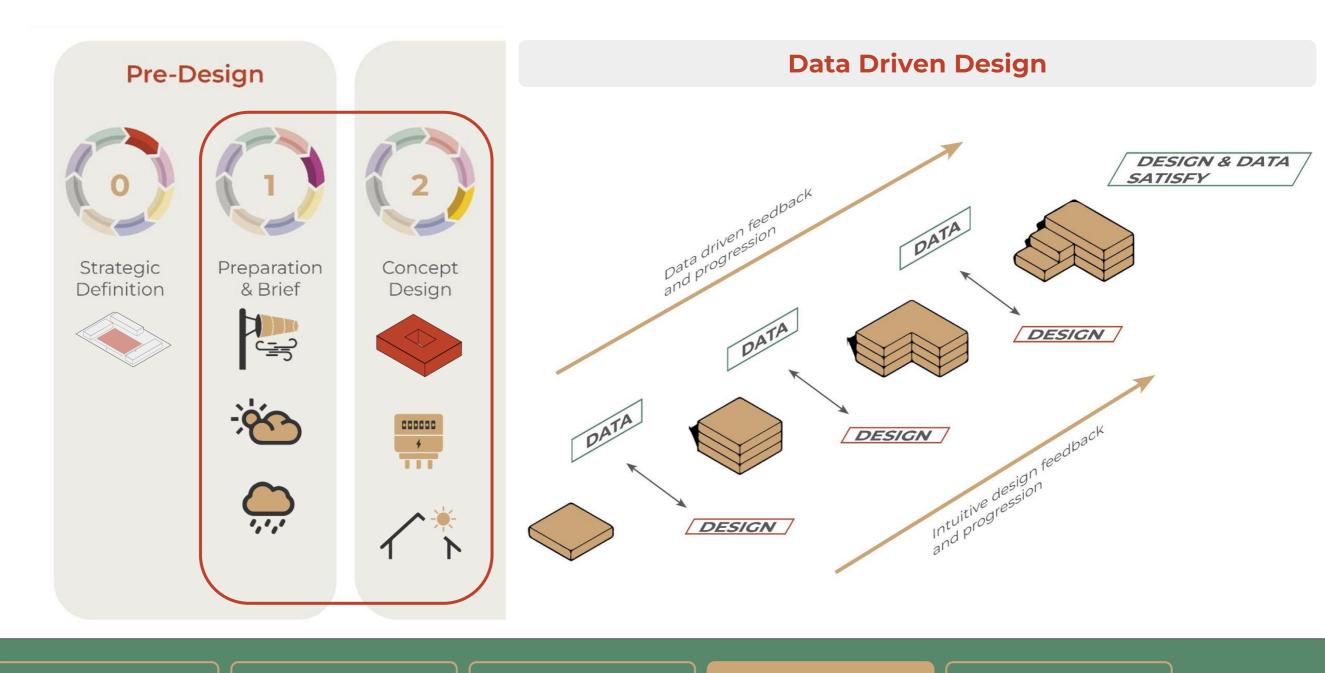
Climate

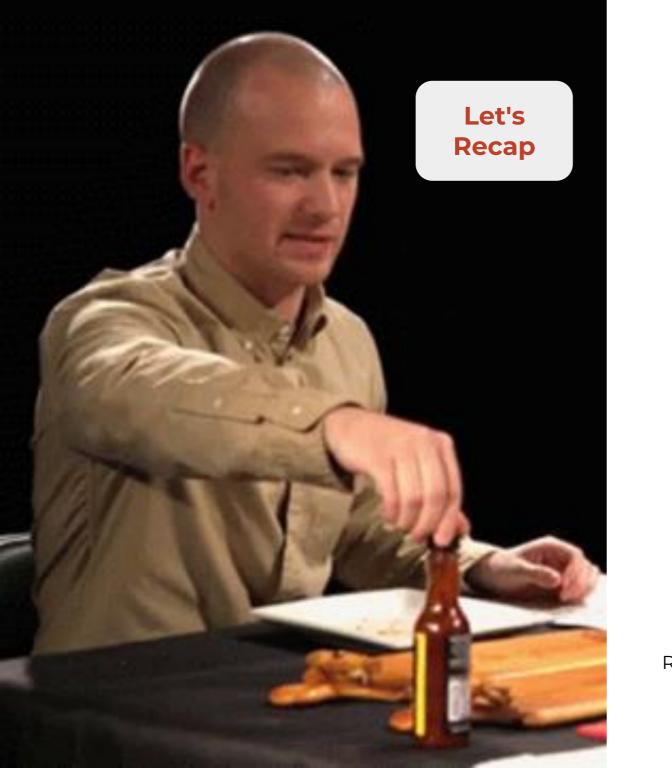
**Design Integration** 



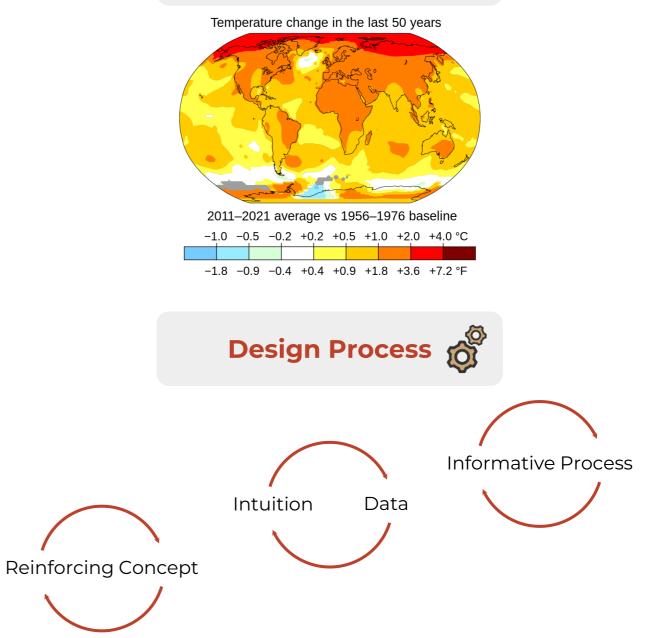




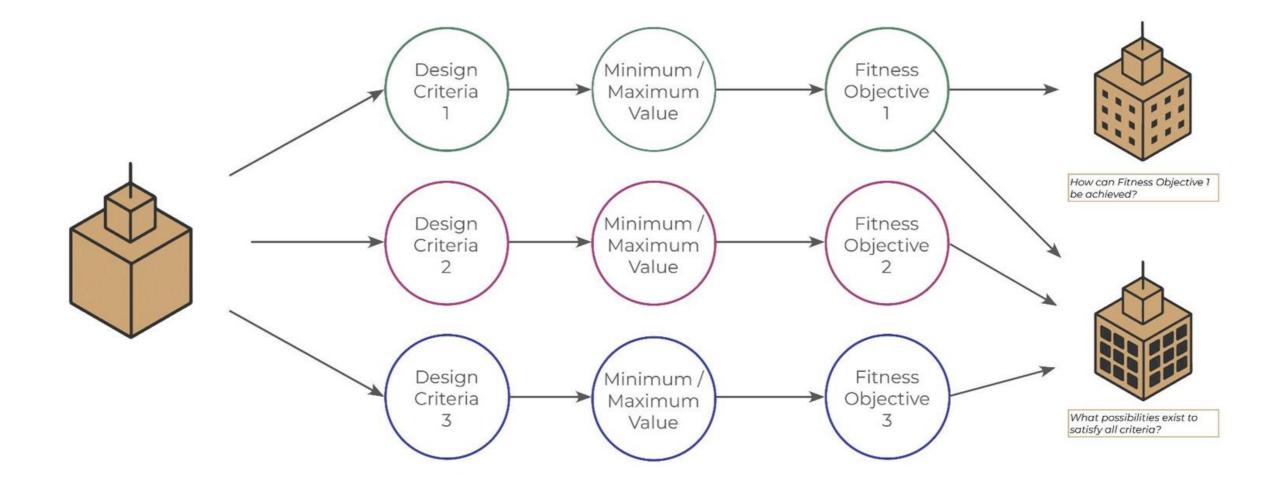




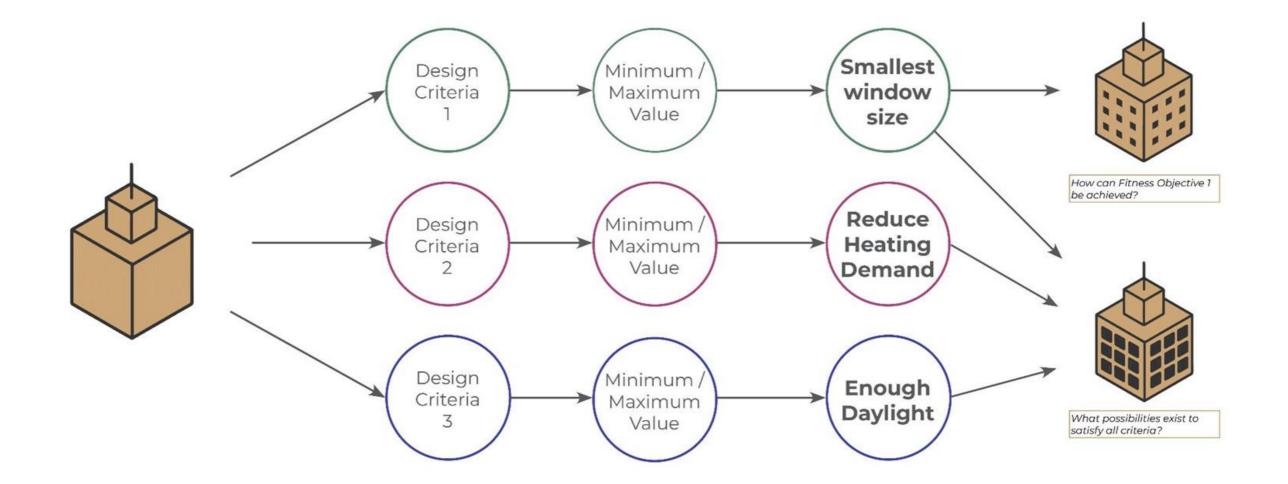


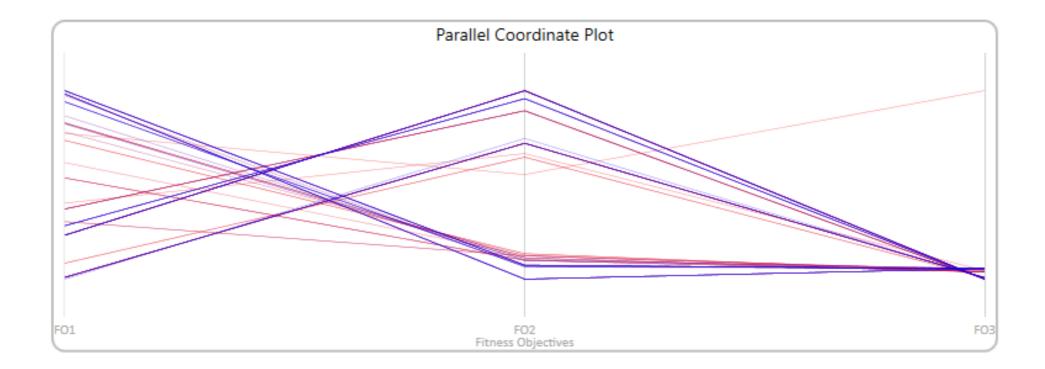




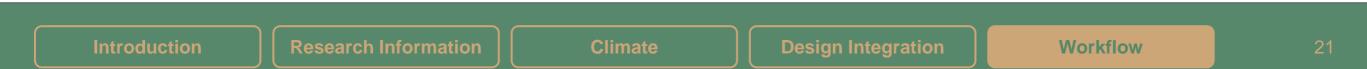


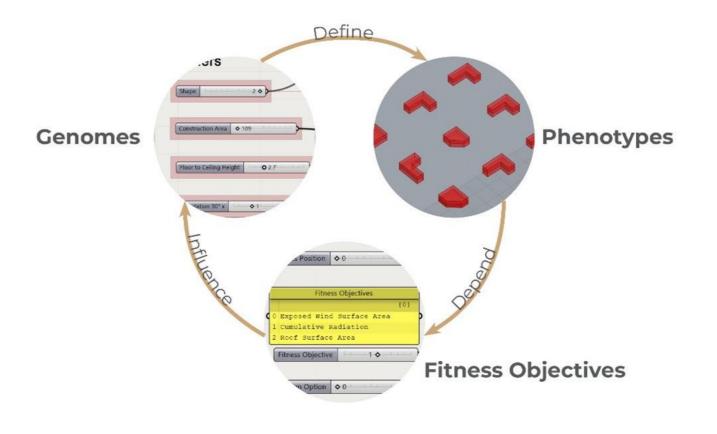
Intr	$\mathbf{od}$	ucti	ion
	uu	ucu	





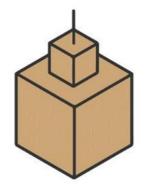
Understanding the trade-offs between chosen criteria





Developing knowledge between cause and effect

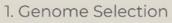
Introduction	Research Information	Climate	Design Integration	Workflow	21



Volume



Fenestration



2. Simulation 3. Results

- 4. Optimization
- 5. Phenotype Selection

Materials



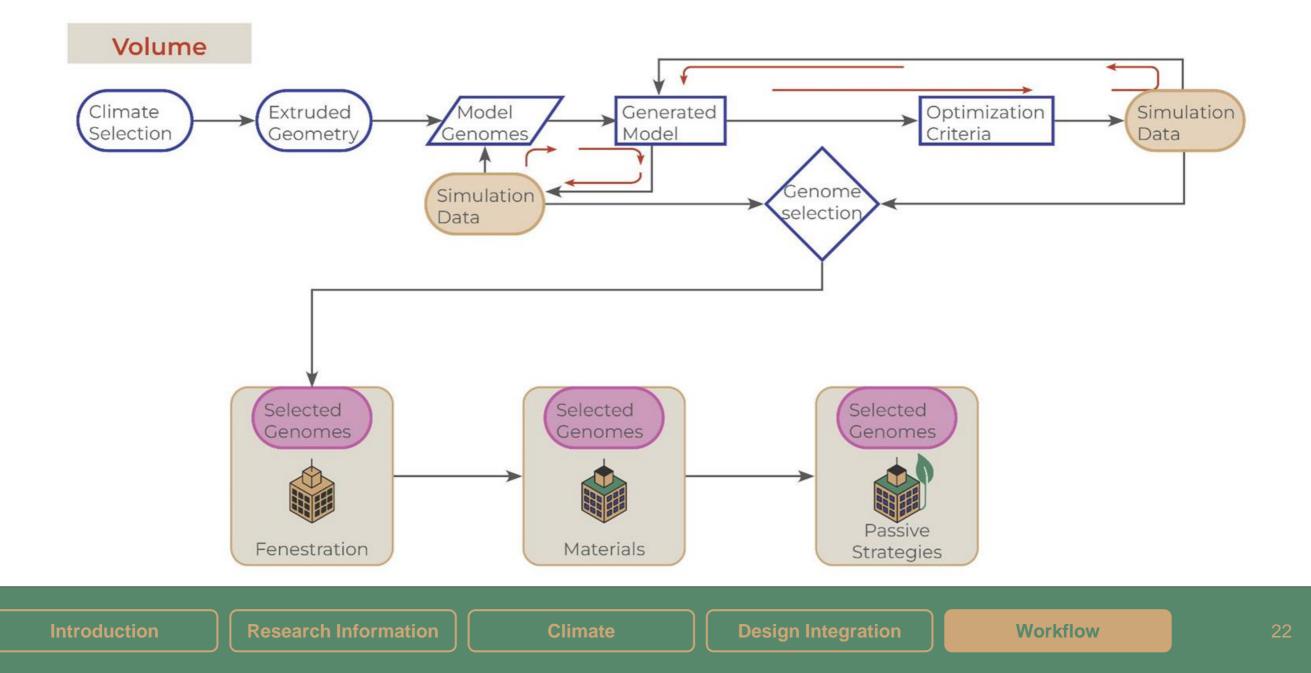
1. Genome Selection

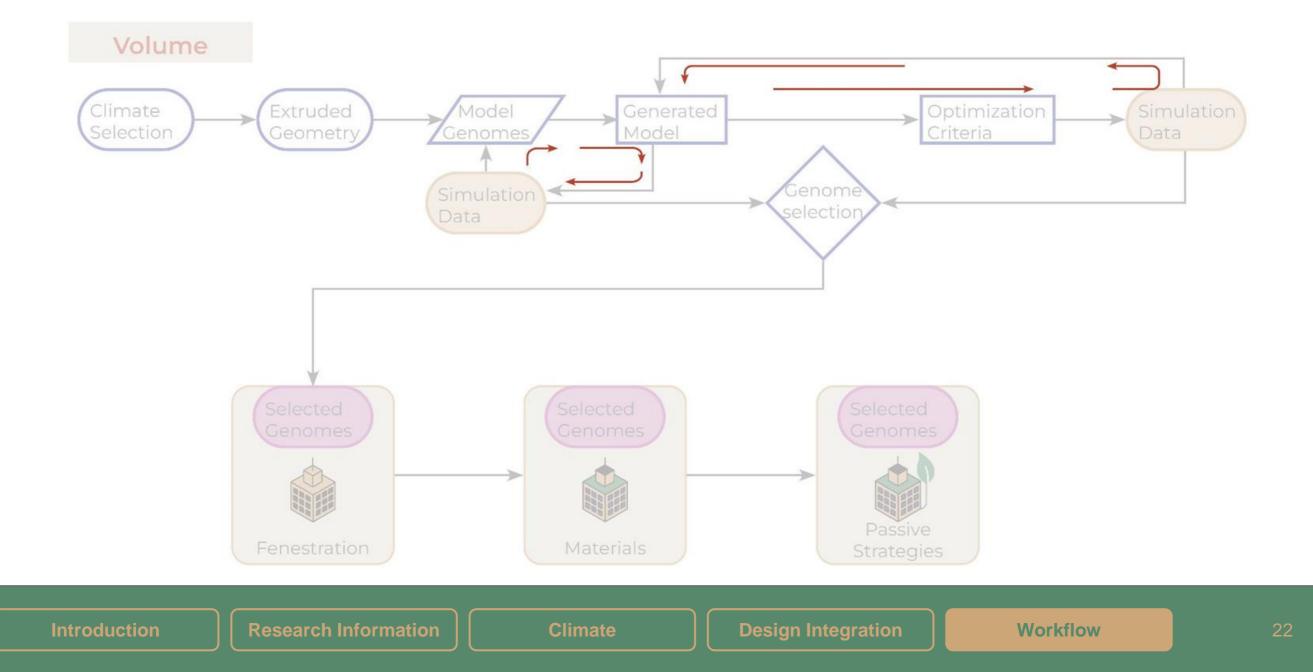
4. Phenotype Selection

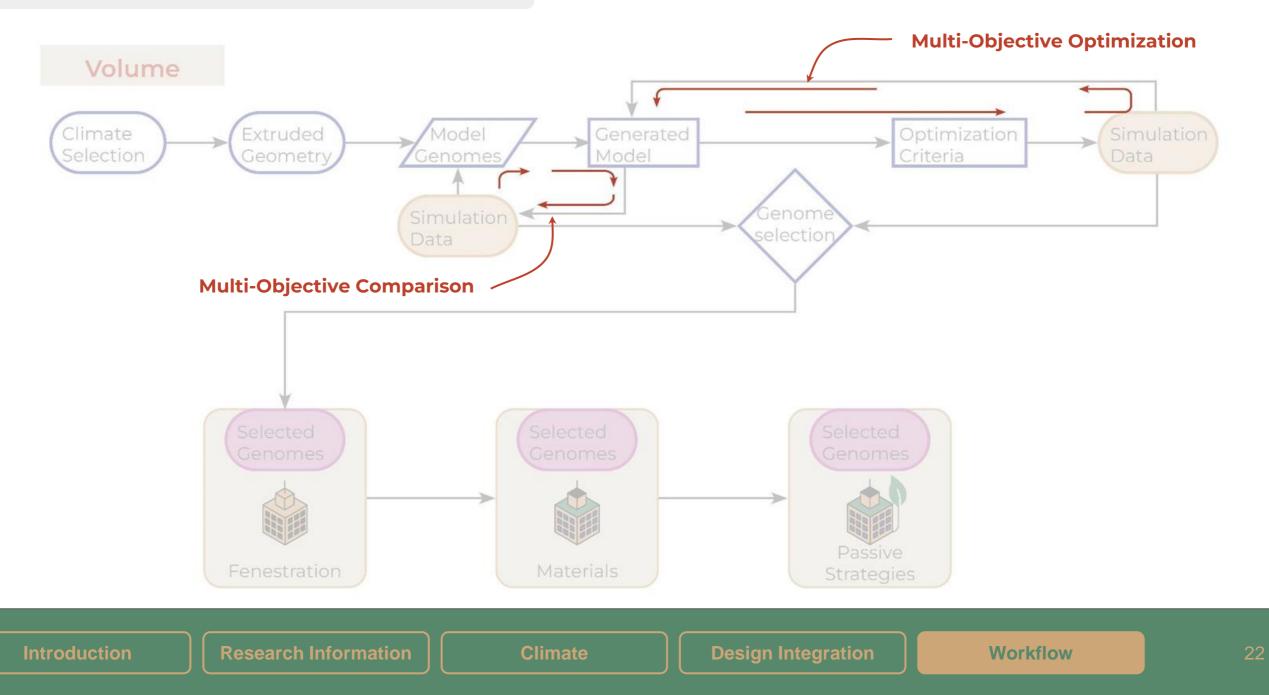
2. Simulation

3. Results

**Passive Strategies** 







Criteria	Multi-Objective Comparison	Multi-Objective Optimization
Users	Clients / Design Team	Design Team / Engineers
Geometric Options Visualization		
Interface	LAST DESERVEY • • • • • • • • • • • • • • • • • • •	
Data Obtained	NAME EXPOSED WIND SUBFACE AREA CUMULATIVE RADIATION ROOF SUBFACE AREA   Geo. 1 CA, 135, BF, 300, FCH 3, ORI 90, COUR, 43 144.293362 1355656.0458 50   Geo. 0, CA, 325, BF, 300, FCH 3, ORI 90, COUR, 0 104.991771 1.011406 25   Geo. 0, CA, 325, BF, 300, FCH 3, ORI 90, COUR, 0 104.034945 952656.5083 25	NAMEEXPOSED WIND SURFACE AREAGeo_0_CA_136_BF_2.9_FCH_2.9_ORI_2_COUR_0 Geo_1_CA_241_BF_2.8_FCH_2.8_ORI_3_COUR_0 Geo_0_CA_309_BF_2.4_FCH_2.4_ORI_1_COUR_0 Cont_CA_400_BF_2.0_FCH_2.0_ORI_0_COUR_0 Cont_CA_400_BF_2.0_FCH_2.0_ORI_0_COUR_0104.25608 218.172986 175.06848 100 551100Image: Cont_CA_400_BF_2.4_FCH_2.4_ORI_1_COUR_0 Cont_CA_400_BF_2.4_FCH_2.4_ORI_1_COUR_0 Cont_CA_400_BF_2.4_FCH_2.4_ORI_1_COUR_0 
Introduction	Research Information Climate Desig	gn Integration Workflow 23

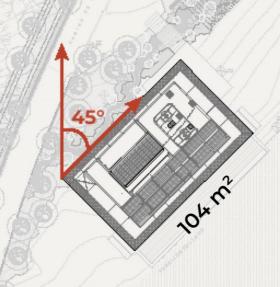
# **CASE STUDY**



## **Case Study Details**

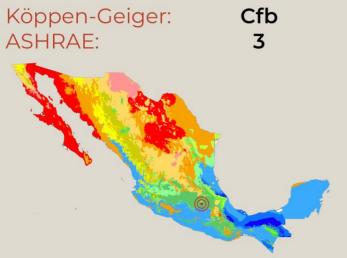


#### Area & Plot Angle



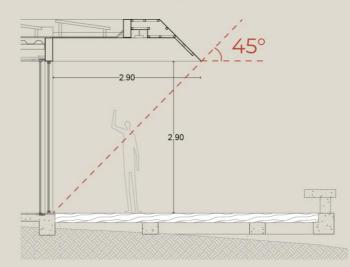


# **Climate Type**



# Window to Wall Ratio North 0.5 0.4 0.1 0.9

## **Passive Strategies**



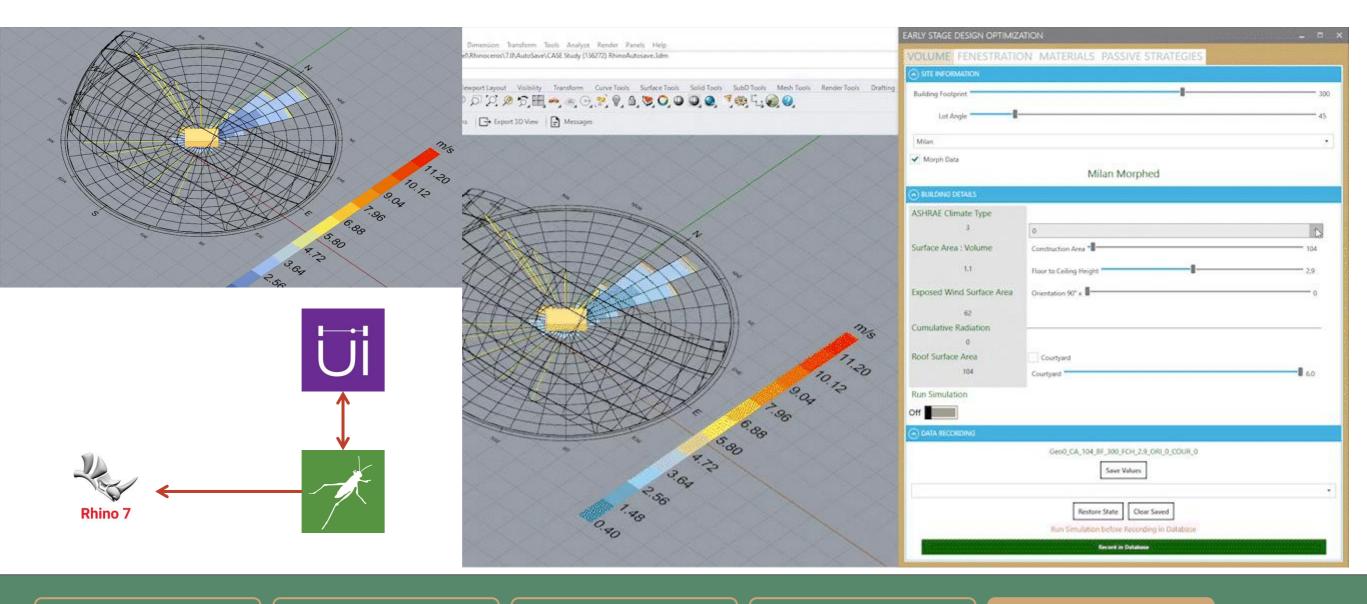
3.90 m<sup>2</sup> K/W

Floor R-Value 0.33 m<sup>2</sup> K/W

Window U-Value 1.65 W/m<sup>2</sup>•K

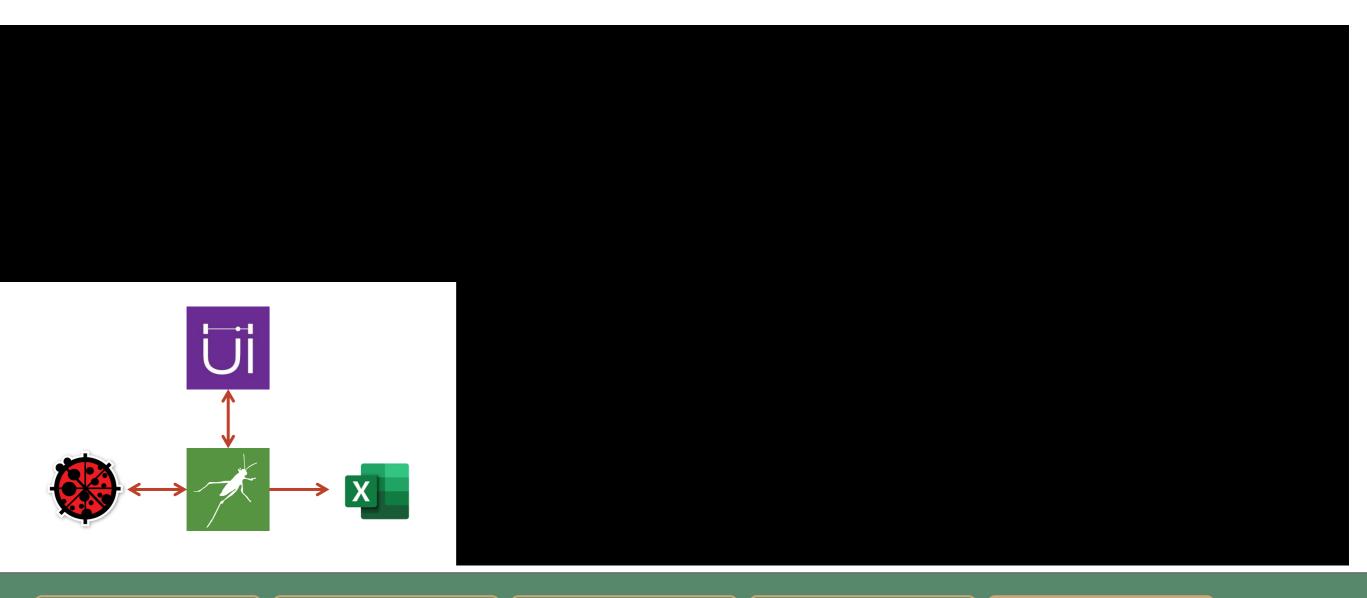
0.39

### **Geometry Selection**



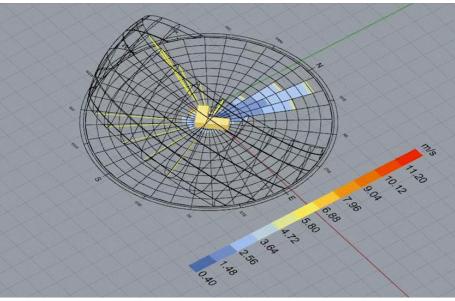
**Design Integration** 

# **Restoring Saved Data**

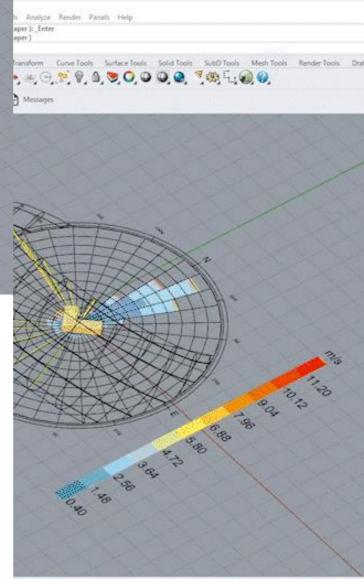


Introduction

## **Fenestration Genome Selection**



Üİ	
<b>1</b>	



g Fenestration Cooling Fenestration Energy Balance UDI Material Energy Balance Material Cooling Mate

SITE INFORMATION		
Building Footprint	1	,
	22.72). M	
Lot Angle		4
Milan		
💽 Morph Data		
	Milan Morphed	
BUILDING DETAILS		
ASHRAE Climate Type		
3	2	•
Surface Area : Volume	Construction Area *	104
12	Roor to Ceiling Height	2.9
Exposed Wind Surface Area	Orientation 90" x	0
76		
Cumulative Radiation		
35000		
Roof Surface Area	Courtyard	
104	Courtyand "	6.0
Run Simulation		
On		
O DATA RECORDING		
	GH02_CA_104_BF_300_FCH_2:9_ORI_0_COUR_0	
	Save Values	
Geo. 2. CA. 104, BF. 300, FCH, 2.9, ORI	180_COUR_0	
- 10 C	Restore State Clear Saved	
	Run Simulation before Recording in Database	

**Research Information** 

Climate

**Design Integration** 

## **Fenestration Result Charts**

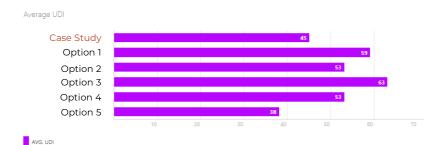
#### Heating and Cooling Comparison Data

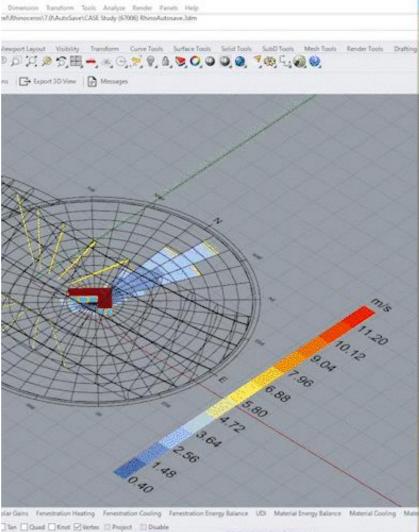


Solar Gains Comparison Data



SOLAR GAINS





Meters Default Grid Swap Otho Planar Ospap SmartTrack Gamball Record History Filter Almolde to

8

AL

#### EARLY STAGE DESIGN OPTIMIZATION VOLUME FENESTRATION MATERIALS PASSIVE STRATEGIES SLIDE ME Fenestration Refresh Geometries Geo 2 CA 104 BF 300 FCH 2.9 ORI 180 COUR 8 **Total Facade Surface Area** 0.5 north\_ 154 mart Wall Surface Area 72 with Window Surface Area 0.5 77 Percentage of Glass Facade 50% Geb2\_CA\_104\_BF\_300\_FCH\_2.9\_ORL\_180\_COUR\_0.0.5\_0.5\_0.5\_0.5 Save Values Geo 2 CA 104 8F 300 FCH 2.9 ORI 180 COUR 0 8.5 0.5 0.5 0.5 -Restore State Clear Saved Run Simulation On I unning a simulation takes around 4 minutes Hun Simulation before Recording in Database Record in Delabase

Introduction

**Research Information** 

Climate

A

**Design Integration** 

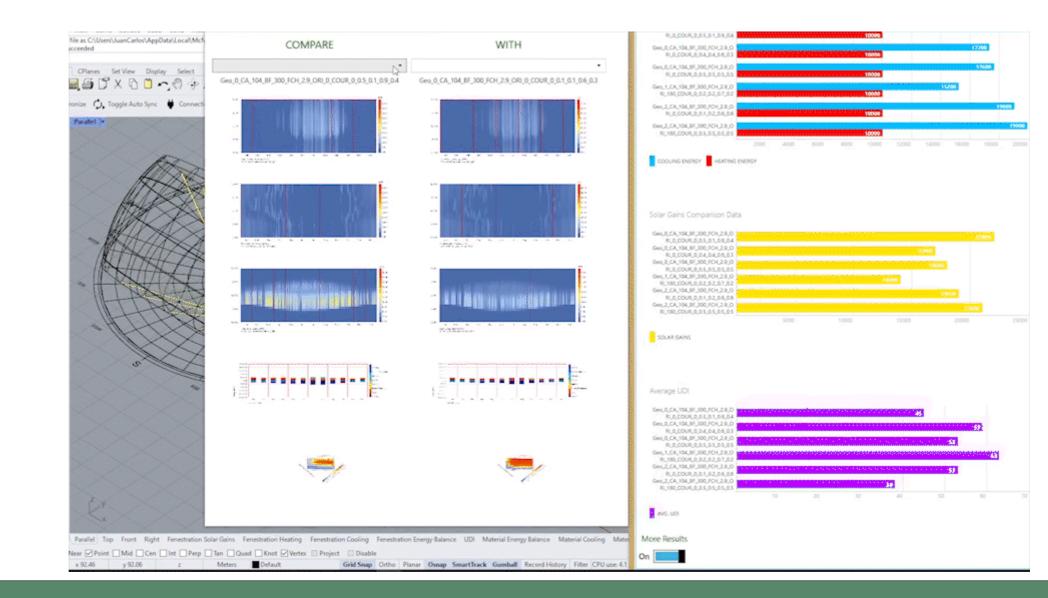
Workflow

29

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21/10/200

## **Fenestration Result Graphs**



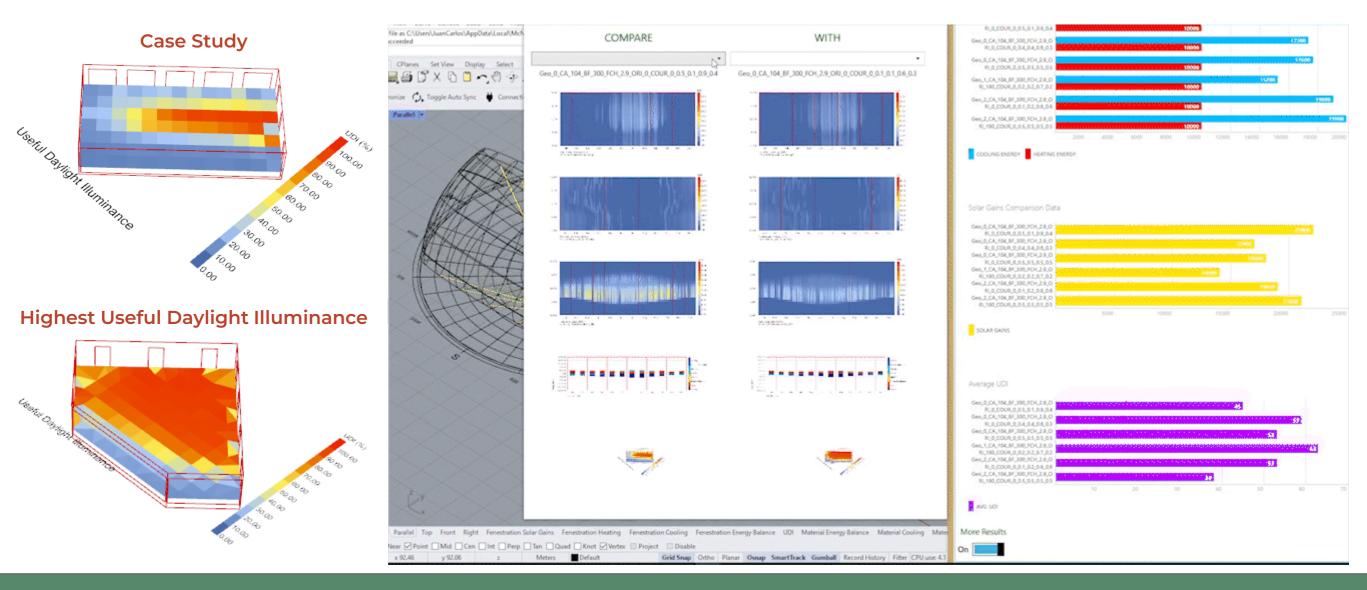
#### Introduction

**Research Information** 

#### Climate

**Design Integration** 

## **Fenestration Result Graphs**

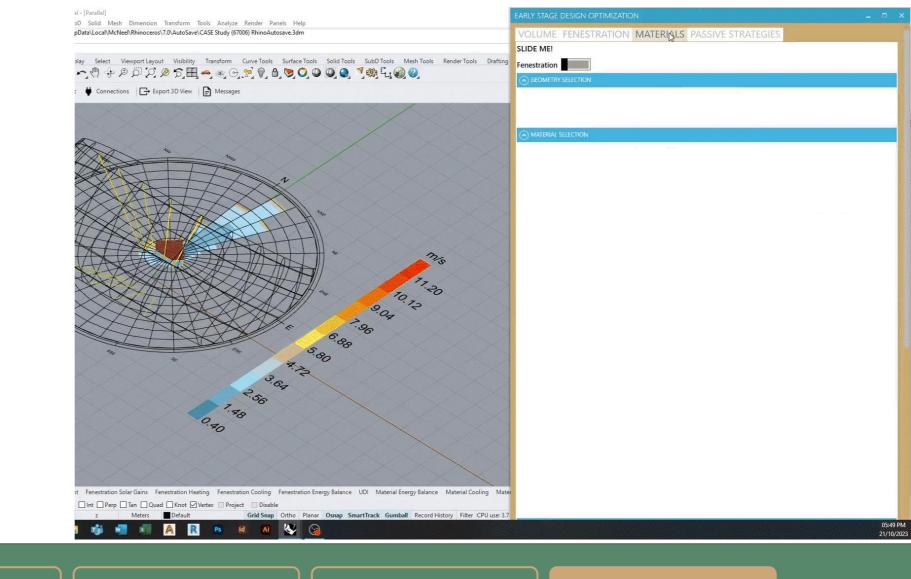


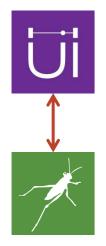
Introduction

Climate

**Design Integration** 

## **Material Genome Selection**





Introduction

**Research Information** 

Climate

**Design Integration** 

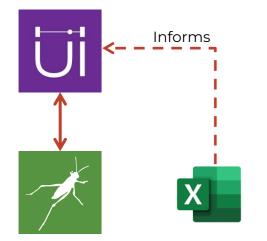
Workflow

31

## **Material Genome Selection**

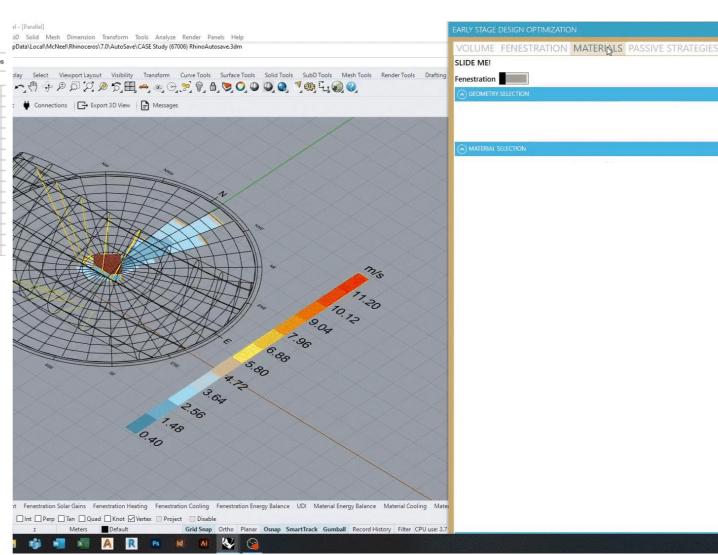
#### Material Assistance Table

Material	Thermal Conductivity	Specific Heat Capacity	Density						(	Commercial	Thickness	es
	λ (W/m•K)	c (J/Kg•K)	p (Kg/m³)							(m	nm)	
ABS Polymers	0.2	1470	1100	1	3	6						Т
Aluminium	200	880	2800	0.15	0.8	1	1.2	1.5	3	4	5	T
Air (Cavity)	0.026	1005	1225	5	10	15	20	25	30	35	40	T
Basalt	35	840	3000	0.55	2.5							T
Brick 1	0.327	1000	850	140								T
Brick 2	0.292	1000	930	120								T
Brick 3	0.232	1000	800	180								T
Brick 4	0.299	1000	910	120								T
Brick 5	0.265	1000	920	120								T
Brick 6	0.4	837	775	80								T
Brick 7	0.19	837	1255	80								T
Brick 8	0.187	1112	1171	100	140	290						T
Brick Lightweight	0.3	840	1000	100								T
Calcium Silicate Panel	0.045	1000	107.5	80	100	120	160	180	200	240	260	T
Cane Fiber Board	0.085	2100	300	8	10	12	16	18	21			T
Cellular Glass	0.06	850	140	40	60	80	100	120				Ť



Introduction

**Research Information** 



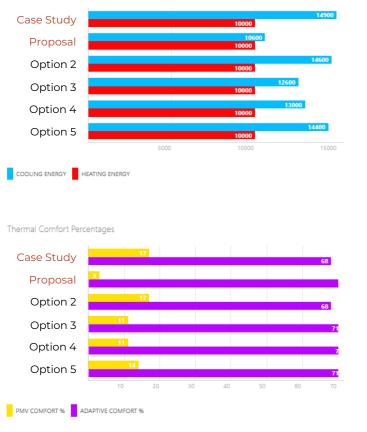
Climate

Workflow

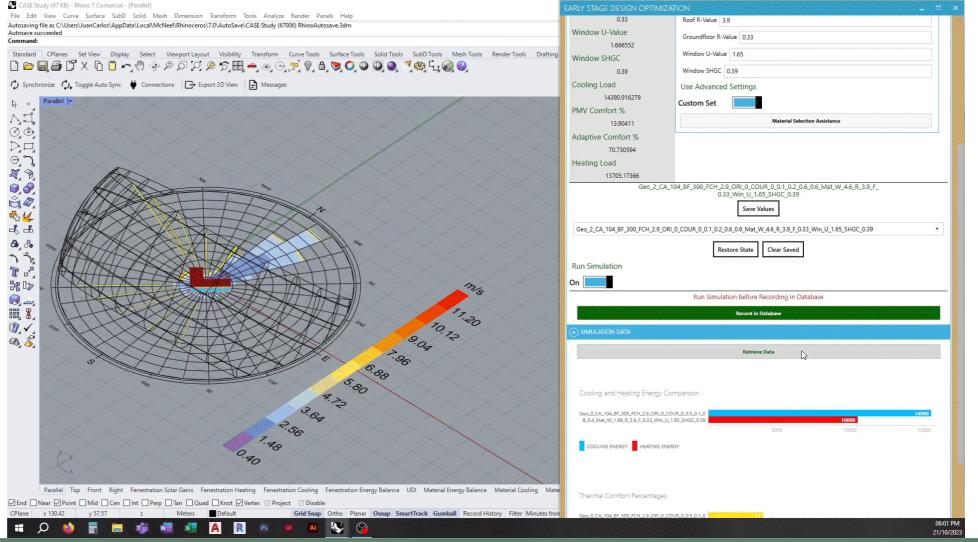
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21/10/202

#### **Material Result Charts**



Cooling and Heating Energy Comparison



**Research Information** 

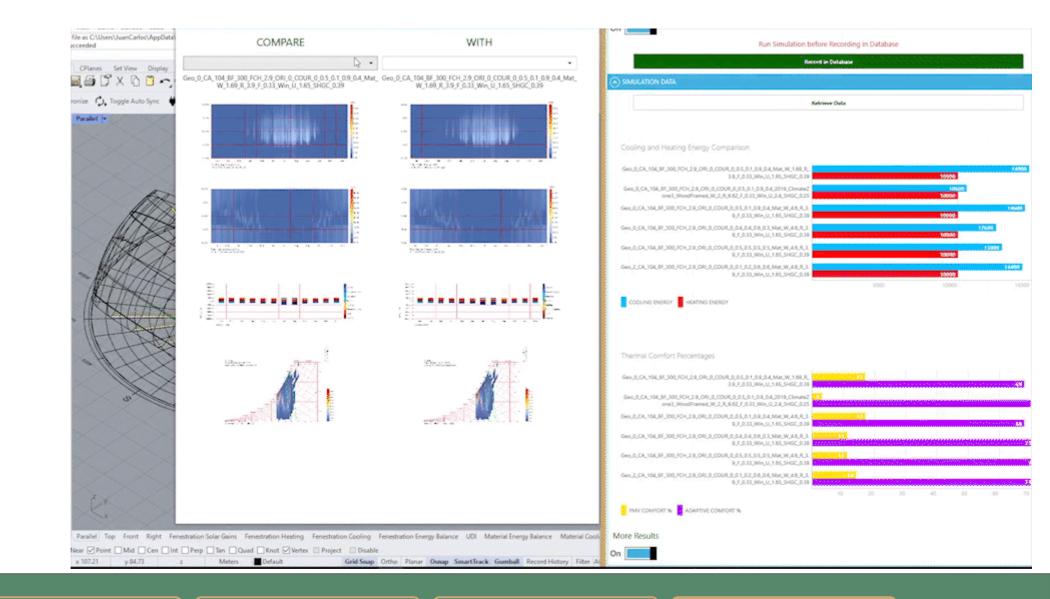
Climate

**Design Integration** 

Workflow

32

## **Material Result Graphs**

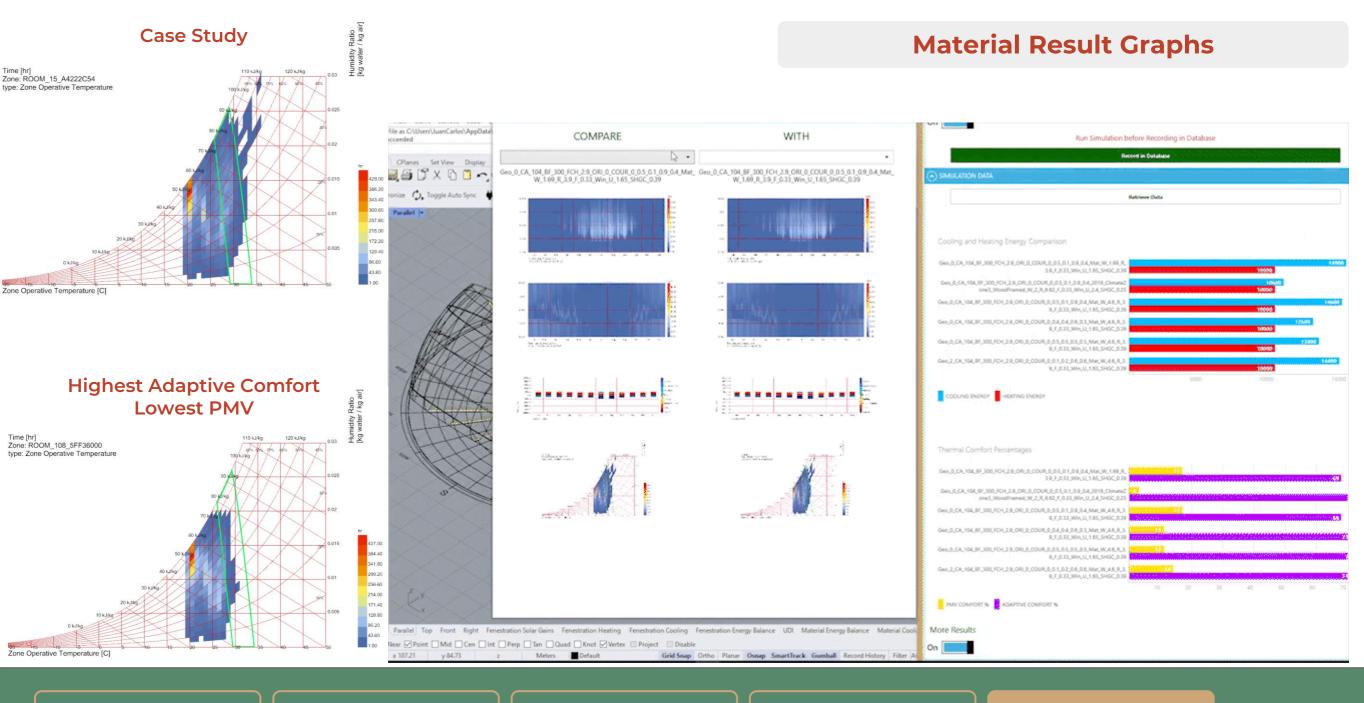


#### Introduction

**Research Information** 

#### Climate

**Design Integration** 



Research Information

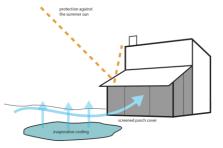
Climate

**Design Integration** 

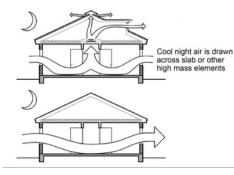
Workflow

33

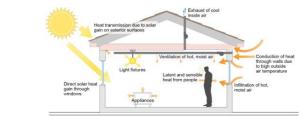
#### **Evaporative Cooling**



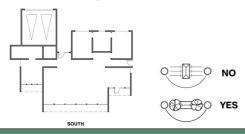
#### Mass + Night Ventilation



#### **Capture Internal Heat**



#### **Passive Solar Heating**



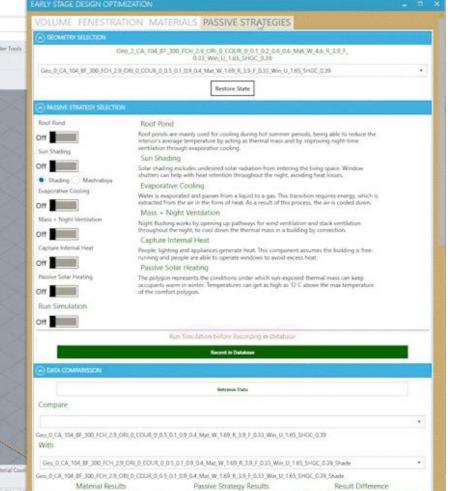


# viae 🖒 Toggle Auto Synz 🕴 Connections 🕞 Export 3D View 🕞 Missages scatel [+ 20 10.12 9.04 1.98 6.88

dy [97 KB] - Ehine 7 Commoial - [Pacallel



# **Passive Strategy Selection**



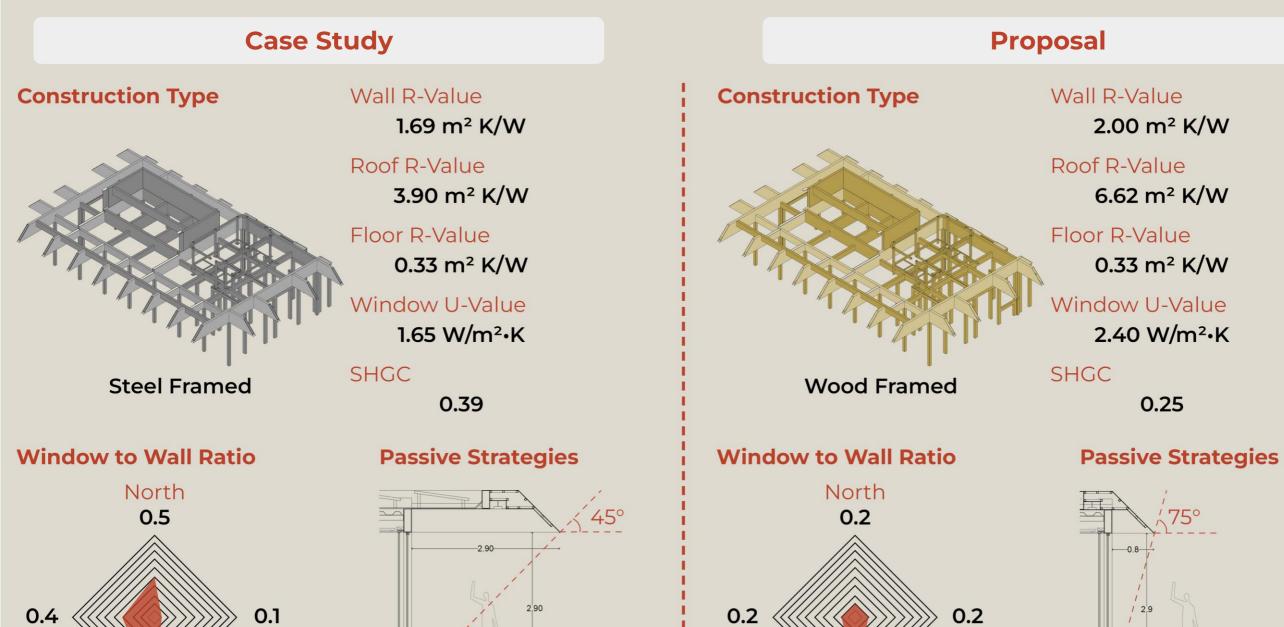
Introduction

Climate

**Design Integration** 

**Workflow** 

06:01 PM

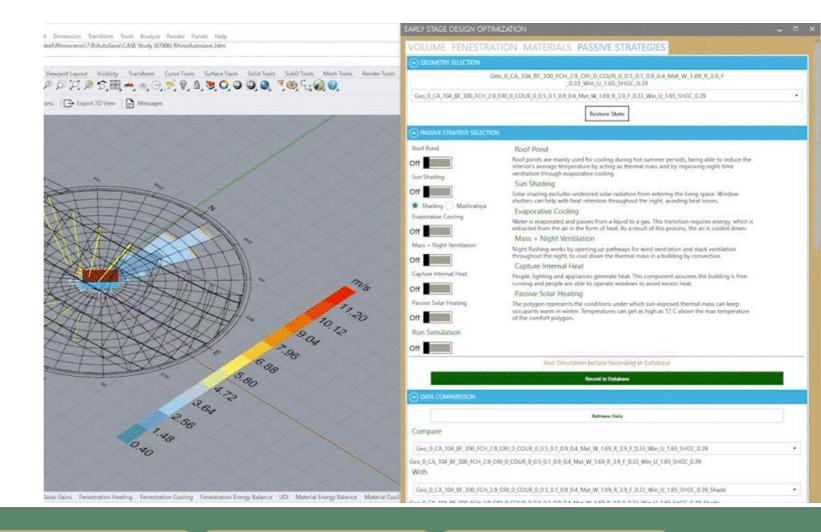


0.7

175°

0.9

#### **Result Comparison**



#### Introduction

**Research Information** 

#### Climate

**Design Integration** 

Case Study	Proposal	Differences
Cooling Load	Cooling Load	Cooling Load
15000	10000	-5000 (-40%)
PMV Comfort %	PMV Comfort %	PMV Comfort %
17	1	-16%
Adaptive Comfort %	Adaptive Comfort %	Adaptive Comfort %
68	77	9%
Heating Load	Heating Load	Heating Load
13000	14000	1000 (7%)

# **Result Comparison**

h Dimension Transform Tools Analyze Render Panels Help	EARLY STAGE DESIGN OPTIM	IZATION	
keef\Rhinoceros\7/I/\AutoSave\CASE Study (67006) RhinoAutosave.3dm	VOLUME FENESTRAT	TION MATERIALS PASSIVE STRATEGIES	
	CEOMETRY SELECTION		
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	Ge	o.D.CA. 104, BF, 305, FCH, 29, DRI 0, COUR, 0, 0.5, 0.1, 0.9, 0.4, Mat, W, 1.69, R, 3.9, F .0.33, Win, U, 1.65, SHGC, 0.39	
ors:   🕞 Export 30 View   🕞 Messages	Geo_0_CA_104_BF_300_FO1_2.9	ORL0_COUR_0_0.5_0.1_0.9_0.4_Mart_W_1.69_R_3.9_F_0.33_Win_U_1.65_5H0C_0.39	1
		Restore State	
	Assave strategy selection		
1.30 1.30	Roof Pond Off Sun Shading Shading Shading Shading Shading Shading Shading Massie Cooling Off Massie Cooling Massie Cooling Capture Internal Heat Off Capture Internal Heat Off Massie Cooling Capture Internal Heat Off Massie Capture Internal Heat Off Massie Cooling Massie Cooling Capture Internal Heat Off Massie Cooling Capture Internal Heat Off Massie Cooling Capture Internal Heat	Roof Pond   Roof ponds are mainly used for cooling during hot summer periods, being able to reduce the interior's average temperature by acting as thermal mass and by improving night-time ventalision through evaporative cooling.   Sun Shiadring   Sala shading esculutes undersined solar radiation from entering the living space. Window shuttens can help with heat retention throughout the night, avaiding heat losses.   Evaporative Cooling   Where is evaporated and papers from a liquid to a gas. This transition requires energy, which is estracted from the air in the form of heat. As a result of this process, the air is cooled down.   Mass + Night Ventiliation   Night flushing works by opening up pathways for wind ventilation and stack ventilation increasional throughout the night, is cool down the thermal mass in a building by connection.   Capture Internal Heat   Prople, lighting and appliances generate heat. This component assumes the building is free- running and people are able to operate windows to avoid encess heat.   Passive Solar Heating   Mass to popling the conditions under which sun-exposed thermal mass can keep occupant warm in winter. Emperatures can get as high as 12 C above the max temperature of the comfort polygon.	
		Run Simulation before Recording in Database	
	Service of the servic	Record in Delabore	
* * * 13 3.et	O DATA COMPARISSON		1.1
2.35 <sup>30</sup>		Retrieve Data	
1.30	Compare		
O.R.O	Geo.,0,CA_104_BF_300_FCH_2.9	ORI_0_COUR_0_0.5_0.1_0.9_0.4_Met_W_1.69_R_3.9_F_0.33_Win_U_1.65_5H0C_0.39	*
	Geo.0.CA_104_BF_300_FCH_2.9_O With	RL0_COUR_0_05_01_09_04_Met_W_169_R_39_F_033_Wer_U_165_SH6C_039	
XXXXXXXXXXXX		ORL0_COUR_0_0.5_0.1_0.9_0.4_Mart_W_169_R_3.9_J_0.33_Win_U_165_SHGC_0.39_Shade	
Solar Gains Fenestration Heating Fenestration Cooling Fenestration Energy Balance UDI Material Energy Balance Material Cool	C 0. CA 104 BE 300 ECH 3.0.0	DE N POLID N NE NE NE NA NA MA MERINA DI SIN E NOS MAL TERIZO CUPP. NON CL. 4.	

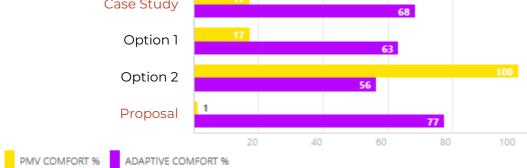
Climate

**Design Integration** 

Case Study	Proposal	Differences
Cooling Load	Cooling Load	Cooling Load
15000	10000	-5000 (-40%)
PMV Comfort %	PMV Comfort %	PMV Comfort %
17	1	-16%
Adaptive Comfort %	Adaptive Comfort %	Adaptive Comfort %
68	77	9%
Heating Load	Heating Load	Heating Load
13000	14000	1000 (7%)

#### Cooling and Heating Energy Comparison





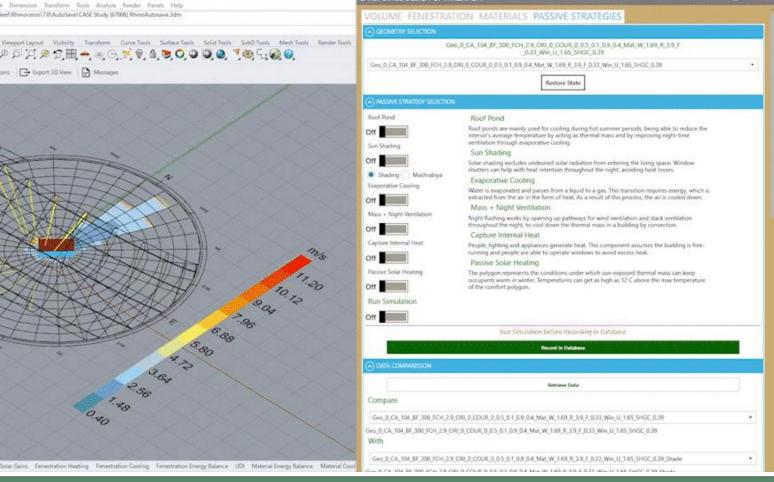
# Dimension Transform Tools Analyze Render Panels Help Jeef\Rhinoceros\7.0\AutoSave\CASE Study (67006) RhinoAutosave.3dm lewport Layout Visibility Transform Curve Tools Surface Tools Solid Tools SubD Tools Mesh Tools Render Tools ons 🕞 Export 30 View 📄 📄 Messages 1.98 9.04 13 6.88 5.80 4.20

3.64

50

20

## **Result Comparison**



Introduction

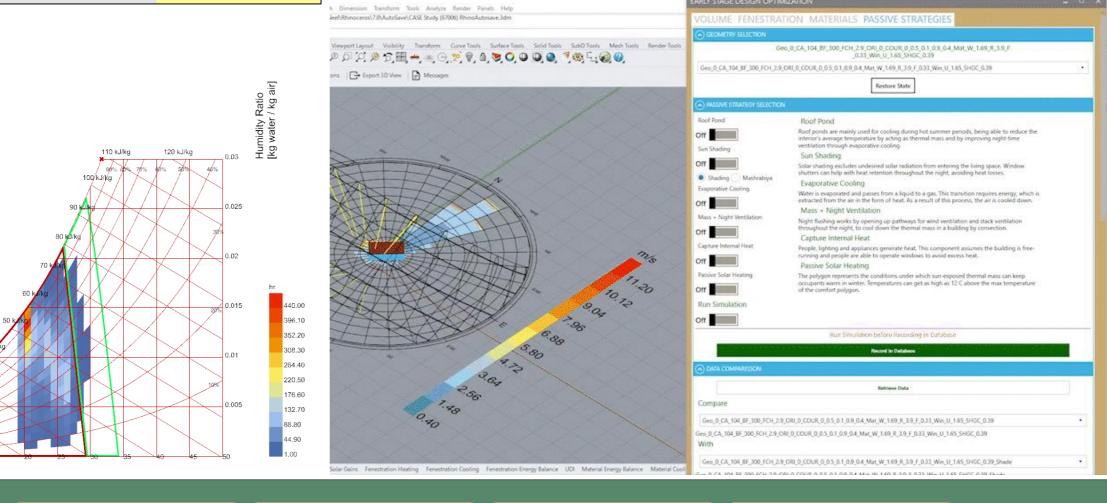
**Research Information** 

Climate

**Design Integration** 

Case Study	Proposal	Differences
Cooling Load	Cooling Load	Cooling Load
15000	10000	-5000 (-40%)
PMV Comfort %	PMV Comfort %	PMV Comfort %
17	1	-16%
Adaptive Comfort %	Adaptive Comfort %	Adaptive Comfort %
68	77	9%
Heating Load	Heating Load	Heating Load
13000	14000	1000 (7%)

### **Result Comparison**



Introduction

10 kJ/kg

0 kJ/kg

Zone Operative Temperature [C]

20 kJ/kg

Time [hr]

Zone: ROOM 125 033E7662

Evaporative Cooling

Mass + Night Vent

Passive Solar Heating

Capture Internal Heat

type: Zone Operative Temperature

**Research Information** 

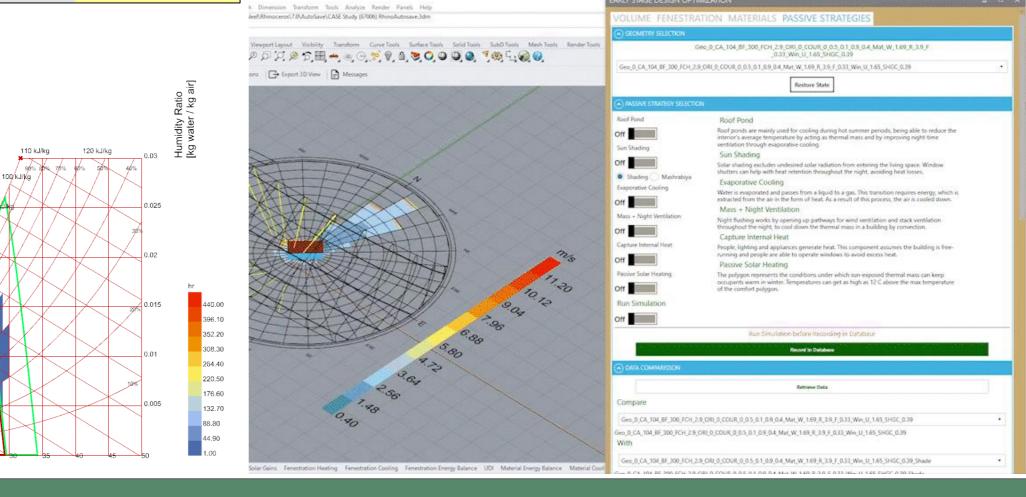
Climate

**Design Integration** 

Case Study	Proposal	Differences
Cooling Load	Cooling Load	Cooling Load
15000	10000	-5000 (-40%)
PMV Comfort %	PMV Comfort %	PMV Comfort %
17	100	83%
Adaptive Comfort %	Adaptive Comfort %	Adaptive Comfort %
68	77	9%
Heating Load	Heating Load	Heating Load
13000	14000	1000 (7%)

80 kl/ka

### **Result Comparison**



Introduction

10 kJ/kg

0 kJ/kg

Zone Operative Temperature [C]

20 kJ/kg

Time [hr]

Zone: ROOM 125 033E7662

Evaporative Cooling

Mass + Night Vent

Passive Solar Heating

Capture Internal Heat

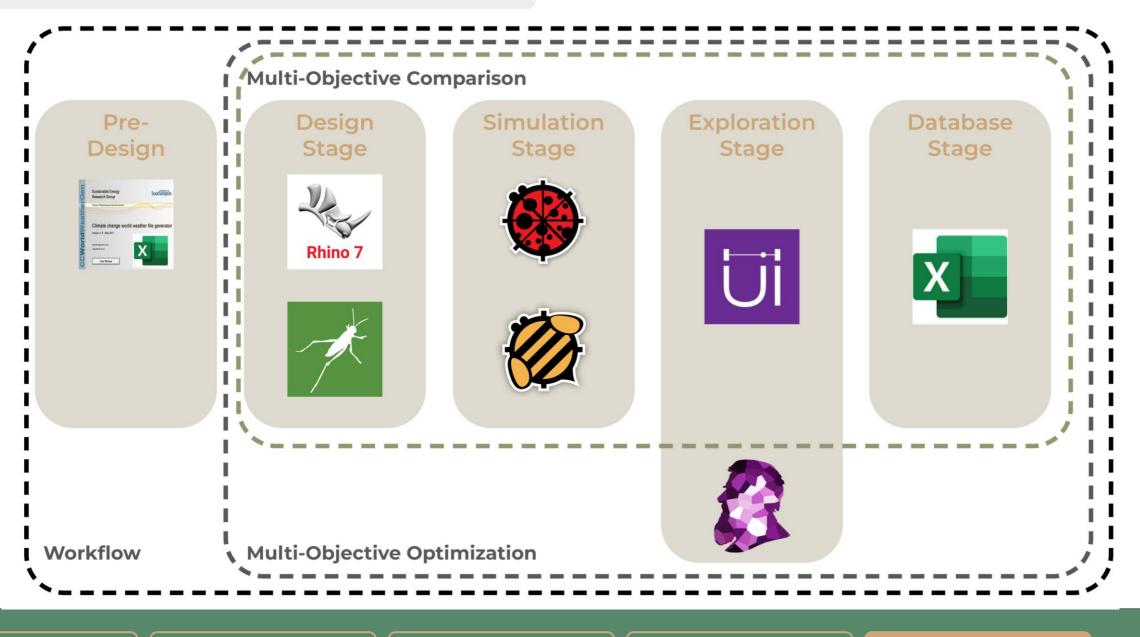
type: Zone Operative Temperature

**Research Information** 

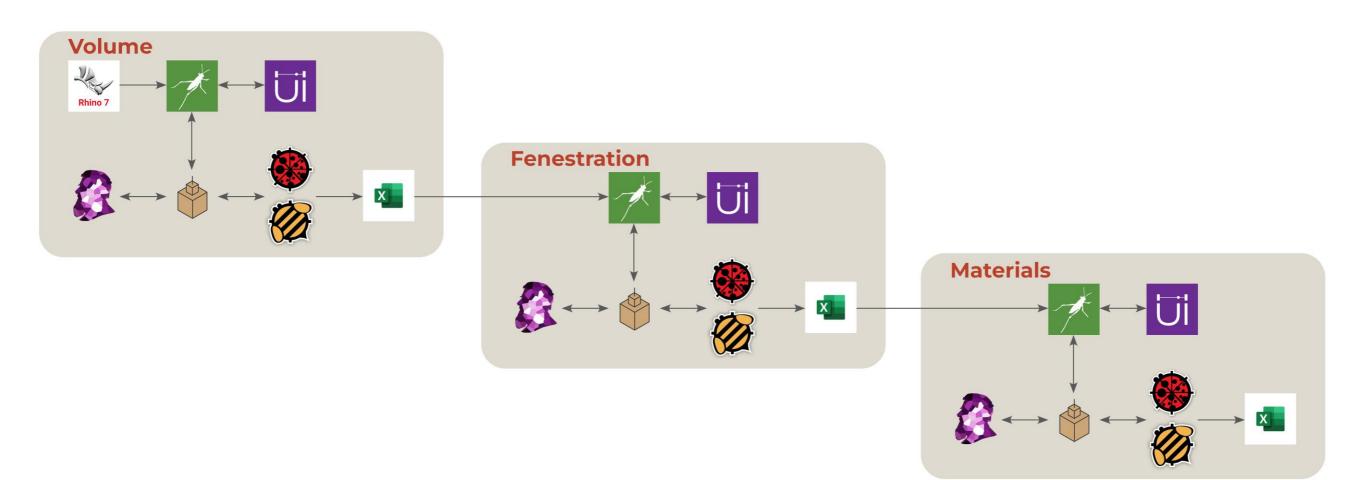
Climate

**Design Integration** 

## Existing Components → Innovative Process

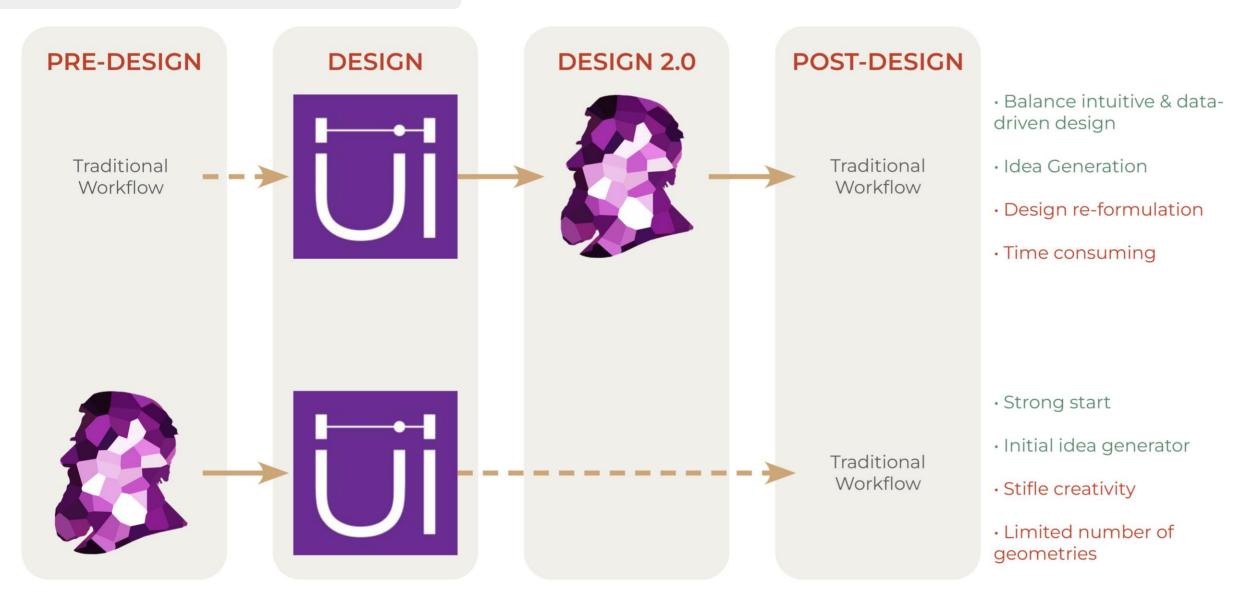


# Existing Components → Innovative Process





# **Optimization Workflow**

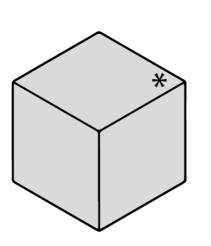


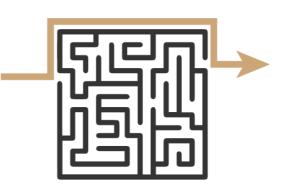
Climate

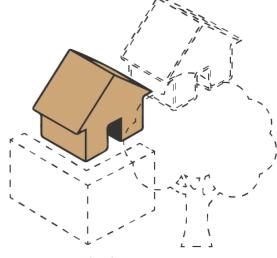
**Design Integration** 

# Limitations









**Omitting Context** 

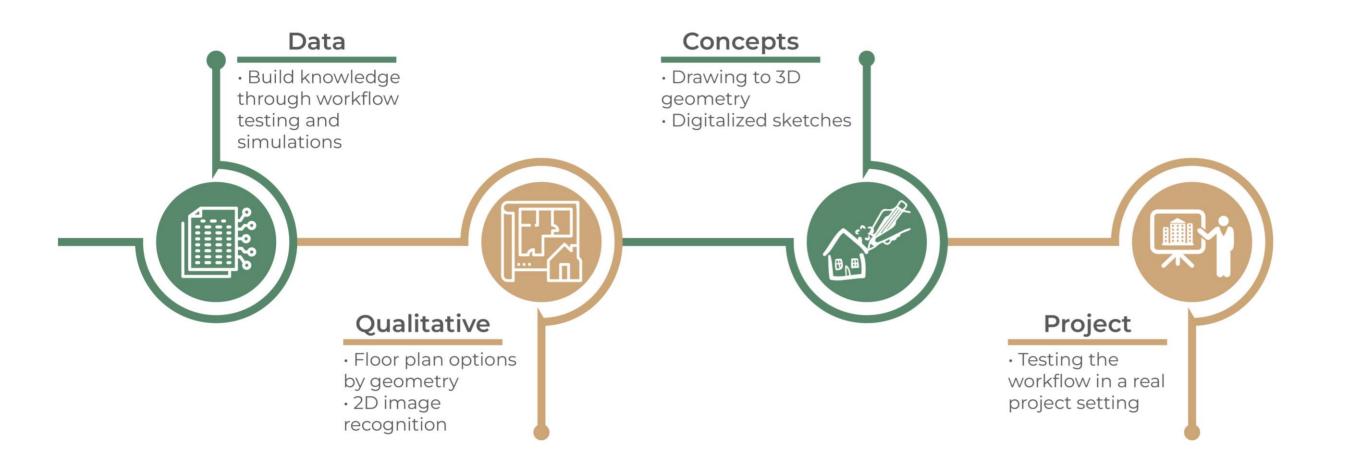
Limited Fitness Objectives

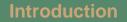
Material Simplification

Simple Passive Strategies



## **Future Potential Integration**





**Design Integration**