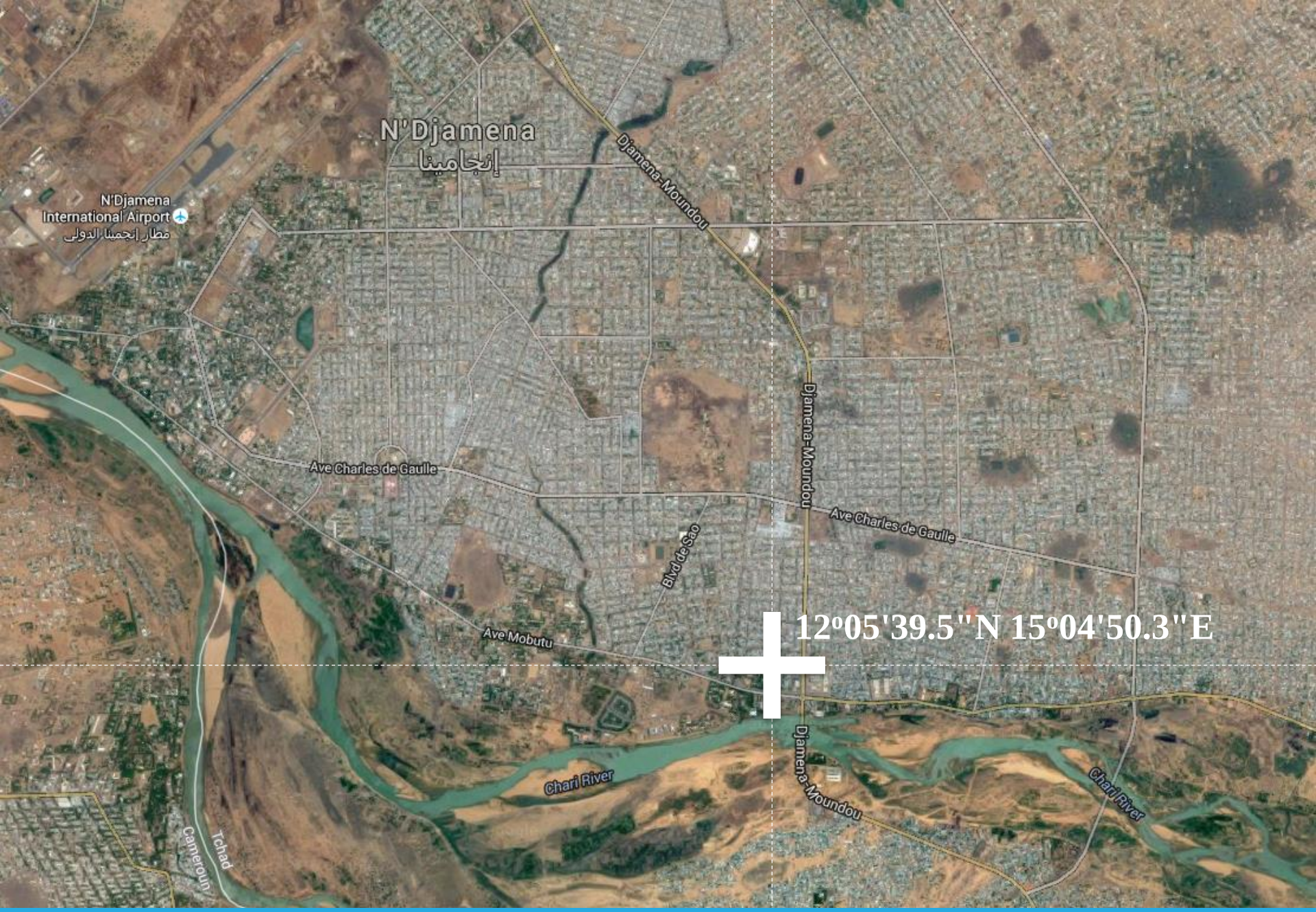
# Appropriate Technology:
# Engineering “as if People Mattered*”

* Quoted from ***Small Is Beautiful*** by E. F. Schumacher 1973

## Appropriate Approach for the Built Environment in Africa
## : Concept Derived from Vernacular Traditions and Current Practices

So Young Hyun | Ove Arup

N'Djamena
Chad
Niger
Sudan
South Sudan
Nigeria
Madama
Djado Plateau
Bardai
Tommi
Zouar
Ounianga Kebir
Faya-Largeau
Fada
Agadez
Abri
Dongola
Al Goled
Iriba
Abeche
Kutum
Al Fashir
El Obeid
Ati
Adre
Al Junaynah
En Nahud
Ghubaysh
Dilling
Nyala
Gereida
El Daein
Adiela
Kadugli
Kano
Maiduguri
Am Timan
Um Dukhun
Bauchi
Gombe
Biu
Maroua
Jos
Garoua
Sarh
Radom National Park
Aweil
Gogrial
Moundou
Doba
Wau
Southern


N'Djamena
إنجامينا
N'Djamena
International Airport
مطار إنجمينا الدولي
Djamena-Moundou
Djamena-Moundou
Ave Charles de Gaulle
Ave Charles de Gaulle
Blvd de Sao
Ave Mobutu
12°05'39.5"N 15°04'50.3"E
Chari River
Djamena-Moundou
Chari River
Cameroun
Tchad

SITE
Collège
Evangélique
Avenue Mobutu
Training
Centre
Guest
House

# Site Survey | What Locally Available

# Site Survey | Case Studies

# Climate Context | Sustainable Design

- Buildings can have extensive direct and indirect impacts on the environment throughout their life cycle.

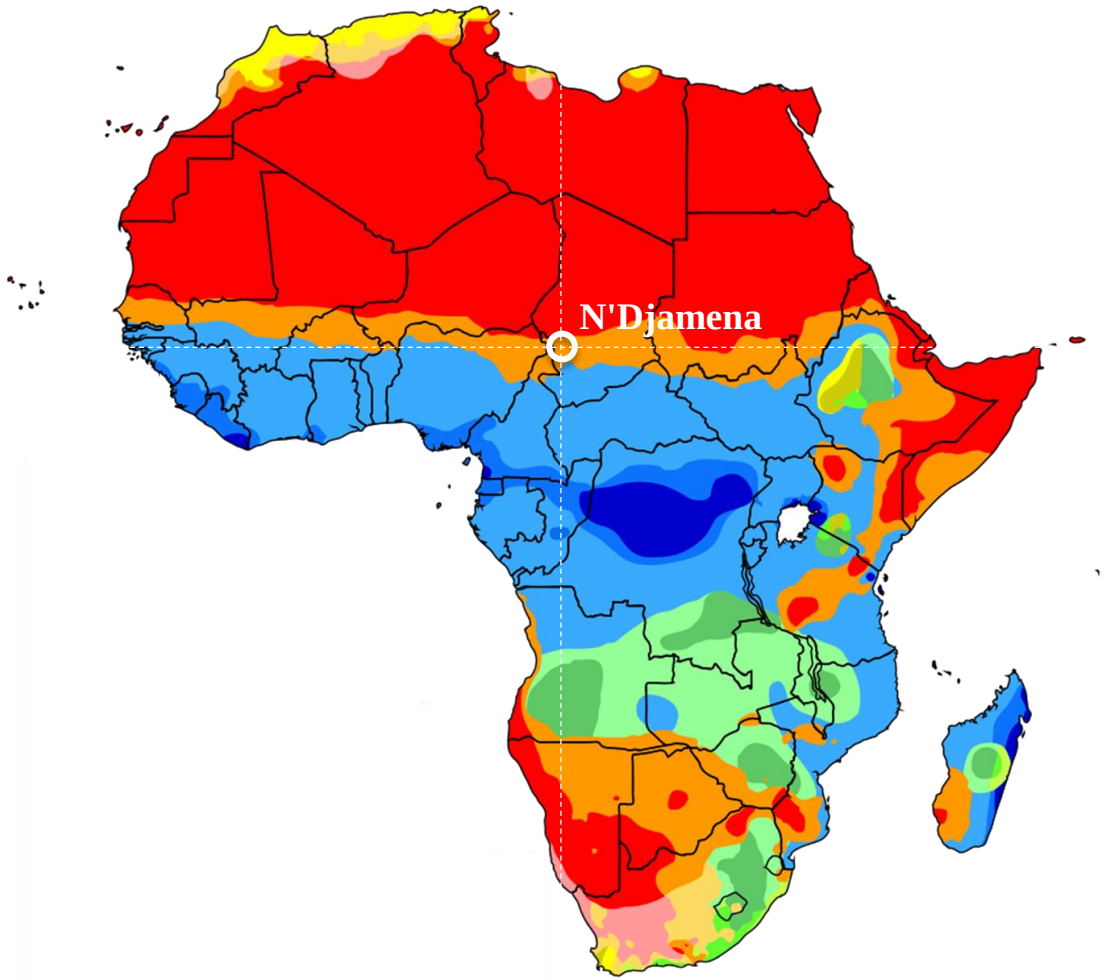
  ✓ The building sector alone, contributes up to 19% of global annual GHG emissions.[1]
  ✓ It consumes up to 32% of all global energy, which will more than double in the next 50 years.[1]

- Buildings also face multiple climate change impacts.

  ✓ Changes in climate not only affect average temperatures, but also extreme temperatures, increasing the likelihood of weather-related natural disasters.[2]
  ✓ Many buildings are vulnerable to progressive changes in climate and to extreme events and have already experienced big increases in damage over recent decades.[3]
  ✓ Natural disasters are increasing in number and frequency, and affect most countries in Africa.[4]

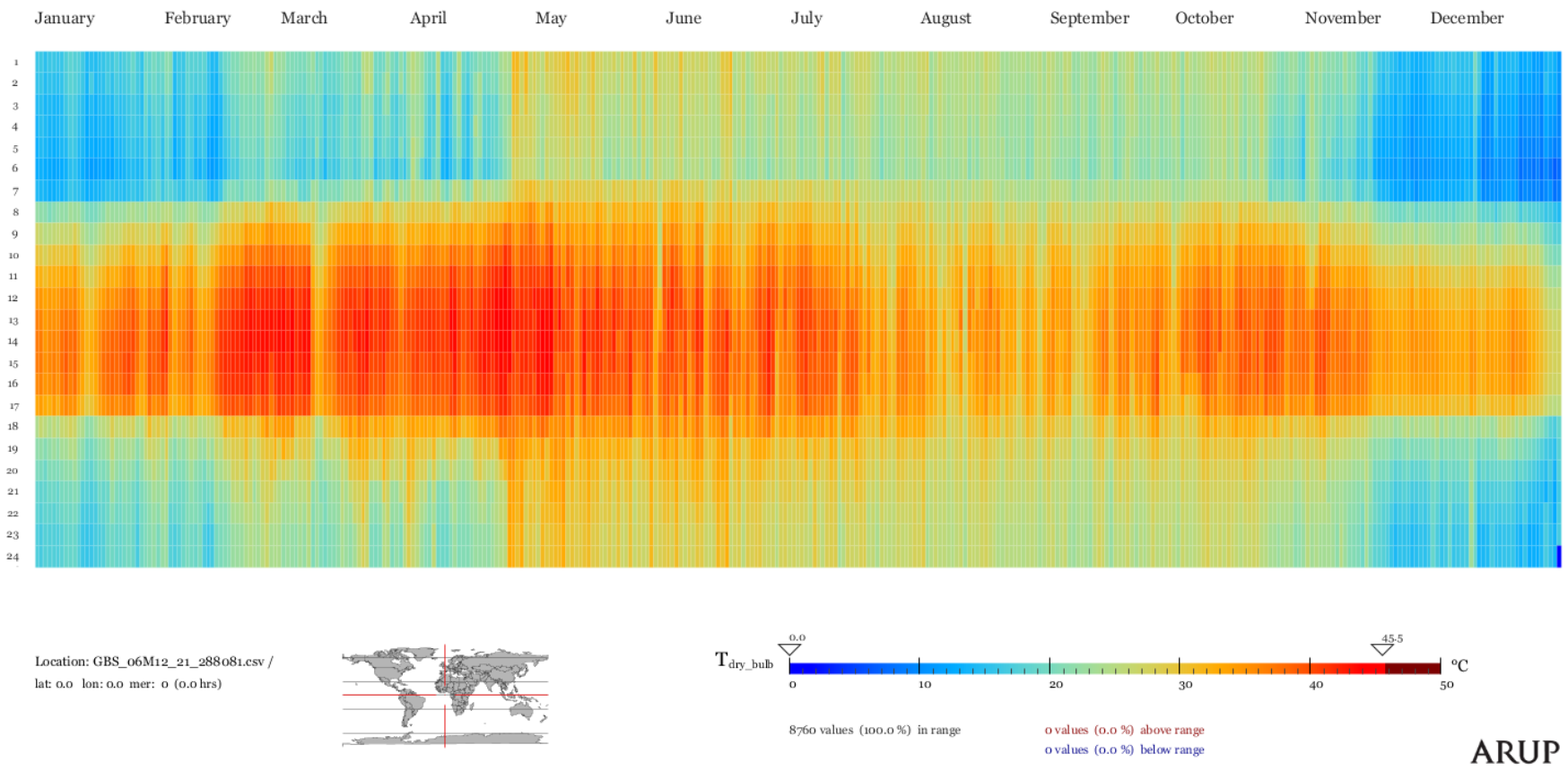
# Climate Context | Sub-Saharan Area

- N’Djamena has a semi-arid climate with a short wet season and a lengthy dry season.



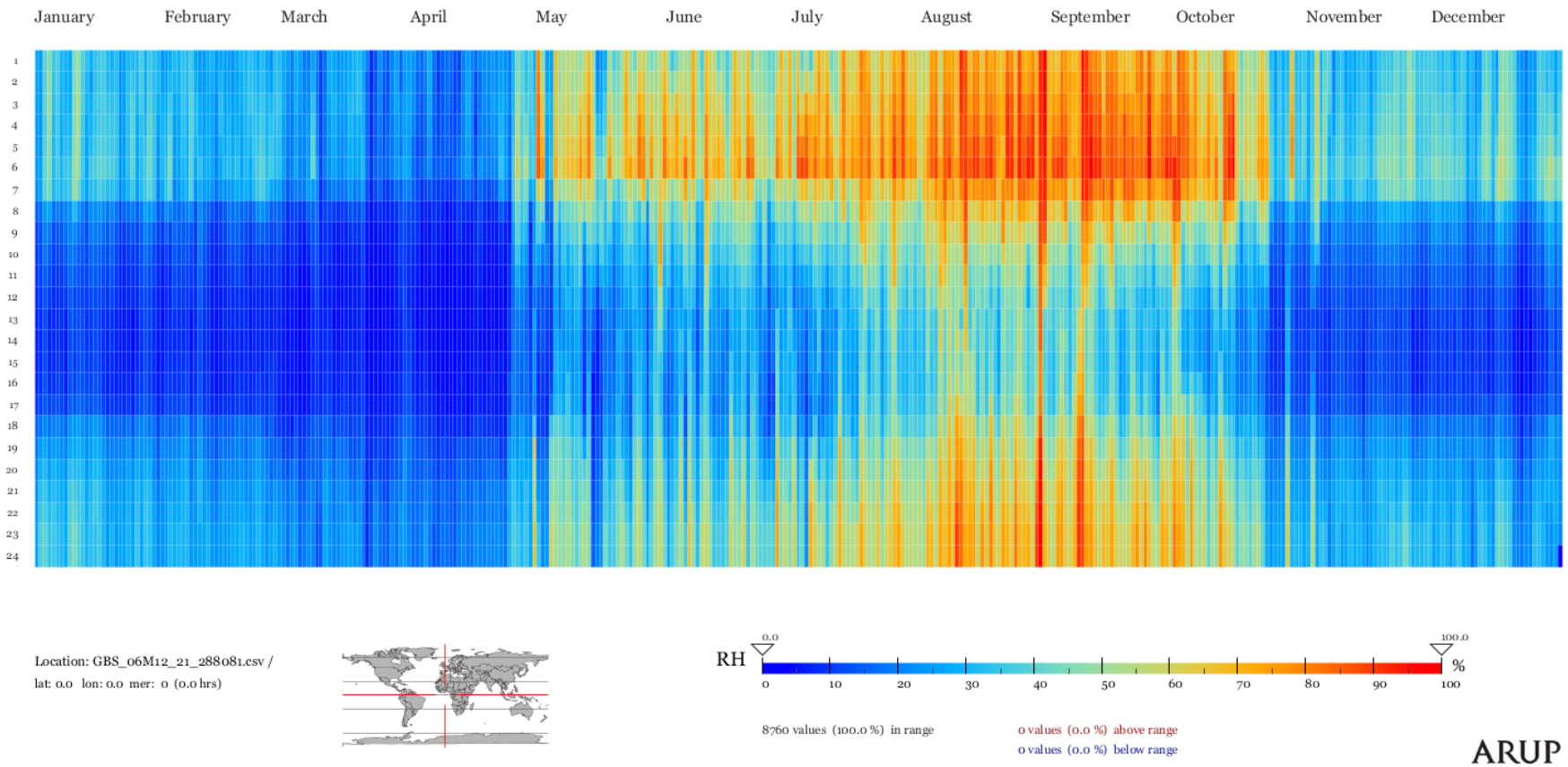
# Climate Context | N'Djamena

- In only one month of the year (August) do average monthly high temperatures fail to cross the 32°C mark.



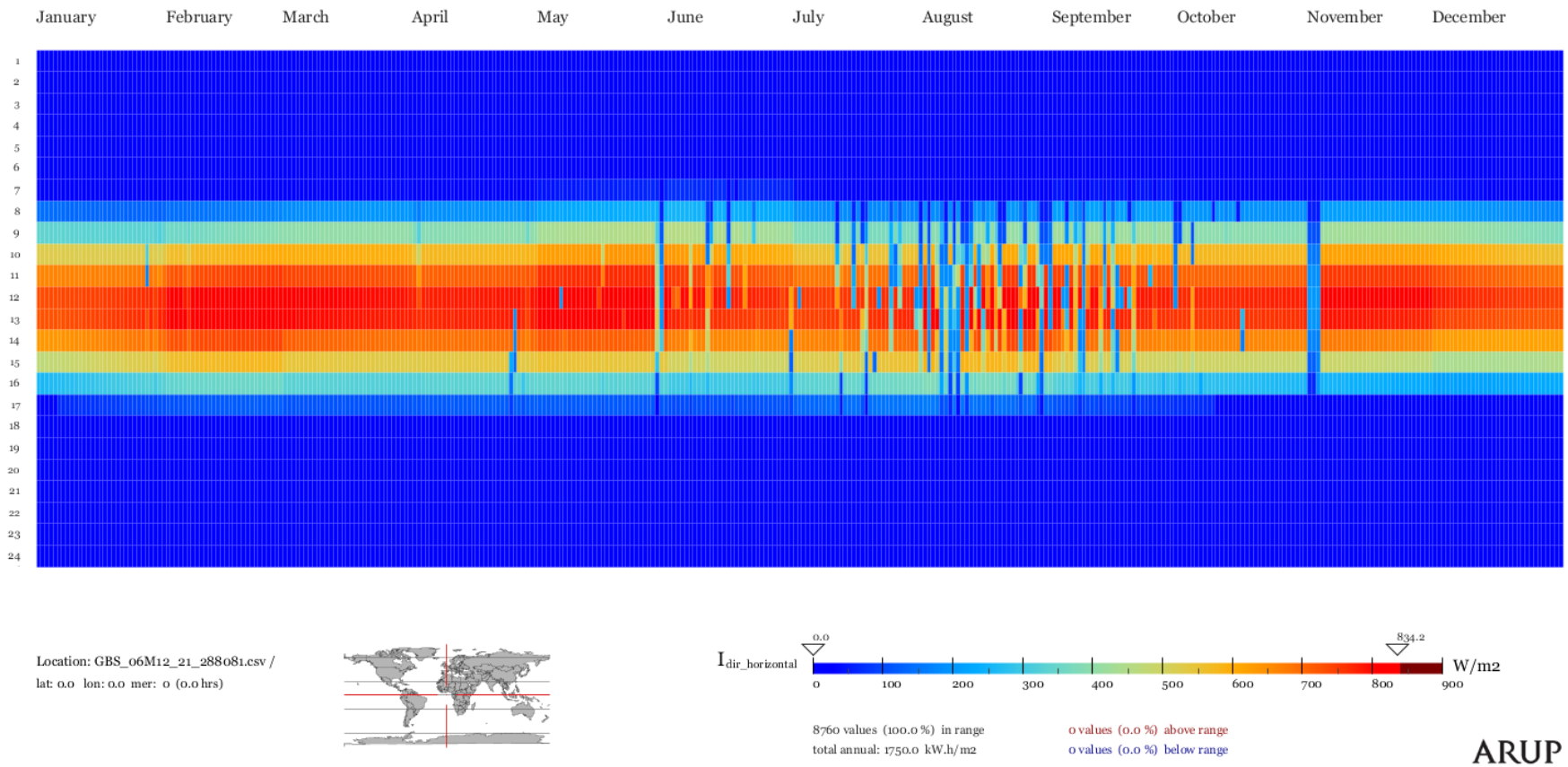
# Climate Context | N'Djamena

- The city receives on average approximately 510 mm of rain annually (Max 175mm in Aug).



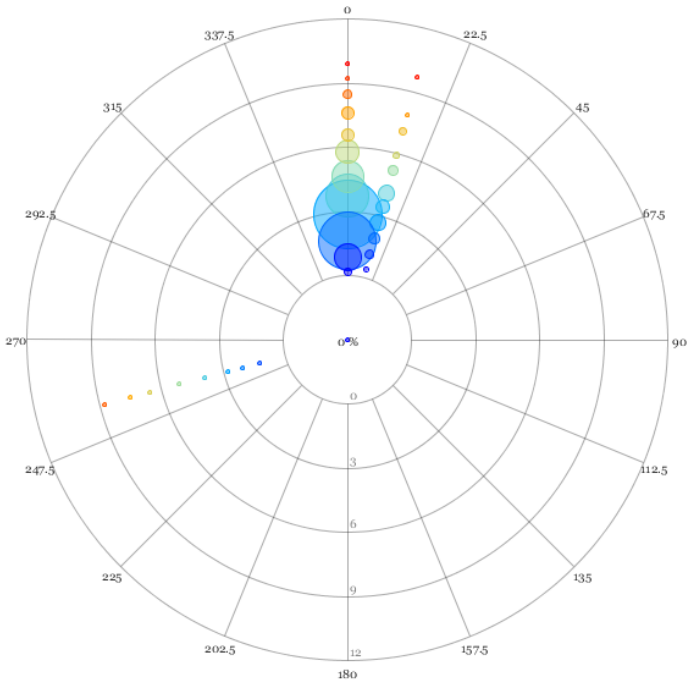
# Climate Context | N'Djamena

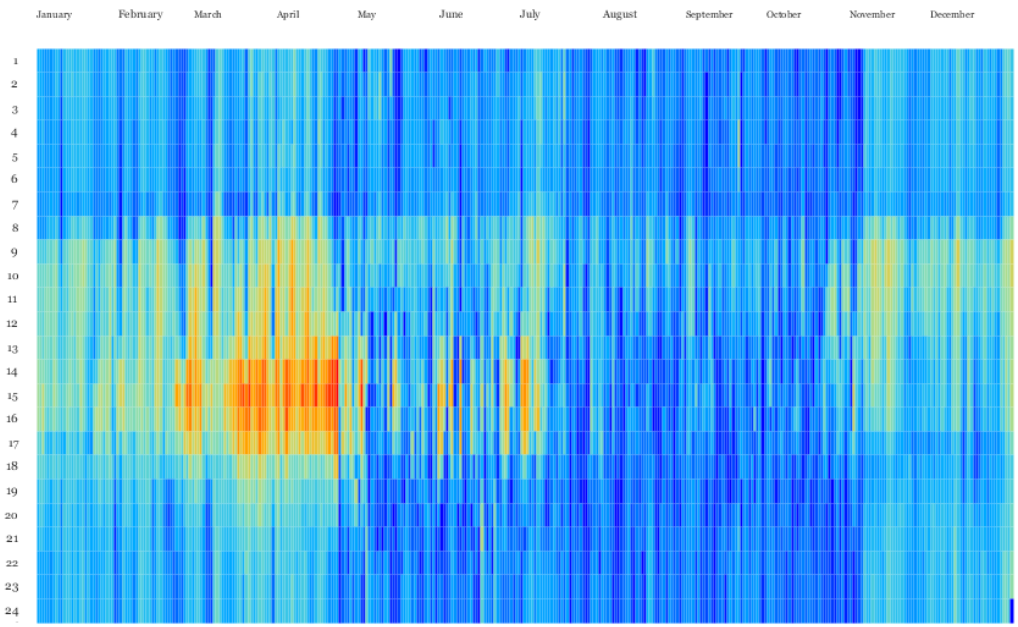
- Chad has daily solar radiation ranging between 4 and 6 kWh/m$^2$, offering a significant energy resource.



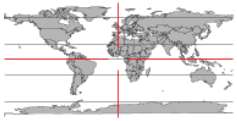
# Climate Context | N'Djamena

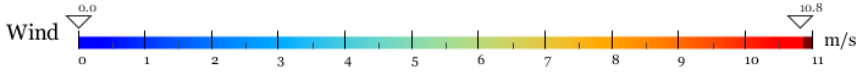
- Prevailing Wind: Dry Season NNE (3.2m/s), Wet Season SW (2.4m/s)




Location: GBS_06M12_21_288081.csv /
lat: 0.0 lon: 0.0 mer: 0 (0.0 hrs)



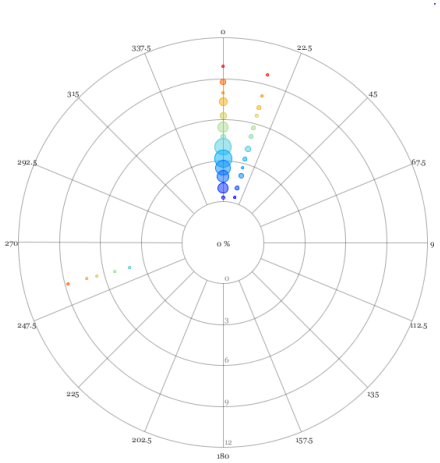


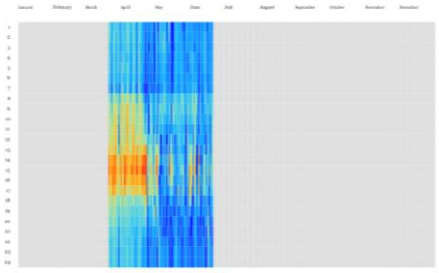

8760 values (100.0 %) in range
0 values (0.0 %) above range
0 values (0.0 %) below range

ARUP

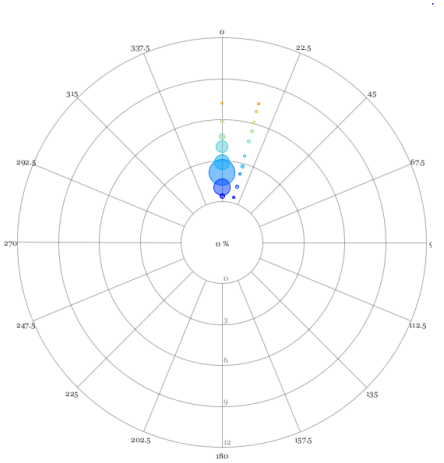
# Climate Context | N’Djamena

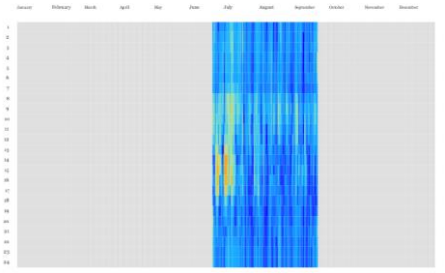
- Prevailing Wind: Dry Season NNE (3.2m/s), Wet Season SW (2.4m/s)



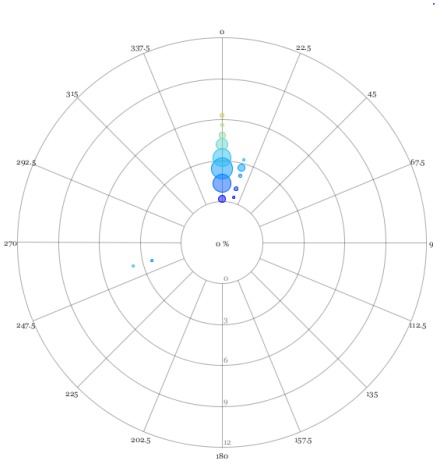


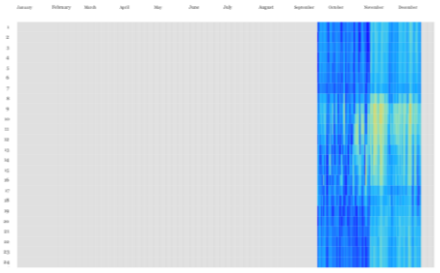
Spring



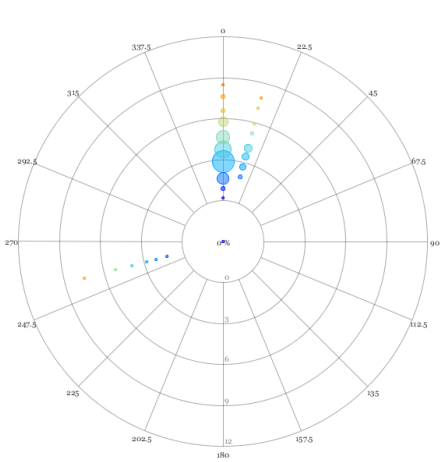


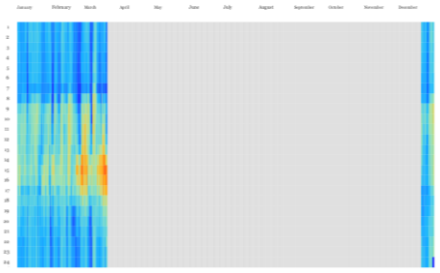
Summer





Autumn





Winter

# Climate Context | Findings for Design Development

- Climate Responsive Design

  - ✓ Perform a site analysis.
  - ✓ Layout the building on the site using an integrative design process.
  - ✓ It’s all about the sun — orient the building based upon cardinal directions.
  - ✓ Minimize the building footprint.

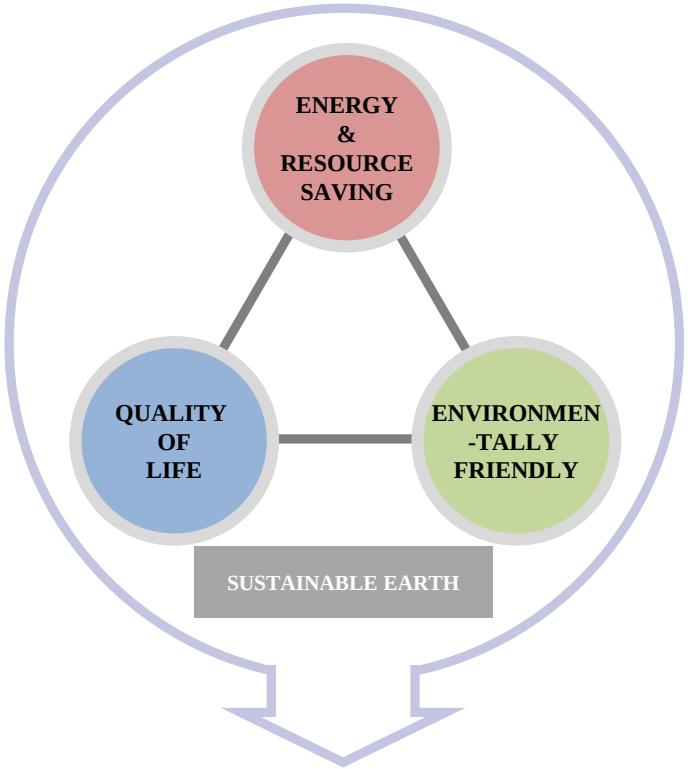
  - ✓ Select the appropriate window areas and glazing types based on orientation.
  - ✓ Building envelope design varies greatly by geographic area.

  - ✓ Design for natural ventilation.
  - ✓ Relax the occupants comfort standards.

  - ✓ Conduct modelling and analysis.
  - ✓ Perform multiple iterations.

# Design Development | What is Appropriate?

- Optimisation of the appropriate design measures is the key for better building performance.




| Design Components | Selection |
|---|---|
| **LOW-ENERGY DESIGN** | |
| **Building Design** | |
| Window to wall ratio (40~50%) | ● |
| High performance glass | ● |
| High performance window frame | |
| High thermal insulation | |
| Double skin façade | |
| Ecotube | ● |
| Vertical shading (east, west facades) | |
| Overhang (south facade) | ● |
| Light shelf (south facade) | ● |
| **Mechanical System** | |
| VAV system | |
| Displacement ventilation system | |
| Radiant heating/cooling | |
| Large temperature difference system | |
| Ice thermal storage system | |
| Variable volume flow system | |
| Free cooling | ● |
| Heat recovery | ● |
| CO2 monitoring system | |
| BEMS | |
| **Electrical System** | |
| Occupancy sensor light control | |
| Daylight responsive lighting control | |
| Solar activated blind system | |
| High efficient fluorescent lamp(T5) | |
| LED lighting | |
| High efficiency lighting fixture | ● |
| High efficiency transformer | |

| Design Components | Selection |
|---|---|
| Standby energy saving powerboard | |
| Outdoor light timer | |
| Peak demand control | |
| **Renewable Energy** | |
| BIPV | |
| PV | ● |
| PV street lighting | |
| PV landscape lighting | |
| Solar hot water system | ● |
| Geothermal heat pump | |
| **RESOURCE SAVING** | |
| **Water Efficiency** | |
| Rainwater harvesting system | ● |
| Greywater recycling system | ● |
| Water efficient toilets and fixtures | ● |
| **Construction Materials** | |
| Use recycled materials | ● |
| Use recyclable materials | ● |
| Use local products | ● |
| **QUALITY OF LIFE** | |
| **Low Impact Design** | |
| Cool roof | ● |
| Green wall | |
| Minimize hard paving | ● |
| Pervious pavement | ● |
| Indoor green /blue space | ● |
| Bicycle parking | |
| **Human Health** | |
| Natural finishing materials | |
| No VOCs materials | |

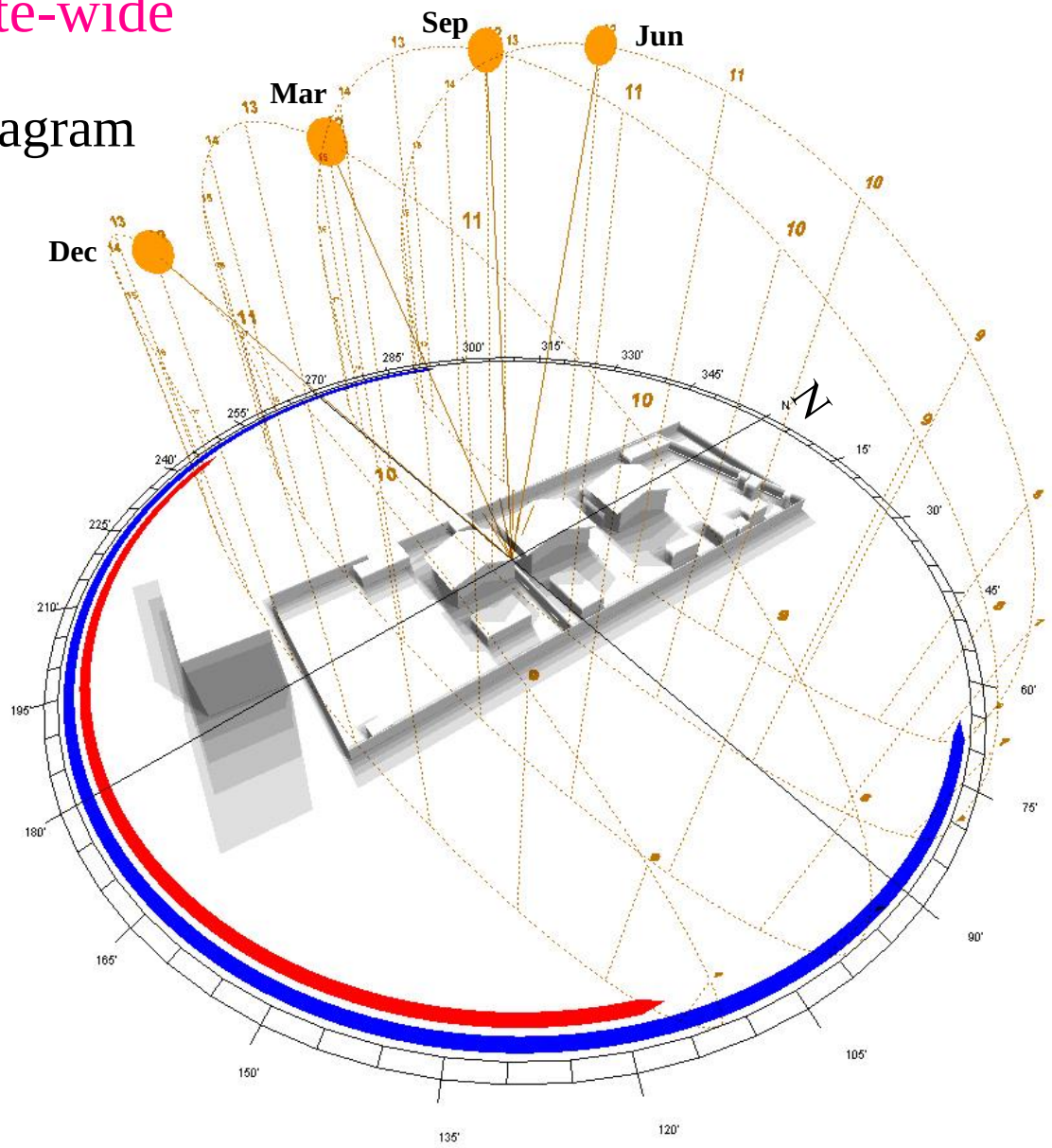
# Design Development | Architecture without Architect

# Design Development | RepuBrick

# Design Development | Green Tech

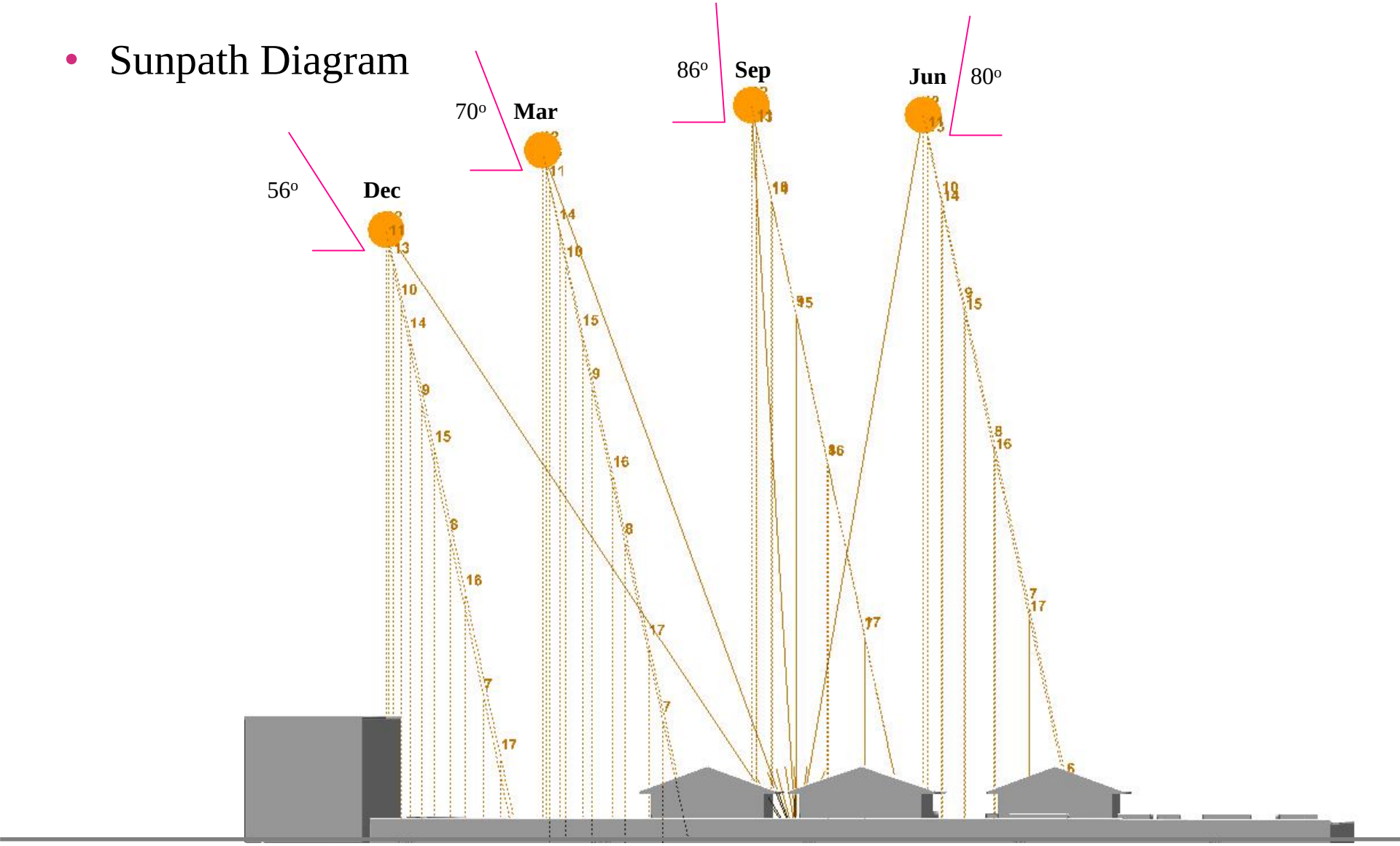
# Analysis | Site-wide

- Sunpath Diagram



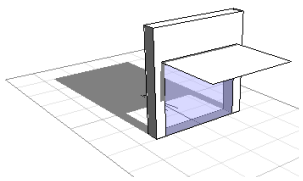
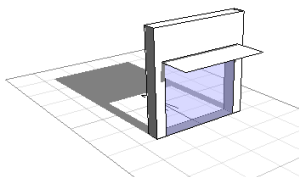
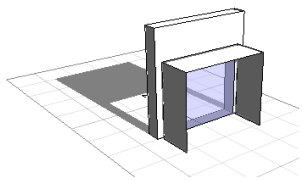
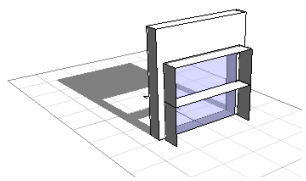
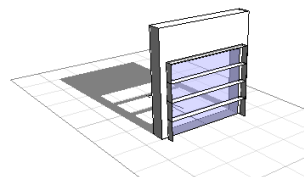
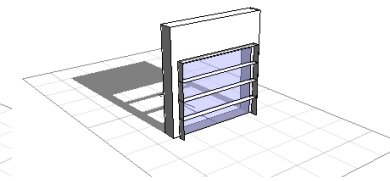
# Analysis | Site-wide

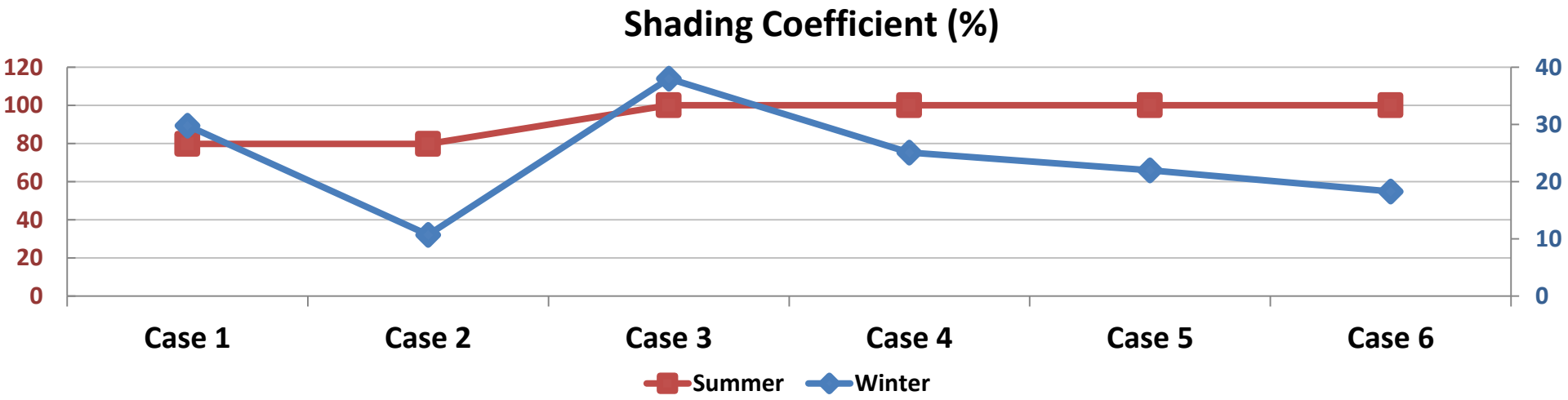
- Sunpath Diagram



# Analysis | Solar Design

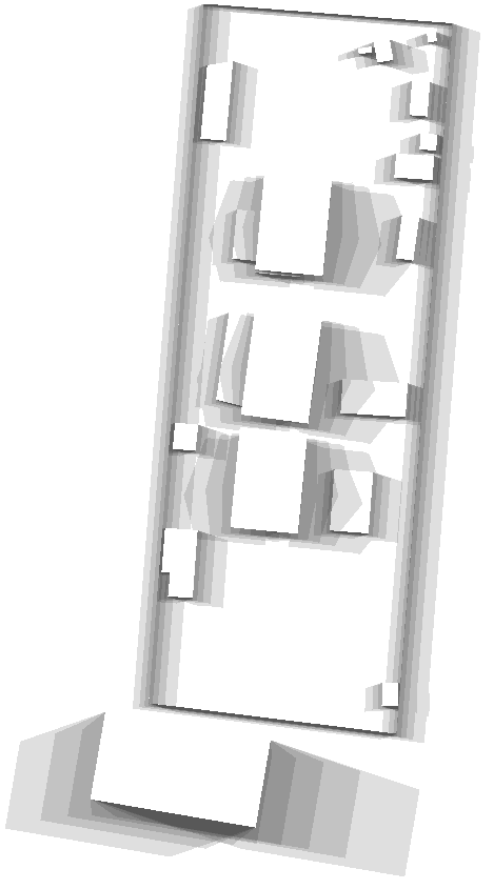
- Shading Optimisation

| Case 1 | Case 2 | Case 3 | Case 4 | Case 5 | Case 6 |
|---|---|---|---|---|---|
|  |  |  |  |  |  |
| Hor_ 2,000 (1ea) | Hor_ 1,000 (1ea) | Hor_ 1,000 (1ea)<br>Ver_ 1,000 (2ea) | Hor_ 500 (2ea)<br>Ver_ 500 (2ea) | Hor_ 250 (4ea)<br>Ver_ 250 (2ea) | Hor_ 200 (4ea)<br>Ver_ 200 (2ea) |

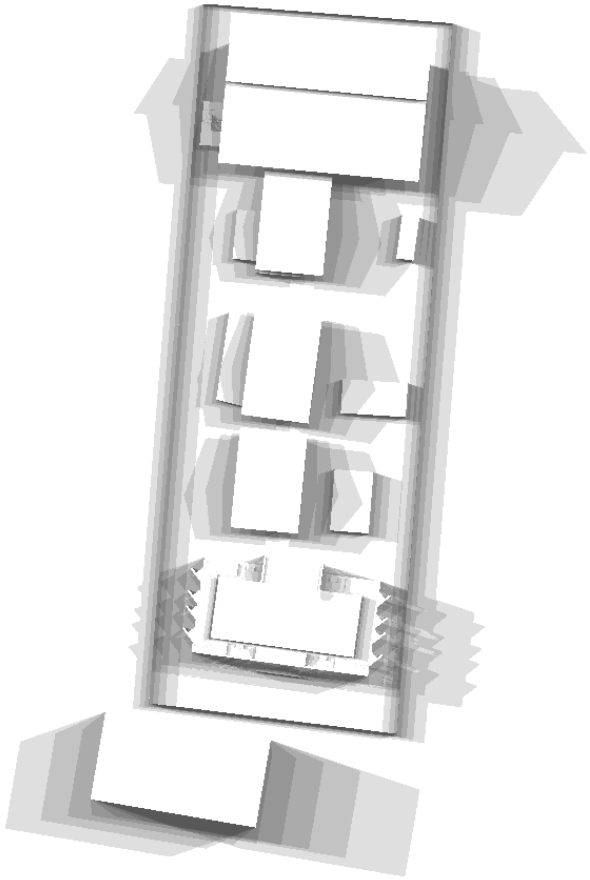


# Analysis | Site-wide

- Shadow Analysis



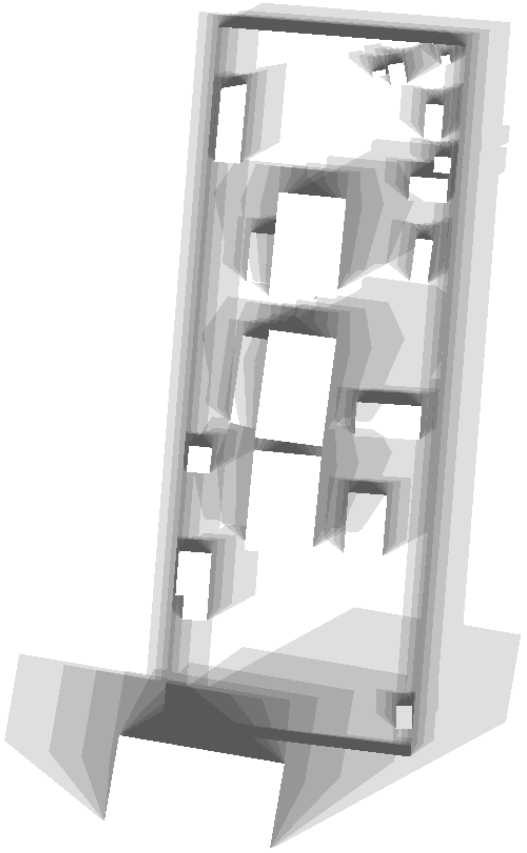
Before Construction
Summer Solstice 09:00-16:00, 60mins Interval



After Construction
Summer Solstice 09:00-16:00, 60mins Interval

# Analysis | Site-wide

- Shadow Analysis

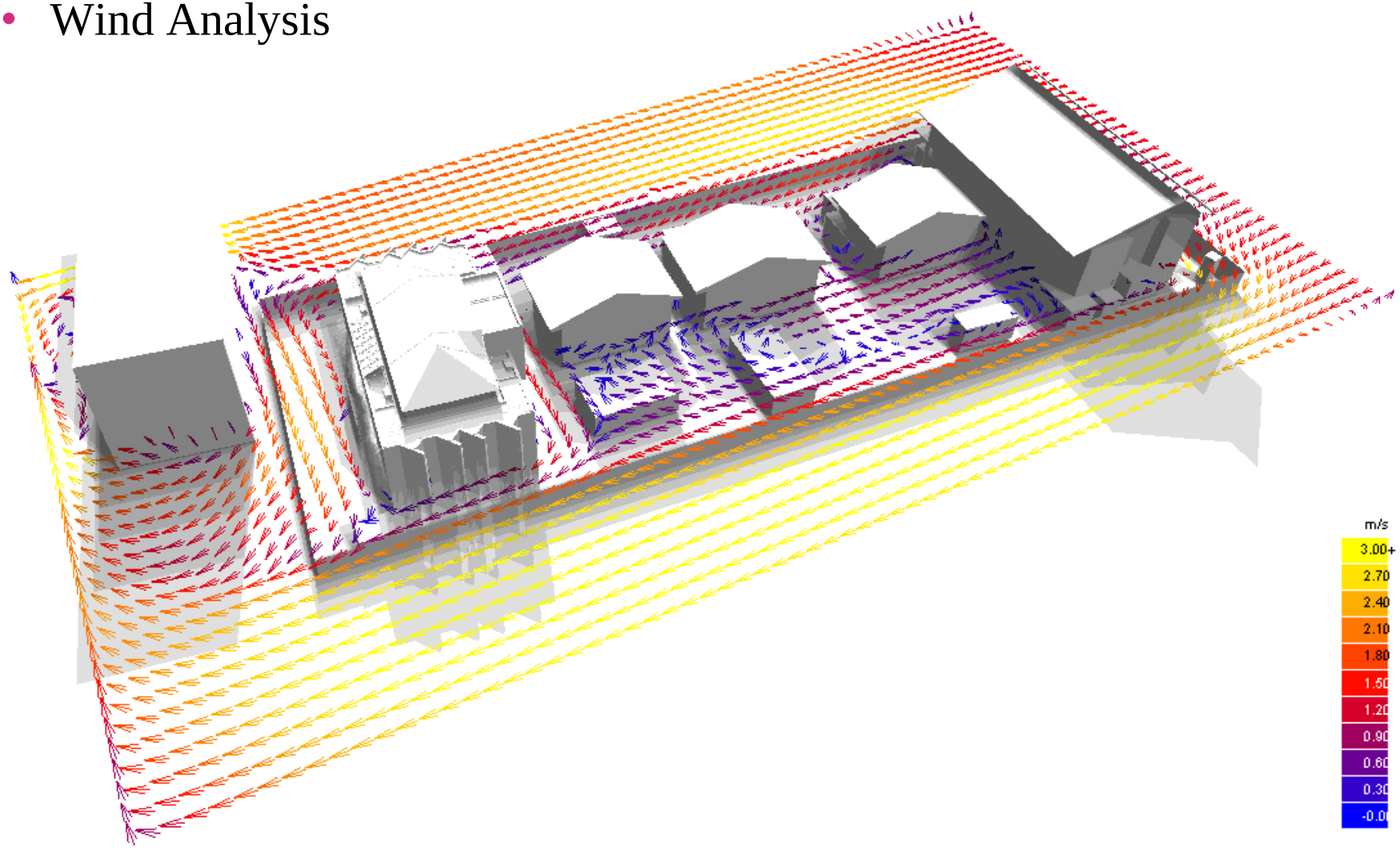


Before Construction
Winter Solstice 09:00-16:00, 60mins Interval

After Construction
Winter Solstice 09:00-16:00, 60mins Interval

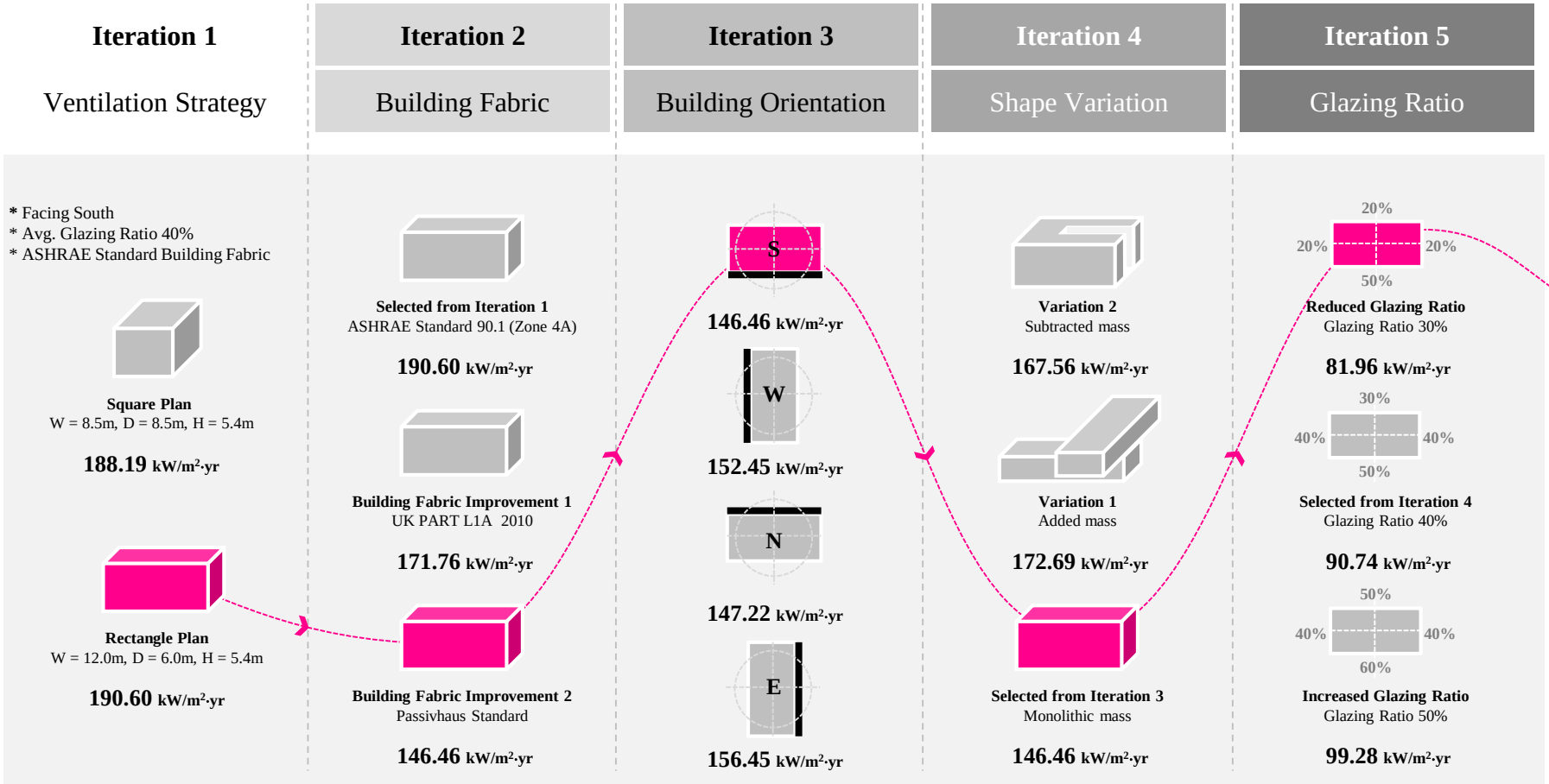
# Analysis | Site-wide

- Wind Analysis



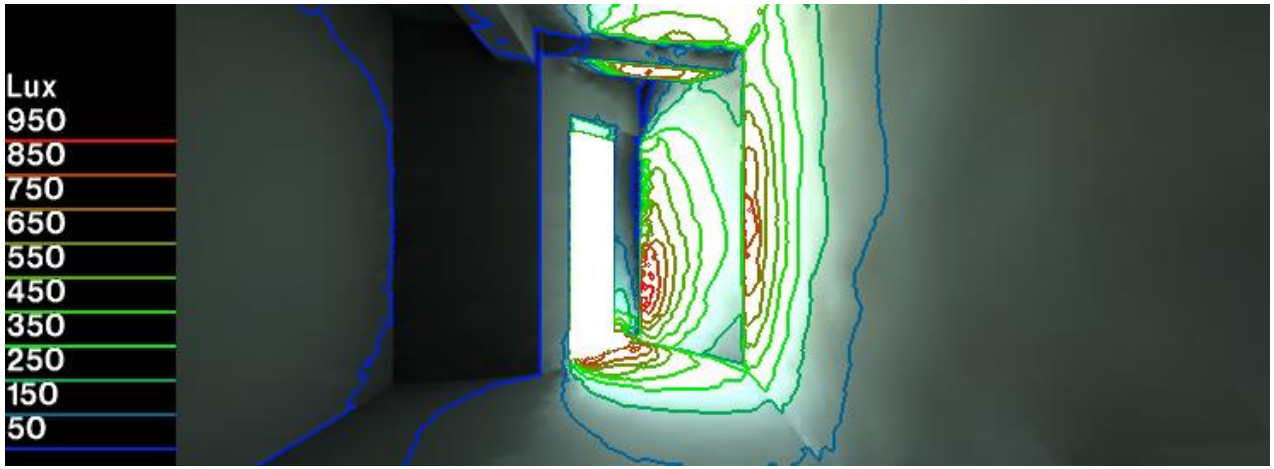
# Analysis | Shoebox

- Thermal Analysis

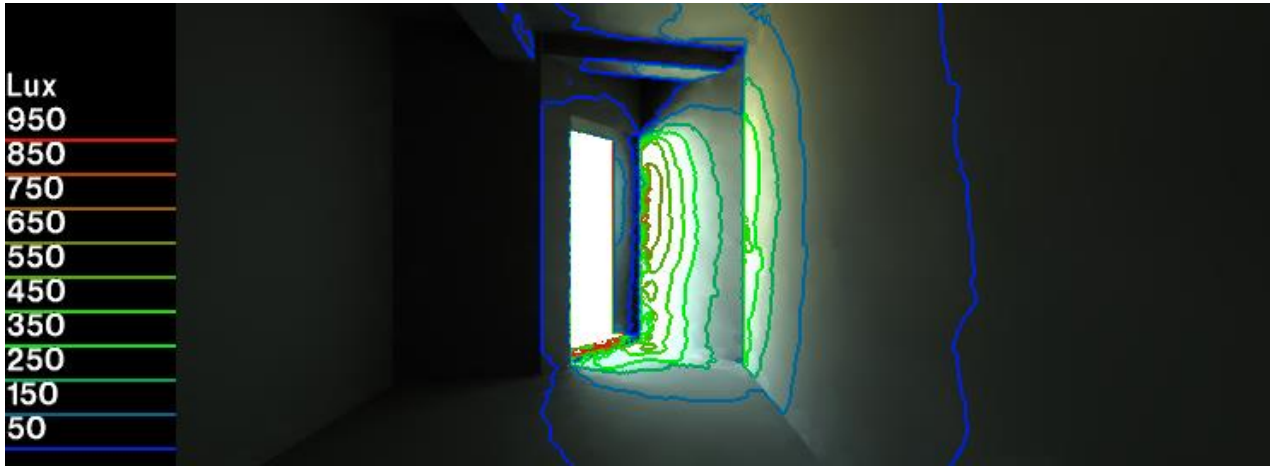


# Analysis | Guesthouse

- Daylighting Analysis




Guest House – Chambre 8
Summer Solstice 12:00




Guest House – Chambre 8
Summer Solstice 12:00

# Next Step | Expected Timeline

## Kick-off

- 01 2016 Site Survey / Design Workshop 1
- 04 2016 Building Permission
- 05 2016 Schematic Design Submission
- 06 2016 Fundraising / Donor Presentation
- 07 2016 Working Progress Report – EKC 2016

## Design Development

- 08 2016 Design Development Stage
- 09 2016 Design Workshop 2
- 10 2016 Construction Starts
- 12 2016 Foundation / Structure Completion
- 01 2016 Construction Site Visit

## Completion

# Next Step | Future Works

- Educational Program

  ✓ Collaborative Engineering Courses w/ University of N'Djamena
  ✓ Training Centre as a Start-up Incubator & Live Case Study

- $200 Housing Prototype

  ✓ Affordable Green Homes for Chad
  ✓ Training for Self-buildable Housing

- Self-sustaining Eco Village

  ✓ Site area: 7.2ha (ca 21,780py)
  ✓ Intentional communities whose goal is to become more socially, economically and ecologically sustainable.