



SDG7: AFFORDABLE AND CLEAN ENERGY

ENSURE ACCESS TO AFFORDABLE, RELIABLE, SUSTAINABLE AND MODERN ENERGY FOR ALL

The Indian Institute of Technology, Gandhinagar (IITGN) is designed as a living laboratory on sustainability, which is integrated into its master plan. The conceptual process emphasised consideration of sustainability factors, which in turn informed the development of the master plan and campus development. The institute operates and maintains buildings following a sustainable management policy/programme and/or a green building rating system. IITGN is the first campus in India to be awarded a 5-star rating by Green Rating for Integrated Habitat Assessment for Large Developments (GRIHA LD) in 2016.

IITGN campus has been designed with key sustainability features, such as solar energy generation, comprehensive waste management, water conservation, purification and recycling, and compost production. Moreover, the campus infrastructure supports passive cooling and energy conservation in all aspects of construction, operations and management.

The IITGN community is actively engaged in promoting sustainability in all its operations. For instance, we are developing a system for real-time monitoring (day-to-day basis) of the carbon and water footprints of the campus.

This initiative will have a considerable impact on reducing energy usage and making the entire campus more energy efficient.

The Master Plan emphasised energy management and several features that make the campus energy efficient were incorporated. Different initiatives and activities have been taken at the institute to promote energy conservation, raise awareness of the community on the campus and in the neighbourhood, thus contributing to achieving Sustainable Development Goal 7.

Research

Extensive research activity is underway at the institute on a wide range of areas related to energy and the institute as a body cooperates and coordinates with the local, regional and national governments on energy conservation and management. The institute facilitates access to research through its library, state of the art laboratories and a conducive learning environment. The institute undertakes research activity on a wide range of areas related to energy, including integrated smart grid, water and energy technologies for smart sustainable cities, sustainable and energy-efficient buildings, intelligent power management systems, efficient storage of clean energy, scalable energy disaggregation, solar energy and brine treatment, electric vehicle and solar cell applications, etc. The institute cooperates and coordinates with the local, state and national government on renewable energy and low-carbon technologies. It advocates for public policies through several research activities, thus contributing to the



achievement of SDG 7. About 100 researchers at the institute are working in different areas related to energy such as decentralised energy trading platform, energy efficiency in desalination, household energy consumption, energy management, solar PV power generation, smart grid resilience, etc. which has resulted in about 70 research publications including articles and conference papers. There were several projects related to the renewable energy sector at the institute during the year 2019-20, examples of which are mentioned below.

- Brine splitting for energy-efficient textile dyeing effluent reuse; Department of Science & Technology
- Complexation on the surface of metal halide perovskite nanocrystals for application as energy materials; Department of Science and Technology
- Design consultancy on methanol and natural gas powered fuel cell systems; Thermax Limited
- Developing techniques for scalable energy disaggregation; Jio Platforms Ltd
- Development of a prosumer driven integrated SMART grid; Department of Science and Technology
- Drivers for electric vehicle applications; Science and Engineering Research Board
- ECO-WET - Efficient coupling of water and energy technologies for smart sustainable cities; Indo-German Science and Technology Centre
- Foundation consultancy for development of proposed 10 GW RE (Wind and/or Solar) projects in Great Rann of Kutch, Gujarat; National Thermal Power Corporation Ltd.
- Harnessing low cost, high-efficiency stable photovoltaics based on layered hybrid perovskites; Ministry of Human Resource Development
- Harnessing solar energy to achieve near-zero carbon emission for brine treatment; Department of Science

and Technology

- High yield exfoliation of layered metal diborides to synthesise boron analogues of graphene for developing a new class of energy storage nanocomposites; Science and Engineering Research Board
- Remedial measures of slope failures at 5 MW solar power plant of GIPCL; Gujarat Industries Power Company Limited
- Smart integrated campus energy monitoring and management system; Science and Engineering Research Board

The focus of research laboratories related to energy at IIT Gandhinagar includes Smart Grids, Power Systems, and Energy Management among others.

Power Systems and Smart Grid Lab

Power Systems and Smart Grid laboratory focus on the research in smart distribution grids/microgrids and integration of distributed generations and energy management. The lab is equipped with a fully digital real-time power engineering simulation platform consisting of Opal-RT (OP4508 F11-3+1) real-time digital simulator - OP5600 and customized modular hardware and firmware for hardware-in-the-loop (HIL) and rapid control prototype (RCP) studies in power systems and smart grid-related research activities. The lab is also equipped with power systems simulation packages – PSCAD, CYMDIST and GAMS Optimisation tools. Research activities are majorly supported by national/international collaborative projects.



Smart Manufacturing and Robotics (SMART) Lab

At SMART Lab, human intuition and intelligence are implemented to design and automate processes and systems. Examples of research areas of this lab include Laser Micropolishing of Metals, Multi-Agent Robotics and Flexible Manipulators.

Electrical Machines and Power Electronics Lab

The lab is equipped to carry out research work on the design, control and diagnosis of various electric machines. These include transformers, rotating electric machines and power converters. Design and analysis of novel and existing topologies are carried out using 2D and 3D electromagnetic finite element analysis in Ansys Maxwell. Test-setups for experimentation on various rotating electric machine topologies are available in the lab.

Energy Systems Lab

The motivation behind the Renewable Energy laboratory facility is to provide a broad range of experimental experience to undergraduate and graduate students in the area of renewable energy. This facility comprises high-quality experimental setups in the area of wind, thermal and solar energy. This experimental facility includes a thermal energy storage training system, solar concentrator training system, wind energy training system and solar PV training and research system. A fuel-cell test system and a heat transfer experimental module have been procured. The **Central Instrumentation Facility (CIF)** has been established to provide sophisticated characterisation services to the researchers within and outside IITGN. It houses several high-end analytical instruments such as

SEM, XRD, AFM, NMR, LC-MS, MALDI-TOF, ICP- MS & ICP-OES, Confocal Microscope and Single Crystal XRD. We have recently added new instruments such as Transmission Electron Microscope (TEM) and Multipurpose XRD with various modules like Powder analysis, Thin Film, SAXS and in-plane scattering for Material Science and Research. The CIF aims to provide a central facility consisting of the latest and advanced analytical Instruments to facilitate multidisciplinary research and to cater to the needs of academic research institutes, universities, and industries for high-end material characterisation. IITGN regularly conducts the Technical Education Quality Improvement Programme (TEQIP) training programme, where CIF facility staff and students are involved in giving short lectures towards the technical and application aspects of CIF Instrumentation. IITGN CIF is on the National I-STEM Portal to avail the usage of the facility by users around the country and internationally. CIF has been catering for the needs of industries at various levels. Many pharmaceutical industries like Sun Pharma, Piramal Pharma, Zydus Research Centre, Cadila Healthcare, Torrent Pharma, Sud-Chemie are the regular users of our facility. Nearly 30 major industries are users of the CIF IITGN. CIF has also been constantly providing services to the universities, institutes and R&D departments. The major goal has been to build an environment that would lead to major collaborations between academic institutes.

Operations

The institute has taken several initiatives to minimise energy consumption. The campus has been designed with low energy and resource consumption as one of the key

considerations. The institute has several features including low-energy sewage treatment, rooftop solar photovoltaic plants, solar water heaters, biogas plant, energy-efficient lights, motors and pumps, use of natural sunlight in corridors, passive cooling systems, a pedestrian-friendly campus and others that serve as evidence to the institute's aspiration to be sustainable.

As a relatively new institution (established in 2008), all the buildings are newly built and energy-efficient with wide use of clean and renewable energy sources. The building design has been optimised to reduce energy consumption/conventional energy demand without compromising on the visual and thermal comfort of the building occupants. All buildings comply with mandatory clauses of the Energy Conservation Building Code (ECBC), 2007. The institute makes an effort to minimise its reliance on carbon-intensive energy industries, such as coal and oil, and invest in solar and biomass for its energy requirements.

Energy efficiency and solar power generation are aligned with the National Missions on reducing carbon emissions and enhancing solar energy capacity. Energy optimisation has been achieved through the use of occupancy sensors in corridors and classrooms in academic blocks, integration of air handling units to the adoption of a Building Management System for efficient management, operations and maintenance, use of astronomical time switches for lighting, ventilation fans and electric heaters, etc. Innovative construction technologies and materials have been used, such as unfired fly ash-gypsum (fly ash from local sources) bricks to reduce the overall embodied energy of the buildings and cavity wall system (air cavities of 300-450 mm wide built between two skin walls) to reduce heat gain. Cross ventilation is provided in all the housing apartments, with two balconies, and two windows in each bedroom; jali screens have been provided to reduce glare. All fans are Bureau of Energy Efficiency (BEE) star rated. Centralised cooling systems and solar power generation to reduce carbon footprint and contribute to climate change mitigation. The Passive Downdraft Evaporative Cooling (PDEC) technique, using a mist pump, has been effectively adopted in student dining halls, which helps reduce the indoor temperature with minimal energy consumption. All the insulation, fire-fighting systems, HVAC systems and refrigerant systems are free from hydrochlorofluorocarbons (HCFC), CFC and halon gases, thus having zero Ozone Depleting Potential (ODP) value.

All street lighting has been designed to adhere to minimum energy efficiency norms as described in Guidelines and Benchmarks for Large Area Developments, Ministry of New and Renewable Energy (MNRE) and The Energy and Resources Institute (TERI), as well as to meet the minimum illumination levels and uniformity coefficient for different street categories. They have also been installed with

astronomical switches that automatically switch the lights on and off based on pre-set times.

All residential buildings have solar water heaters installed on their rooftops. The housing area has 90 solar hot water units (three per building), each with a capacity of 500 litres per day. The hostel area has 44 solar hot water units. The hostel units each have an electrical backup, set on timers, to provide additional heating for three hours in the morning and three hours in the evenings. LED lights are used in many locations throughout campus. All the road and pathway lights are LED and 74 per cent of the parcel lights are LED. All internal light fixtures in the Academic Complex are LED, except for some special lighting in the auditoriums and some common areas.

Under government guidelines, the maximum rooftop solar photovoltaic system capacity installed at consumer premises shall be up to a maximum of 50 per cent of the consumer's sanctioned load/contract demand. During the first phase of construction, the institute installed solar panels for renewable energy accordingly and is currently planning to install more solar panels as the load grows.

Construction of housing and hostels involved the use of confined masonry technology (the first large scale application in India), which is earthquake resistant while being more economical than the conventional reinforced concrete frame construction. It reduces the amount of concrete being used thereby reducing the embodied energy of the buildings. Low environmental impact materials such as Armstrong (for false ceiling tiles), marine-grade plywood (for built-in furniture), natural stones and vitrified tiles (for flooring), and wood polymer composite and uPVC (for internal door frames, shutters and window panels) are used in the building interiors.

The institute is designed to be pedestrian and cycling-friendly and offers public transportation modes for the transportation of IITGN community members both on the campus and outside (covering areas up to a distance of approximately 20 km toward the nearest town of Gandhinagar). Modal shift from motorised vehicles to non-motorised vehicles like bicycles or walking is encouraged. Segregated cycle tracks are provided along pedestrian paths and vehicular roads. Ample shaded cycle parking facilities are provided throughout the campus to encourage cycling. The entire campus has been designed as a barrier-free place with universal access.

Visitors to the campus are requested to park their cars near the administration building and walk from there.

Possession and use of personal motor vehicles by the students is not permitted. Regular emails are sent to the students regarding no vehicle use on campus. Any student needing to park a personal vehicle for special situations or needs must apply to the Dean (Student Affairs) with full justification.



Energy Performance Index (EPI) for all the built areas on the campus is calculated on an annual basis, which contributes to assessing the energy utilisation. Regular monitoring of the site's energy consumption is ensured by installing digital meters at the utility grid and each building level point source. Sub-meters for water pumping, outdoor lighting and common areas are installed. Performance monitoring and validation are conducted through the implementation of operation and maintenance protocol. Air Handling Units (AHUs) have been integrated into the Building Monitoring System (BMS) for efficient energy management, operations and maintenance.

The vital statistics for the year 2019-20 are as follows:

Total energy used : 26567 gigajoules

Total energy used from low-carbon sources : 2222 gigajoules

Percentage of energy used from low-carbon sources : 8.4%

Education

The institute offers several graduate and undergraduate courses on sustainability and also specifically on energy-related subjects. It offers sustainability-focused immersive educational courses that provide students with the knowledge and/or skills to contribute to the achievement of SDG 7. The institute aims to undertake curriculum development by implementing modules on sustainability in existing courses and advancing education on sustainability nationally and globally. It promotes student,

academic and research exchanges on sustainability with institutions across the country and abroad. The institute conducted several workshops and short courses focused on energy during 2019-20. These were designed to provide a knowledge-sharing platform to initiate and strengthen research networking as well as explore the possibility of joint research projects and training in the area to help society with sustainable solutions. The following graduate and undergraduate courses related to energy were offered in 2019-20.

CE 202: Sustainability and Environment

EE 331: Electrical machines

EE 332: Power Systems

EE 333: Power Electronics

EE 425: HVDC Transmission and FACTS

EE 426: Electric Vehicle Technology

EE 611: Restructured Power Systems: Operation and Management

EE 629: Power Electronic Converters

EE 643: Solar Photovoltaics: Physics, Technologies and Applications

EE 650: Power System Dynamics and Control

EH 302: Elements of Earth System Science

ES 103: Introduction to Electrical Systems

ES 632: Energy Systems

ME 636: Fuel Cell and Battery Systems

ME 642: Energy-efficient design of separation processes

MSE 626: Light Metal Alloys for Automotive Industry

Details of workshops, invited lectures and short courses conducted at the institute that linked to energy are as follows:

Distributed Energy Resources and Energy Management

A workshop on Distributed Energy Resources and Energy Management was organised by IIT Gandhinagar in collaboration with SERB on 3-4 December, 2019. It was designed to discuss DERs modelling, optimal energy management, battery storage/EV battery management, and demand response algorithms. The workshop provided a platform for knowledge networking and was attended by PhD and MTech students from various institutions across India.

Energy Management for Smart Sustainable Cities

A workshop on Energy Management for Smart Sustainable Cities was organised by IIT Gandhinagar during 5-6 February, 2020. The workshop was conducted in collaboration with the Indo-German Science and Technology Centre, which is also a sponsoring agency for one of the ongoing research projects at the institute “ECO-WET: Efficient Coupling of – Water and Energy Technologies for Smart Sustainable Cities (2018-2021)”.

Design, Optimisation and Data-driven Applications of Smart Energy System

The Electrical Engineering discipline organised a two-day workshop on Design, Optimization and Data-driven Applications of Smart Energy System on 18-19 February, 2019, as a part of the Department of Science and Technology – UK-India Education and Research Initiative collaborative project. The workshop was coordinated by Prof Naran Pindoriya.

The following short courses and lectures related to SDG 7 were organised by the institute:

- Short course on “Soiling Effects on Solar Energy Generation” by Dr Mike Bergin (Duke University), Dr Chinmay Ghoroi (IITGN), and Dr Naran Pindoriya (IITGN), from 6-10 January, 2020.
- Short course on ‘Nanostructured Materials for Solar Energy Applications’ by Dr Andreas Schüler, EPFL, Switzerland, from 15-20 February, 2020.
- Invited lecture on “New Frontiers in Stochastic Modeling of Smart Distribution Grids” by Prof Bala Natarajan, Kansas State University, on 27 August, 2019.
- Invited lecture on “Operation and Protection of Future Electric Power Systems” by Prof Campbell Booth, the University of Strathclyde in Glasgow, Scotland, on 13 January, 2020.

Community outreach

The institute organises various activities and takes initiatives to promote awareness regarding energy efficiency among the community members. It conducts safe driving drives for the campus and the neighbourhood, along with monitoring implementation of the road traffic safety on the campus. The institute promotes green commuting on campus, by encouraging the community members for walking and cycling, and defines the structure and rules for keeping the campus noise-free. It inculcates behavioural changes and contributes to increased awareness amongst the community members of IITGN and nearby villages. Constant appeals are made to switch to energy-efficient CFLs/ LED bulbs and switch off all electrical appliances when not in use. The institute encourages the community to avoid lifts and use stairs, with a dual advantage for human health and energy savings.

The institute organised several programmes to promote engagement with industry, policymakers and grassroots organisations in the area of energy, such as the Sustainability Fair, Sustainability Seminar Series and Climate Action Now (CAN) workshop series. A broad range of stakeholders including professionals in the industry, NGOs, academicians and public officials, in addition to IITGN faculty and students, participated in the various events. The programmes facilitate networking among researchers and professionals engaged in the sphere of energy.

1. Sustainability Fair 2020

Dr Kiran C Patel Centre for Sustainable Development at IIT Gandhinagar hosted its second annual Sustainability Fair on 28 February, 2020, attended by 150 participants. The Sustainability Fair is aimed at fostering collaborations between IITGN faculty and organisations and industries in the area of sustainable development. The Fair serves as a platform for government bodies, NGOs, and other organisations working in the area of sustainable development to share ideas and practices on water, pollution & waste management, energy, climate change, wildlife & ecosystems. Nearly 30 exhibitors, including government agencies, NGOs, welfare organisations, and industry leaders showcased a wide range of sustainable development practices, projects, products and services. Some of the prominent exhibitors included Climate Change Department, Government of Gujarat; Centre for Environment Education; Foundation for Ecological Security; GEER Foundation; Geological Survey of India; Arvind Envisol Ltd; Gujarat Biotechnology Research Centre; International Water Association; Savy Electric Vehicles Private Limited; Sundarvan Nature Discovery Centre; UNICEF; Wildlife

Trust of India; among others. Whali, a life-sized model of the whale shark was also on display at the exhibition by the Wildlife Trust of India to spread awareness about whale sharks and their conservation. The event featured three keynote speakers: Kartikeya Sarabhai, Founder and Director, Centre for Environment Education; Dr Ratan Chand Jain, Ex-Chairman, Central Groundwater Board; and Sarbjit Singh Sahota, Emergency Specialist, Disaster Risk Reduction Section, UNICEF India. The Sustainability Fair concluded with a networking session to explore knowledge sharing and academia-Industry partnerships around a wide range of sustainable development themes including water. Students, faculty, research scholars, representatives of government, advocacy agencies and industries attended the event.

2. CAN2020

IITGN collaborated with the Gujarat Ecological and Education Research (GEER) Foundation on a Mega Workshop Series CAN 2020, Climate Action Now, A Gujarat State Initiative. The workshop series was structured around three themes: Climate Change Policy and Governance, Climate Action and Industry, and Climate Change Science and Research. Each segment comprised three workshops, a total of 9 workshops under the CAN 2020 workshop series, held over three months. The workshops covered seminal issues of energy, water, health, ecosystem and biodiversity, agriculture & food security, climate science, climate technology and solutions, climate policy, the economics of climate change, climate disaster, vulnerable communities, socio-cultural issues of climate change and other allied subjects, focusing on the state (Gujarat) and national level priorities.

The first segment of Climate Action Now (CAN) 2020 Workshop Series was held from 11 to 28 February, 2020 on "Climate Change Policy and Governance". This workshop series included talks on different sectors that are directly linked to climate change, including climate policy, environment, water, agriculture, power, energy, sustainable urban and rural development, industry and mining, climate risks and vulnerability, sustainable transport, forests, biodiversity and wildlife and climate finance and economics. 12 theme-based technical sessions included talks by 44 expert speakers who were invited from different parts of the country. The speakers represented organisations ranging from the Forest Survey of India, Indian Council of Forestry Research and Education, Ministry of Environment, Forest and Climate Change, Bankers Institute of Rural Development, Small Industries Development Bank of

India, The Energy and Resources Institute, Centre for Environmental Planning and Technology, Indian Institute of Management, Gujarat International Finance Tec-City, Gujarat Mineral Development Corporation, Gujarat Institute of Disaster Management, Deendayal Port Trust, Sardar Patel Renewable Energy Research Institute, Gujarat Energy Development Agency, etc. More than 300 people participated in CAN 2020 and shared thoughts, experiences and knowledge. The workshop facilitated networking amongst participating individuals and organisations.

3. Sustainability Seminar Series

Building Sustainable Infrastructure: Advanced Spray and Jet Cooling for New Materials and Technologies
Facilitator: Prof Vladan Prodanovic, Chemical and Biological Engineering, University of British Columbia, Canada | Seminar held on 17 October, 2019

Building a resilient, affordable and acceptable infrastructure in the energy and transportation sectors remains one of the key goals for sustainable growth in a low carbon economy. This often includes the application of new materials and technologies developed to lower greenhouse gas emissions and reduce human impact on climate change. The presentation provided a review of controlled accelerated cooling (ACC) technologies applied globally, discussed research opportunities and implementation challenges, and reviewed current research activities at the Centre for Metallurgical Processing Engineering at the University of British Columbia. Dr Vladan Prodanovic is a senior instructor in the Departments of Chemical and Biological Engineering, and Mechanical Engineering at the University of British Columbia (UBC) Canada, and Director of the Master of Engineering Leadership programme in Clean Energy Engineering. His professional interest and expertise are in the area of multiphase flow and heat transfer, sustainable energy systems, and energy efficiency.

IITGN constituted a dedicated Green Office, which has a pivotal role in monitoring and implementation of various efforts related to the green campus. The Green Office comprises a team of faculty, staff and students who work for creating better awareness implementing various activities that contribute to eco-friendly and sustainable practices on the campus and neighbourhood villages. It is one of the major bodies participating in sustainability efforts actively promoting awareness among the campus residents and in the wider community; focusing more particularly on waste management, compost production, and awareness programmes (on campus as well as in neighbouring villages). It aids in steering sustainable

development practices, inculcating behavioural changes and contributing to increased awareness amongst the community members of IITGN and nearby villages.

The Kiran C Patel Centre for Sustainable Development, established in 2019, addresses major sustainability challenges and promotes collaboration among faculty and students on developing practical solutions through integration of advanced research, traditional knowledge and field understanding. Its principal focus areas are water, pollution and waste management, energy, climate change and natural resources, wildlife and ecosystems. It aims towards developing a strong outreach programme of training, education, awareness and community engagement on sustainable development and promoting networking and collaboration among scholars, policymakers, industry, non-profit organisations and other stakeholders. The Centre conducts an annual Sustainability Fair and a regular Sustainability Seminar Series to encourage active collaboration and networking amongst a broad range of stakeholders.

KPCSD has established several fellowships, grants and awards over the past year to support research, projects and thesis work aligned with the major objectives of the Centre. The Centre also launched several initiatives to promote impactful work on Covid-19 research projects and

publications with the aim:

1. To enable the implementation/ testing/ validation of laboratory research in the field (to help alleviate the last-mile problem)
2. To strengthen and complement sustainability-related research and development activities already being undertaken by various IITGN faculty and students
3. To positively impact the campus and immediate neighbourhood and community in sustainable living and development

Examples of some of the major initiatives by the Centre include financial support for sustainability-related projects/ theses, IITGN-CSD Young Alumni Fellowship, Student Sustainability Grant and KPCSD Covid-19 Research Award.

The Green Office and Kiran C Patel Centre for Sustainable Development play a vital role in promoting policies and practices and supporting research related to sustainability. The Green Office majorly plays a key role in promoting sustainability in campus operations. The Kiran C Patel Centre for Sustainable Development is an umbrella for academic programmes and research in the areas of sustainability and climate change.

