

# **WALKING THE TALK**

**MAKING OF A  
SUSTAINABLE CAMPUS**

## **THE ANIL AGARWAL ENVIRONMENT TRAINING INSTITUTE AAETI**





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## THE ANIL AGARWAL ENVIRONMENT TRAINING INSTITUTE (AAETI)

**AAETI** is a project of the Centre for Science and Environment (CSE). A learning, training and innovation centre designed to find appropriate and affordable solutions to some of the most pressing problems faced by the global South — from climate change, air pollution and urban mobility to water and waste management and environmental degradation.

The institute has been named after the late Anil Agarwal, CSE's founder-director and a leading figure in India's environmental movement.

The Institute will conduct its courses on this campus through six schools of learning. The faculty will comprise some of the foremost experts in their fields — from India and other countries. It aims to build capacities of a range of audiences — regulators, lawmakers, communicators, professionals, students, civil society members and administrators.

Currently, the campus can house some 100 guests and some 40-50 permanent staff. The cafeteria has a sitting capacity of 150 people. The academic block has 6 classrooms of various sizes with their capacities ranging from 35 people to 124. The campus also houses CSE's pollution monitoring laboratory, which is designed as India's first faecal sludge testing laboratory.

We hope you will enjoy our campus. It is our dream to make it a living laboratory of ideas and practice and a place where deliberations, dialogue and dissent can thrive.

### Name

**Anil Agarwal Environmental Training Institute**

### Location

Nimli, Rajasthan

### Climate zone

Composite (Extreme summer and winter with warm-humid monsoons)

### Typology

Institutes

### Site area

39,090 sq.mt (9.66 Acres)

### Gross area (including basement)

9,800 sq.mt

### Air conditioned area

2,900 sq.mt

### Cost

₹40 crores

### Occupancy schedule

24 hours: residential

8 hours: academic and administration

### Owner

Center for Science and Environment, New Delhi

### Architecture, landscape and interior design

Pradeep Sachdeva Design Associates

### Structural design

Arvind Gupta Consultants

### Water and wastewater

Krim Engineering Services

### HVAC and electrical consultants

McD Built Environment Research Laboratory Pvt Ltd

### Energy consultants

Environmental Design Solutions Pvt Ltd

**With collaboration from CSE's energy, water, buildings, wastewater and solid waste management teams**



# OBJECTIVES OF AAETI'S GREEN CAMPUS

**When we** began working on AAETI we had a lot of ideas about what 'green' meant. But as we have worked on these concepts and put them in practice, we have learnt a lot of what works and what does not. We are presenting this documentation of our sustainability plan, not because we believe this is the best or the final word on green buildings. But because we need to use each such learning to build a community of practice of green architecture. We need to do and we need to measure what we have done and why.

But firstly, what have we tried to put into practice. What is a green building?

## Energy: Materials, insulation and appliances

1. Minimise the footprint of the building so that it is as compact as possible and utilise maximum daylight. We have designed our building in such a way that maximum daylight is achieved and at least usage of artificial light is required.
2. Build to optimise on the local ecology and climate – build around the sun and the wind. This practice of passive architecture brings down the energy footprint.
3. Insulate as best as possible – the choice of building material is important.
4. Shade the building so that direct sun is avoided and ventilate so that wind becomes important for 'comfort'.
5. All this done, choose the most efficient heating, ventilation and air conditioning system (HVAC), which is best for long term energy use. Decide on temperature in building so that it is not too cold or too hot. Dress for the season and for

comfort. Make sure there is ventilation and that there are fans – comfort is not only about temperature but about the design for air in the room and on our bodies.

6. Choose efficient appliances – use this to reduce energy use further.

7. When all has been done to reduce energy demand, then plan for the energy generation (as much as possible) to be from renewable sources.

## Water-waste

8. Make the campus water neutral – take less from groundwater than what you put back.

9. Ensure all sewage is treated locally.

10. Ensure that all treated sewage is re-used and the wastewater is recycled.

## Garbage

11. Fully segregate at source.

12. Minimise the use of plastics and non-biodegradables in the campus – move towards zero-plastic use over time.

13. Reduce food waste – educate people about taking only as much as they need.

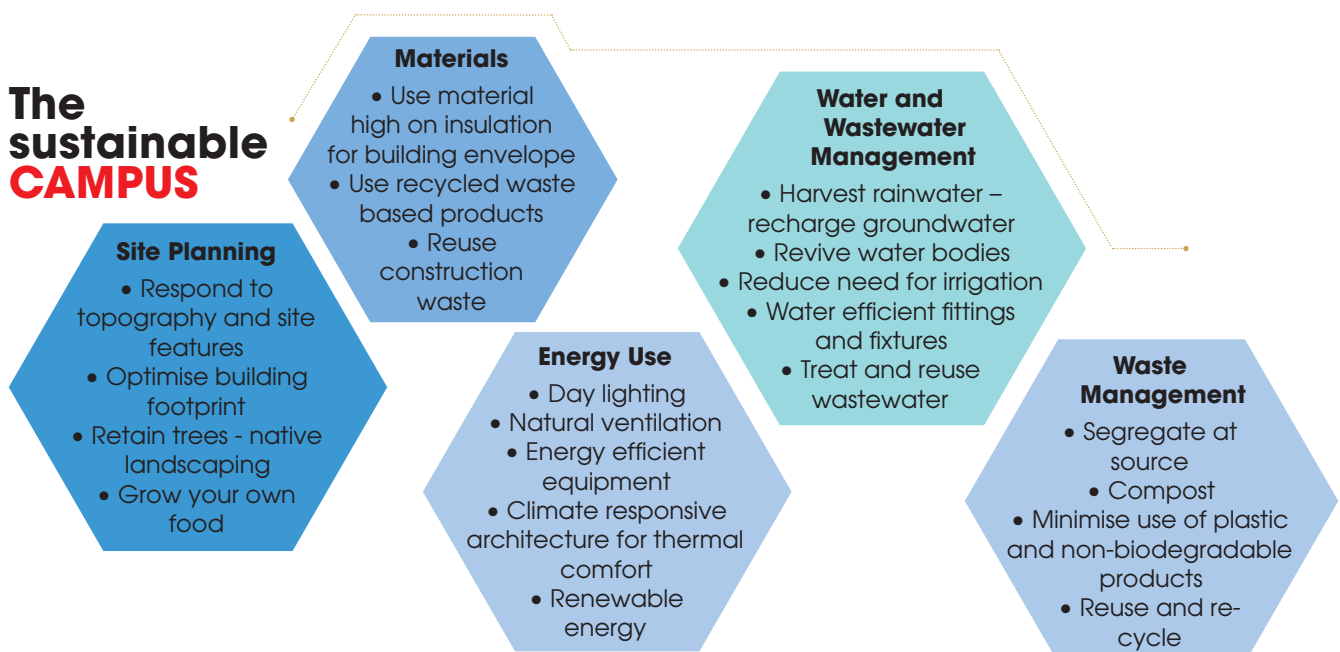
14. Compost all biodegradable waste on site.

15. Recycle all other waste – segregate and plan its reuse. Work towards no waste for landfill.

Monitor all the above, after the building is commissioned. Report and revise goals. Must know what is working and what is not.

Connect the design building and operational performance so that sustainability goals are met.

## The sustainable CAMPUS



## UNDERSTANDING THE SITE

**The project** site is semi-arid and highly undulated with a seasonal stream (nallah) cutting through the plot. Topographically, the site is a shallow valley with the nallah being the lowest point, and the highest points located along its eastern and western edge.

### Location

**Nimli Village,  
Tehsil Tijara, Alwar,  
Rajasthan**

### KEY DISTANCES

Delhi (via Bhiwadi)  
**121km**

IGI Airport (via  
Bhiwadi)  
**111km**

Gurgaon (via  
Bhiwadi)  
**86km**

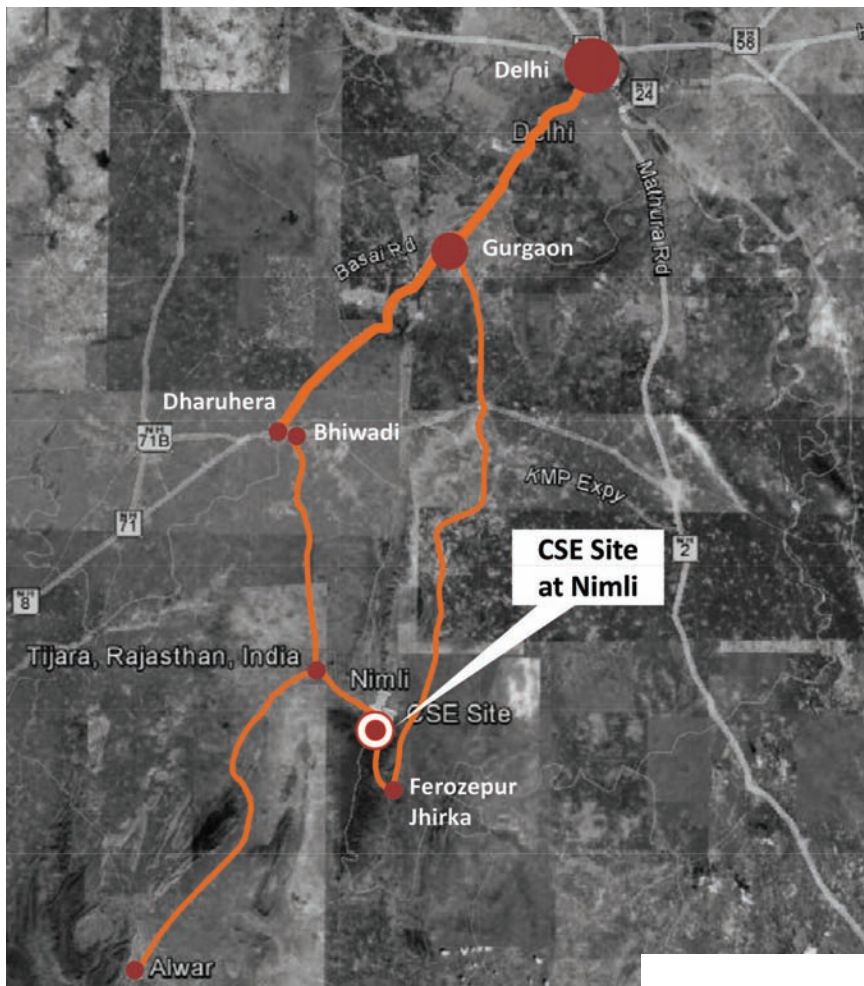
Gurgaon (via  
Ferozpur Jhirka)  
**108km**

Bhiwadi  
**46km**

Alwar  
**62km**

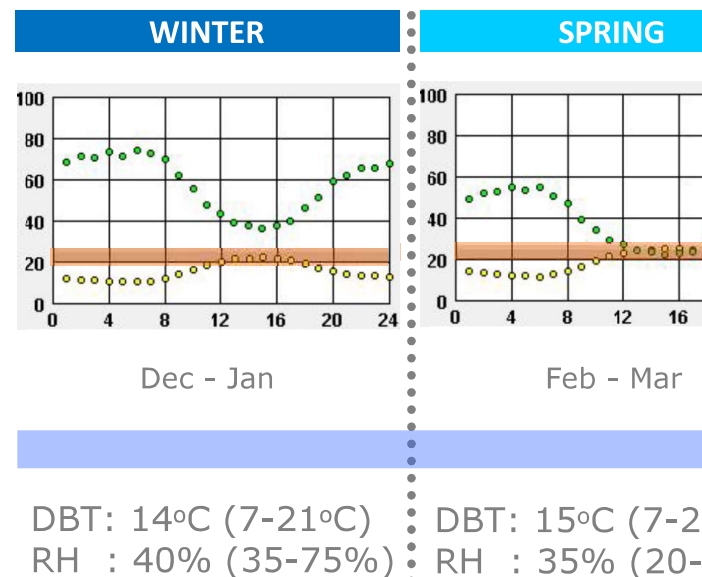
Tijara  
**15km**

Ferozpur Jhirka  
**11km**



..... Hourly DB Temperature (deg)

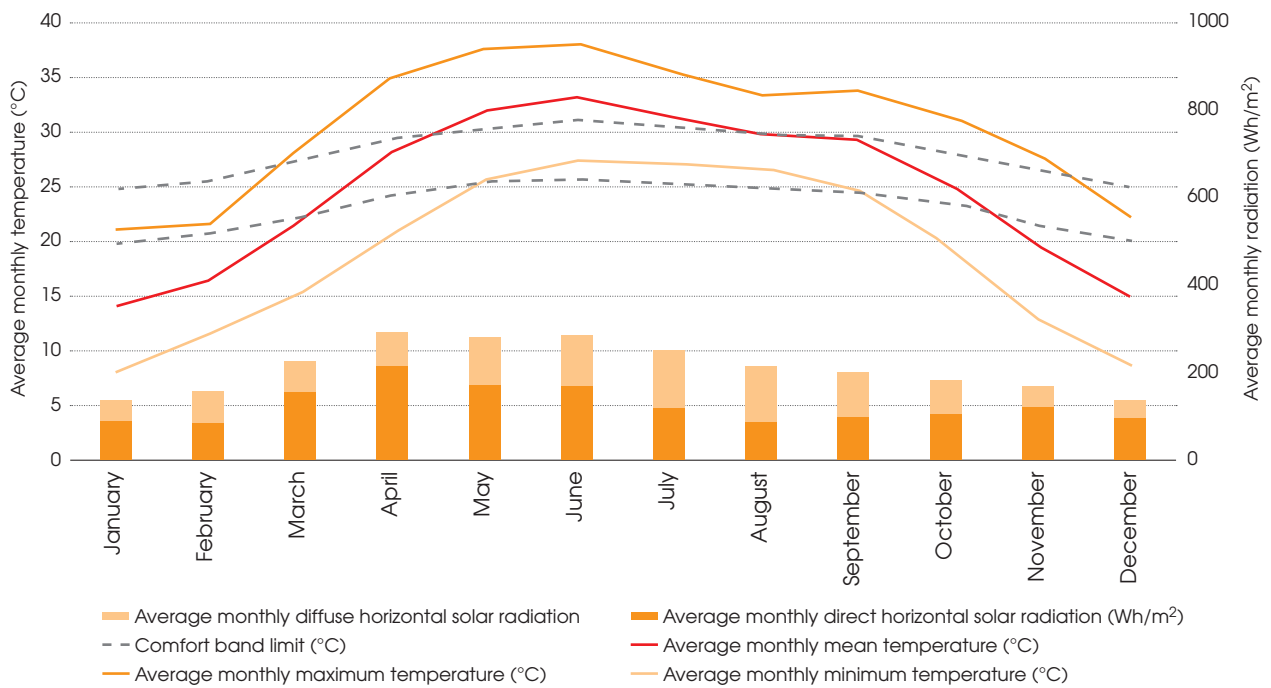
**DIURNAL  
VARIATIONS FOR DBT  
& RH**  
The Diurnal variations  
for dry-bulb  
temperature (DBT) is  
**8-15°C** and relative  
humidity (RH) is **30-  
40%**



# CLIMATE

## Extremes: Winter, summer and monsoons

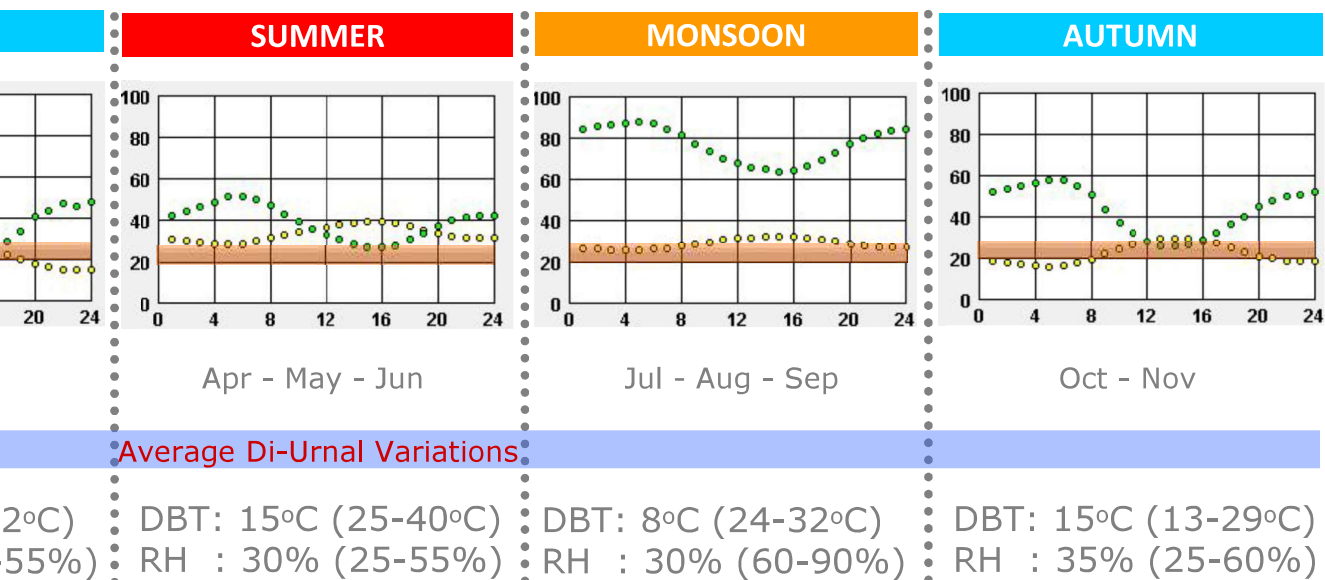
### Climate summary | New Delhi



C)

..... Hourly Relative Humidity (%)

Comfort temperature range

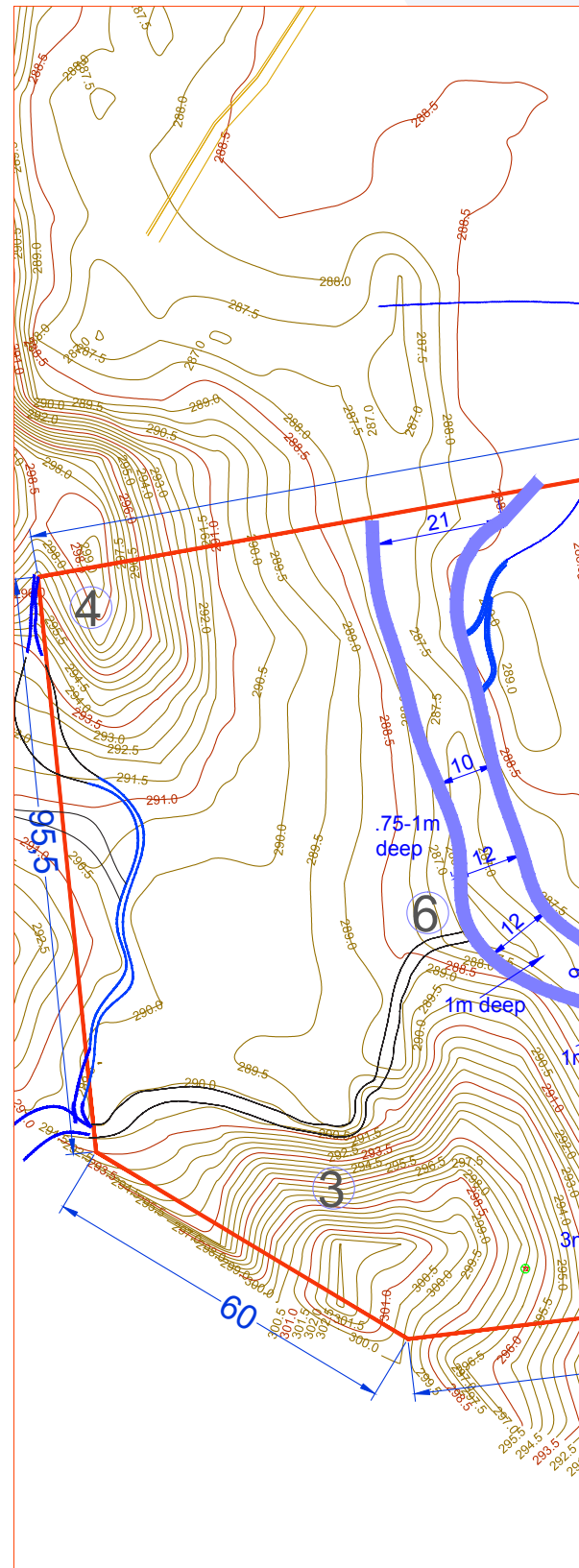
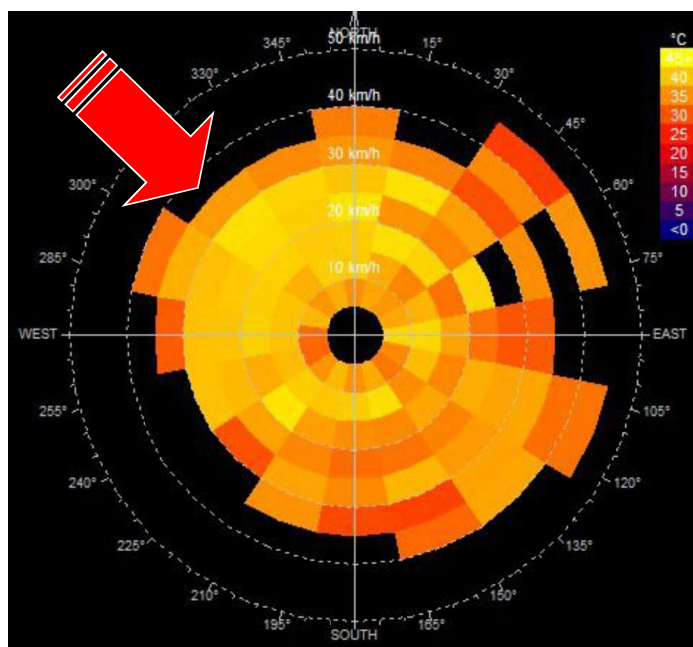


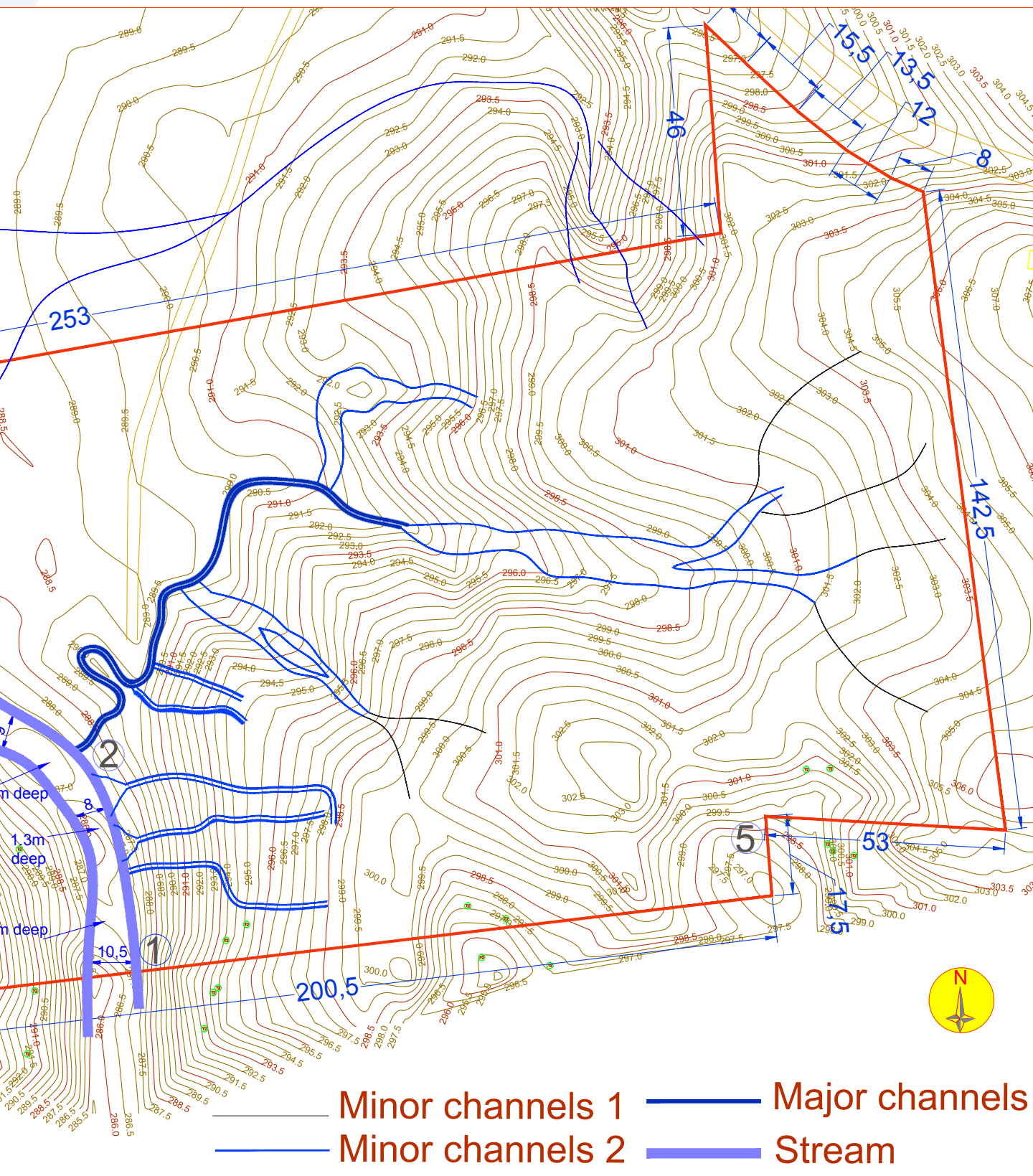


## Map of drainage and topography of the area

**The site** is part of the larger natural drainage pattern of the area, the nallah (seasonal stream) cuts through the site; and the catchment is vast. If not planned carefully the campus would be flooded during monsoons and would have water scarcity in the rest of the season.

**Buildings need to be protected from hot summer winds that predominantly come from north-west.**





## UNDERSTANDING WHAT WE MEAN BY 'COMFORT'

### What is comfort?

**In Neemli**, the average peak summer temperature reaches 44°C and drops to 7°C. During the monsoons, humidity can be as high as 80-100 per cent, making for unbearable heat. The advantage we have is our 'microclimate' – shrub-forests surrounding the campus and a seasonal wind regime. Buildings can be designed and air conditioning and heating provided to maintain certain temperature and humidity conditions.

But first we needed to agree on the room temperature that makes us comfortable?

There are standards that define indoor comfort conditions but their relevance to Indian environment is questionable. When CSE was deliberating this, the National Building Code (NBC) prescribed 25-30°C for naturally ventilated buildings and 21-23°C for air-conditioned buildings independent of weather conditions outdoors. In 2016, NBC revised its comfort conditions, based on adaptive comfort model developed by the Ahmedabad based CEPT university. This new approach recognizes that people's thermal comfort needs depend on their past and present context and that these needs vary with the outdoor environmental conditions of their location. Under this model, there are three different typologies for buildings; naturally ventilated (19-35°C); mix-mode building (23-28°C) and air conditioned building (24-26°C). AAETI would fall under mixed-mode, where we use air conditioning in limited areas and for limited period of the year.

But what is the right temperature for comfort? To put the confusion to test, CSE carried out an "unscientific survey" of its staff to figure out what temperature conditions they felt comfortable working in, to help establish a comfort range. CSE office space is equipped with room air-conditioners, ceiling fans and openable windows, and staff is regularly found to playing around with a mix of these three to make themselves comfortable. When questioned most people said they are comfortable at 23-24°C. But when the temperature was actually measured at their workstation, we found that most did not complain of discomfort unless the temperature climbed above 28-29°C.

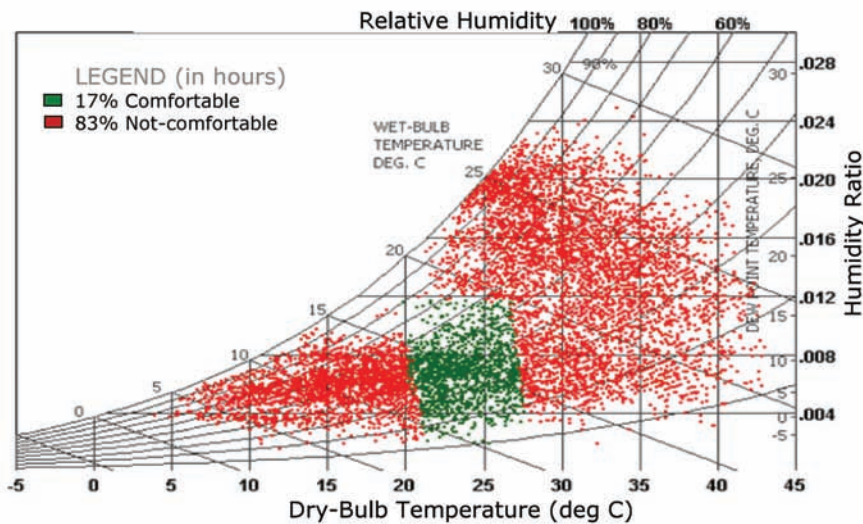
What is clear is that our 'sweet' temperature zone will define sustainability of the project. This means that we need to also ensure that we dress for climate – adopt Japan's famous bushshirt rule so that clothing would be local climate appropriate – no ties, suits in summer.

We agreed our campus buildings would be designed for thermal comfort conditions of 26 ± 2°C for summer and 18°C for winter.



## ASHRAE standard 55 comfort model for air-conditioned spaces

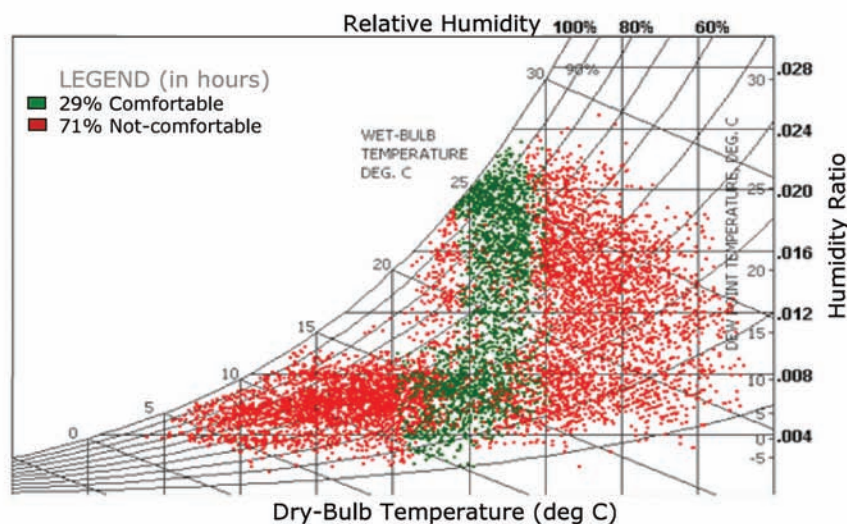
### Details of ASHRAE standard 55 comfort model



- ⊙ This model of thermal comfort is based on dry bulb temperature, clothing level (clo), metabolic rate (met), air velocity, humidity, and mean radiant temperature.
- ⊙ Dry Bulb temperature from 20-27°C is considered comfortable
- ⊙ Annually, only 17% out of 8760 hours are comfortable without any air-conditioning as per this comfort model.

## ASHRAE standard 55 comfort model for non air-conditioned spaces

### Details of ASHRAE standard 55 adaptive comfort model



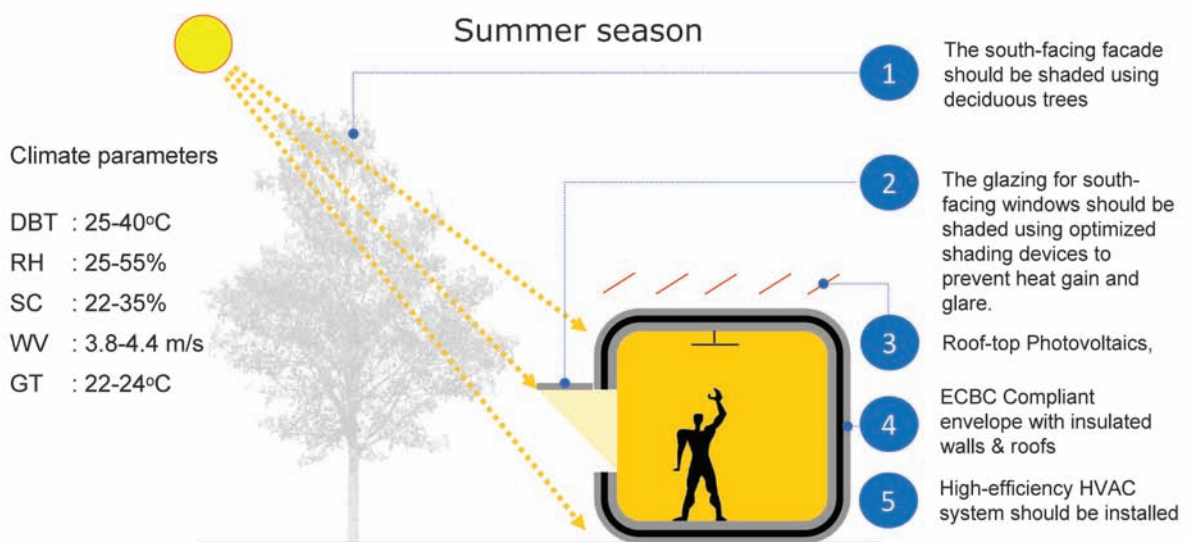
- ⊙ This model assumes that occupants adapt their clothing to thermal conditions, and are sedentary (1.0 to 1.3 met). There must be no AC System.
- ⊙ Dry Bulb temperature from 20-30°C is considered comfortable
- ⊙ Annually, about 29% out of 8760 hours are comfortable without any air-conditioning as per this comfort model.

## DESIGNING FOR THE CLIMATE: PASSIVE ARCHITECTURE

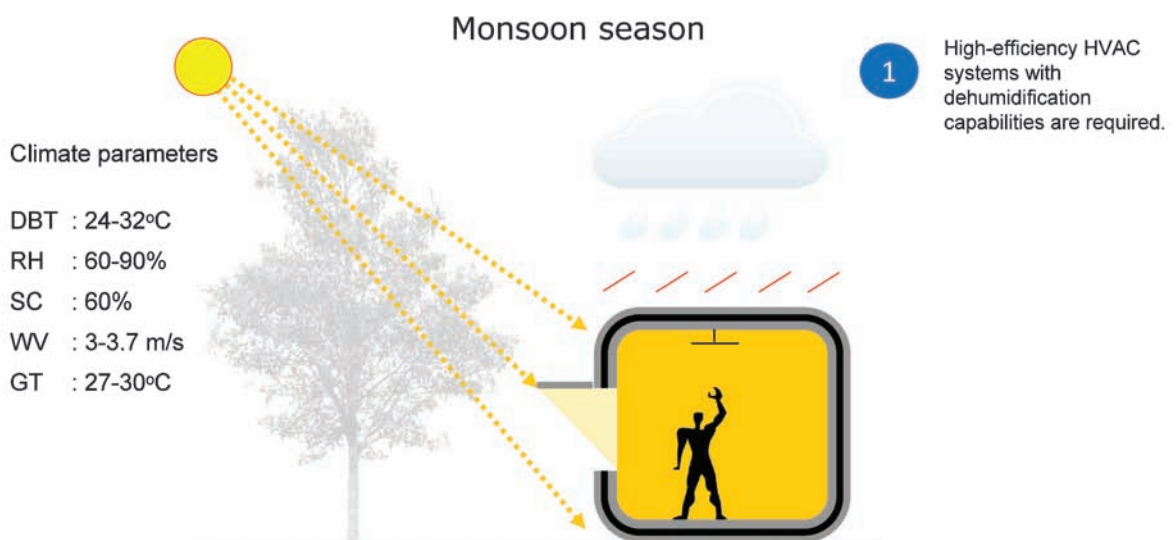
**Rajasthan's traditional** architecture has mastered the modern art of passive building design – dense, compactly built structures with narrow passages that minimise direct exposure to the sun and the use of wind for ventilation. We learnt from this and practiced this and more at AAETI.

### We found that we needed to design for the sun.

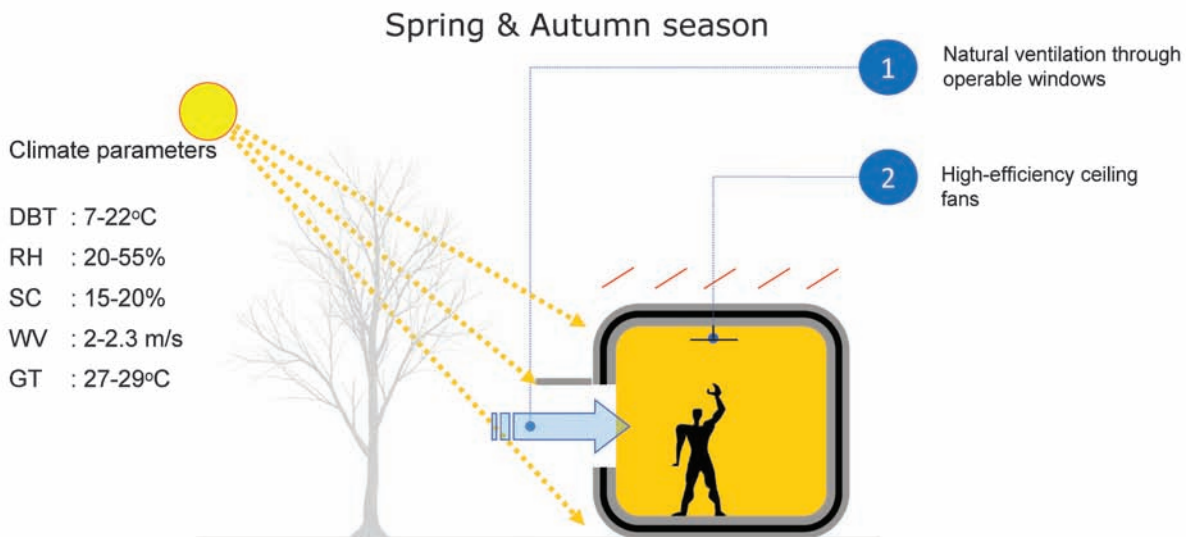
#### Envelope shading, window shading, highly efficient envelope & HVAC



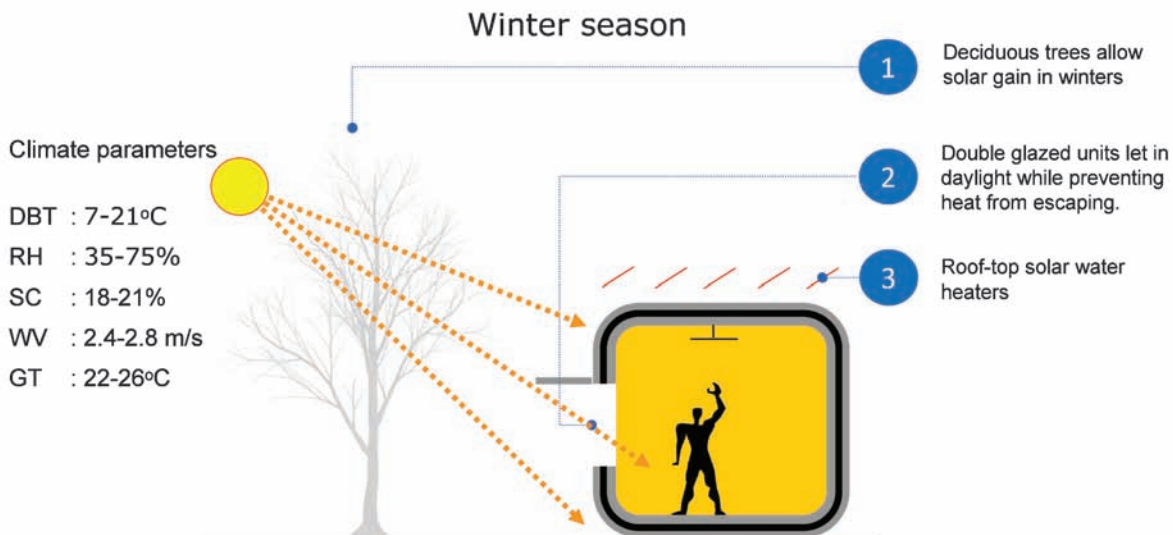
#### High-efficiency HVAC with dehumidification



## Natural ventilation and indoor air movement



## Passive solar gains, High thermal mass & Glare prevention with shading devices



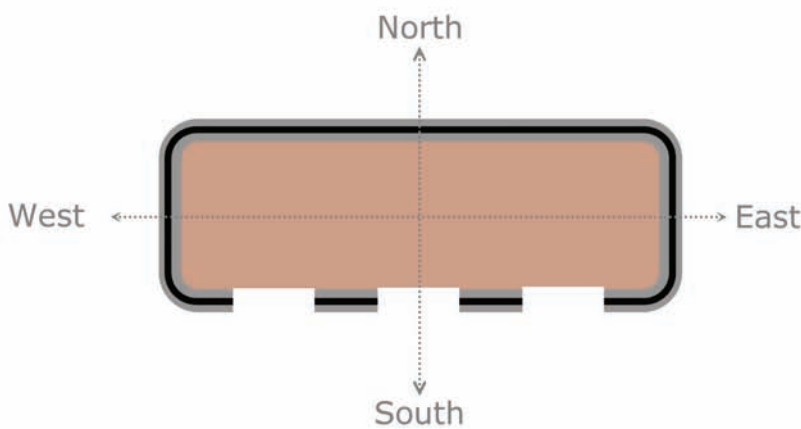
**First, we** have oriented most of our buildings in the east-west direction, which reduced exposition to the harsh summer sun – or in other words, our building are facing north-south. Where we could not do so (canteen and guest house) we introduced special design interventions.



Now roughly 90 per cent of the windows and ventilators (fenestrations) open in the north or south direction.

**North-South orientation, less than 30% Window Wall Ratio, narrow floor-plate depth & light shelves**

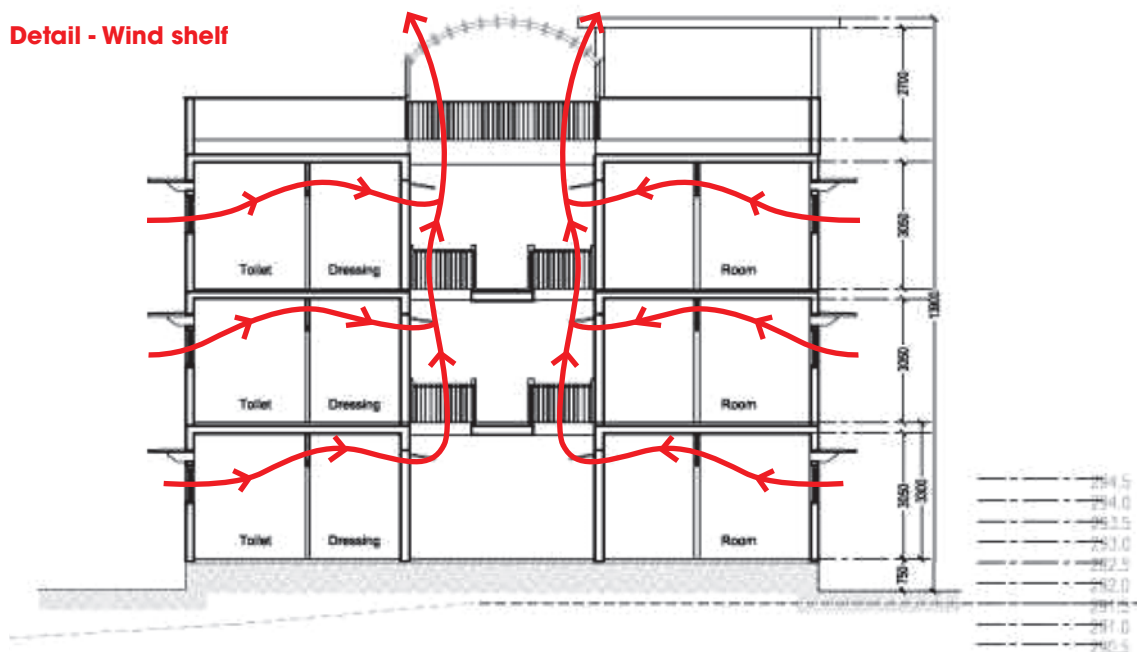
**Strategies for designing the built form**



- 1 The North-South orientation ensures that heat gain is reduced from the East & West.
- 2 This orientation also enables better heat gain from the south facing windows in winter
- 3 Narrow floor-plate depths ensure that daylight penetrates deep into the spaces as well as helping natural ventilation
- 4 Light-shelves cut-out glare as well as increasing daylight penetration

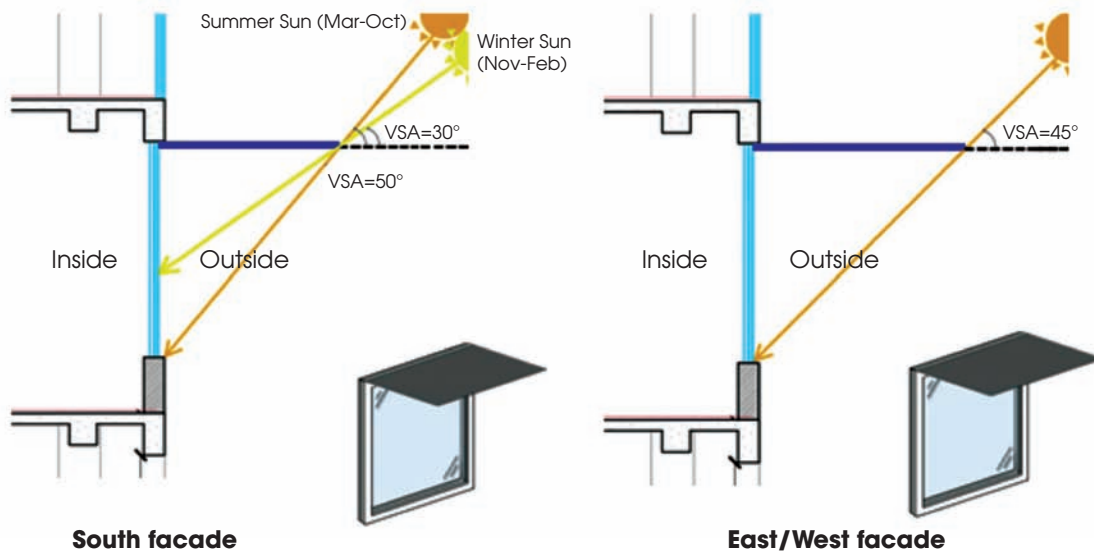
**Second, buildings** are designed with courtyards or cut-outs to provide natural ventilation and day-lighting. The student housing block has a double loaded corridor design (a single central corridor with student rooms flanking on both side) which made it tricky to have cross-ventilation as windows in the rooms had access to outdoors only in one direction. This has been solved with introduction of special wind shelves in the corridors that allow the hot air from building to escape facilitating cross ventilation in all rooms. It also helps bring in natural light to the corridor as well.

**Detail - Wind shelf**



**Third, most** importantly, we have extensive and deliberate use of chajjas – horizontal sunshades – on all windows to further cut down exposure to direct sunlight.

### Facade specific shading recommendations



Site Shadow Range  
Summer Solstice: 22nd June  
Time : 08:00 - 17:30



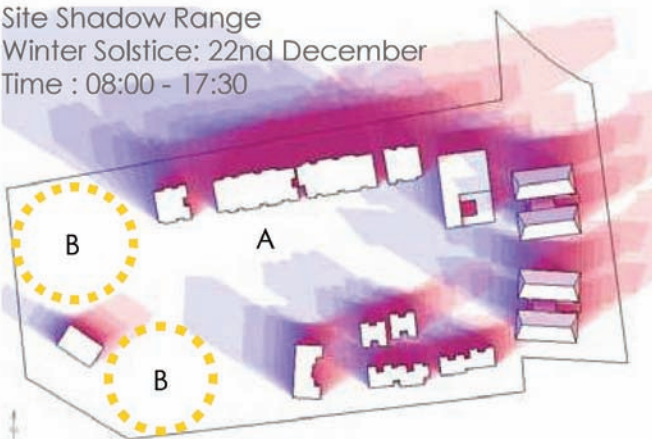
- Evening shadows
- Morning shadows

#### Strategy

##### Outdoor Thermal Comfort

- Shaded courtyards
- Shaded pavements & parking
- Shaded OAT
- Sit-outs and Outdoor activity zones in shaded areas between buildings.

Site Shadow Range  
Winter Solstice: 22nd December  
Time : 08:00 - 17:30



- Evening shadows
- Morning shadows

#### Strategy

##### Bright sunny winter spaces

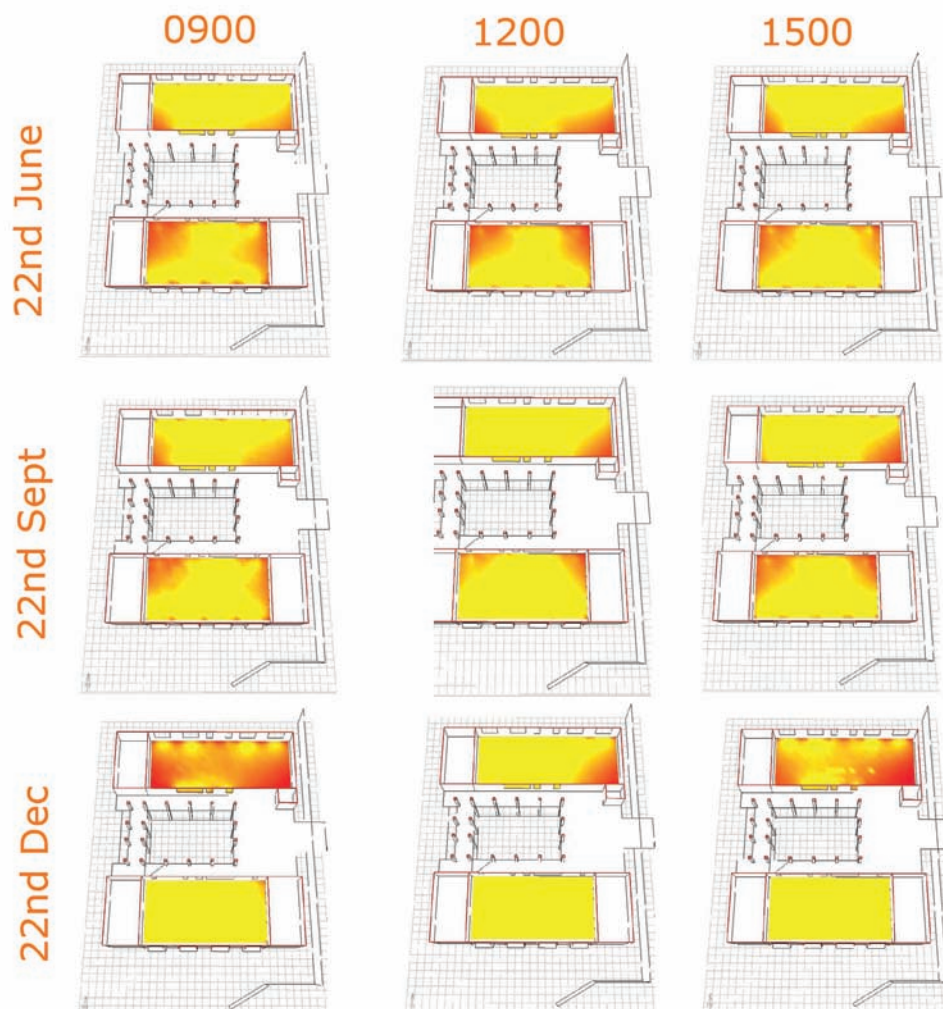
- The central open space (A) receives adequate sunlight during winters.
- Locate ground-based solar PV arrays in areas (B) receiving adequate sunlight even in winters.

**Fourthly, cross-**ventilation is ensured in all spaces including the ones not meant for regular human habitation (the monkey problem is making us close some of these spaces, but we are trying to find ways to balance the ventilation requirements).

**Adequate daylight levels are achieved in 100% of the regularly-occupied areas**

Lux	As per the NBC, teaching spaces require upto 500 lux
500+	
450	The current layout receives adequate daylight in the lecture halls and other regularly occupied areas throughout the year.
400	
350	
300	
250	<200 lux : 0% of the area
200	200-300 lux : 3-6% of the area
150	300-400 lux : 17-22% of the area
100	400-500 lux : 26-34% of the area
50	500-600 lux : 29-35% of the area
0	600-700 lux : 9-15% of the area
	>700 lux : 3-5% of the area

## Academic block





# FINDING THE RIGHT BUILDING MATERIAL: FOR EMBODIED ENERGY AND INSULATION

**Architectural design** with elements like courtyards and fenestrations help a building to breathe and regulate internal comfort conditions. But a building's ability to achieve and retain these thermal conditions is governed by the material used in the building envelope.

Further, as manufacturing of building materials is also associated with massive environmental degradation (stone and sand mining) and greenhouse gas emissions, we need to find the right building material with the least embodied energy and the highest insulation (and of course cost, today and tomorrow).

The measure used to calculate the material's insulation is U-value – the amount of thermal energy that the material allows to pass through. The lower the U-value the most insulating is the material. Our energy consultants helped to map the U-value of different building materials:

## Different U-Value of material

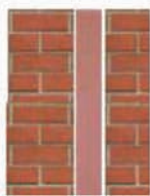
External wall assembly and insulation	Total thickness (mm)	U-value (W/sq.mt/K)	Cost (INR/sq.mt.)	HVAC energy savings (%)	HVAC plant downsizing (%)
230mm brickwall + 50mm insulation + external cladding	395	0.46	900 + cost of external cladding	13.3	13
230mm brickwall + 50mm insulation + 115mm brickwall	395	0.42	1,075	14.5	13.9
200mm Cement Stabilized Earth block wall + 50mm insulation + 100mm Cement Stabilized Earth block	365	0.43	1,300	13.9	13.5
200mm flyashbrick wall + 50mm insulation + external cladding	250	0.44	1,050 + cost of external cladding	13.9	13.5
200mm Hollow Concrete block wall + 50mm insulation + external cladding	225	0.40	1,200 + cost of external cladding	14.5	13.9
200mm AAC block + 50mm insulation + external cladding	225	0.36	1,450 + cost of external cladding	15.4	14.7
200mm AAC block + 25mm insulation + 100mm AAC block	325	0.42	1,625	14.5	13.9
300mm AAC block	300	0.47	1,350	13.3	13

## Based on the above we narrowed down our search to the following:

Composite walls of brick, hollow concrete & AAC blocks XPS insulation were compared to evaluate which wall section is best suited to the needs of the project

### Options for external wall sections

#### Wall-section: Option 1



Outer : 115mm brick  
Insulation : 50mm XPS  
Inner : 230mm brick

**U-value: 0.42 W/sq.mt/K**

Total thickness: 395mm  
Cost: ₹3,000 per sq.mt

#### Wall-section: Option 2



Outer : 115mm Hollow  
concrete block  
Insulation : 50mm XPS  
Inner : 230mm Hollow  
concrete block

**U-value: 0.40 W/sq.mt/K**

Total thickness: 395mm  
Cost: ₹3,000 per sq.mt

#### Wall-section: Option 3



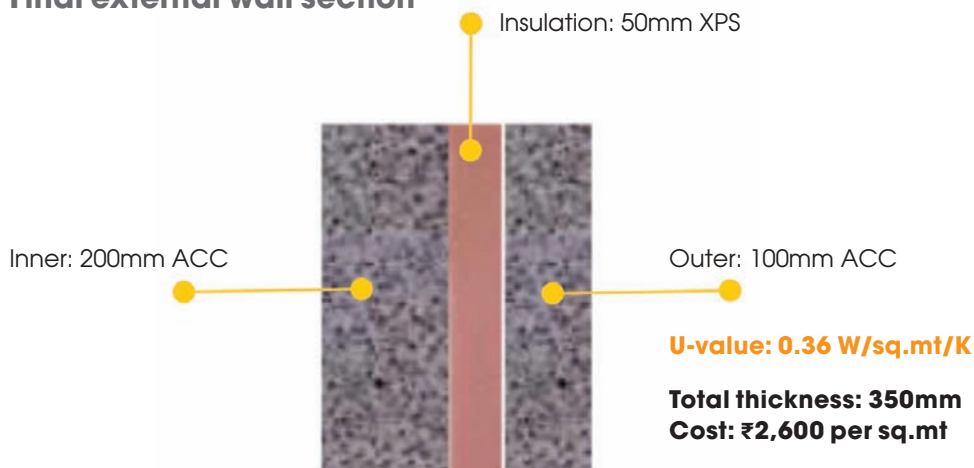
Inner : 100mm AAC  
Insulation : 25mm XPS  
Outer : 200mm AAC

**U-value: 0.42 W/sq.mt/K**

Total thickness: 325mm  
Cost: ₹2,200 per sq.mt

## We finally agreed on this option:

### Final external wall section



We decided to use 50mm XPS sandwiched between a 200mm and a 100mm AAC block walls.

This was the most insulating walling combination with a U-value of 0.30 W/sq.mt./K which is considerably better than the prescribed standard of 0.44 W/m<sup>2</sup>K by the energy conservation building code (ECBC). Now the ECBC prescribes 0.40 W/sq.mt./K.

The Aerated Autoclave Concrete (AAC) block were used because they are manufactured using high recycled waste (flyash) and provide better insulation. Flyash bricks were used for non-structural work and partition while ACC blocks are used in the envelope owing.

Initially we were sceptical as XPS is a petroleum based product with high embodied energy and pollution. But comparative data showed us that improved insulation would reduce energy requirements of the building and this would outstrip the embedded energy and pollution of XPS.

## Roof:

**Huge energy** losses happen here. So, it was decided to use a combination of 100 mm XPS with 100 mm RCC on the roof. We also used the “cool roof” technique to reflect solar heat. At AAETI, broken white and recycled ceramic tiles of 13 mm thickness are used on the roof to reflect the heat.

## Windows: Plugging the leakage

**Windows though** strategically located for maximum daylight and cross-ventilation are still major medium for heat gain/loss in the building.

To minimise this we used windows with double glazing with a U-value of 2.8 W/m<sup>2</sup>K and effective solar heat gain coefficient (SHGC) of 0.25 -- direct solar heat penetrating through glass. This low level of SHGC has been achieved with the use of high performance glass, combined with heavily shaded windows. Without the shading, we would have had to use darker tint glass, which would have reduced the visual light into the interiors.

To ensure quality daylight, window glass with visual light transmittance (VLT) of 81 per cent is used at AAETI.

Our estimate is that the investment in insulation and materials would bring down the energy demand of the building by over 20 per cent as compared to a conventional building.

This is the biggest investment at AAETI. We have to now see how it works to reduce our energy demand and to make the building comfortable for all.



## HEATING AND COOLING: FINDING A SYSTEM LOW IN ENERGY AND YET COMFORTABLE


**Our climate** is about the extremes – very hot and very cold and very humid. In conventional buildings we move from using air conditioners to space heaters for most of the year, adding to energy bills and all the environmental impact that goes with it.

Active ‘cooling’ to ensure thermal comfort is needed in the months of May to July (3 months) and active heating for 1 month, mid-December to mid-January.

So, we began discussions on the ideal Heating, Ventilation and Air Conditioning (HVAC) system, keeping in mind that we wanted a system that could be powered by solar energy – we wanted to plan for a campus that could go completely off-grid in the future. We met people; travelled to different projects where alternative HVAC systems had been installed; studied the economics and finally looked at the data:

### Comparison for different systems which was proposed for the finalization of system

Description	VRF	3 stage evaporative cooling with decentralised heat pump	3 stage evaporative cooling with central heat pump	Radiant cooling system with central heat pump	Radiant cooling system with central VAM
Load or Capacity	72 TR	56,000 CFM + 56 TR	56,000 CFM + 27 TR	46TR	47 TR
Peak power demand kW	86.40	66.36	43.2	32.20	12.4
Capital cost (lakhs)	50.40	123.20	107.60	142.17	250.4
Per unit cost ₹/kWh	8.00	8.00	8.00	8.00	8.00
Operating cost (lakhs)	16.35	9.55	10.51	9.61	5.7
Pay back		10.72	9.80	13.62	18.8
Demand kWh/day	1,617.41	588.00	588.00	803.71	309.5
Solar PV	269.57	98.00	98.00	133.95	51.6
Total capex (lakhs)	346.92	231.00	215.40	289.52	307.1
PV area required in sq.mt	2,156.54	784.00	784.00	1,071.62	5,702.7



The decided to invest in a 3-stage evaporative cooling system but we decided to implement the system so that it was decentralised – different buildings would have their own version of the system, based on their requirements.

### **The system was selected for the following reasons:**

- a.** The energy consumption would be almost half as compared to the other best systems
- b.** The overall capital cost would be lower, if we accounted for the generation of electricity through solar or wind. The objective for planning was to try and make the campus off-grid.
- c.** The choice of a modular and decentralised system would allow us to innovate and to monitor energy use in different conditions.
- d.** We also decided to avoid compressor/refrigerant based cooling for major duration of the year and yet we could make the spaces comfortable.

As we implemented the scheme, we have made changes – based on our learnings of our needs and what we could afford.

## AAETI'S HVAC SYSTEM – OPTIMISING FOR CLIMATE AND ENERGY REQUIREMENTS

The campus has five different systems – we want to see how these work and what is the energy-comfort quotient that we can monitor and then build upon or better.

### Student/Guest Housing (SH1 and SH2)

#### 3-stage evaporative cooling system with heat pump-chiller

**The system** is primarily based on moving air – large quantities through the ducts and during the period when we need heating or cooling, the heat pump chiller kicks. It's a system based on the old-fashioned desert cooler, but made more efficient through its direct and indirect technology of cooling air. When the heat-pump chiller is operational for de-humidification (during monsoons), the system also provides hot water as a by-product.

In the first stage, the air is cooled indirectly by pipes carrying water which is humidified in the second stage through direct evaporation. This is an improved version of classic desert cooler and is perfect for hot and dry season which is the dominant weather in Rajasthan.

The third stage which uses the refrigerant for cooling instead of water kicks in only when the ambient air has too much humidity rendering evaporative cooling redundant. This system restricts the use of energy intensive to 2-3 months of monsoon.

Hot-water provided as the by-product of the system is used to meet hot water requirements of the campus. Additionally, it doubles up as space heating in winters.

All rooms are provided with ceiling fans to serve as the first means to tackle rising heat as they most efficient and prudent means to get cool if the temperature is off by a few degrees only.

TOTAL  
BUILT AREA

**4,493**  
sq.mt.

**SH1: Unit 1**  
serves the top  
2 floors and is  
installed on the roof  
and its capacity is

**12,500**

Cubic Feet  
Minute (CFM)

**SH1: Unit 2**  
serves  
3 floors,  
basement, ground,  
first and its  
capacity is  
**15,000**  
CFM

**SH2:**  
1 unit and its  
capacity is  
**15,000**  
CFM



**The heat pump-chiller is installed on the roof of the cafeteria, provides space heating and space cooling and domestic hot water.**

**When the chiller is working then the air-handling system (AHU) operates at 50 per cent capacity in terms of the volume of air that is handled.**

## **Operations: Guidance**

- 1.** For most of the year, we plan to use only air-cooling. Even in the peak summer months, we would like to use the air-cooling system, with fans and open windows for ventilation.
- 2.** We have controls on each floor and the unit can be switched off manually. The administration needs to accommodate people in the building so that the air-handling unit of unoccupied areas can be switched off.
- 3.** In the air-handling unit, we have used variable frequency drive so that the system automatically increases and decreases the cooling capacity depending upon demand.
- 4.** We get hot water as a by-product of running the chiller. In rooms we have insulated hot water tanks.
- 5.** The HVAC system will work between 18-26°C.
- 6.** The system will turn on the hot air (heating) when the ambient temperature is 18°C and below
- 7.** The system will turn on the cold air (cooling) when the ambient temperature is 26°C and above and the humidity is roughly 70 per cent.
- 8.** Administration can check this through the humidity sensor, which is in the air-handling unit, which is displayed on the programme logic controller.
- 9.** The opening of windows is bad when the heat-pump chiller is working as it will make the system inefficient and even lead to its collapse, as it will have to keep working to provide temperature control. Think of it like your home AC/heater working overtime to control temperatures, if you have opened doors or windows.
- 10.** However, it is good to open doors and windows when only evaporative cooling (air-handling unit) is working, as it will improve ventilation and air-flow.
- 11.** Hot water is a by-product of the heat-pump chiller and is not the primarily reason for its operations.
- 12.** We have not installed individual room temperature control devices, partly because of the expense. We have the following options
  - a.** Put thermo-meters in all rooms (with guidance on when to open windows)
  - b.** Install manual air flow, which requires administration to open and close the vents entering each room (₹ 9,000 + civil work for damper)
  - c.** Install individual switch off in all rooms (₹ 40,000 per room)
- 13.** The hot water through the heat-pump is more efficient option than the boiler-type geysers. But at a later stage we may want to consider increasing the efficiency of our system by installing hot water systems based on solar energy.

## Cafeteria

**We use** a variation of the 2-stage evaporative cooling system.

The main dining hall and serving area is on air-cooled system (13,500 CFM); for temperatures above 26°C.

We have a provision to add a cooling coil in the air-handling unit, which would make it 3-stage evaporative system.

The current heat-pump chiller has been designed to provide for cooling/heat with the additional installation of cooling coil. We will monitor the 'comfort' levels of this system and then decide.

We have installed a hot water system using solar energy for exclusive use of the kitchen.

## Academic Block

**We use** another variant of the 3-stage evaporative system but this time with the use of water-cooled chillers.

Two air handling units of 15,000 CFM and 12,500 CFM each.

The air-handling unit is attached to a water-cooled chiller (30 tonnes). This will give us cooling in classroom in peak summer/high humidity periods.

There is no space heating in the academic block, because the building is highly insulated and most times the classrooms are used during day time with high-occupancy density (human heat).

There is no hot water here.

## Laboratory

**Lab system** is separate (independent VRV 18 hp or roughly 15 tonnes). This gives heating and cooling. The Variable Refrigerant Flow (VRF) system in Air Conditioners (AC), is an advanced split AC system which can have more than one indoor outlets for each compressor unit installed outdoors. Further, this system varies the flow of refrigerant to indoor units based on demand and the outdoor unit has one or more compressors that are inverter driven. In short, VRF is the most efficient version of conventional room AC system.

Also we have separate ventilation machine for 6 hp fresh air and carbon and fine-filter exhaust for septage and microbacterial laboratory.

## Guest-house

**We use** the conventional room air conditioner (11 ACs of 1.5 tonnes), but these come with R 290 refrigerant gas – ozone and climate friendly gas.

## Support Housing

**2-stage** evaporative system.

Air handling unit of 12,500 CFM for all floors.

We have a provision for installing water or air based chiller with heat pump in future.

## Gym/fitness centre

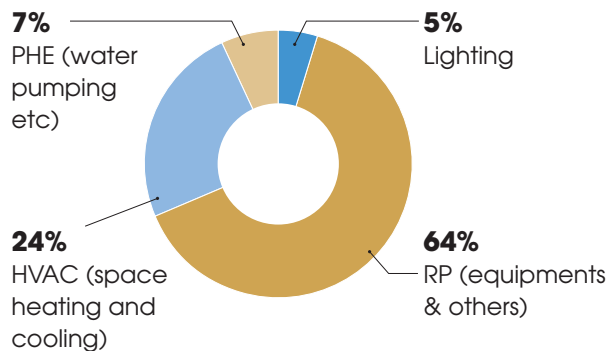
**Five ACs** of 1.5 tonnes each with R 290 refrigerant gas.

# ESTIMATING ENERGY USAGE

**We needed** to see where we used electricity before we would monitor or reduce.

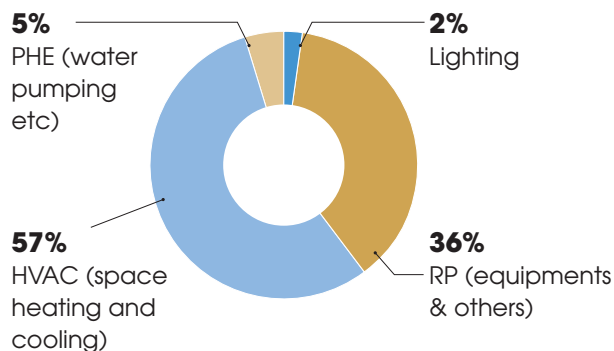
## Electrical Demand Load (kW)

Total  
**284 kW**

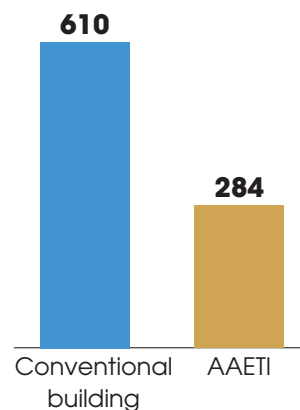


## Energy Demand (kWh/day)

Total  
**2,382 kWh/day**



## Comparison of electrical load (kWh)



**Based on** the load and energy demand of different buildings, we calculated how much solar PV would be required to meet full demand and also the area required to install the system. According to this estimation, our total connected load is 473 kW, Peak Demand Load will be 284kW; consumption would be 2,382 kWh/day and for this demand we would require a solar PV system of 310 kWp, which in turn would require some 2,790 sq. mt. of land area (rooftop and surface).

However, we as you will find later, we have not installed the full solar system yet and because of the requirements of our laboratory (which was planned subsequently), we will have higher consumption.



## SMART APPLIANCES: REDUCE ENERGY USE FURTHER

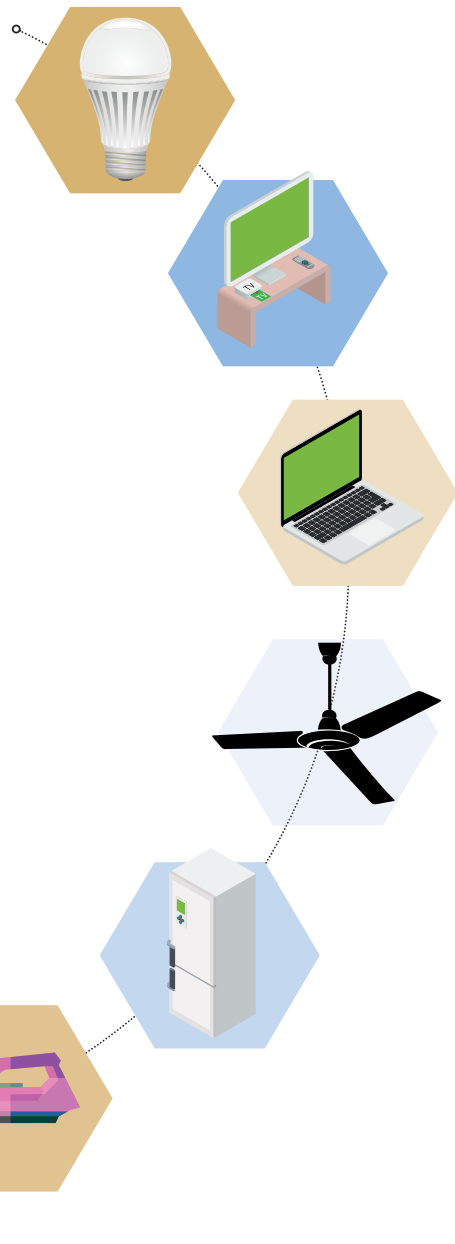
**We have** installed energy efficient fans that use only 28W, one-third of a conventional fan.

The objective is to reduce lighting needs though use of filtered sunlight as much as possible. The campus is designed to filter in day light into the interiors after cutting out heat and glare. Windows have been limited to just 30 per cent of the wall area and strategically located for maximum daylight.

Day-lighting potential of the windows have been enhanced by providing them with light-shelves in classrooms. A light shelf is a horizontal surface that reflects daylight deeper into a building than it would naturally travel from a typical window. Light shelves are placed above eye-level and have high-reflectance upper surfaces, which reflect daylight onto the ceiling which further reflects it deeper into the space. Corridors in the student hostels have day-lit using special wind shelves which double up as skylight.

With this done, we hope that the campus doesn't require artificial lighting during the daytime for majority of the year. All the artificial lighting requirement on the campus are met by energy efficient lights.

In a conventional building, 85 per cent of energy consumption is linked to HVAC and lighting usage which can be controlled by design and building management. The remaining 15 per cent comes from the use of appliances – everything from computers, kettles and refrigerators. Now that we have reduced our HVAC and lighting energy footprint, we need to monitor use of other equipment and see what we can do to rationalise consumption. This is our operational step.



# SOURCING RENEWABLE ENERGY

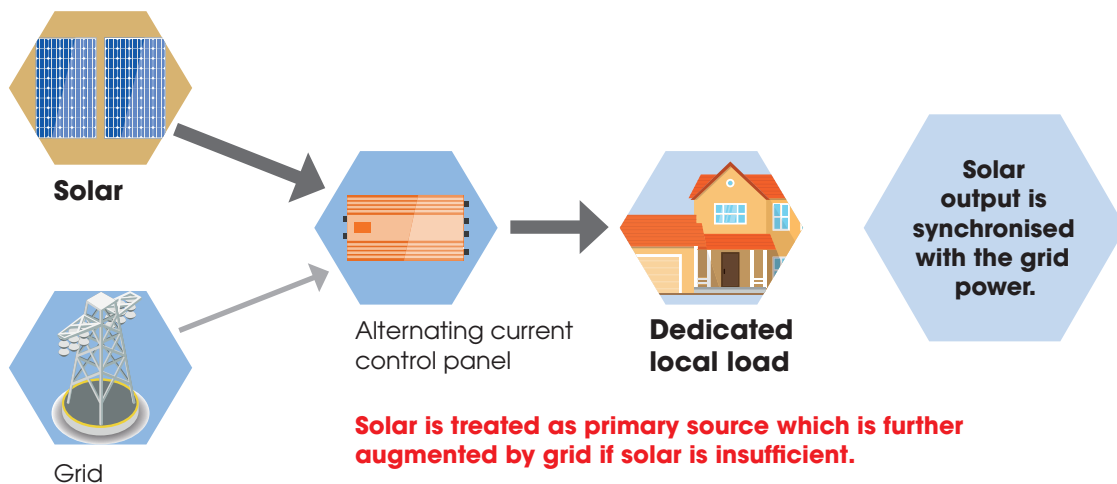
**Now that** the campus energy requirement has been reduced, the next step is to generate energy from renewable sources. Our objective is to go completely off-grid over time. This will depend on how efficiently we can use our systems and to see how we can make our laboratory more energy efficient.

Currently, we have installed a solar system to meet our primary needs and the rest comes from the grid. Our solar system is grid-interactive so what we do not use we will feed into the grid.

## Operation of on-grid solar power plant

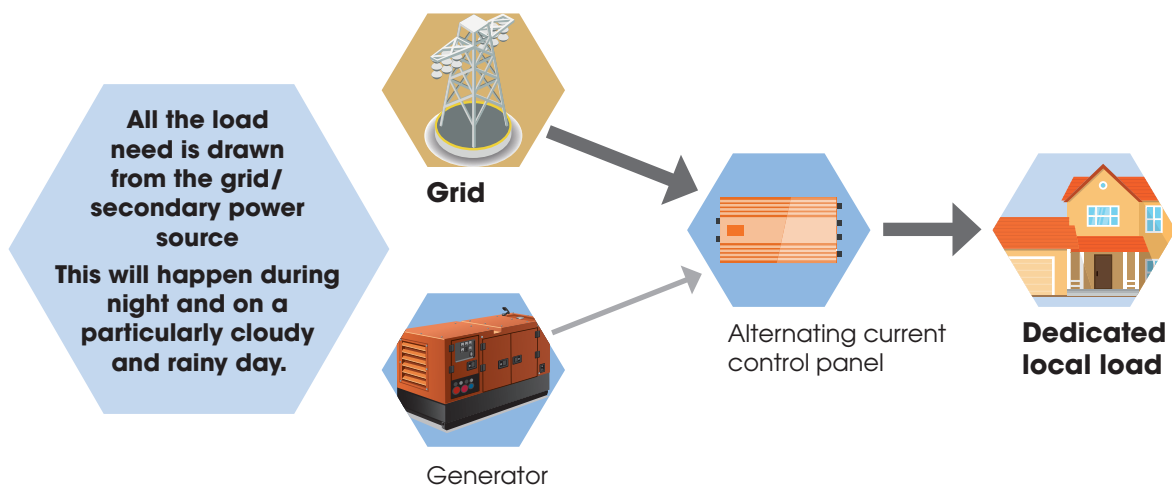
### SCENARIO 1 -

**Grid & solar are available**

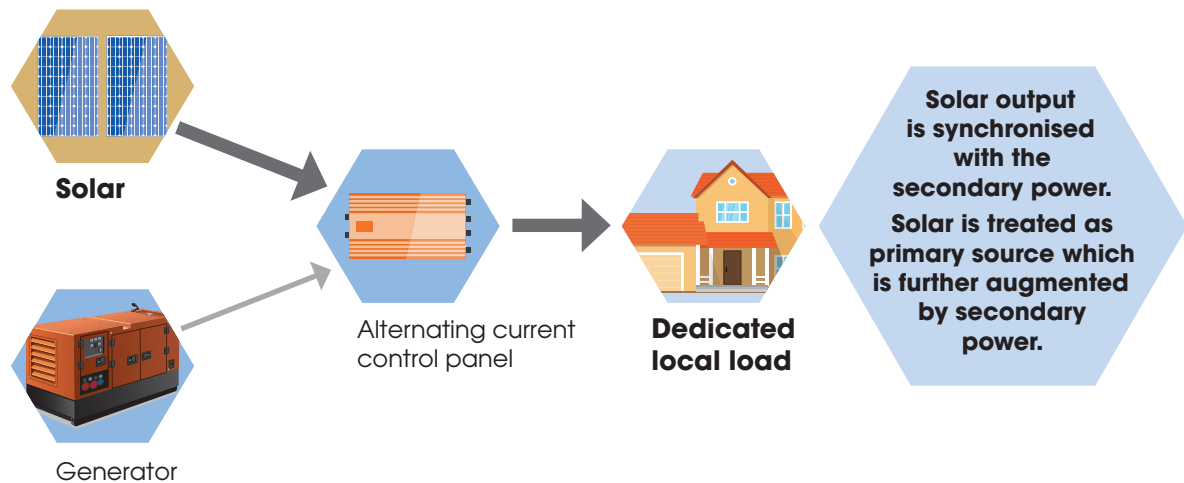


### SCENARIO 2 -

**Solar is not available.**



### SCENARIO 3: Secondary power & solar are available



Currently, the campus has 70 kWp of solar PV system in place which is capable of meeting 20-25 per cent of our projected energy demand. This will be scaled up in phased manner to meet the entire energy requirement. The connection to the national grid also eliminates the need for battery bank to store the harvested solar energy while providing opportunity to sell the excess solar energy that campus will eventually generate.

CSE has signed an agreement under RESCO model so that we will pay a flat rate of Rs 5.50 per unit for 12.5 years for the entire system. There is no tariff revision provided.

The company is responsible for the design, supply, installation and commissioning as well as the O&M of the 70 kWp of solar power. After 12.5 years, the plant will be transferred to CSE.

The cost of power we buy from Rajasthan state electricity board is ₹ 8 per unit; therefore, we are saving ₹ 2.5 per unit and also get power from our own rooftop.

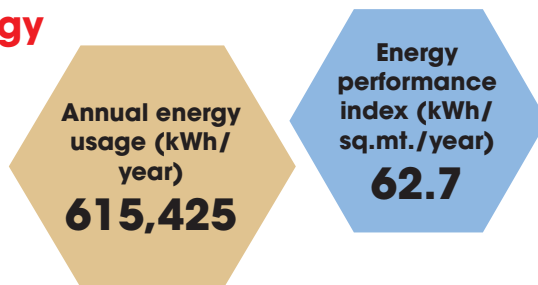
We still require generators and UPS for backup for our computers and lighting needs during power-outages.



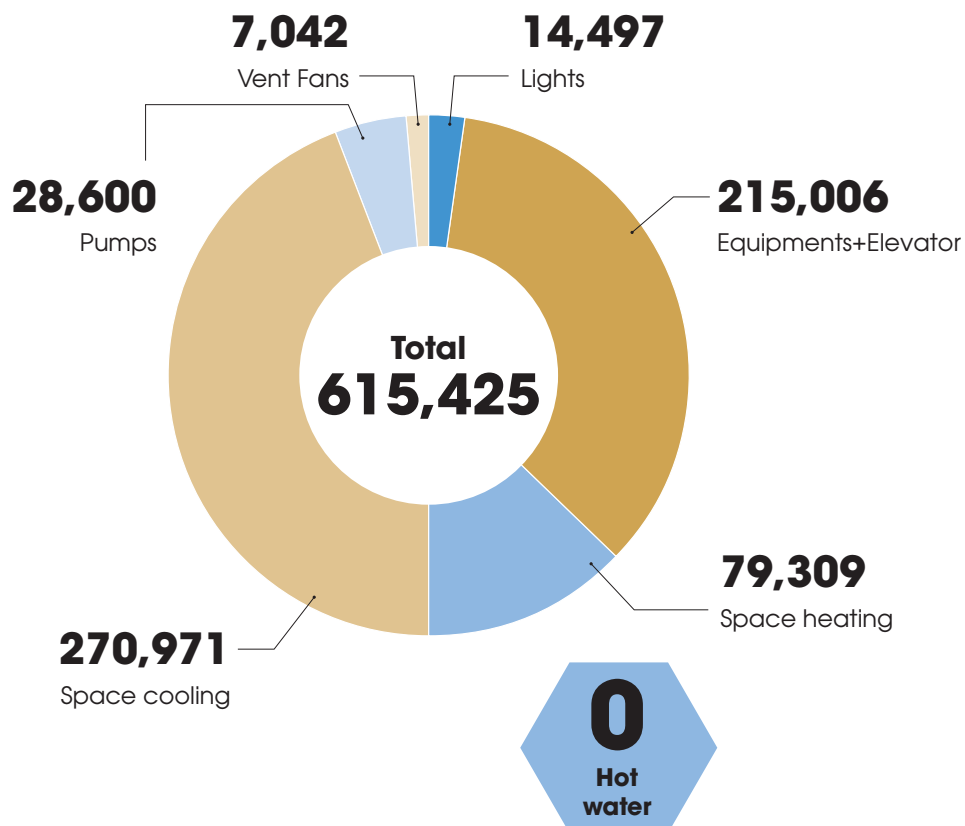
## CALCULATING AAETI'S ENERGY BENCHMARK

**Based on** design and implementation it is estimated that the 9,800 sq.mt. campus would consume about 62.7 kWh/sq.mt./year of energy once fully operational. This is 49 per cent lower than the energy efficiency requirement an institutional building under ECBC. This is also 46 per cent lower than the UNDP-BEE energy benchmark of 117 kWh/sq.mt./year for institutional buildings in composite climate.

### AAETI's energy summary



### AAETI Design (kWh/year)



# BUILDING A WATER NEUTRAL CAMPUS: TAKING LESS THAN WHAT WE GET FROM NATURE

## Preserving natural drainage

**AAETI** is surrounded by Aravallis and this means that the catchment of water is huge – the hills drain into the plains. We also have a seasonal water channel that flows through our campus. The first task we had was to map the rainwater channels and then to estimate our water needs. The objectives for water management were:

- To augment water availability by ensuring that we could channelise the flowing water to improve recharge and to store rainwater for our use.
- To minimise water demand through careful budgeting.
- To ensure that all wastewater – sewage and greywater from use – was treated for re-use.
- To regularly monitor groundwater levels to ensure that we would not deplete our aquifers.
- To regularly monitor quality of water supplied for use in the campus.

Overall less than nine percent of the land is utilized for construction, which allows us space for green and other environmental functions.

## Rainwater harvesting and groundwater monitoring

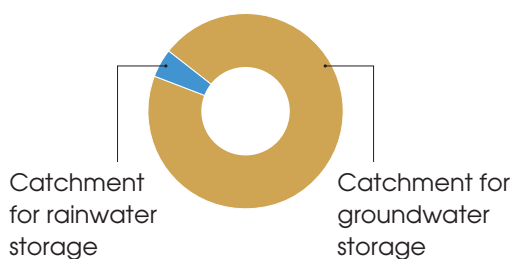
**It is** estimated that the site has a rainwater harvesting potential of about 11,400 Kilo Litre (KL) annually. Due to the terrain of the area it is further estimated that the site will be able to collect and recharge additional run-off from the surrounding areas of around 12,000 KL annually.

### To harvest this rainwater, we have done the following:

- Built two underground rainwater storage tanks with combined holding capacity of 200 KL under the academic block and cafeteria. Based on the average rainfall of the area, the combined roof area will harvest roughly 913 KL annually. These would meet all the water requirement of the cafeteria for 190 days during the non-monsoon season. Currently, we have a provision to pump this stored water directly to our drinking water system. To ensure the quality of water, we have first a bypass for the first rain; de-silting chamber and after the rainwater tanks we have a disc-filter (sand-filter) and then in addition we have aquaguard with UV. We will regularly monitor the quality of drinking water in our lab.
- Built eight re-charge wells in different locations so that rainwater used to augment groundwater aquifers.
- We will also build more gabion and checkdams in the campus over time as we begin to understand water flows and can hold, recharge and drain rain.

With this done, we will recharge our groundwater and also ensure that when it rains, we do not flood.

**Total area of the Site: 39,100 sq.mt.**



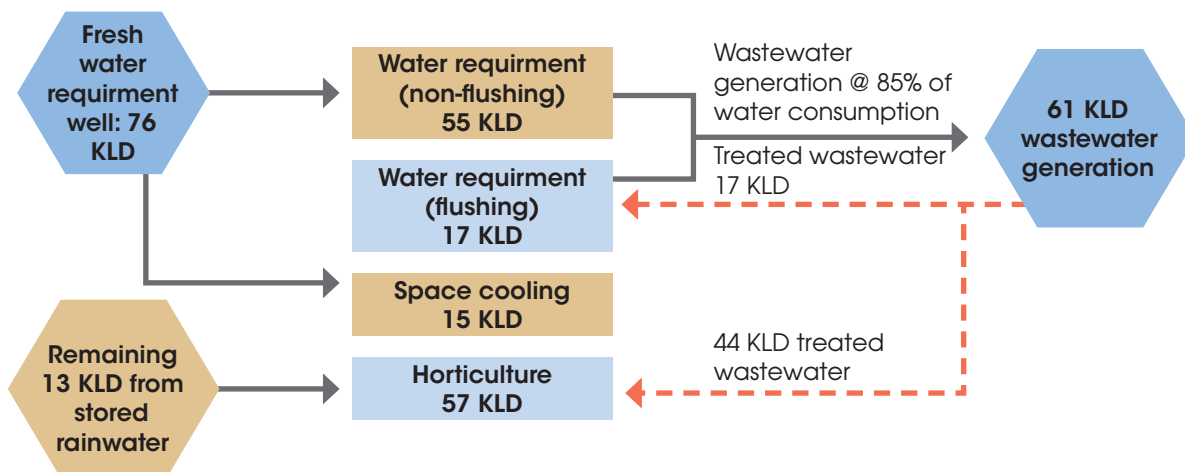
### Rainwater storage

Building	Roof Area (Sq.M.)	Collection potential Yearly (KL)
Academic Building	604	380.52
Cafeteria & recreation	845	532.35
<b>Total</b>	<b>1,458</b>	<b>912.87</b>

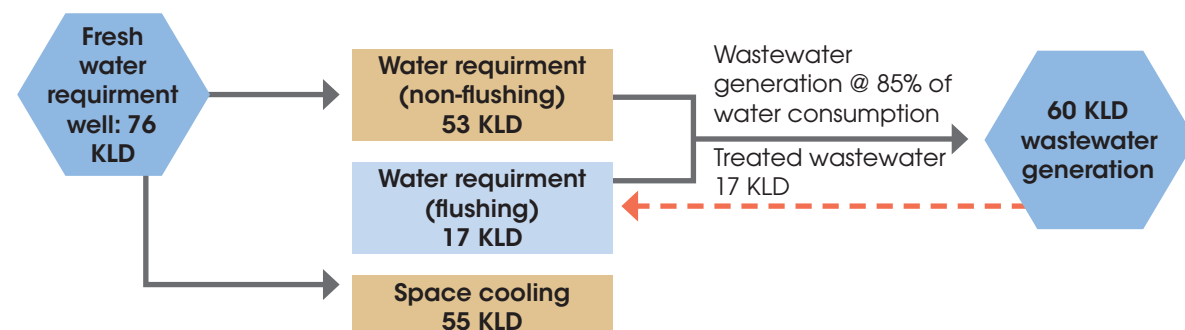
## Water budget

**The campus** is estimated to extract a maximum of 76 KLD/day for all its flushing and non-flushing purposes, during non-rainy days. The extraction of water through the borewell is being monitored by the flow meter attached to the borewell. To measure the impact of the recharge of rainwater in the ground, two piezometers have been installed to measure the impact in the first two levels of aquifer – one piezometer is near the natural stream and the other near the entrance. This will allow us to monitor our usage and take corrective steps. Efficient water fixtures and conservation has helped in bringing down water consumption of the campus by about 36 per cent. Water consumption is pegged at 86 LPCD as against standard 135 LPCD.

### Daily water consumption balance chart (non-rainy days)



### Daily water consumption balance chart (rainy days)

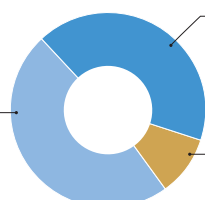


*Note: 2 KLD of canteen water will be supplied from stored rainwater. Hence the fresh water demand in rainy days come down from 55 KLD to 53 KLD*

### Water requirement at AAETI (in KLD)

**35 (48%)**

Water required for irrigation



**31 (42%)**

Freshwater required for buildings

**7 (10%)**

Water required for flushing

## DECENTRALISED SYSTEMS FOR SEWAGE: RECYCLING AND REUSING

**The objective** is to use and demonstrate decentralised sewage technologies at AAETI. The total wastewater generation is estimated at 61 KLD, when the campus is fully operational.

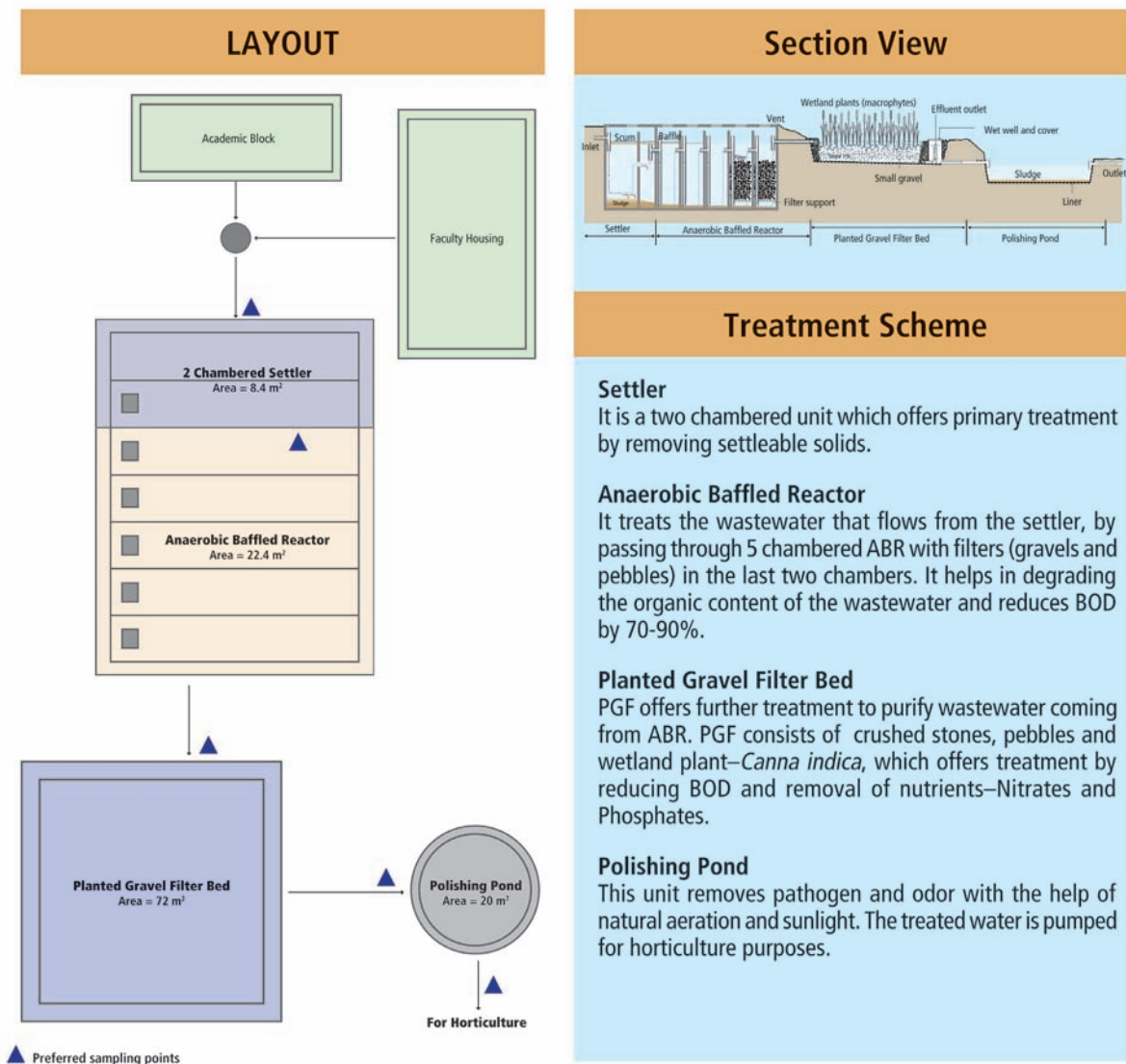
Given this we have designed four separate systems for wastewater treatment at the campus, adding up to 30 KLD roughly.

- 1. Decentralised wastewater system (DWWTs)** is designed to take the sewage of the academic building and faculty housing. The system design is for 8 KLD. This system is based on an anaerobic system, where the sewage passes through settler, baffled reactor and then treated in an aerobic polishing pond. The quality of treated water is fit for horticulture (SEE CHART). CSE will be regularly collecting samples from the inlet and outlet as well as from different parts of the wastewater treatment system to check on its efficiency of treatment.
- 2. Soil Biotechnology based wastewater treatment system**, which is designed to take the wastewater from the cafeteria and the student housing and support staff. This system is 20 KLD. This is a patented technology of IIT-Mumbai and here wastewater is treated through various layers of the bioreactor. The treated wastewater from this system is designed to be used for flushing. The treated water from this system will be pumped to an overhead tank and from here it will be pumped to the flushes in the academic block, student housing, cafeteria and the support housing (SEE CHART). CSE will also regularly collect samples from 3 points of this system – inlet, outlet and mid-way to check on quality.
- 3. Improved septic tank**, which is designed to take the wastewater only from the guest house. This system is small, only 1 KLD. But the objective is to see how we can improve a conventional septic tank system, which is widely used across India and other parts of the developing world. In this case, the septic tank is 3-chambered (as against the widely used 2 chamber system). The first and second chamber is for settling and the third chamber improves the quality of sewage through bio-degradation. The treated waste is then passed through a soak pit and discharged into the ground. CSE will develop a protocol to check on the quality of treated wastewater septic tank.
- 4. Prefabricated septic tank** for the Gym – to test how such a system will work. This has two-chambers and treats on-site.

The CSE lab wastewater is treated separately. The chemical and wet waste from the laboratory is disposed into a lined tank, where it will be neutralized with lime. We have two tanks of which only one will be functional at a time. The capacity of each tank is 1,000 litres.

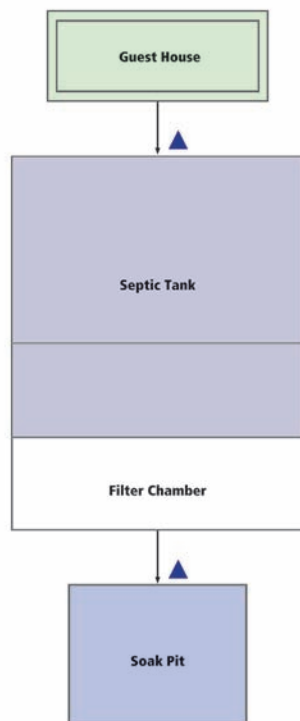


## Decentralised wastewater system



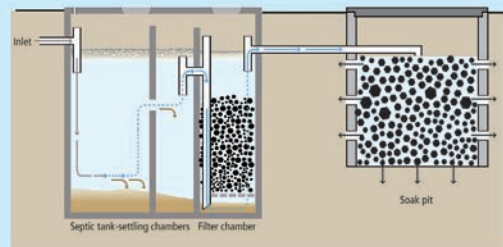
## Improved septic tank

### LAYOUT



▲ Preferred sampling points

### Section View



### Treatment unit

#### Septic tank

The first two chambers of the septic tank are designed to separate the settable solids by allowing them to settle down.

#### Filter Chamber

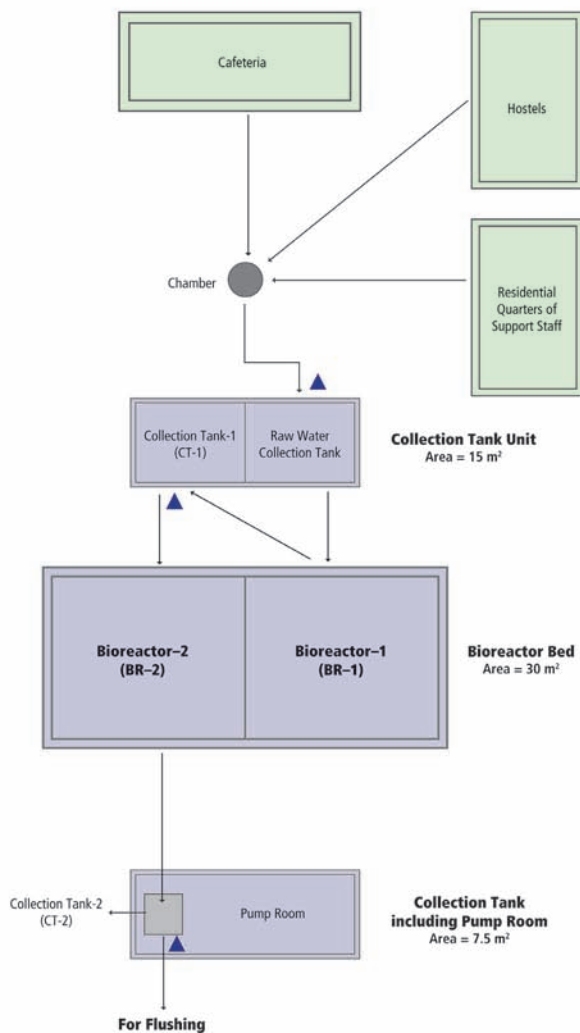
The effluent from the second chamber enters the filter chamber. The filter is of crushed stones. As the effluent passes through the filter layer, it undergoes anaerobic biodegradation. The anaerobic microbes that are attached to the filter layers play important role in reduction of organics and further removal of solids.

#### Soak Pit

A soak pit is a covered, porous-walled chamber that allows water to slowly soak into the ground. Treated effluent from the improved septic tank is discharged to this chamber from which it infiltrates into the surrounding soil.

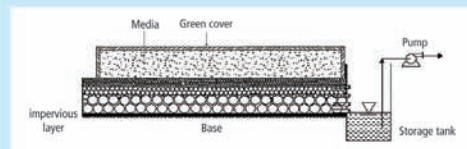
# Soil Biotechnology System

## LAYOUT



▲ Preferred sampling points

## Section View



## Treatment Unit

### Raw Water Collection Tank

Wastewater from cafeteria, hostels and residential quarters of support staff is collected in the tank.

### Bioreactor Bed

There are two bioreactors (BR-1 & BR-2) that consists of various layers of crushed stones, jute bags, crushed bricks with media which supports microbial growth.

### Collection tank

The treated water from the bioreactor bed (BR-1) gets collected in a collection tank (CT-1). Further the treated water gets collected in another collection tank (CT-2).

### Overhead Tank

The treated water is stored in the overhead tank and further distributed for flushing in toilets.

## WALKING THE TALK ON SOLID WASTE MANAGEMENT

**Our objective is to move towards a 'Zero Waste Campus'**

**This requires us to do the following:**

1. Ban certain non-recyclable material from entry into the campus – plastic carry-bags, pet bottles and other materials, which are disposed off in our orange and red box.
2. Find alternatives to material, which is not recyclable, for instance, tea bags, shampoo and soap sachets, food packed in multi-layered packaging (chips, biscuits etc).
3. Segregate all material at source.
4. Compost all biodegradable material on site.
5. Reduce food wastage – in the first year, we want to reduce wastage to half (please help when you take your food).
6. Recycle all other material through informal recyclers.

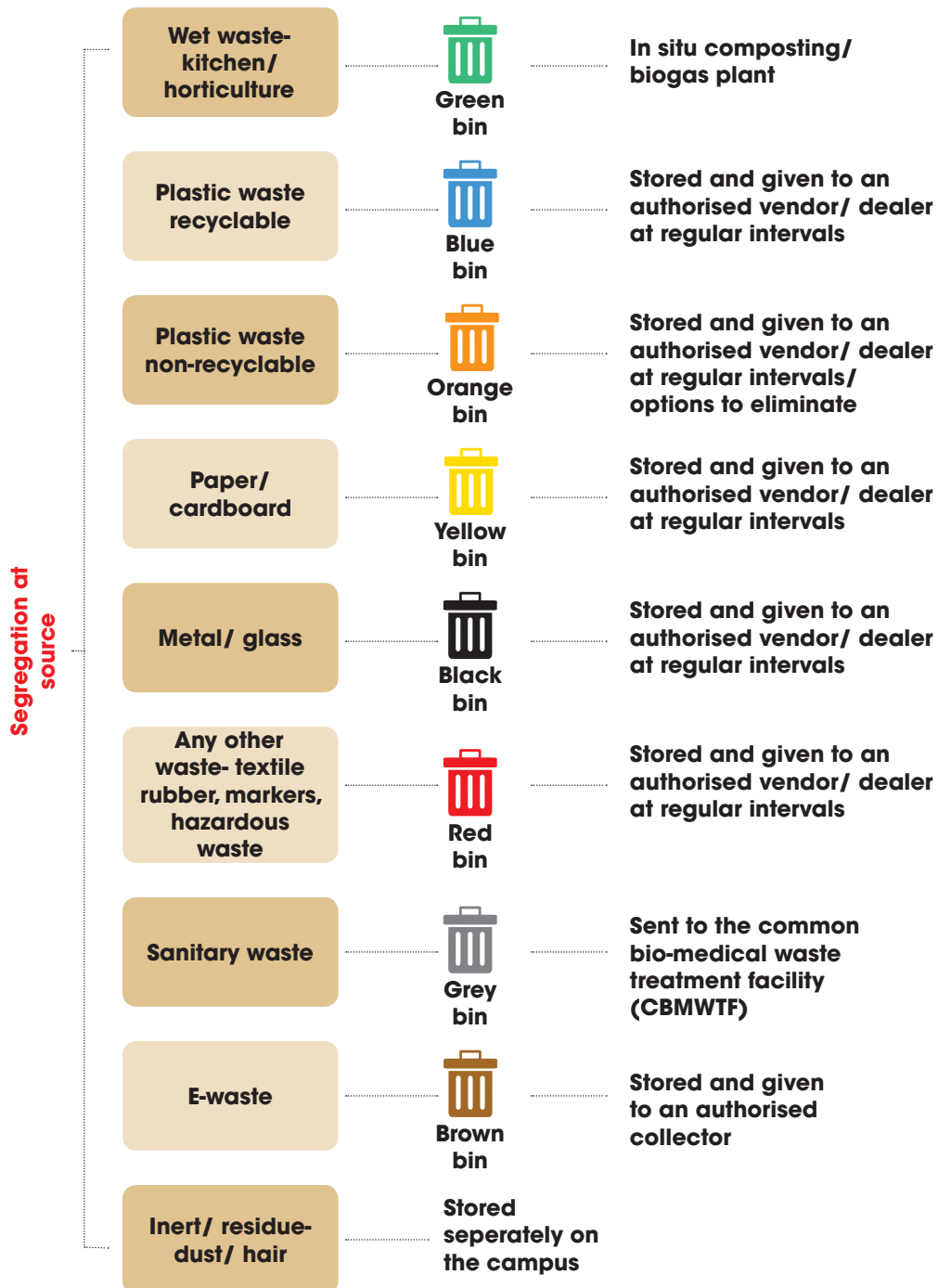
The detailed plan for solid waste is given in the "Walking the Talk" volume 2.

But please look out for the following bins and help us minimize and segregate, segregate and segregate.





## Waste generated



## MONITORING FOR GREEN PERFORMANCE

**We have** invested into a green building. But we know that “green” is as “green” does in daily life. In other words, the actual performance of the building in terms of reduction of energy, water and waste will hugely depend on how consciously we use AAETI and how we make it a ‘living machine’. For this we need to live the change.

But first, we need to monitor the usage of resources carefully in the building and then use this to improve our performance.

**We will do the following:**

### Monitoring protocol for AAETI: what to monitor; why and from where the sample/data will be collected

Objectives		Location	Periodicity / reading
Energy: to ensure we keep to design level of EPI	Meter 1	Entry Gate	
	Meter 2	Canteen basement	
	Meter 3	Academic Building ground floor	
	Meter 4	Student Housing 1 ground floor	
	Meter 5	Student Housing 2 ground floor	
	Meter 6	Support Staff Housing ground floor	
	Meter 7	Fitness Centre ground floor	
	Meter 8	Guest House ground floor	
	Meter 9	Support Staff Housing ground floor	
Water levels: to ensure that water levels do not decline but get augmented	Piezometer 1	Entrance	
	Piezometer 2	Stream	
	Water Meter	At the bore well	

Objectives		Location	Periodicity/ reading
Drinking water quality: ensure there is no contamination	Aquaguard 1	Academic building	
	Aquaguard 2	Cafeteria	
Wastewater	DWWTS:	Inlet of settler	
Ensure effective treatment and no contamination		Inlet to ABR	
		Inlet to planted gravel filter	
		Inlet to polishing pond	
		Final outlet	
	Soil Biotech	Inlet to raw water collection tank	
		Collection tank 1	
		Final outlet	
	Septic tank	Developing protocols	
Solid waste			
Reduce food wastage to half	Cafeteria	Where food plates are emptied	
Eliminate 'Orange' plastic – non- recyclable	Orange box		
Weather station (the RainWise Portable Weather Logger (PORTLOG) operates as a completely self contained system. No power is required. The solar/battery supply will power the system continuously)	1. Wind speed 2. Wind direction 3. Temperature 4. Humidity 5. Dew point 6. Barometer 7. Rainfall 8. Solar radiation	Next to site-office huts	

## LIVING THE CHANGE: WHAT WE NEED TO DO

None of this is possible, without your active engagement.

We have to be the change. We have to live the change.

**Please, please help us make AAETI a green campus by doing the following:**

- 1. Do not open your windows and doors, when the air-conditioning is on** – our heating and cooling system is based on a heat-pump chiller and it will have to over-work and over-use energy if you open windows or doors. Do use your fan when air conditioning is on as it will give you maximum 'comfort' conditions.
- 2. Do enjoy the windows or use the balcony (but protect yourself from monkeys please) when the air-cooling system is on.** Our building is designed so that you can enjoy ventilation.
- 3. Wear climate-appropriate clothing so that we do not have to over-heat or over-cool our campus.** Our temperatures are set at 26°C for summer and 18°C for winter.
- 4. Take your water bottles and fill them up at our water dispensers so that we do not have to use bottled water.** We are checking the quality of drinking water regularly.
- 5. Do not waste food please.** We have made this an objective of our campus. Please take only as much as you will eat.
- 6. Segregate your waste** – read the waste manual for details
- 7. Do not bring non-recyclable plastic** – particularly pet bottles into the campus and all other materials we are trying to eliminate, which are not recyclable.

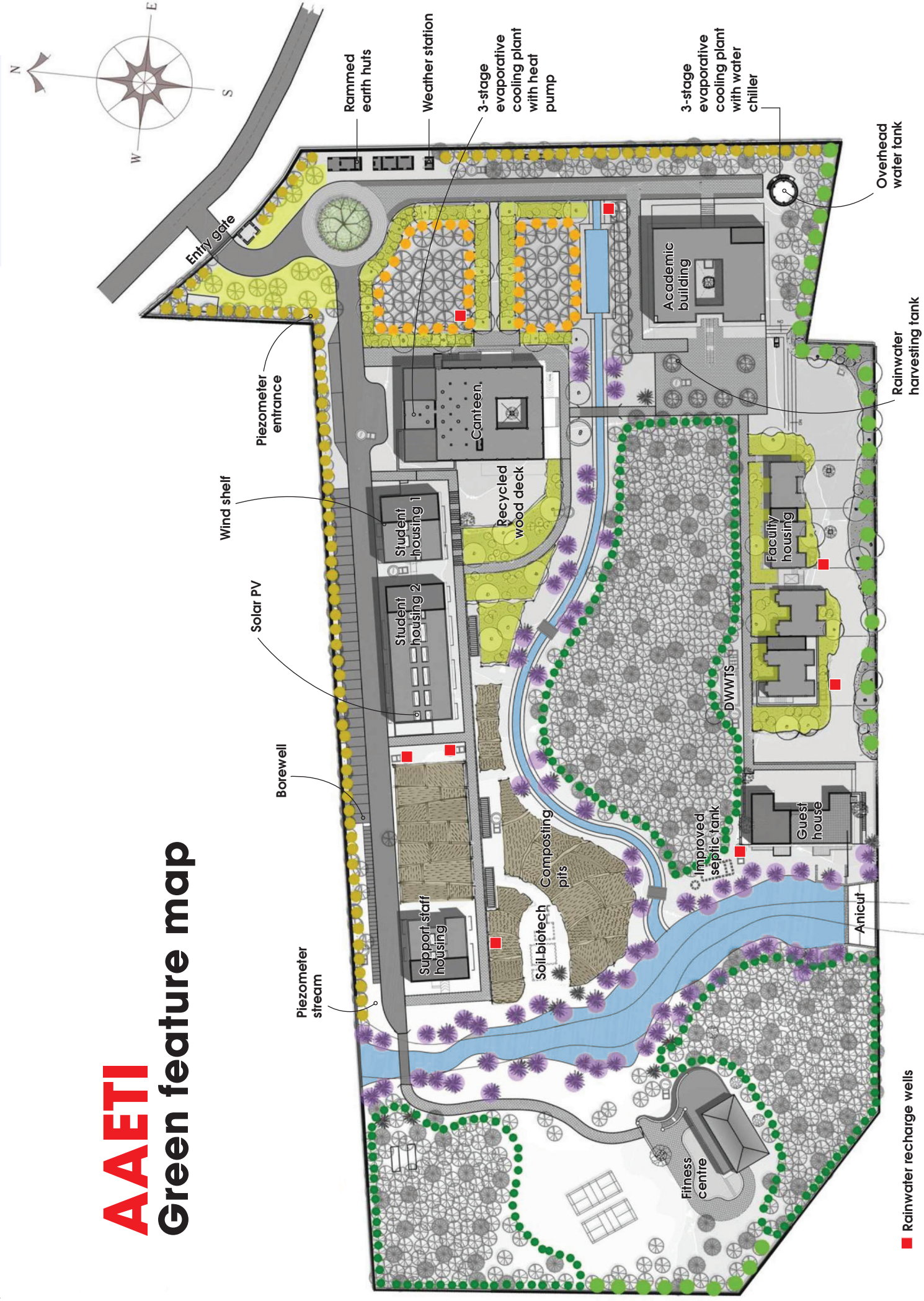
**Enjoy the campus and tell us what more we can do to improve its facilities and your experience.**

**From all of us at CSE**



# AAETI

## Green feature map







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