ARK-E3020 Sustainable Design Principles

# Computational Cycle: Performative Form

**Toni Kotnik**

**Professor of Design of Structures**



1

## Rethinking Waste


hut made of mammoth bones
Mezhirich, Ukraine, around 15´000 BC

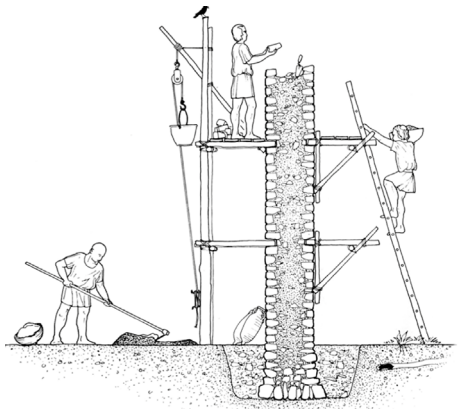


2

## Rethinking Waste & Regionality

*"Luxury stone represented only a small proportion of a building's actual bulk. … Almost all the rest, the structural bulk, was built using materials and techniques that carefully minimized transport costs whilst still ensuring structural strength. … 76% of the volume was composed of materials quarried within 20 km of the site."*

Barnabas Calder & G. A. Bremner
Buildings and energy: architectural history in the climate emergency
The Journal of Architecture, 26:2 (2021), 79-115




Roman concrete with brick facing
Palatine Hill, Rome



3

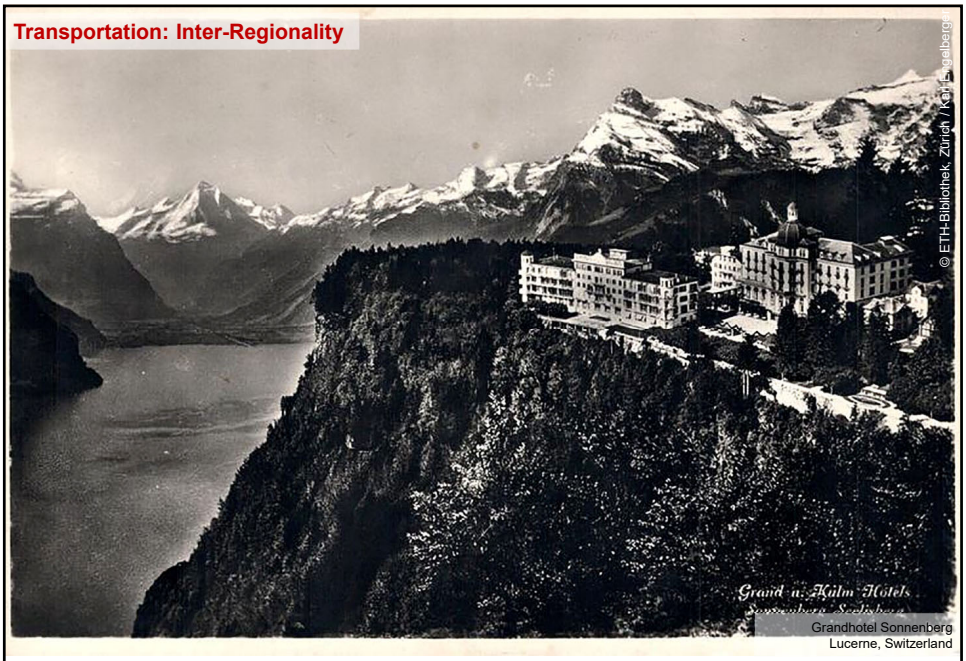
## Abundance of Material


steam locomotive as one driver
of the Industrial Revolution



4

## Transportation: Inter-Regionality



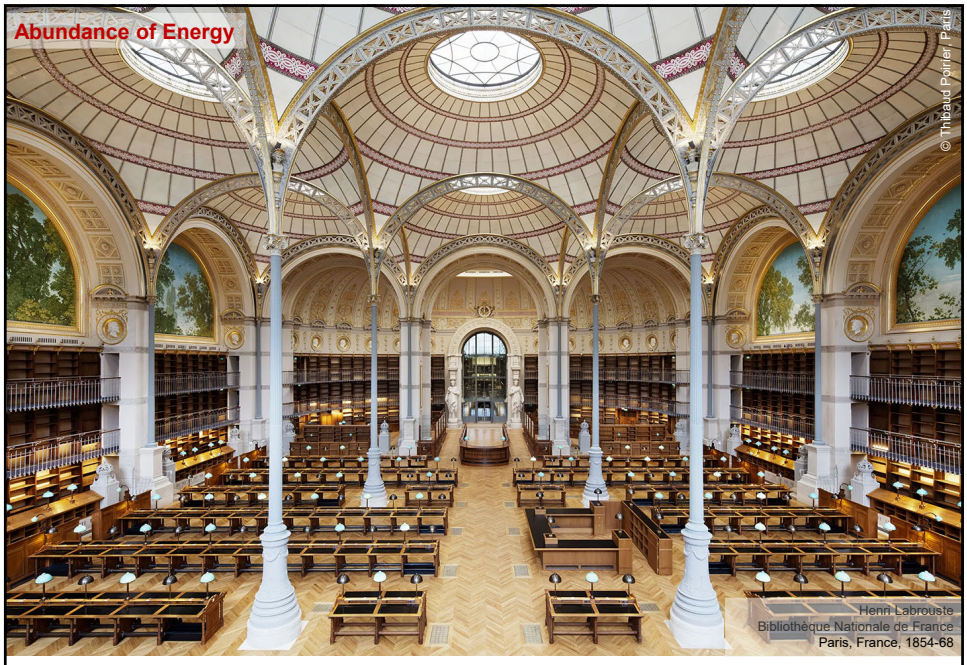



Grandhotel Sonnenberg
Lucerne, Switzerland



5

## Abundance of Energy





Henri Labrouste
Bibliothèque Nationale de France
Paris, France, 1854-68



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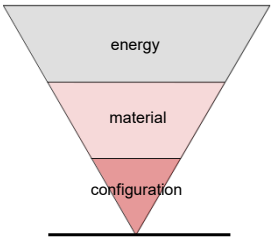
**Abundance of Energy**
**Abundance of Material**
**Transportation**

**Contemporary Design Thinking**




**Regionality**
local conditions

**unstable**



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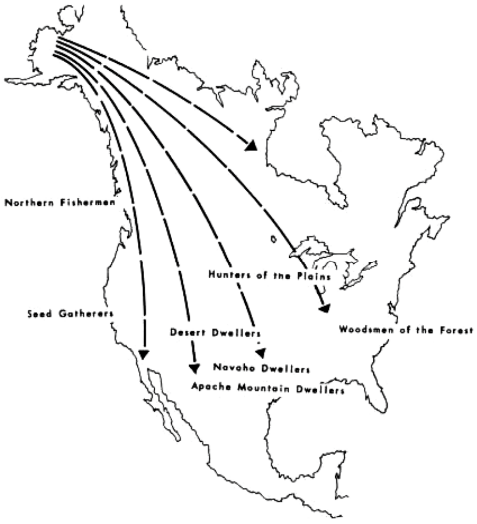
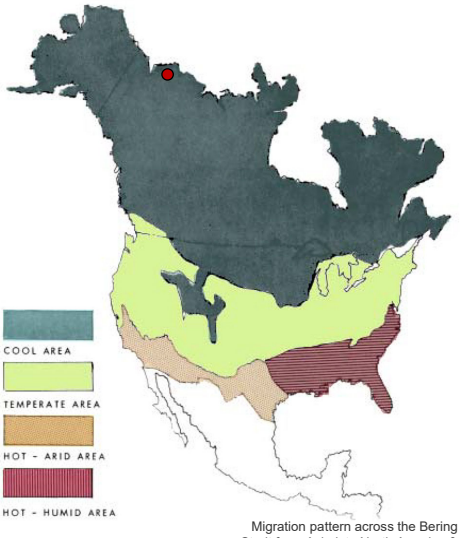
**Native Americans**




Migration pattern across the Bering Strait from Asia into North America & regional climate zones



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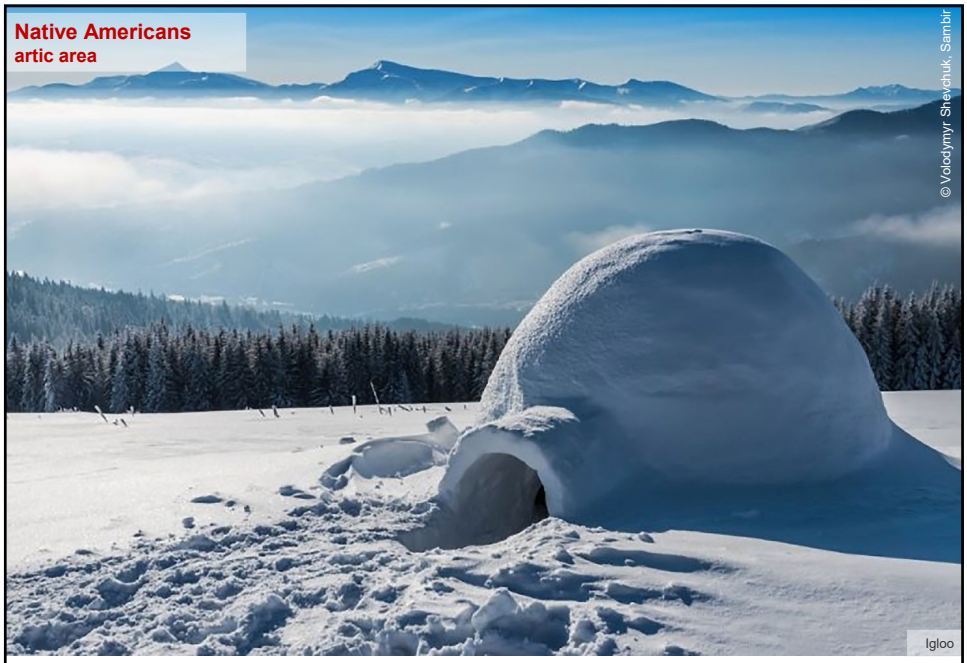
## Native Americans
artic area

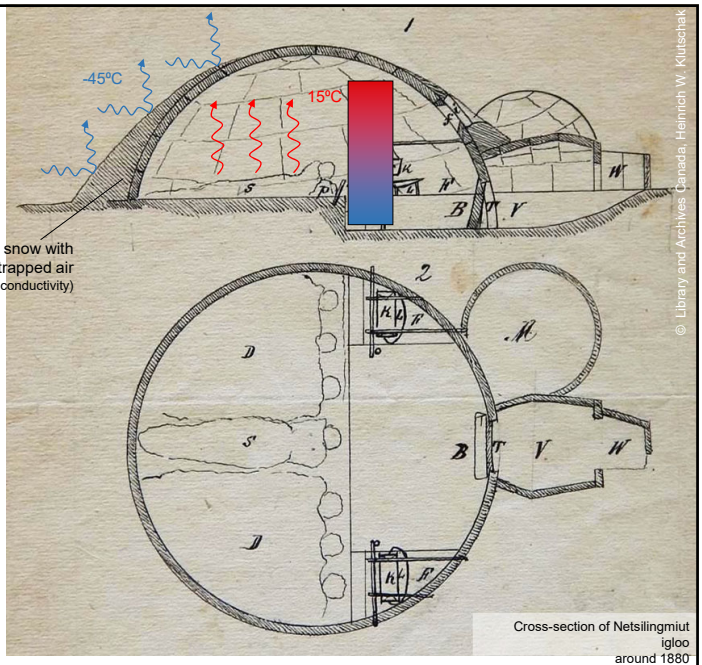



Igloo



9

## Native Americans
artic area

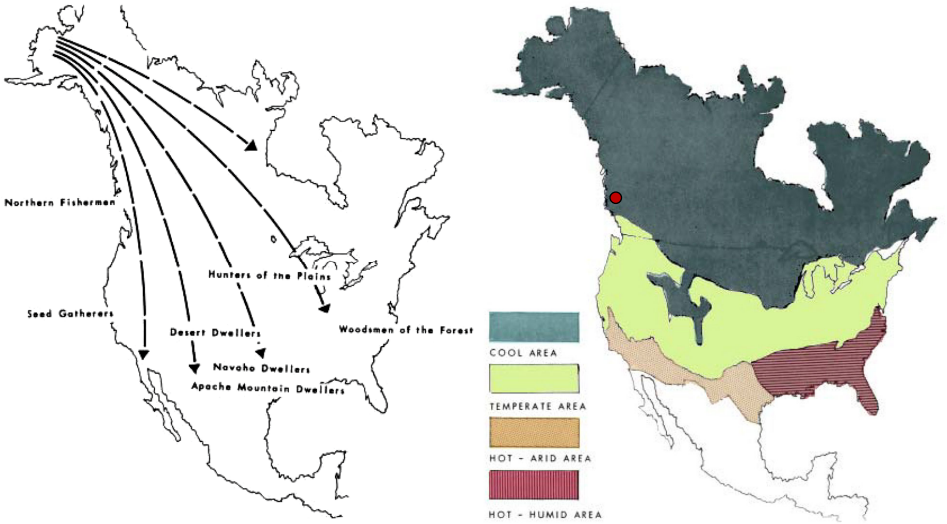



Cross-section of Netsilingmiut
igloo
around 1880



10

## Native Americans




Migration pattern across the Bering Strait from Asia into North America & regional climate zones



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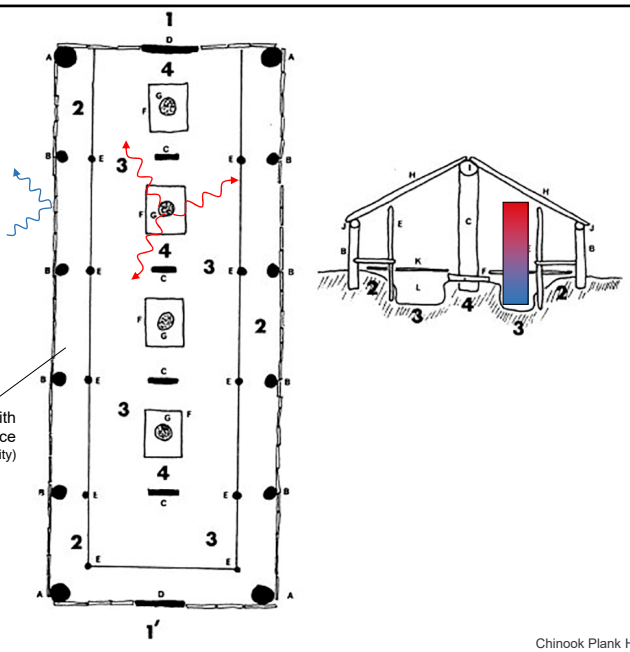
## Native Americans
### Cool area




12

## Native Americans
### Cool area






Chinook Plank House



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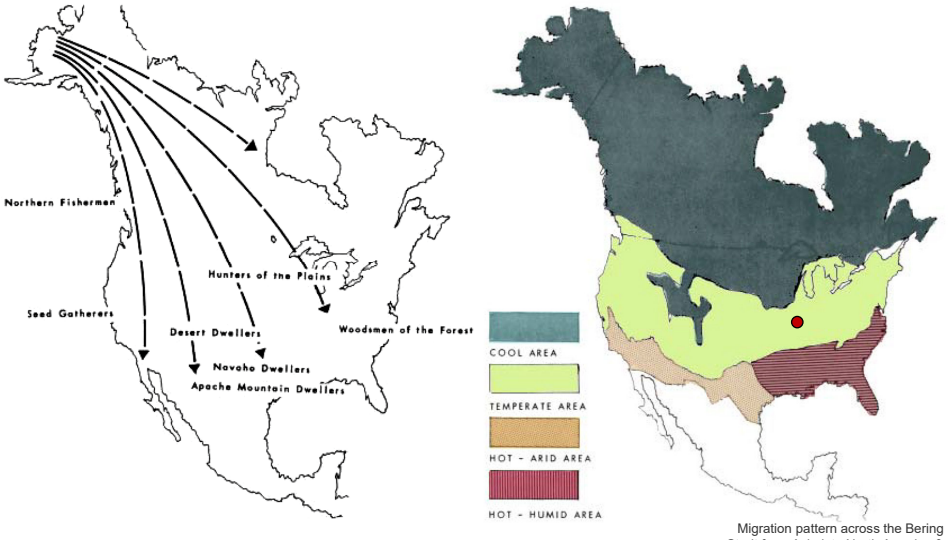
## Native Americans




Migration pattern across the Bering Strait from Asia into North America & regional climate zones



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## Native Americans
### Temperate area

Shoshoni Skin Tepee



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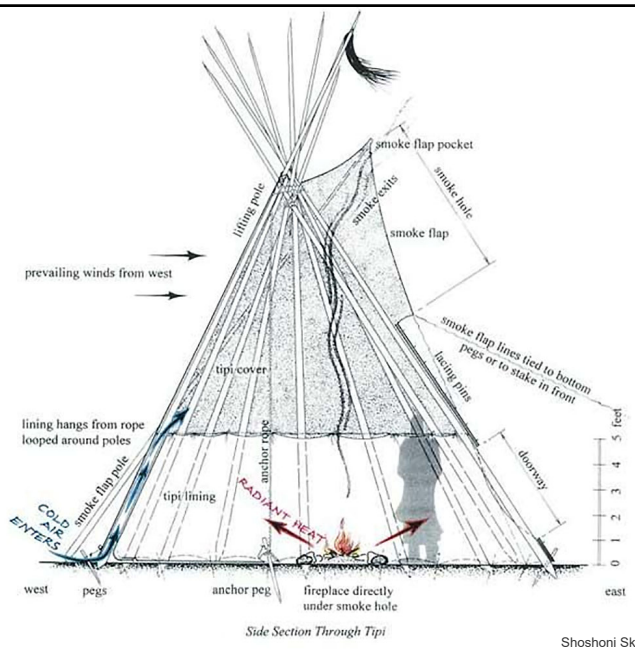
## Native Americans
### Temperate area




© Paul Goble, Rapid City

Shoshoni Skin Tepee



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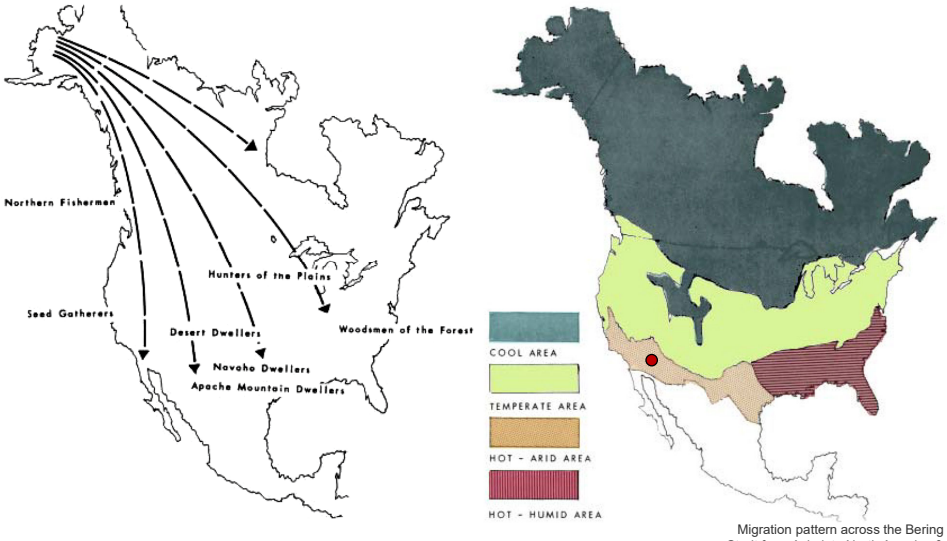
## Native Americans




Migration pattern across the Bering Strait from Asia into North America & regional climate zones



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## Native Americans
### Hot-arid area


Multi-level adobe dwelling, Taos Pueblo



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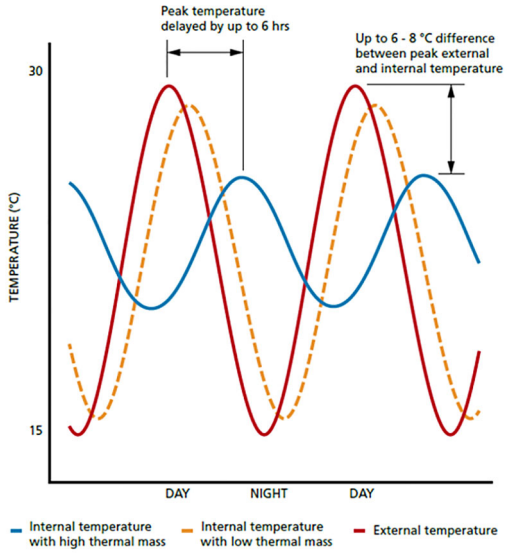
## Native Americans
### Hot-arid area




Effect of thermal mass



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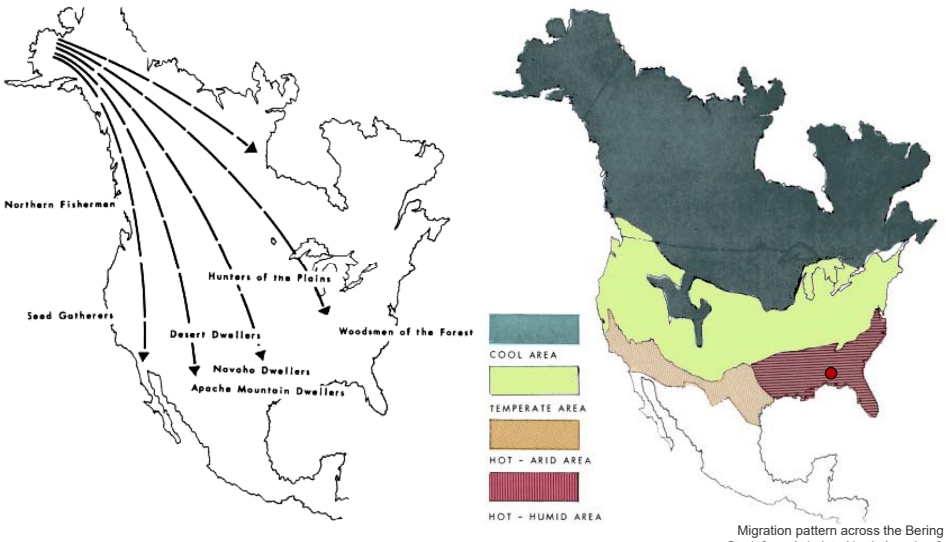
## Native Americans




Migration pattern across the Bering Strait from Asia into North America & regional climate zones



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## Native Americans
Hot-humid area


© Evangelio Gonzalez, Villa Rica

Chickee House



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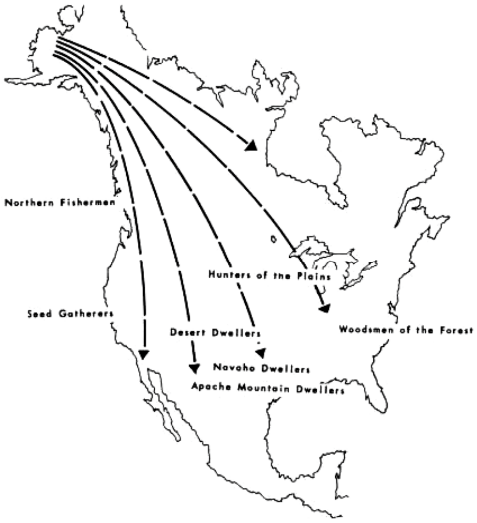
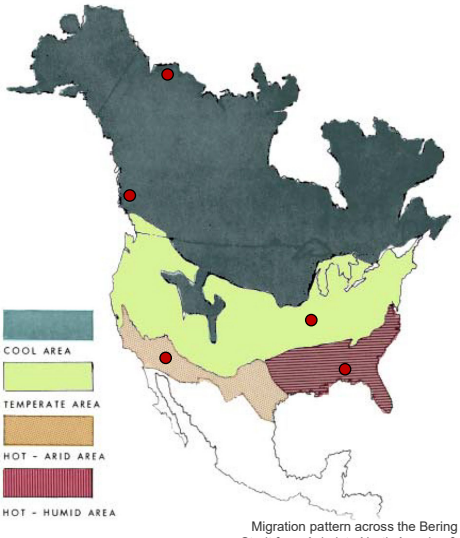
## Native Americans




Migration pattern across the Bering Strait from Asia into North America & regional climate zones



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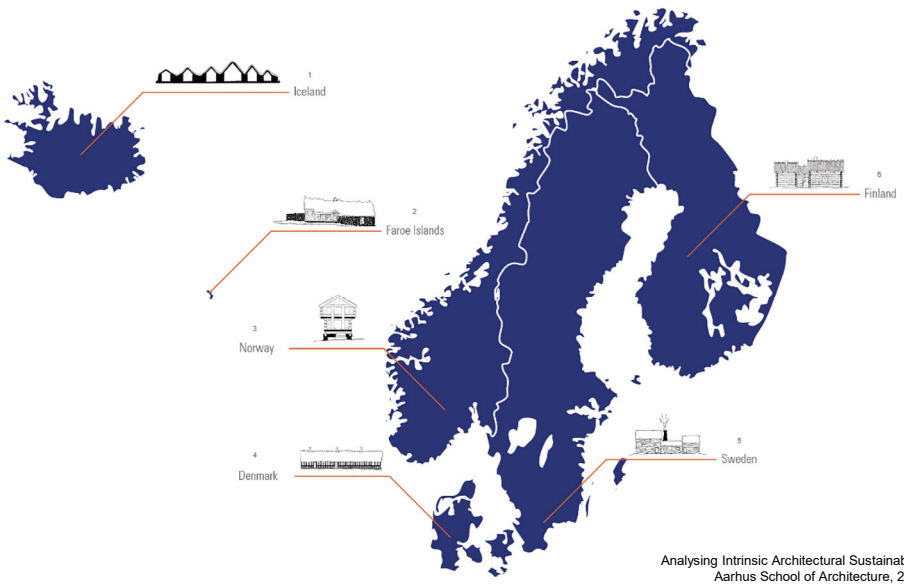
## Nordic Vernacular




Analysing Intrinsic Architectural Sustainability
Aarhus School of Architecture, 2020



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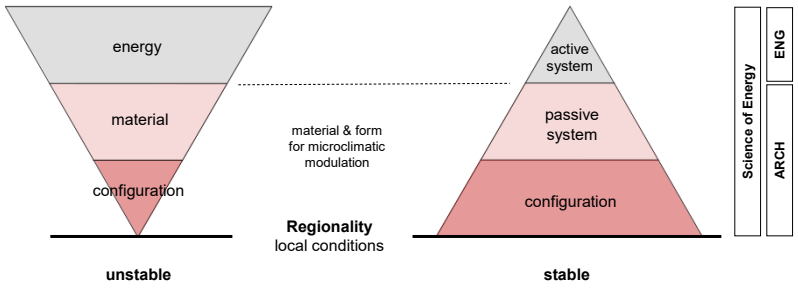
## Abundance of Energy
## Abundance of Material
## Transportation

**Contemporary Design Thinking**

**Sustainable Design Thinking**



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## Heat exchange

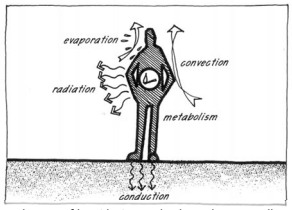
*"As life has arisen through the hidden aspects of natural laws, so for the better or worse the rules of nature command that life make a close adjustment to natural background."*

Victor Olgyay: Design with Climate
Princeton University Press, 1963

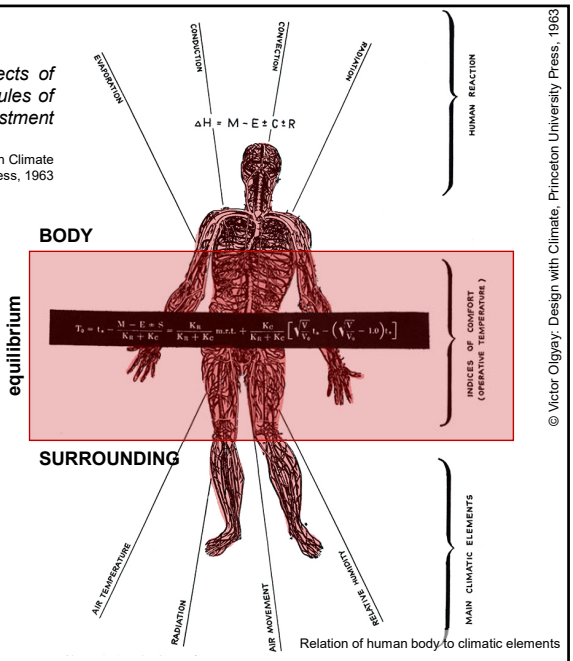
## Microclimatic modulation

*"The architect´s problem is to produce an environment which will not place undue stress upon the body´s heat-compensation mechanism."*

Victor Olgyay: Design with Climate
Princeton University Press, 1963




exchange of heat between body and surrounding




Relation of human body to climatic elements

© Victor Olgyay: Design with Climate, Princeton University Press, 1963



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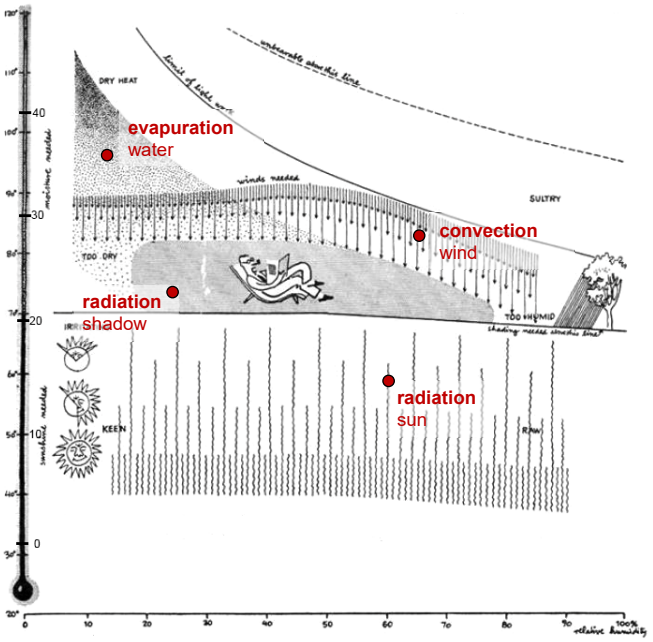
## Bioclimatic chart




© Victor Olgyay: Design with Climate, Princeton University Press, 1963



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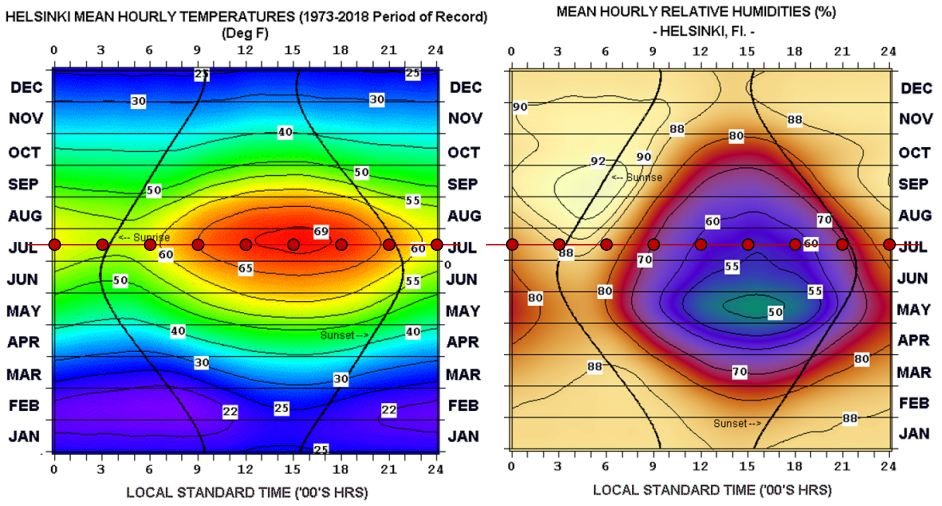
## Local condition



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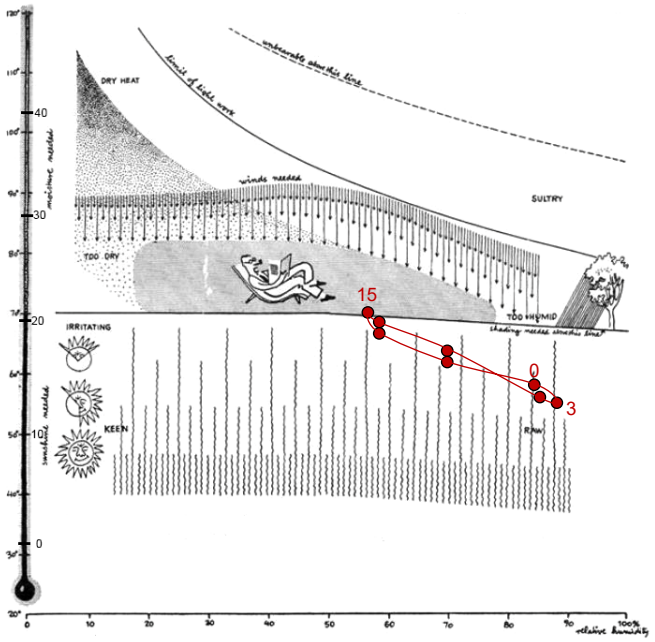
## Bioclimatic chart





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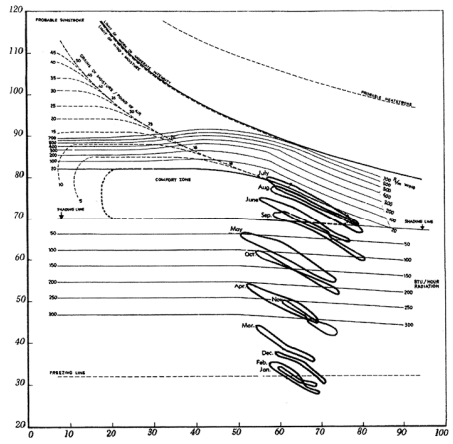
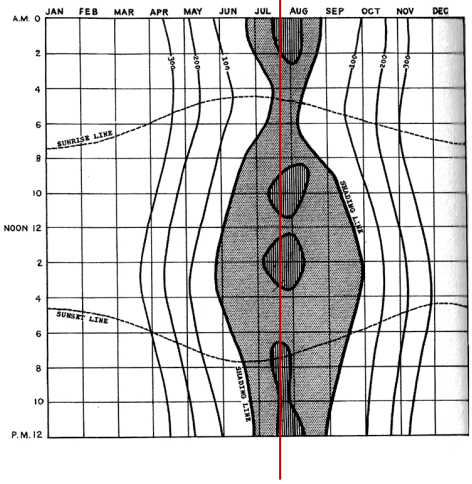
## Bioclimatic chart
### Timetable of climatic needs

need for shading and some additional cooling by wind






© Victor Olgyay: Design with Climate, Princeton University Press, 1963

evaluation of New York City



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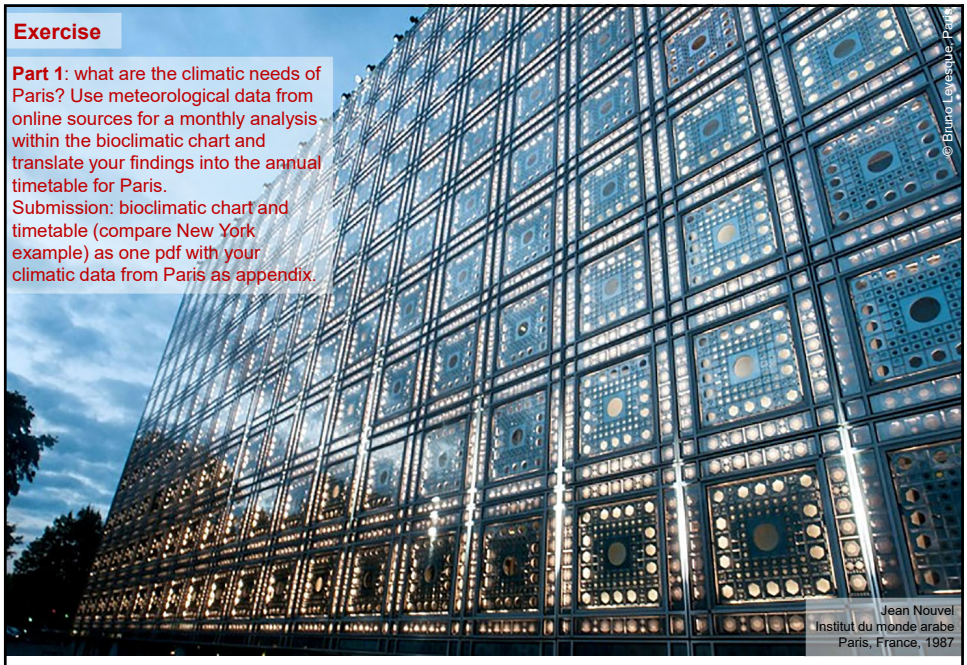
## Exercise

**Part 1**: what are the climatic needs of Paris? Use meteorological data from online sources for a monthly analysis within the bioclimatic chart and translate your findings into the annual timetable for Paris.
Submission: bioclimatic chart and timetable (compare New York example) as one pdf with your climatic data from Paris as appendix.



© Bruno Leyeste, Paris

Jean Nouvel
Institut du monde arabe
Paris, France, 1987



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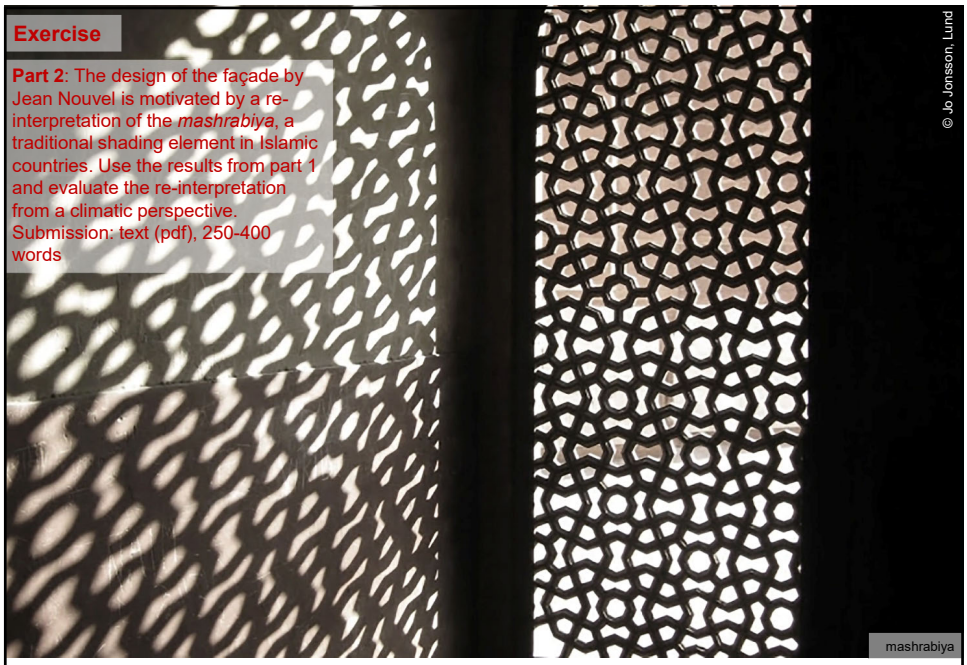
## Exercise

**Part 2**: The design of the façade by Jean Nouvel is motivated by a re-interpretation of the *mashrabiya*, a traditional shading element in Islamic countries. Use the results from part 1 and evaluate the re-interpretation from a climatic perspective. Submission: text (pdf), 250-400 words




A"DS Aalto University Design of Structures

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Toni Kotnik, Professor of Design of Structures

Computational Cycle
Performative Form
12.10.2022

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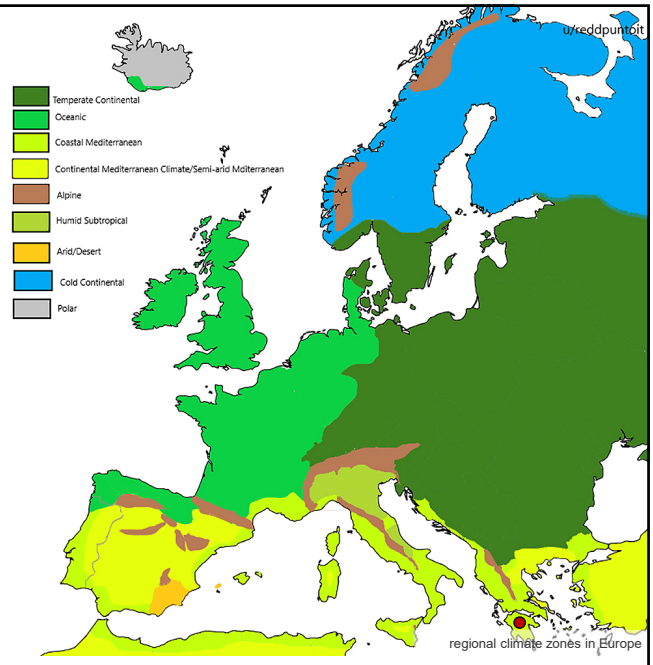
## Design Application
### Hot-humid area




A"DS Aalto University Design of Structures

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Toni Kotnik, Professor of Design of Structures

Computational Cycle
Performative Form
12.10.2022

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Athens



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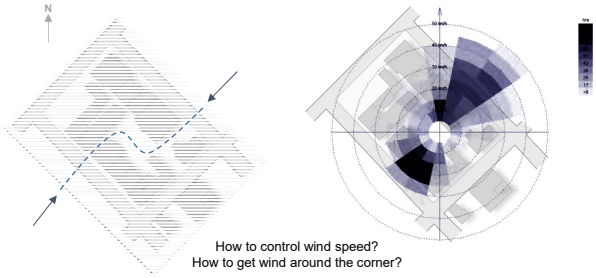
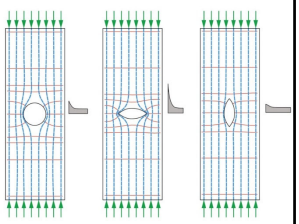
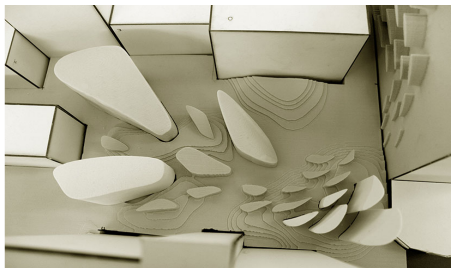
**Aim:** activation of courtyard as space of social interaction
**Req:** cooling down of space by increased convection

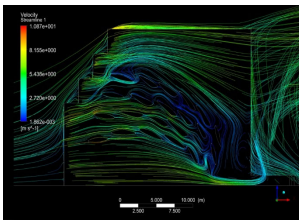


How to control wind speed?
How to get wind around the corner?



control of wind speed through geometry





Courtyard Development
Athens, Greece, 2010



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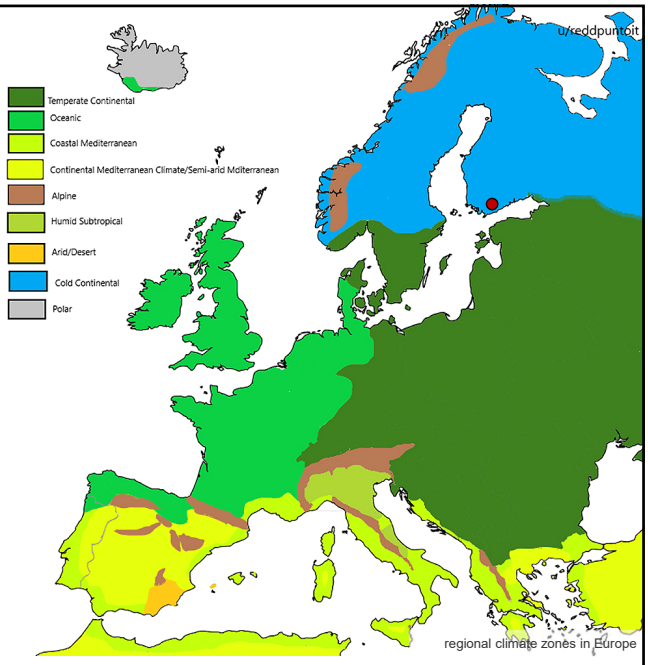
## Design Application
## cool area

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Computational Cycle
Performative Form
12.10.2022

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A"DS Aalto University Design of Structures

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Toni Kotnik, Professor of Design of Structures

Computational Cycle
Performative Form
12.10.2022

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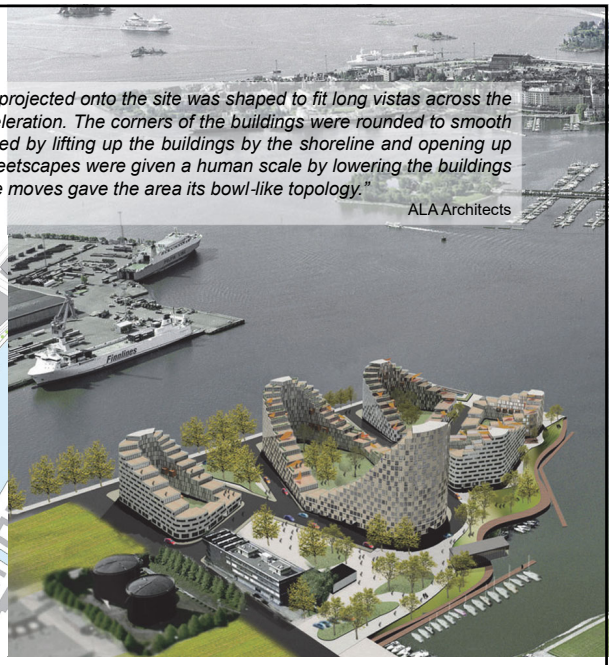
**Design proposal by ALA**
winning project from competition 2018

*"A traditional Helsinki city block structure projected onto the site was shaped to fit long vistas across the site and broken up to minimize wind acceleration. The corners of the buildings were rounded to smooth out wind loads. Sea views were maximized by lifting up the buildings by the shoreline and opening up the public spaces outward to the sea. Streetscapes were given a human scale by lowering the buildings down to two floors in central areas. These moves gave the area its bowl-like topology."*

ALA Architects





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**Design proposal by ALA**
winning project from competition 2018

**Problem 1:** wrong assumption on wind direction & speed


Dan Palarie: Understanding Sustainability in Finland
Local Environmentalism and Potential for Sustainable Design
Master Thesis, 2018



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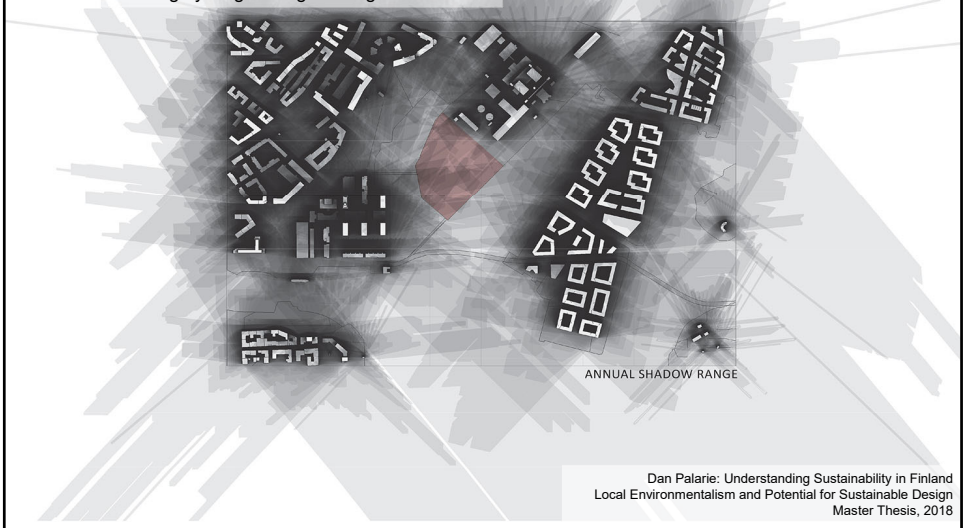
**Design proposal by ALA**
winning project from competition 2018

**Problem 1:** wrong assumption on wind direction & speed

**Problem 2:** shading by neighboring buildings

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Master Thesis, 2018



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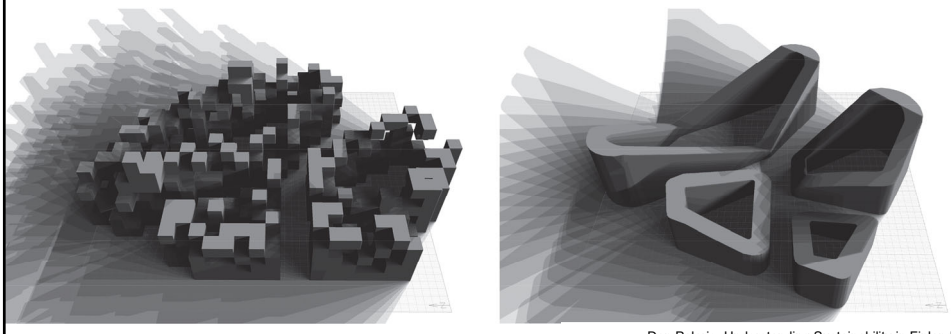
**Design proposal by ALA**
winning project from competition 2018

**Problem 1:** wrong assumption on wind direction & speed

**Problem 2:** shading by neighboring buildings

**Revised proposal based on optimization of heat gain, vista and wind**



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Local Environmentalism and Potential for Sustainable Design
Master Thesis, 2018



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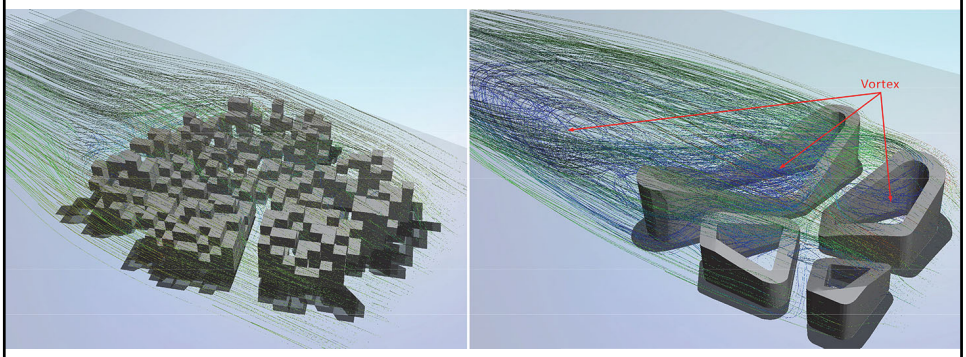


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Local Environmentalism and Potential for Sustainable Design
Master Thesis, 2018



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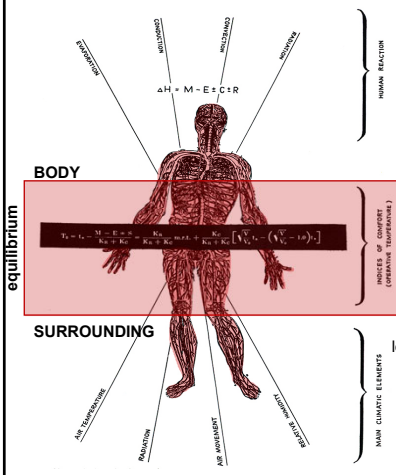
**Complexity**
**Interacting parameter**

learning from nature
**animal architecture**

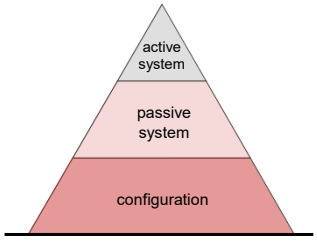
different methodology required

**Sustainable Design Thinking**




material & form
for microclimatic
modulation

**Regionality**
local conditions




**stable**

Science of Energy
ENG
ARCH



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