CLIMATE SENSITIVE DESIGN OF A DORMITORY

BY: NAZ JAMAL OMER

Region: Sardenia, Italy

Location: Bosa, 40.296 N 8.497 E

Content

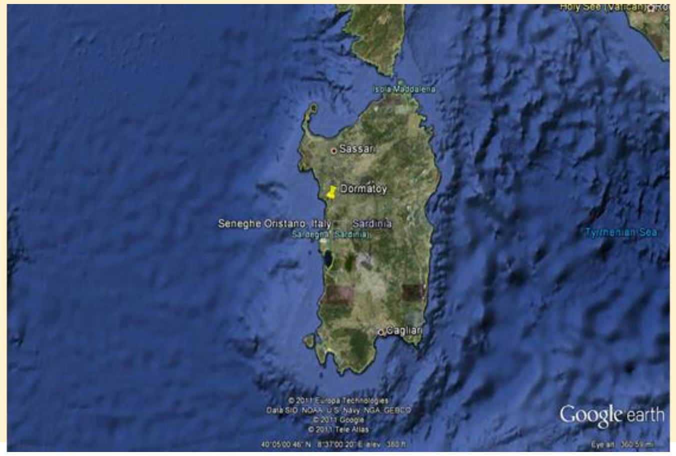
1

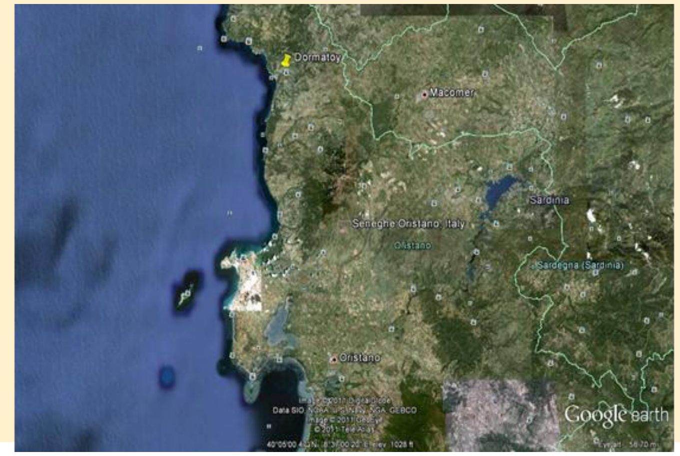
Executive Summary

Overlooking river Temo in the city of Bosa, Sardinia, our team created a 96 student dormitory to serve the students of “Universita Degli Studi Di Sassari.» The design of the building passed through the following phases:

- Climate and Socio-cultural study that combined data from the Klimahause with other sources of data
- A Massing Study
- A climate sensitive strategic study to select appropriate methods of design
- The final design in AutoCad

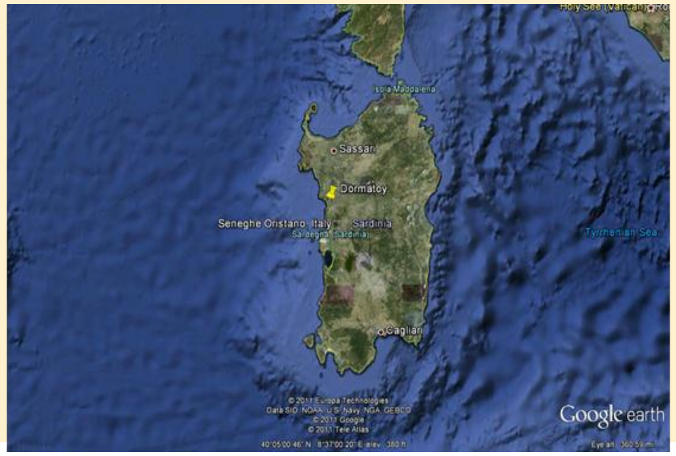
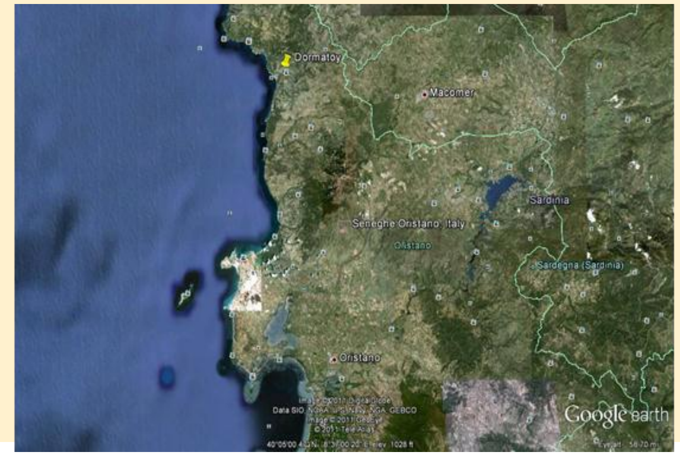
The phases are discussed in detail in this presentation.





2 Site Selection

- 2.1 Climate Zone
- 2.2 Proximity & Accessibility to University
- 2.3 Site Plan


2.1 Site Selection (Climate Zone)

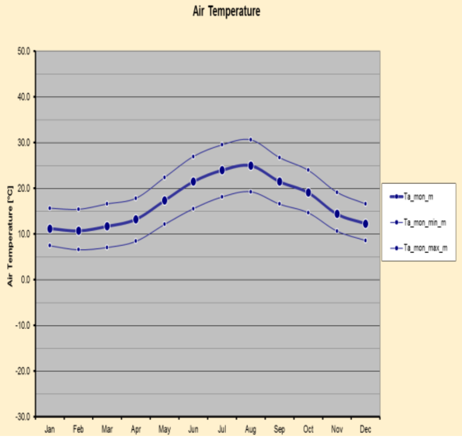
- ## Selection of Klimahause climate zone
  - Our team selected the climate zone exemplified by the city of Seneghe in Sardinia, Italy.
  - Since Meteonorm does not contain data for Seneghe, and since the requirement of site selection is to select a location near an educational institution, we selected the city of Bosa, Sardinia. It is located 25.6 Km North West of Seneghe.
  - The Klimahouse writings in Sardinia's section suggest that northwestern region of Sardinia is cooler than the rest of Sardinia.
  - The student house will serve the educational institution "Universita Degli Studi Di Sassari.»

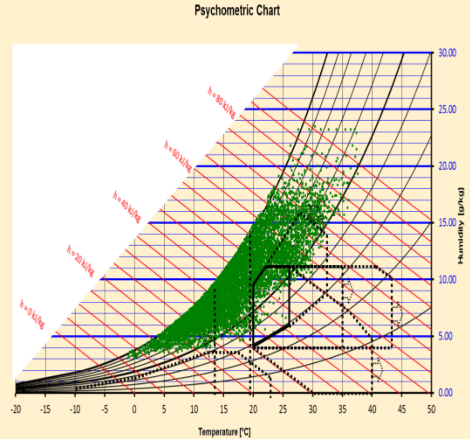
2.2 Site Selection (Proximity & Accessibility to University)

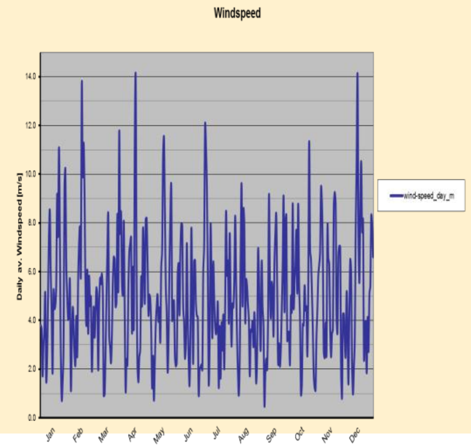
- Proximity
  - The student house is 270 meters away from the campus [1] and accessible via
    - Walking (3 minutes)
    - Biking (less than one minute)
    - Car (less than one minute)

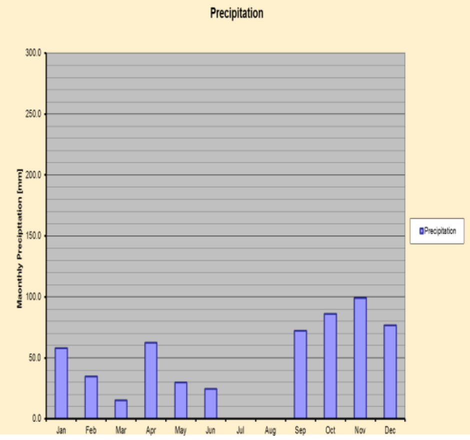
Site Plan (Scale 1: 500)[2]

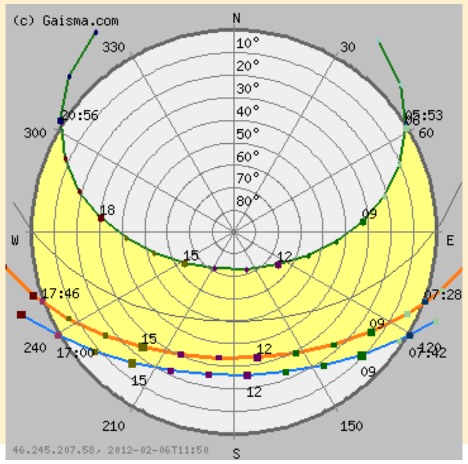
2.3





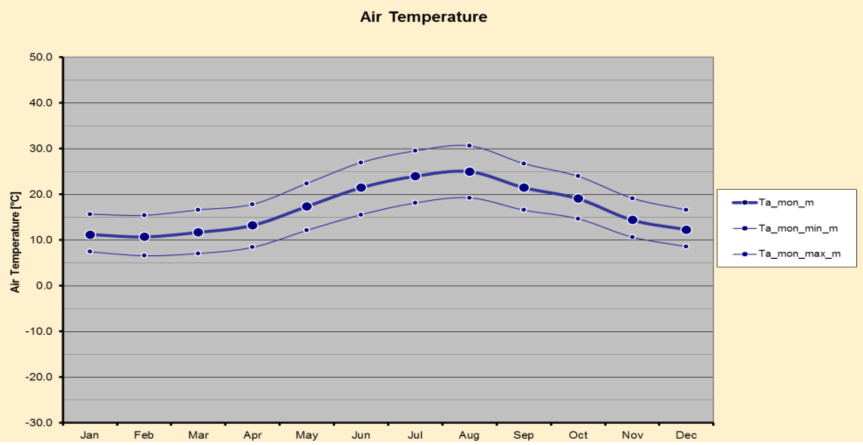


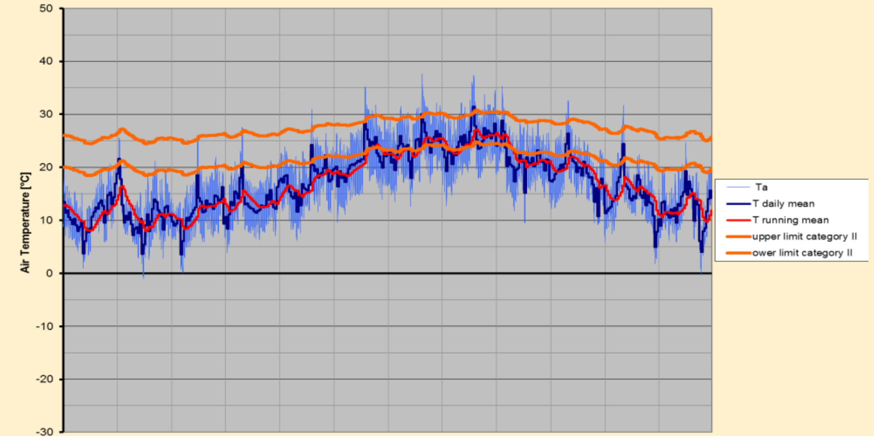


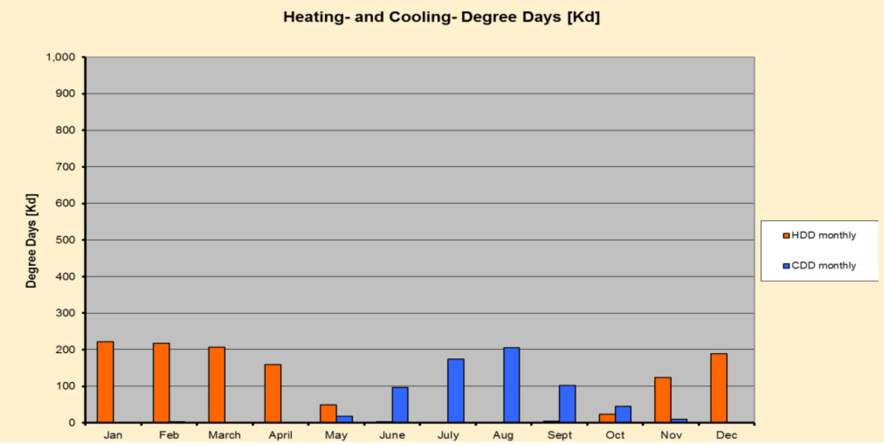


3 Climate Data[3]

- 3.1 Air Temperature
- 3.2 Humidity
- 3.3 Wind
- 3.4 Precipitation
- 3.5 Solar Radiation



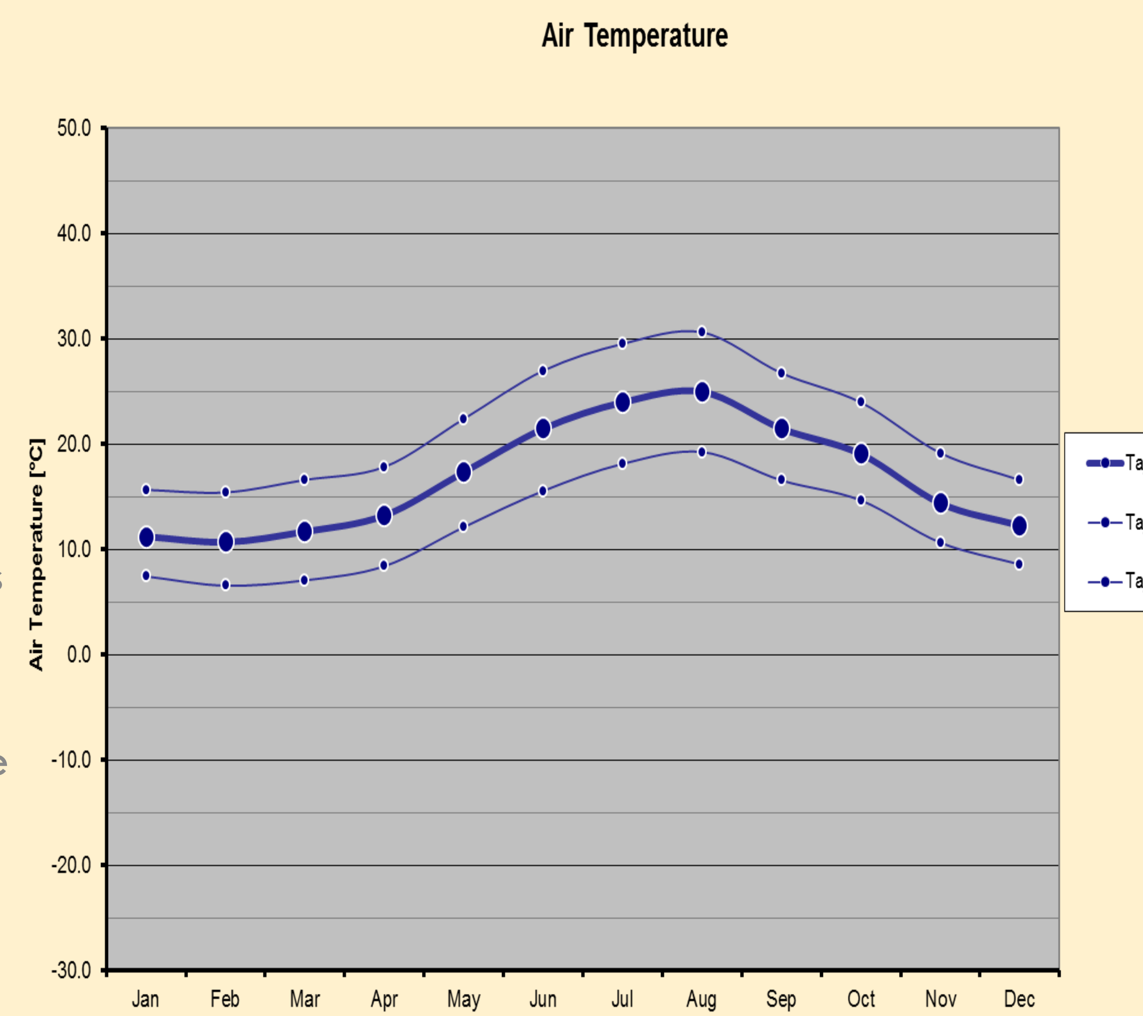


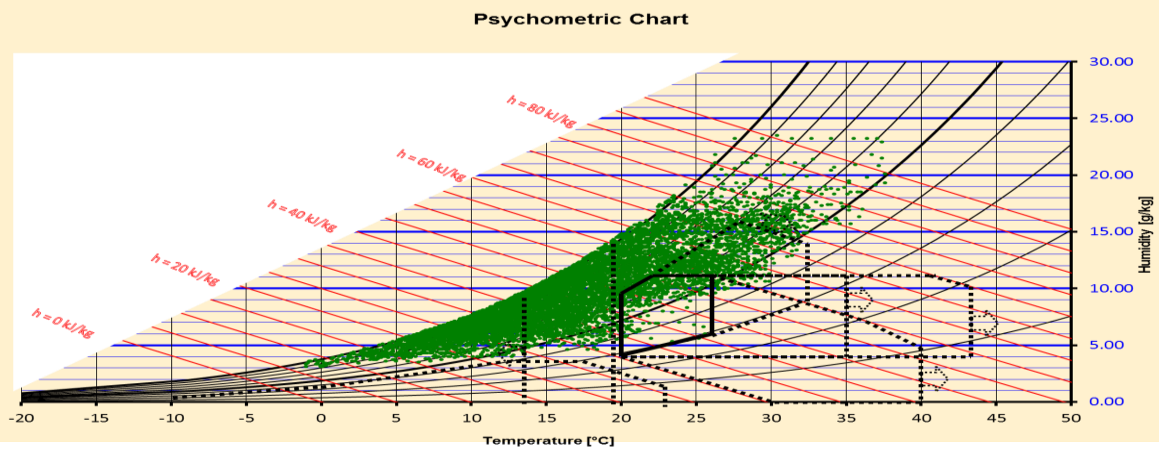


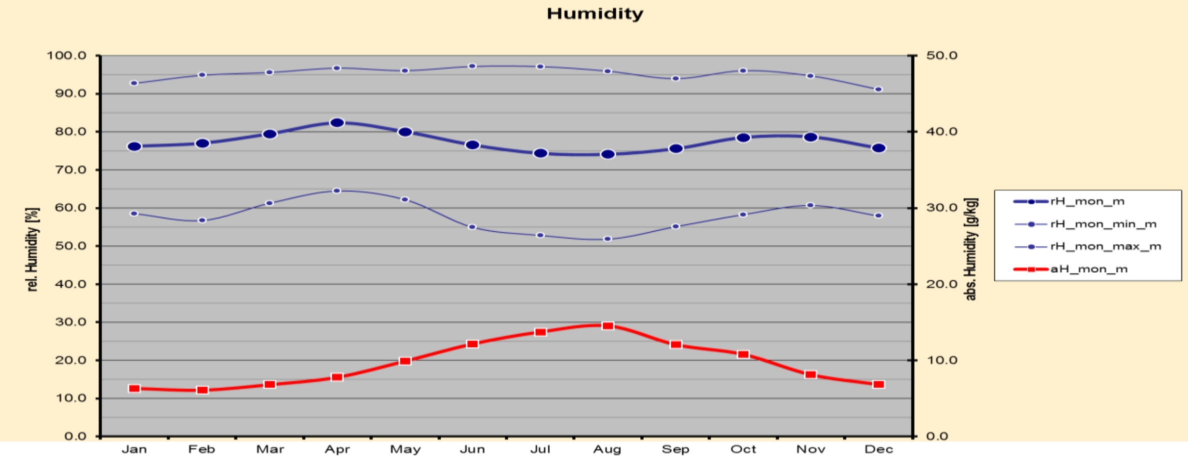
3.1 Climate Data (Air Temperature)

- The analysis of the air temperature annual data reveal the following observations:

1. Maximum & minimum air temperatures after removing outliers are 31 C and 6 C, respectively.
2. While the climate perception from the klimahause that it is mostly hot and humid, the air temperature data reveal that heating degree days are higher than the cooling degree days (6 months HDD, 2 months mixed, and 4 months CDD)
3. The reason for observation no 2 is according to Klimahause notes" The northwest of Sardinia is cooler and has higher precipitation as the southeast, but in summer the entire island is suffering under scorching heat. The vegetation is dying out threateningly; the danger of forest fire is rising constantly. Agriculture is possible only with artificial irrigation and water levels of rivers are lowering so deep that water even has to be rationed."
4. The night/day variations are wide enough to consider cooling methods such as night flushing (min temperature is always below 20 C even during the hottest month.)
5. Passive solar solutions will be the primary heating strategy since winter temperatures are relatively mild. But too cold to be only compensated by internal gains throughout the year

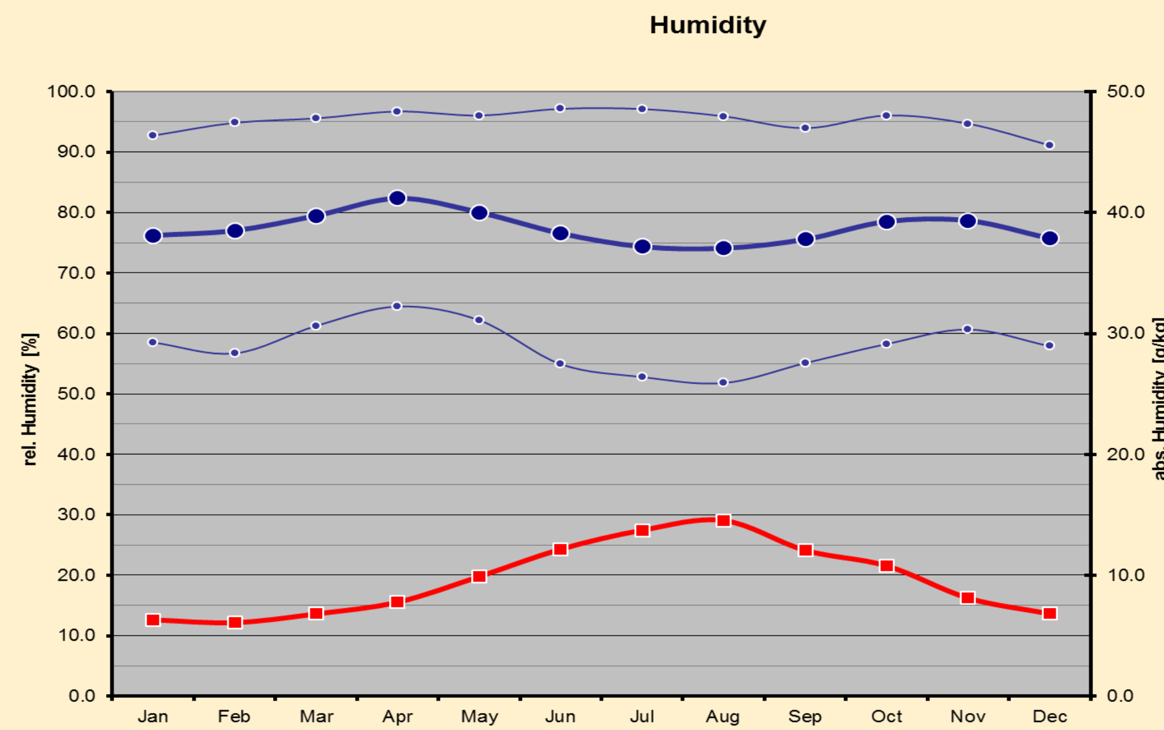


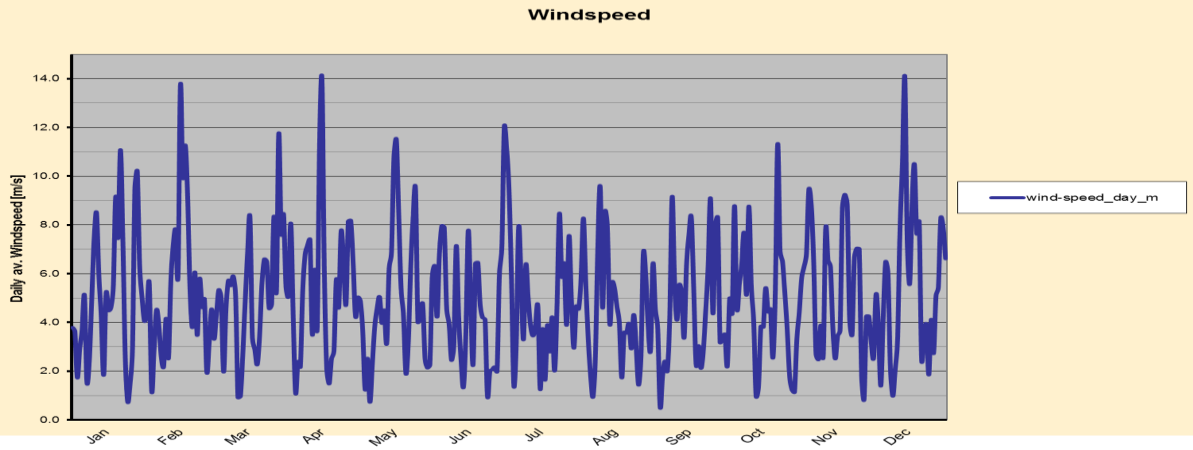


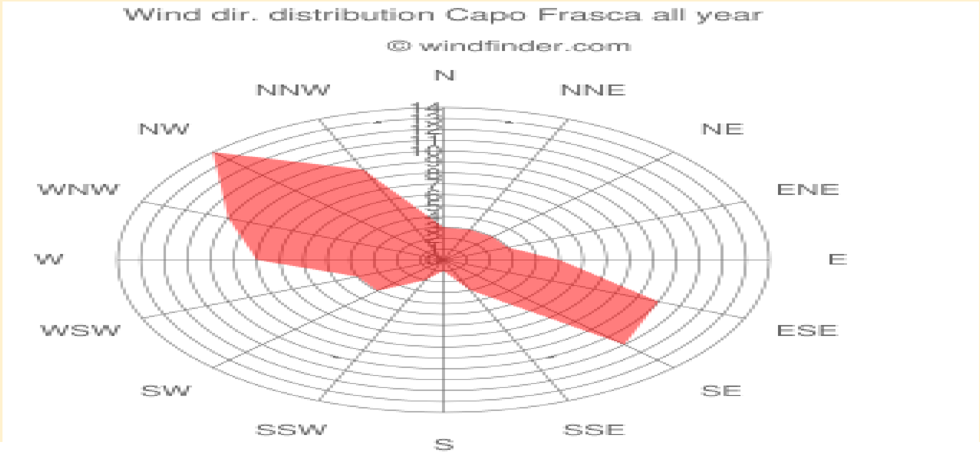


3.2 Climate Data(Humidity)

- The analysis of the humidity annual data reveal the following observations:
  1. The absolute humidity is between 10 and 15 g water/kg dry air during the hot months. And never below 6 g/kgair throughout the year.
  2. Because of the absolute humidity data, evaporative cooling methods would be practically useless.
  3. The wide range of the relative humidity between day and night confirms the wide daily temperature variations.

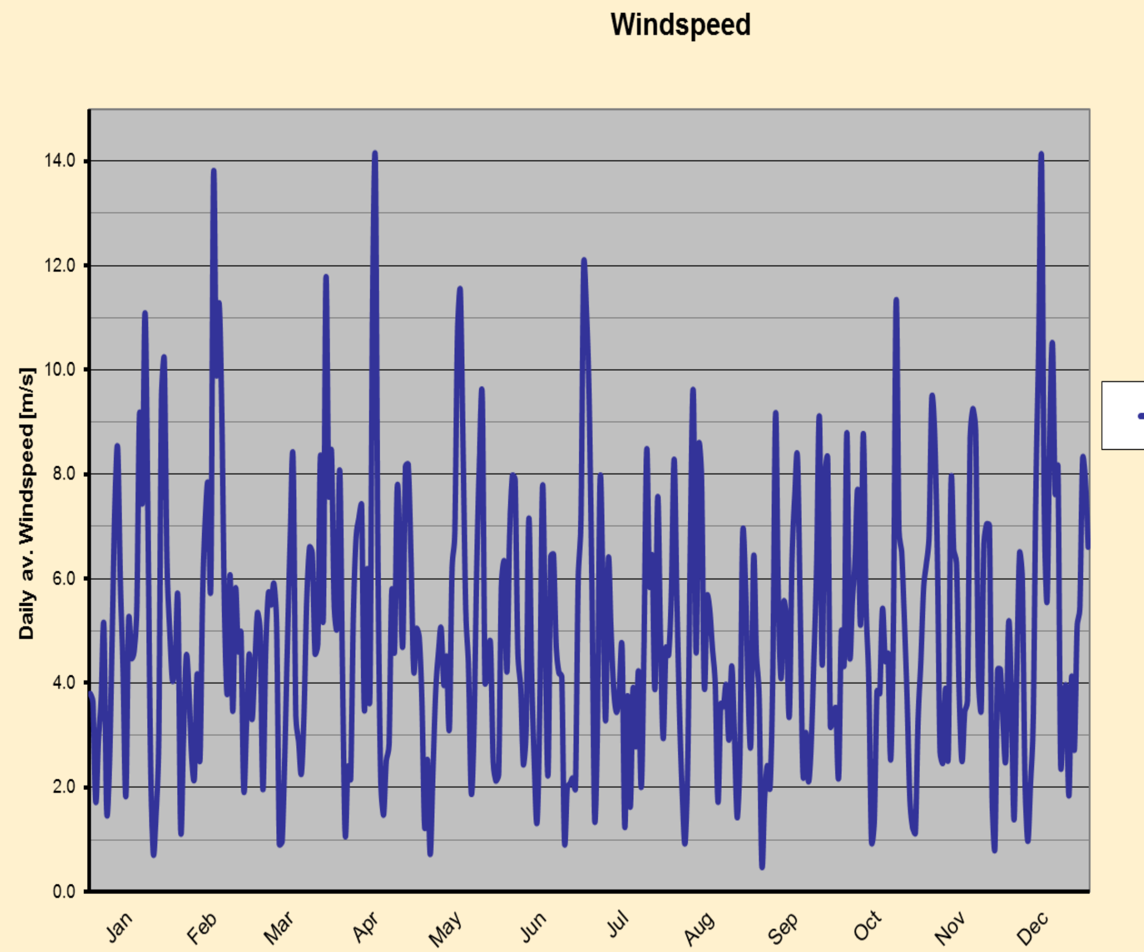


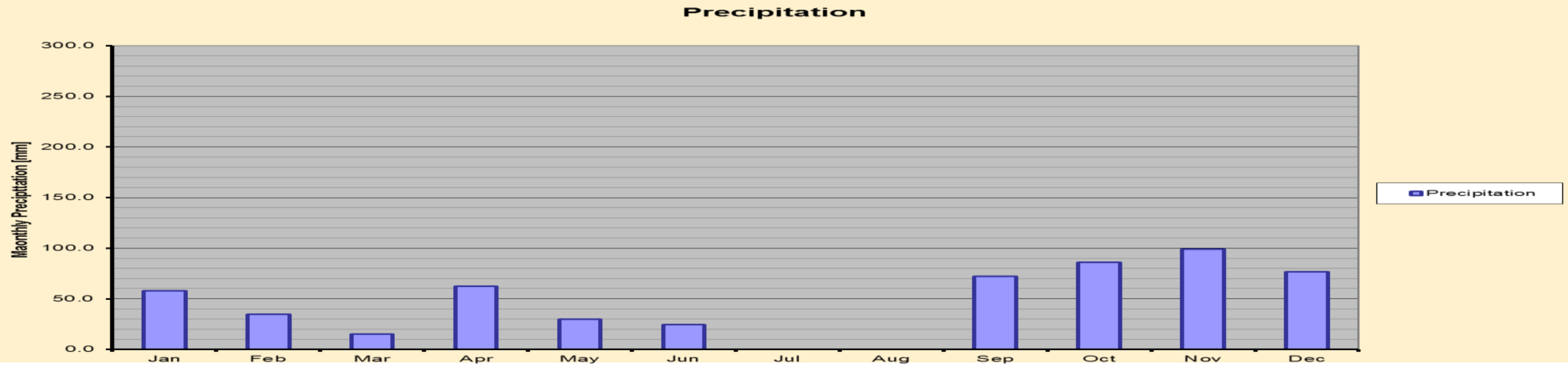




3.3 Climate Data(wind)

- The analysis of the wind annual data reveal the following observations:
  1. The wind is almost consistently strong and uni-directional, from NW-SE or from SE-NW
  2. The sirocco wind carries a lot of humidity along with Sand from the southeast especially in the summer months.
  3. From observation 1, the winds can be used as method of outer wall cooling through convection
  4. From observation 2, protection is needed to avoid sand infiltrations.

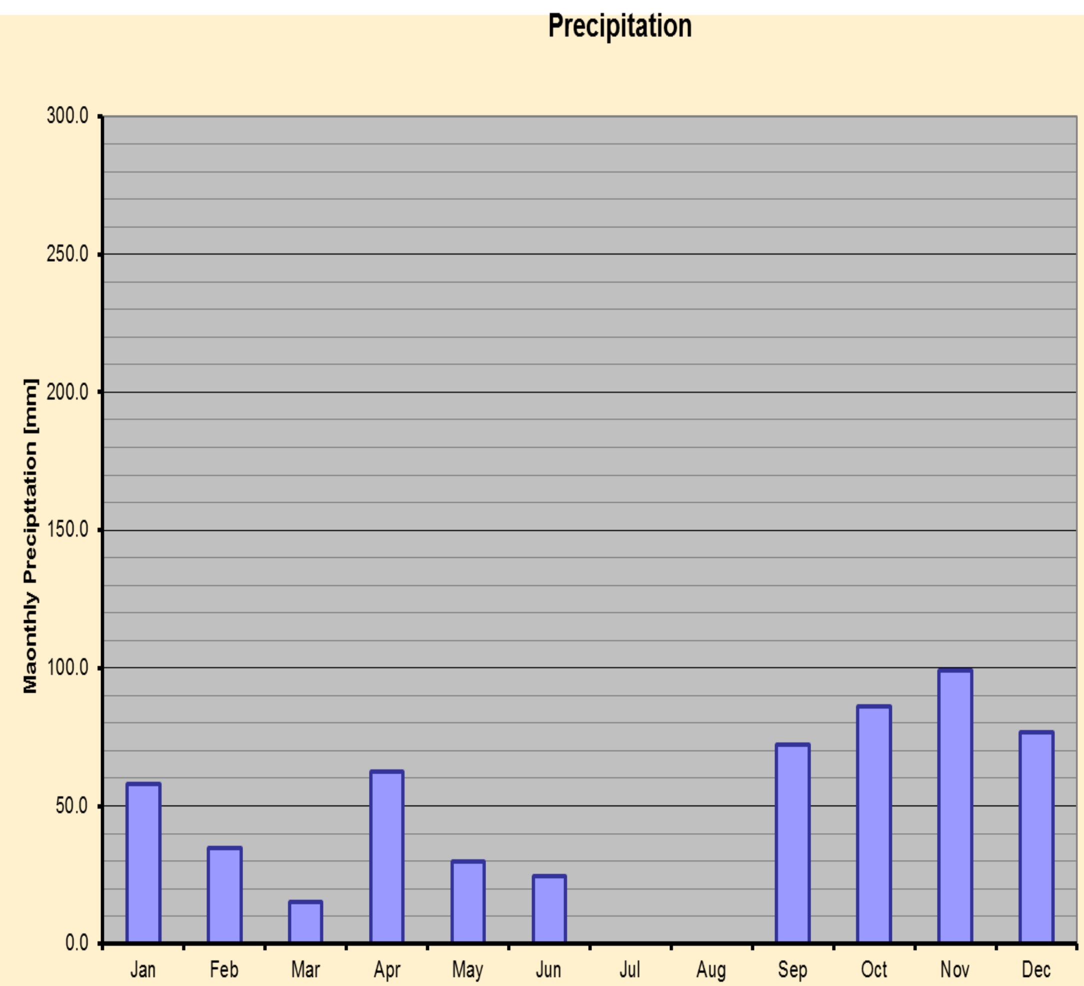


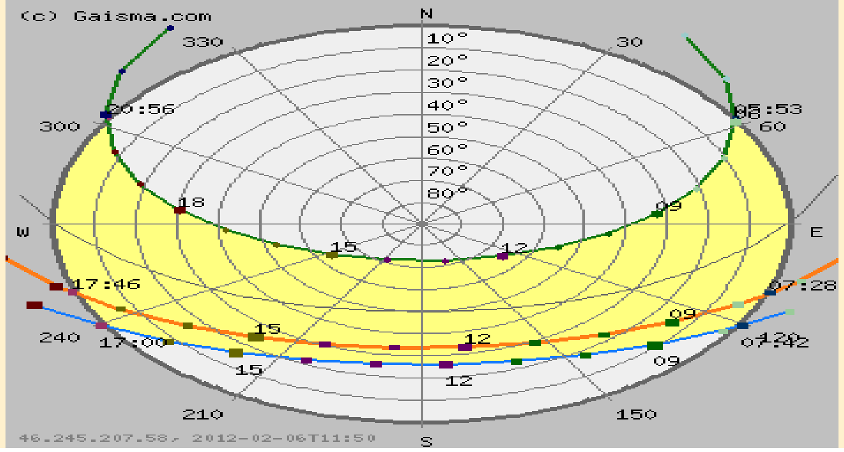


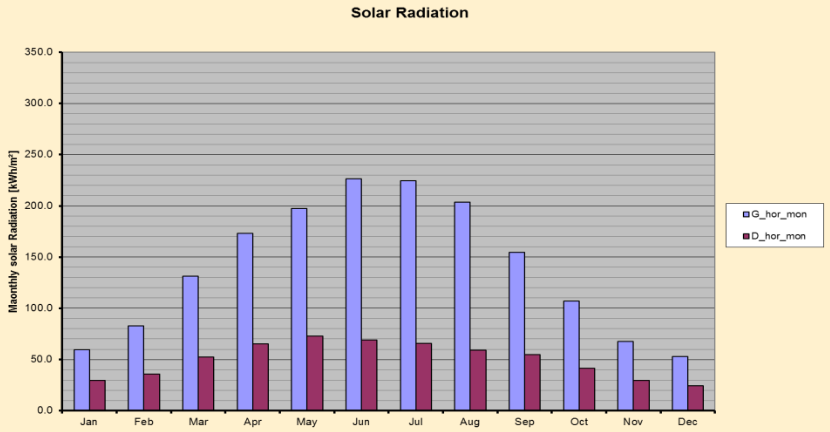
3.4 Climate Data(precipitation)

- The analysis of the precipitation annual data reveal the following observations:

1. There is zero rainfall in July and August, 15 mm monthly in March, and a maximum of 100 mm in November
2. On average, the monthly rainfall for the year is 47 mm. But more than 80% of the yearly precipitation is falling in September until March. But that doesn't mean continuous rainfall. Because on average there are just 65 rainy days in Sardinia, that means days with more than 1 mm precipitation.
3. The data confirms the observations from the klimahause about aridity complaints because the rain comes intensely but in very short periods of time. Therefore, the benefits of these rain is limited with what earth could carry. Unfortunately, it does not carry much because of deforestation and agriculture
4. Tourism overuse of water as well as the decaying water infrastructure also contribute to the problem of wasting precious amounts of water.



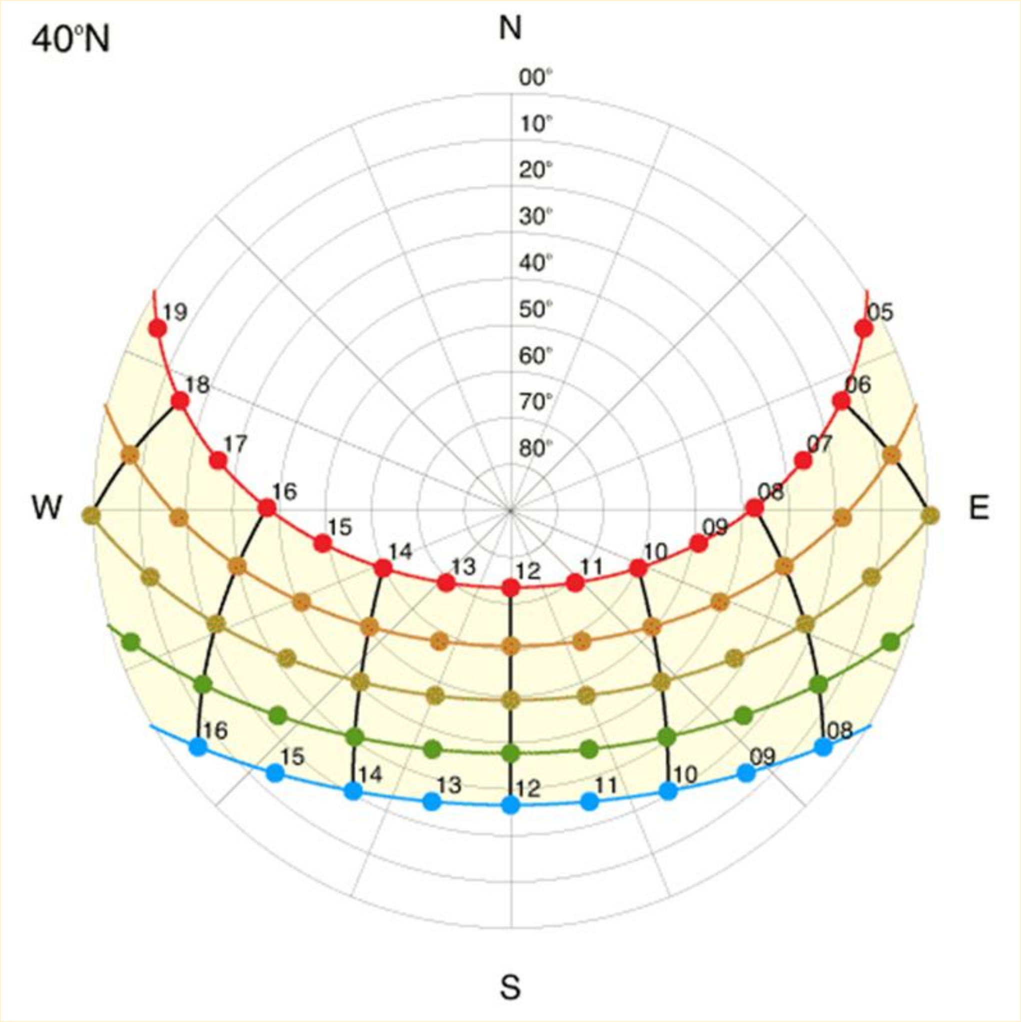




3.5 Climate Data(Solar Radiation)

- The analysis of the Solar Radiation annual data reveal the following observations:

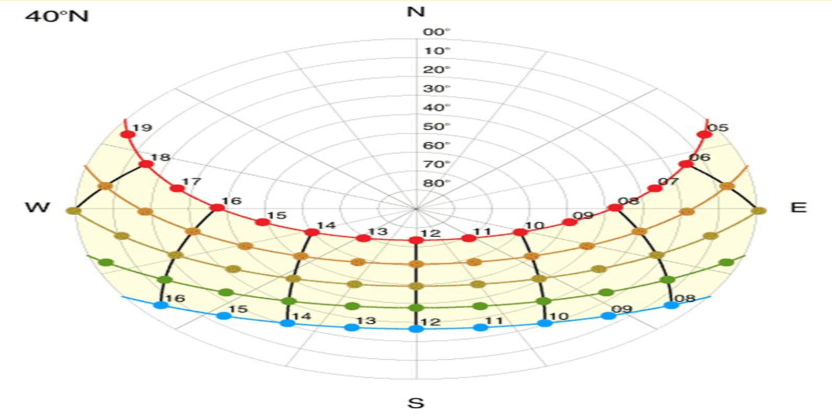
1. The sun is southern in Bosa, which means that the southern, southeastern, and southwestern facades, as well as the southern part of the roof, get the majority of the solar radiation.
2. Sardinia's average annual hours of sunshine: 2635 h [5]. Which means that daylight exists 30% of annual hours.
3. The diffused portion of solar radiation is approximately 20% of the direct solar radiation in the summer.
4. Given the nature of the location (open space from the south, south west and most of the south east), local shading is negligible.

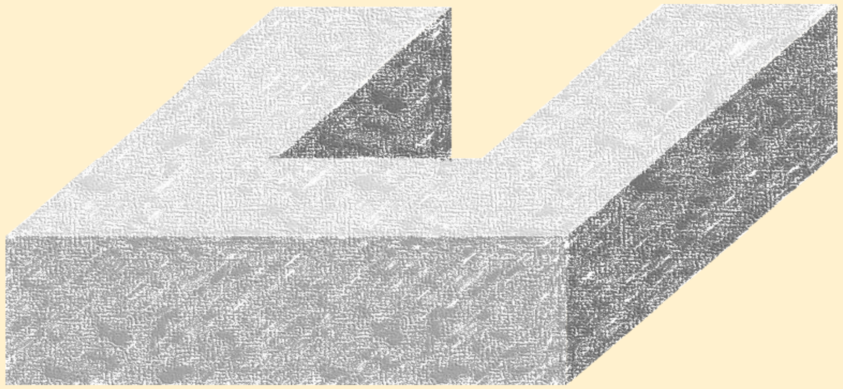
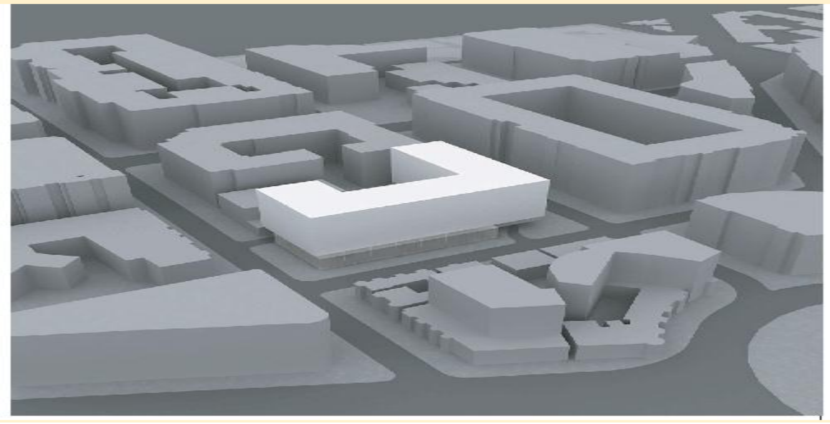


4 Socio-Cultural Factors

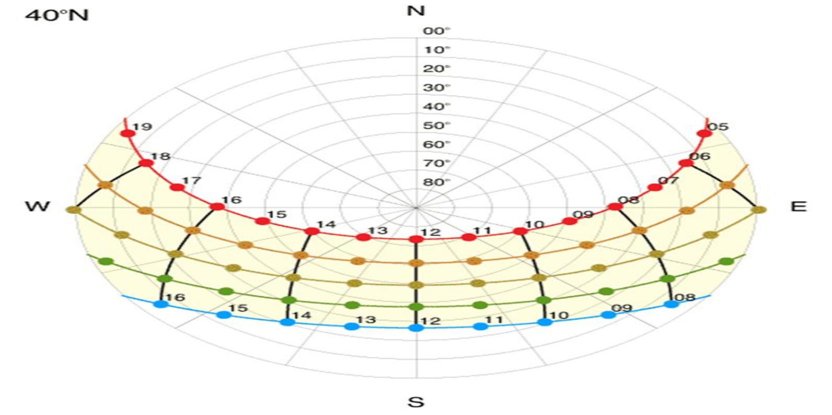
- While the socio-cultural factors for Sardinians are typically Mediterranean, the fact that we are designing a student dormitory makes the study of these factors both, simpler and distinctive.
- For example, students are always less wealthy than the average Sardinian. And, therefore, compactness, efficiency, and simplicity will have much more influence on the design.
- Also, the building usage during the summer is less critical than normal because of the mild usage of student houses during summer vacations. However, The student house facilities can be utilized by the community during summer.
- Building Materials
    - Historically, Sardinians built on raw earth using stones (volcanic stone such as granites, basalts, tuff and trachyte alternating with metamorphic schist or sedimentary stones like sandstones and lime stones), wood, and Adobe. [6]
    - Nowadays, natural stones is still in use along with concrete, wood, ceramics, plastics, steel and fired bricks

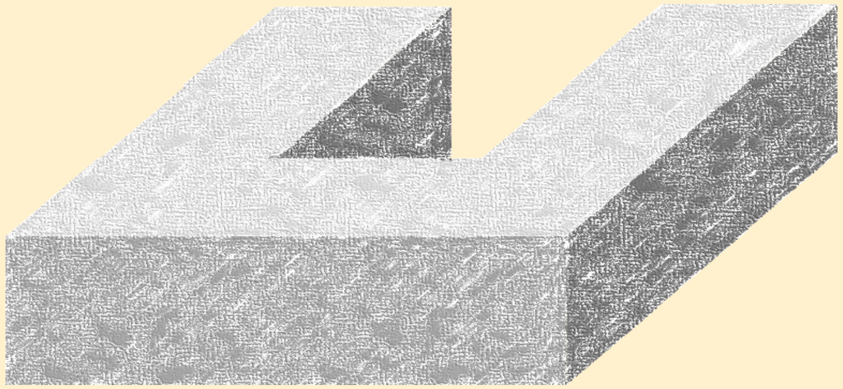
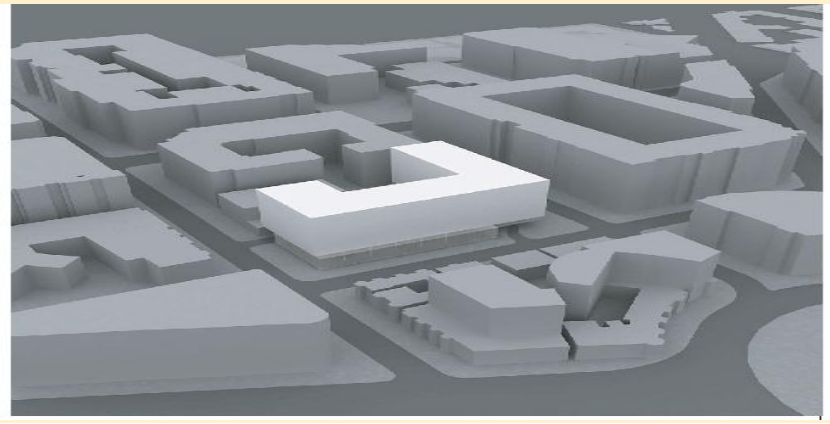


5 Massing Study

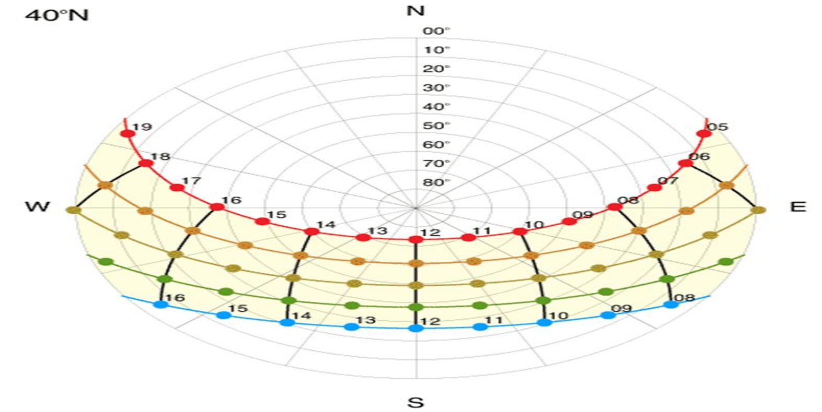
- 5.1 Conceptualization Criteria
- 5.2 Shape Selection

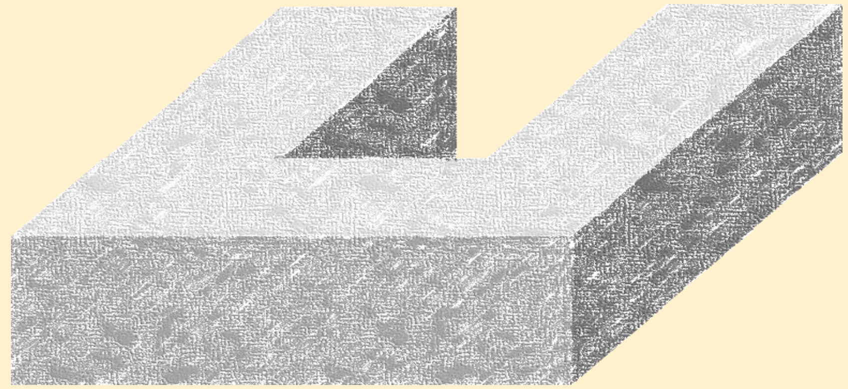
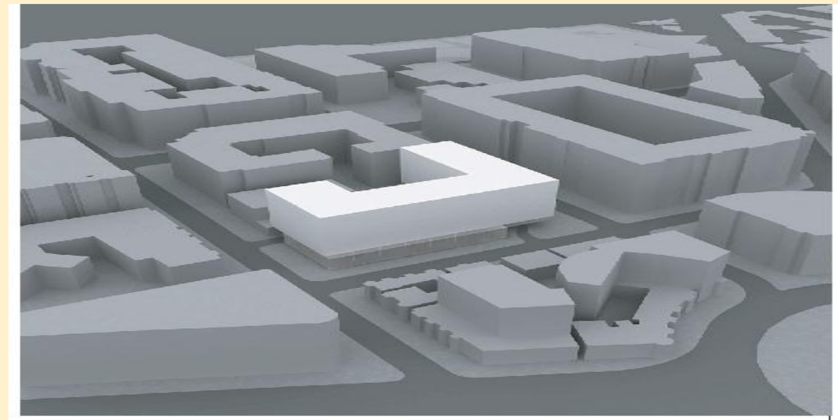


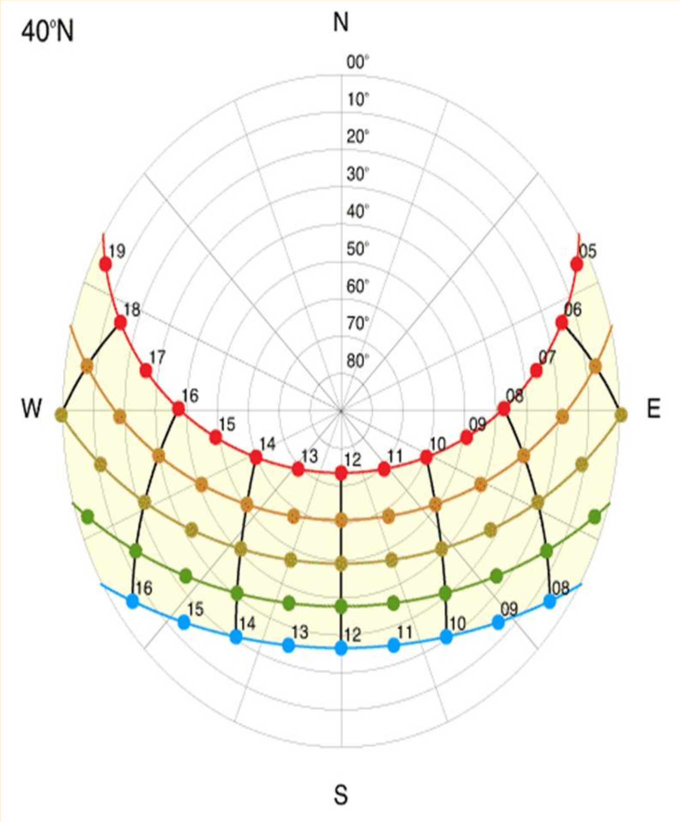
5.1 Massing Study(Conceptualization Criteria)

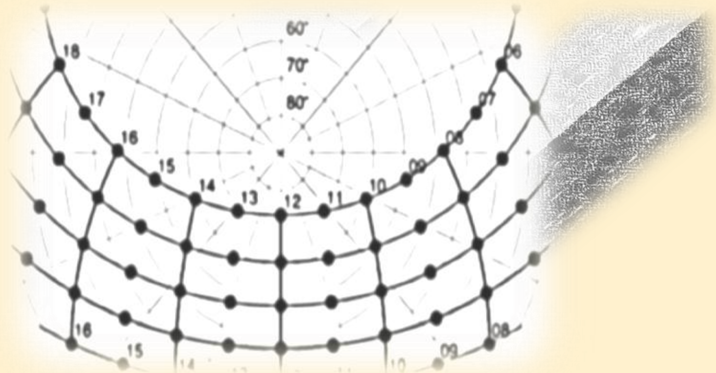
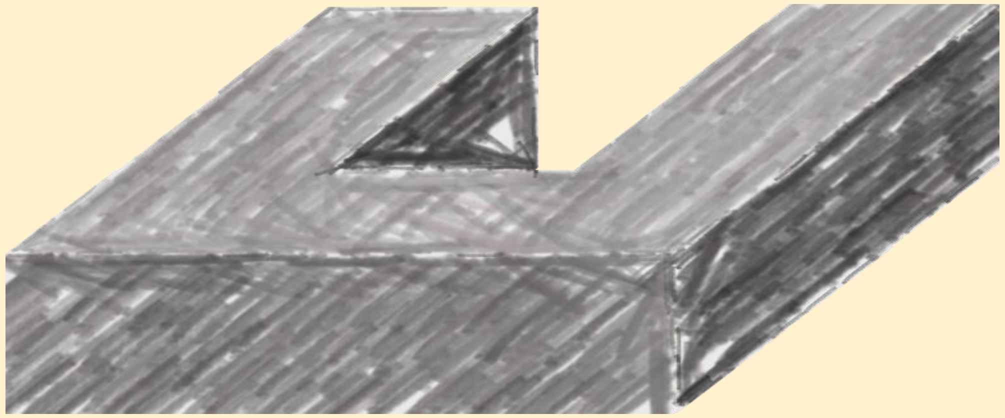
- Based on the climate data, the building use, and the sustainability principles, the team decided on the following criteria to visualize the building shape:
  - Ability to accommodate solar energy harnessing solutions
  - Protection from wind
  - Compactness
  - Simplicity
  - Efficiency
  - Heat Retention/Rejection
  - Lighting Comfort.

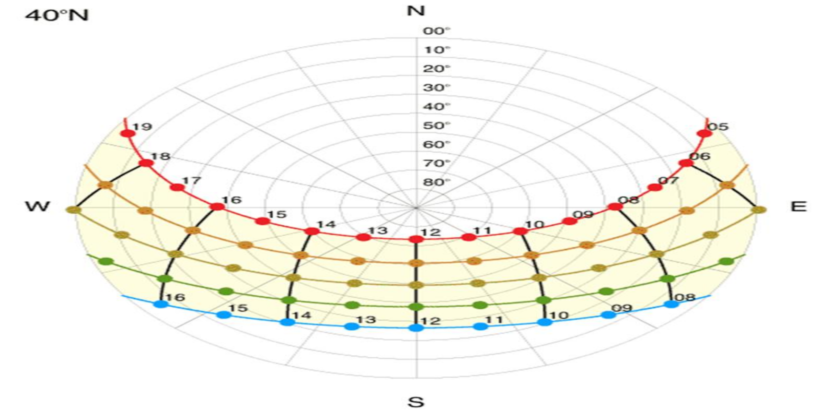


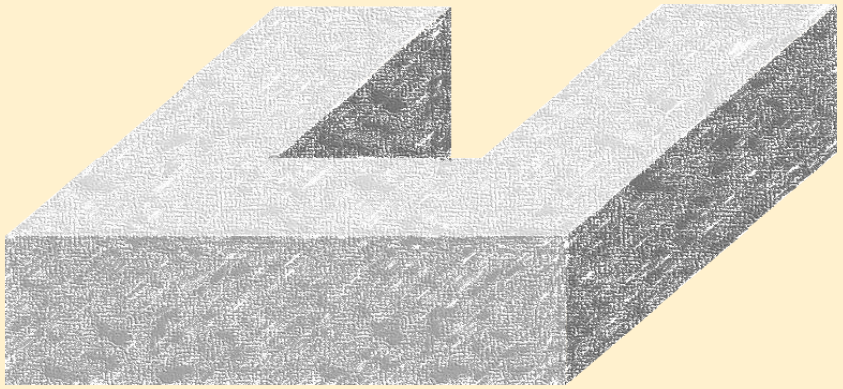



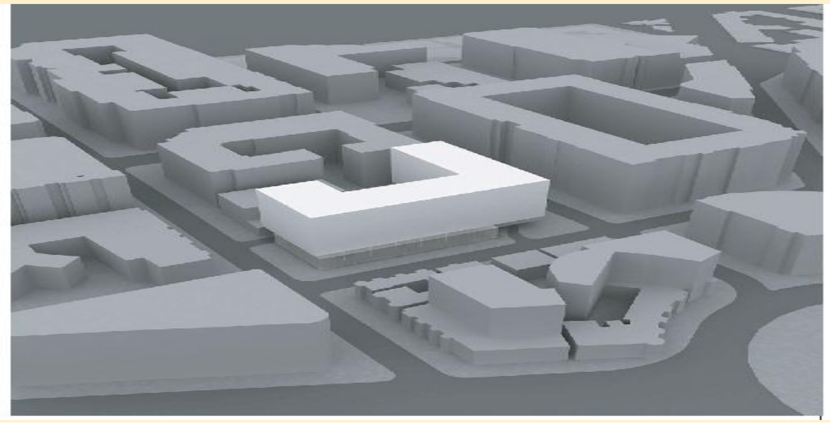
5.2 Massing Study(Shape Selection 1)



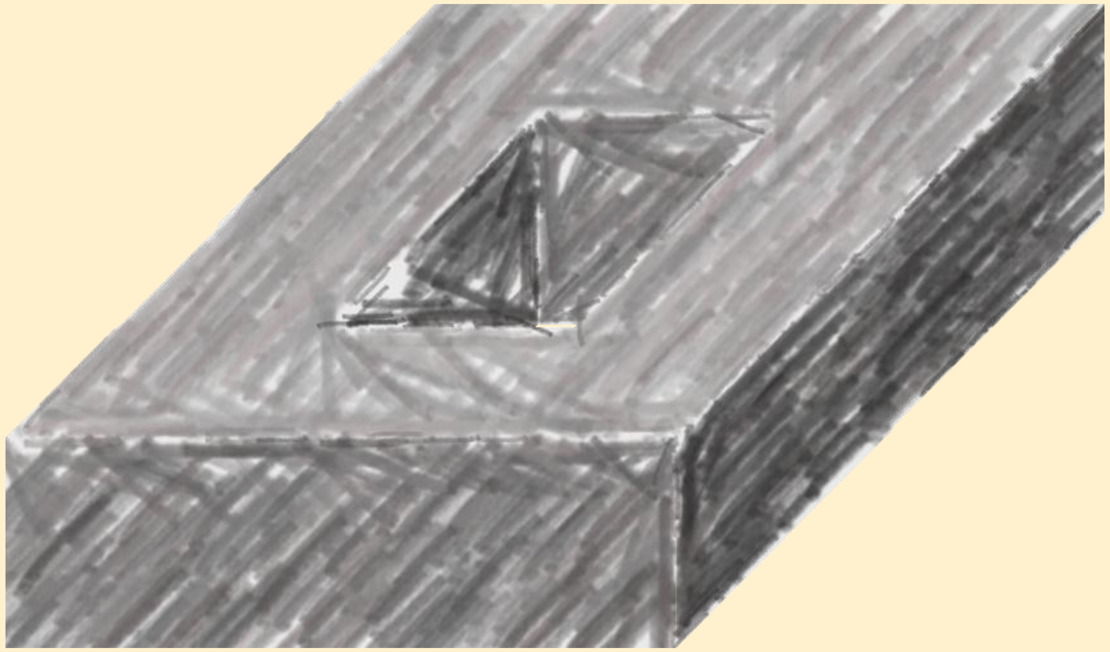



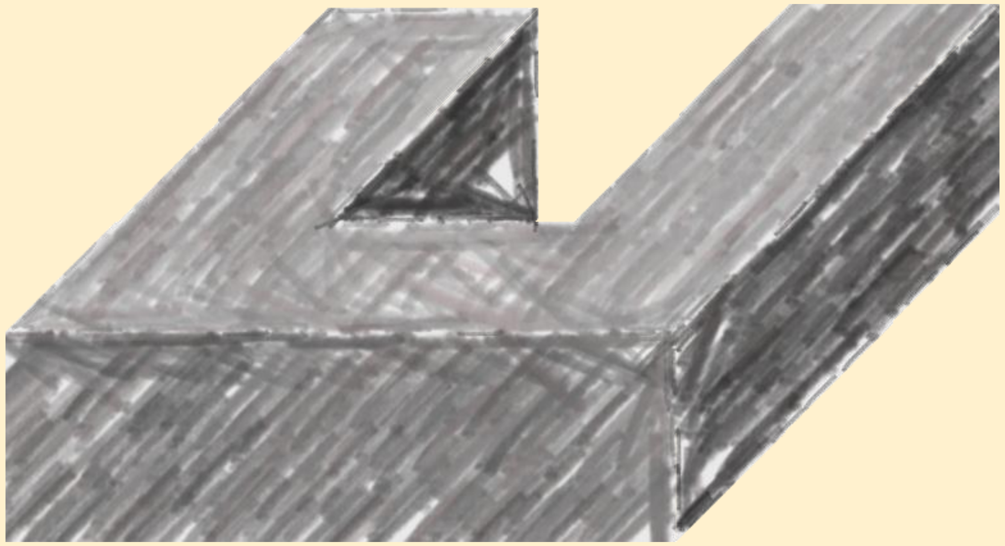


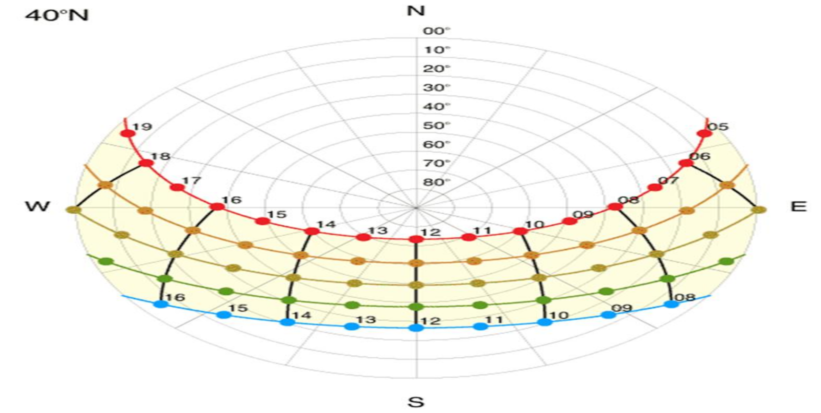


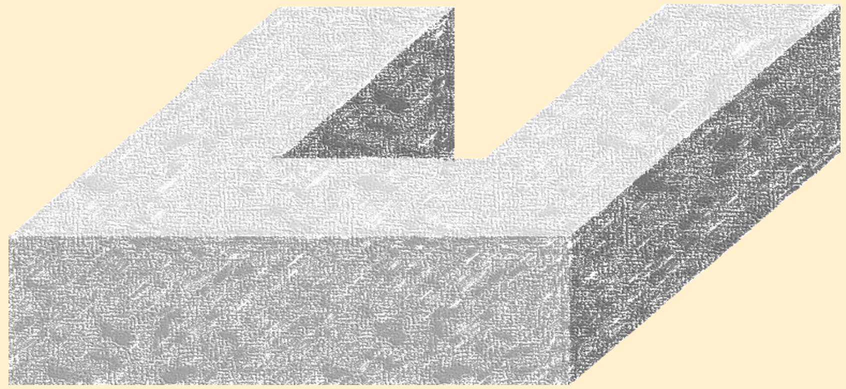
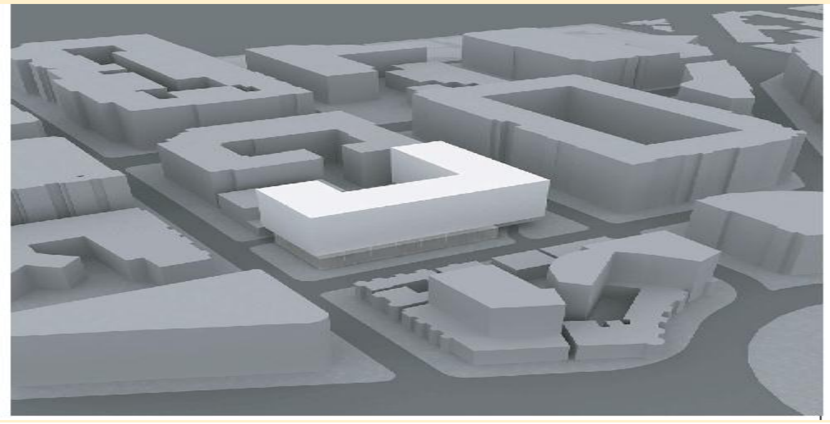


5.2 Massing Study(Shape Selection 2)

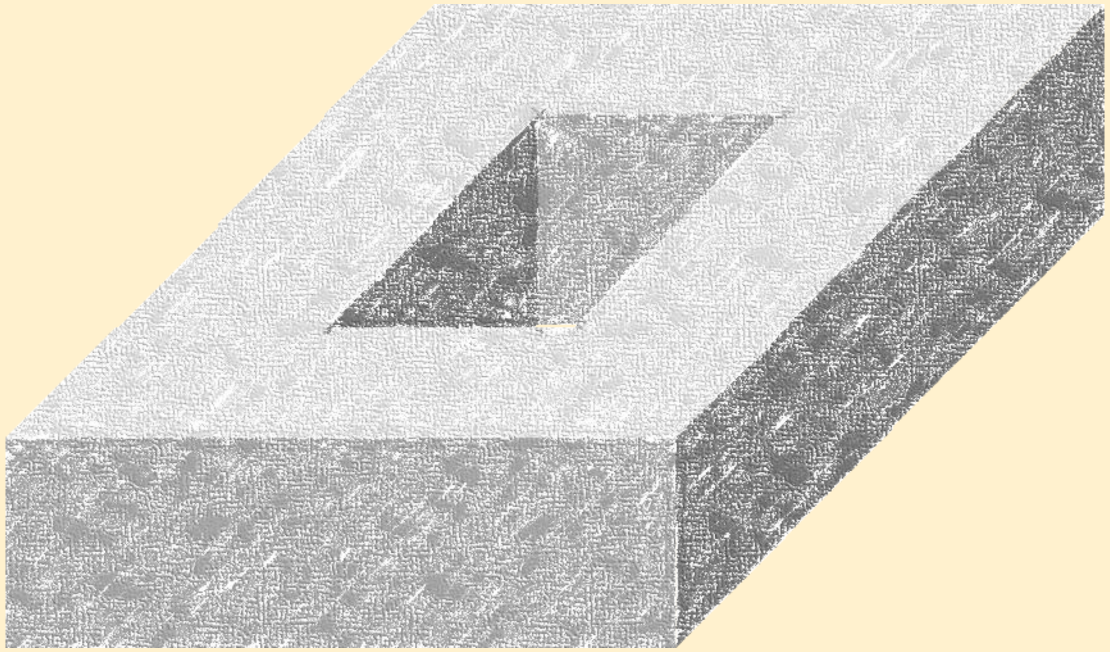
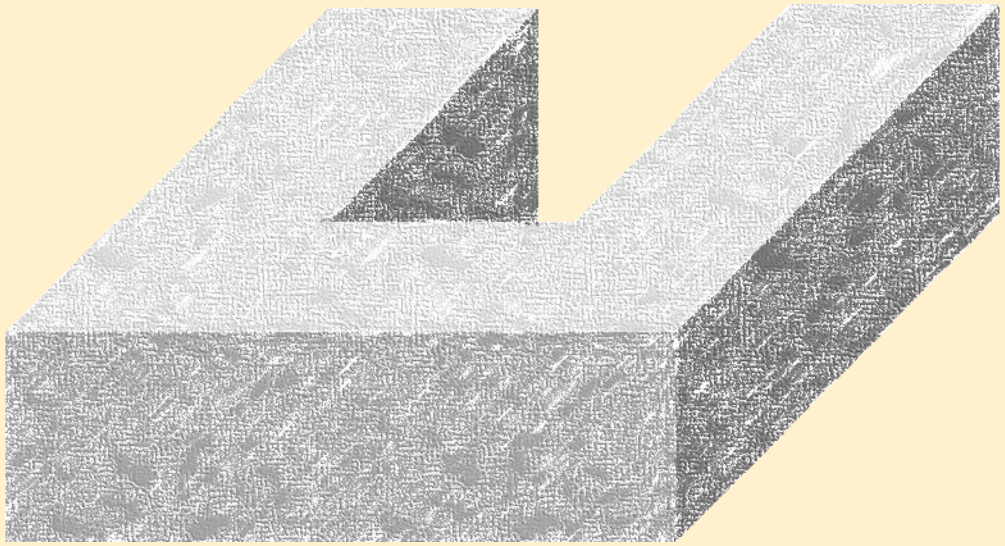






5.2 Massing Study (Shape Selection 3)

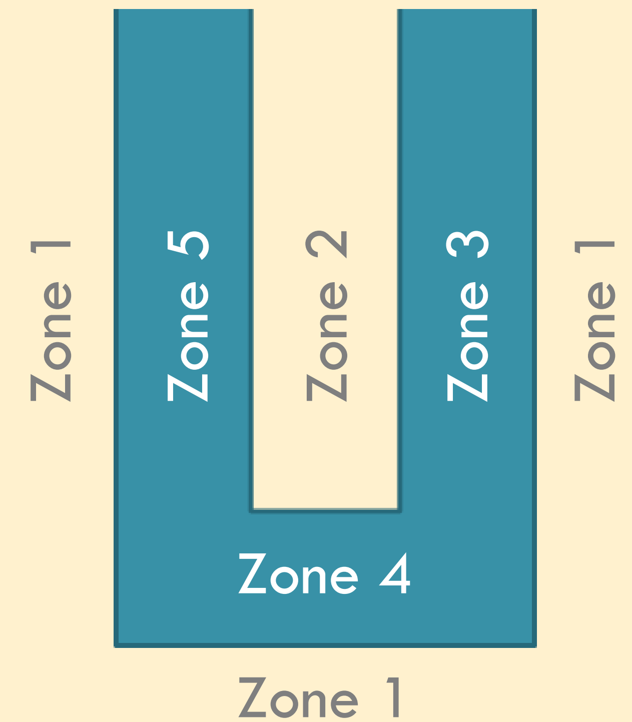



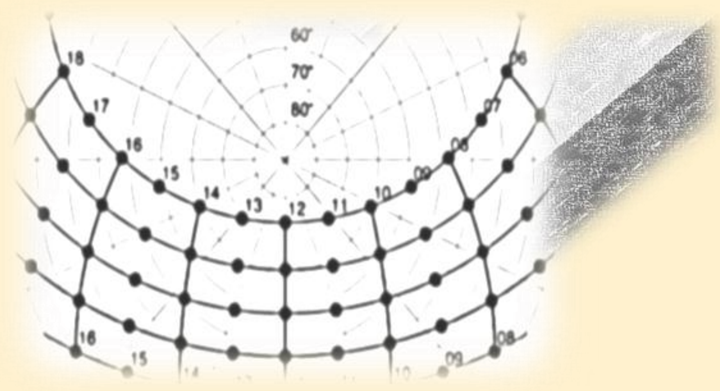

6 Design Strategies

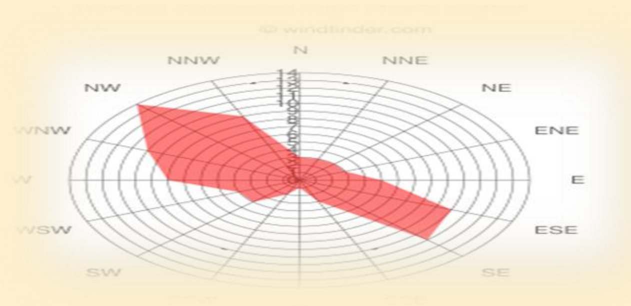
- 6.1 Building Introduction
- 6.2 Primary Design Strategies
  - 6.2.1 Tier 1 Basic Building Design
    - Building Orientation for Solar Gains & Wind Protection
    - Climate zoning through outdoor garden
    - Windows Sizing & Movable Shutters
    - Night Flushing
    - Insulation
  - 6.2.2 Tier 2 Passive Systems
    - Roof PVs for lighting and appliances
  - 6.2.3 Tier 3 Active Systems
    - Direct Solar water/wall heating
    - Outdoor dehumidification through condensation
- 6.3 Secondary Design Strategies

6.1 Design Strategies (Building Introduction)

- The following definitions help clarify the discussions in this section:
  - The Building: looking over the Temo River, the building is a two-story U shaped Student House where the horizontal front of the building (Zone 4) is oriented to the South with an approximate 20 degrees inclination to the west. Each floor is 3.5 meters high to increase
    - 1) tenants' level of comfort through extra room height,
    - 2) Solar gains on outer walls,
    - 3) Shading in the garden (Zone 2), and
    - 4) Wind protection.
  - The Zones:
    - Zone 1: Means the climate uncontrolled zone surrounding the building. In other words, south of zone 4, west of zone 5 and east of zone 3.
    - Zone 2: is the climate enhanced garden surrounded by the building.
    - Zones 3,4,5: are the different sides of the student house itself

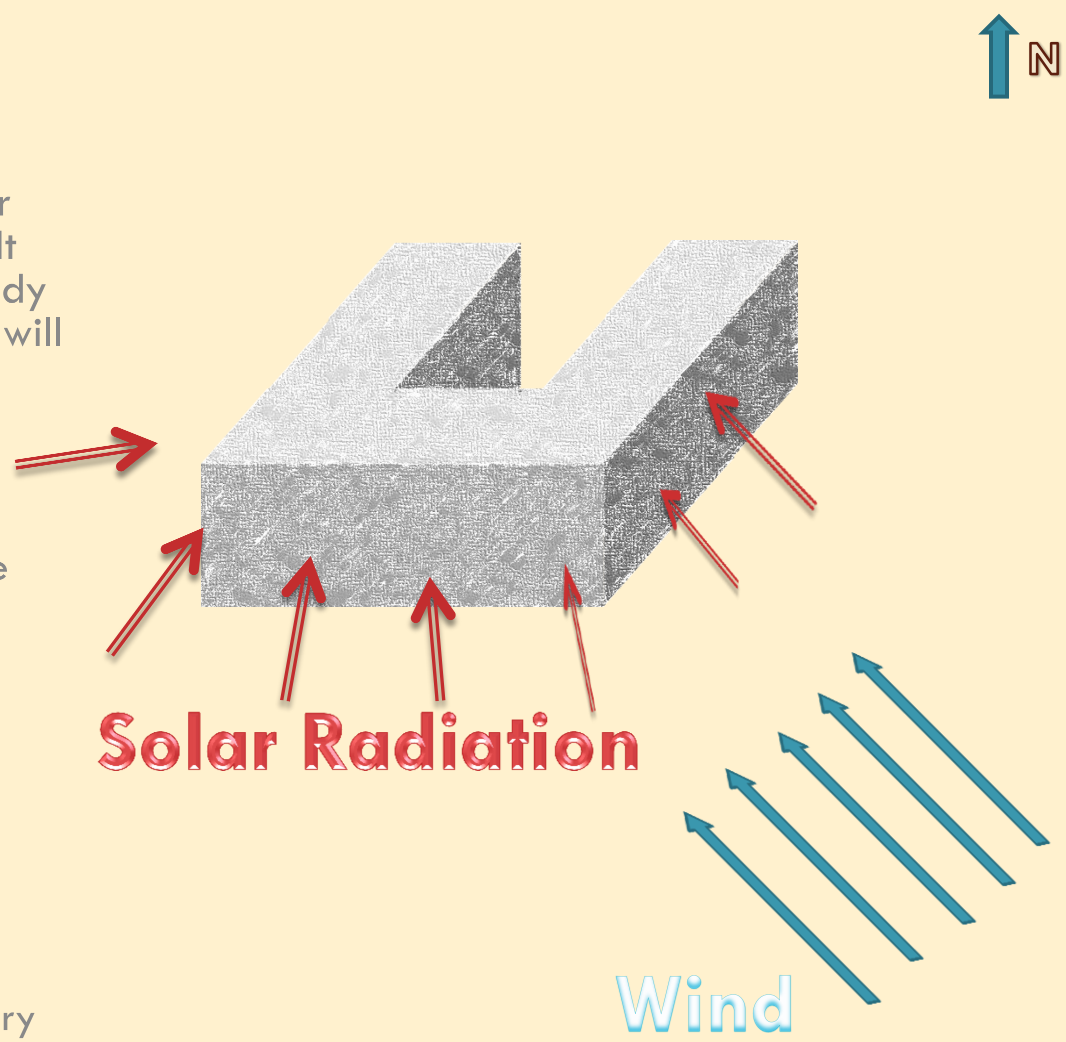


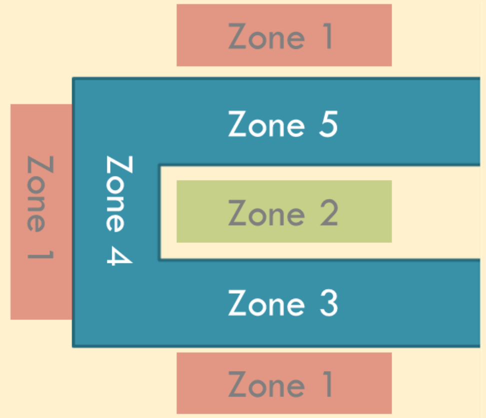


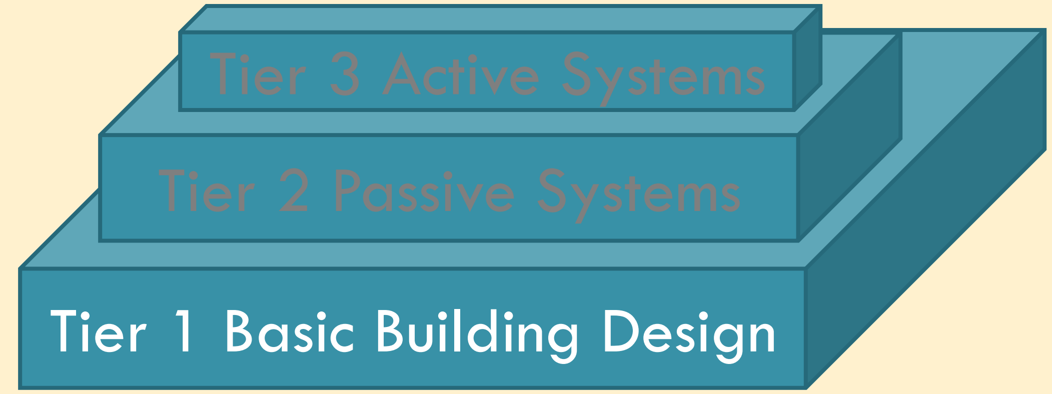


6.2.1 Design Strategies(Primary: Tier 1 Basic Building Design)

- Building Orientation for Solar Gains & Wind Protection:
  - Strategy Description:
    - Both, placing the building as illustrated, and increasing the floor level to 3.5 meters result in larger exposure to solar radiation. It also protects the outdoor recreation area (Zone 2) from the windy /dusty conditions throughout the year. Additionally, the garden will be naturally shaded most of the day.
  - Strategy Effect on:
    - Winter (Heating Days)
      - Solar Radiation more intense due to larger exposed surface area.
    - Summer (Cooling Days)
      - The increased solar radiation will be offset by
        - Smaller windows
        - Movable shutters
        - Wall insulation
    - Lighting
      - Windows of the Southern, SE, & SW facades are the primary source of sunlight in the building

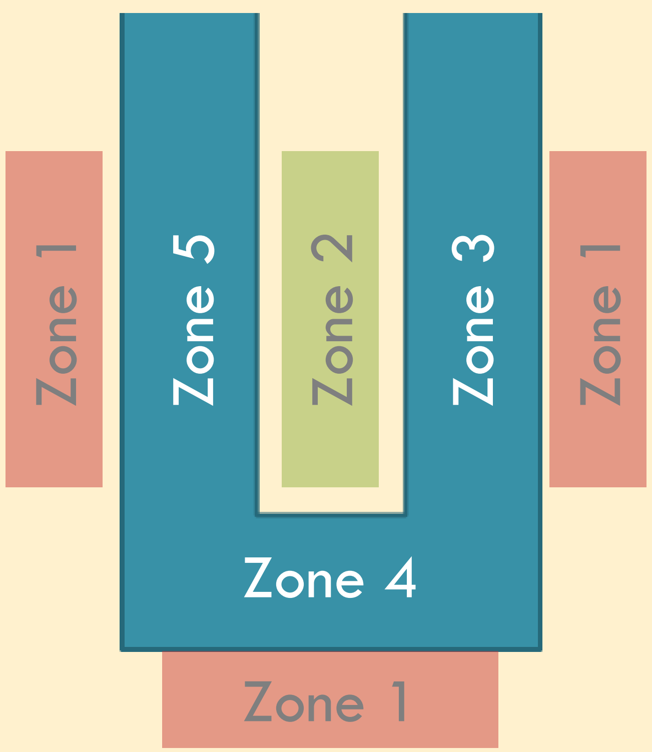






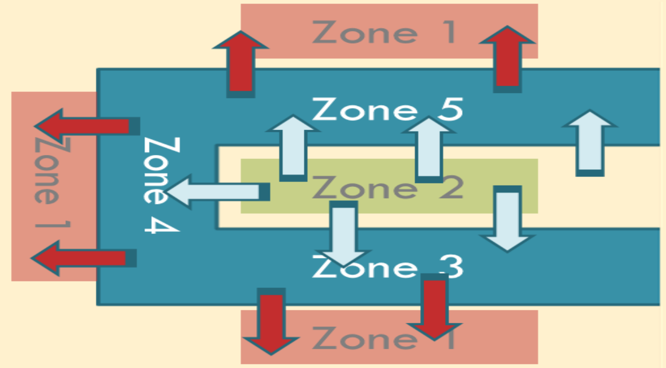
6.2.1 Design Strategies(Primary: Tier 1 Basic Building Design)

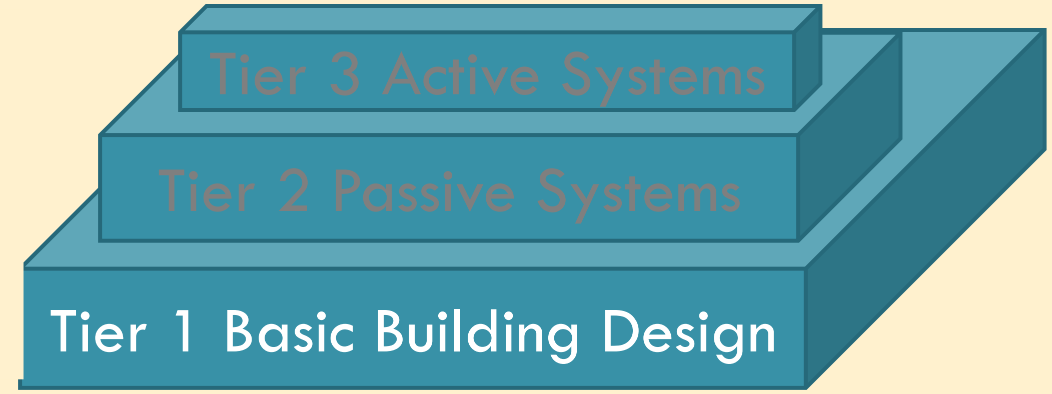
- Climate zoning through outdoor garden:
  - Strategy Description:
    - The garden (zone 2) climate will be intermediately enhanced so that it will be more comfortable than zone 1. Consequently, zone 2 will be the main source of ventilation and night flushing for the zones inside the building. Zone 2 climate will be enhanced through
      1. Shading
      2. Plantation
      3. Dehumidification system (see 6.2.3)
  - Strategy Effect on:
    - Winter (Heating Days)
      - Cold air from zone 2 will be offset by
        - Garden wall insulation
        - Garden wall internal heating through solar heated water circulation.
    - Summer (Cooling Days)
      - The enhanced temperatures and lower humidity of zone 2 will increase the effect of daily temperature variation (night flushing cooling). It will also be the source of building ventilation.
    - Lighting
      - Windows of the garden walls are the secondary source of sunlight in the building



6.2.1 Design Strategies(Primary: Tier 1 Basic Building Design)

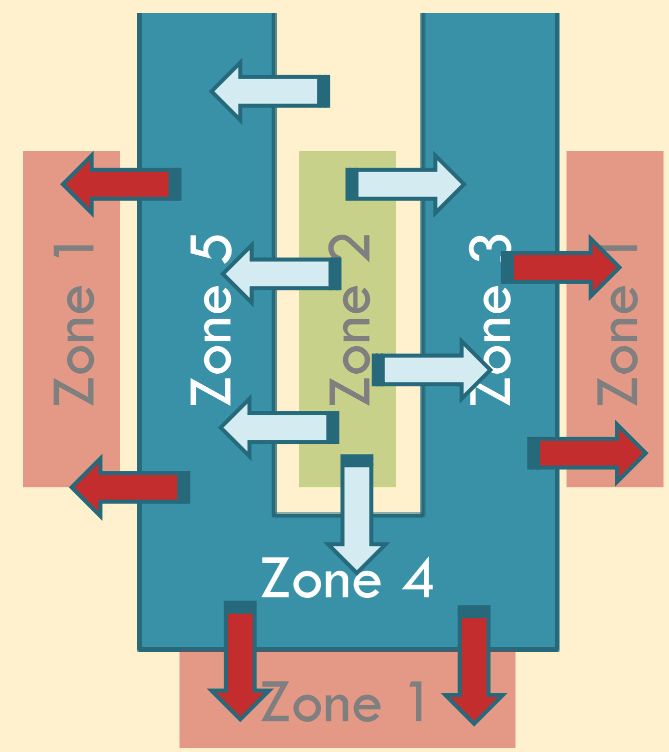
- Windows Sizing & Movable Shutters:
  - Strategy Description:
    - Windows overlooking zone 1 will be smaller than windows overlooking zone 2, and they will be triple glazed. All windows will have movable shutters (see picture)
  - Strategy Effect on:
    - Winter (Heating Days)
      - Opening the movable shutters during winter allows for the exploitation of the solar energy exposed to the building.
    - Summer (Cooling Days)
      - Making the windows on outer walls smaller as well as closing the movable shutters helps in reducing the building's exposure to solar radiation.
    - Lighting
      - Movable shutters allow for sunlight even when closed. So that there are some natural lighting even in the most extreme summer days.

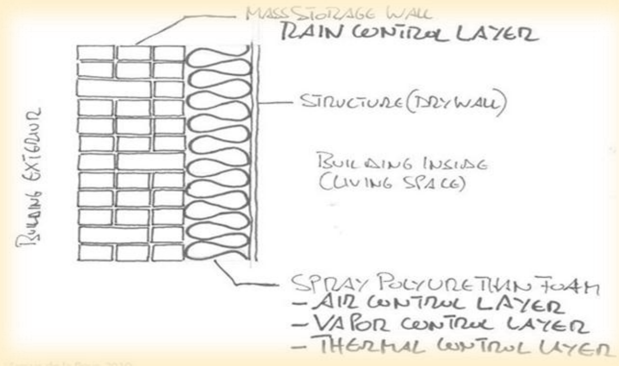


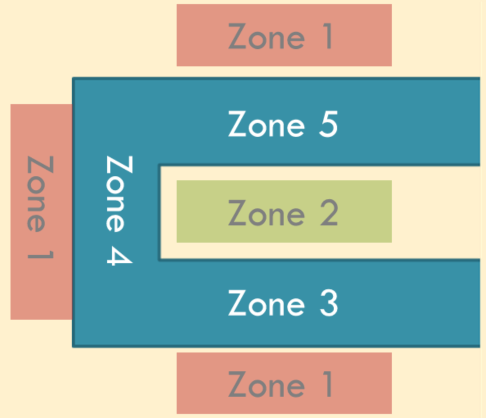


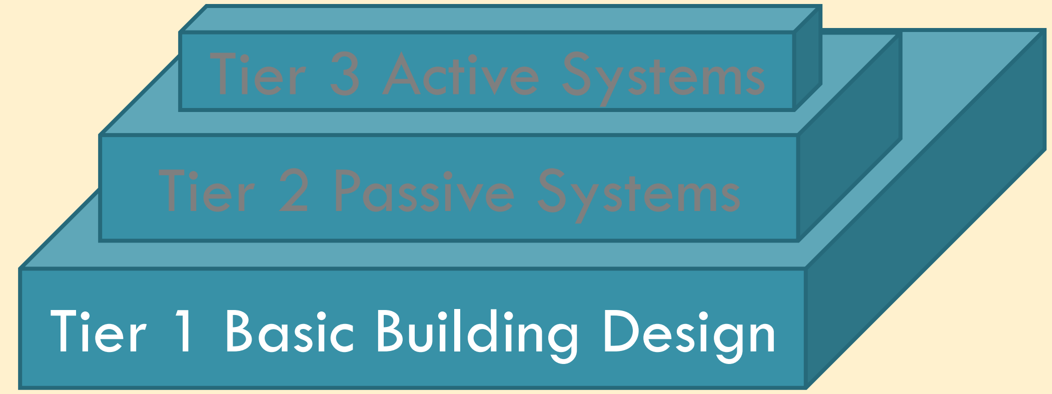
6.2.1 Design Strategies (Primary: Tier 1 Basic Building Design)

- ## Night Flushing:
  - **Strategy Description:**
    - Since
      - The minimum temperature is always below 20 C even during the hottest month, and
      - Temperature day/night variations are between 7 and 10 degrees C all year long.
    - Cooling via night flushing can be used effectively
  - **Strategy Effect on:**
    - Winter (Heating Days)
      - Not to be used in winter
    - Summer (Cooling Days)
      - The garden will be used as the primary source for night flushing since its climate is a couple of degrees more comfortable than the outdoors.
    - Lighting
      - No effect on lighting.



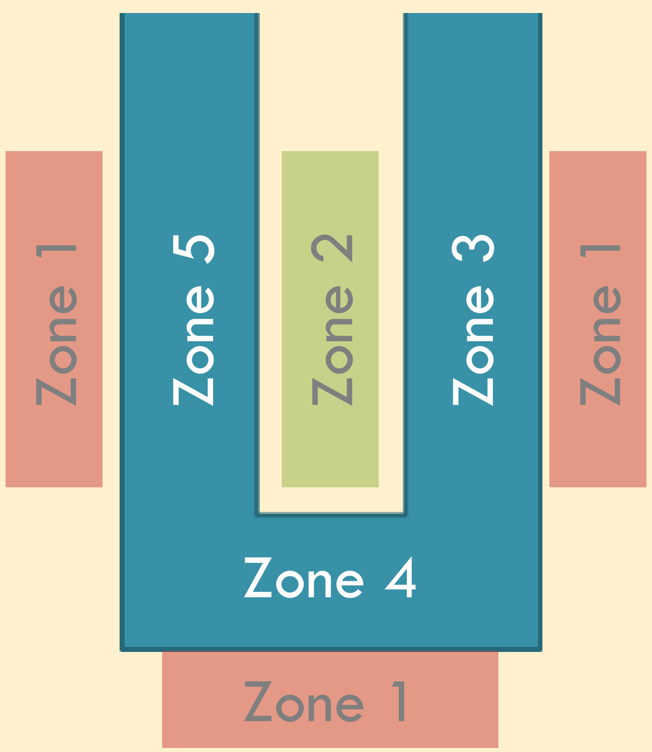


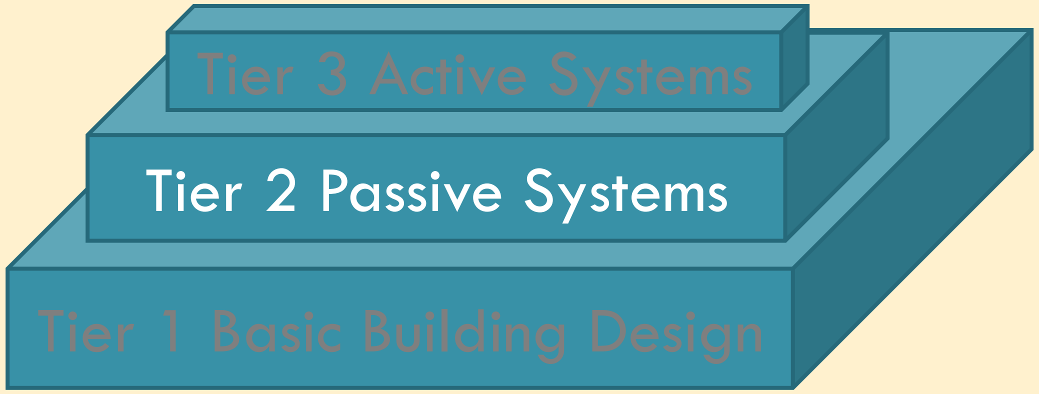




6.2.1 Design Strategies (Primary: Tier 1 Basic Building Design)

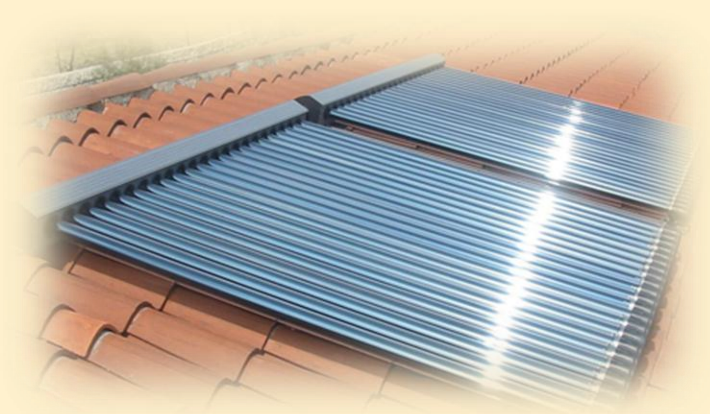
- Insulation:
  - Strategy Description:
    - While insulation is advantageous during heating days (winter), over insulation can result in undesirable heat gains during the cooling days (summer). Therefore, while the roof and outer walls will be heavily insulated (no more than 10 cms), the garden walls will be lightly insulated to allow for moderate infiltration of zone 2 climate.
  - Strategy Effect on:
    - Winter (Heating Days)
      - The roof is insulated in order to both, avoid solar heat infiltration, and preserve the solar energy for heating domestic water and water for winter wall heating systems.
    - Summer (Cooling Days)
      - Insulation of roof and outer walls will ensure that the primary source of heat infiltration is the garden facades.
    - Lighting
      - No effect on lighting.

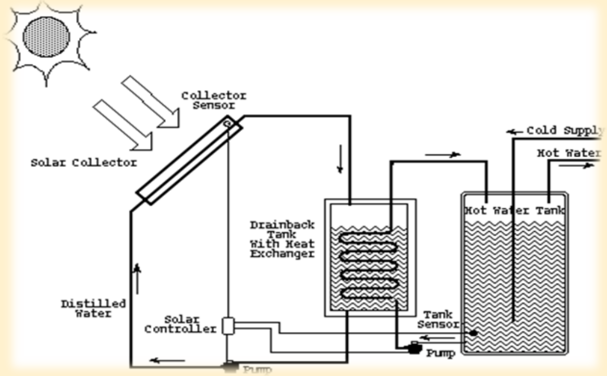


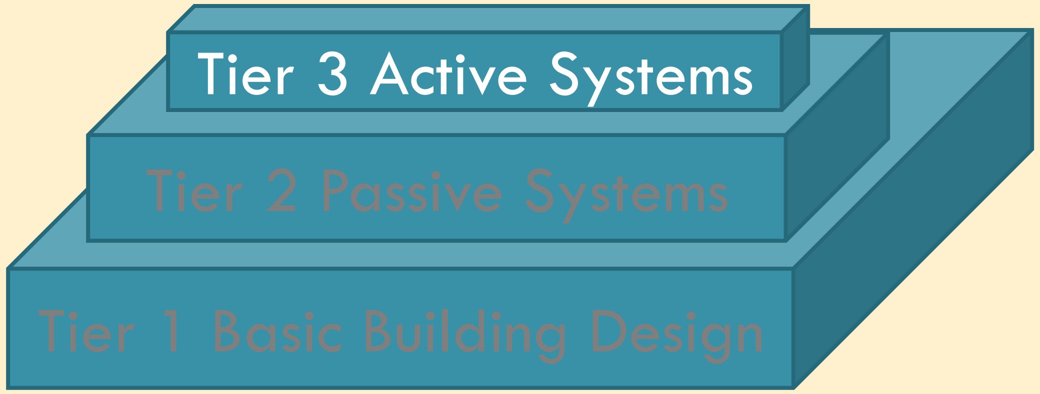


6.2.2 Design Strategies(Primary: Tier 2 Passive Systems)

- Roof PVs for electric lighting and appliances:
  - Strategy Description:
    - The roof area is more than 300 m2. Therefore, this space will be used for generating electricity through photovoltaic panels. But since sunshine is only available 30% of the year's hours, the building is still primarily powered by the grid.
  - Strategy Effect on:
    - Winter (Heating Days)
      - The dependence degree on the grid is more during the winter.
    - Summer (Cooling Days)
      - The dependence degree on the grid is less during the summer.
    - Lighting
      - The auxiliary power source for all artificial lightings are the PV panels.

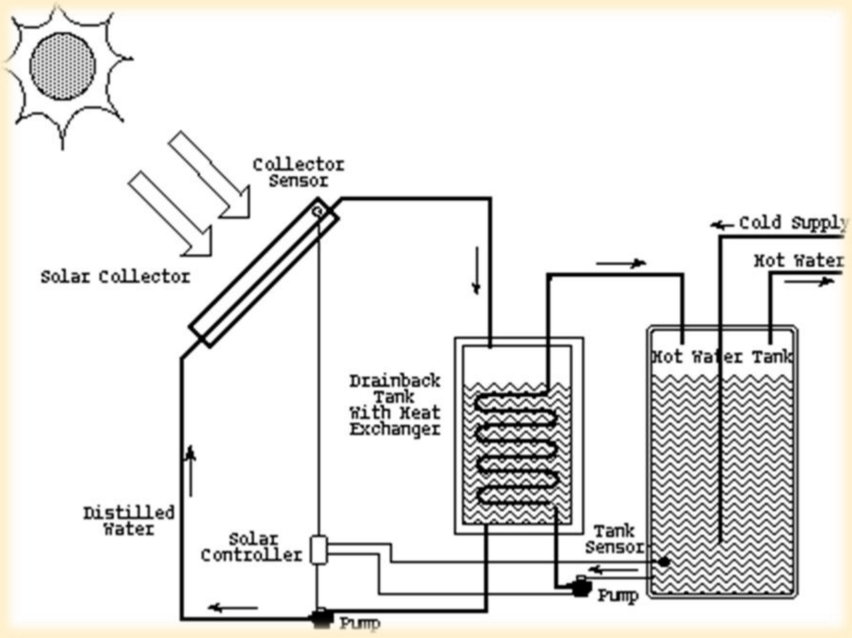


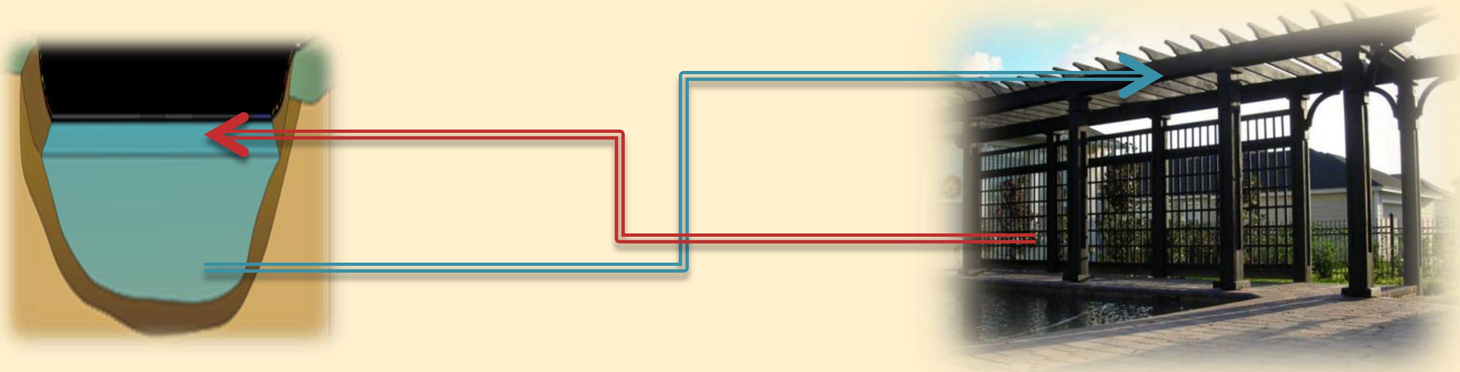


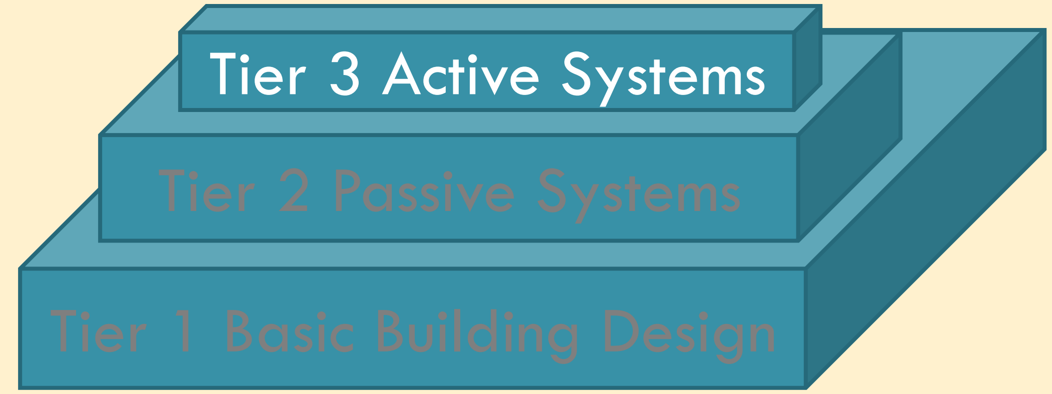


6.2.3 Design Strategies (Primary: Tier 3 Active Systems)

- Direct Solar water/wall heating:
  - <u>Strategy Description:</u>
    - Using the uncovered area of the roof, a solar water heating system that serves two functions is used:
      - Function A: Domestic water heating.
      - Function B: Winter outer wall heating.
  - <u>Strategy Effect on:</u>
    - <u>Winter (Heating Days)</u>
      - PV and grid will power the pumps of the system.
    - <u>Summer (Cooling Days)</u>
      - PV will suffice to power the pumps as the system will only be used for function A
    - <u>Lighting</u>
      - No effect on lighting.

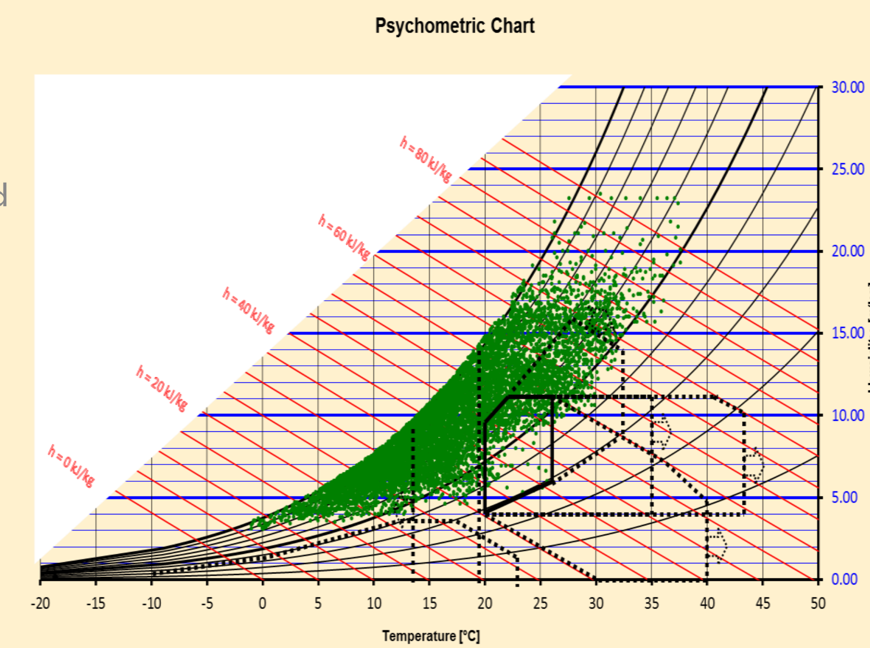






6.2.3 Design Strategies(Primary: Tier 3 Active Systems)

- Outdoor dehumidification system through condensation:
  - Strategy Description:
    - The system attempts to lower the absolute humidity of the garden (zone 2) through closed heat exchanging between river Temo and the local climate of the garden. The system would work provided the following assumptions:
      - The water temperature of river Temo is always lower than the dew point temperature of the garden's climate (approximately between 18 and 22 degrees C in the summer).
      - The Temo river does not dry up during the summer.
    - System Components:
      - Circulation water pump: to transport water from river to garden and back.
      - Circulation pipes
      - Condensation structure: Installed across the garden. See right for an example.
      - Condensate water collectors and tank.
  - Strategy Effect on:
    - Winter (Heating Days)
      - The system is not used during the winter except if the relative humidity exceeds 60%.
    - Summer (Cooling Days)
      - The system brings Zone 2 climate closer to the comfort zone (see psychometrics) and will be powered by PV.
    - Lighting
      - No effect on lighting.



Design Strategies (Secondary)

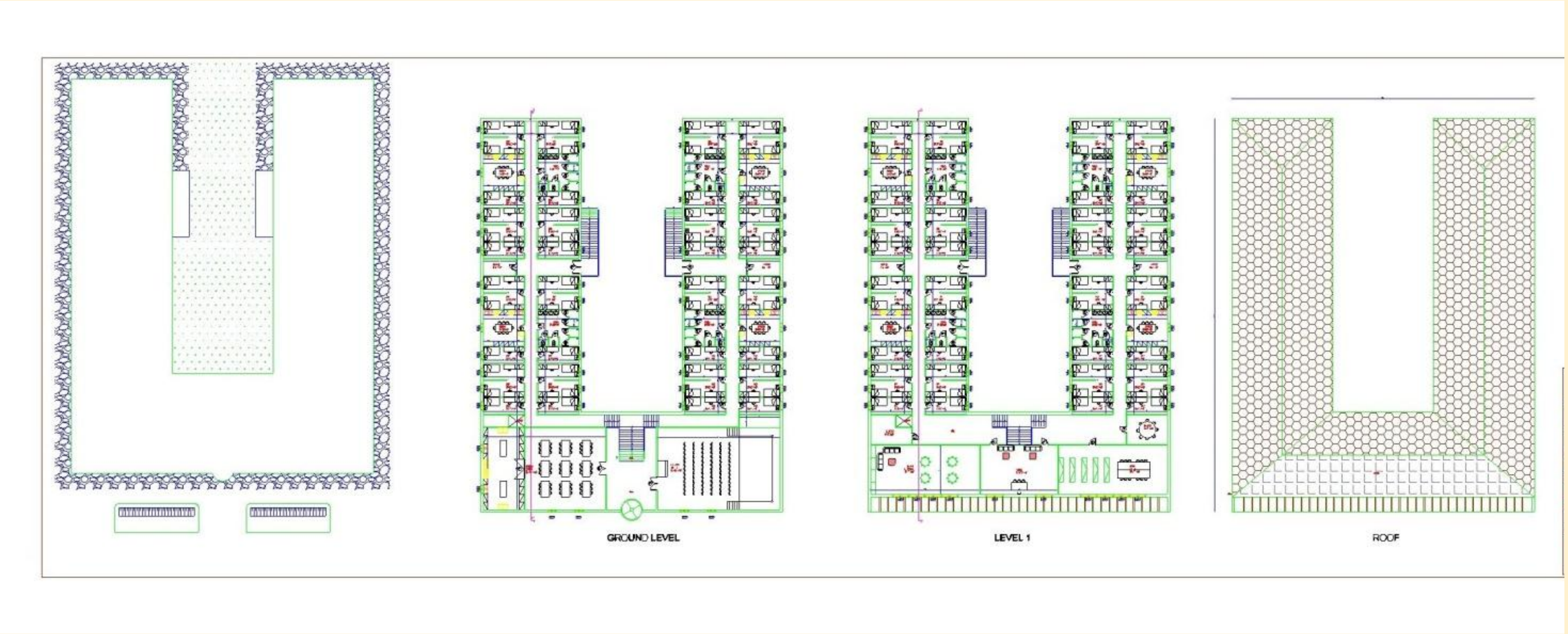
6.3

	Tier 1	Tier 2	Tier 3
Winter	• Building clustered with neighbors in the north and east.		
Summer	• Palm Trees in front of Southern façade as wind and sand breaker • Building Materials and colors similar to neighbors (see picture on cover page) • Because of the wind's strength one dimensionality, heat is carried away from the east and west walls through convection. • Used revolving door in the main entrance to protect from sand.		

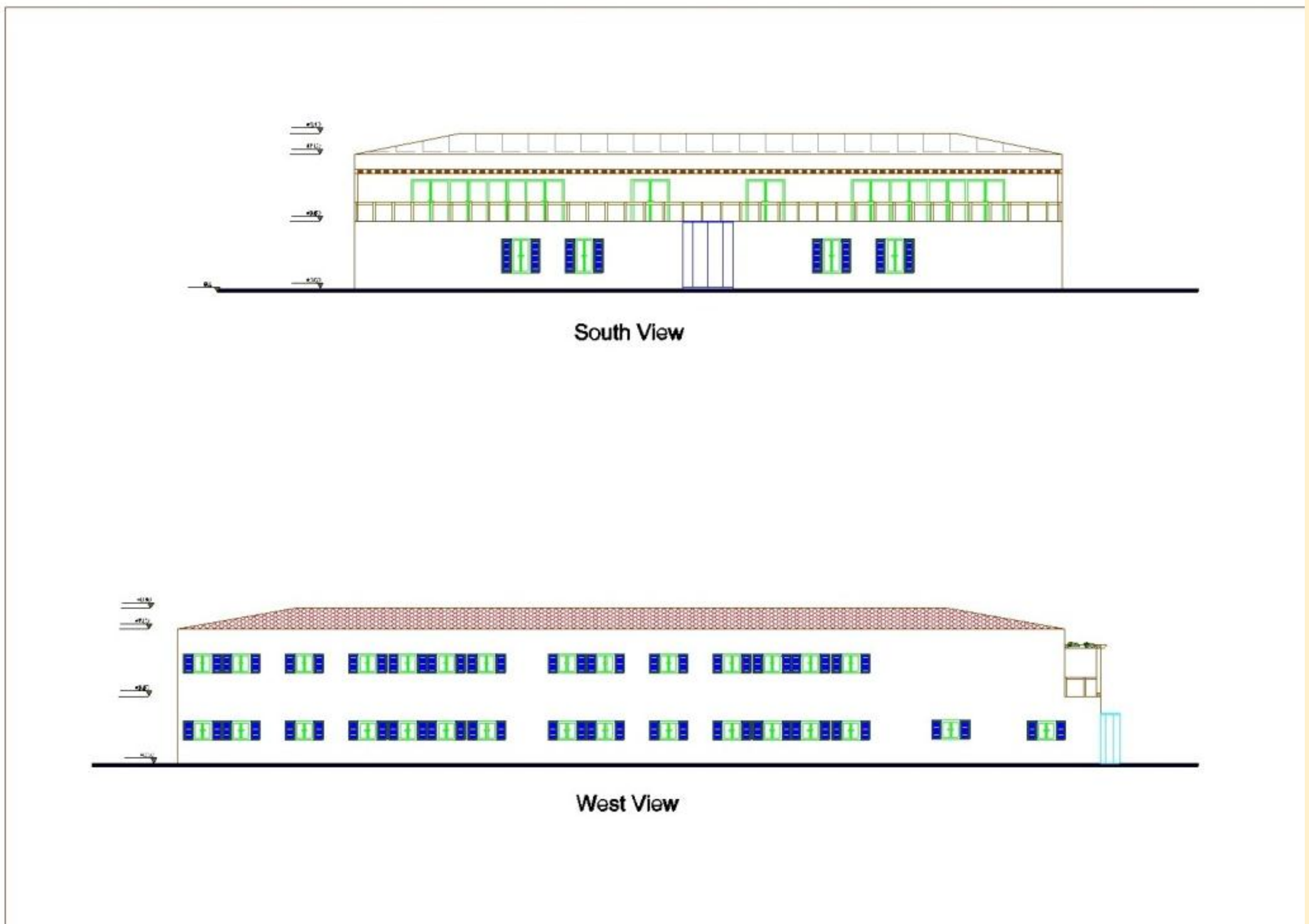
7 Design Output (AutoCAD Files Available)

- 7.1 Floor Plan
- 7.2 Facades
- 7.3 Cross Section

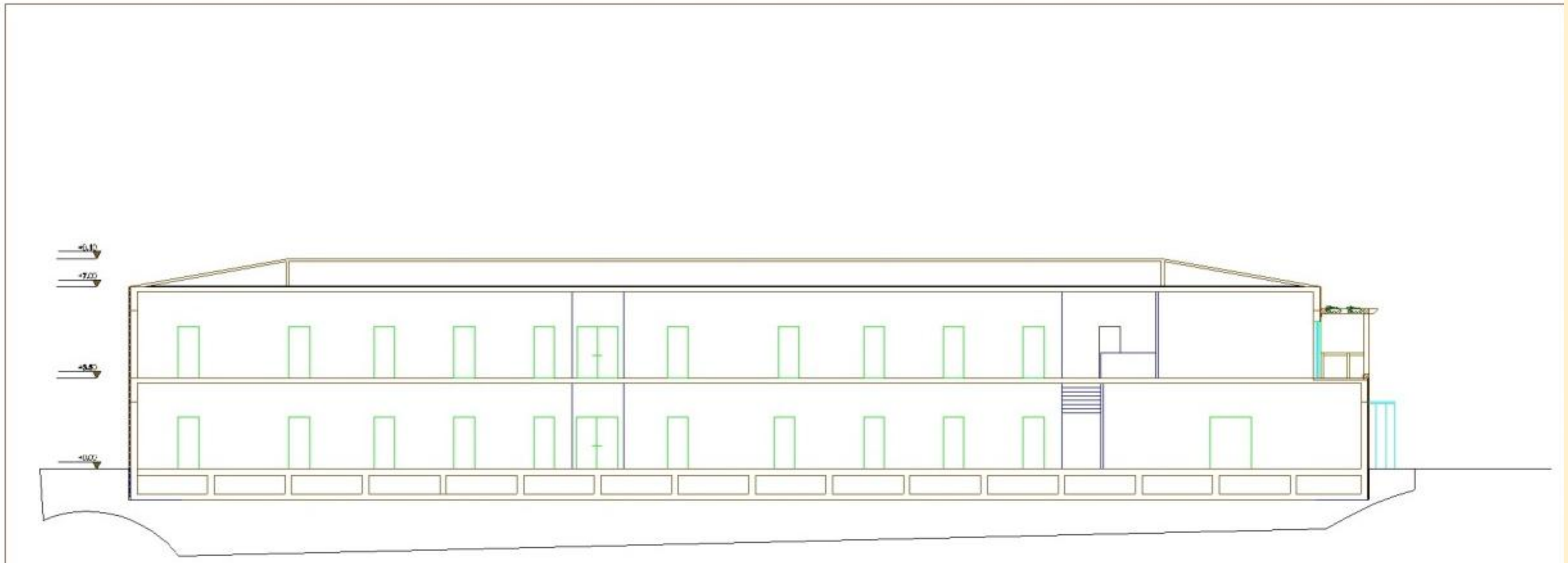
7.1 Design Output (Floor Plan)



7.2 Design Output (Facades)



7.3 Design Output (Cross Section)



Section A-A'

References

- [1] Calculation of Distance 270 meters, 3 minutes walk from the following link http://maps.google.com/maps?saddr=1,+Via+Giovanni+Xxiii,+Bosa,+OR+08013,+08013,+Italia+(Universita+Degli+Studi+Di+Sassari)&daddr=Lungo+Temo+Alcide+De+Gasperi&hl=en&ll=40.296274,8.497954&spn=0.001115,0.002631&sll=40.29628,8.497818&sspn=0.001115,0.002631&geocode=FQLgZgIdkq-BACFEKdOpY-hMgg%3BFXndZgIdpKaBAA&dirflg=w&mra=ltm&t=m&z=19)
- [2] http://www.openstreetmap.org/# map to scale 1:500
- [3] All Climate Data were extracted from Meteonorm Software Version 6.1 for Bosa, Sardinia, Italy
- [4] Wind direction chart from the link below. It's for Copa Frasca, Sardinia just south of Bosa http://www.windfinder.com/windstats/windstatistic_capo_frasca.htm#
- [5] http://www.climatedata.eu/climate.php?loc=itxx0155&lang=en caligary, Sardinia
- [6] Carlo Atzeni; "Stone masonry in rural sardinian building.Evolution of the traditional building techniquesbetween XIX and XX century"; Proceedings of the First International Congress on Construction History, Madrid, 20th-24th January 2003,ed. S. Huerta, Madrid: I. Juan de Herrera, SEdHC, ETSAM, A. E. Benvenuto, COAM, F. Dragados, 2003.