Logic to Artefact

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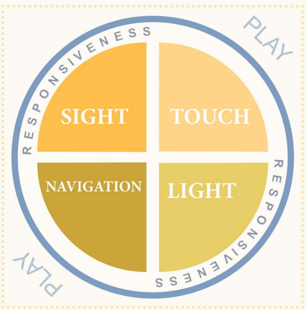
A Shelter for Play

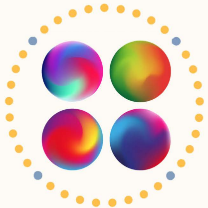


The shelter for play is responsive to sight, touch, light, and navigation to feature its playfulness nature. This project's focus is to develop a light-responsive design

Project Brief

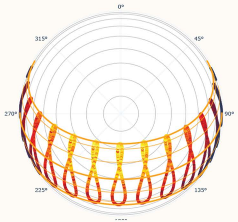
Playfulness

The main objective of this project is to present a solar-responsive skin that could change its responsiveness features parametrically and represent a playful design by changing its color. The shelter is located in Bristol and made of a steel structure with wooden panels. The panels are covered with thermochromic coatings that are passively tempreture-sensetive.



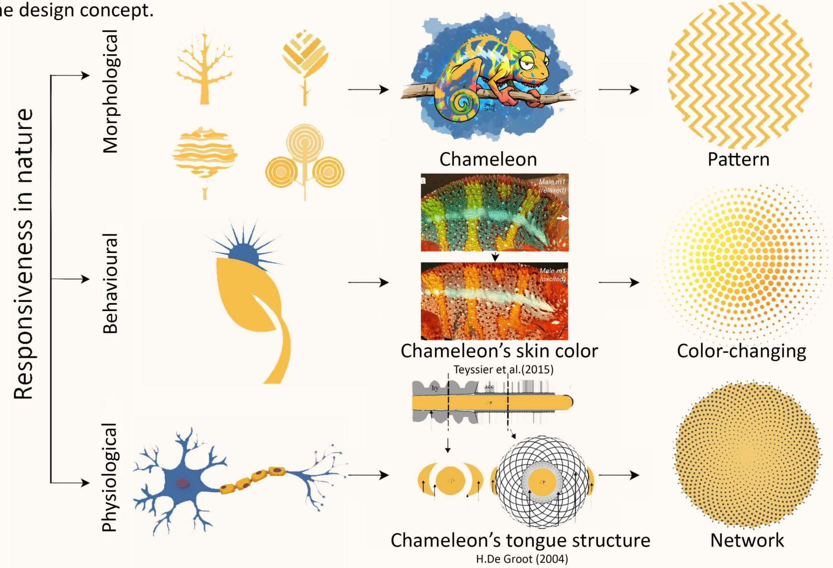
Computational Environmental Design

The integration of environmental considerations and computational methods in ligned with the design theory has led to a solar-responsive design. The energy generation potential of the shelter has been analysed for different formal iterations and throughout a year. The final form has been chosen based on the radiation and shadow studies.

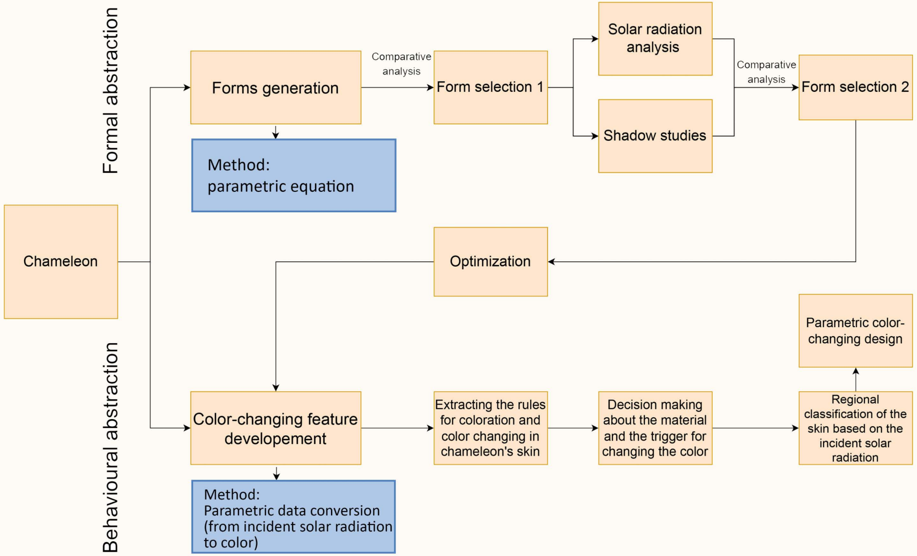


Theory

This project follows *'biomimetics'* as a design approach and uses computational design as a tool to develop the design concept.



Design process



Material

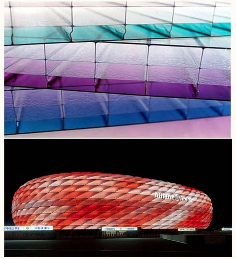
Colour-changing materials

Smart material	Trigger
Photochromic	Light
Electrochromic	Electrical energy
Thermochromic ✓	Temperature
Mechanochromic	Mechanical energy
Chemochromic	Chemical energy

Among the above options, thermochromic material is chosen considering the fact that the incident solar radiation recieved by a surface has a direct relationship with the temperature of that surface. Thermochromic (TC) coatings are dynamic solar control coatings that switch over time from high solar absorption at low temperatures to low solar absorption at high temperatures (A. Butt e t al.,2021). Also, there has been some research that introduce thermochromic films/coatings that can attain multiple color change.

Reversable thermochromic process, Zhang et al.(2022)

Color-changing materials

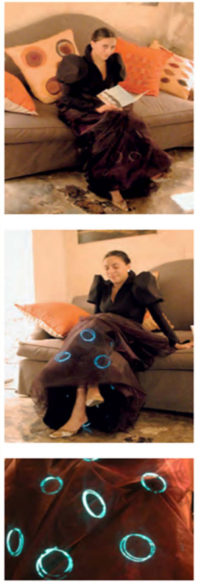


Allianz Arena, photo credit: Signify

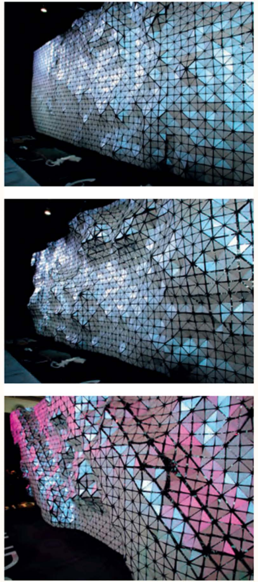
facade product Rodeca Bicolor

Building with a color-changing coating, Credit: EmmaOlivsSmith

Laban Dance Centre, London, Arup



Kinetic dress during various activities, Cute Circuit research laboratory



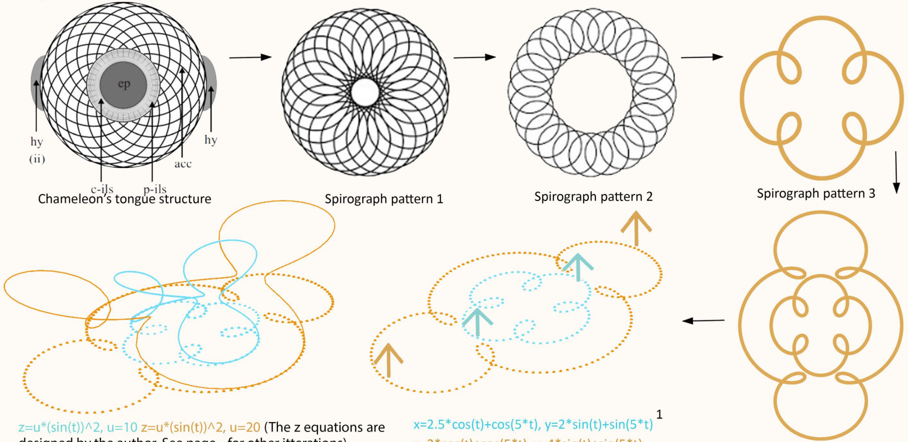
Aegis Hyposurface, dECOI Architects

https://www.rodeca.de/en/highlights/design-series/bicolor-1.html
Ritter, A. (2007) Smart materials in architecture, interior architecture and design. Basel; Berlin; Boston: Birkhäuser.
https://arquitecturaviva.com/works/centro-de-danza-laban-londres-8
https://www.scientificamerican.com/article/new-color-changing-coating-could-both-heat-and-cool-buildings/

Abstraction: Form

Parametric equation

The form has been generated inspired by chameleon's tongue structure pattern (spirograph) using .the parametric equation method. Playing with z coordinate equations of the two generated curves has shaped the design.



z=u*(sin(t))^2, u=10 z=u*(sin(t))^2, u=20 (The z equations are designed by the author. See page... for other itterations)

x=2.5*cos(t)+cos(5*t), y=2*sin(t)+sin(5*t) [1]
x=2*cos(t)+cos(5*t), y=4*sin(t)+sin(5*t)

1. The initial equations for x and y coordinates are x=2*cos(t)+cos(5*t) and y=2*sin(t)+sin(5*t) using the *'geogebra'* website. The equation for z coordinates and further manipulation on the x and y equations has been done by the designer based on the architectural considerations.

Form Generation

The x and y coordinates are constant. Different itterations have been developed by changing z coordinate.

1

Curve1/Equation= (u2sin(t))^2, u=1.79
Curve2/Equation= (usin(t))^2, u=4.37

2

Curve1/Equation=(ucos(t))^2, u=2.08
Curve2/Equation=(usin(t))^2, u=4.08

3

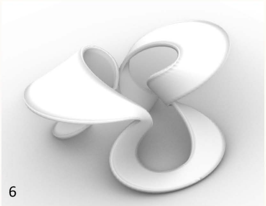
Curve1/Equation=(2u1.7sin(t))^2, u=0.84
Curve2/Equation=(5usin(t))^2+5, u=0.73

4

Curve1/Equation= (u2sin(t))^2, u=1.79
Curve2/Equation= (ucos(t))^2, u=4.37

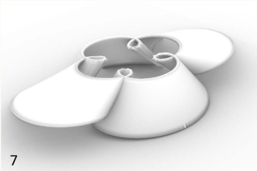
5

Curve1/Equation= (usin(t))^3, u=2.17
Curve2/Equation= (usin(t))^2, u=4.08



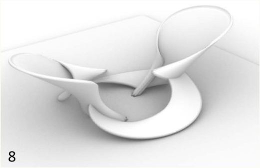
6

Curve1/Equation=(u*2*sin(t)+cos(t))^2, u=1.70
Curve2/Equation=(2usin(t))^2, u=2.23



7

Curve1/Equation= usin(t)^2+cos(t)^2, u=1.49
Curve2/Equation= (u*2*sin(t))^2, u=1.56

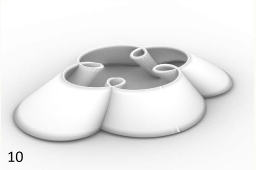


8

Curve1/Equation=u(sin(t)+cos(t))^4, u=2.15
Curve2/Equation=usin(t)^2, u=5.14

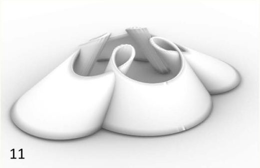
9

Curve1/Equation=u(sin(t)cos(t))^2+6, u=0.1
Curve2/Equation=2usin(t)^2, u=4.13



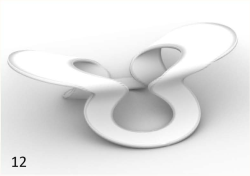
10

Curve1/Equation= u(sin(t)cos(t))^2+6, u=0
Curve2/Equation=usin(t)cos(t))^2, u=4.13



11

Curve1/Equation=u(sin(t)cos(t))^2+6, u=19
Curve2/Equation=usin(t)cos(t))^2, u=4.13



12

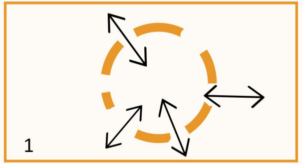
Curve1/Equation=usin(t)^2, u=10
Curve2/Equation=usin(t)^2, u=20

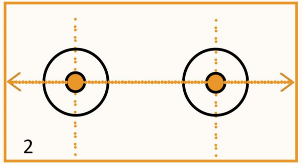
Form selection

3 forms (1, 6, 12) have been selected based on the following criteria:

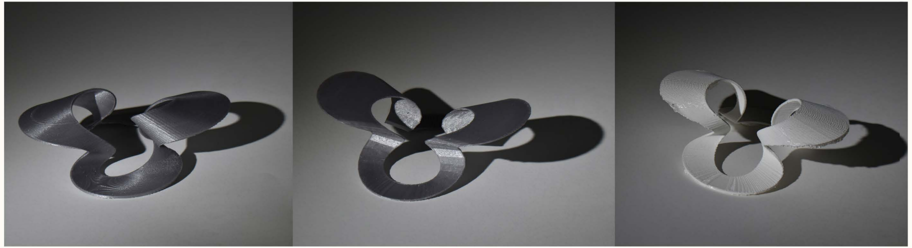
1. The form should provide a **semi-open** space so that it can enhance the concept of playfulness by encouraging exploration, offering flexibility, and enhancing the connection to nature

2. The shelter should provide the integration of **stillness and movement** qualities in support of the concept of a playful shelter





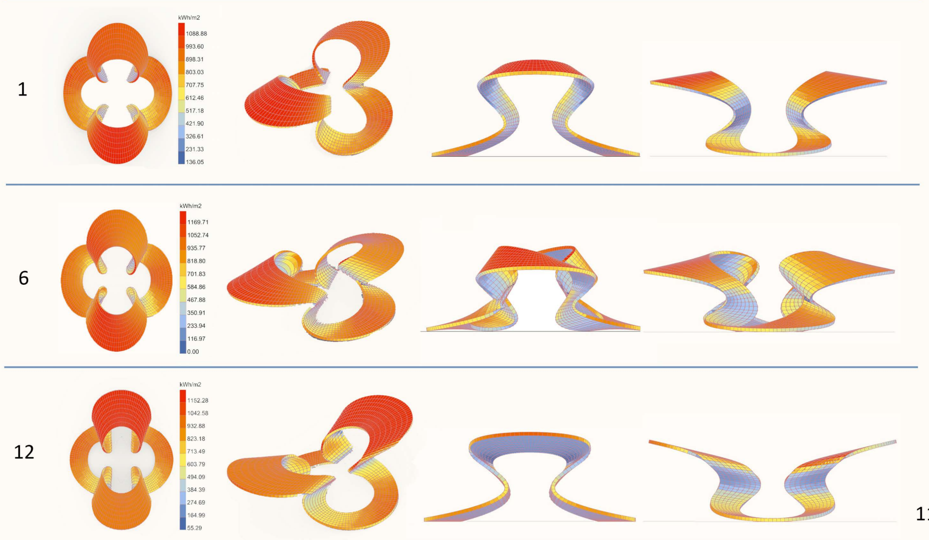
Fabrication



Radiation analysis

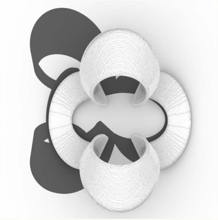
Among the 3 selected forms, form 12 receives the most amount of solar radiation which makes it a better option for energy generation by BIPVs.

Form Plan Perspective Front Right

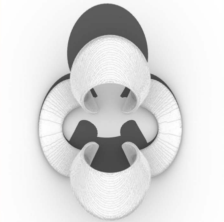
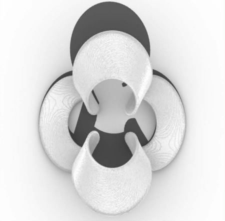


Shadow study

21st June, 9 A.M

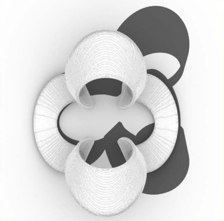
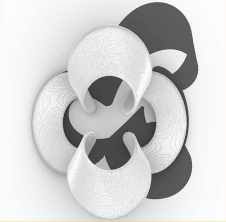
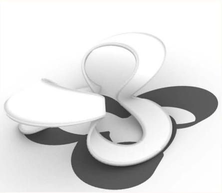
View	Form1	Form6	Form12
Plan			
Perspective			

21st June, 12 A.M

View	Form1	Form6	Form12
Plan			
Perspective			

Shadow study, 21st June, 15 P.M

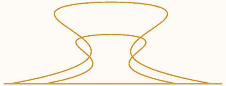
A comparative analysis has been done based on the forms' area of shadow in 21st June. Although the shadow coverage of all 3 forms at 12 a.m are almost the same, form 12 's shadow coverage at 9 a.m and 15 p.m is more than the other 2 forms. So, based on the radiation and shadow study, this form has been selected for the shelter.

View	Form1	Form6	Form12
Plan			
Perspective			

Optimization

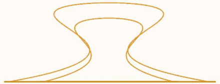
Maximizing solar radiation can result in maximizing solar panel efficiency because solar panels convert the energy from the sun's radiation into electrical energy. Therefore, the more solar radiation that reaches the panels, the more electrical energy they can produce.

Here, an optimization of skin's shape has been done to maximize the incident solar radiation using the combination of Galapagus and Ladybug. The shape has been created from 2 curves each of which has a u value for its z coordinate. Changing the u value has resulted in different shape variations. In the optimization step, the u value range has been redefined and limited considering the functional considerations. The results shows the shape with maximum u value for both of the curves is an optimized shape.

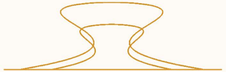


u1=Min, u2=Max

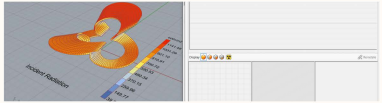
u1=Max, u2=Min



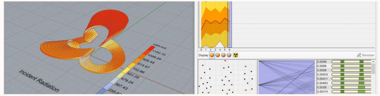
u1=Max, u2=Max



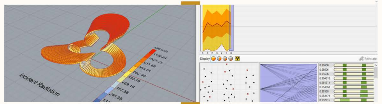
u1=Min, u2=Min



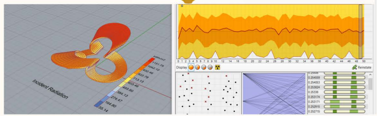
Maximum incident radiation= 1141.48kWh/m^2



Maximum incident radiation= 1150.1 kWh/m^2



Maximum incident radiation= 1138.84 kWh/m^2



Maximum incident radiation= 1151.79 kWh/m^2

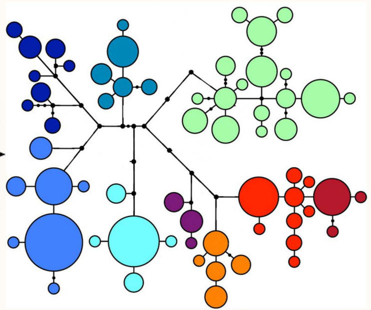
Abstraction: Skin’s feature

Regional classification

Chameleons can change different skin regions to different colours (due to a cellular classification) and while one region becomes more orange or red, another one becomes more bluish or whitish. The Schematic diagram represents different colors based on regional classification which is the principle of this project’s abstraction to achieve a color-changing configuration.

Chameleon’s skin

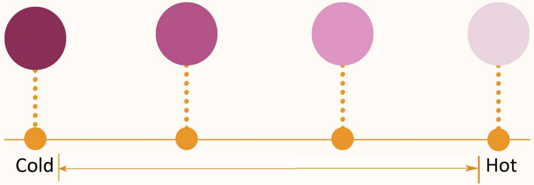
Abstraction

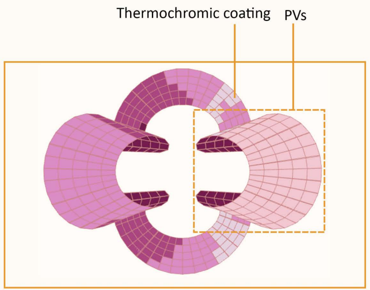


Regional classification as a principle for the color-changing feature abstraction

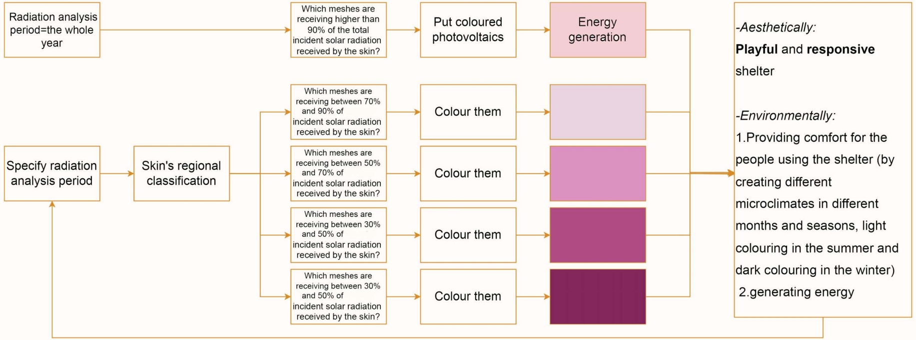
Abstraction: Skin’s feature

Parametric Design





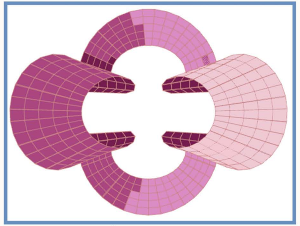
Shelter’s coloration, September

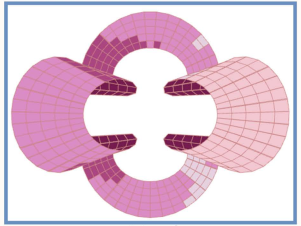


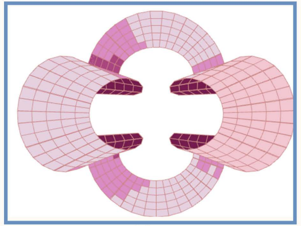
Color-changing iterative process inspired by chameleon

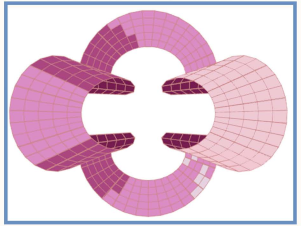
Color changing iterations

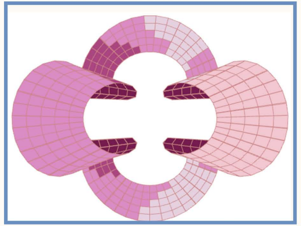
As expected, the coloration in warmer months of the year is lighter that the coloration in colder months of the year. This feature can affect the microclimate around the shelter and occupants' comfort in a positive way.

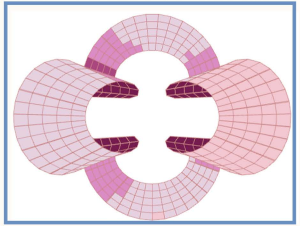

January


March

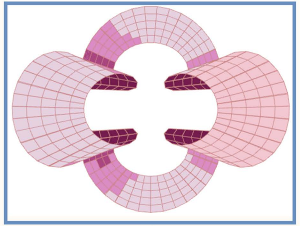

May

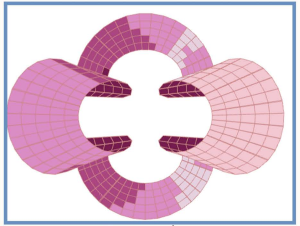

February

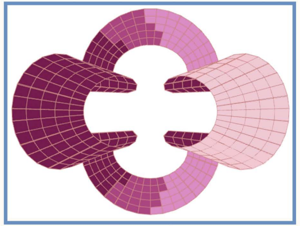

April

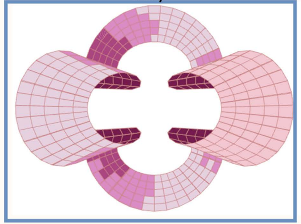

June

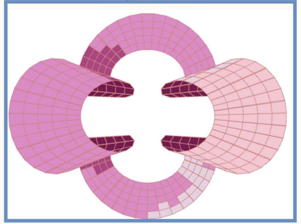
The coloured solar panels have been used in order to maintain consistency in the design. This would help the solar panels blend in with the overall aesthetic of the design, rather than standing out as a jarring element.

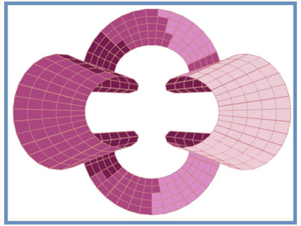

July


September


November


August

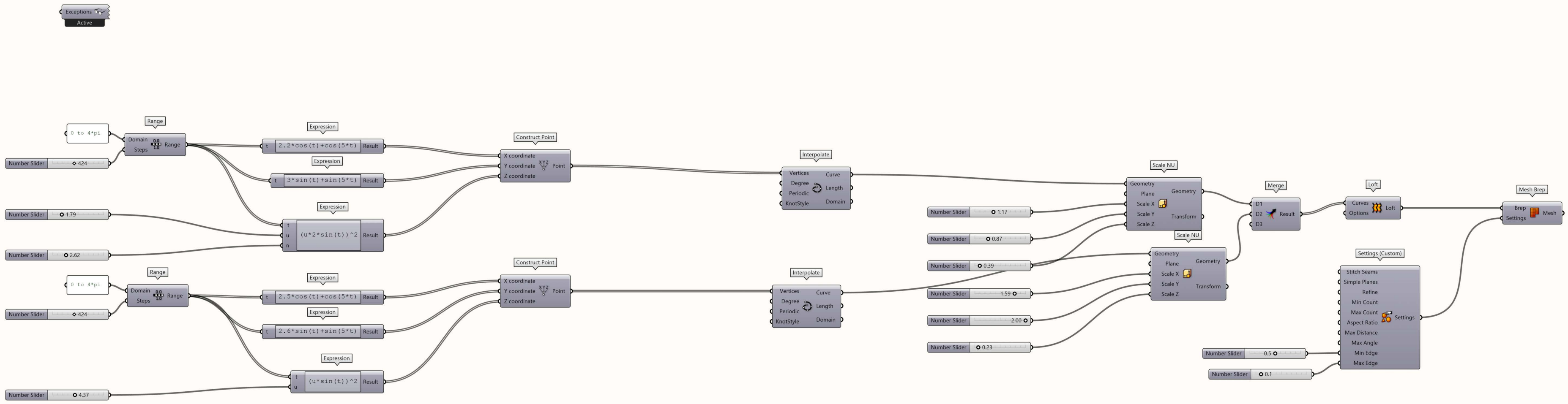

October


December

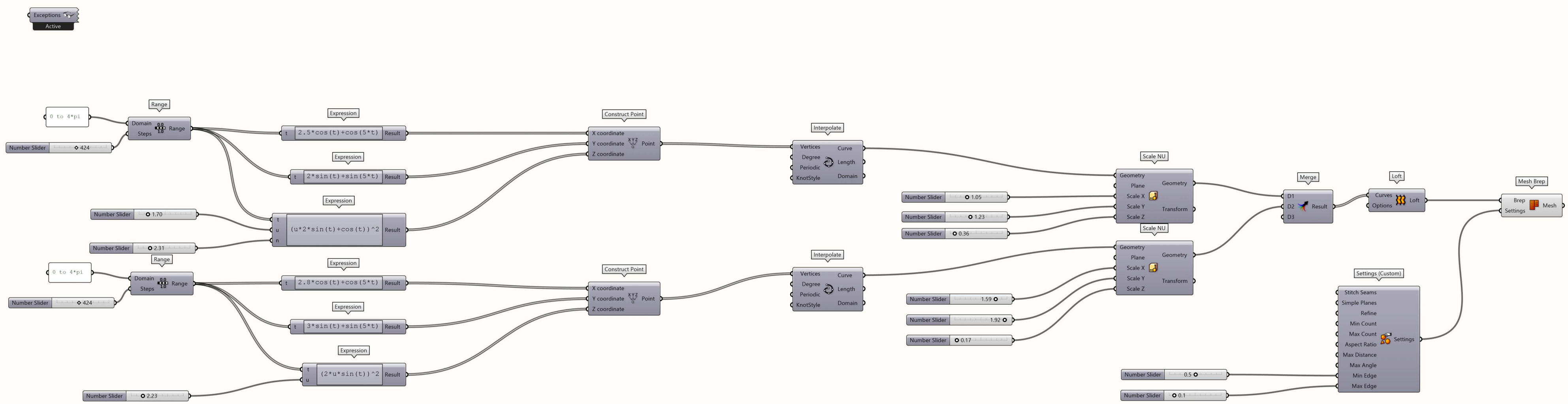
Coloration in a summer day

Coloration in a winter day

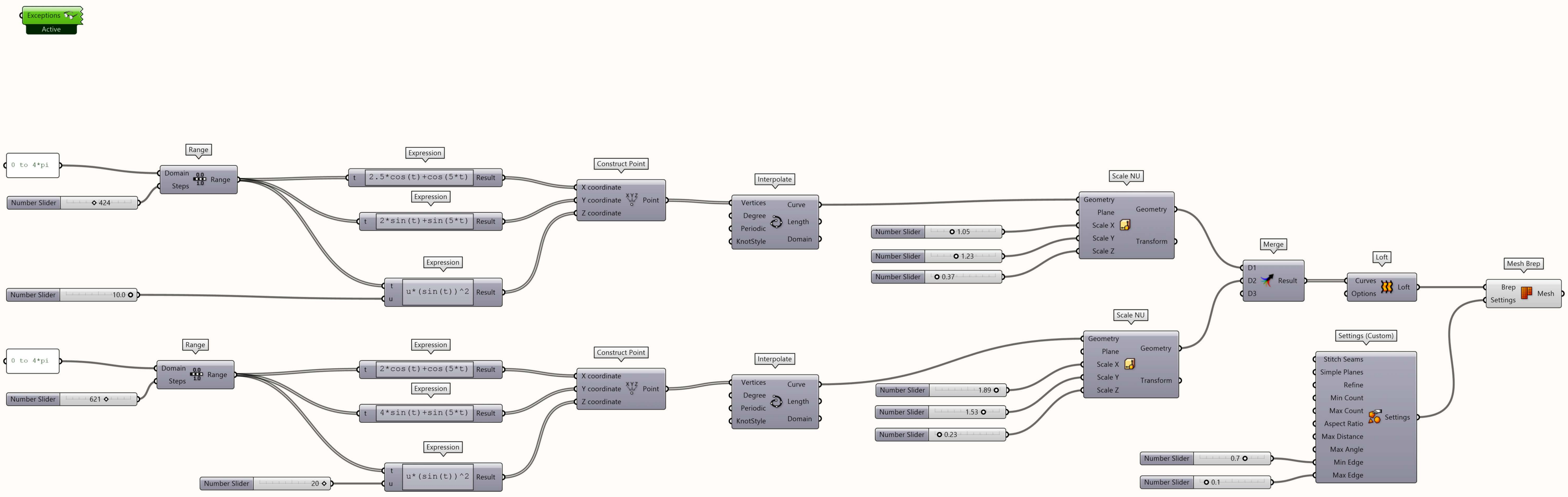
Form-Iteration1



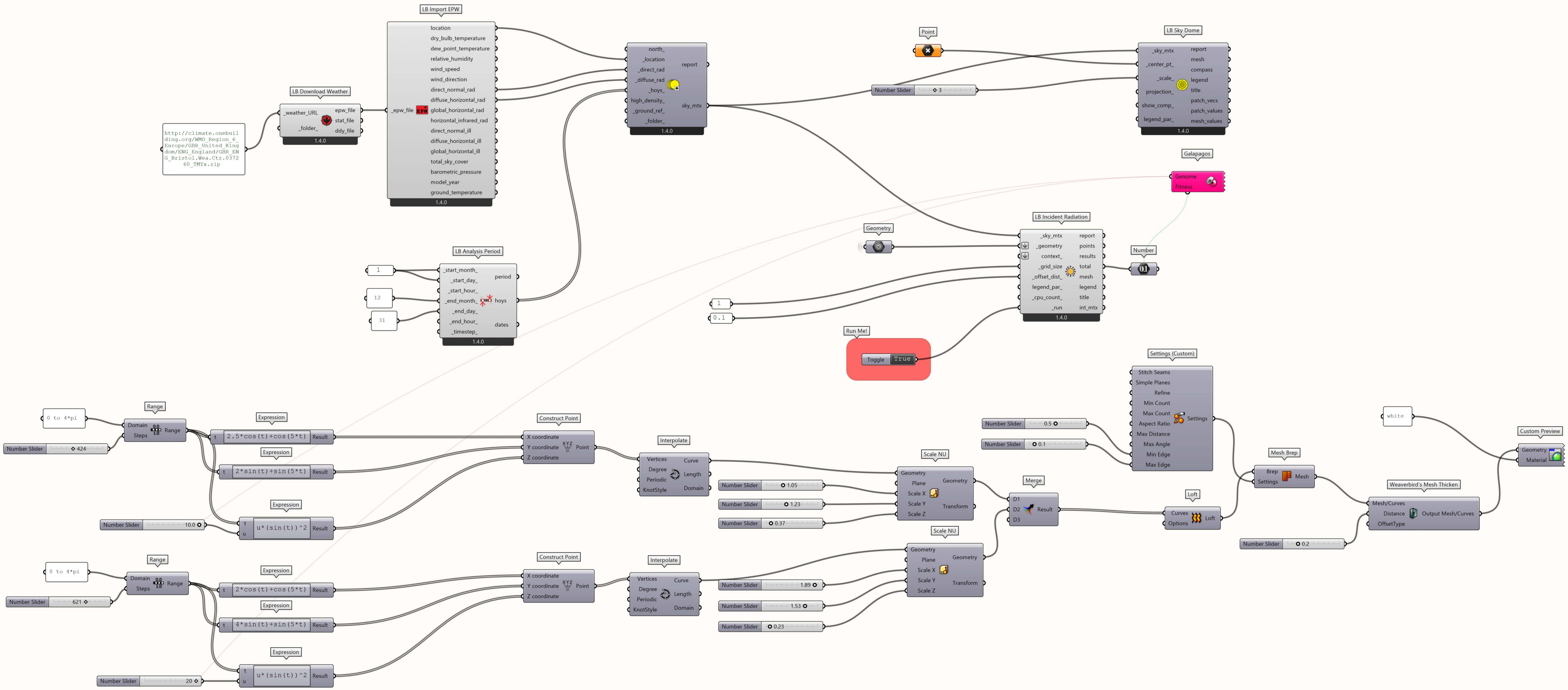
Form-Iteration6



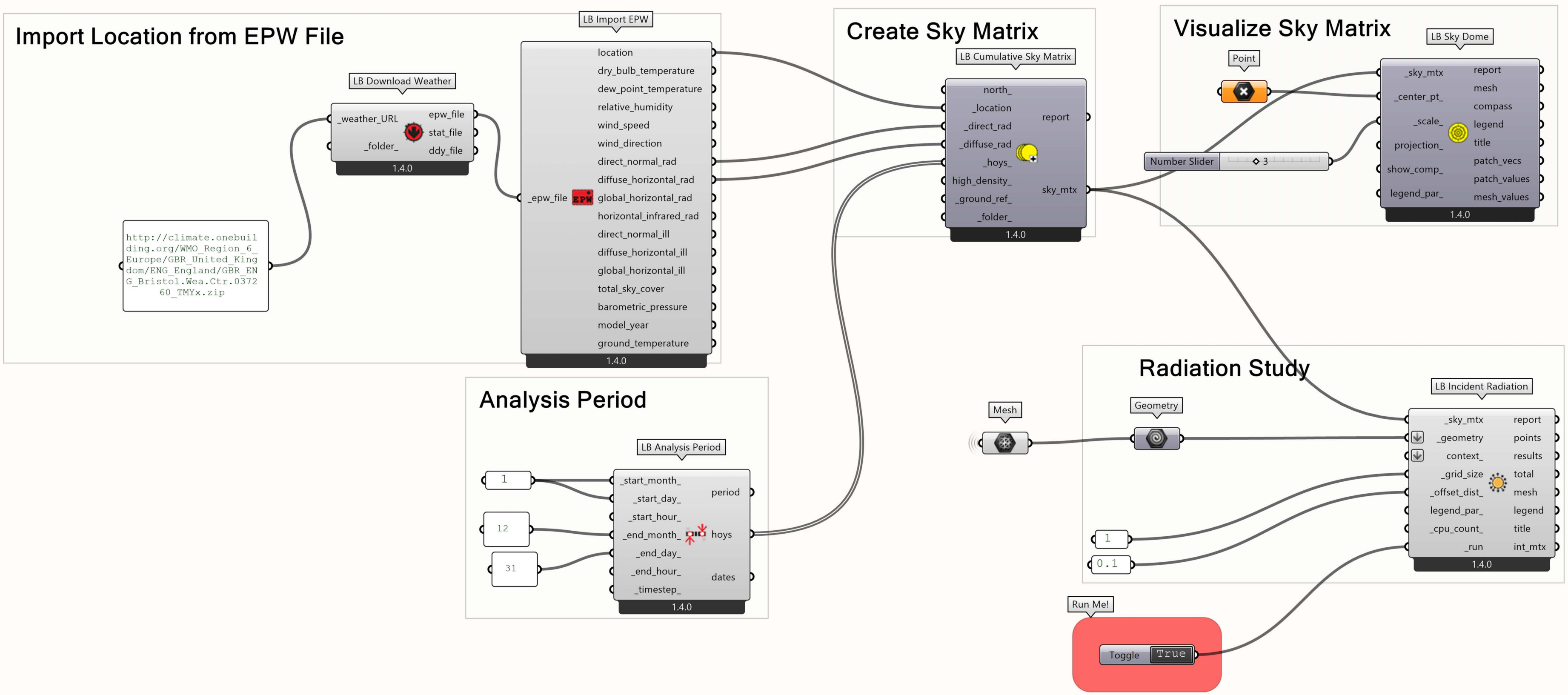
Form-Iteration12



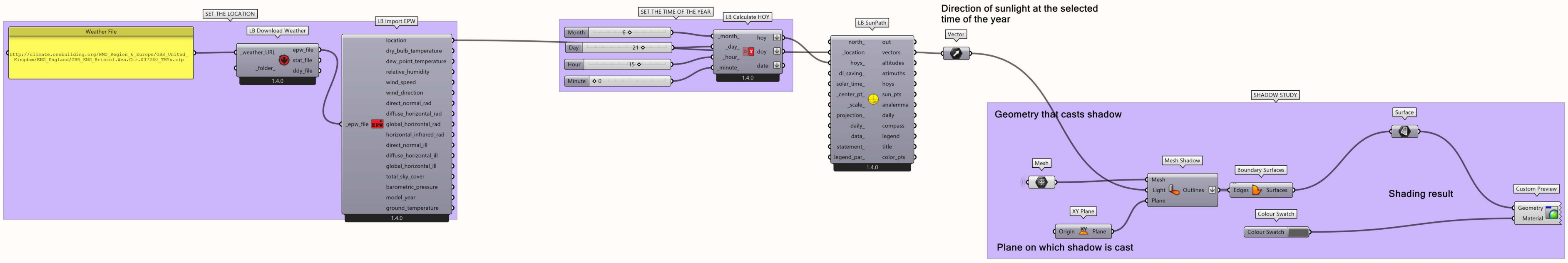
Form-Optimization



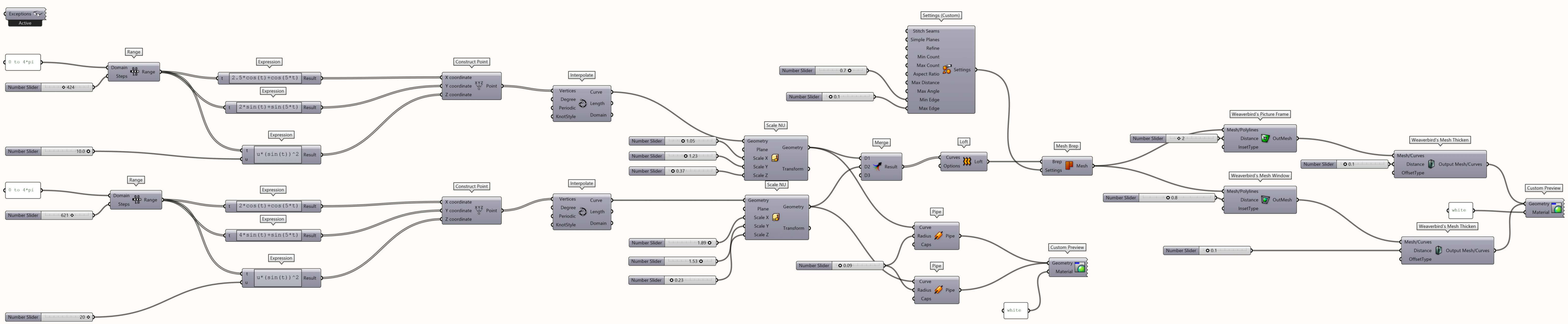
Radiation analysis



Shadow study

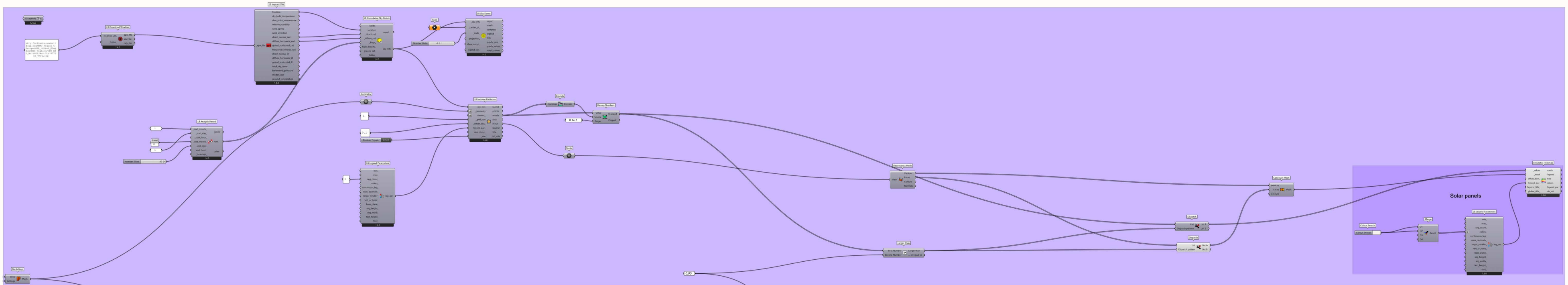


Final form



Coloration

Locating solar panels on the shelter (based on the whole year solar radiation study)



color-changing meshes