Transitional space design in the concept of architectural thermodynamics

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Schedule of workshop

Tuesday (18th Oct)

Lecture of "Transitional Space Design in concept of Architectural Thermodynamics", by Tiantian Du

Location : 36 (EWI) - Timmanzaal , EWI Faculty; 10:00 am - 4:30 pm

Wednesday (19th Oct)

Work

Location: Protospace of Hyperbody, 9:30am - 5:30 pm

Thursday (20th Oct)

Final presentation + short speech of Nimish

Location: 01 WEST 060, BK Faculty, 1:30 pm - 4:30 pm

Part 1:
Transitional Space

Transitional space

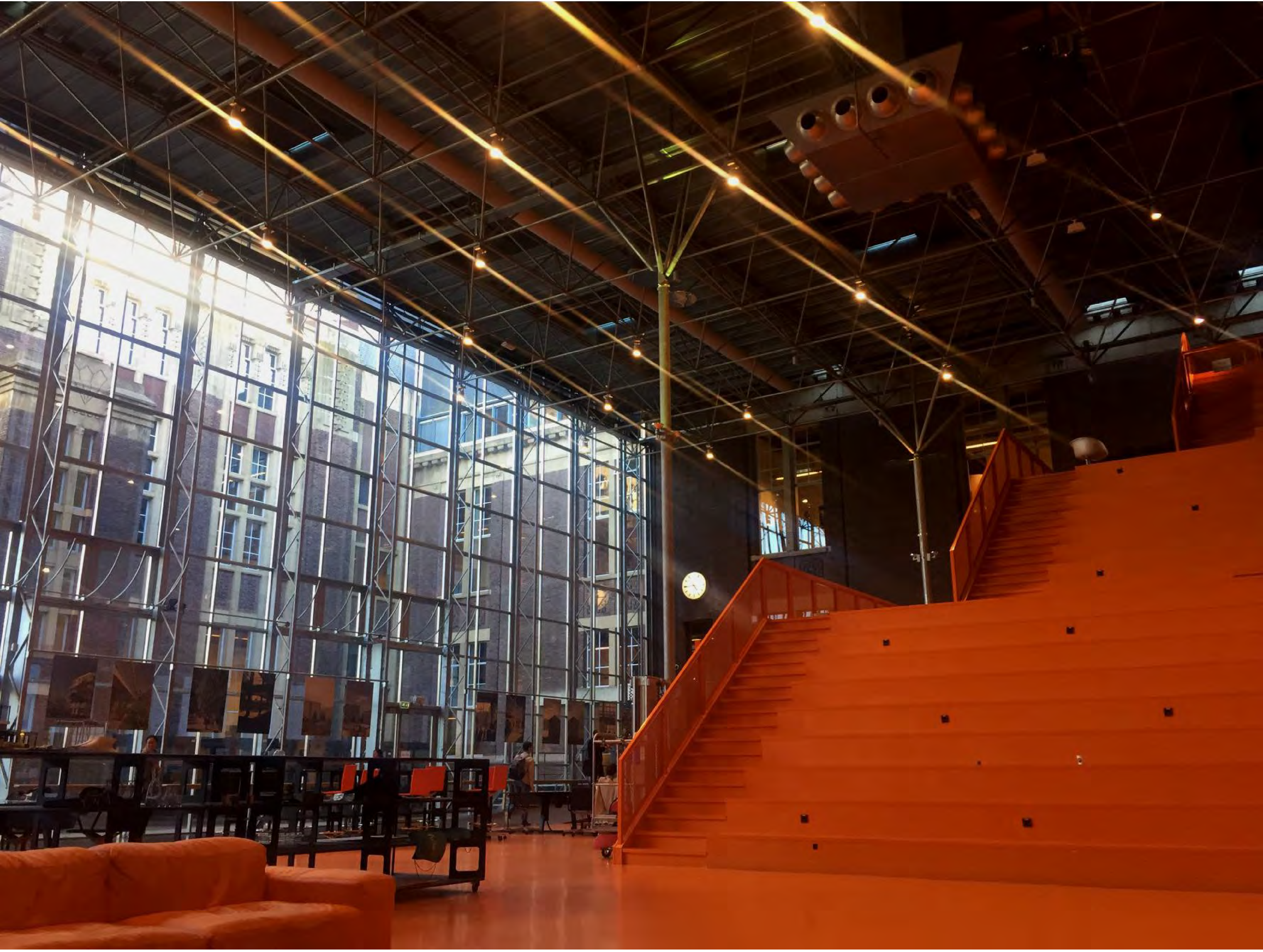
Transitional spaces are locations where the physical environmental bridges between the interior and exterior environment.

These zones are the "in- between" spaces where the indoor and outdoor climate is modified, and they are without mechanical control systems.

Transient conditions in indoor space and in what we define as transitional spaces are characterized by dynamic, variable, unstable, or fluctuating conditions. Transitional conditions are quite complicated and compounded by the effects of many variables such as temperature differentials, solar radiation, wind, and localized micro-climates.

Atirum of office
medium of **Light, Scenery**

Courtyard
medium of natural elements:
Light, Wind, Tree, Grass



Orange Hall of Campus
medium of social life:
Communication, Presentation, etc

Part 2
Architecutral Thermodynamics

1. Definition

Architectural Thermadynamics is the use of concepts and the laws of **thermodynamics** in architectural design or theory, in individual unit, buildings, or city planning.

History:
In the late 1970s, the first course on "**architectural thermodynamics**" was taught at Georgia Institute of Technology.

Thermodynamic Materialism
In 2013, Harvard University Graduate School of Design offered a course entitled **"Air in Motion/ Thermodynamic Materialism"**, in which **air or space** is treated and studies " thermodynamically ", which reveals the different developing directions of this theory in the contemporary context.

2. History of Energy in architecture

2.1 Energy crisis

In 1973, the energy crisis provoked the debate on the relationship between architecture and energy, in which people learned that comfort came with a price.

2.2 Petroleum price went down

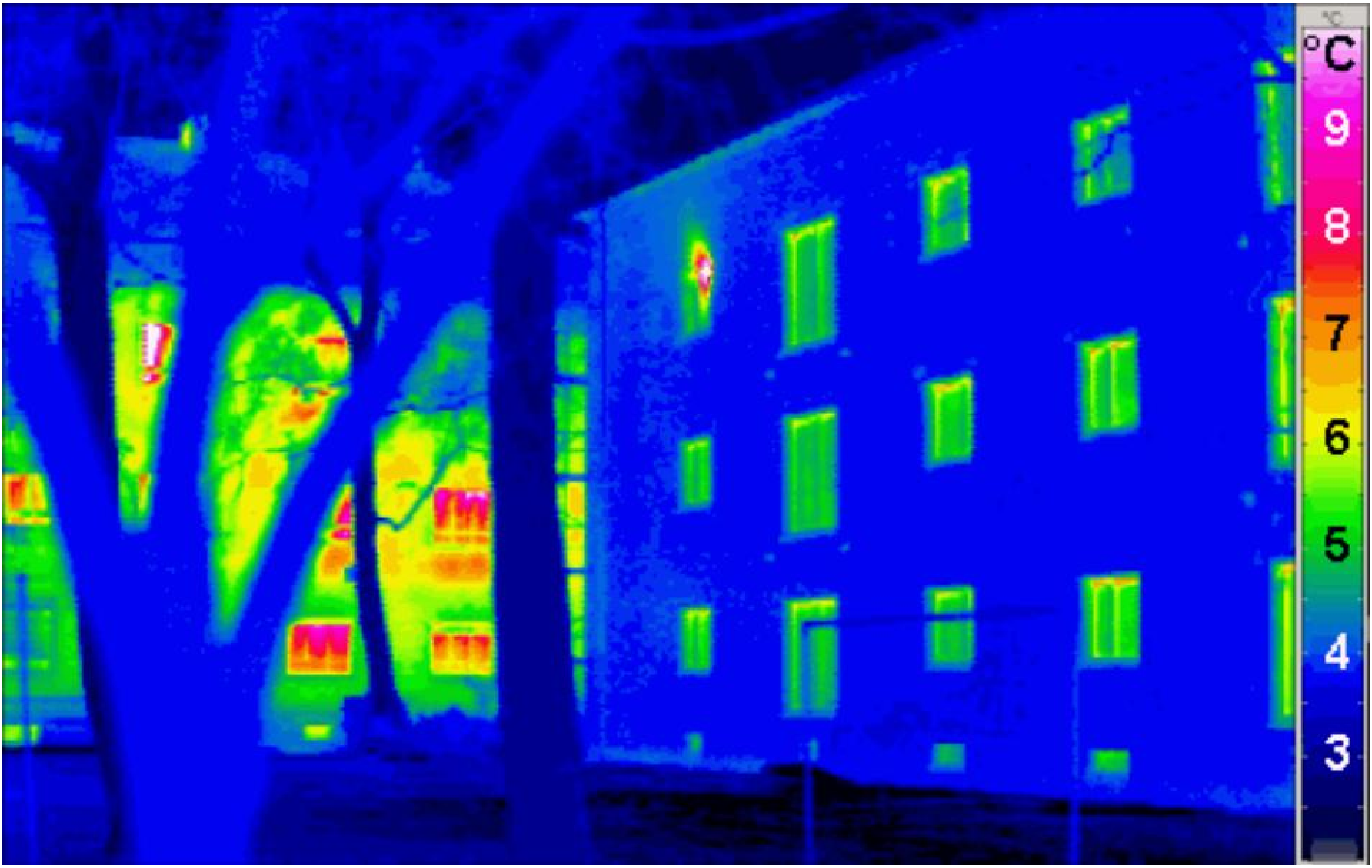
In the mid-1980s, withe the price of petroleum went down again, energy problem faded out the main discussion, just becoming a discourse of post-modernity.

2.3 Sustainable building

Forty years later, for now, we are experiencing an climatic, economic, and environmental crisis again that dwarfs the 1970s. The current debate is quite **radical,** taking the form of an energy paranoia, with the belief that **all energy consumption, per se, is bad**. That is the so-called "sustainable building". Unfortunately, the sustainability is mainly decked with the heraldry of environmental certificates, adorned with very expensive gadgets.

This kind of "environmental functionalism"is mostly based on recourse to **"specialists",** feeding on the specialized languages of the sciences, like the entropy, gas emissions of the greenhouse effect, adiabatic cooling, or the cycle of life. All this **release the character of architects**, and not having brought energy into the project from the start. Indicating lots of problems.

Passive Houses



Standard:

a. Annual Heating and Cooling demand: not more than 15 kWh/m2

b. Electricity consumption: not more than 120 kWh/m2 per year

c. air exchange: not leak more air than 0.6 times per hour at 50 Pa

Zero Energy Building

Definitions:

- **Zero net site energy use**
- **Zero net source energy use**
- **Net zero energy emissions**
- **Net zero cost**
- **Net off-site zero energy use**
- **Net zero-energy building**

LEED-Certified Buildings Are Often Less Energy-Efficient Than Uncertified Ones

One study found that even in Washington, D.C., the U.S. Green Building Council’s own backyard, many of the LEED-certified buildings were the **least energy-efficient** of all comparable buildings.

There’s nothing wrong with saving energy, but unfortunately “green” building ratings systems such as LEED offer little more than **a plaque and a press release**. What’s worse, these rating systems make buildings **more expensive to build, and thus to occupy**.

Break:

Discussion about what's your idea about the "Sustainable Building"

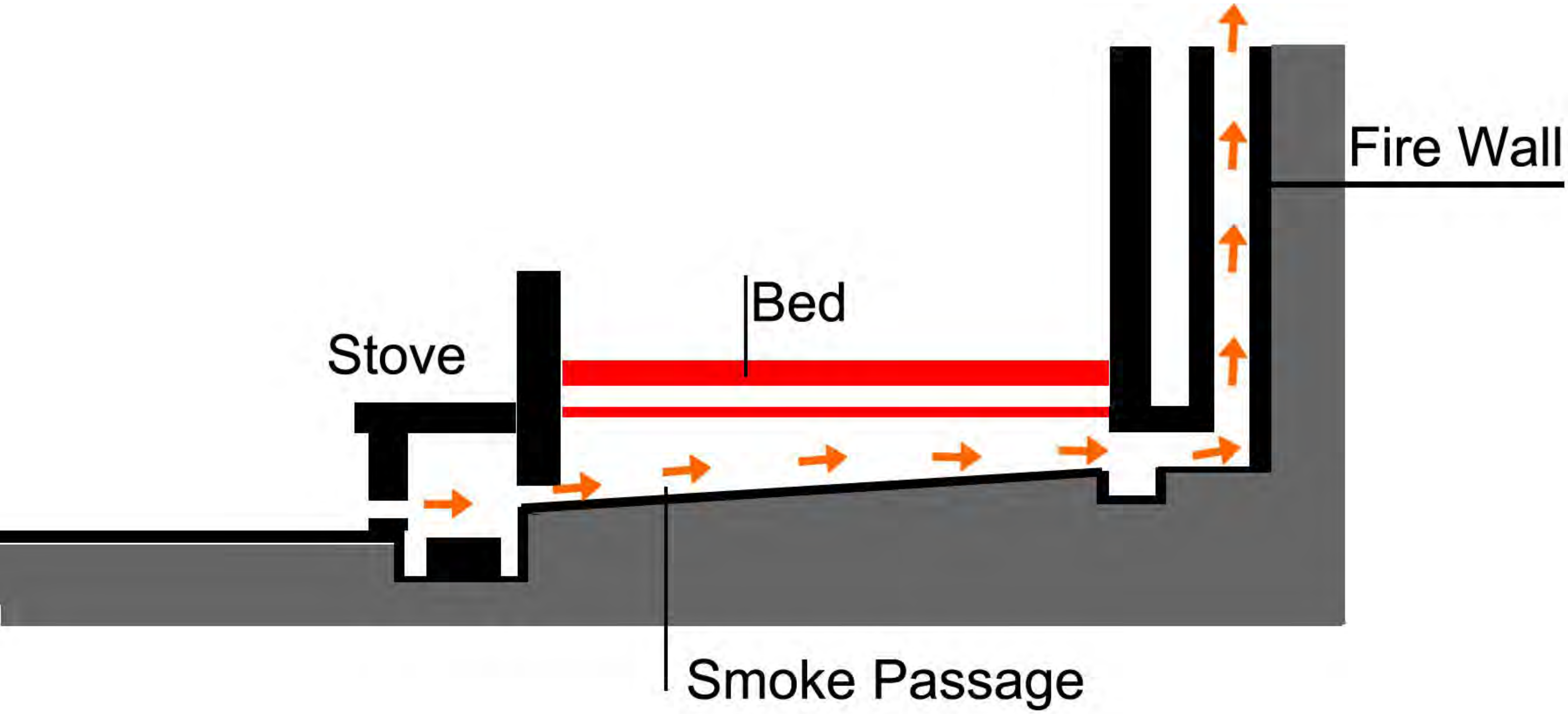
2.4 From high-tech to “Environmental-Tech”

There are still other architects that tried to find more efficient ways of managing energy, **not only through machines but also through architectural forms themselves**. Design strategies are less and less dependent on the mechanical production of comfort, as they progressively incorporated **passive ways** of managing energy. The environmental-tech took **vernacular architecture** but stripped it of ideological connotations, giving importance only to its features.

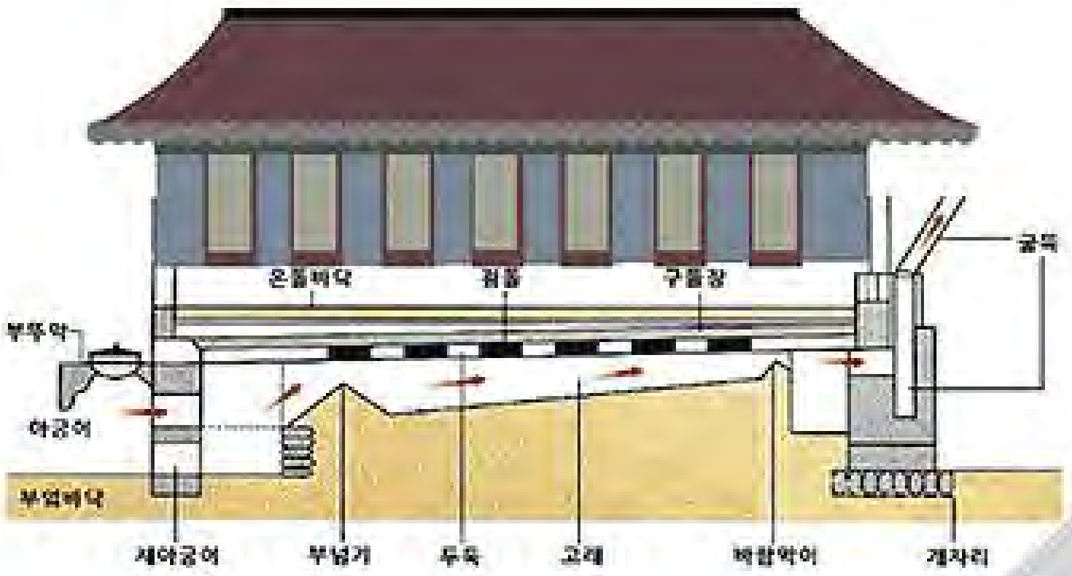
Ralph Hopkinson draw the attention on energy in architecture should translate into a true “**environmental aesthetic**”, in which a design method where human response to the environment could be **taken into account from the very start of project**.

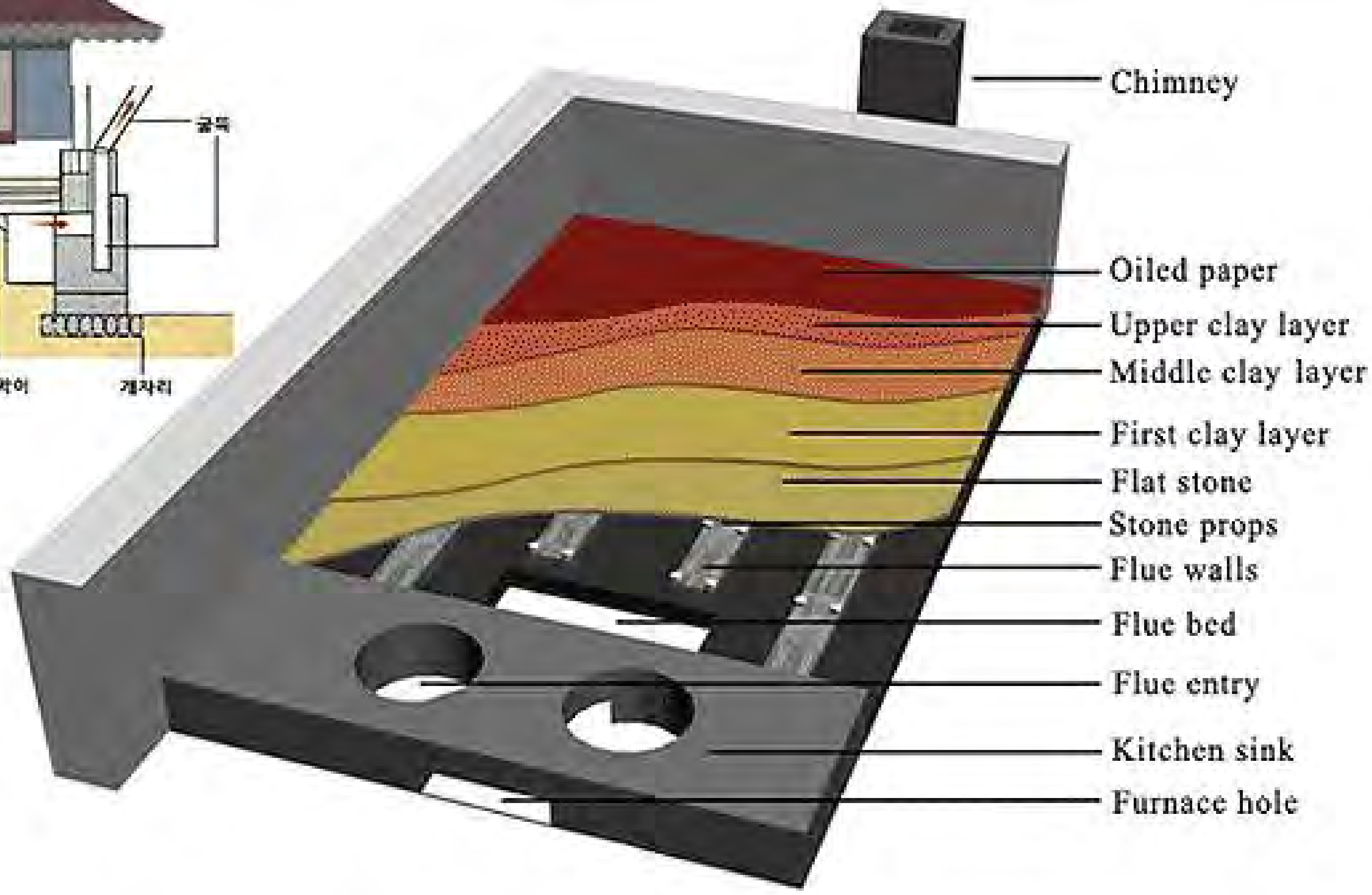
Vernacular Architecure

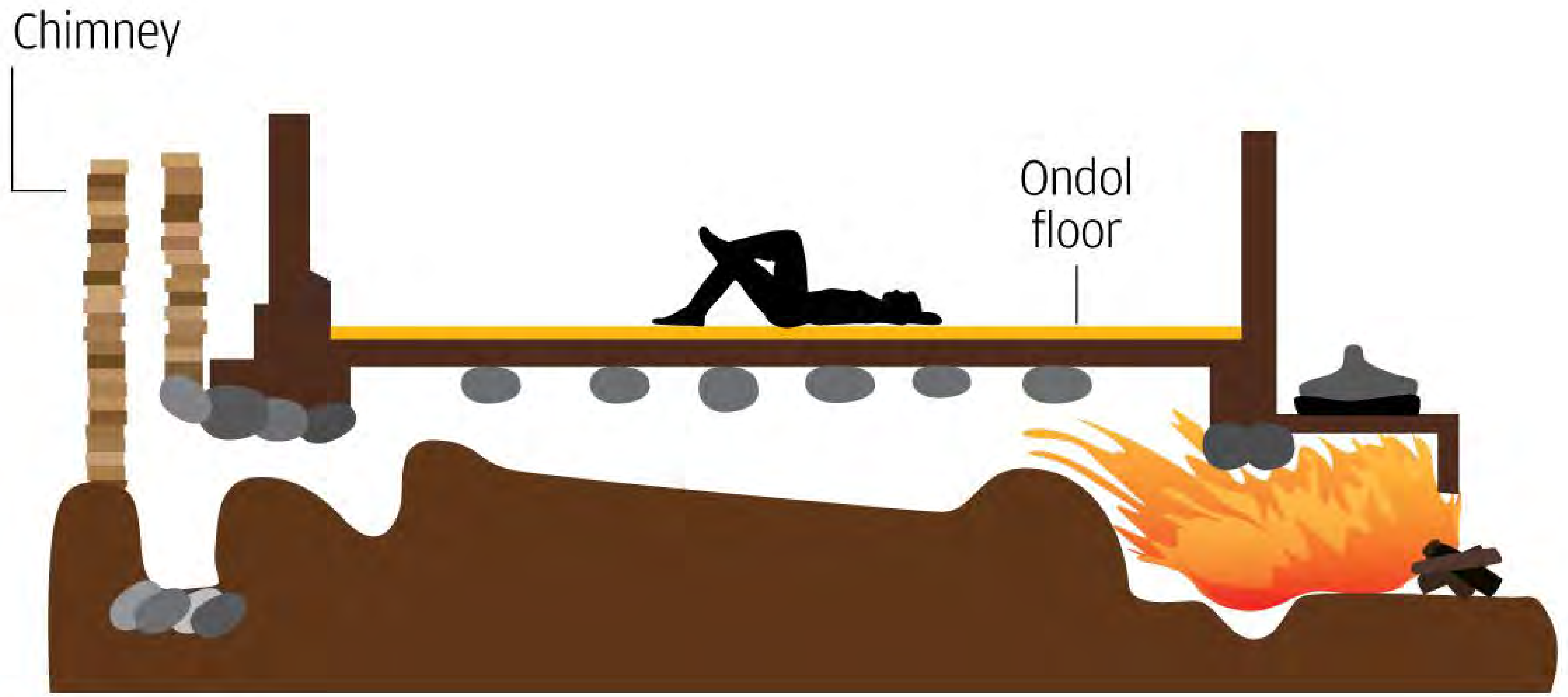
a. Chinese Kang- Bed Stove


Fire Wall
Bed
Stove
Smoke Passage

b. Korean Ondol



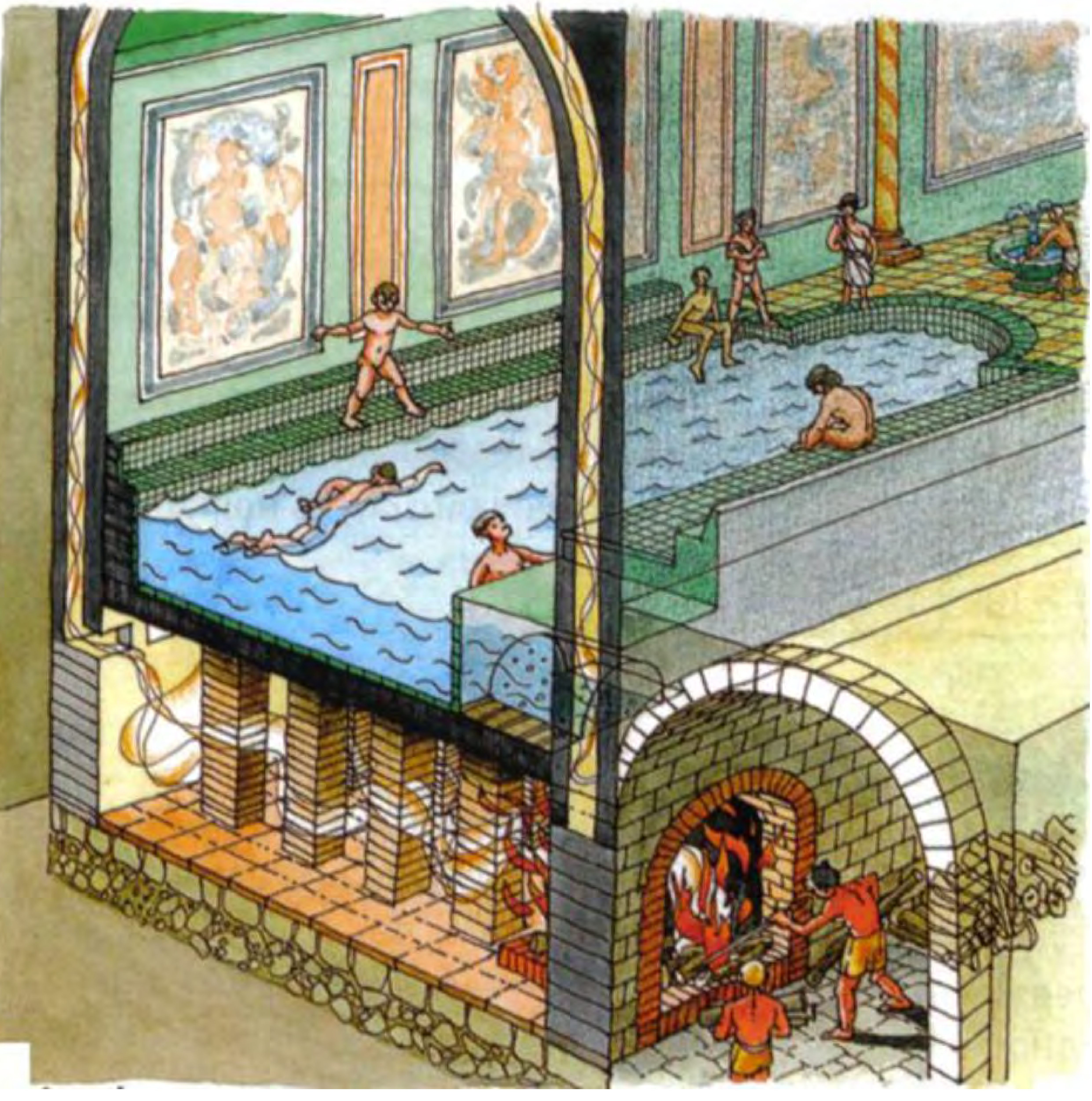


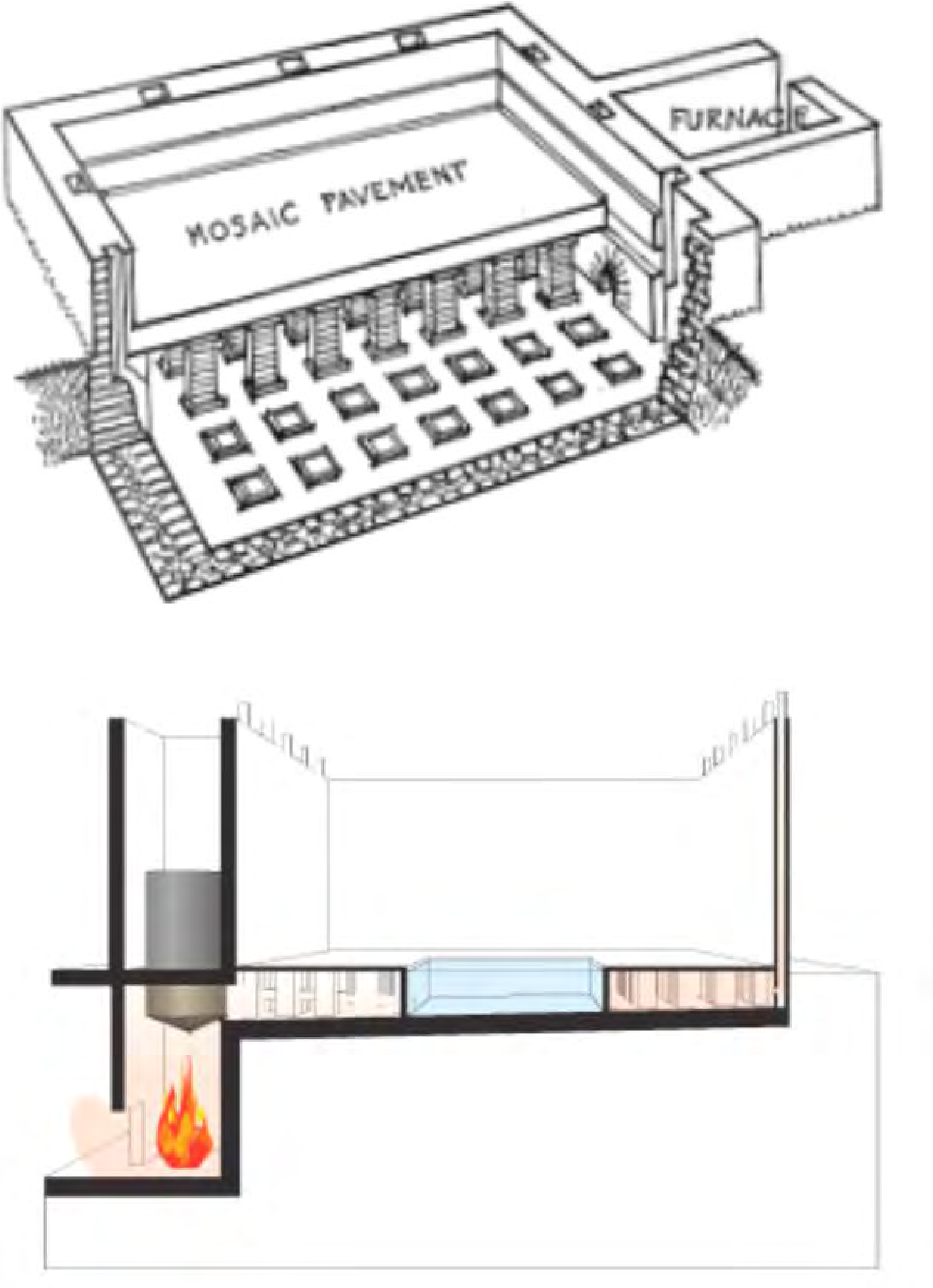


Source: Wikipedia SCMP

C. Roman hypocaust system

Ancient Roma Baths



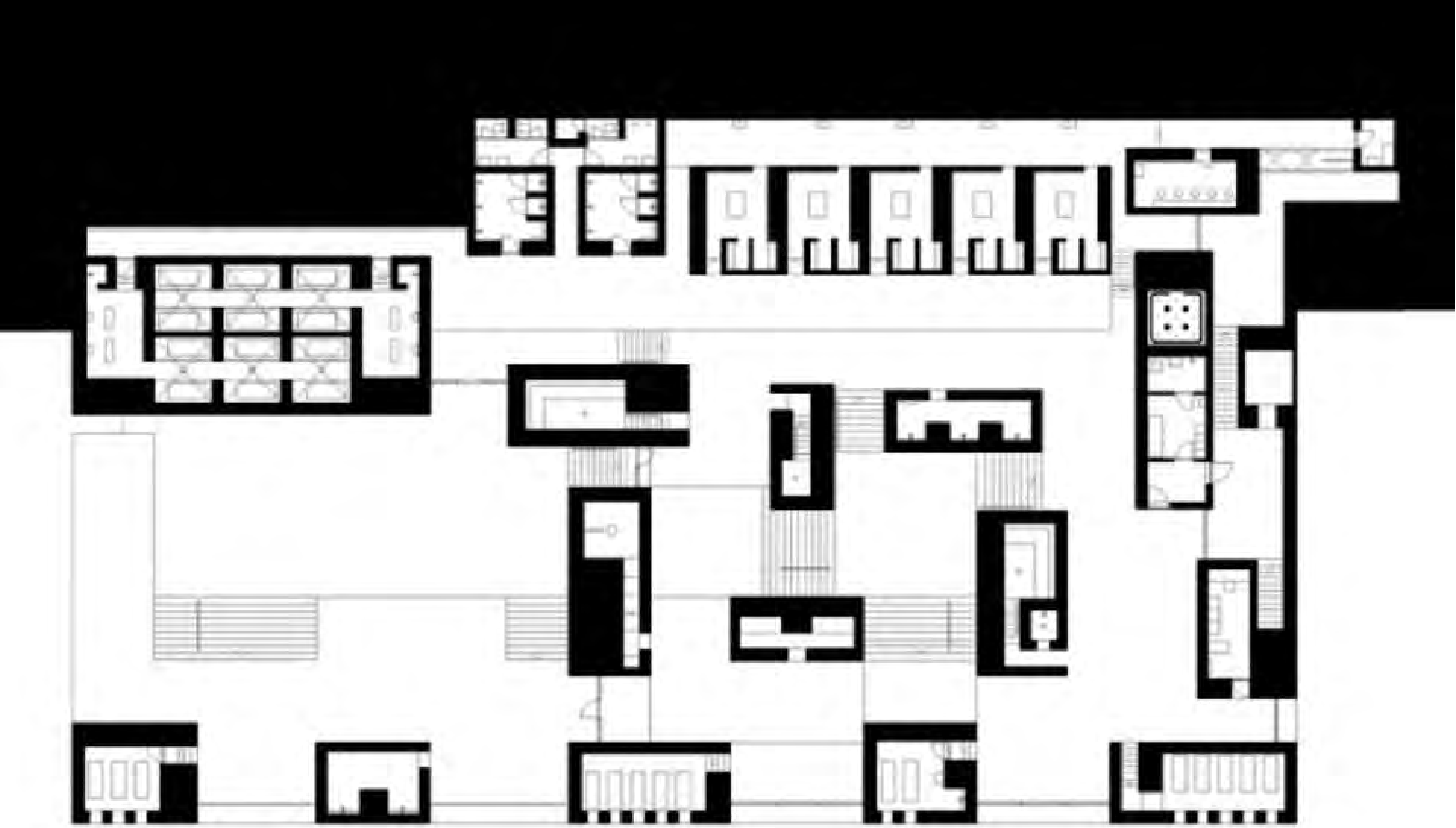


Roman Hypocaus system

SANAA
Zollverein School of management and design

Thermal Baths Vals, Switzerland， Peter Zumthors, 1996

“Mountain, stone, water – building in the stone, building with the stone, into the mountain, building out of the mountain, being inside the mountain – how can the implications and the sensuality of the association of these words be interpreted, architecturally?” Peter Zumthor

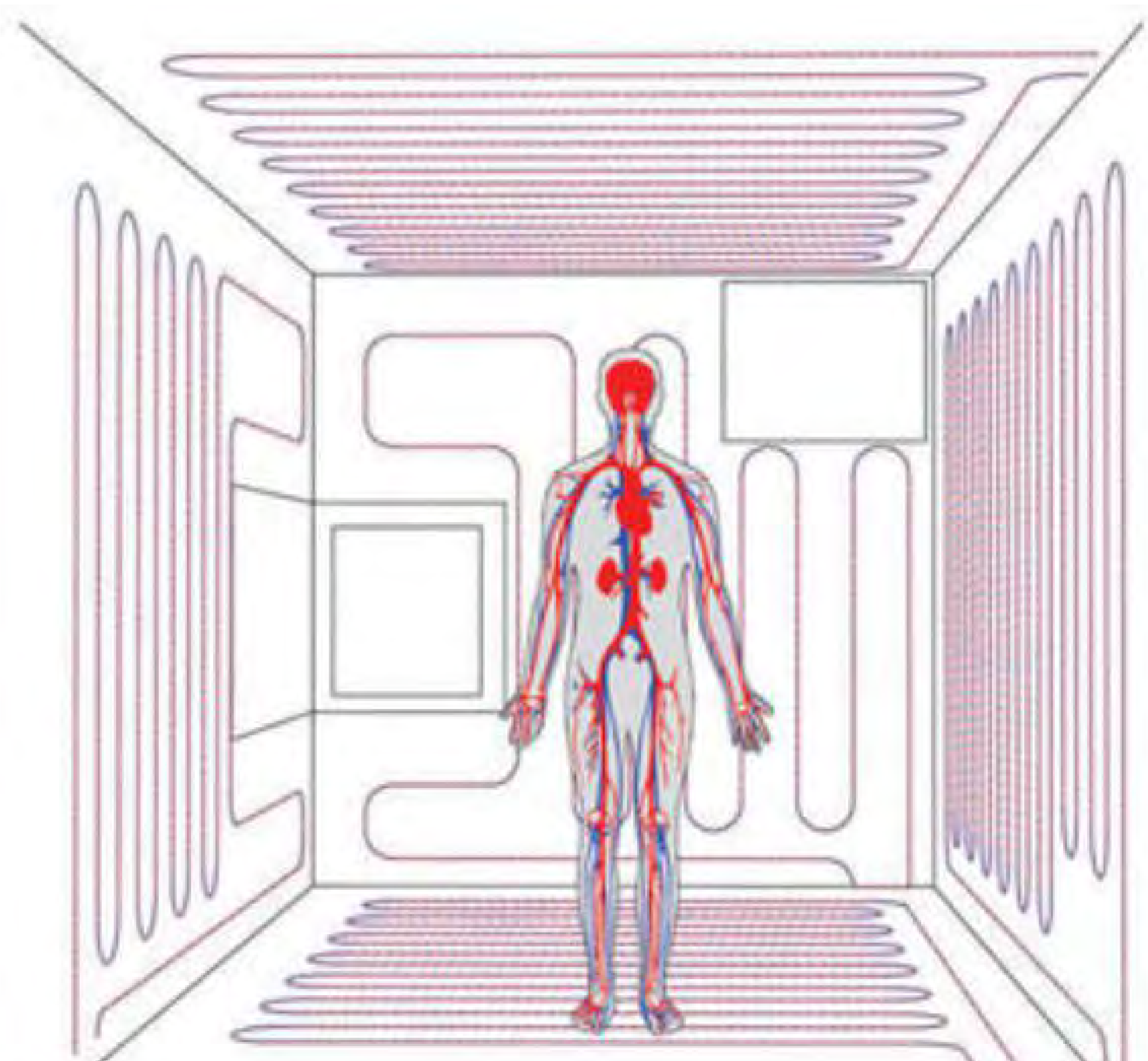
The structures usage of **massive concrete walls and pools of water** provide excellent usage of **thermally active materials** that can adequately control the buildings temperature and humidity levels.

Part 3:

Theory Basis of Architectural Thermodynamics

1. Physiology

Human body is a **hydronic, thermally active surface system**. Heat energy is transferred in and around a body through the hydronic circulatory system. The heart circulates heat through the blood back and forth between the core of the body to its skin, a thermally active surface.



Body- hydronic, thermally active surfaces system
- Kiel Moe

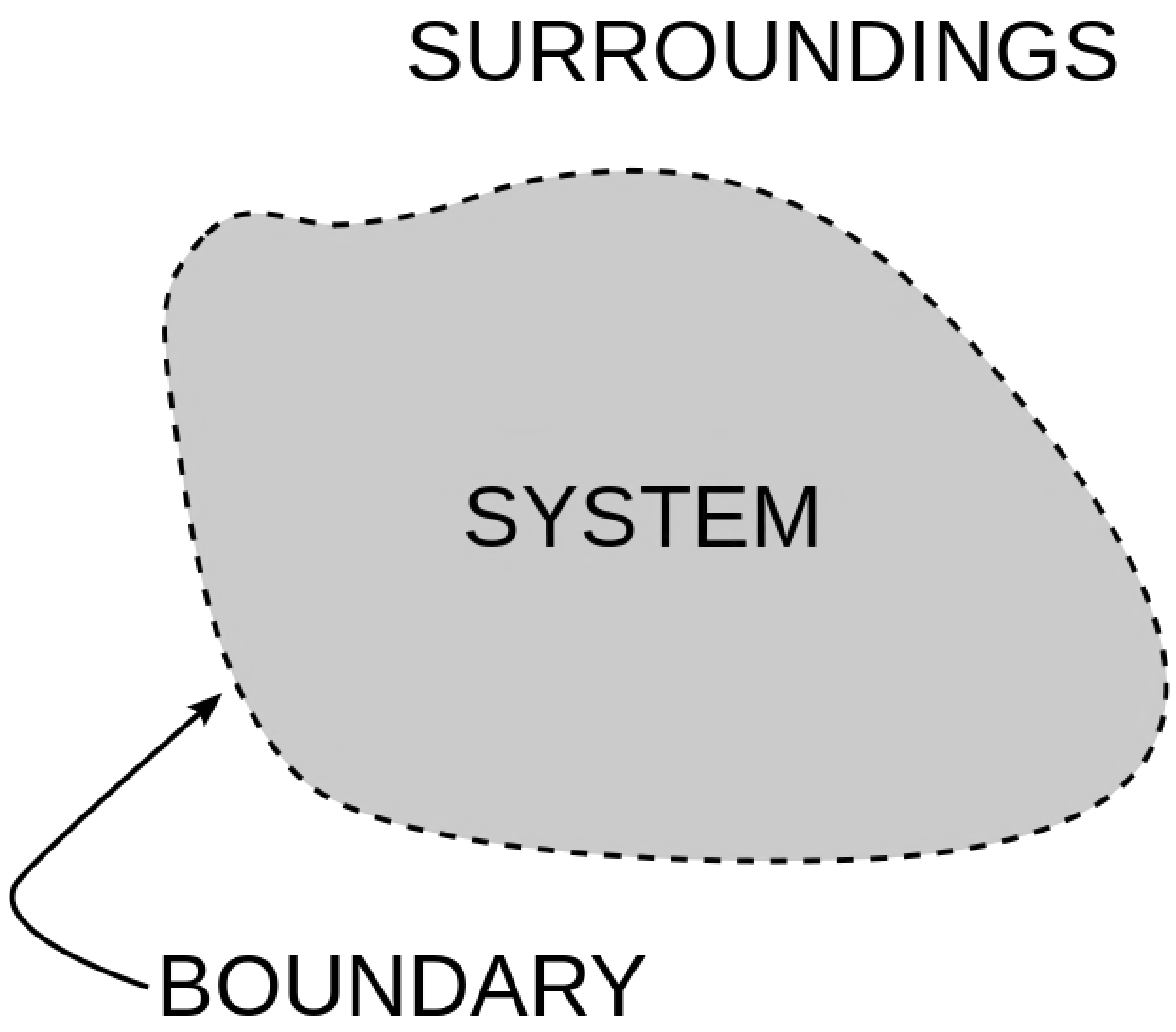
2. Non-equilibrium system

"Not only are these systems open," Ilya Prigogine and Isabella Stengers note, "but also **they exist only because they are open**. They feed on the flux of matter and energy coming to them from the outside world........"

The buildings are radically contingent, gradient-dependent, dissipative systems. Great amounts of energy and material is intaken and dissipated in the buildings, in order to constitute function of their construction, operation, use, and maintenance.

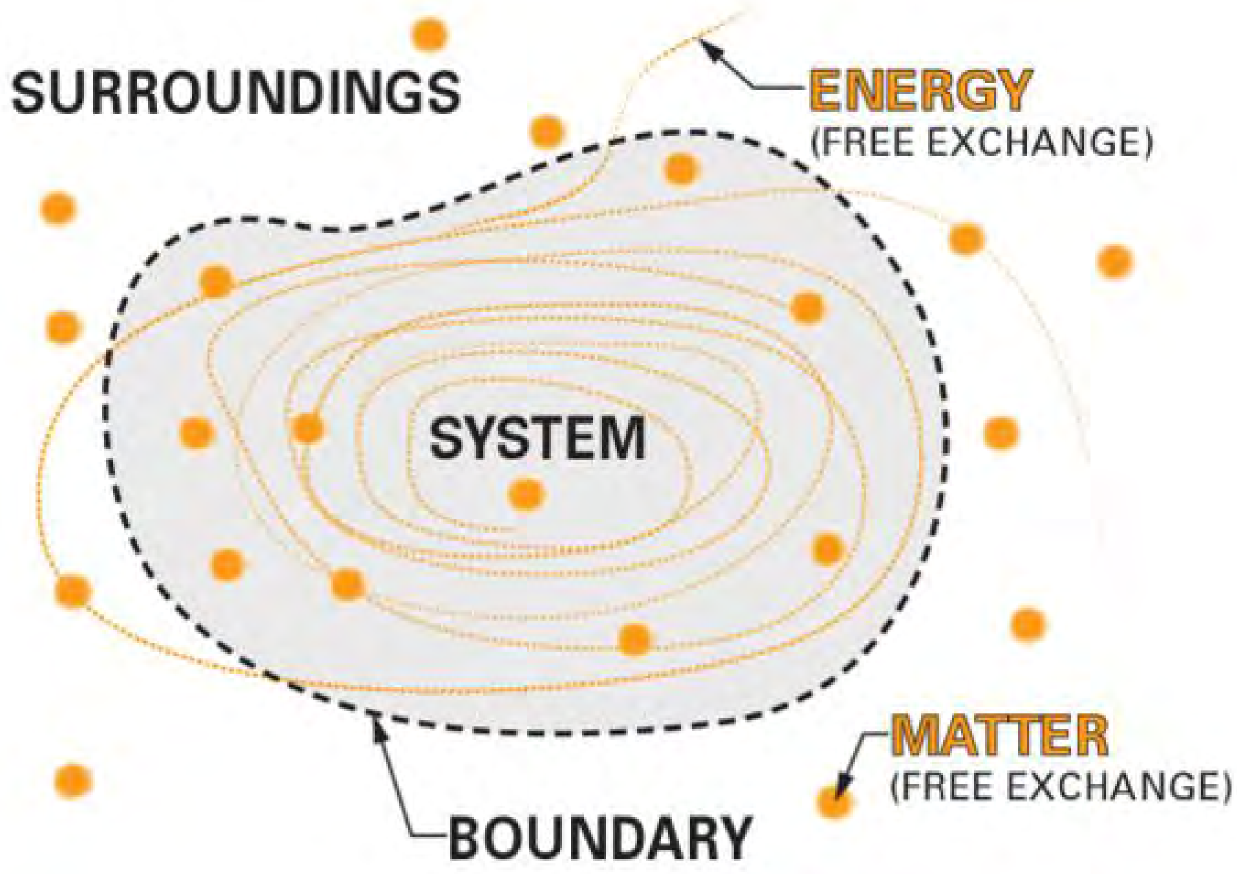
That means buildings are **open systems,** exchanging energy and material with their surroundings. With the theory study of non-equilibrium system, the buildings should be designed to find the **maximum of power** of these dissipative systems.

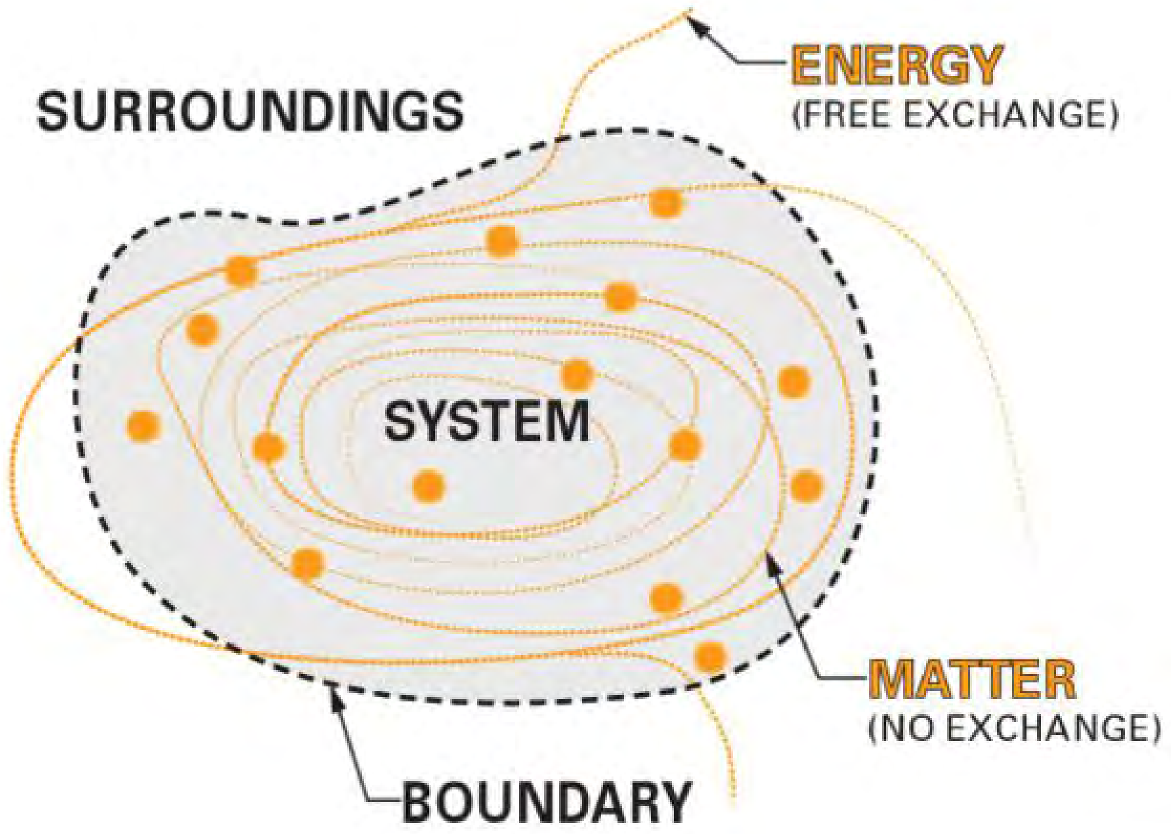
Thermodynamic System



A diagram of a generic thermodynamic system

An important concept in thermodynamics is the **thermodynamic system**, a precisely defined region of the universe under study. Everything in the universe except the system is known as the **surroundings.** A system is separated from the remainder of the universe by a boundary which may be notional or not, but which by convention delimits a finite volume. Exchanges of **work, heat, or matter** between the system and the surroundings take place across this boundary.



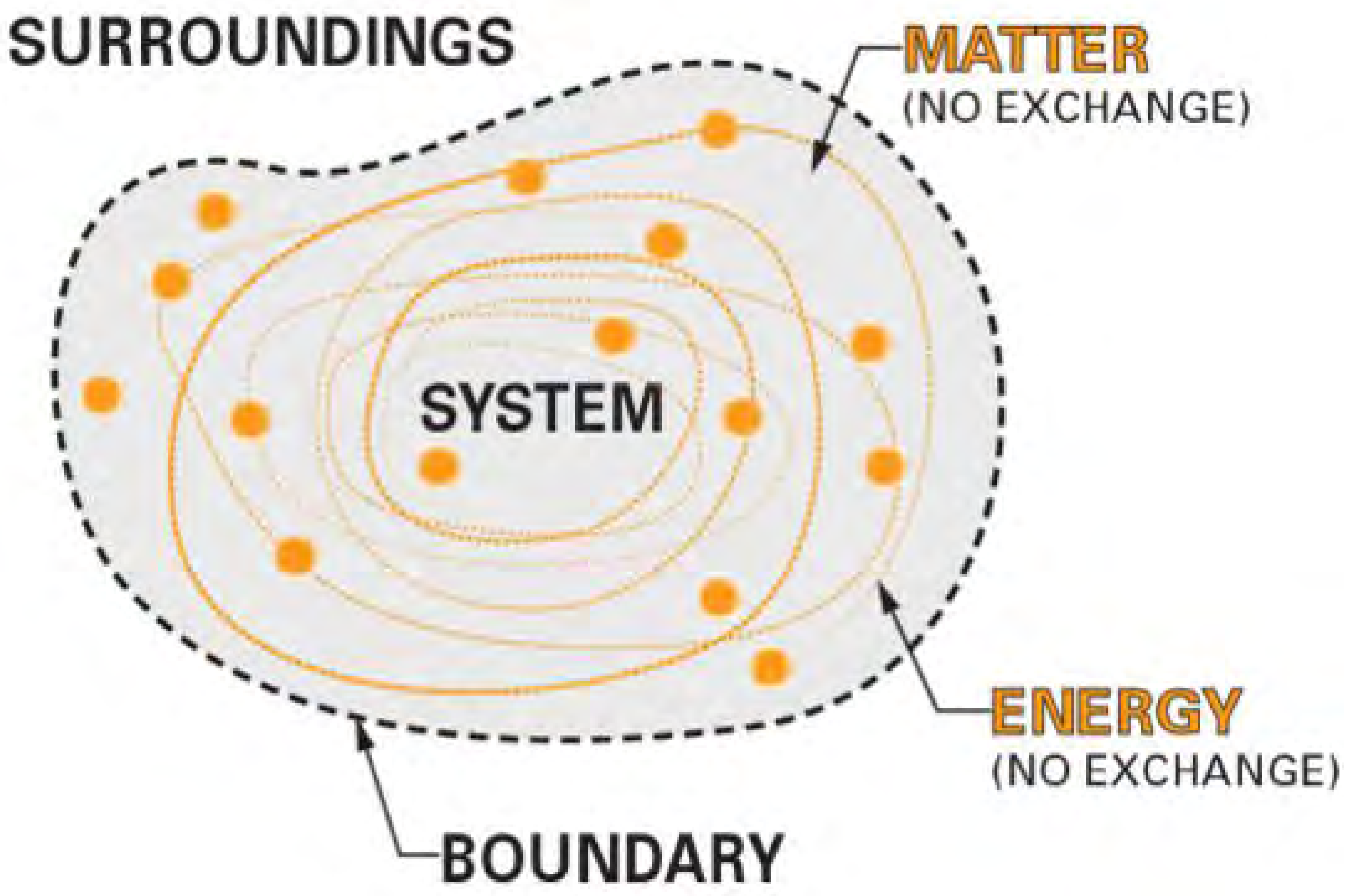


A. Open System:
exchange matter and energy

Current energy system design in architecture frequently suffers unconsidered or inadequate system boundary definition.

B. Closed system:
exchange energy, but not matter

greenhouse, exchange of energy is paramount ,can be considered a closed system for the stated boundary period, but only for that stated time period.



C. Isolated system

No exchange of energy and matter

All buildings and urbanization exist as non-isolated systems

Type of system	Mass Flow	Work	Heat
Open	√	√	√
Closed	×	√	√
Thermally Isolated	×	√	×
Mechanically Isolated	×	×	√
Isolated	×	×	×

Part 4:

Main Architects

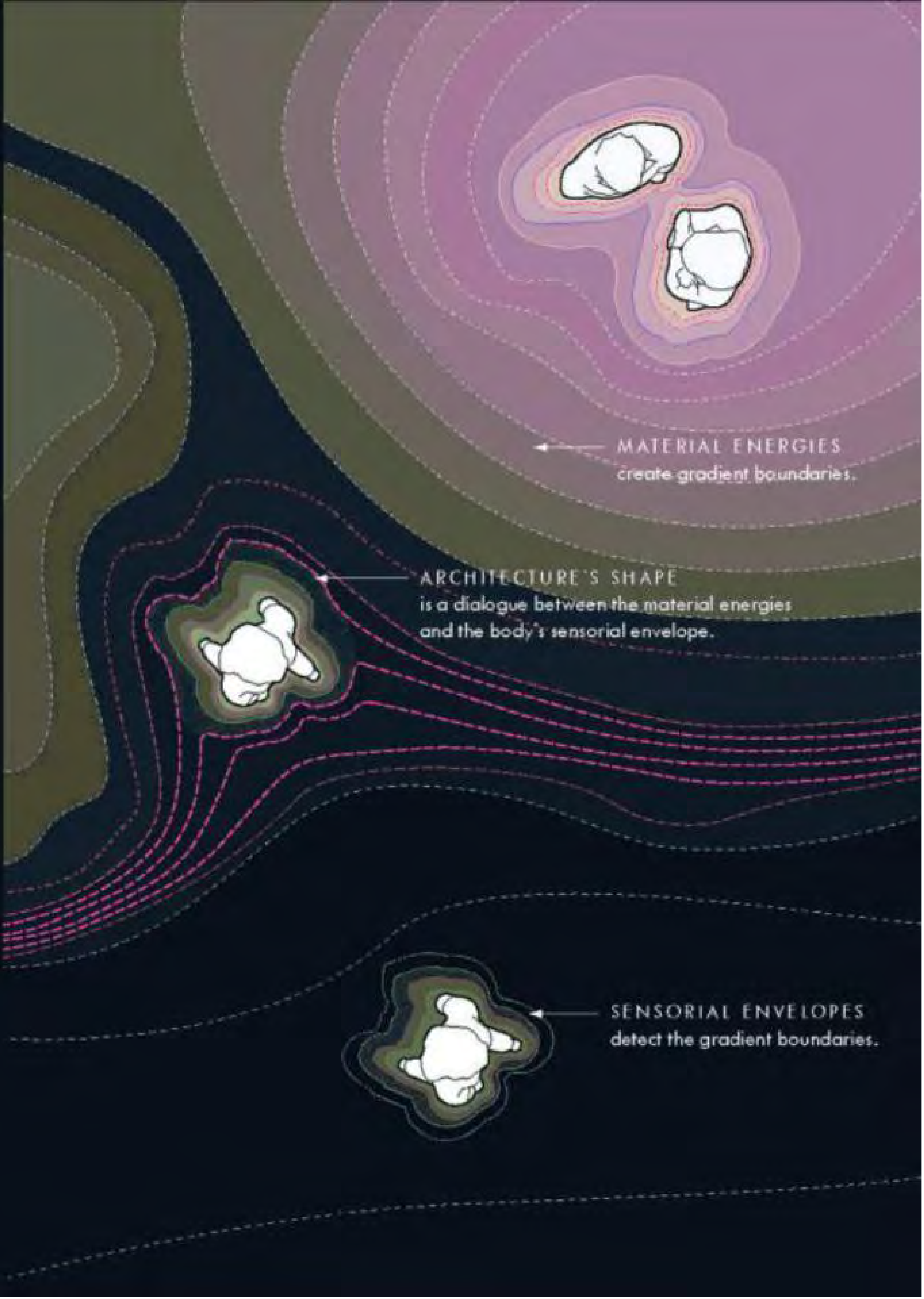
1. Boundary (Sean Lally)

"Gradient boundaries"

The climatic materials are surrounded by gradient boundaries, which are elastic and vairable as the climatic context changes and external forces interplay with the project.

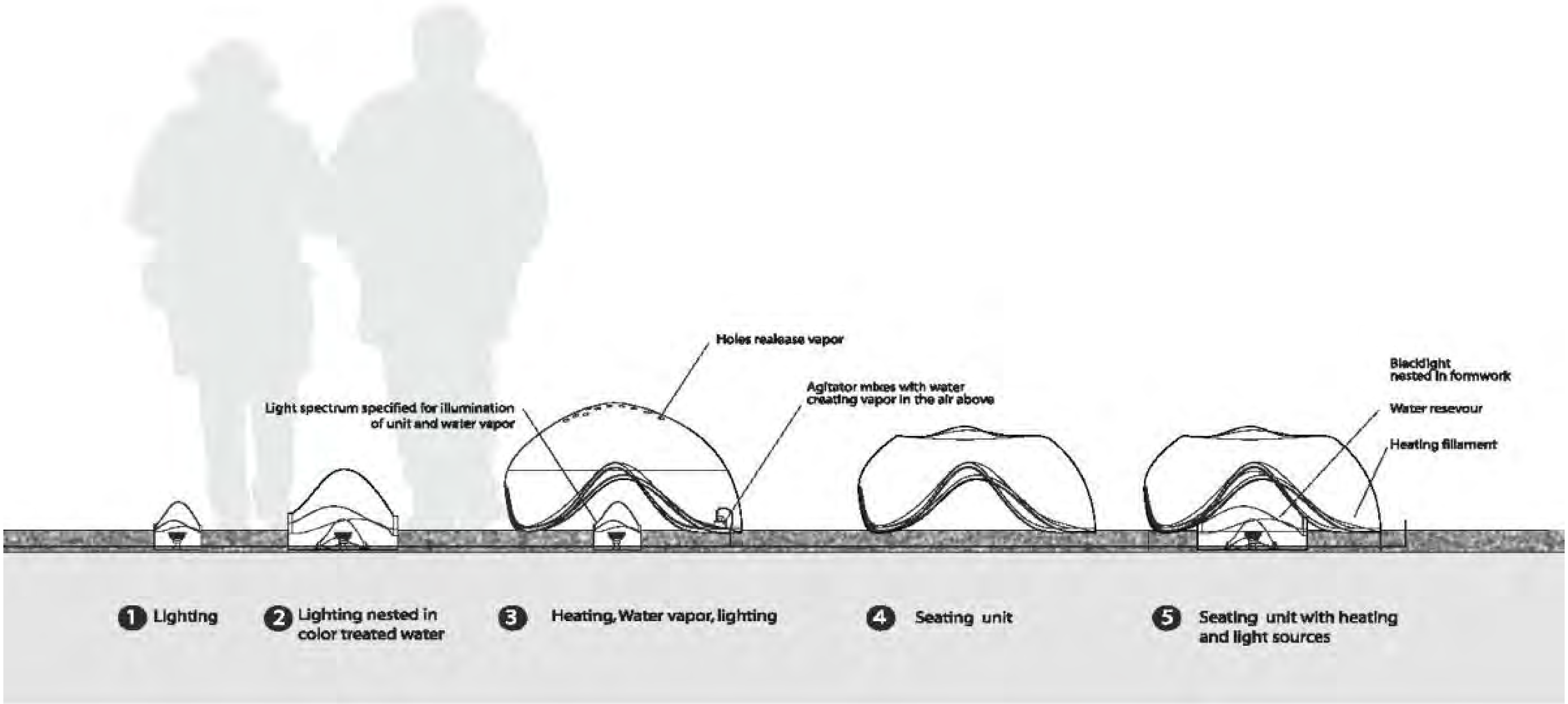
Through the application of "climatic materialities" and built of "gradient boundaries", **multiple zones** (micro-climates) are created to pull from the existing climatic context, creating distinct and definable edges, boundaries and transitions of these materials.

"Wall" and "geometry" are no longer the primary means of spatial organization, the spatial control of climatic material provides endlessly potential organizational opportunities.



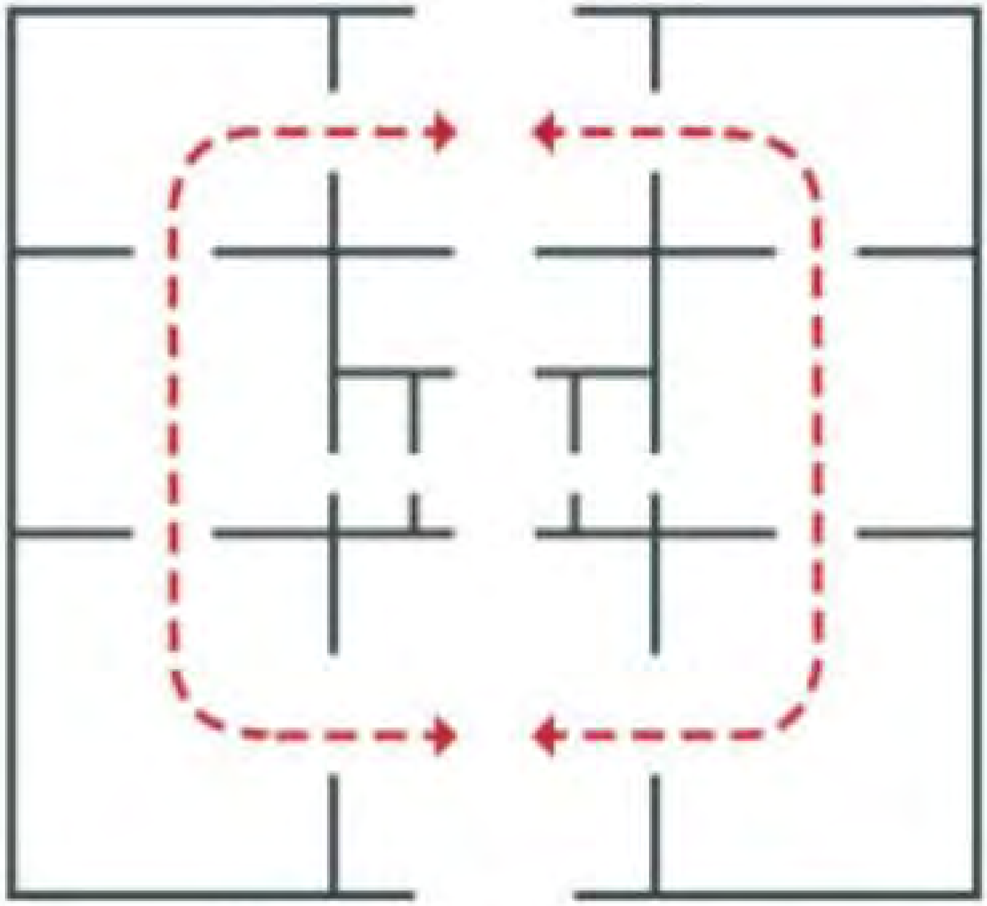
Material energies, create gradient boundaries.

Architecture's shape, is a dialogue between the material energies and the body's sensorial envelope. Sensorial envelopes, detect the gradient boundaries.

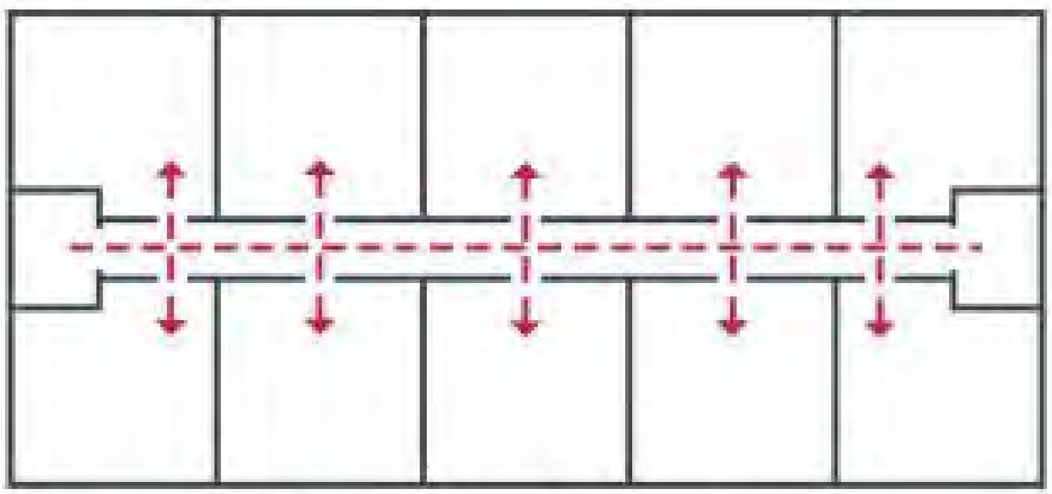


Sean Lally, Weathers, Wandering,2008-09

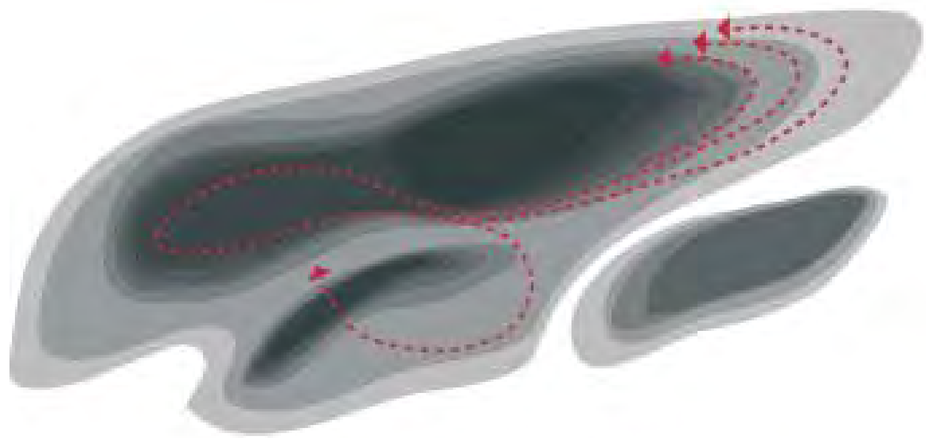
Sean Lally, Weathers, Wandering,2008-09



Necklace Circulation
(Walls & Surfaces)



Corridors and Destinations
(Walls & Surfaces)



Gradients of Intensities
(Material Energies)

Sean Lally, Gradient Spatial Typologies Diagram, 2008

In the article "Figures, doors and passages", Robin Evans reminds us that the strategies we use to divide space simultaneously play a role in how we as inhabitants are brought back together, and points to the implications this has on our spatial and social organisations.

Gradient Spatial Typologies is a look at how these material energies can offer opportunities for future organisation.

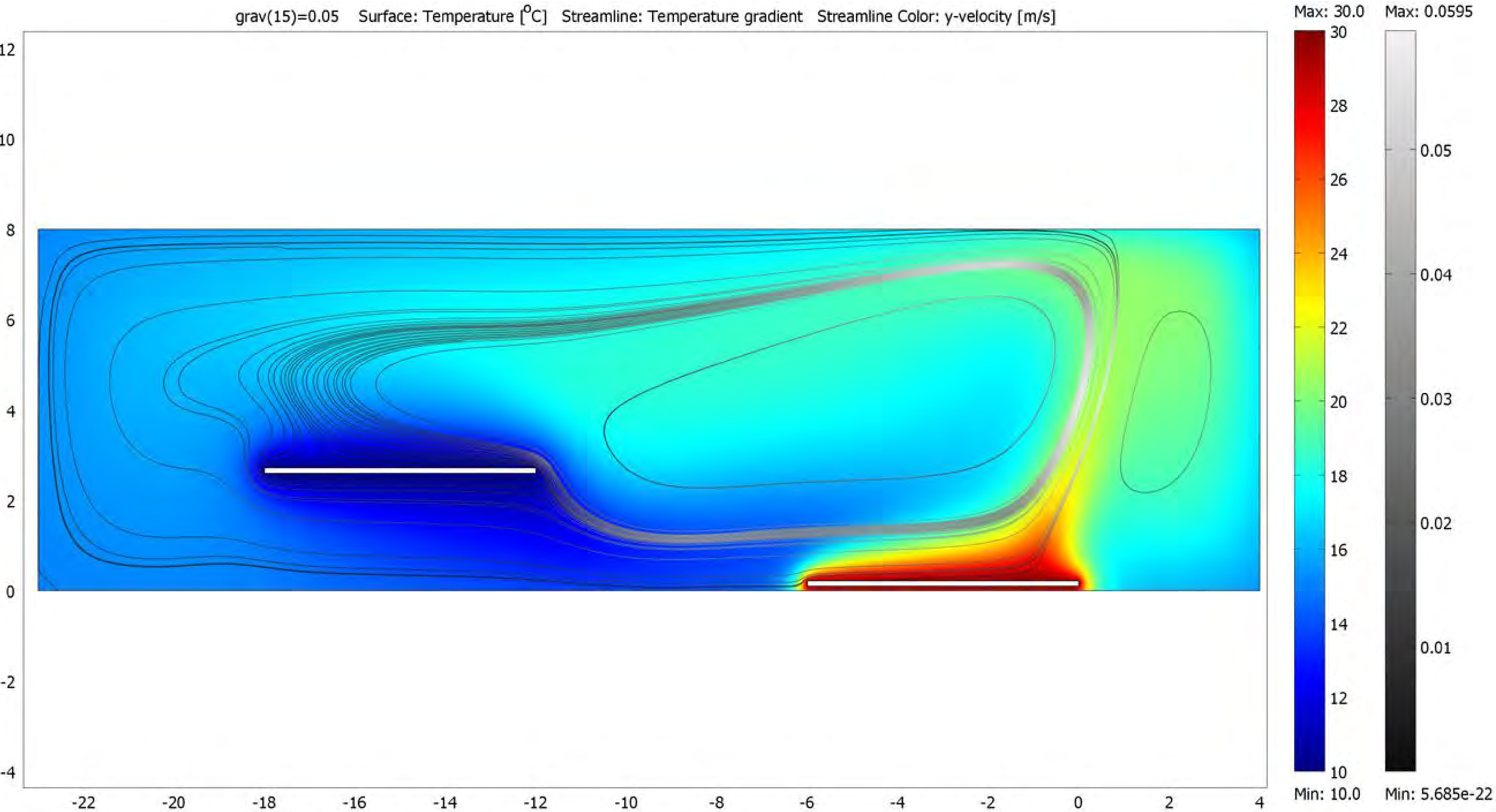
4. Meteorological architecture (Philippe Rahm)

Radiation / Conduction/ Convection / Pressure/ Evaporation / Digestion

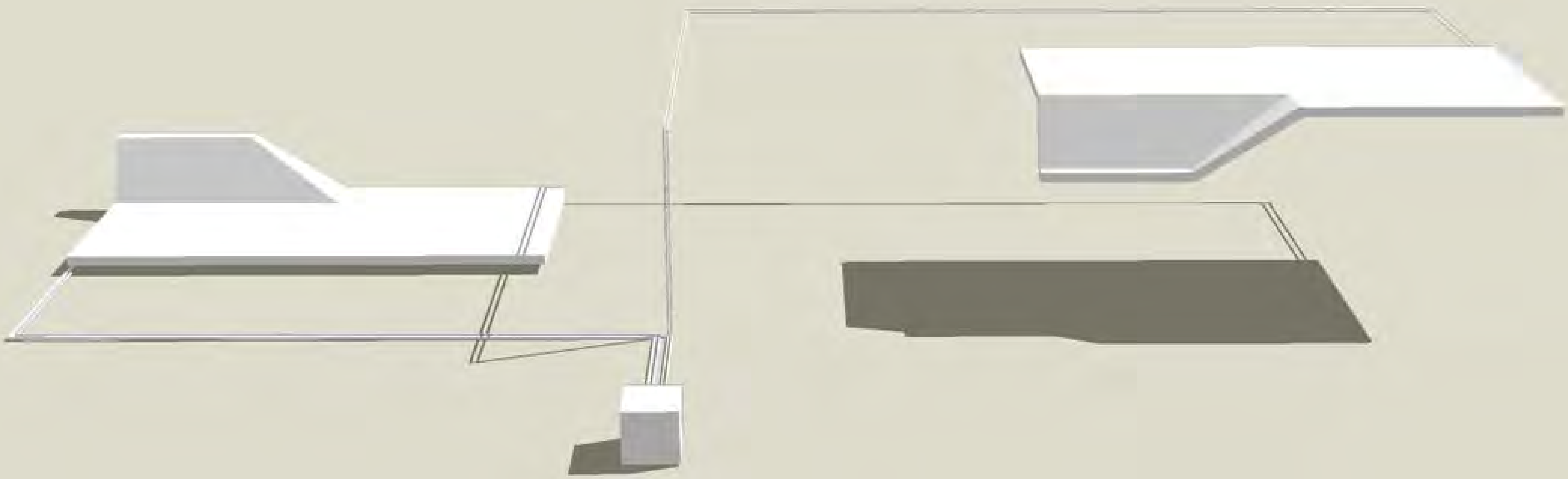
With the advancements in the fields of life sciences, molecular and genetic biology, the works of Philippe Rahm formulate new sorts of typologies within the realms of **meteorology and physics**, articulating the movements of air, the transformation of water into vapour, the rates of renewal of a mass of air, sound pressures, temperature and respiration, perspiration and metabolism, applying the creations **stemming from the search into new sorts of plan for the design process**. Most of Philippe's work can be classified into the following categories: **radiation, conduction, convection, pressure, evaporation and digestion**.

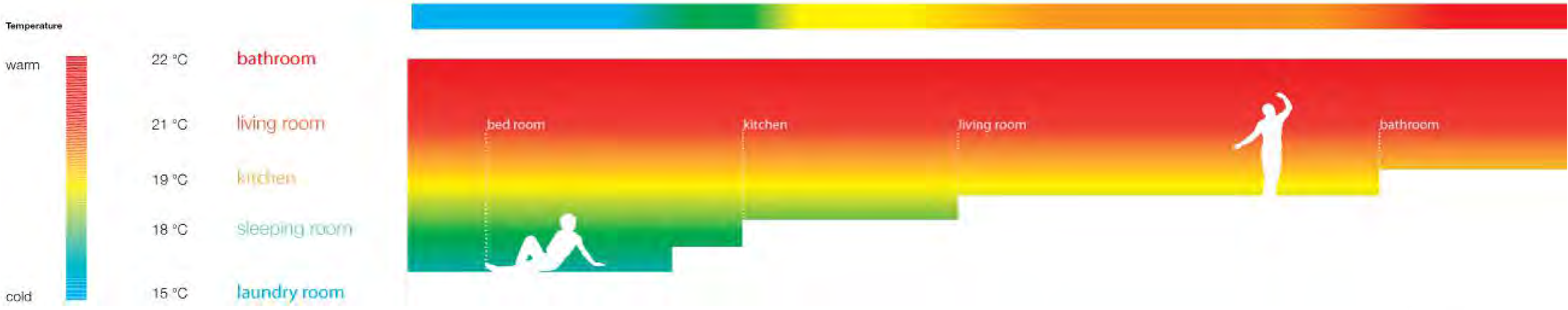
Out There: Architecture Beyond Building.
Philippe Rahm Architects. "Digestible Gulfstream"

A ‘Digestible Gulf Stream’ is the prototype for architecture that works between the **neurologic and the atmospheric**, developing like a landscape that is simultaneously gastronomic and thermal.

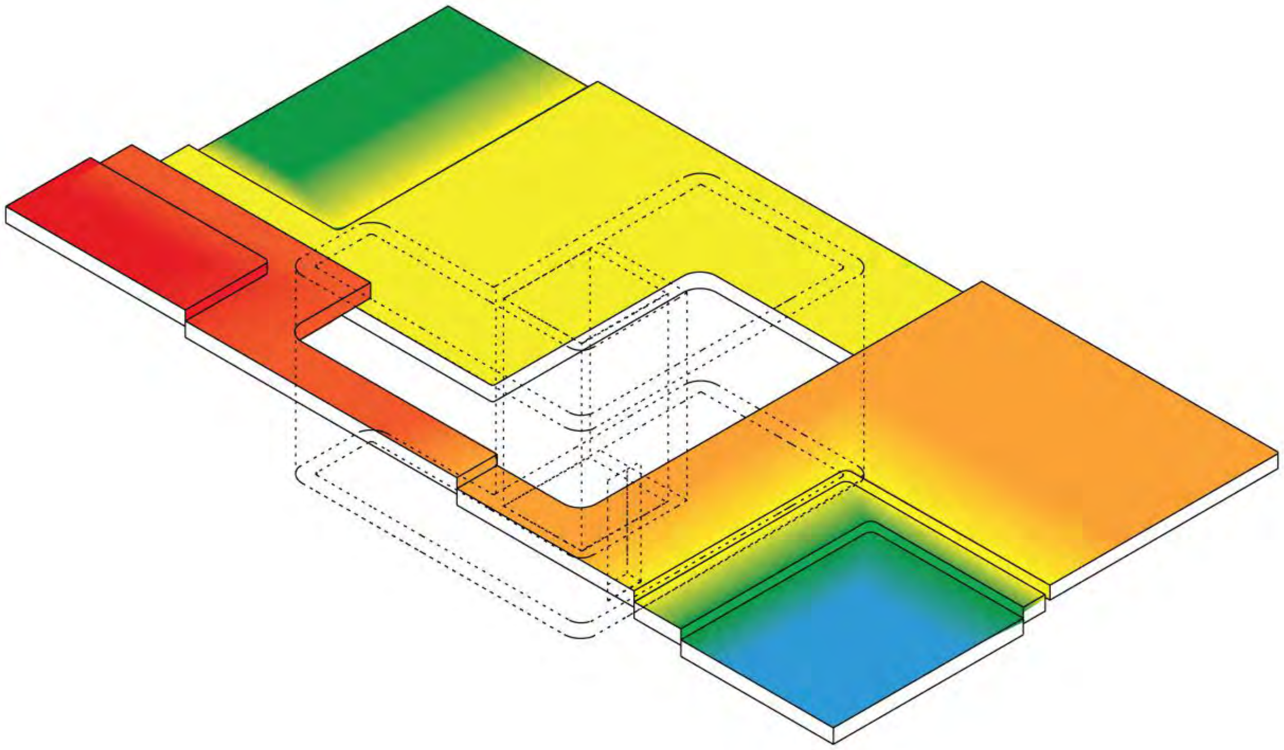


Here, two horizontal metal planes are extended at different heights. The lower plane is heated to **28°C**, the upper one is cooled to **12°C**. Like a miniature Gulf Stream, their position **creates a movement of air using the natural phenomenon of convection**,

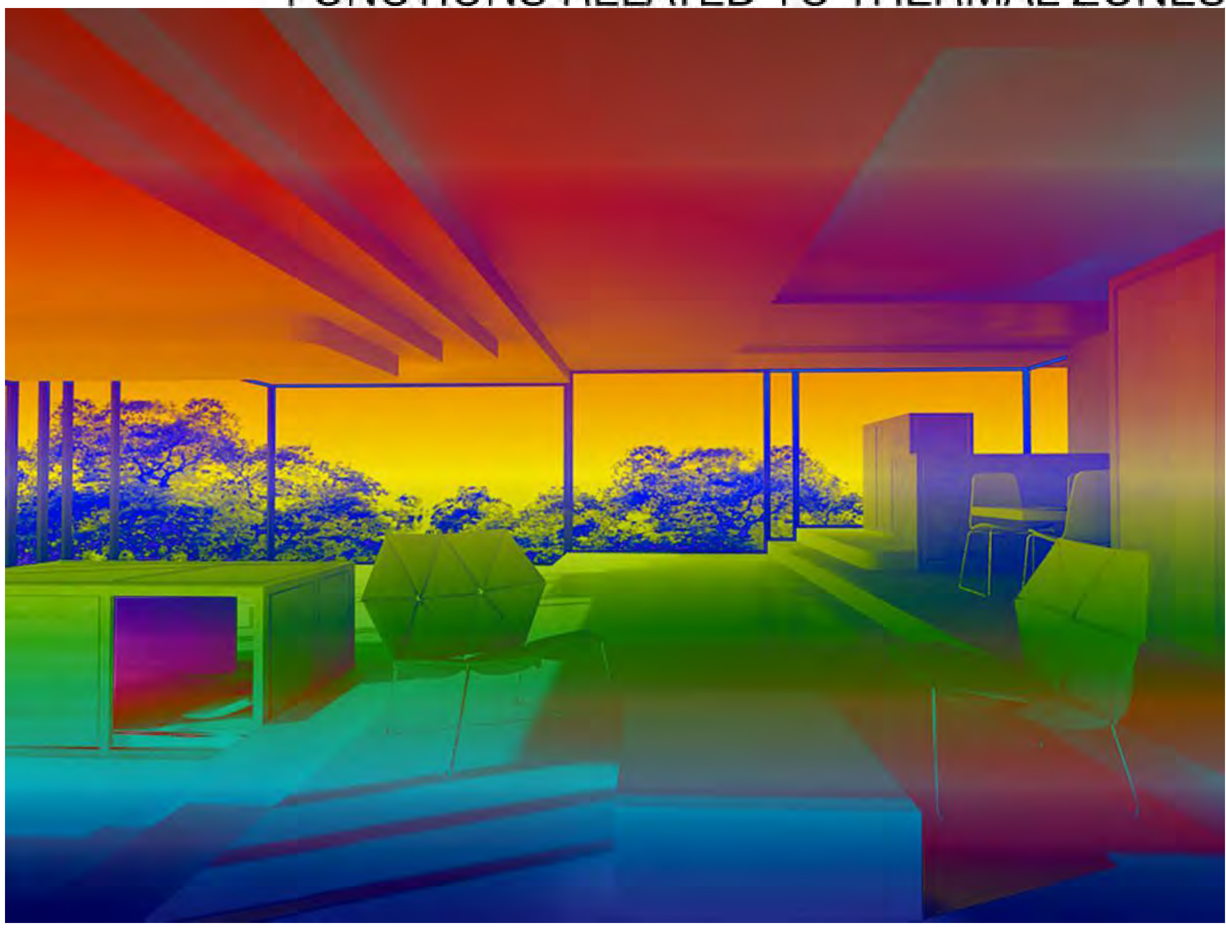




SECTION_APARTMENT
FUNCTIONS RELATED TO THERMAL ZONES



LANDSCAPE OF APARTMENT
RELATED TO THERMAL ZONES



Convection

Convection apartments, Hamburg,2010,a building as a convection shape

Radiation / Conduction/ Convection / Pressure/ Evaporation / Digestion

Most of Philippe's work can be classified into the following categories: **radiation, conduction, convection, pressure, evaporation and digestion**.

5. Materialism

As for the materials, architects traditionally define a physical boundary, relaying on the material found in and around the structures, or geometries and forms.

However, the “material energies” of **thermal variation, air velocity, light spectra and electricity** have the potential beyond merely produce moods or effects along a surface. “Material energies” is a way to **deploy them as building materials in and of themselves**, rather than release from dependence on surfaces and services.

Blur Building, Diller Scofidio + Renfro
Temporary media pavilion built for the 2002 Swiss Expo, Switzerland

"31,400 needlepoint jets emitted tiny droplets to form a ghostly and magical **mist** that enveloped vistiors in an artificial cloud hovering above a lake."

"inhabit that fuzzy grey zone that exists between architecture and art, between **creating 'real' buildings and designing experiences** that illuminate the meaning of architecture.

A smart weather system reads the **shifting climatic conditions** of temperature, humidity, wind speed and direction and regulateds water pressure at a vaiety of zones.

Break:

Discuss about

"Architectural Thermodynamics"

what is real? what is unreal?

Part 5: Case Study

a. Design Structure (PPT-2)

b. Case study with the software

(Ladybug+Honeybee/ Octopus)

Part 6:
Grasshopper components

Honeybee+Ladybug

Download:
http://www.food4rhino.com/project/ladybug-honeybee?etx

Installation instruction:
https://github.com/mostaphaRoudsari/ladybug/blob/master/resources/Installation_Instructions.md (step by step)

Instruction:
http://www.grasshopper3d.com/group/ladybug
https://www.youtube.com/watch?v=ubkHdERn8a8

Examples:
https://hydrashare.github.io/hydra/index.html?keywords=LBExampleFiles
https://hydrashare.github.io/hydra/index.html?keywords=HBExampleFiles

Honeybee+Ladybug(instruction)

Here are four separate playlist:

Ladybug: Introduction and Weather Data Analysis
https://www.youtube.com/playlist?list=PLruLh1AdY-Sj_XGz3kzHUoWmpWDXNep1O

Ladybug: Comfort tools
https://www.youtube.com/playlist?list=PLruLh1AdY-Sho45_D4BV1HKcIz7oVmZ8v

Honeybee: Energy Analysis
https://www.youtube.com/playlist?list=PLruLh1AdY-SgW4uDtNSMLeiUmA8YXEHT_

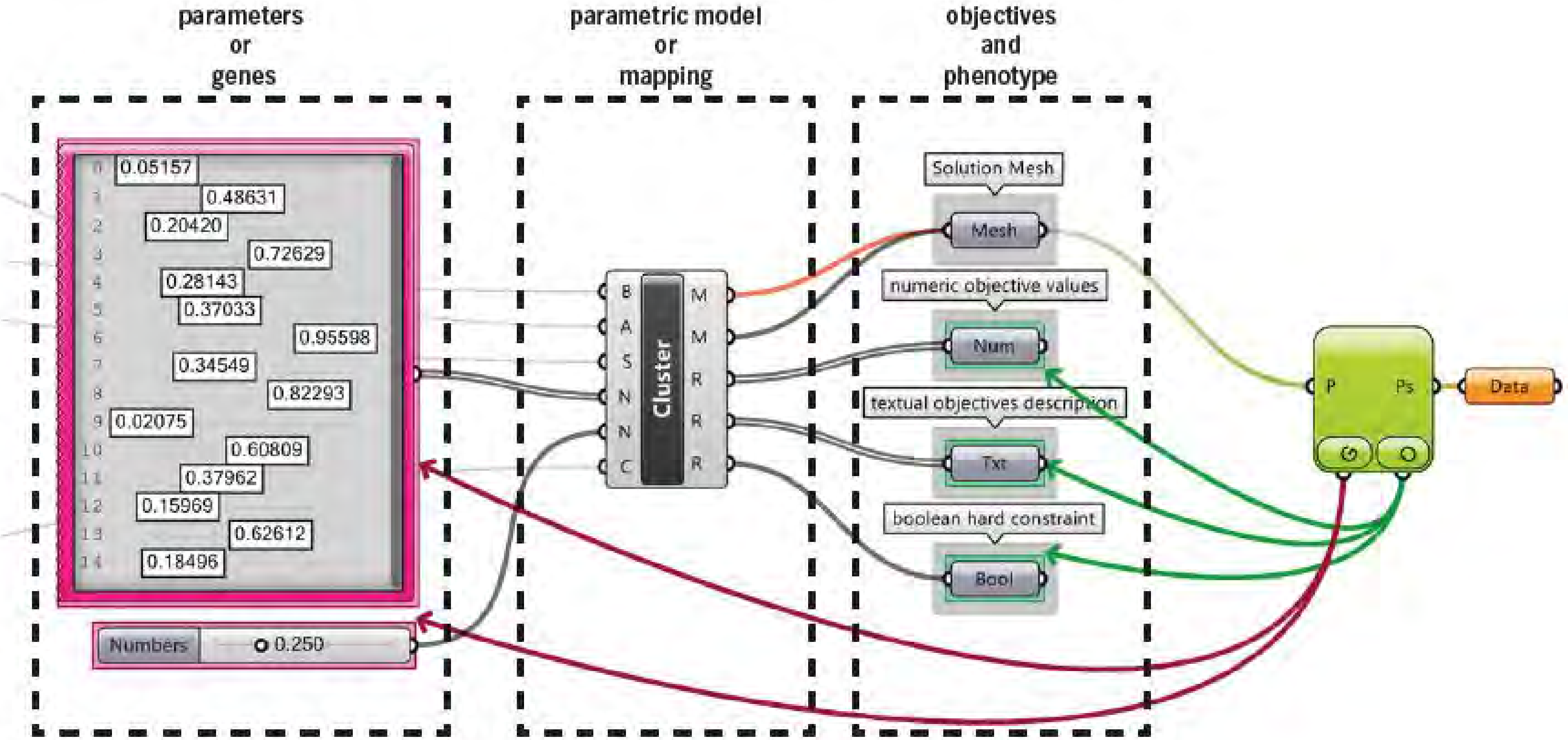
Honeybee: Daylighting
https://www.youtube.com/playlist?list=PLkjfDmSc5OryXkWSt57ltJFU4qXD5ss1v

Octopus

- download:
  http://www.food4rhino.com/project/octopus?etx

- instruction: within the install files

- examples:
  http://www.grasshopper3d.com/group/octopus/page/octopus-examples



parameters
or
genes
parametric model
or
mapping
objectives
and
phenotype
0.05157
0.48631
0.20420
0.72629
0.28143
0.37033
0.95598
0.34549
0.82293
0.02075
0.60809
0.37962
0.15969
0.62612
0.18496
Numbers
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Cluster
Solution Mesh
Mesh
numeric objective values
Num
textual objectives description
Txt
boolean hard constraint
Bool
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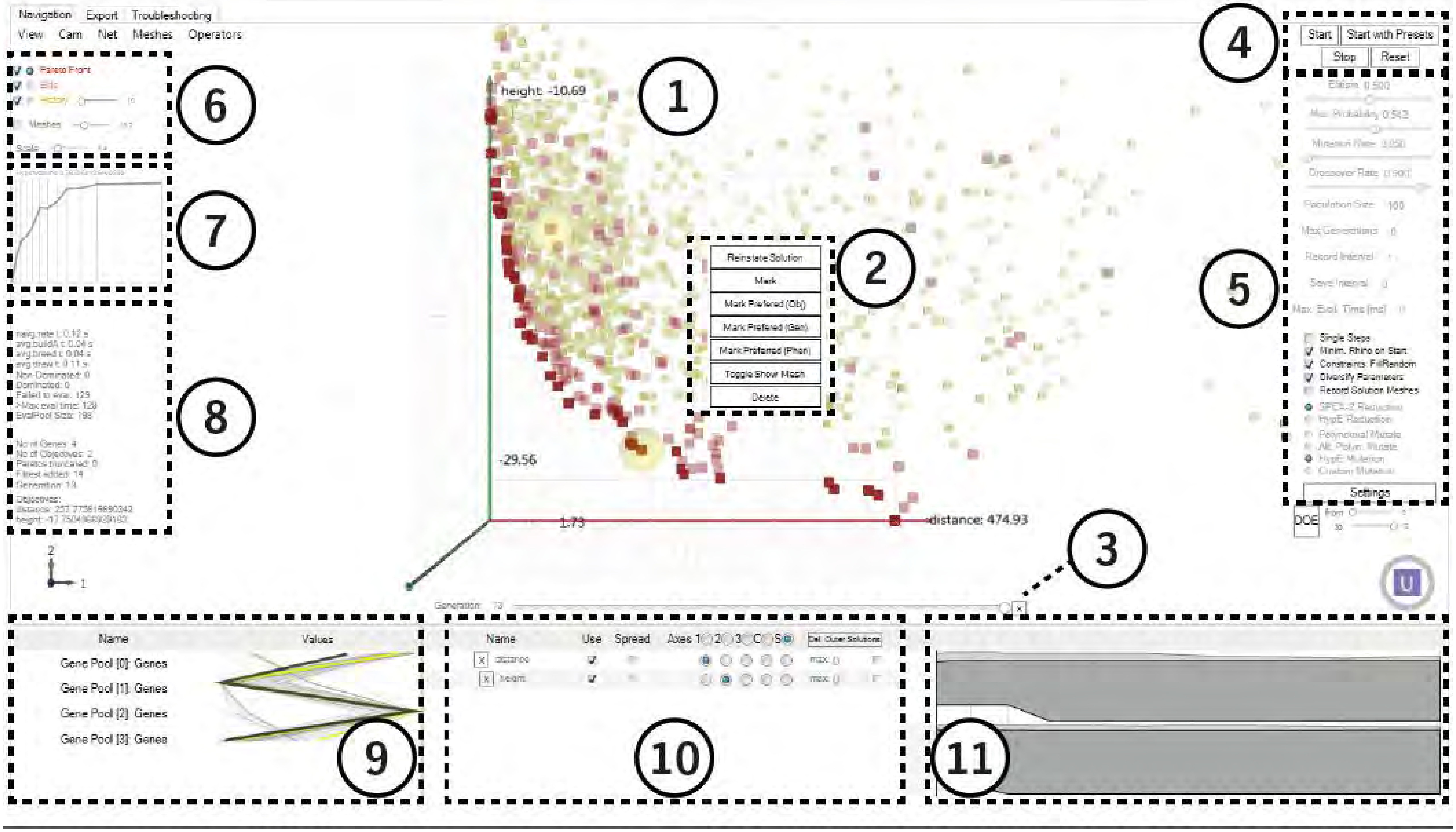

Navigation
Export
Troubleshooting
View
Cam
Net
Meshes
Operators
height: -10.69
-29.56
1.73
distance: 474.93
Reinstate Solution
Mark
Mark Prefered (Obj)
Mark Prefered (Gen)
Mark Prefered (Phen)
Toggle Show Mesh
Delete
Start
Start with Presets
Stop
Reset
Single Steps
Minim. Rhino on Start
Constraints: FillRandom
Diversify Parameters
Record Solution Meshes
Settings
DOE
Name
Values
Gene Pool [0]: Genes
Gene Pool [1]: Genes
Gene Pool [2]: Genes
Gene Pool [3]: Genes
Use
Spread
Axes 1
Del. Outer Solutions
1
2
3
4
5
6
7
8
9
10
11

Part 7
Workshop

Design subject: Atrium

(1) Size: 24*24*15(height)

(2) Location: Harbin, China

(3) Variables: Shape, Skylight,Facades

(4) Target: Optimized Daylighting Distribution / Energy Saving for daylighting

Furthur communication

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