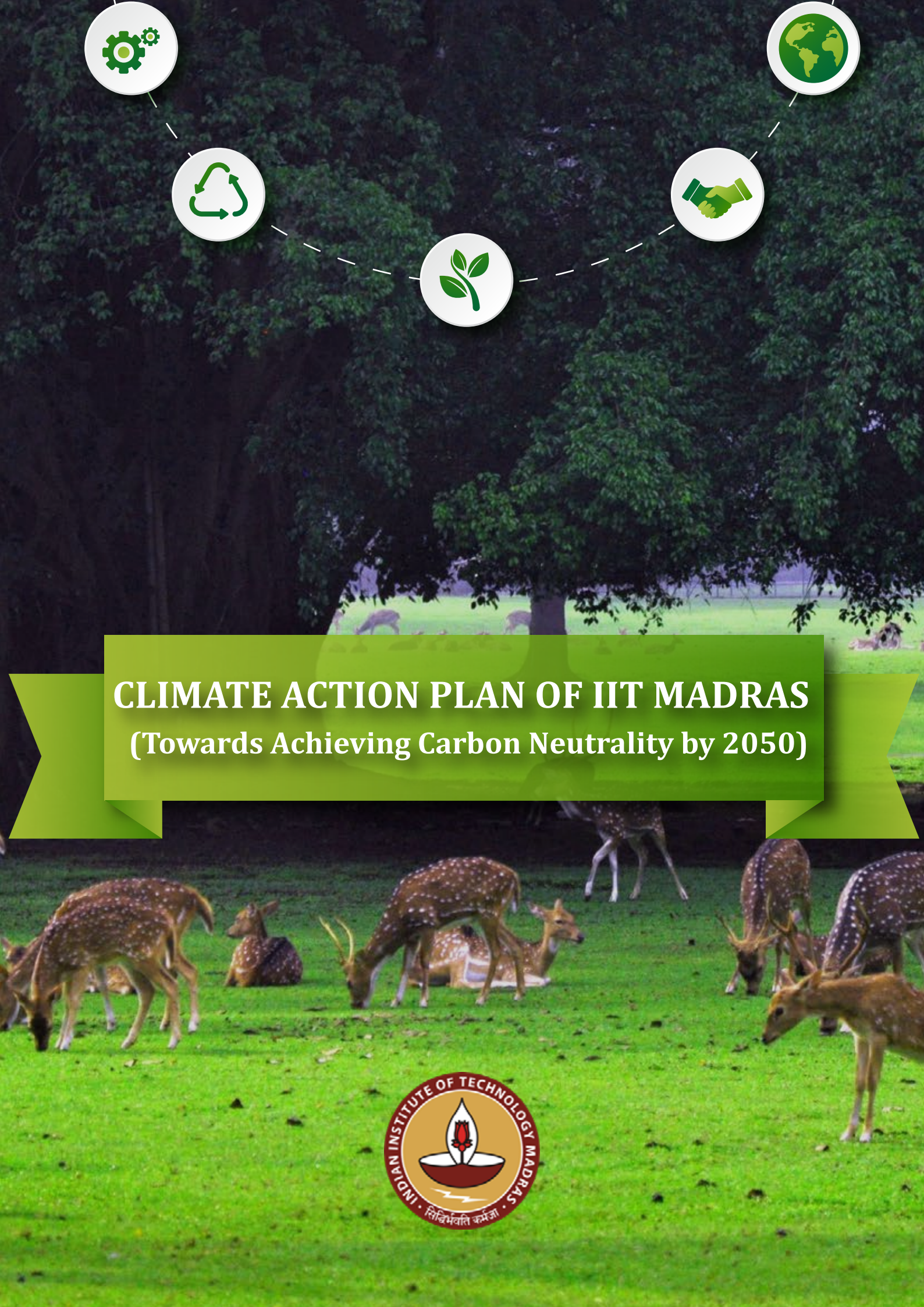


CLIMATE ACTION PLAN OF IIT MADRAS

(Towards Achieving Carbon Neutrality by 2050)

CONTENTS

FOREWORD BY DIRECTOR

Dear Partners and Friends of IIT Madras:

We at IIT Madras have a strong commitment to find sustainable solutions to not only the developmental challenges the community on the campus faces but also the challenges that our nation faces. For this, we take a multi-pronged approach. First, we wish to lead by example, and implement innovative systems for preserving the rich bio-diversity, managing the precious water resources, and converting the so-called waste into value added products for recycling, generate and move toward utilizing renewable energy and take policy decisions which lead to responsible consumption. I am happy to inform you that what we have demonstrated on our campus regarding resource utilization and recycling in the last few years is now motivating other academic establishments in India and also many urban local bodies to try similar methods and policies.

Secondly, we recognize that our students will have to play a leading role in managing the society in future, and we prepare them adequately to take up those responsibilities. We offer a large number of courses which have sustainability as a backdrop and which are related to solving climate-change related problems. We have been offering a full-fledged master's program in Environmental Engineering for the last two decades. We are planning to start an international Interdisciplinary Masters in Energy Systems and an international Master's program in Water Security.

Thirdly, as one of the foremost educational institutions in India, it is our responsibility to carry out research to find innovative solutions which are economical and long lasting. IIT Madras has partnered with leading universities in Germany to set up the Indo-German Centre for Sustainability (IGCS), more than a decade ago. IGCS has been actively engaged in finding climate-change adaptation measures for coastal areas as well as seeking sustainability solutions in energy, land-use, waste and water. Since 2018, we are the lead for an inter-institutional centre for Sustainable Treatment, Reuse and Management for Efficient, Affordable and Synergistic Solutions for Water" (SUTRAM for EASY WATER). After we were accorded the status of Institution of Eminence, we have started ten research initiatives leading to Centres of Excellence for conducting cutting- edge research to address issues of climate change mitigation, adaptation and sustainable development.

Finally, the IITM Research Park, founded by the Institute, enables the translation of many of the innovative technologies developed by our faculty, students and also others to get translated into products which will help the nation toward achieving sustainable development goals as well as dealing with challenges posed by the climate change.

We are fully aware that we should be vigilant and not get into a comfort zone, especially with regard to facing the brunt of climate change. Therefore, we commit ourselves to further actions which will reduce our carbon footprint, and new and renewed academic programs which will create a large pool of talent to address climate change related issues in future. The present document on our Climate Action Plan describes where we are now and provides us guidance for our future actions.

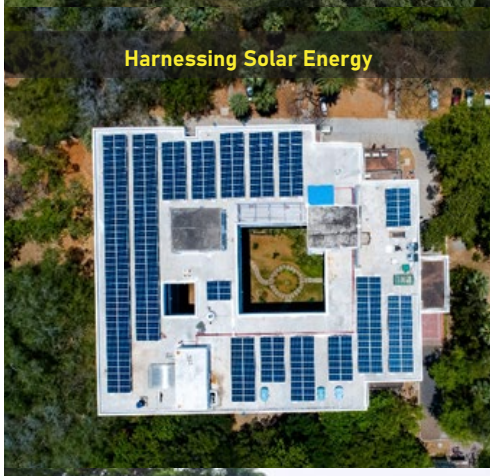
Sincerely,
Bhaskar Ramamurthi
Director

PREAMBLE

The Indian Institute of Technology-Madras (IITM) boasts a unique campus among the academic institutions of the world. The campus is spread out over an area of 661 acres, and is residential comprising of faculty and staff residences, academic complexes and hostels (student dormitories). IITM is located adjacent to the Guindy National Park (GNP) unique for its rich biodiversity. The abundant and diverse flora (298 observed species) provides an ideal habitat for its equally diverse fauna (35 species including endangered species like the blackbuck). In addition, the campus attracts 51 species of avifauna and an equal number of butterfly species. It is an ecological island outside protected areas. Therefore, maintaining a green campus and contributing to carbon neutrality is a natural interest and a social responsibility for the IITM community. Hence, IITM has taken several initiatives and adopted unconventional solutions to conserve and protect its environmental and ecological obligations. These solutions are also geared towards bringing to reality the sustainable development goals as envisaged in its Vision, Mission and Master Plan . IITM recognizes that achieving these sustainable development goals are essentially dependent on their ability to adapt plans with regard to climate mitigation and climate adaptation. This report reveals IITM's current efforts towards climate action and sustainability, and the future roadmap of activities to reach the goals in these two spheres.

Arial View of the New Academic Complex

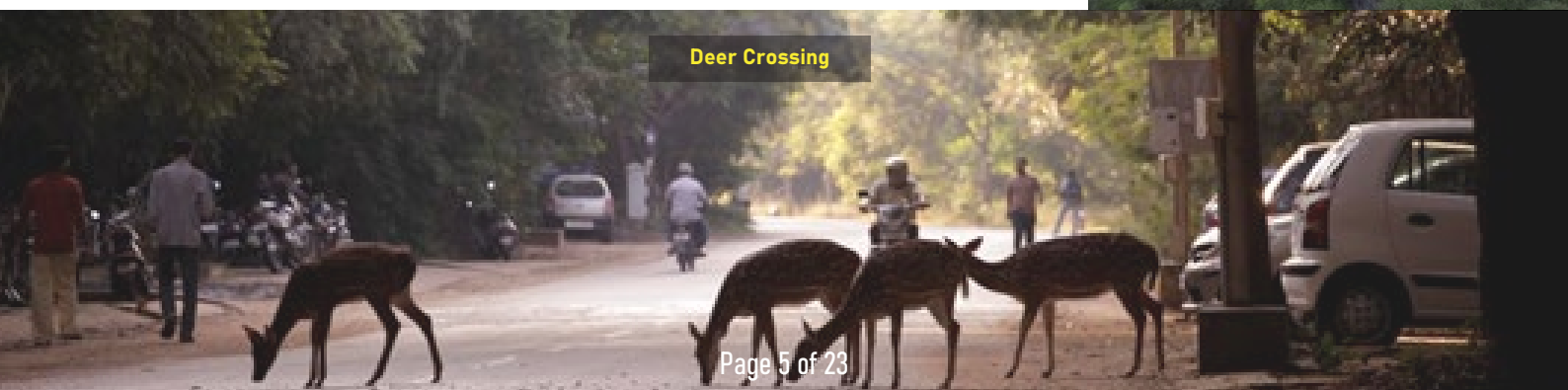
Harnessing Solar Energy



Gateway of IIT Madras

Arial View of the Lake in IIT Madras Campus

Deer Crossing



1. CURRENT STATUS ON BIO-DIVERSITY AND CARBON FOOTPRINT

1.1. Green Cover & Bio-Diversity

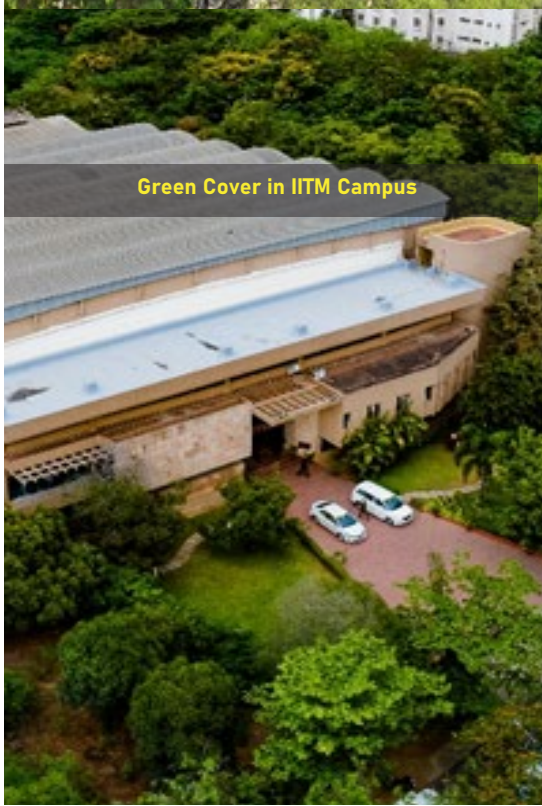
❖ The 250 hectare campus consists of four rather distinct ecological zones viz., the Academic Zone, the Residential Zone, the Hostel Zone and the Wilderness Zone. Each of these four zones are comparable in size (approximately 60 ha), although not similar in shape, configuration, topography and history. While the Academic and Residential zones were a part of the Guindy Deer Park earlier, the low-lying Wilderness Zone that occupies the eastern side was the northern limit of the once extensive Pallikaranai Marsh (a natural flood plain situated in South Chennai). The Hostel Zone was a transitional agricultural land procured from the adjoining villages.

The campus area is covered with thick vegetation that has been nurtured over the years. Due to the sustained efforts undertaken by IITM over the years, the green cover of IITMat present is around 67%. If we also include the marshy land and water bodies on campus, it accounts for a total of around 75%.

❖ IIT Madras Campus continues to be a home to about 600 species of plants, butterflies, and vertebrate animals, including the endangered Blackbuck (flagship species) of the institute that warrants special attention over the other species

Number of Species expected to be seen on Campus

Selected Groups of Organisms	Number of Species expected to be seen on Campus
Plants	350-400
Butterflies	50-55
Fishes	15-20
Frogs & Toads	9-10
Lizards	10-12
Snakes	15
Tortoises/ Turtles	3
Birds	60-80
Mammals	20-25
Total	530-620



Green Cover in IITM Campus

Grazing Ground for Blackbuck and deer

❖ The blackbuck, once plentiful is now a rare species largely confined to protected areas. It's conservation status as per IUCN Red list, is under 'Least Concern', while it is listed under Appendix III of CITES. In Tamil Nadu, it is found only in Guindy National Park, Point Calimere Wildlife Sanctuary and Vallanadu Blackbuck Sanctuary. The only other location outside these protected areas where the blackbuck is found is in the Indian Institute of Technology Madras. The hunting of the blackbuck is prohibited under Schedule I of the Wildlife Protection Act of 1972. However, the conservation of this species is hampered by the absence of grass lands. It is believed that only one per cent of the former numbers survive now. The major causes are poaching, habitat destruction, habitat fragmentation, urbanization and neglect. Recently, a new threat has emerged in the form of free-ranging dogs .

About a decade ago, the population of the blackbuck was numbered a meagre 12. The key challenges faced by blackbuck in the IITM campus can be grouped into- a) habitat, b) food, c) water, and d) threats. Over time, the administration has undertaken several interventions to improve the habitat of these ungulates and to reduce the threat posed by free ranging dogs,. Due to these efforts the population of the blackbuck has increased to 30. This growth pattern has also manifested in the case of the spotted deer population as well.

❖ Reclamation and enhancement of water-logged areas: IITM has low lying areas along the north-eastern side of the Institute to an extentof around 40 hectares. This area had been sustained by open and natural drains from elsewhere within the campus and the surplus from the Guindy National Park . This area has been planted with native tree species that can sustain extended periods of waterlogging like Acacia nilotica, Terminalia arjuna, Barringtonia acutangula, etc.. These trees have the distinction of being a habitat for avifauna (both migratory and native birds).

Improved Habitat for Deer

1.2. Water Conservation

❖ IITM recognizes that a key component of maintaining a sustainable campus and reducing the carbon foot print is to conserve water resources, practice responsible consumption and implement water recycling and water reuse practices. Hence, rainwater harvesting is implemented for all the buildings; this harvested water is conveyed through open unlined drains and closed conduits to the capacity enhanced lake and to recharge certain existing and defunct bore wells. IITM has also constructed check dams across storm water drains to retain water and recharge the water levels.

IITM is blessed with a natural lake (water spread over an area of 31,000 m2 with a net capacity of 180,000 m3). This lake collects the surface runoff within the campus and the surplus from the GNP, which is located upstream. During the year 2019-20, an additional area of 25,000 m2 was added to the existing water body to pave way for additional storage of runoff water. This water body supports the fauna within the IITM for its drinking water needs apart from being a niche habitat of fishes, amphibi-

❖ By way of the treatment and conjunctive use of treated wastewater, domestic water requirements to the tune of 35% has been attained, reducing the need to purchase resources from the Chennai Metro Water. We are also using the treated wastewater for horticulture and for cooling the centralized air conditioning system. The overall reduction in the water freshwater consumption is

1.3. Energy Management

❖ The main source of energy for IITM is the utility electricity grid. For instance, during November 2021, with all the residential, academic and hostel loads, the institute drew 1.8 million units from the utility grid.

❖ Reducing utility power consumption is one of the key ways to reduce the carbon footprint.

❖ As with the case of any commercial infrastructure, campus air conditioning is one of the major loads. Over the years the institute has mandated the use of energy efficient air conditioner installations to optimize power consumption. The newly built academic complex has centralized air conditioning which implements variable air flow controls and building management systems to reduce the energy consumption.

❖ In the academic zone, the Institute has progressively replaced all the light fittings with LED lights. Solar water heaters are used in the dormitories, and guesthouses in a bid to reduce utility power consumption.

❖ IITM has installed 3 MW of rooftop solar PV systems , which during tNovember 2021, consumed 0.14 million units of energy, or about 7% of the total energy consumption.

❖ The campus today is a vast area rand requires transportation to facilitate easy commute to the various zones. It must be noted that the academic zone is situated at a distance of about 1.5 km from the main entrance and the heart of the hostel sector is more than 2 km away. The Institute operates a bus service free of charge for those who wish to commute between the various points of the campus. A large number of campus residents use this facility and thus, avoid personal transport.

❖ Motorized transport use is prohibited for the vast majority of the on-campus student population in a move to reduce the emissions and improve safety. Students are encouraged to use pedal cycles only, and students with special needs are provided with motorized electric vehicles. There are dedicated pedestrian walkways created to connect the buildings in the academic zone.

1.4. Estimation of Present Carbon Emissions

The present rate of carbon emissions are estimated using the following data. These calculations are only approximate, but they provide a fair idea about our position with respect to achieving carbon neutrality.

Si.No	Item	Value
1.	Monthly energy consumption for entire campus (Data from Nov. 2021)	1,800,000 kWH
2.	Energy storage from roof top solar	139,886 kWH
3.	Net electrical energy consumed per month	1,660,114 kWH
4.	Approximate electrical energy consumed per year	19,921,368 kWH/year
5.	% of electricity generated by TANGEDCO that is thermal	78%
6.	Emission factor for electricity generated from thermal plants	0.85
7.	Kg of CO2 emitted per year due to electrical energy consumption	13,208 tCO2/year
8.	Yearly diesel consumption by the institute (Engineering Unit + Computer Center + Institute Busses and vehicles) (based on average value for three years before pandemic started in 2020)	91300 L
9.	Kg of CO2 emitted per year due to diesel consumption (Emission factor: 2.68 kg of CO2 per liter of diesel)	245 tCO2/year
10.	LPG consumption in residential sector: No. of households occupied = 1069 Average consumption: 1.5 cylinders per household/month Total number of cylinders consumed per year	19242 cylinders per year
11.	Kg of CO2 emitted per year by LPG used in cooking in residential sector (Emission factor: 42.5 kg/ cylinder)	818 tCO2/year
12.	LPG consumption in hostels and guest houses: Total number of cylinders consumed per year	10,000 cylinders per year
13.	Kg of CO2 emitted per year by LPG used in cooking in hostel sector (Emission factor: 42.5 kg/cylinder)	425 t of CO2 /year
14.	Transport emissions by campus residents a) Road transport (Assumed 10km daily travel by visitors on campus + 20km daily travel by 1400 households - 1 car+ 1 two-wheeler each) b) Aviation emissions (Assumed 300 students and 600 faculty makes two domestic travel and 0.8 international travel/year)	2923 tCO2/Year 1144 tCO2/Year
15.	Total CO2 emitted per year	18,763 tCO2/year
16.	Assuming, 67% of tree cover in the IITM campus of 661 acres, CO2 sequestered by the campus per Year (assuming 80% of a maximum of 4 t of carbon sequestration per year per acer) =0.67*661*0.8*4*(44/12)	5,196 t CO2/ year

2. CURRENT PRACTISES UNDERTAKEN TO FOSTER BIODIVERSITY, ENVIRONMENTAL & ENERGY MANAGEMENT

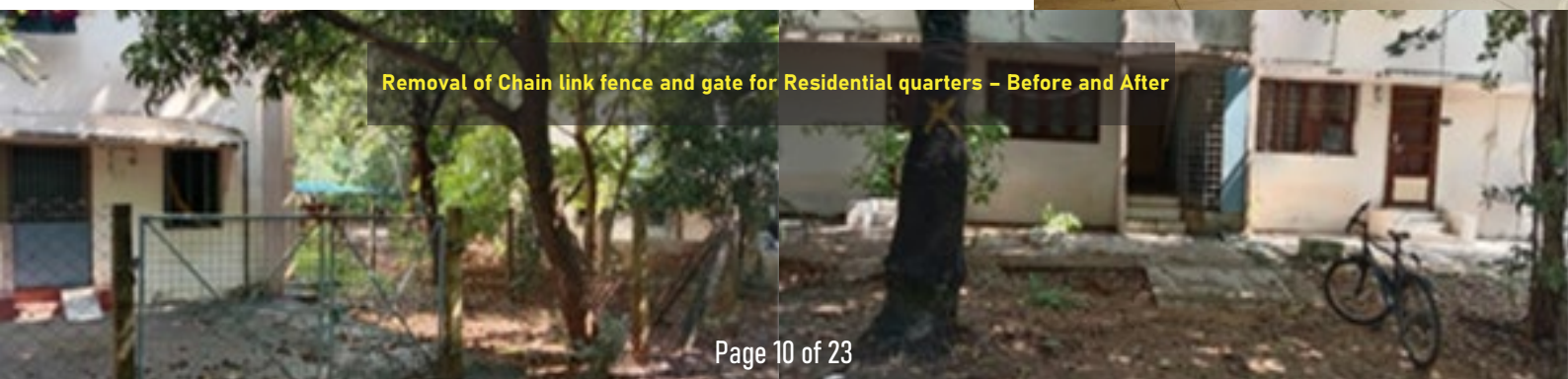
The Institute is committed towards maintaining a healthy level of green cover, preserving biodiversity, responsible water and energy consumption. The details of the present practises followed by IITM toward this goal are presented below.

A. Conservation of Blackbucks

- We realised that blackbucks prefer open grasslands with intermittent tall grass or bushes, especially for delivering and nursing their young. Hence, we created 4 acres of open space by removing juliflora growth and paved the way for a grassland.
- As locations for this purpose were unavailable elsewhere within the campus. We decided to utilise the existing multi-purpose stadium (area of about 5 acres), football and hockey grounds (about 5 acres) as grasslands and populate it with the native grasses. Thus, by doing so, we managed to bring in about 14 acres of additional area and convert it into the grassland habitat. The barricades around these sports utilities had been removed for the mutual benefit of students as well as the Cervids.
- Barriers, which include the chain link fences measuring a little over 2000 rm. in the staff quarters and departments have been removed to allow the free movement of deer and blackbucks. Additionally, the barriers have been removed at the multi-purpose stadium (about 5 acres), football & hockey grounds (about 5 acres) which are also under the grassland habitat. IITM has also planted specific tree species that provide food for the Cervids within the core areas. The horticulture section also takes care of providing water troughs at over seventy strategic locations for the Cervid population (blackbuck and spotted deer). These containers also feed several smaller fauna including bonnet macaque, squirrels and birds.

Removal of juliflora jungle and planting of native grasses

Conversion of lawn turf into dual purpose grasslands as well as sports field



Removal of Chain link fence and gate for Residential quarters – Before and After

B. Preserving Trees

❖ IITM values the rich diversity in the species of trees on campus. If a selected area requires any of the trees to be removed, these trees are burlapped and translocated with due care elsewhere within the campus . The survival rates of these translocated trees at present are as high as 80%. In addition, compensatory afforestation is taken up voluntarily to the ratio of 10:1, planting ten trees for every one tree felled or dead after translocation.

❖ The alumni and other benefactors of the Institute have also generously contributed towards these afforestation efforts on campus and helped us improve our green cover.

❖ Over the years, invasive alien species like Mesquite (Prosopis juliflora) and Cassia siamea (kassod tree) etc. started suppressing the growth of native vegetation leading to loss of habitat for the natural fauna found inside the campus. A high court order to clear the juliflora jungle, had led to removal of this species from near the water bodies and drainage channels. This was followed by the planting of native tree species in order to sustain the species diversity as well its abundance within the habitat.

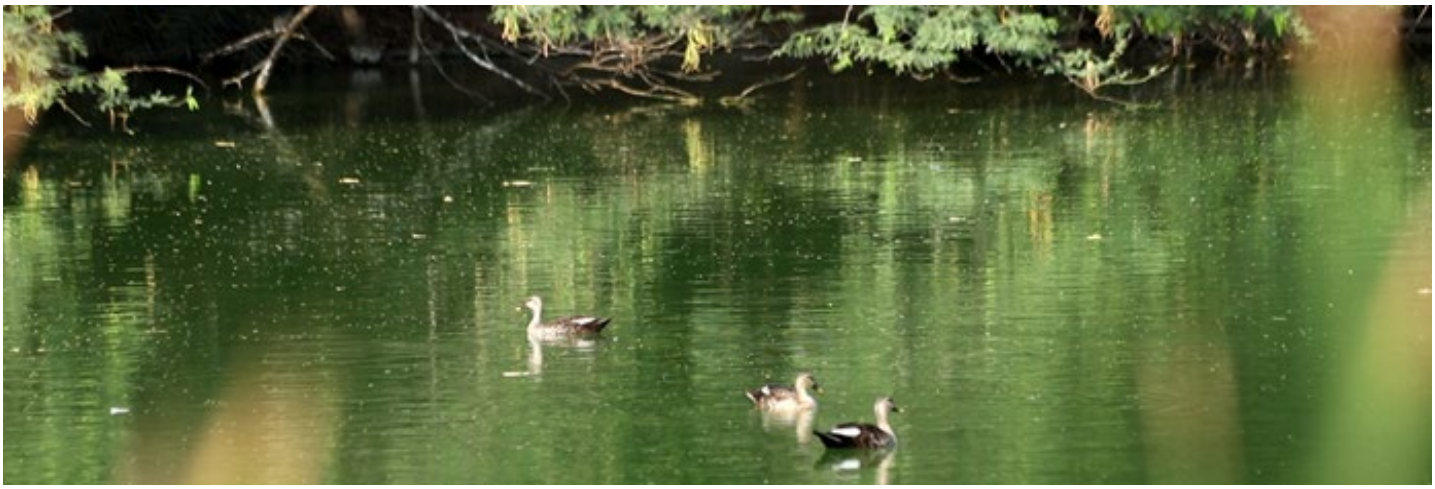
❖ Miyawaki gardens have been developed adjacent to the newly constructed housing complexes (Chera, Chola and Pandya) to improve the green cover, species variation and abundance in a considerably shorter time.

Trees balled, bur lapped and translocated elsewhere

C. Reclamation and Enhancement of Waterlogged Area

❖ IITM has low lying areas along the north-eastern side of the Institute to the extent of about 40 ha., this had been sustained by the open and natural drains from elsewhere within the campus and the surplus from the GNP. This surplus flow of water from this area was routed through an open drain that connects the IITM with the Buckingham canal. During monsoon failure, these areas were infested by the mesquite trees. Even though mesquite is an invasive alien species (IAS), it does support avifauna in several ways from being a perching ground to a full-fledged habitat. However, the subsequent inundation of water over long periods could not sustain these trees. Therefore, we decided to plant native tree species that can endure extended periods of waterlogging like Acacia nilotica, Terminalia arjuna, Barringtonia acutangula, etc. which have the distinction of being a habitat for avifauna (both migratory and native birds).

Removal of Prosopis in water logged areas and planting of native trees tolerant to submergence



D. Water Conservation and Management

❖ Water, the value of this ubiquitous resource is best understood by any Chennai resident, compared to the residents in any other metropolitan city in India. It had proved its might both during the adverse conditions of flood and scarcity. Therefore, the Institute had made utmost efforts to conserve, efficiently utilise and manage this resource.

❖ At IITM, rainwater harvesting is undertaken for all buildings; the harvested water is then conveyed through open unlined drains and closed conduits to the capacity enhanced lake and to recharge certain existing and defunct bore wells. There are also check dams constructed across storm water drains to retain water and recharge the water sources

❖ IITM is blessed with a natural lake that collects surface runoff from within the campus and the surplus from GNP located upstream. During the year 2019-20, an additional area of 25,000 m2 was added to this existing water body to pave way for the additional storage of runoff water. This water body supports the fauna within the Institute for its drinking water needs apart from being a niche habitat for fishes, amphibians, and insects.

❖ This lake is conjunctively used by the Institute for its domestic water requirements throughout the year at 0.8 mld. In addition, the surplus treated water from the sewage treatment plant (STP) is being pumped into the lake. The Institute uses this treated STP water for maintaining all the landscapes and uses a dual pipeline for flushing the toilets in all the residential and institutional buildings

❖ To support the water ecosystem and to curtail dominance of the invasive species of fishes and algal blooms, specific fish species (rohu, catla and mirghal) had been identified and stocked into the water body to occupy the various layers. Water quality monitoring is carried out on a regular basis to maintain the purity of the water body since it is used conjunctively.

❖ The largest liquid waste is the domestic sewage that is generated by the residents on campus and these wastes are completely managed within the campus and is not by the Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB). The Institute can boast that its 4 MLD state of the art Sewerage Treatment Plant using SBR technology has been in operation within the Institute since 2016 for treatment of wastewater from the residential, academic and hostel zones. With adequate planning and research, this plant is expected to take care of the growing needs of the Institute over a considerable period. It provides treated wastewater to fulfil the complete demands for toilet flushing and irrigating the gardens and landscapes. Through the treatment and conjunctive use of treated water, the domestic water requirements have reduced by 35%. Due to this, the overall freshwater procured from the CMWSSB was reduced by 40-45% of the total requirement.

State of the Art 4 MLD Sewage Treatment Plant

E. Gaseous Waste Management

❖ Gaseous waste from the laboratories are equipped with filtration systems that sink most of the gaseous waste and they are disposed of as per norms.

❖ Backup diesel generator sets are seldom used and they are equipped with long chimneys to capture particulate matter

❖ Trees suited for absorbing particulate matters of 2.5 and below (e.g., Tabebuia rosea) are planted inside the campus along the avenues and at strategic locations.

F. Solid Waste Management to Protect Environment

❖ Waste is unavoidable, and it grows in relation to the number of residents in the Institute. While efforts are taken to sensitise the residents on minimising the generation of waste. We are also attempting other conventional and innovative methods for managing, upcycling and recycling this waste matter

❖ Solid Wastes are classified into hazardous, biomedical waste, e-waste, domestic waste and organic waste (one from thick vegetative areas and the other from residential households). As per the government mandate, disposal of hazardous waste is being outsourced to the Tamil Nadu Waste Management Agency and biomedical waste management is outsourced to GJ Multiclave. E-waste generated within the campus is collected centrally and sent to an authorised agency for appropriate management.

❖ The 'OW Zone' is a group of about 100 employees managed by the campus community welfare trust. They have been entrusted with the task of door-to-door collection of source-segregated domestic waste from the residential quarters.These waste matters are further sorted,segregated, recycled,and disposed accordingly as compost and upcycled.

❖ The money earned from the sale of manure generated on campus is shared by the self-help group 'OW Zone' in the campus, which employs mostly women from underprivileged sections of society.

❖ On average 1.5 to 2.0 tonnes of food waste (cooked and uncooked rejects) are generated from the 20 hostels and two guest houses within the Institute. About 800 kg of this food waste is fed to a biogas plant that generates fuel equivalent to 5-7 cylinders utilising LPG (14.5 kg cylinder) and it is also used to generate steam for cooking in the kitchens. About 150-200 kg of the raw cut vegetable waste is composted and the resultant vermicompost is utilised as fertiliser for the landscapes within the campus.

❖ Waste generated after forest cleaning (dead and fallen branches and twigs) and removal of leaf litter especially during summer is essential to avoid bushfires. This process is entrusted to a specialised agency for collecting the waste and upcycling them in the 12 composting pits. The manure from these composting pits is used for maintaining the landscapes within the Institute.

G. Energy Efficiency Measures

❖ As high-rise buildings replace the existing buildings, both the conventional solar water heaters and photovoltaic panels are installed to generate power that minimises purchase from the grid. So far, there are solar water heaters installed in all 20 hostels and 2 guest houses. Their photovoltaic panels generate an equivalent of 32,26,301 kwh (more than two percent of the total usage as per GRIHA) during the year 2018-19.

❖ Improving the energy efficiency of campus consumption has been an ongoing effort at IITM, which has again contributed towards the reduction in the carbon footprint. As in the case of any commercial infrastructure, campus air conditioning is one of the major loads. Over the years the Institute has mandated the use of energy efficient air conditioner installations to optimise power consumption. The recently constructed academic complex has centralised air conditioning and implements variable air flow controls and building management systems to further achieve reduction in energy consumption. In the Academic zone, the Institute has progressively replaced all light fittings with LED lights.

❖ The Institute operates a bus service free of charge for those who wish to commute between the various points in the campus. Many campus residents use this facility and avoid personal transport. Further, the use of motorised transport by the vast student population on campus is prohibited. Students are encouraged to use pedal cycles only. IITM has constructed dedicated pedestrian walkways to interconnect buildings in the Academic zone.

❖ We also have a biogas plant in place, wherein about 800 kg of food waste is fed to a biogas plant that generates fuel equivalent to 5-7 cylinders of LPG (14.5 kg cylinder) and the same is used to generate steam for cooking in the kitchens. Additionally, about 150-200 kg of uncooked cut vegetable waste is composted and the resultant vermicompost is utilised for fertilising the landscapes within the campus.

Roof tops effectively used for Solar heating as well as Solar power generation

H. Eco-friendly Construction Practises

❖ The recent construction activities taking place on campus is being done vertically to reduce the land space. To ensure sustainable construction practises, we comply with GRIHA standards and the Institute often undertakes innovative products and processes that are pro-nature and ensures net zero emissions. Additionally, eco-friendly construction materials are replacing conventional ones to reduce the carbon footprint. They include the use of fly ash as a partial replacement to cement and the conventional baked earthen bricks, the use of energy efficient electrical and lighting fixtures, water-saving plumbing and sanitary fixtures, heat reflective tiles are used for rooftops to decrease the heat load, District Cooling System, and upgrading the water supply network to minimise water wastage. In addition to these, we also include special conditions and penalty clauses in all construction contracts for protecting the environment.

I. Rules and Regulations

❖ IITM has constituted a Campus Environment Management Committee. This committee comprises members from different departments, student representatives, non-teaching staff, NGOs, headed by The Dean (Planning). The scope of this committee is to advise on any additional footprints which can occur due to the construction of new buildings, pathways, fencing and other infrastructure. The committee also inspects each site before, during and after the infrastructure development for ensuring that compliance and bench marks on environmentally sound and good management practises are maintained. The committee also suggests alternate locations/designs in order to accommodate existing native trees and landscapes.

❖ There are several rules and set-processes for maintaining the ecological balance at IIT Madras campus. The segregation of waste at the source (residences for instance) is mandated.

❖ The agency given the task of waste management is required to do further sorting after collection and recycle or compost the waste.

❖ A 'Plastic Committee' has been constituted at the Institute, to strictly implement the ban on single use plastics inside the campus. This committee also facilitates awareness and sensitization programs within the campus and among the students.

❖ The entire campus is declared as a litter-free zone. This is achieved by installing monkey-proof dust/litter bins along the sides of the roads. The hardware for these bins are designed by the Engineering Unit. All these litter bins have location specific QR codes for the purpose of monitoring. A mobile app 'CLinsti' (software created by the students of IITM) facilitates the management of the litter bins by enabling a communicating mechanism to identify and act on the virtual complaints which can be raised by almost anyone using the application.

3. ALIGNING OF ACADEMIC MISSION

The main aim of this report is to address the issue of reducing IITM's physical greenhouse gas emission outputs. However, since IITM's primary mission is to educate people and carry-out research which would result in innovative solutions to the challenges faced by the society. Herein, we outline the efforts undertaken by IITM to imbue climate change issues into the core of the institutional pillars: (1) Teaching and Learning and (2) Research and Innovation.

Many academic departments and centres across IITM are working independently and in partnership in the area of sustainability, which includes the cause of carbon neutrality. IITM hopes to cultivate new leaders in sustainability and create innovations which will help society.

Teaching and Learning

❖ IITM offers a basic course on "Ecology and Environment" for all its undergraduate students. This is a mandatory course for all the students, irrespective of their major. The primary objective of the course is to make students aware about the issues related to sustainability and climate change. This is to ensure that whichever profession they take up or whatever research they carry out in the future, these activities will be aligned with the causes of sustainability, climate change mitigation and adaptation.

❖ There are more than 20 undergraduate and graduate courses, offered as electives, which are related to sustainable development, renewable energy sources, climate dynamics, climate economics, and energy management etc.

❖ IITM offers a two-year graduate program in "Environmental Engineering". The majority of these courses are oriented to the cause of sustainability . There are also a few courses which directly address atmospheric physics and chemistry, and climate change.

❖ IITM offers a two year graduate program in "Hydraulics and Water Resources Engineering". Here again, the courses related to water management have a significant orientation towards sustainability. One course directly addresses sustainability in river basin management.

❖ Indo-German Centre for sustainability, which is a collaborative effort between IITM and The Technical University of Berlin and University of Kiel in Germany, offers one winter school and one summer school every year. These are two week intensive schools and they engage 30 students in each school. These schools have been offered since 2011.

❖ IITM is proposing to offer a two-year "International Interdisciplinary Masters in Energy Systems" program. The world is moving steadily towards a future where engineers cut across from their established domains in their expertise and skills. It is imperative for IITM to build a generation of students trained for these interdisciplinary careers. The proposed two year international interdisciplinary master's program (MTech) proposed at IIT Madras has the ability to harness the unique and world-class strengths of IITM in teaching and cutting-edge research. It will also provide a compelling value proposition for international students. This specially curated program is expected to have great appeal to international students, exposing them to our pedagogy and "levelling the playing field" for students in the first two semesters via the research skills, maths and engineering courses. It will also provide them a holistic university education by incorporating culture and humanities courses.

A new international centre known as, "Global Water and Climate Adaptation Centre – Aachen, Bangkok, Chennai, Dresden (ABCD-Centre)" has been established at IIT Madras, in collaboration with University of Aachen, University of Dresden and Asian Institute of Technology (Bangkok), with funding from DAAD, a German Academic Exchange Program. As part of this centre, a new international graduate program in "Water Security" is being planned. We expect to launch this program in two year's time.

Research and Innovation

A number of faculty members from different departments are actively involved in research related to sustainability and climate change, individually and also in collaboration with others. Several centres of excellence have been initiated in recent years to facilitate this highly inter-disciplinary domain of research.

The Department of Science and Technology (DST) has been funding the establishment of a Centre of Excellence in "Climate Change Adaptation of Coastal Infrastructure", as part of the Indian contribution to the Indo-German Centre for Sustainability. Fifteen faculty members from different departments across IITM are collaborating with their counterparts in Germany to study various aspects of climate change. The special focus is to study the effect of climate change on extreme weather events such as cyclones, their impact on coastal infrastructure, and water and waste management facilities. They are working towards discovering sustainable measures which can be adapted in coastal regions in response to climate change and in response to the rise of sea levels. More than 15 graduate students and research associates are engaged in this research.

❖ The Department of Science and Technology (DST) has established an inter-institutional centre at IITM. This centre is known as "Water Technology Research & Innovation Centre for Sustainable Treatment, Reuse and Management for Efficient, Affordable and Synergistic Solutions for Water" (WATER-IC of SUTRAM for EASY WATER). This centre came into existence on October 28th 2018. It was formally inaugurated on January 25th 2019 at IIT Madras by our then honourable minister for Science and Technology, Earth Sciences, Environment, Forests and Climate Change. This centre is a unique pan India inter-institutional interdisciplinary centre, with participation from seven well known academic institutions and two reputed CSIR Laboratories. The objective of this proposed centre is to develop strategies and technologies for sustainable treatment, reuse and management of water, addressing the pressing issues related to quality, quantity and service delivery.Twenty scientists from interdisciplinary backgrounds such as Environmental Engineering, Environmental Biotechnology, Water Chemistry, Instrumentation, Water Resources Engineering, Chemical Engineering, Toxicology, Geology etc. are working together in this centre.

❖ A new international centre known as, "Global Water and Climate Adaptation Centre – Aachen, Bangkok, Chennai, Dresden (ABCD-Centre)" has been established at IIT Madras, in collaboration with the University of Aachen, University of Dresden and Asian Institute of Technology (Bangkok), with funding from DAAD, a German Academic Exchange Program. This will facilitate the exchange of researchers among the participating institutes and foster collaborative research in the area of climate adaptation and water security.

❖ After IIT Madras had been accorded the status of Institute of Eminence (IoE), it has established several prospective centres of excellence (PcoE) to carry out cutting edge research. Several of these centres focus their research on issues related to sustainability and climate adaptation.

Technologies for Low Carbon and Lean Construction (TLC):

The construction industry's contribution to economic and social growth for India is well-known. However, this industry generates a significant amount of waste, creating challenges with sustainability; additionally, there is significant waste of resources and time in construction projects. The PcoE for the TLC project aims to develop innovative low-carbon, lean construction technologies for minimising waste throughout the construction value-chain, and lead solution implementation across organisational, and policy levels.

Water and Sustainability:

Water management has been hindered by challenges in availability, quality and distribution. These issues are interlinked in the recent paradigm of circular economy to achieve sustainability. PCoE of Water and Sustainability will explore fundamental questions to gain improved understanding of the processes underlying water resources, its quality and treatment techniques. This will lead to new developments in reliable process models, efficient water and wastewater treatment technologies, novel water quality monitoring sensors, and paradigms for water infrastructure planning. The overall thrust is on addressing the fundamental issues of water security and sustainability in the backdrop of rapid development and impending climate change.

Advanced Gas Turbine Engines:

PCoE on AGTET develops complementary technologies towards future aviation, with focus on significant reduction in carbon footprint with need for more efficient, less polluting, hybrid and lighter gas turbines, and to scale hybrid electric technologies.

Carbon Dioxide Capture, Utilisation and Storage (CCUS):

The Carbon Dioxide Capture, Utilisation and Storage lab represents a multi-disciplinary approach towards mitigation of CO2 emissions. The problem of reducing CO2 emissions, particularly serious for a fossil-fuel heavy nation like India, and there is rich scope for research and development in several promising areas. The vibrant CCUS lab team works on a 3600 solution scheme, encompassing studies on CO2 separations using specialised materials, development of optimal routes for CO2 storage and sequestration via gas hydrates, and a slew of reaction options for converting CO2 to useful and value-added chemicals.

Energy Storage and Conversion:

The Advanced Centre for Energy Storage and Conversion (ACESC) focuses mainly on two areas:

Li-S Battery Research: (a)Development of layered cathode materials for controlling the polysulfide shuttling effect besides modification of the separator/interlayer, (b) Understanding the polysulfide shuttling effect mitigation of the cathode materials by Kinetic Monte Carlo simulations, and (c) Development of 2032 coin cell Li-S battery and Optimization for a cell capacity of 1 Ah/g.

Solar Cell Research: (a) Development of cheap HTMs for efficient and stable perovskite solar cells (b) Evaluation of PSC's stability under extreme climatic (temperature and pressure) conditions.

Micro-grid Technologies:

This PCoE aims to do the following:

- Developing technologies for micro-grids which are suited for diverse sites, especially with regard to Indian conditions.

- Maintaining focus on methods of energy and grid management. This will lead to techniques which would work even if preponderance of one particular source is not feasible.Energy sources would be considered as distributed and not co-located, which would offer considerable flexibility for deployment. Each site offers potentially different types of locally available energy sources.

Renewable Energy Systems:

This centre aims to demonstrate a definitive pathway "Towards 100% Renewable Energy in India." The key focus of this project is renewable energy generation mechanisms supported by energy storage systems that includes battery storage and chilled water storage, along with an energy management system to optimally manage the overall generation, storage and consumption. A pilot demonstration at the IIT Madras Research Park will showcase the technology readiness and economic viability of shifting towards a 100% renewable energy in a commercial complex, which could also be adopted by other sectors such as industrial and residential.

Photo- and Electro- Chemical Energy Sciences:

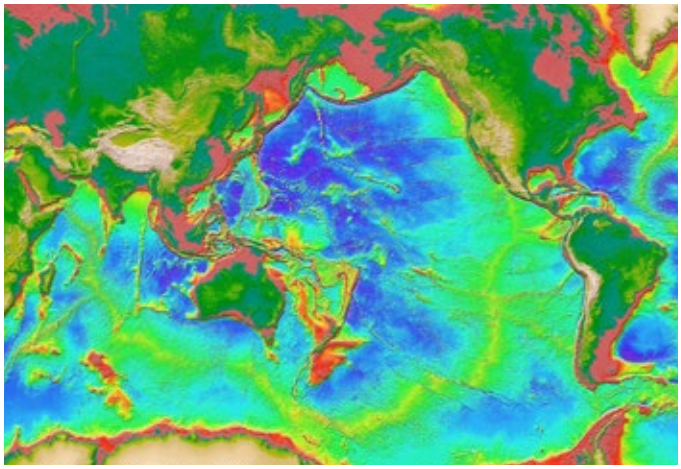
The Centre for Photo- and Electro- Chemical Energy Sciences & Technology (C-PEC) has proposed to carry out basic scientific research and technology development in the areas of photochemical, electrochemical and photoelectrochemical energy conversion and storage. Many important energy related problems associated with energy conversion and storage devices including, solar fuels, batteries, supercapacitors, fuels cells, and electrolyzers shall be considered under this centre. A selective set of challenging, but also achievable targets related to solar water splitting and metal-air batteries have been proposed. They will be carried out in the next five years, aiming at high impact research papers and product development leading to startups.

Atmospheric and Climate Sciences:

The atmosphere, the layer of gases surrounding the Earth's surface, has continuously been evolving since its onset. On the other hand, we understand that climate, which is the pattern of long-term variations in various atmospheric parameters affecting our lives, is strongly influenced by the atmosphere's conditions. Thus, the continually evolving state of the atmosphere, in turn, affects the earth's climate, which has been severely perturbed in recent years due to increased anthropogenic activities. The climate system and complexities are unique over the Indian region and the increasing pollution levels are strongly affecting regional climate and ecosystem health in the Anthropocene. In this PCoE, we try to answer the questions about the complex interactions and multiphase processes in the Earth System Science using advanced laboratory techniques, field measurement campaigns, and numerical models.

Geophysical Flows:

In this centre, we seek to synergistically combine novel field measurements and fundamental geophysical fluid dynamics studies to advance our understanding of the northern Indian Ocean regions, and their impact on climate modelling and predictions. The state-of-the-art field measurements, which would include pioneering work on observing the atmosphere and the ocean surface using unmanned aerial systems, will focus on the largely unexplored coastal regions (up to around 300 km from the land) of the Indian Ocean. This centre is motivated by sensitivity studies on large-scale climate models, the observational studies in turn will motivate specific process studies in the lab via experiments and fine-scale numerical simulations. The results of these studies would then be fed back into the large-scale climate models. The proposed research bridges the gap between fundamental science and improved ocean models/forecast, leading up to the societal benefit of improved climate prediction under the Indian National Monsoon Mission.



4. FUTURE ACTIONS

IIT Madras is Committed to set up processes that will ensure a continuous effort to reduce energy consumption and promote use of renewable sources of energy for targeting a reduced carbon footprint. These are actions proposed to be undertaken, besides the continuation of present sustainable campus operation measures with respect to water, waste and land management.

❖ The footprint of air conditioning loads in the older academic complex is proposed to be reduced further by transitioning to the more energy efficient district cooling approach. This will entail circulating chilled water from a central plant to all the academic zone areas.

❖ The Institute plans to transition to a centralised energy monitoring system, some elements of which are already in place. In the year 2022, IITM plans to take up a thorough audit of all its facilities with an aim to establish the total carbon footprint and identify paths for further action. IITM would also formulate a monitoring committee to ensure adherence to the goals leading to carbon neutrality. Specifically, the following parameters would be analysed

a) Electrical energy consumed by buildings and streetlights, and the campus electrical distribution system.

b) Solar Energy Inputs.

c) Air conditioning loads - extent of energy efficiency realised and the further possibilities.

d) Diesel Consumption for power generation (backup) and transport.

e) The impact of personal vehicles on campus will also be studied and guidelines regarding the usage of personal motor vehicles will be formulated.

f) Potential to use biomass as an energy source will be assessed.

It is also proposed to generate a GIS map of energy consumption at various locations to track and identify possible facilities where improvements would be feasible.

❖ IITM also has a satellite campus located at Thaiyur which is being developed as a hub for large research centres that would be established in future. This fledgling campus will be developed with the ideas of carbon impact right from the beginning. The proposed energy audit would cover the Thaiyur campus also.

❖ There are a few battery-operated e-rickshaws and e-buses running on an experimental basis within the campus. We are also undertaking efforts which are in an advanced stage to introduce e-buses as a replacement for the conventional fossil fuel powered buses. Charging stations for these electric vehicles had been installed in select locations within the Institute, the same shall be scaled up based upon the usage by the residents.

❖ A detailed study will be commissioned to look into the carbon footprint of air travel that is carried out by people who are invited to the campus for various academic activities such as conferences, thesis evaluation, committee work and faculty recruitment.

❖ At present the estimation of sequestration of CO2 by the forest cover in the campus is based on approximate methods. A detailed study will be commissioned to estimate the CO2 sequestration by tree cover in the campus (based on number of trees, canopy cover, type of trees etc.). The study will also provide recommendations for increasing CO2 sequestration potential of the campus.

THANK YOU