Masters of science Architecture for Sustainability / Architecture Construction City
Parametric & Algorithmic Modeling | A.Y. 2024/2025
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Politecnico di Torino

PALAZZO DEL LAVORO

Parametric & Algorithmic Modeling

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Juan Martin **DOSMAN**	s335274
Youssef **NASR EL DIN**	s344493

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TEAM COMPOSITION

Dudu Dilan
CAM

East Facade

Belemir
TOPKAYA

South Facade

João
BARBOSA

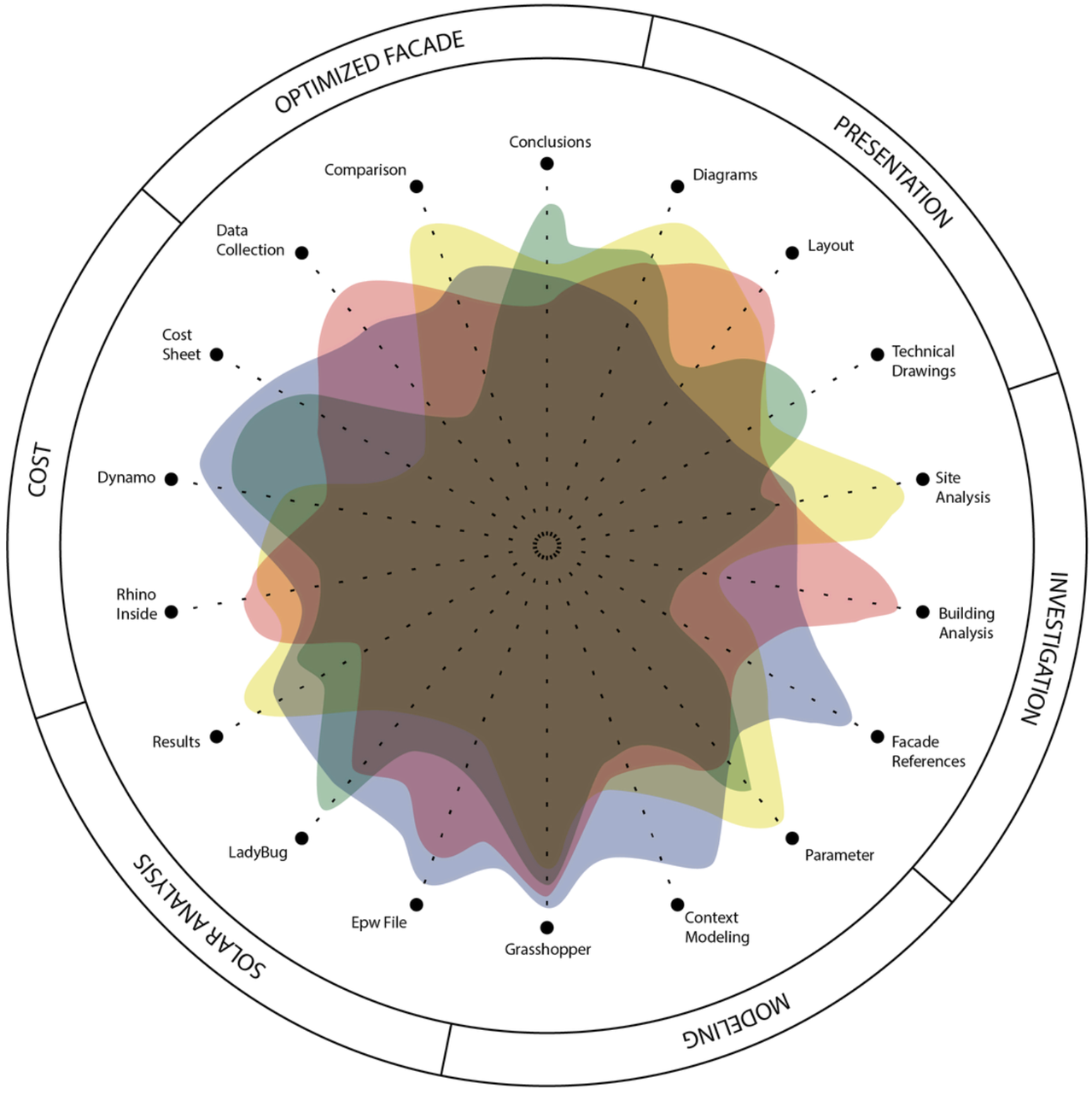
West Facade

Juan Martin
DOSMAN

North Facade

Youssef
NASR EL DIN

West Facade



History of Palazzo Del Lavoro

In 1961, Italian engineer Pier Luigi Nervi, in collaboration with architect Gio Ponti, designed the Palazzo del Lavoro in Turin as part of Expo 61, which celebrated the 100th anniversary of Italy's unification. The structure features a modular roof with 16 umbrella-like sections supported by central columns, reflecting Nervi's innovative engineering approach and the modernism of Italian architecture. Construction began in February 1960 and was completed by the end of December, officially opening on May 6, 1961. Three days after the inauguration, Queen Elizabeth II visited the building and praised it, saying, "This represents a century of Italy's economic progress, its modern industry, and its promise of future active development." (fondazione.groupmaire.com)

The Palazzo del Lavoro is located in the Italia '61 Urban Park in the Nizza Millefonti-Lingotto district, near the southern entrance of Turin. With its proximity to Lingotto and the Po River, it holds a significant position and has historical importance due to its connection with the 1961 Expo and the 1959 Master Plan, which commemorated the centenary of Italian Unification. The site exemplifies modern urban design with green spaces and easy access to key locations such as the Lingotto shopping center and train station.

Over time, the building fell into disuse and was abandoned from the 1970s onward. A fire in 2015, along with years of neglect, has left the structure in dire need of restoration. (ribaj.com)

Despite its current state, the Palazzo del Lavoro remains an important symbol of Turin's industrial heritage and urban renewal efforts, reflecting the city's historical and modern evolution.

PROJETC AIM

Work Distribution

Our aim is to design a dynamic, sustainable, and cost-effective facade system using parametric and algorithmic design principles. By leveraging advanced computational tools such as Rhino, Grasshopper, Ladybug, and Revit, we seek to achieve a design that balances aesthetics, performance, and practicality.

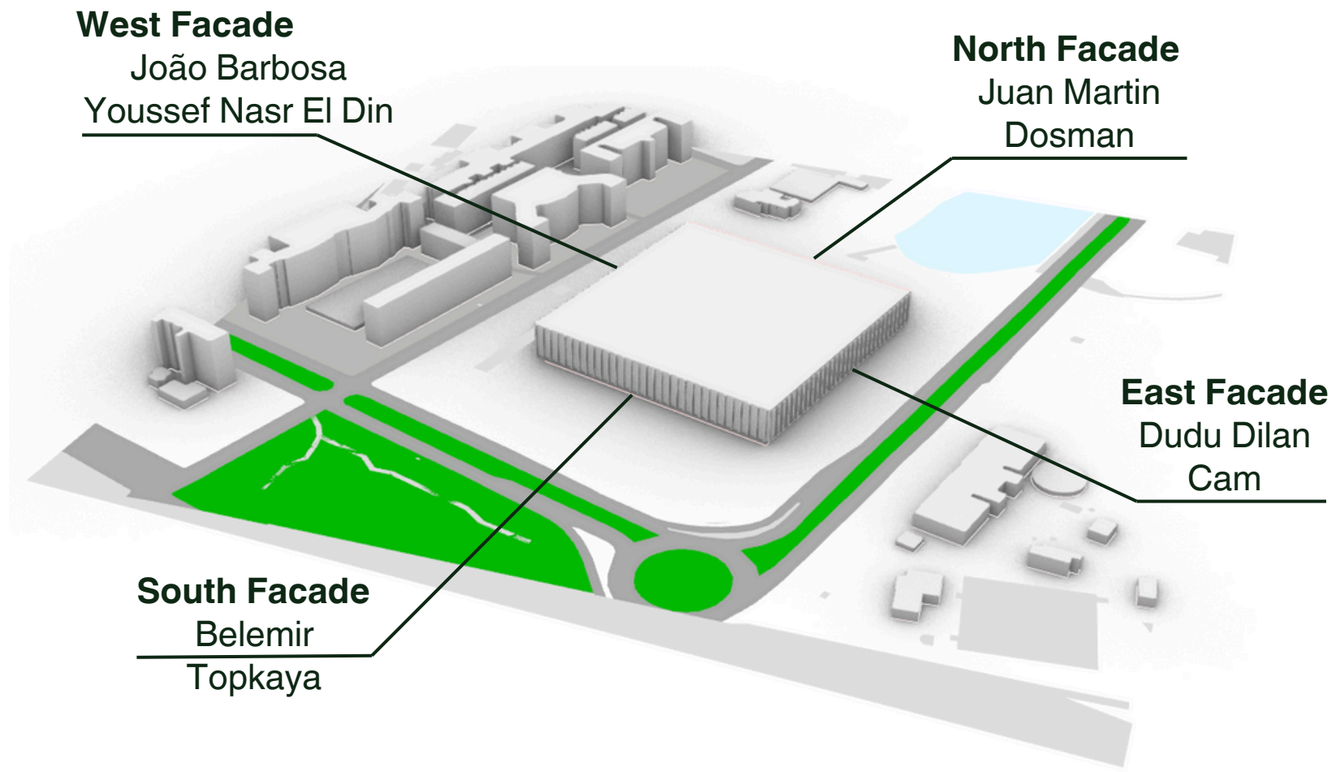
The steps that we are going to follow:

Step 1: **Facade Design with Parametric Flexibility**

Step 2: **Solar Analysis for Energy Efficiency**

Step 3: **Cost Analysis and Feasibility**

Step 4: **Integration of Sustainable Practices**



Vision

This project exemplifies the potential of computational tools to create innovative architectural solutions. By combining aesthetic exploration, environmental performance, and cost-conscious design, we aim to deliver a facade that is both forward-thinking and grounded in practical realities.

Work Flow

Tools and concepts learned by cronogical order

Pattern Design, using a Visual Programming Language to simulate real and complex patterns into Rhino

BIM is created, with the addition of information to the model and the use of interoperability between tools and people

Rhino → **Grasshopper** → **Ladybug** → **Revit** → **Dynamo**

3D Model, base context to work on, enviroment creation

Solar Analysis, using real data accorrding to Torino weather, into Grasshopper

Automation and parameter analysis into Revit

INTEROPERABILITY

Interoperability among softwares is the essential key that allowed the creation of the final model. Only with the use of different programs and plugins it was possible to go from the first steps to the last results.

DATA RESEARCH AND WORK SHARING PLATFORMS

At the beginning, in order to obtain informations regarding the project, the use of Data Search articles published on Google and YouTube videos were essential. In the same way, the work sharing platforms, especially WhatsApp and Canva helped the communications and the sharing of information among members of the group.

MODEL

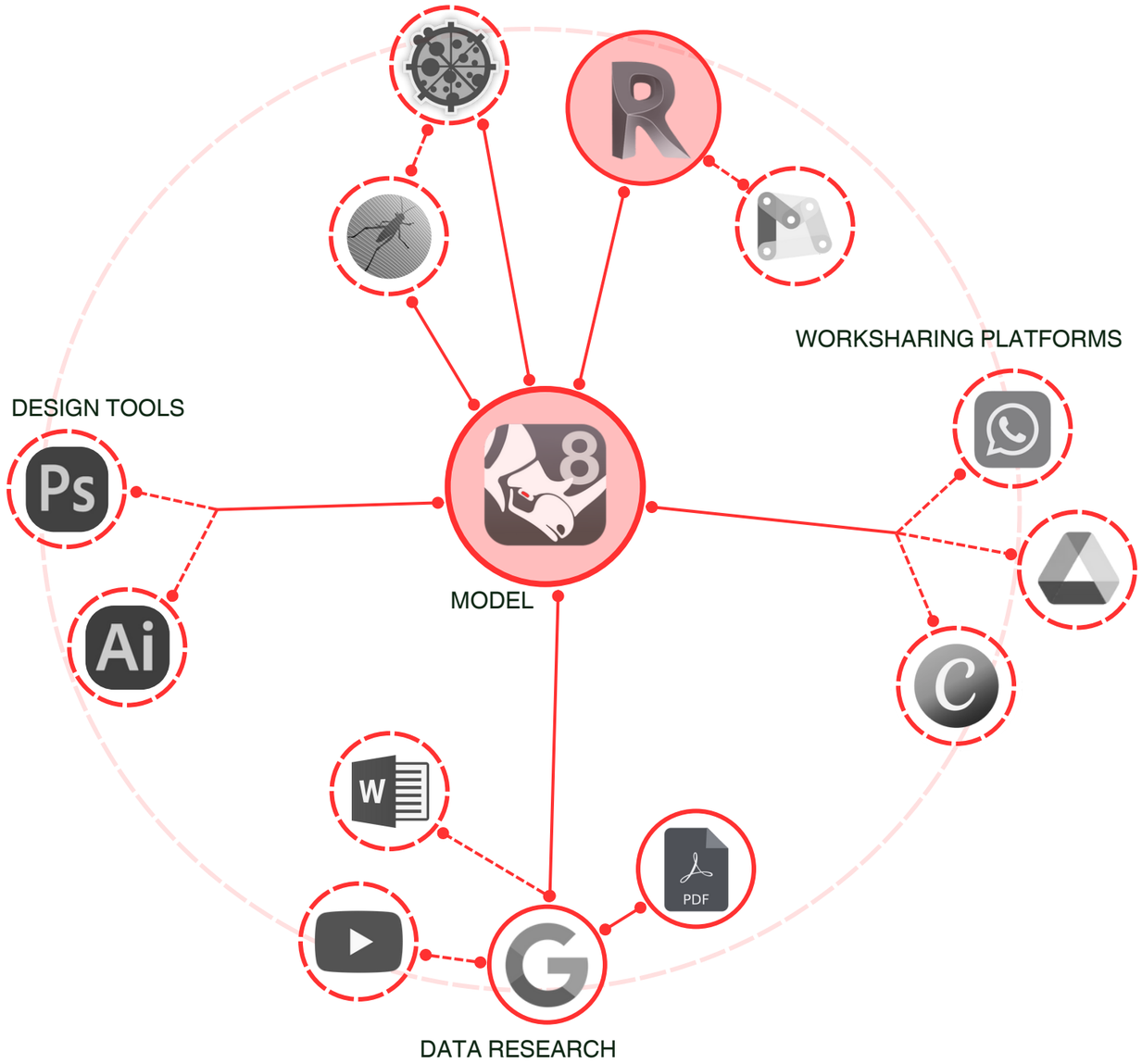
During the study of the project of the Droneport, that drived us for all the entire development of the work, the first models were produced. Using Rhinoceros and Grasshoper, the model started to appear. On the other hand, the first complications start to show themself as well.

ECONOMIC ANALYSIS

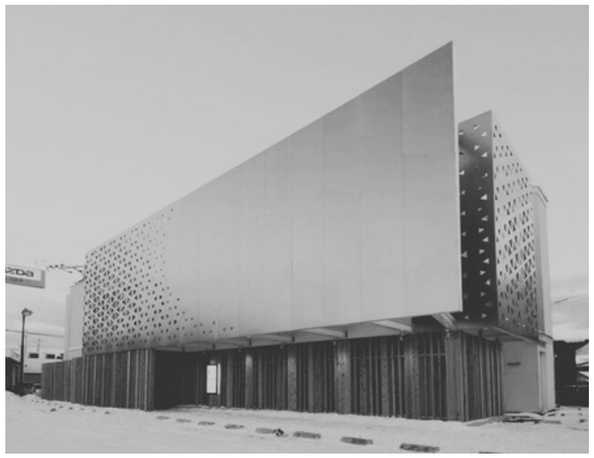
In order to make the economic analysis, after the importation of the model inside Revit thanks to the use of the plugin Rhino Inside Revit, we have completed the cost analysis with Dynamo. Difficulty encountered during Rhino to Revite transfer, in fact, the model was not recognised as a family in Revit firstly.

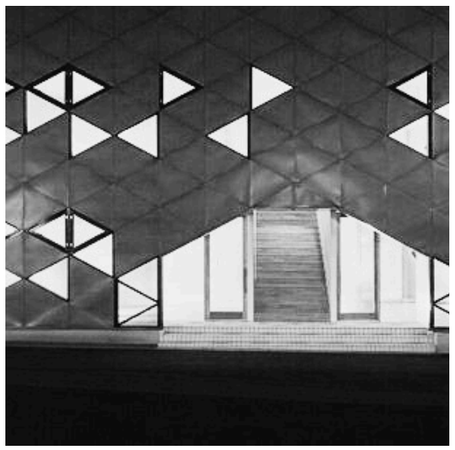
DESIGN TOOLS

The interoperability between different design tools of Adobe Creative Cloud was useful for the final presentation. Canva and Illustrator was used in order to making illustrations and diagrams; then Photoshop for colour correction, graphic design. The file formats were compatible across all applications and all files we used were stored, accessed and shared through Canva which enabled us to work on the project at the same time. It promoted the consistency and efficiency in design workflow.



REFERENCES





Why We Chose Triangle And Rectangular as the Shapes for Our Design

Parametric Control of Geometries
Both shapes are advantageous for parametric manipulation:

- Triangles: Easily adapt to complex surfaces (e.g., triangulated meshes or panels for curved structures).
- Rectangles: Serve as the foundation for grid systems that can be algorithmically transformed into tessellations, patterns, or responsive facades.

By embedding parametric rules, such as the relationship between size, orientation, or density, the designer gains control over geometric relationships while maintaining flexibility to modify the design based on performance criteria or aesthetic preferences.

Algorithmic Design's Preference for Basic Primitives
In algorithmic workflows, simple geometric primitives like triangles and rectangles serve as the "building blocks" for more complex forms. By defining algorithmic rules, these shapes can evolve into intricate designs:

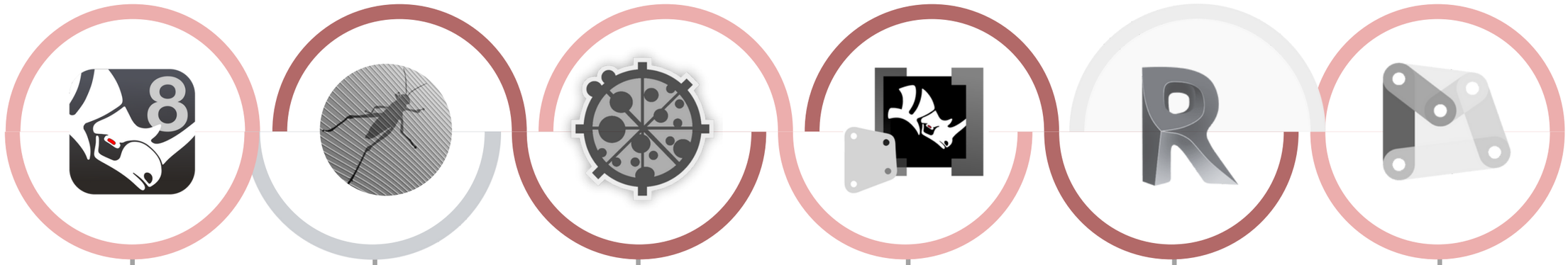
- Triangles can be subdivided or connected to form Voronoi patterns, diagrid structures, or tessellations.
- Rectangles can be parametrically altered to explore variations like proportions, angles, or curvature.

Integration in Algorithmic Tools
In tools like Rhino/Grasshopper or Autodesk Dynamo, triangles and rectangles are computationally efficient to work with:

- Triangles: Used in meshing algorithms for 3D surfaces due to their ability to conform to curved geometries.
- Rectangles: Used in grid-based systems for layouts, facades, and parametric subdivisions.

East Facade _Dudu Dilan Cam

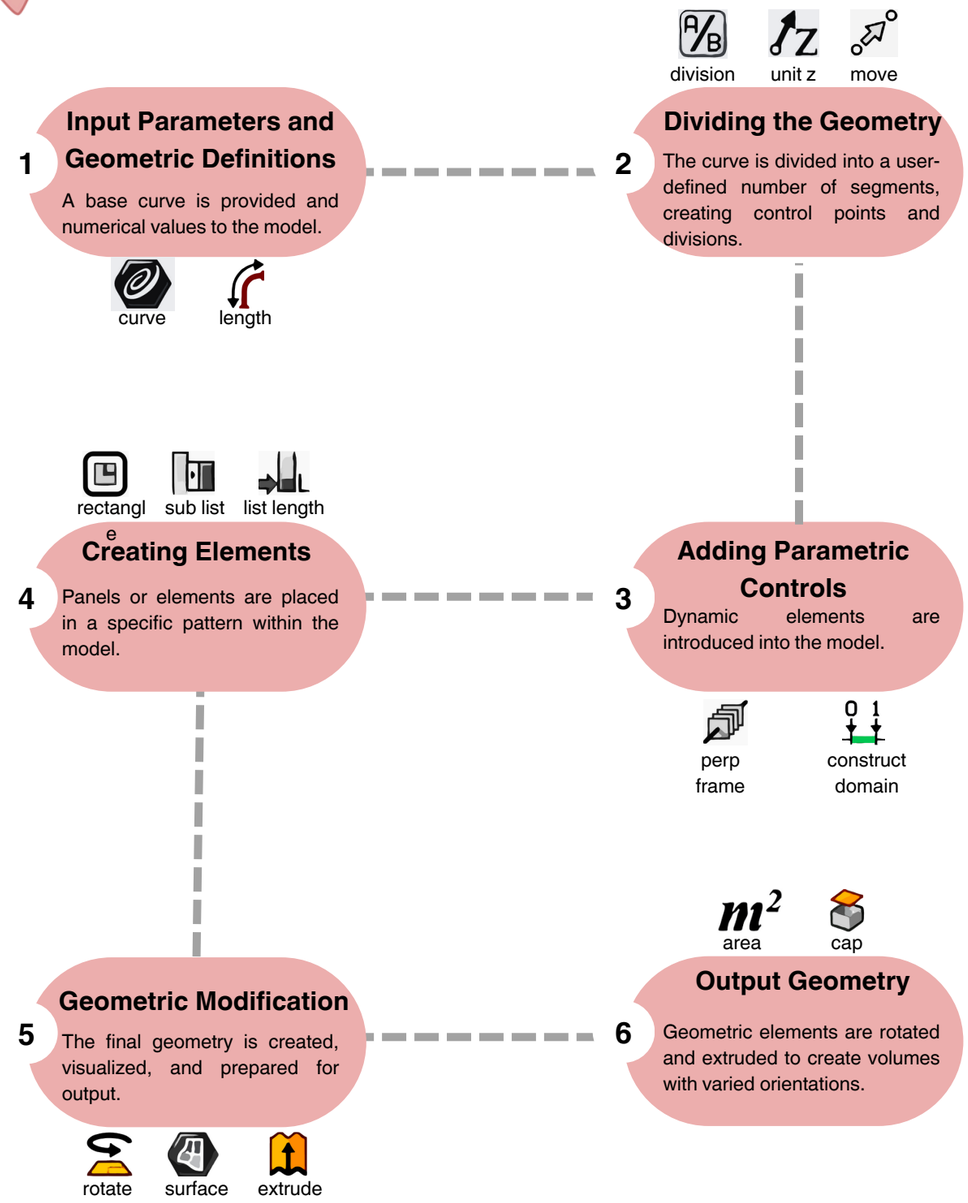
METHODOLOGY

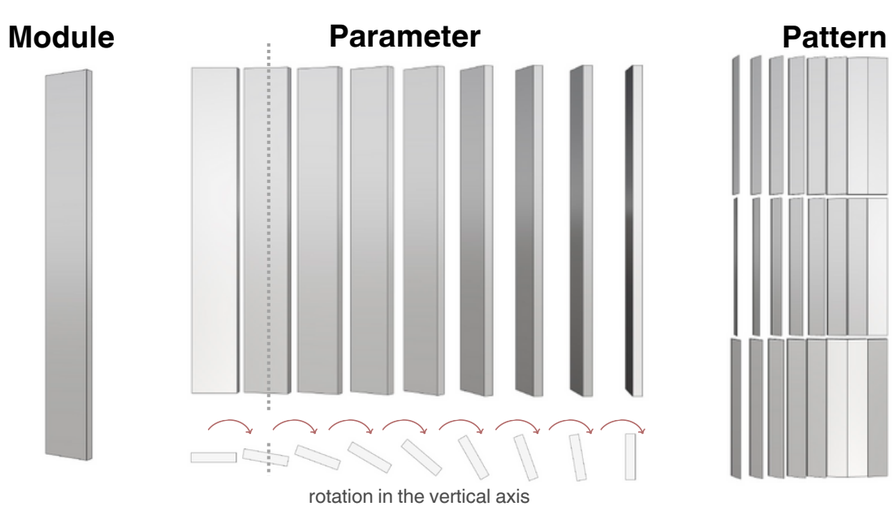


- Layers
- 3D Geometry
- Module
- Pattern
- Parameter
- EPW
- Solar Radiation
- Brep
- Generic Models Categorizing
- Parameters
- Schedule
- Element List
- Total Cost

East Facade _Dudu Dilan Cam

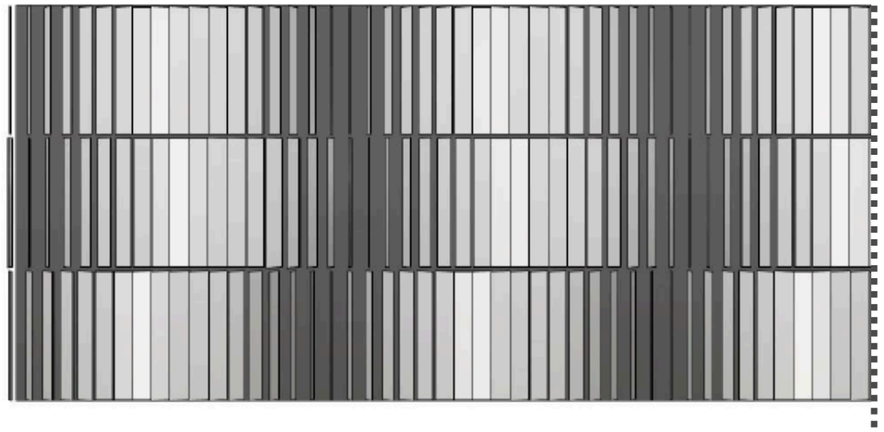
Development Of Facade Modeling

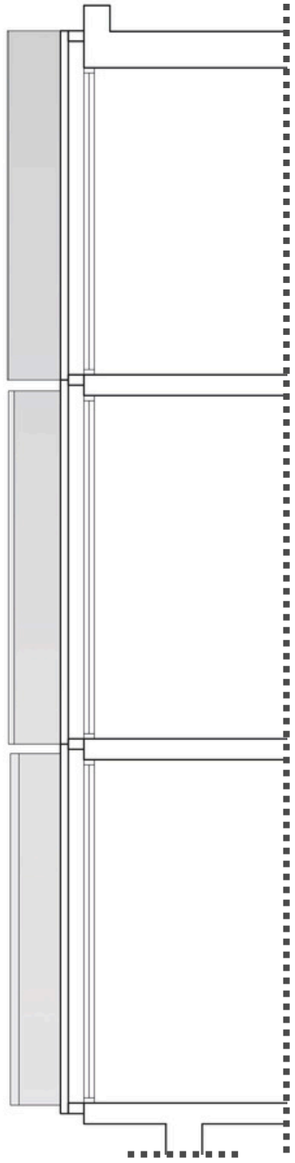




The parametric facade design focuses on a modular and dynamic approach. The base module is defined as a rectangle, with its primary parameter being the ability to rotate along the vertical axis. The pattern is organized with three modules stacked vertically and eight modules arranged horizontally, creating a structured yet adaptable layout. This design is applied to the east-facing facade, optimizing its visual and functional performance.

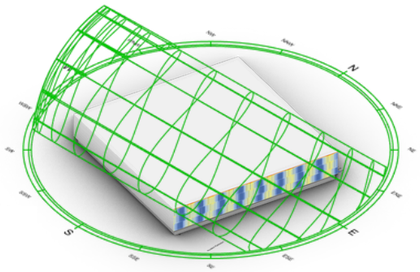
Facade



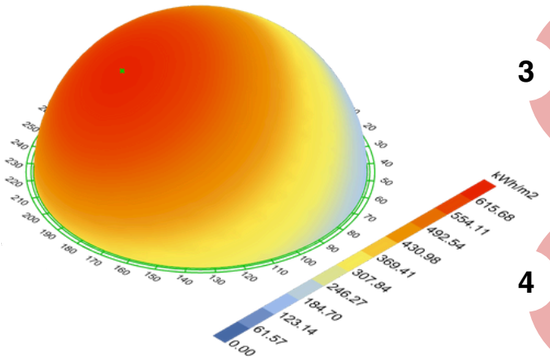


East Facade _Dudu Dilan Cam

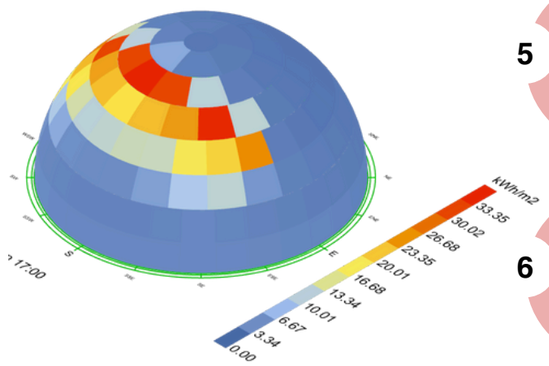
Sun Path



Radiation Dome



Sun Globe

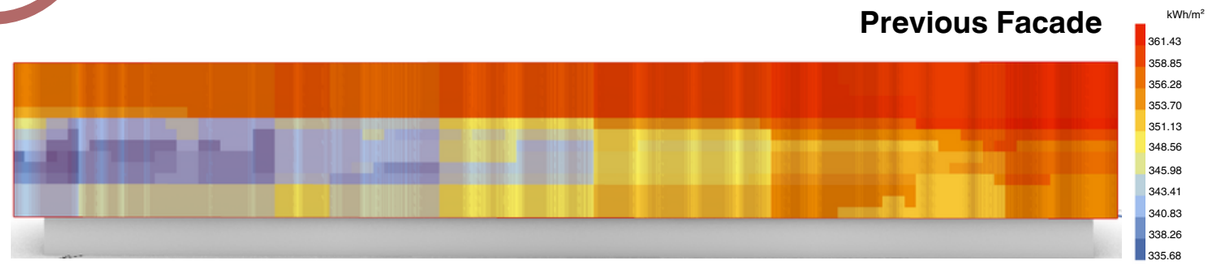


Work-flow

1. **Load Climate Data (EPW File)** — Download EPW; Import EPW
2. **Define Sun and Sky Conditions** — Sky Matrix; Sunpath; Radiation & Sky Dome
3. **Perform Solar Radiation Analysis** — Incident Radiation
4. **Apply the Parametric Panel** — Panel Geometry
5. **Perform Solar Radiation Analysis Again** — Incident Radiation
6. **Calculate Reduction Percentage** — Reduction Formulas

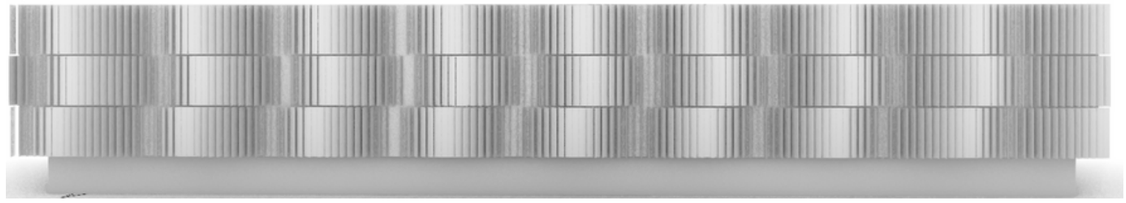
SOLAR ANALYSIS

Previous Facade

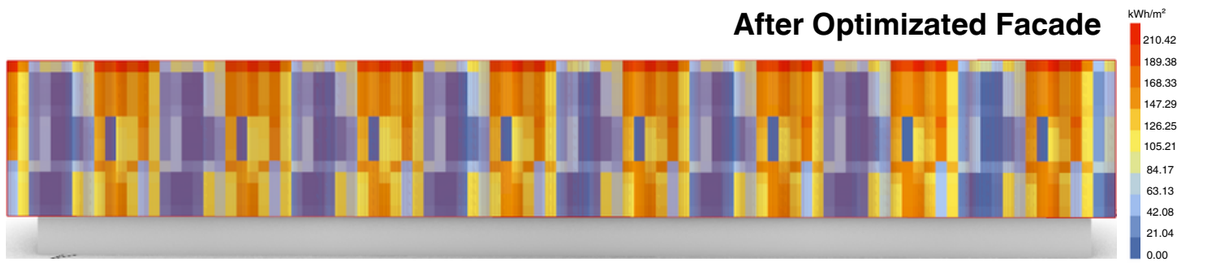


The East Facade receives significant solar radiation, especially in the morning when the sun rises from the east. This exposure is particularly strong during summer when the sun is at higher altitudes, leading to increased direct solar gain. As seen in the graphic, this results in considerable heat accumulation on the facade.

Optimizated Facade



After Optimizated Facade



After implementing the optimized facade, there is a substantial reduction in solar radiation, with a 77.33% decrease. This improvement is achieved through parametrically designed rectangular elements that rotate based on the exposure levels of different parts of the facade, effectively reducing direct sunlight penetration while maintaining daylight access.

Solar Radiation Reduction: 77.33%

East Facade _Dudu Dilan Cam

Using Rhino.Inside Revit, a connection between Rhino and Revit was established to enhance the workflow.

A custom schedule was prepared in Revit, including columns for ID, count, volume, and cost, which were defined through a Project Parameter.

Elements categorized under “Generic Models” were extracted using the Categories and All Elements of Category nodes in Dynamo.

The geometric data of each element was used to compute its volume.

Costs were calculated by applying the formula Cost = Volume × 1000, and the overall total was derived by summing up all individual costs.

1 **Rhino inside Revit**

2 **Creating Schedule**

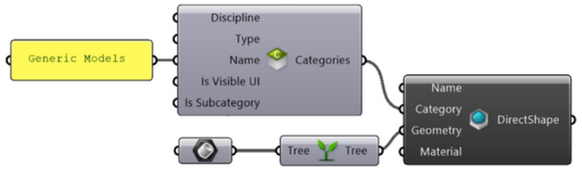
3 **Identify Elements ‘’Generic Models’’**

4 **Volume Calculation**

Total Cost

5 **Cost Calculation**

1



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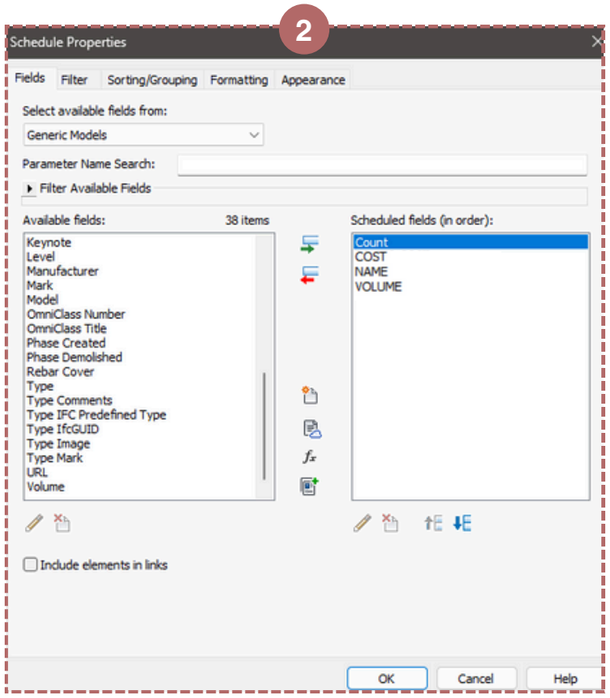


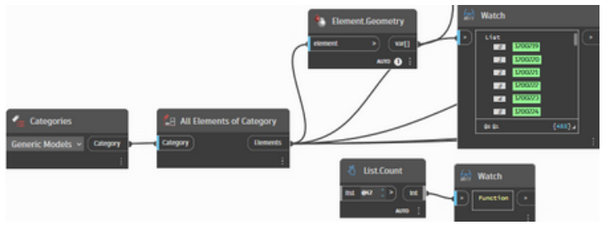
<Generic Model Schedule>

A	B	C	D
Count	COST	NAME	VOLUME
1	445	1200219	0.445
1	673	1200220	0.673
1	841	1200221	0.841
1	937	1200222	0.937
1	955	1200223	0.955
1	899	1200224	0.899
1	779	1200225	0.779
1	613	1200226	0.613
1	659	1200227	0.659
1	815	1200228	0.815
1	920	1200229	0.92
1	958	1200230	0.958
1	919	1200231	0.919
1	804	1200232	0.804
1	619	1200233	0.619
1	380	1200234	0.38
1	106	1200235	0.106
1	178	1200236	0.178
1	445	1200237	0.445
1	673	1200238	0.673

Total Count of Elements: 453
Tolal Volume: 314,592 m³

Total Cost: **314 592€**

3



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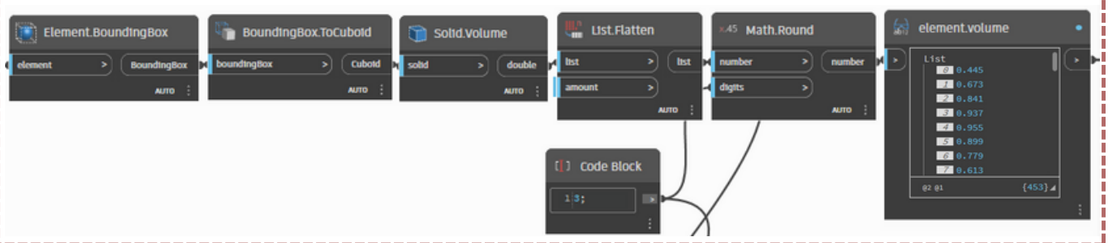

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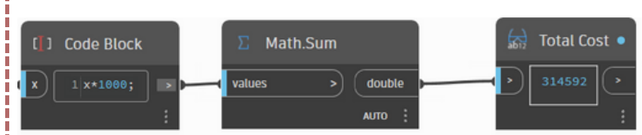
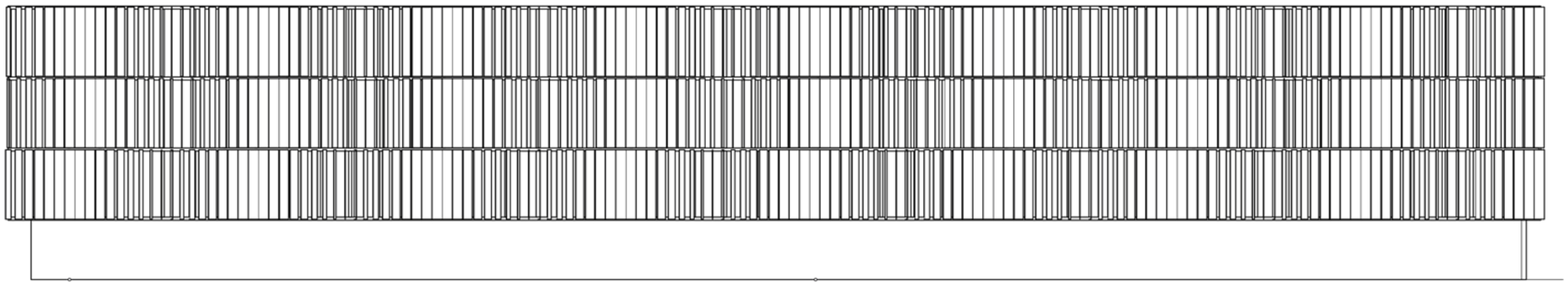
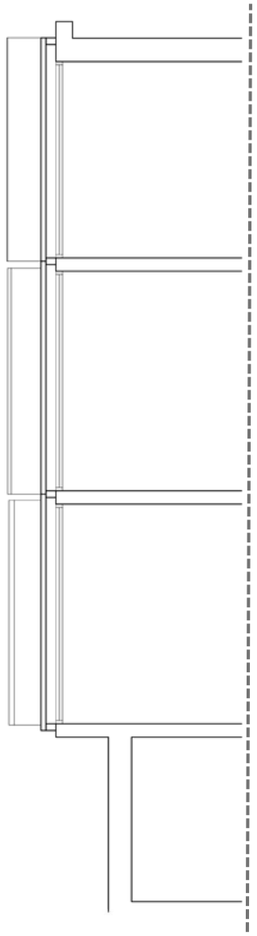
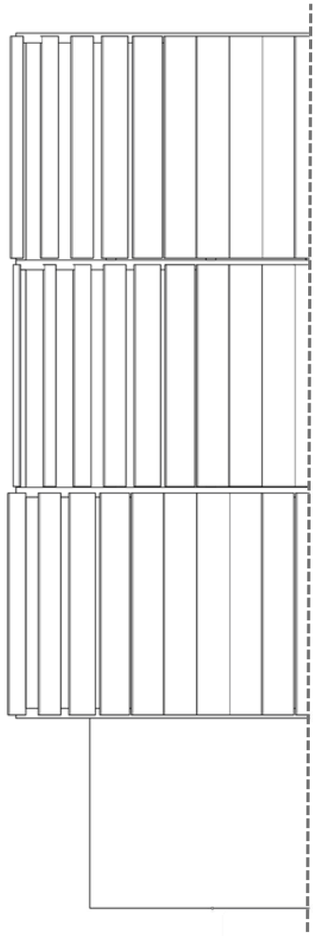




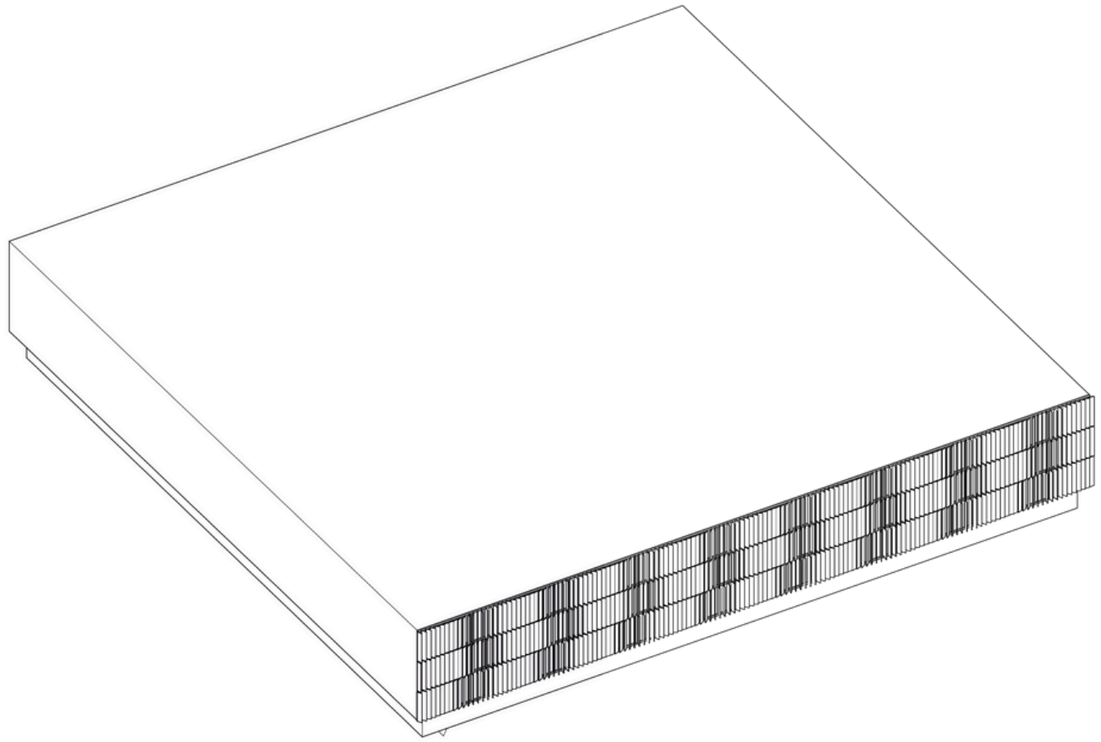
1 East Archiectural Building Elevation
1:200



2 Archiectural Building Section
1:100



2 Archiectural Building Elevation
1:100



3 3D View

Politecnico Di Torino
Master 2024/2026

Group 7
Members

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Turkey
East Facade

Belemir Topkaya
Turkey
South Facade

Joao Barbosa
Portugal
West Facade

Juan Martin Dossman
Colombia
North Facade

No.	Description	Date
1	North Archiectural Building Elevation	31/01/2025
2	3D View	31/01/2025
3	Archiectural Building Section	31/01/2025

Parametric and Algorithmic Modeling

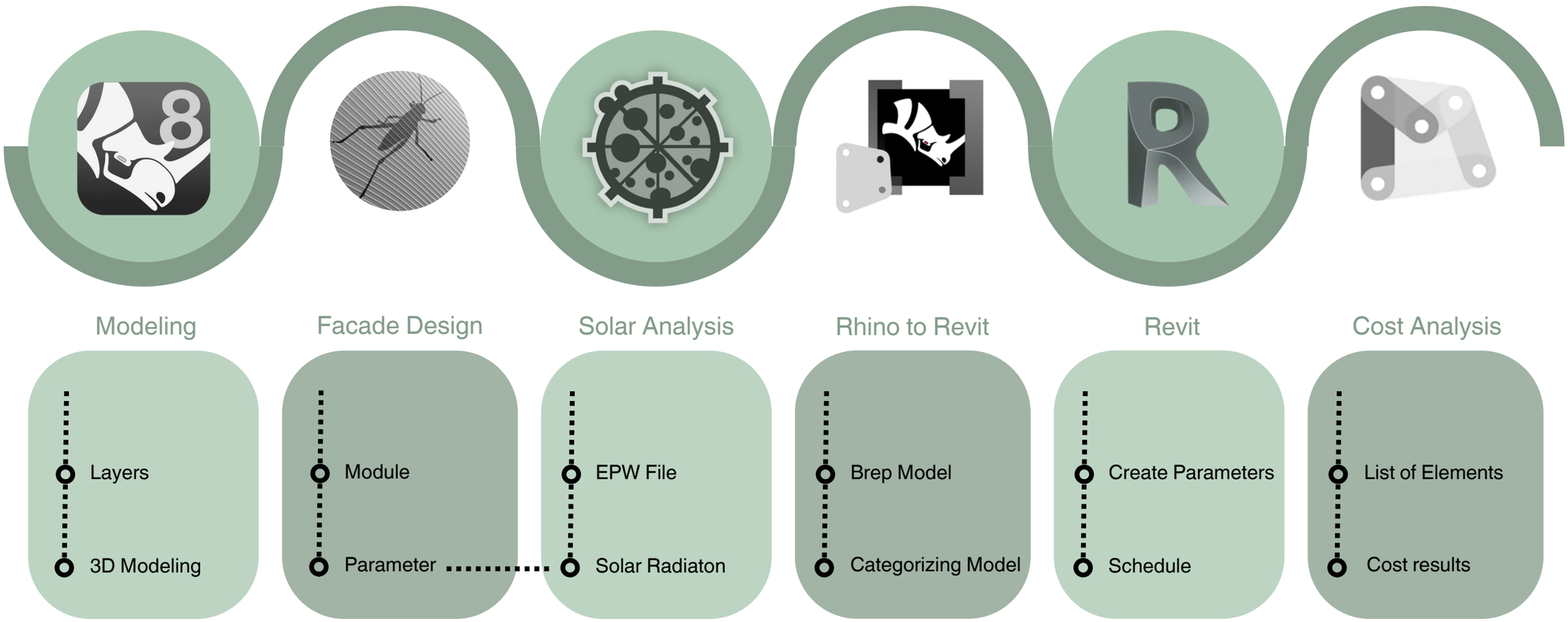
Palazzo del Lavoro

Anna Osello, Andrea Rolle, Matteo Del Giudice
Group 07

Project facade	East
Date	31/01/2025
Drawn by	Dudu Dilan CAM
Checked by	Group 7
	A101
Scale	1:200

South Facade_Belemir Topkaya

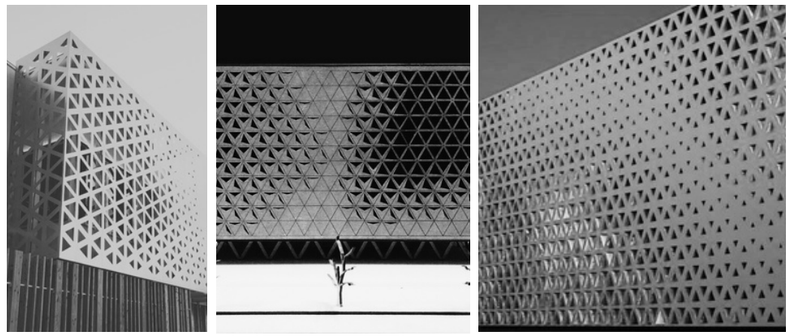
METHODOLOGY DIAGRAM



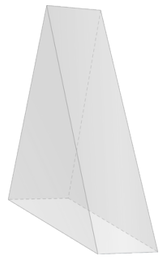
South Facade_Belemir Topkaya

FACADE DESIGN

References



Module

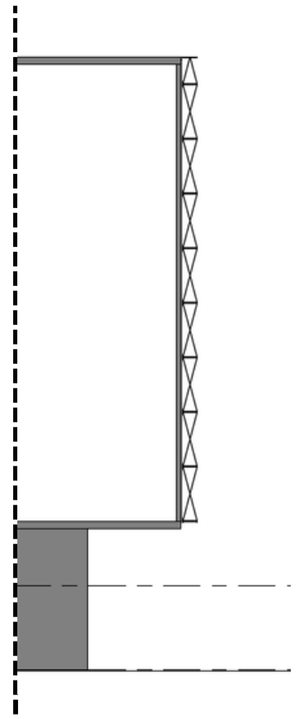


Triangle:

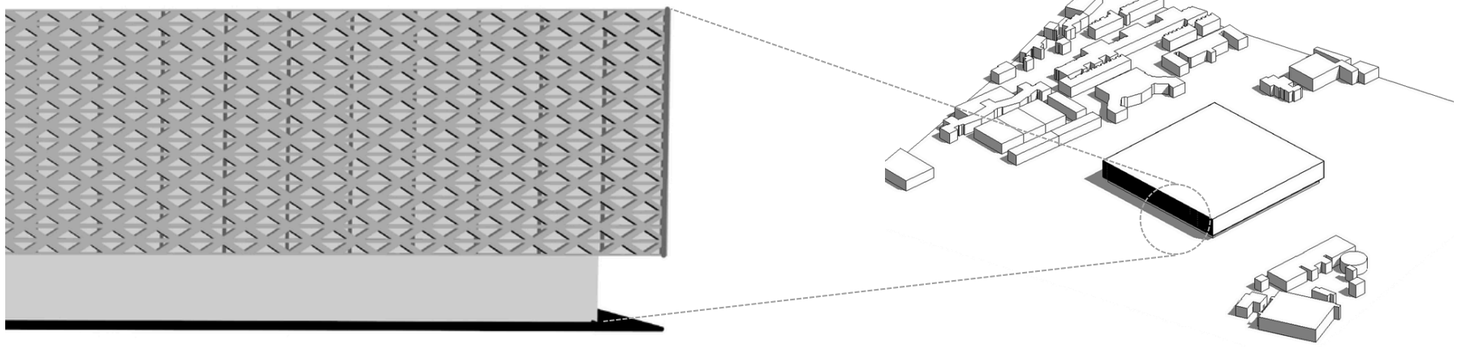
Scale
"playing with the size from the center point"

Parameter

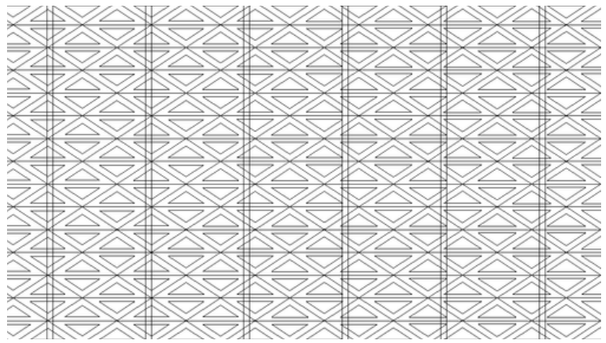
System Section



Facade

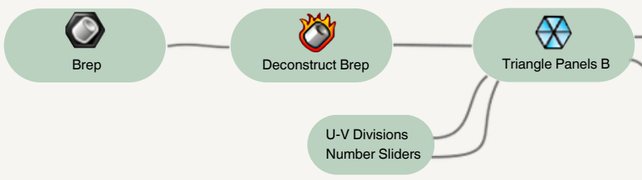


Pattern



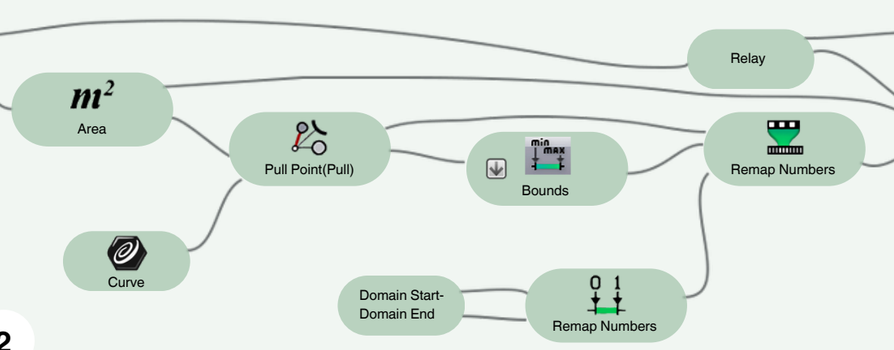
TECHNICAL WORKFLOW

I placed a Brep container in Grasshopper, deconstructed it into surfaces, and applied triangular tessellation using the Triangle Panel B component from LunchBox. Number sliders controlled the U and V divisions for adjustable panel density.



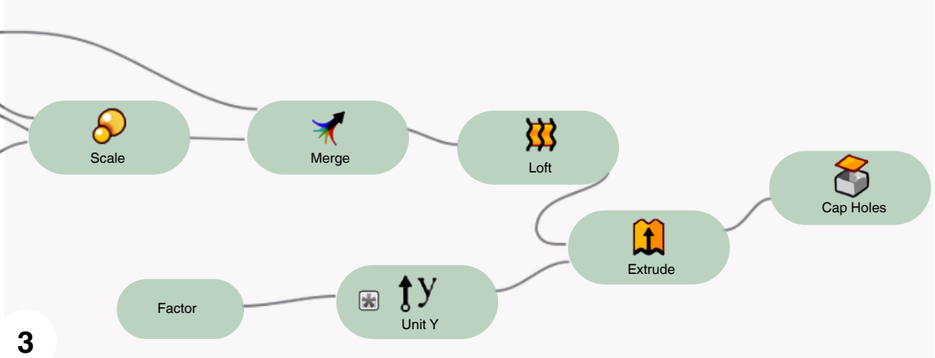
1

I created a gradient effect by scaling panels based on their distance from an attractor curve. Using the Area component, I found each panel's centroid, then calculated distances with Pull Point. These distances were remapped using Remap Numbers, with Bounds defining the source domain and Construct Domain (controlled by sliders) setting the scaling range.



2

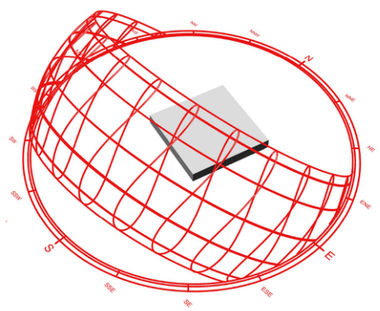
I scaled panels using the Scale component, reducing sizes near the attractor curve to create a gradient effect. The Merge component combined scaled and unscaled panels, ensuring alignment with grafted outputs. Finally, the Loft component connected corresponding panels, generating a continuous surface for a dynamic and responsive facade, extruded to create volumes.



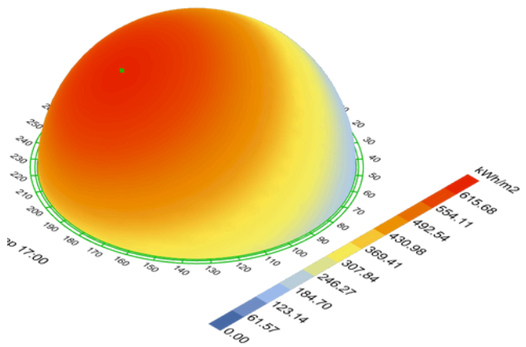
3

South Facade_Belemir Topkaya

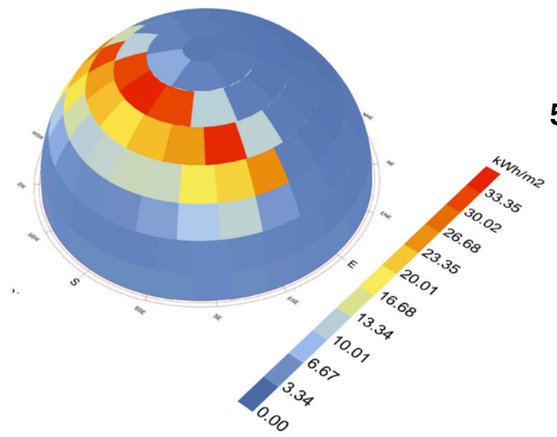
Sun Path



Radiation Dome



Sun Globe



WORK-FLOW

Load Climate Data (EPW File)

1. Download EPW
   Import EPW

Define Sun and Sky Conditions

2. Sky Matrix
   Sunpath
   Radiation & Sky Dome

Perform Solar Radiation Analysis

3. Incident Radiation

Apply the Parametric Panel

4. Panel Geometry

Perform Solar Radiation Analysis Again

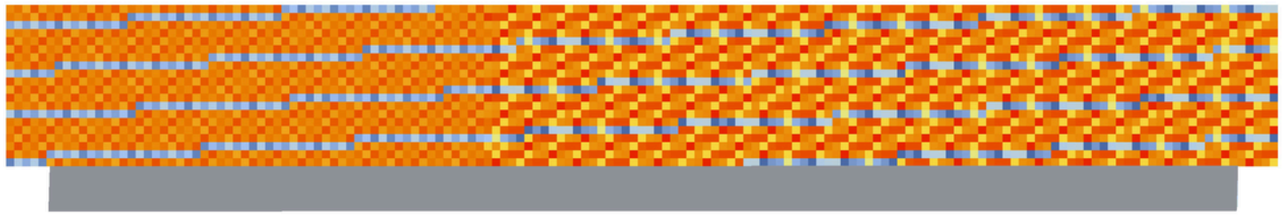
5. Incident Radiation

Calculate Reduction Percentage

6. Reduction Formulas

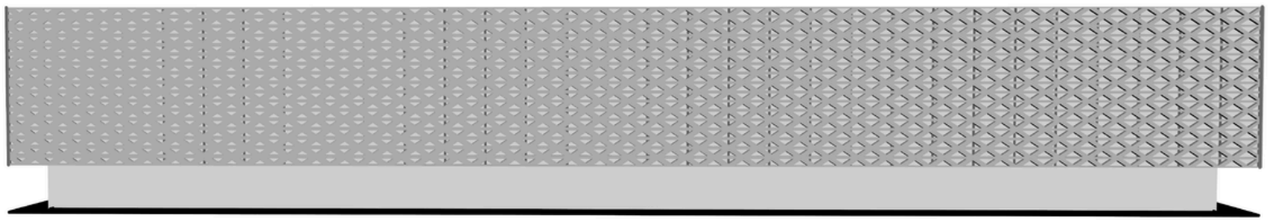
SOLAR ANALYSIS

Before Optimized Facade

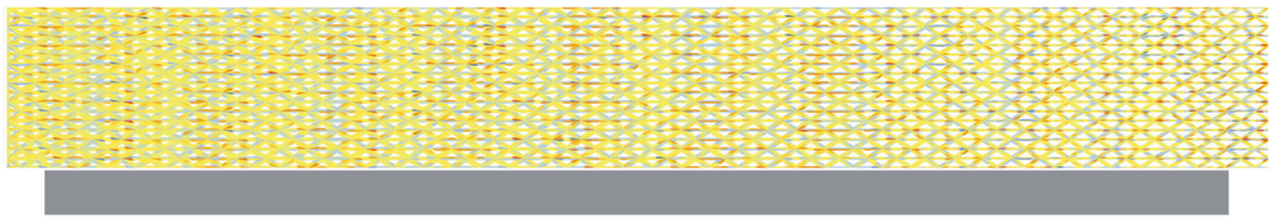


The South South West facade recieves maximum solar radiation. As illustrated in the simulation, the radiation ranges between 0 to 480 KWh/m2.

Optimized Facade



After Optimized Facade

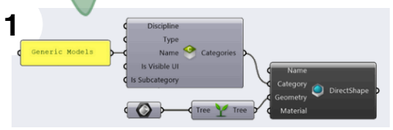


After optimizing the facade the radiation ranges between 254.42 Kwh/m2 and 254.50 Kwh/m2. As a result this reduces the solar radiation up to 10 percnet. With the optimized facade the South side of the building recieves lesser radiation.

Solar Radiation Reduction: 72.6%

South Facade_Belemir Topkaya

1



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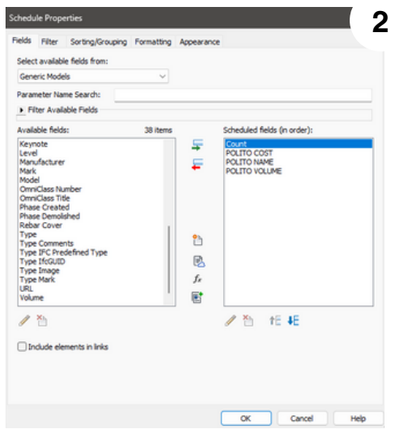
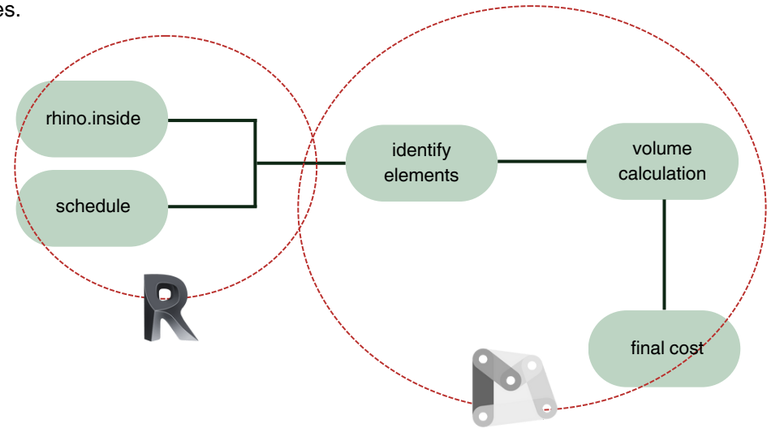


With Rhino.Inside Revit, created a connection between Rhino and Revit to improve workflow efficiency. A custom schedule in Revit was set up, incorporating ID, count, volume, and cost as Project Parameters. In Dynamo, elements classified as Generic Models were identified and their volumes were calculated. The cost for each element was determined using the formula and the total cost was obtained by summing all individual values.



Generic model schedule 4914		
Type	Volume	cost
facade 1	0.159 m³	783 €
facade 1	0.159 m³	783 €
facade 1	0.159 m³	783 €
facade 1	0.159 m³	783 €
facade 1	0.159 m³	783 €
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facade 1	0.159 m³	783 €
facade 1	0.159 m³	783 €
facade 1	0.159 m³	783 €
facade 1	0.159 m³	783 €
facade 2	0.268 m³	1,316 €
facade 2	0.268 m³	1,316 €
facade 2	0.268 m³	1,316 €
facade 2	0.268 m³	1,316 €
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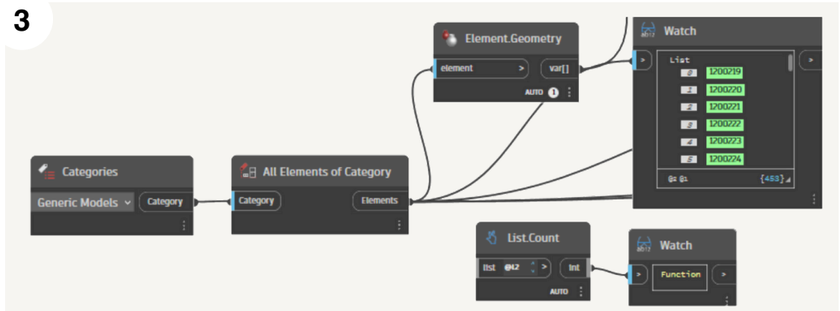
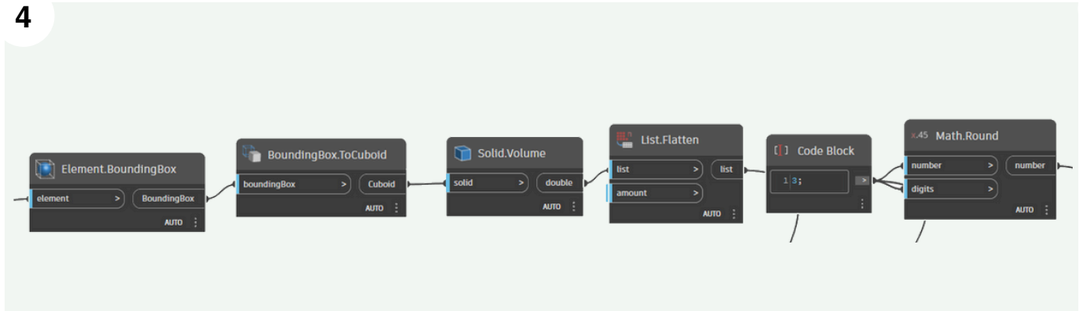
facade 2	0.268 m³	1,316 €
facade 2	0.268 m³	1,316 €
facade 2	0.268 m³	1,316 €
Grand total: 1495	398.579 m³	1,958,619 €

3



4



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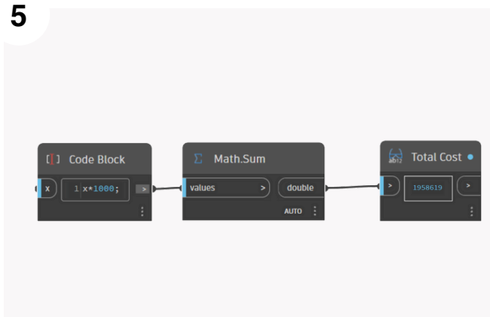


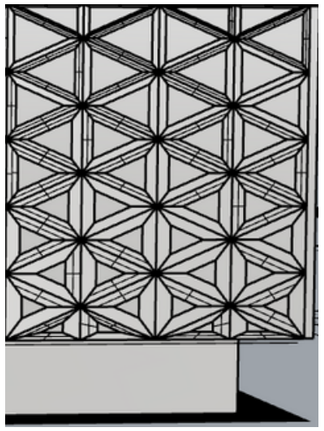
ELEMENT DESCRIPTION	MATERIAL	COST PER m3 (€)	TOTAL VOLUME (m3)	MATERIAL COST	TRANSPORTATION COST (€)	DISTANCE (km)	TOTAL COST(€)
Triangle Rotating Panels	Aluminum	4914	398.57	1.958.619	360	15	1.958.979

West Facade_João Respeita Barbosa

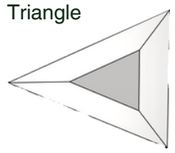
Pattern Design (Rhino + Grasshopper)

The design of this façade is based on a modular triangular pattern, chosen for its structural efficiency and aesthetic versatility.
To introduce variation and adaptability, I selected scale as parameter. The façade is first divided into a triangular grid, creating a consistent modular framework. Then, a traction line is applied at the bottom of the façade, acting as a reference point for transformation. The triangles closest to this line are smaller, while those further away increase in size, generating a gradient-like effect.

Facade

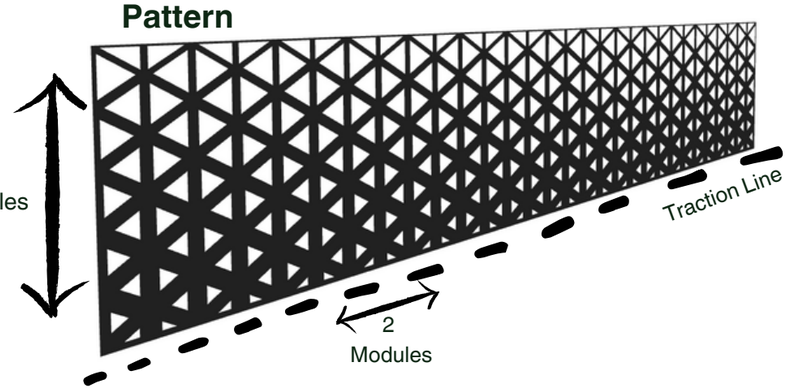


Module
Triangle



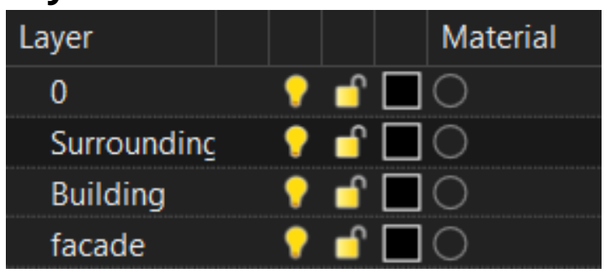
Parameter
Scale

Pattern



This approach not only enhances the visual depth of the façade but also introduces a functional aspect, potentially influencing shading, light permeability, and ventilation. The variation in scale can be further adapted to respond to environmental factors, optimizing the design for solar performance or airflow control.
By integrating these parametric principles, the façade will achieve a balance between aesthetic expression, structural logic, and environmental responsiveness, aligning with contemporary architectural trends.

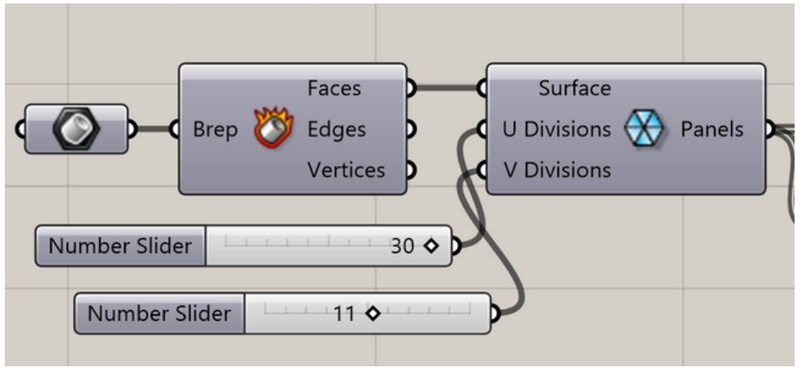
Layer Section in Rhino



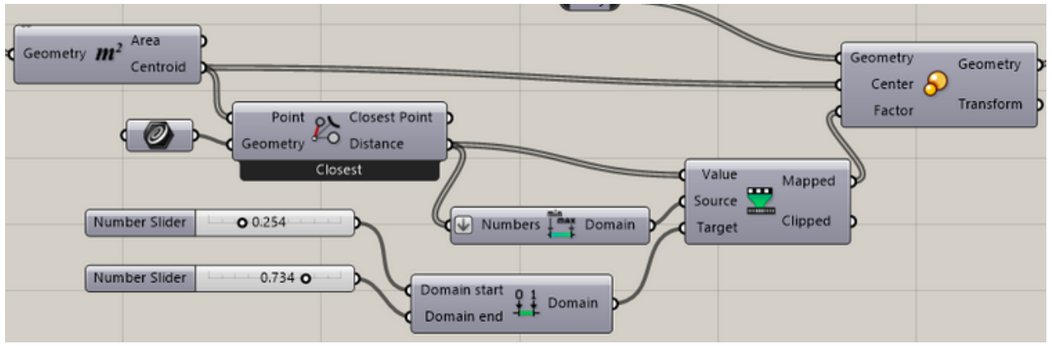
For better organization and understanding

Grasshopper Script

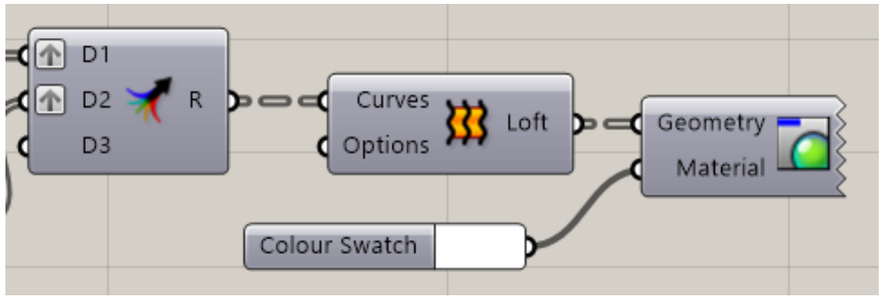
1 - Creation grid of triangles



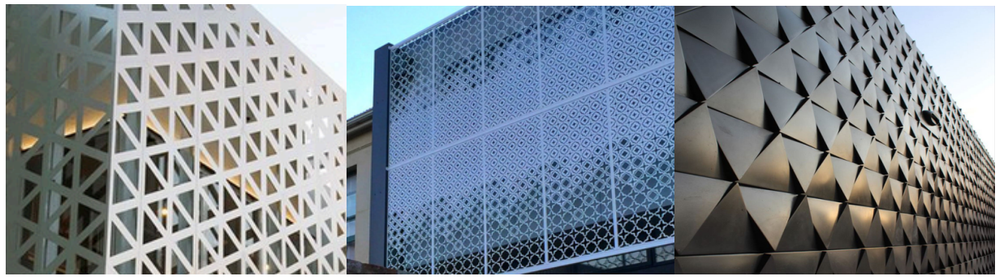
2 - Creation traction line and size domain for scaling the triangles



3 - Merging the 1 + 2 geometrys and setting white as the colour of the material



References

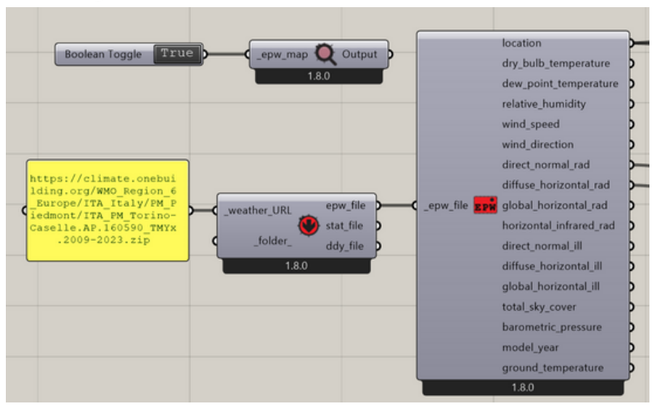


West Facade_João Respeita Barbosa

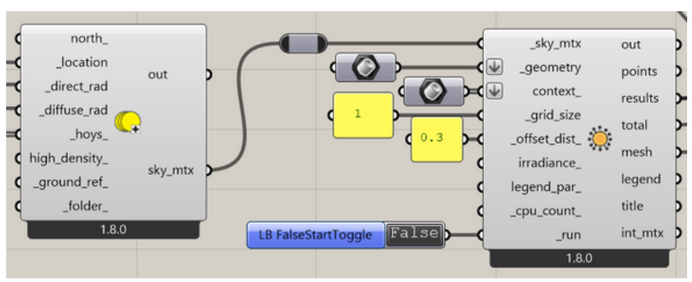
Solar Analysis (Ladybug in Grasshopper)

Grasshopper Script

1 - Getting the EPW file with climate data from Turin

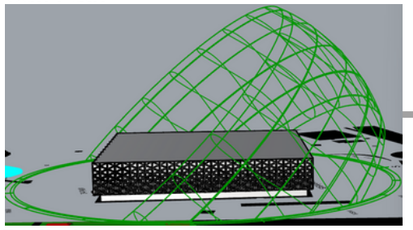


3 - Solar Incident Radiation on the facade before and after the new pattern

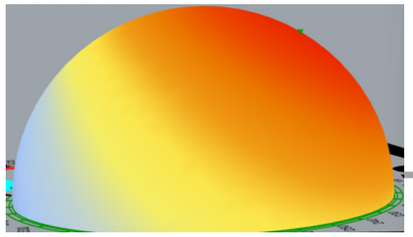


2 - Generation of Sun Path, Radiation Dome and Sun Globe

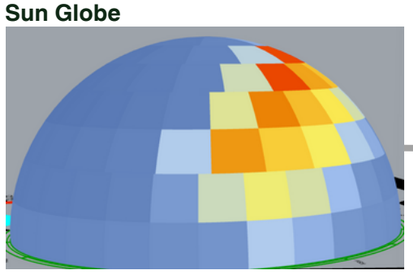
Sun Path



Radiation Dome



Sun Globe



How to calculate % of reduction

The formula to calculate the **percentage reduction** is:

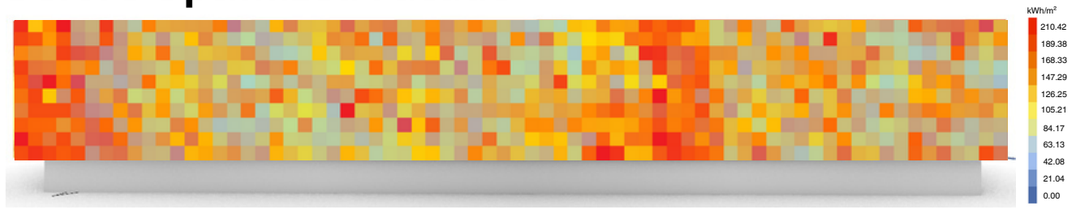
$$\text{Percentage Reduction} = \left(\frac{\text{Initial Value} - \text{Final Value}}{\text{Initial Value}}\right) \times 100$$

In my case:

$$\text{Percentage Reduction} = \left(\frac{397725.201 - 236382.005}{397725.201}\right) \times 100$$

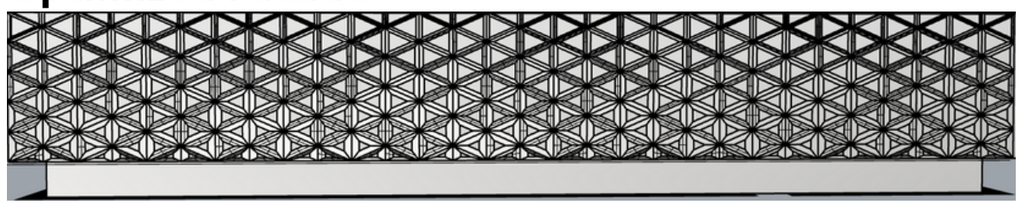
This gives approximately **40.57%** reduction in solar radiation.

Before Optimized Facade

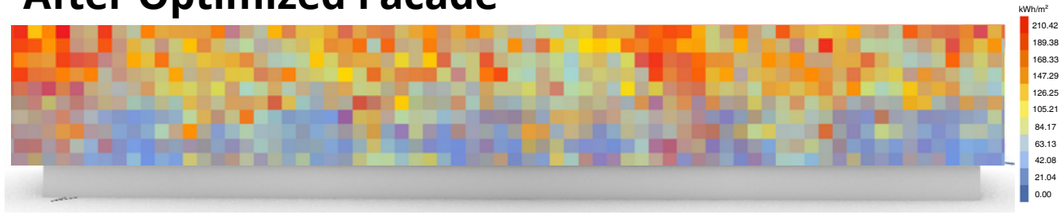


The west facade receives a solar radiation of **397 725.201 kWh**.

Optimized Facade



After Optimized Facade



After applying the optimized facade, the new solar radiation is **236 382.005 kWh**, most of this radiation is obtained in the late afternoon and before the sunset so one good proposal for this buildings use could be a school or a library, whose interest of usability would be more in the early hours (morning), giving this facade of the building a discount for it's lower optimization (comparing to others).

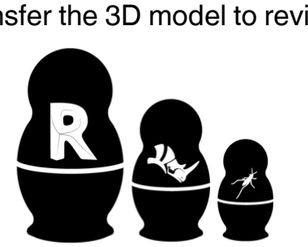
Solar Radiation Reduction: 40.57%

West Facade_João Respeita Barbosa

Cost Analysis (Revit + Dynamo)

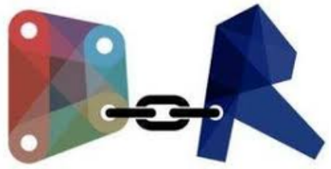
For the cost analysis, I try to use Rhino.Inside.Revit to integrate my parametric 3D model into Revit, in order to allow me to define appropriate categories and parameters for the different components of the façade, ensuring an accurate representation of its structure and materials. Had trouble in this step so could not use the tools correctly... so to have some costs for comparasion I did the cost analysis manualy, counting the number of modules and multiply it with an hypothetical volume. Given this fake amount of volume for my facade, lastly I multiplied with the cost per volume that I researched.

1 - Rhino.inside.revit
Transfer the 3D model to revit

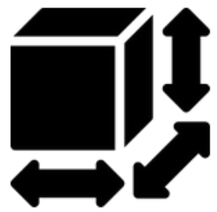


2 - Create Schedule
BIM starts, adding information to our 3D model with 3 parameters: name, volume and cost

3 - Dynamo into Revit
for automation of calculations, create a list of elements



4 - Volume Calculation
for each element (triangle module)



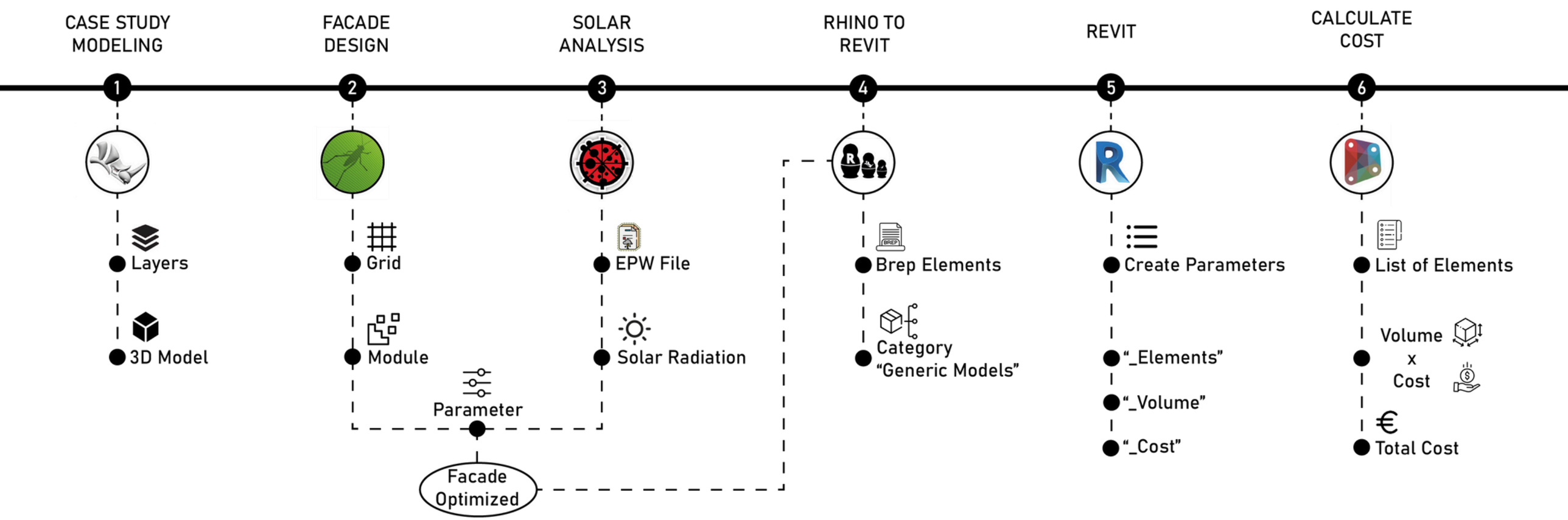
5 - Total Cost Calculation

This automated workflow not only ensures precision in cost estimation but also provides flexibility for future modifications in design parameters, allowing real-time updates on material quantities and expenses. Taking advantage of interoperability among tools.

ELEMENT DESCRIPTION	MATERIAL	COST PER m3 (€)	TOTAL VOLUME (m3)	MATERIAL COST	TRANSPORTATION COST (€)	TOTAL COST(€)
Triangle Scaling Panels	Stainless Steel	20.077	372,98	7.488.319,46	540	7.488.859,46

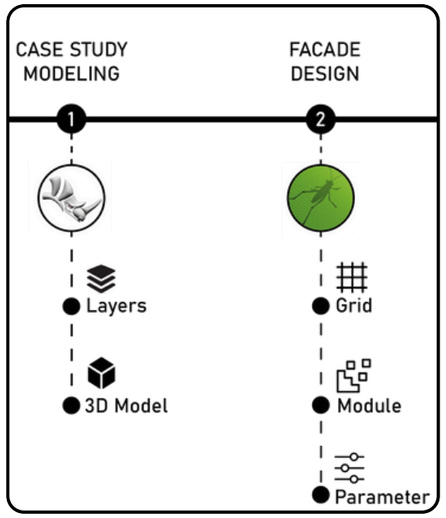
North Facade_Juan Martin Dossman

METHODOLOGY DIAGRAM



North Facade_Juan Martin Dossman

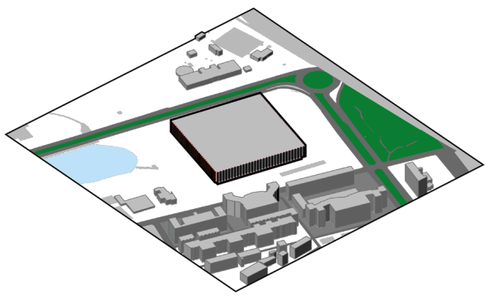
CASE STUDY MODELING



Layers Division

Layer	Material
CONTEXT	
05 Floor	
04 green	
03 Water	
02 Roads	
01 Building	
PALAZZO DEL LAVOR(	
NORTH FACADE	

Modeling Base



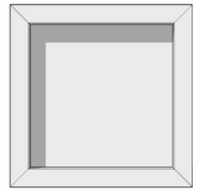
References

I decided to work with a grid of 78x10 squares, in which each square was going to a module. This module will have a structure with a central square element that is going to rotate in his central vertical axis depending on the solar radiation received. The pattern is going to be composed by 10 vertical modules an 3 horizontal modules. The complete facade will have 26 patterns.

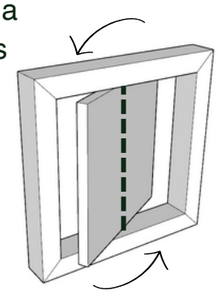
This organized structure helps to have a comfortable workflow, allowing to divide modeled elements in categories needed.

FACADE DESIGN

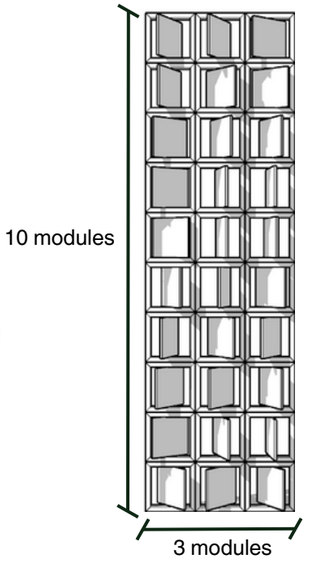
Module
Square



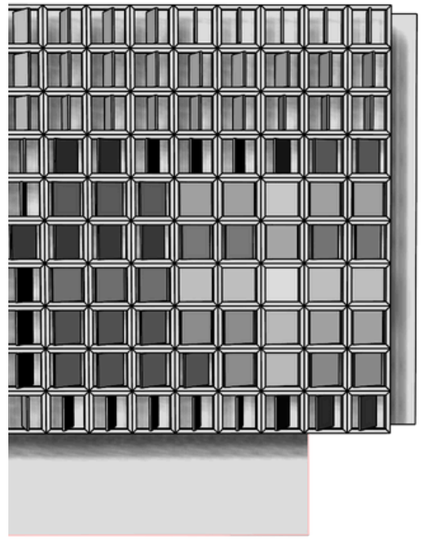
Parameter
Rotation in a vertical axis



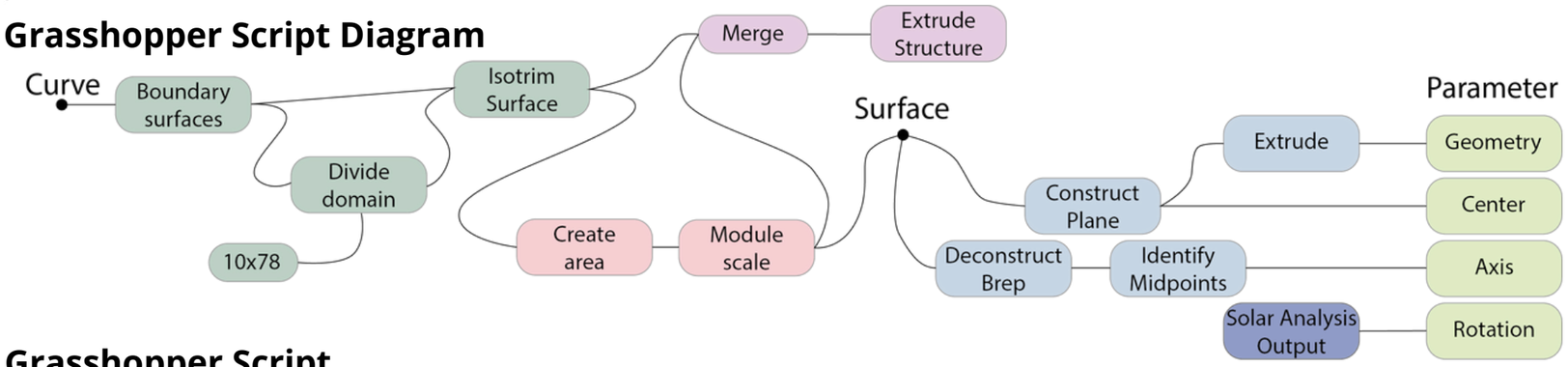
Pattern



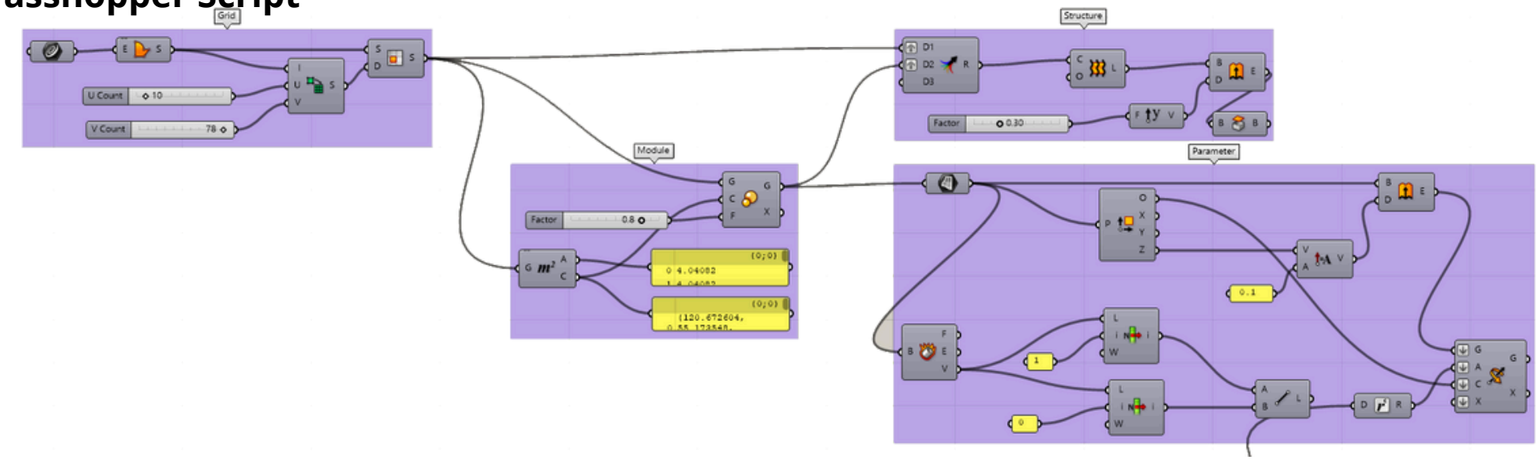
Facade



Grasshopper Script Diagram

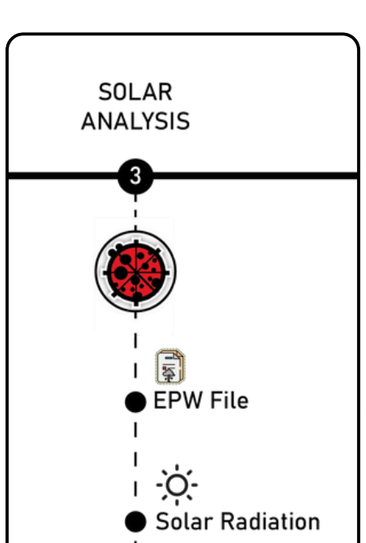


Grasshopper Script

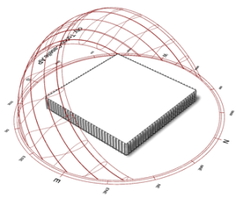


North Facade_Juan Martin Dossman

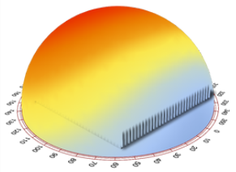
SOLAR ANALYSIS



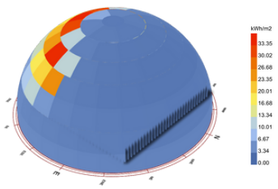
Sun Path



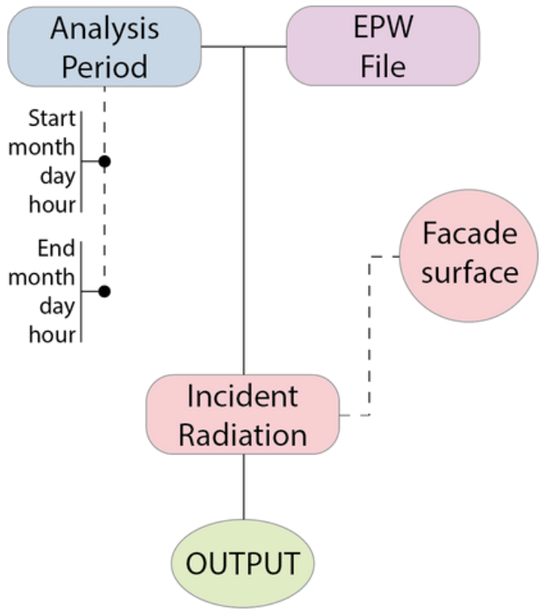
Radiation Dome



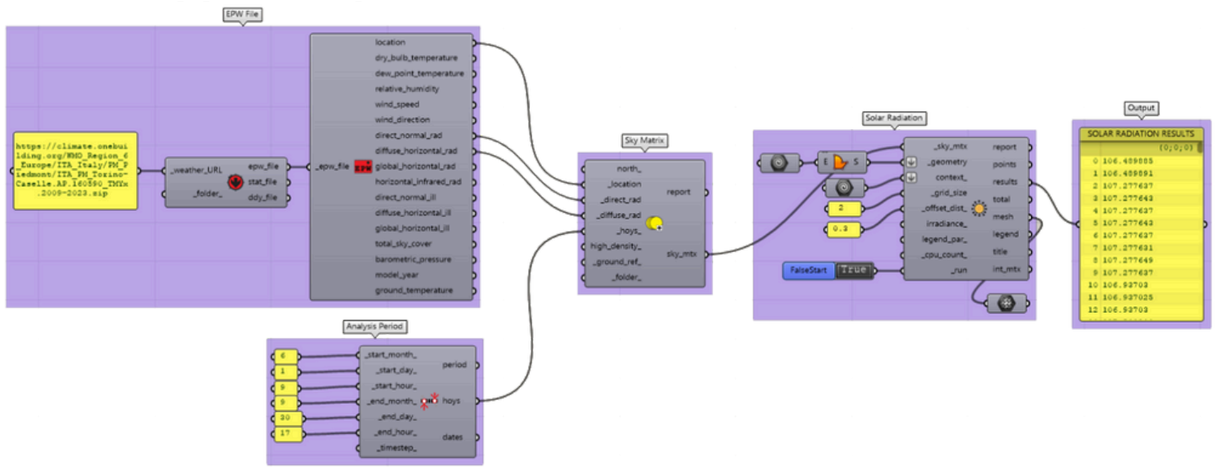
Sun Globe



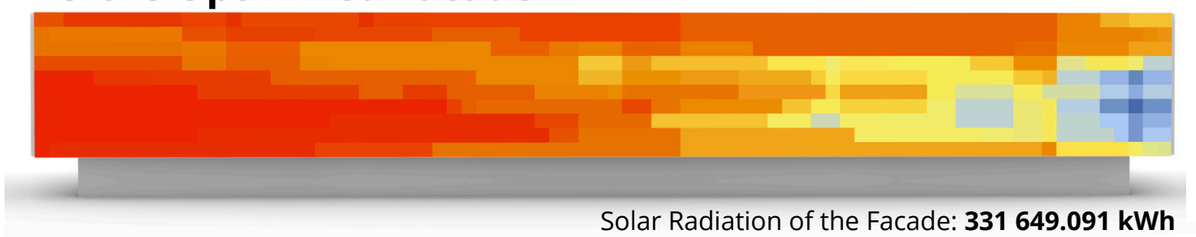
Grasshopper Script Diagram



Grasshopper Script



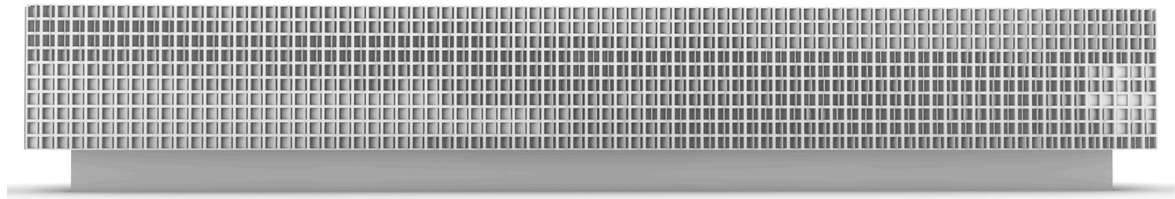
Before Optimized Facade



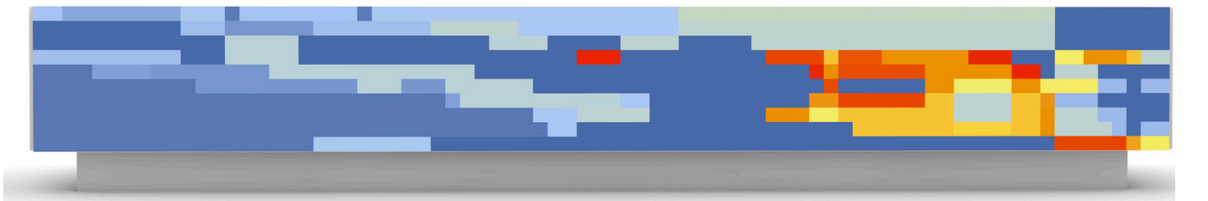
Solar Radiation of the Facade: **331 649.091 kWh**

The North Facade is the one that receives the least solar radiation thanks to the building location in the northern hemisphere and the sun is mostly to the south. However, as we can see in the graphic, in summer when the sun reaches higher altitudes, there is mostly indirect sun exposure on the facade, but direct exposure from the east side.

Optimized Facade



After Optimized Facade



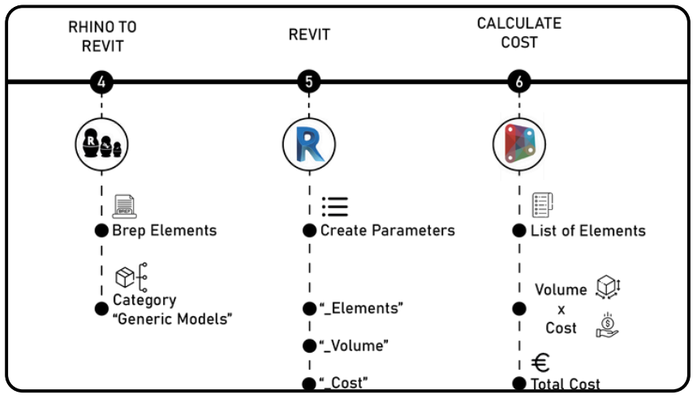
Solar Radiation of the Facade: **24 368.558 kWh**

After the optimized facade, we can see that there is a big reduction of the solar radiation, thanks to its rectangular elements that rotate depending on the exposure level of each part of the facade. The east side now receives less radiation and the west side, who normally receive very little radiation, keeps opened to catch the sun exposure.

Solar Radiation Reduction: 92.65%

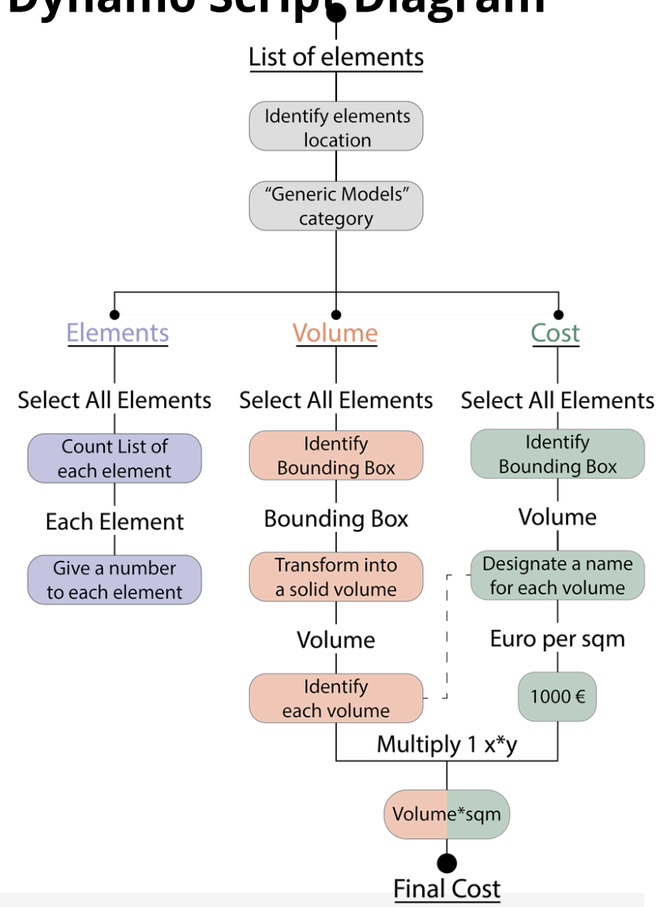
North Facade_Juan Martin Dossman

Cost Analysis

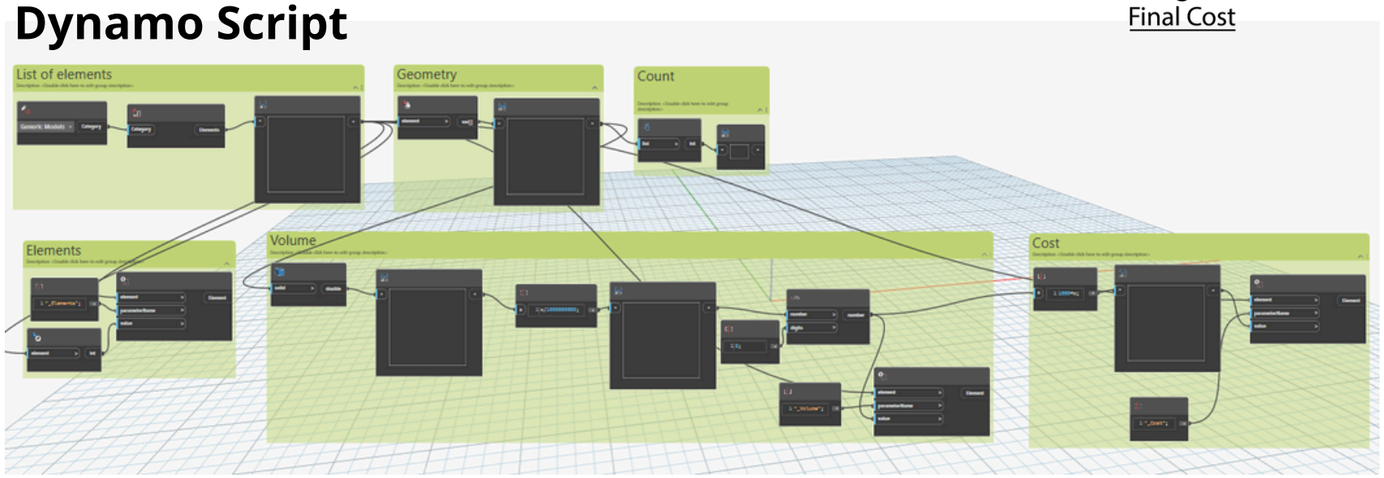


After importing the Rhino file to Revit with Rhino Inside, we used VPL. In this case, with a Dynamo script we were able to calculate the final cost of the facade, and then have the results on a Revit Schedule. Each module has it own structure, so we got two elements pero module, having to sum them all at the end and have the complete cost.

Dynamo Script Diagram



Dynamo Script



Rotating Elements

1595531	0.26 m³	260
1595532	0.26 m³	260
1595533	0.26 m³	260
1595534	0.26 m³	260
1595535	0.26 m³	260
1595536	0.26 m³	260
1595537	0.26 m³	260
1595538	0.26 m³	260
1595539	0.26 m³	260
1595540	0.26 m³	260
1595541	0.26 m³	260
1595542	0.26 m³	260
1595543	0.26 m³	260
1595544	0.26 m³	260
1595545	0.26 m³	260
1595546	0.26 m³	260
1595547	0.26 m³	260
1595548	0.26 m³	260
1595549	0.26 m³	260
1595550	0.26 m³	260
1595551	0.26 m³	260
1595552	0.26 m³	260
1595553	0.26 m³	260
1595554	0.26 m³	260
1595555	0.26 m³	260
1595556	0.26 m³	260
1595557	0.26 m³	260
1595558	0.26 m³	260

Structure

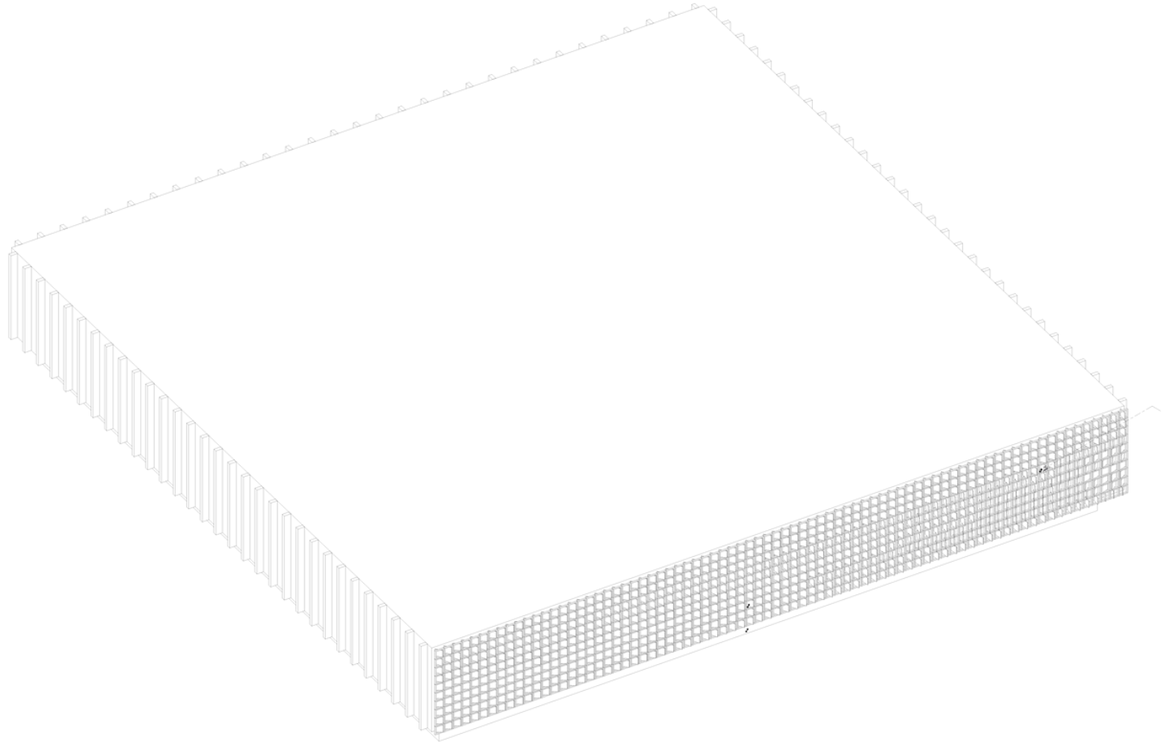
1596311	0.42 m³	420
1596312	0.42 m³	420
1596313	0.42 m³	420
1596314	0.42 m³	420
1596315	0.42 m³	420
1596316	0.42 m³	420
1596317	0.42 m³	420
1596318	0.42 m³	420
1596319	0.42 m³	420
1596320	0.42 m³	420
1596321	0.42 m³	420
1596322	0.42 m³	420
1596323	0.42 m³	420
1596324	0.42 m³	420
1596325	0.42 m³	420
1596326	0.42 m³	420
1596327	0.42 m³	420
1596328	0.42 m³	420
1596329	0.42 m³	420
1596330	0.42 m³	420
1596331	0.42 m³	420
1596332	0.42 m³	420
1596333	0.42 m³	420
1596334	0.42 m³	420
1596335	0.42 m³	420
1596336	0.42 m³	420
1596337	0.42 m³	420
1596338	0.42 m³	420

<Generic Model Schedule>

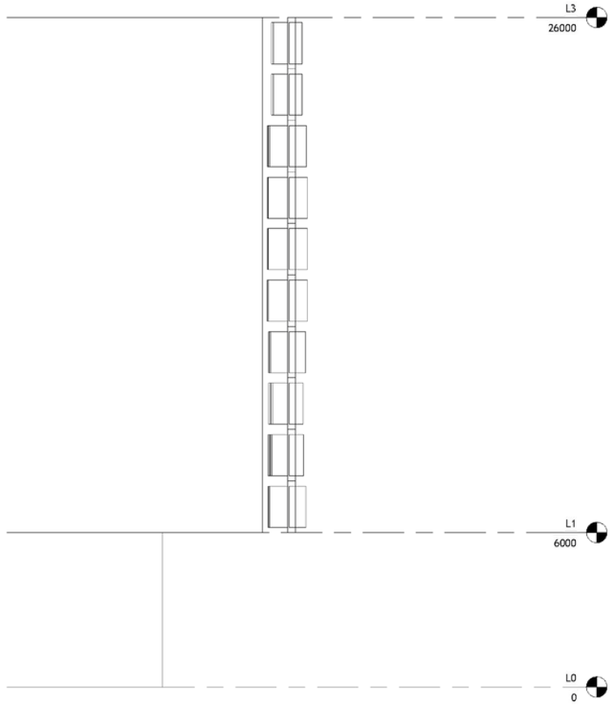
A	B	C
_Elements	_Volume	_Cost
Grand total: 1561	530.40 m³	530400

Total Cost: **530 400€**

1 North Archiectural Building Elevation
1:200



2 3D View



3 Archiectural Building Elevation

Politecnico di Torino

Politecnico Di Torino
Master 2024/2026

Group 7
Members

Dudu Dilan Cam
Turkey
East Facade

Belemir Topkaya
Turkey
South Facade

Joao Barbosa
Portugal
West Facade

Juan Martin Dossman
Colombia
North Facade

No.	Description	Date
1	North Archiectural Building Elevation	31/01/2025
2	3D View	31/01/2025
3	Archiectural Building Section	31/01/2025

Parametric and Algorithmic Modeling

Palazzo del Lavoro

Anna Osello, Andrea Rolle, Matteo Del Giudice

Group 7

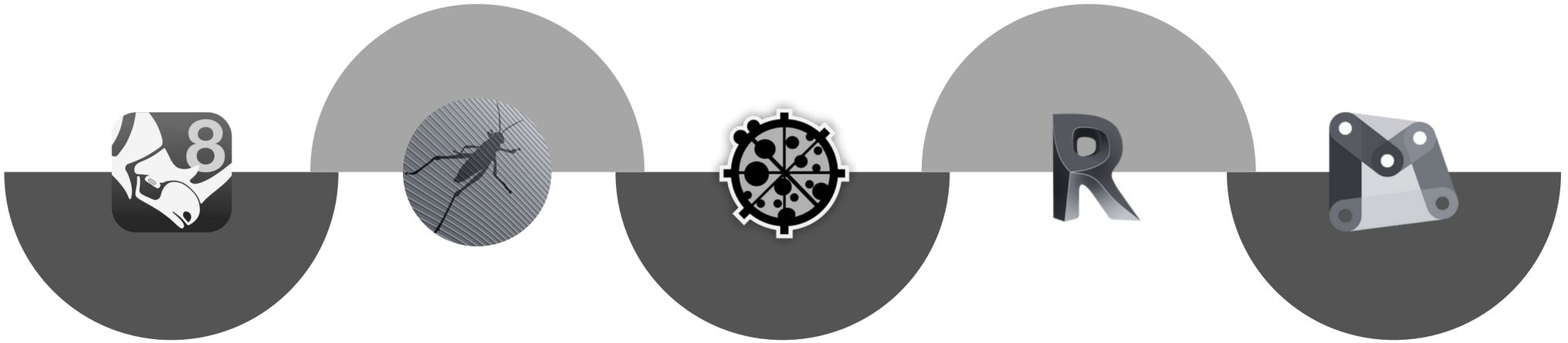
Project facade	North
Date	31/01/2025
Drawn by	Juan Martin Dossman
Checked by	Group 7

A102

Scale 1:200

West Facade _Youssef Nasr El Din

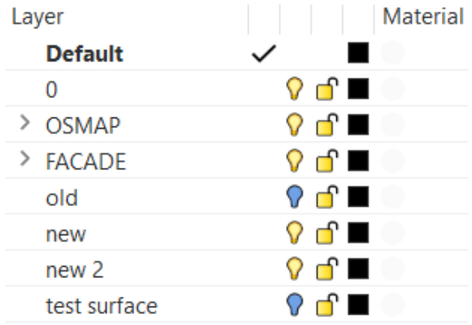
METHODOLOGY DIAGRAM



West Facade _Youssef Nasr El Din

The façade's design utilizes a modular triangular pattern, chosen for its efficient structure and adaptable visual appeal. To incorporate variety and flexibility, I employed scale as a key parameter. The façade begins with a uniform triangular grid, establishing a consistent modular base. A traction line positioned at the bottom serves as a reference for transformation. Triangles nearest to this line are designed smaller, while those further away grow in size, creating a gradient-like visual effect.

Layer Section in Rhino

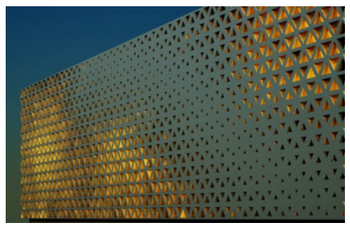


This design not only adds depth to the façade but also improves shading, light control, and ventilation. The size variations can be adjusted to optimize sunlight and airflow.

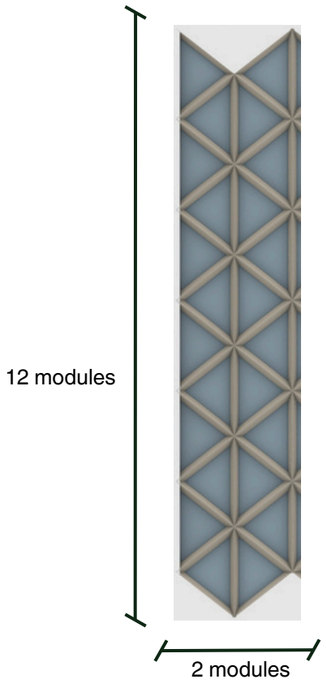
By using these parametric principles, the façade balances beauty, structure, and environmental efficiency, following modern architectural trends.

FACADE DESIGN

References

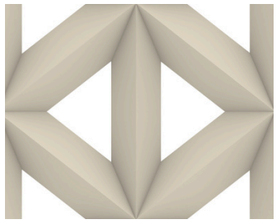


Parameter

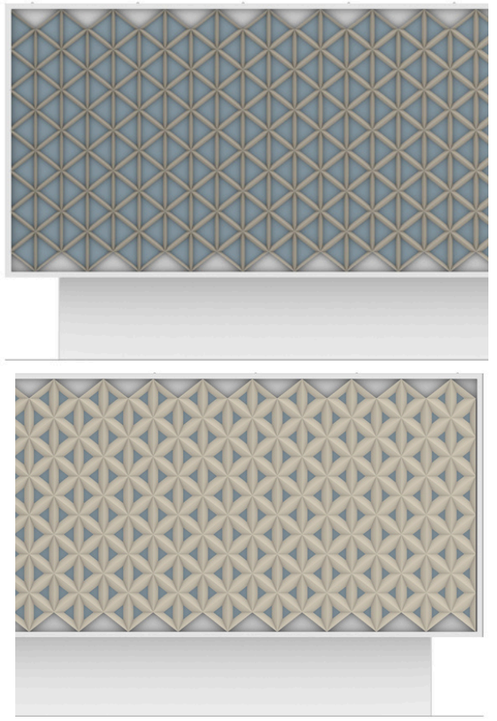


Module

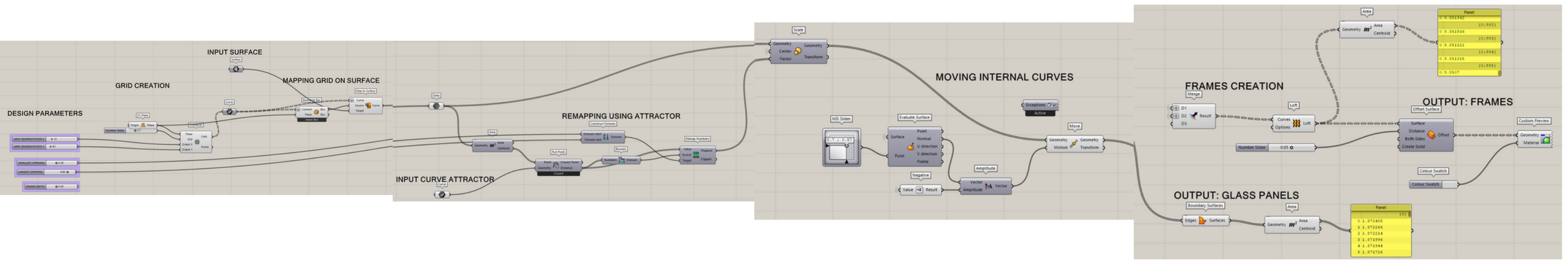
Triangle



Facade



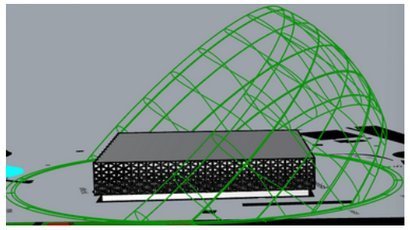
Grasshopper Script



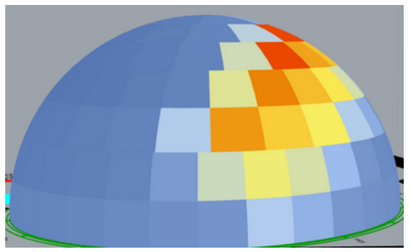
West Facade _Youssef Nasr El Din

SOLAR ANALYSIS

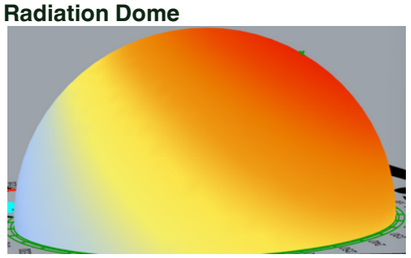
Sun Path



Sun Globe



Radiation Dome



How to calculate % of reduction

The formula to calculate the **percentage reduction** is:

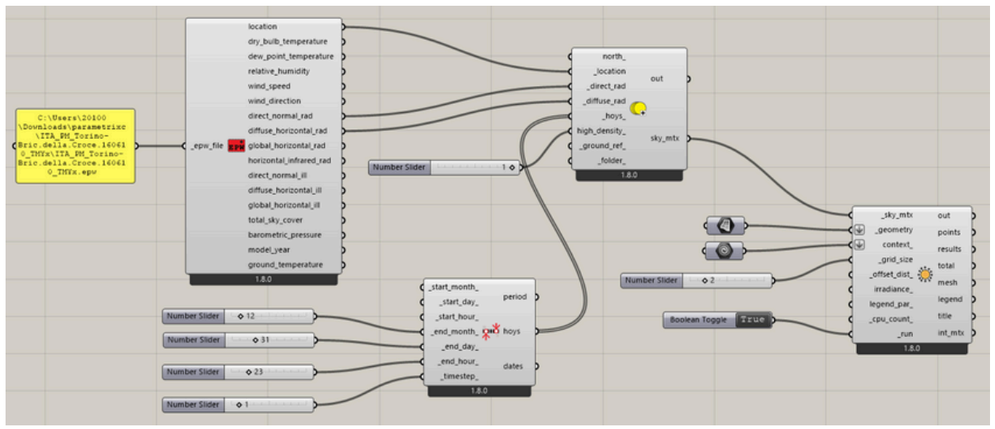
$$\text{Percentage Reduction} = \left(\frac{\text{Initial Value} - \text{Final Value}}{\text{Initial Value}}\right) \times 100$$

In my case:

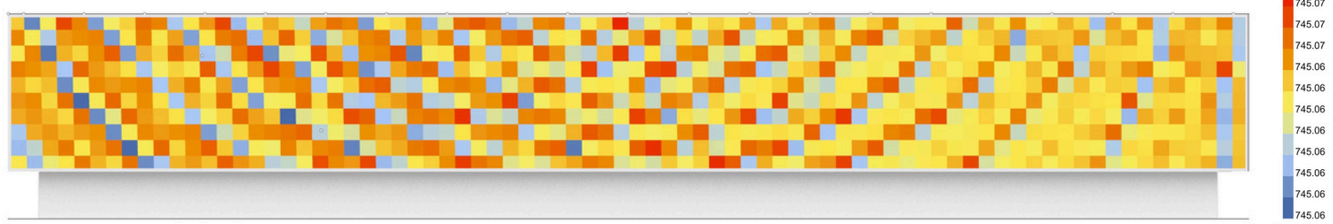
$$\text{Percentage Reduction} = \left(\frac{397725.201 - 93247.427}{397725.201}\right) \times 100 = 76.56\%$$

This gives approximately 76.56% reduction in solar radiation.

Grasshopper Script

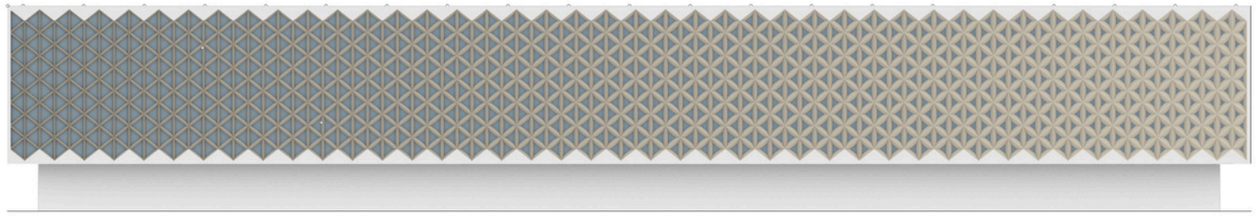


Before Optimized Facade

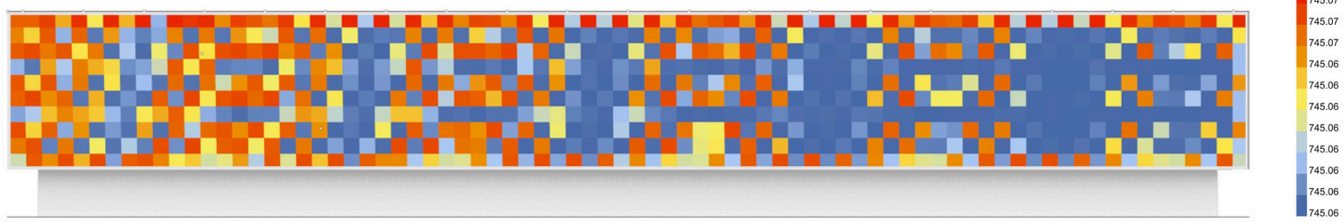


The west facade receives a solar radiation of **397 725.201 kWh**.

Optimized Facade



After Optimized Facade

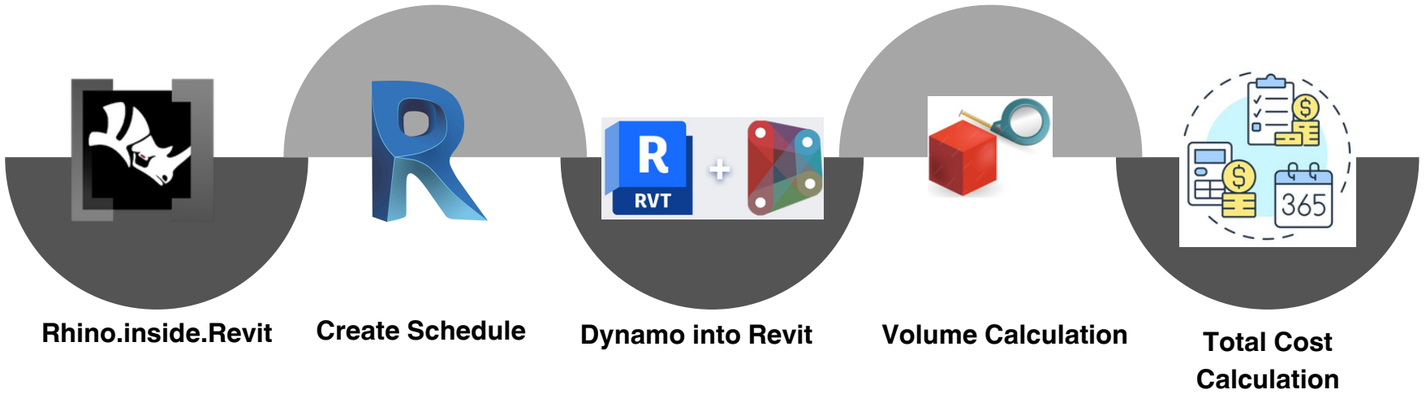


With the optimized facade in place, the new solar radiation level is **93 247.427 kWh**. The majority of this radiation is received in the late afternoon and just before sunset. A suitable use for this building could be a school or a library, as their peak usage typically occurs in the morning. This would justify a discount for this facade, given its lower optimization compared to others.

Solar Radiation Reduction: 76.54%

West Facade _Youssef Nasr El Din

cost Analysis



- Attempted to use Rhino.Inside.Revit to integrate a parametric 3D model into Revit.
- The goal was to define appropriate categories and parameters for façade components to ensure accurate structural and material representation.
- Faced difficulties using the tools correctly, preventing proper implementation.
- As an alternative, performed manual cost analysis:

  1- Counted the number of modules.

  2- Multiplied by an estimated volume.

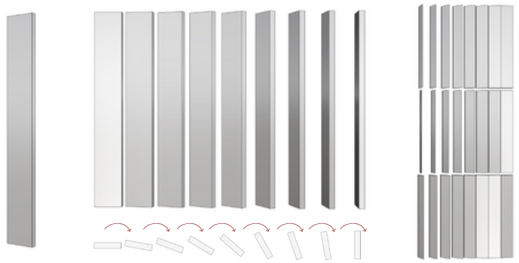
  3- Used this volume and multiplied it by the researched cost per volume for comparison.

Element	Triangle Panels
Material	Stainless steel
Total count of elements	997
Total Volume m3	354.60
Cost (€) m3	19.55
Material Cost	2.481.020.70
Transportation Cost	600
Total Cost (€)	2.481.620.70

FACADE COMPARISON

East Facade

Module **Parameter** **Pattern**



SOLAR ANALYSIS

Before Optimized Facade

After Optimized Facade

Solar Radiation Reduction: **77.33%**

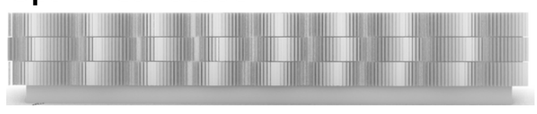
COST ANALYSIS

Generic Model Schedule

Total Count of Elements: 453
Tolal Volume: 314,59 m³

Total Cost: **314 592€**

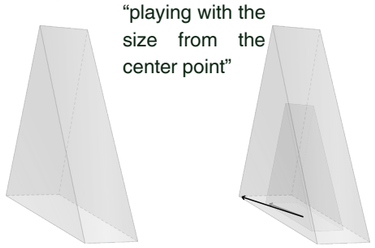
Optimized Facade



South Facade

Module **Parameter** **Pattern**

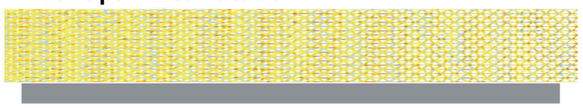
Triangle: Scale "playing with the size from the center point"



SOLAR ANALYSIS

Before Optimized Facade

After Optimized Facade



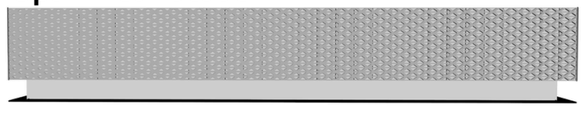
Solar Radiation Reduction: **72.6%**

COST ANALYSIS

ELEMENT DESCRIPTION	MATERIAL	COST PER m3 (€)	TOTAL VOLUME (m3)
Triangle Rotating Panels	Aluminum	4914	398.57
MATERIAL COST	TRANSPORTATION COST (€)	DISTANCE (km)	TOTAL COST(€)
1.958.619	360	15	1.958.979

Total Cost: **1.958.979€**

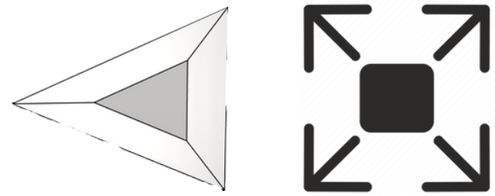
Optimized Facade



West Facade

Module **Parameter**

Triangle



SOLAR ANALYSIS

Before Optimized Facade

After Optimized Facade

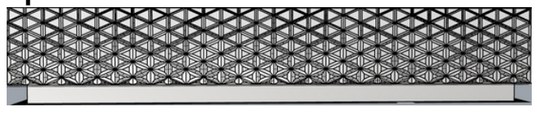
Solar Radiation Reduction: **40.57%**

COST ANALYSIS

MATERIAL COST	TRANSPORTATION COST (€)	TOTAL COST(€)
7.488.319,46	540	7.488.859,46

Total Hypothetical Cost: **7.488.859,46€**

Optimized Facade

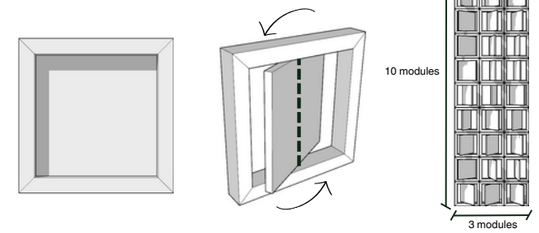


North Facade

Module **Parameter** **Pattern**

Square

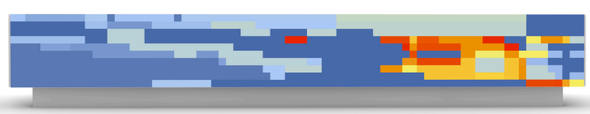
Rotation in a vertical axis



SOLAR ANALYSIS

Before Optimized Facade

After Optimized Facade



Solar Radiation Reduction: **92.65%**

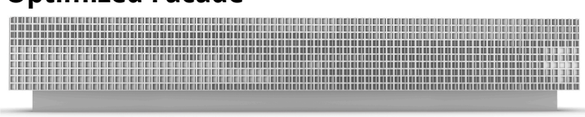
COST ANALYSIS

<Generic Model Schedule>

A	B	C
_Elements	_Volume	_Cost
Grand total: 1561	530.40 m³	530400

Total Cost: **530 400€**

Optimized Facade



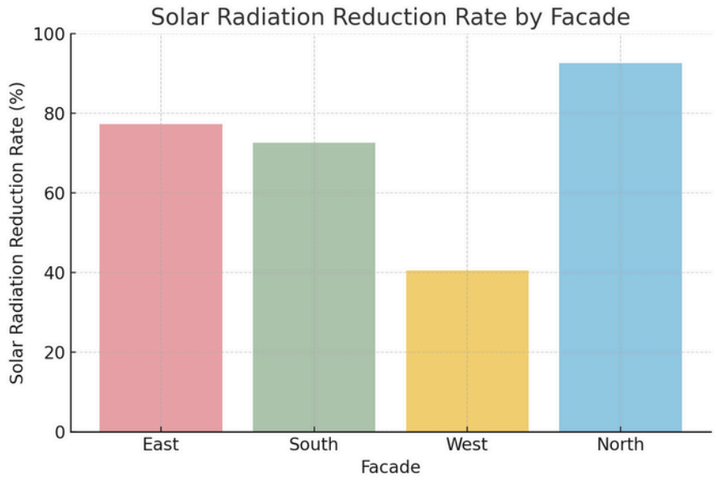
CONCLUSION

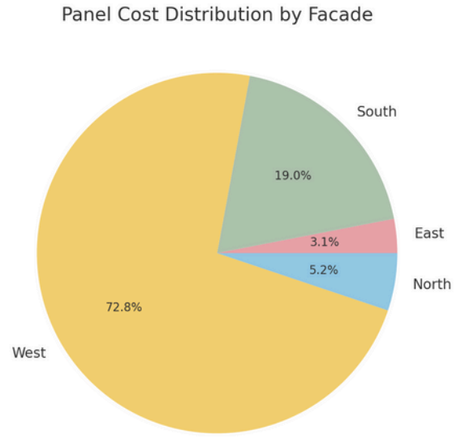
After analyzing the four facades of the Palazzo del Lavoro building with parametric design and solar cost evaluations, we can confidently say that not all facades offer the same balance of efficiency and cost-effectiveness. Our decision was based on two main factors:

1) Solar Radiation Reduction Rate – How effectively the facade minimizes solar exposure and improves energy efficiency.
2) Total Cost – The financial feasibility of implementing the design.

Facade	Solar Radiation Reduction Rate	Panel Cost (Euro)
East	77.33%	314,592
South	72.6%	1,958,979
West	40.57%	7,488,859
North	92.65%	530,400

Looking at the numbers, the West facade is immediately ruled out—it has the lowest solar reduction rate while also being by far the most expensive option. The North facade, although the most effective in reducing solar radiation, comes with a considerably higher price tag than the East facade. South, on the other hand, performs well but at a high cost.
This brings us to the most reasonable choice: the East facade. It strikes the best balance, achieving a 77.33% reduction in solar radiation while requiring the lowest investment of all four options. This makes it not just a smart financial decision, but also a highly effective one in terms of energy efficiency.





Final Choice: **East Facade**
Why?
High efficiency: A **77.33% reduction** in solar radiation means strong energy performance.
Cost-effective: At **314,592 Euros**, it is the most budget-friendly solution.
Balanced approach: It achieves an excellent trade-off between cost and performance, making it the smartest investment.