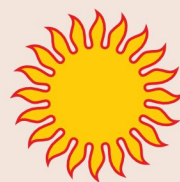


ANNUAL REPORT 2025-26



SPRERI
Striving for Excellence



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Highlights of the Year

The Sardar Patel Renewable Energy Research Institute (SPRERI) focused on multidisciplinary research activities, addressing national priorities related to clean energy, circular economy, biomass utilization, industrial decarbonization, sustainable agriculture and rural livelihood enhancement. In the Solar Energy Division, several innovative technologies were developed and evaluated. A waste engine oil-based nanofluid was developed for solar thermal applications demonstrating enhanced photo-thermal conversion efficiency and improved heat transfer characteristics. A PV powered cooking system was successfully developed to enable clean cooking during non-solar hours. The division also developed a green steam-based extraction system for high-value aromatic and medicinal products.

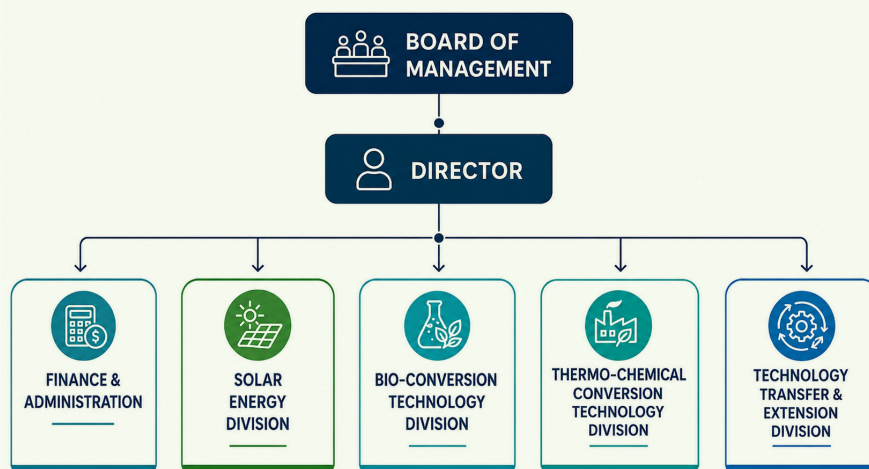
The Bio-conversion Technology Division continued to advance value-added utilization of agricultural biomass. The institute successfully scaled up the production of pharmaceutical grade microcrystalline cellulose (MCC) from agricultural residues. Bio-lubricants derived from microalgal lipids were synthesized and characterized for industrial applications. A horizontal flow anaerobic digester was optimized to improve biogas yield under high-solids operation. The research efforts on biological conversion of biogas to methanol demonstrated encouraging methanol yields under optimized operating conditions. The Institute also developed lignin- and nanocellulose-based biodegradable nanobiocomposites with enhanced mechanical and functional properties for advanced material applications.

The Thermo-Chemical Conversion Technology Division developed and demonstrated a bio-oil burner for industrial thermal applications. The biomass pellet combustor was automated for efficient utilization of high-ash biomass pellets improving operational reliability. Low-cost portable biochar kilns of different capacities were developed to promote decentralized biomass valorization at the farm level. Significant progress was made in carbon capture through the development of an integrated CO₂ mineralization system utilizing biomass ash in conjunction with biogas plants. The TCC division also developed a biochar-based wastewater treatment system for Bulk Milk Chillers (BMCs), demonstrating effective treatment of dairy effluent under field conditions. The institute also initiated an extensive statewide assessment of agricultural crop residues across Gujarat to establish a comprehensive biomass resource database for future bioenergy planning. Studies were also undertaken on advanced photocatalytic materials and hydrogen production pathways to support future clean energy technologies.

Technology transfer and commercialization remained an important focus during the year. The large-scale solar hybrid dryer technology was transferred to an industrial licensee for commercialization. Institute strengthened its outreach and extension activities through large-scale demonstrations, training programmes, awareness campaigns, and technology dissemination initiatives. The Institute continued to support government agencies and industries through technical consultancy, resource assessment studies, and field surveys. Institute organized several scientific and outreach events during the year such as National Seminar on “Advances in Microalgae for Carbon Capture, Biofuels and Value-Added Products”. SPRERI also hosted the 29th Annual Workshop of ICAR-AICRP on Energy in Agriculture and Agro-Industries from 29–31 January 2026 attended by more than 50 Scientist from 16 participating centres. The Institute organized a flagship 17th Open House programme on 25–26 February 2026, attracting approximately 1,800 visitors. The programme featured a poster competition, the “Green Spark” inter-school quiz, and a technology exhibition. The institute also celebrated its 47th Foundation Day, recognized retired employees and long-serving scientists. During the year, SPRERI also expanded its collaborations with industries, academic institutions, government organizations, and research agencies through 09 Memoranda of Understanding (MoUs), thereby strengthening knowledge exchange, and commercialization efforts. Collectively, these achievements reflect the institute’s continued commitment towards advancing renewable energy technologies for sustainable development, supporting rural livelihoods, and contributing to India’s transition towards a low-carbon and resource-efficient economy.

The Organization & Structure

Sardar Patel Renewable Energy Research Institute (SPRERI), established in 1979, is an autonomous, not-for-profit research organization governed by a Board comprising eminent technologists, scientists, industrialists, and representatives from both Central and State Governments. It is recognized by the Department of Scientific and Industrial Research (DSIR), Government of India, as a Scientific and Industrial Research Organization (SIRO), and is also approved as a Research Association under clause (ii) of sub-section (1) of section 35 of the Income Tax Act, 1961. SPRERI primarily generates its operational funding through merit-based projects awarded by government and non-government entities. These are further supported by Indian Council of Agricultural Research (ICAR), Govt. of India and by the Government of Gujarat (GoG). Service-based activities such as consultancy, technology evaluation, testing, and training, also enables the institute to function in a financially self-sustaining manner. As a nationally reputed research institution in the field of renewable energy, SPRERI is recognized by several universities and academic bodies for postgraduate research. The institute specializes in three core areas: solar energy, bioconversion, and thermochemical conversion of biomass. Numerous renewable energy systems and devices developed at SPRERI have been successfully commercialized and are now manufactured by industrial partners for widespread deployment. In addition to research and development, SPRERI is actively engaged in the promotion and dissemination of renewable energy technologies through field trials, demonstration projects, training and entrepreneurship development programmes, awareness campaigns, and integrated rural development initiatives, particularly in tribal areas.



Vision & Mission

Vision

SPRERI will be an organization that will develop environment friendly Renewable Energy Technologies that are efficient and economically viable for society.

Mission

To achieve excellence in research, development, and commercial development of renewable energy technologies including education and training for the promotion of environmentally sustainable technologies with public-private cooperation for India and developing global economies.



Board of Management

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Shri Bhikubhai B Patel

Chairman, Charutar Vidya Mandal, Vallabh Vidyanagar, Anand

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Ms. Bhaktiben Shamal (Nominee Govt. of Gujarat)

Joint Secretary, Department of Energy & Petrochemicals, Govt. of Gujarat, Gandhinagar

Shri Manish S. Patel

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Er. Sydney Lobo

Senior Technical Advisor, Clean Tech Space, Mumbai.

Former Head - Sustainability and Clean Technology Projects, Tata Power Company Ltd., Mumbai

Prof. Datta Madamwar

Scientific Advisor & Director University Research Centre, Charotar University of Science and Technology, CHARUSAT, Changa

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Former Executive Director Indian Oil Corporation (R&D), Faridabad

Former Chief Executive Officer, Indian Oil Technologies Ltd., Faridabad

Former Chair, DBT-IOC, Centre for Advanced Bioenergy Research, Faridabad.

Prof. Anuradda Ganesh

Adjunct Professor, Indian Institute of Technology, Madras

Former Professor & Head, Department of Energy Science & Engineering, IIT Bombay

Former Chief Technical Advisor and Director, CUMMINS Technologies India Limited, Pune

Prof. Satish B. Agnihotri, IAS

Professor, Centre for Technology Alternatives for Rural Areas (CTARA), IIT Bombay

Former Secretary, Ministry of New and Renewable Energy, Government of India

Former Secretary (Coordination & Public Grievances), Cabinet Secretariat, Government of India

Er. Vivek Amin

Chief Executive Officer, Bomin Industries Pvt Ltd, Ahmedabad

Dr. A. Mahesh

Assistant Professor, C. L. Patel Institute of Studies and Research in Renewable Energy, Anand, Gujarat

Mr. Apoorva Oza (Till December 2025)

Chief Executive, Aga Khan Rural Support Programme, Ahmedabad

Member-Secretary

Dr. Anil Kumar Dubey

Director, SPRERI, Vallabh Vidyanagar



1.1 Waste engine oil based nanofluid for solar thermal applications

A process was developed to produce nanofluid from waste engine oil for solar thermal applications. The nanofluid was dispersed in paraffin oil (base fluid) at different volumetric concentrations (0%, 3%, 5%, 10% and 30% v/v) to synthesize nanofluids with enhanced thermal and optical properties. Thermal conductivity analysis indicated that conductivity increased with increasing WEO concentration.

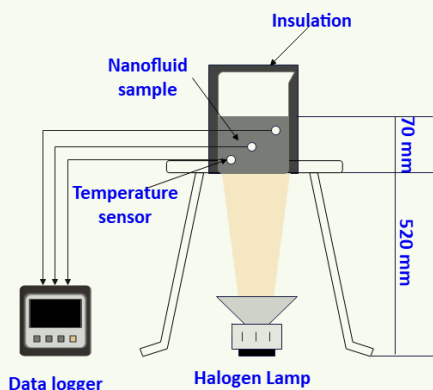


Figure 1.1: Opto-thermal measurement set-up

The 30% nanofluid exhibited the highest thermal conductivity, showing approximately 3% enhancement over the base fluid. An opto-thermal experimental setup as shown in Figure 1.1 was developed to evaluate the thermal response of nanofluids under controlled irradiation conditions. Experimental results (Table 1.1) demonstrated that the 3% v/v nanofluid exhibited the best thermal performance, achieving an average temperature of 67.9 °C and a maximum temperature of 84.3 °C compared to 57.9 °C and 69.8 °C for the base fluid.

Table 1.1: Average and Maximum temperatures of nanofluid at different concentrations

Nanofluid Concentrations (% v/v)	Average Temperature (°C)	Maximum Temperature (°C)
In Base fluid	57.9	69.8
3	67.9	84.3
5	65.5	81.0
10	62.5	76.6
30	60.6	72.9

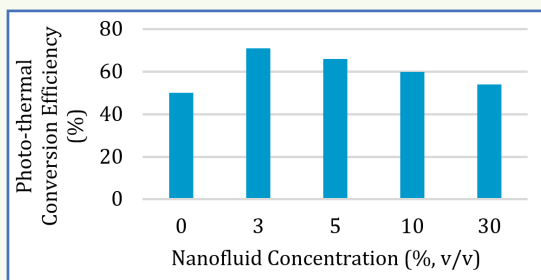


Figure 1.2: Photo-thermal conversion efficiency

Opto-thermal conversion efficiency was estimated using an energy balance approach. As shown in Figure 1.2, the base fluid exhibited a photo-thermal conversion efficiency of nearly 50%, whereas the 3% v/v nanofluid achieved the highest efficiency of approximately 71%. Further increase in concentration of nanofluid reduced the photo-thermal conversion efficiency due to optical shielding effects, increased scattering, and particle agglomeration. The study demonstrated the use of low-concentration WEO-based nanofluid to improve solar thermal absorption and heat transfer characteristics.

1.2 Solar PV-based indoor day-night green cooking solution

A solar photovoltaic (PV)-based indoor cooking system integrated with thermal energy storage (TES) was developed and evaluated (Figure 1.3) for enabling clean and green cooking during non-solar hours. The developed system consisted of 2.3 kWp solar PV system integrated with electric coil heater (1 kW) and a phase change material based thermal energy storage (2.5 MJ storage capacity).

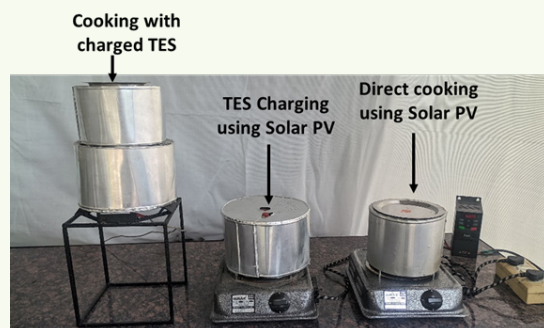


Figure 1.3: Thermal energy storage-based e-cooking prototype for indoor set-up

The potassium nitrate (KNO_3) was used as PCM for TES owing to its high thermal stability and melting temperature of 334 °C. The TES unit gets charged in 90 minutes, with a total heat input of 4963 kJ

Table 1.2: Water boiling test of TES System

Sr. No.	No. of batches	Water quantity (Litres)	Avg. initial temp. (°C)	Final Temp. (°C)	Temp difference (°C)	Time taken (min)
1.	4	1.0	30	95.8	65.8	18
2.		1.0	30	95.8	65.8	20
3.		1.0	30	95.1	65.1	37
4.		1.0	30	85.0	55.0	50

The system successfully demonstrated heating of 1 L water from 30 °C to 95 °C during the first three discharge cycles, indicating efficient utilization of stored heat energy. The first batch achieved a temperature rise of 65.8 °C within 18 minutes, while subsequent batches showed gradual increase in heating time and slight reduction in final temperature due to progressive depletion of stored thermal energy. By the fourth batch, the final temperature reduced to 85 °C with a

resulting in a charging thermal efficiency of 46%. The heat discharge performance of the TES unit was evaluated through standard water boiling and cooking tests and results are shown in Table 1.2.

longer heating duration of 50 minutes. The system achieved a discharge efficiency of 66.6%, while the overall thermal efficiency of the TES system was estimated to be 30.6%. The temperature profile during both charging and discharging is shown in Figure 1.4, highlighting the heat absorption and release behavior of the PCM under real operating conditions. On a single TES discharging cycle, the system successfully cooked two batches of rice (200 g each) and one batch of lentils (200 g).

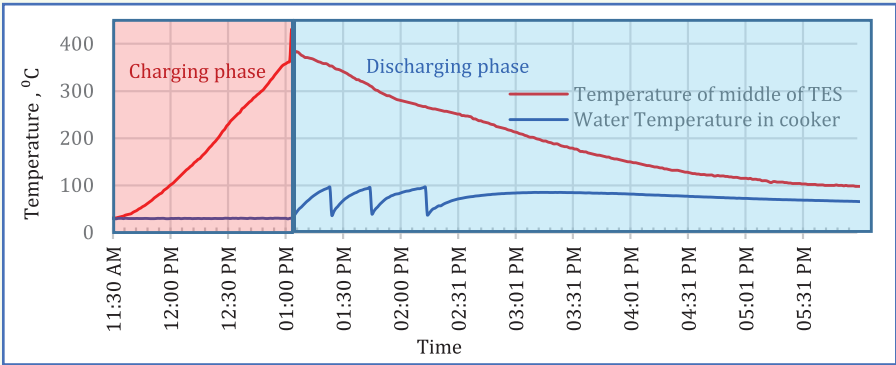


Figure 1.4 : Temperature profile of TES and water during water boil test

1.3 Green steam-based extraction system for high-value aromatic and medicinal products

The baseline operational data for steam based oil extraction from medicinal plants was generated by integrating developed oil extractor unit with conventional biomass based boiler. Experimental studies were conducted to extract the oil from neem and eucalyptus leaves as feedstock materials. Testing of integrated system was performed with batch loads of neem/eucalyptus of 5 kg and 10 kg under steam pressures ranging from 2 to 5 kg/cm². The system successfully generated

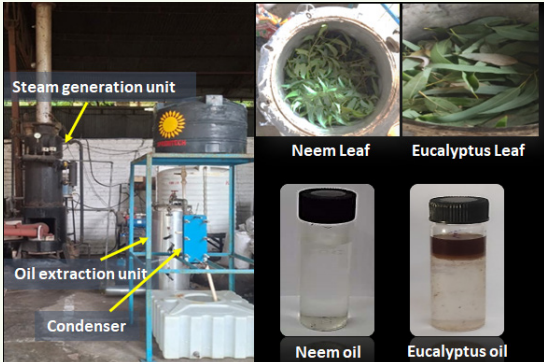


Figure 1.5: Experimental setup for biomass fired oil extraction system and the extracts of neem and eucalyptus oil

condensate containing aromatic compounds from both feedstock. The neem leaf condensate generated were of 18.5 L and 25.0 L with 5 kg and 10 kg batch loads of feedstock, respectively in 2.0–2.5 hours of operation. The condensate exhibited characteristic of neem oil aroma. Eucalyptus leaf extraction on the other hand demonstrated strong aromatic condensate formation and essential oil recovery (Figure 1.5). A dedicated control panel was developed and integrated with parabolic trough collector (PTC) to improve the steam flow. The system was also integrated with linear actuator and pressure reduction throttle valve for precise operation.

1.4 Thermal energy storage-based solar refrigerator for fish

A cold thermal energy storage (c-TES)-integrated refrigerator system was developed for the storage of fish and other perishable commodities. The developed system consisted of a 300 L deep freezer integrated with a single-phase compressor (260 W), a 2 kVA solar inverter, and a 590 Wp solar PV panel. The system (Figure 1.6, *top*) was also integrated with a 60 MJ cold thermal energy

storage (c-TES) unit to enable sustained cooling during non-sunshine hours. Preliminary evaluation of the system was carried out using a load of 36 L of water filled in bottles (Figure 1.6, *bottom*). The load temperature decreased from room temperature to 0 °C after 16 sunny hours of operation. Thereafter, the power supply from the solar PV system was disconnected to assess the thermal backup duration provided by the c-TES. It was observed that the load temperature was maintained within the range of 0 °C to 2 °C for 48 hours. The c-TES-assisted solar refrigerator for off-grid storage of fish under intermittent power conditions is currently under evaluation.

1.5 Development of indirect solar hybrid dryer for large-scale continuous drying of agro-produce

A large-scale indirect solar hybrid drying system of 1000 kg/batch capacity was designed for continuous drying of agro-produce. The system was designed to operate at a maximum hot air temperature of 70 °C with an air velocity of 1.0 m/s. The air distribution system was designed to supply hot air from both ends of the drying chamber, for drying uniformity and ease in tray movement during operation. The system takes heat from hot water (max 95 °C) stored in a buffer tank of 4000 L capacity indirectly through a heat exchanger to heat the air in drying chamber. To maintain the buffer tank temperature provision for solar evacuated heat pipe collectors during daytime and a biomass combustion-based hot water generator during night-time operation is provided. This hybrid configuration ensures continuous drying independent of solar intermittency. The system would be installed for field evaluation by an FPO namely, *One Gujarat Organic Farm Producer Cooperative Society Ltd.* for different agro-produce. The design of system as shown in Figure 1.7 & 1.8 would meet the specific requirement of site for field evaluation. The technology has been transferred to a licensee for commercialization.



Figure 1.6: Modified refrigerator (*top*) and water as load in chamber (*bottom*)

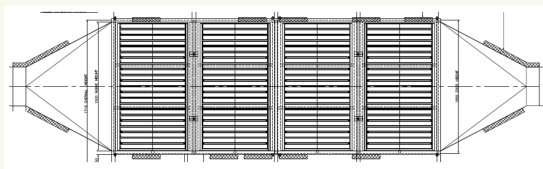


Figure 1.7: Dryer chamber front elevation with tray arrangement

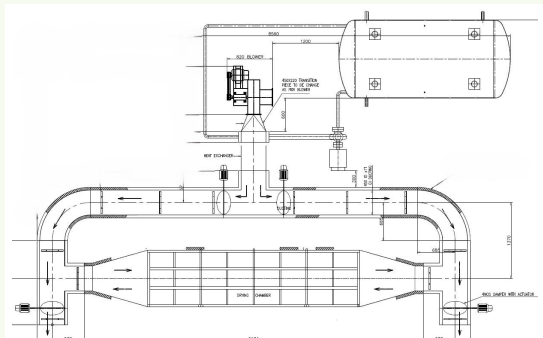


Figure 1.8: Design of drying chamber, heat exchanger and ducting arrangement

1.6 Removal of micro plastics from agro-industrial wastewater

A laboratory-scale solar PV-assisted electrophoretic deposition (EPD) system was developed (Figure 1.9) to investigate the feasibility of removal of micro plastics from agro-industrial wastewater. The experimental setup comprised of a graphite-based cathode and a copper plate-based anode for low-voltage DC operation. The simulated wastewater was prepared in tap water at a concentration of 1 g/L to facilitate

visual monitoring of removal of micro plastic. Experimental studies conducted at an applied voltage of 5 V DC demonstrated successful deposition of plastic particles onto the electrode surface, indicating migration and separation of suspended micro plastics from wastewater. The developed system achieved a micro plastic removal efficiency of 67%. Further investigations are being conducted to optimize operating parameters to achieve 90% removal efficiency. The study highlights the potential of integrating solar PV-powered electrophoretic deposition systems for decentralized and sustainable treatment of agro-industrial wastewater contaminated with micro plastics and other organic pollutants.

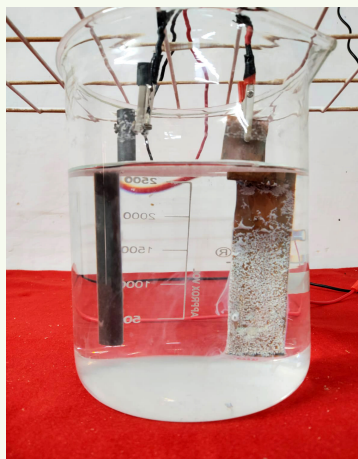


Figure 1.9: Electrophoretic deposition setup

2.1 Production of MCC from agricultural residues for application in functional material development

The optimized process for the production of microcrystalline cellulose (MCC) from rice straw and banana fiber was further advanced towards applications in functional material development. The process was scaled to 5 kg/batch yielding 1.5 kg MCC (75% recovery of cellulose present in biomass), confirming scalability of the developed process. Further, MCC was successfully impregnated with silver nanoparticles (AgNPs), producing antimicrobial MCC–AgNP nanocomposite blends with broad-spectrum antibacterial activity. XRD analysis of nanocomposite confirmed nanoparticle incorporation through the presence of characteristic silver diffraction peaks ($\sim 38^\circ$ and $\sim 44.5^\circ$) and maintaining the cellulose with a crystallinity index of 64%. The AgNP-MCC composite at 5 mM AgNP concentration demonstrated broad spectrum antibacterial efficacy with different strains (Figure 2.1).

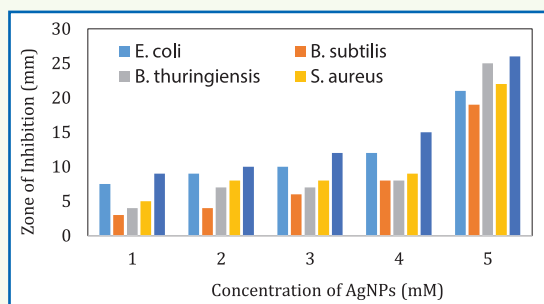


Figure 2.1: Zone of inhibition with different concentration of AgNP-MCC composites against different types of bacteria

PVA-based composite films reinforced with MCC were developed using different concentrations of PVA (2.5–5%), MCC loading (up to 1%), and varying glycerol concentrations. MCC-incorporated films showed higher tensile strength than their respective control confirming the reinforcing effect of MCC. The formulation, P5M0.5 film exhibited higher tensile strength (12.0 MPa) as compared to control PVA film (11.7 MPa). Water absorption

studies revealed composition dependent swelling behavior of composites. The higher glycerol concentrations increase moisture uptake whereas MCC incorporation improves structural stability of the films. Additionally, the antimicrobial composite AgNP-MCC/PVA (5% PVA + 0.5% AgNP-MCC) film were prepared using solvent casting method exhibiting smooth, flexible, and structurally stable morphology with uniform nanoparticle dispersion. Antibacterial activity of prepared film against *Klebsiella pneumoniae* showed clear inhibition zones of 20–22 mm confirming successful transmission of antimicrobial functionality into the polymeric film matrix (Figure 2.2). The study establishes a technically viable, scalable, and functionally advanced route for developing MCC-based biomaterials and antimicrobial composite films from agro-residues for packaging.



Figure 2.2: Antibacterial activity of AgNP-MCC/PVA composite film against *Klebsiella pneumoniae*

2.2 Bio-lubricants production using microalgae derived lipids

The microalgae strain (*Nephrocytium sp.*) showed maximum total lipid production of 46.6%. The biomass yield 2.5 g/L was obtained using dairy wastewater. The experiments on production of microalgae were performed using alternate nitrogen and carbon sources. The use of commercial NPK fertilizer in V-pond showed increase in biomass yield from 2.5 g/L to 4.7 g/L with 35% lipid content. The process for synthesis of bio-lubricant were optimized by making transesterification of castor oil using methanol and NaOH as catalyst. The methyl

group present in the methyl esters were replaced by adding trimethylolpropane (TMP), neopentylglycol (NPG) and pentaerythritol (PE) in the presence of the lipase enzyme. The viscosity of biolubricants synthesized using higher alcohols showed 19.1 mm²/s with NPG, 11.1 mm²/s with TMP and 17.8 mm²/s with PE which was higher than the base oil (10.2 mm²/s) (Table 2.1). The tribological properties of the biolubricants produced from castor oil were also analyzed and found under ISO VG 11 category suitable for light-duty industrial equipment. The biolubricant synthesized from microalgal lipids had 34 mm²/s viscosity which belongs to ISO VG 32 category, suitable for hydraulic systems, compressors, and other industrial machinery.

Table 2.1: Properties of biolubricants from castor oil and microalgal lipid

Fatty Acid Methyl Ester (FAME)	Kinematic viscosity (mm ² /s at 40 °C)	Density (g/cm ³)
FAME of castor oil (FCO)	10.2	0.91
FCO + NPG	19.1	0.92
FCO + TMP	11.1	0.89
FCO + PE	17.8	0.91
FAME of Microalgal oil (FMO)	10	0.87
FMO + NPG	34	1.03

2.3 Biomethanation of napier grass: Circular economy approach

The biomethanation study conducted on Napier grass juice (NGJ) was observed to have higher biogas yield (0.23 m³/kgVS) as compared to raw and dejuiced napier grass substrate, with >80% reduction in volatile solids (VS). Further study was conducted using NGJ in 50 L capacity anaerobic hybrid reactors (AHR) with organic loading rates (OLR) ranging from

2 to 12 g/L at thermophilic conditions. The HRT in the anaerobic hybrid reactor was maintained for 3-days. The biogas and methane yield in thermophilic condition at steady-state phase (12 g/L) was 0.37 and 0.25 m³/kgVS, respectively. The chemical oxygen demand (COD) and VS reductions of 75% and 78% were observed, respectively.



Figure 2.3: Pellets of dejuiced Napier grass biomass
On increasing the OLR from 12 to 20 g/L, the digester got destabilized resulting in a drop in biogas production (50-60 L/kg VS). The dejuiced napier grass was used for biomass pellet production to promote circular economy in biogas generation. The calorific value of pellet from dejuiced napier grass was found to be 16.3 MJ/kg which could be used as solid fuel (Figure 2.3). The microbial dynamics were analysed in the AHR showed that majority of mixed culture belongs to methanogenic and hydrogenotrophic group (*Methanoculleus*, *Methanobrevibacter*, and *Methanocorpusculum*) which can use H₂ and CO₂ for methane production (Figure 2.4). However, second abundant group of methanogens were acetoclastic (*Methanosarcina*) bacteria which can use acetic acid as substrate. Owing to these microorganisms, there was equilibrium between acetoclastic and hydrogenotrophic methanogens leading to higher methane content in the biogas produced.

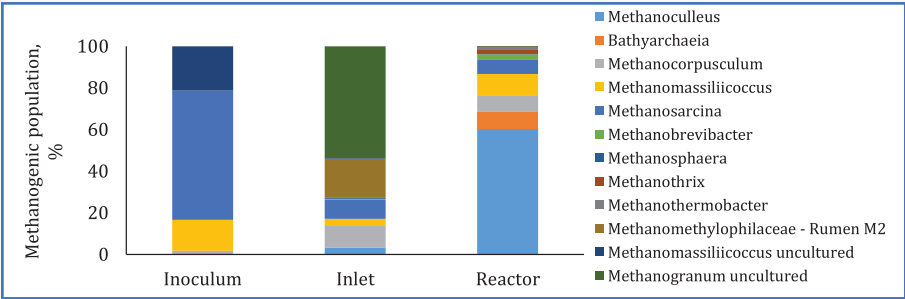


Figure 2.4: Microbial community present in anaerobic hybrid reactor

2.4 Development of horizontal flow anaerobic digester for biogas production

Horizontal flow anaerobic digesters (HFAD) of 300 L capacity was developed and optimized for biogas production from cow dung as a substrate (Figure 2.5). The reactor was operated at 13% total solids (TS) with a hydraulic retention time (HRT) of 22 days and the average biogas yield was 70 L/kg TS. The movement of feed stock in the reactor got improved with the use of auger type impeller having provision for axial mixing of feed stock. The reactor was operated with 9% TS with HRT of 35 days and showed average biogas yield of



Figure 2.5: Horizontal flow anaerobic digester

150 – 200 L/kg TS. After achieving stable reactor operation, the TS content was again increased to 13% while maintaining the HRT at 35 days, resulting in a biogas yield of 170–200 L/kg TS. The increased retention time from 22 days to 35 days significantly enhanced reactor performance, improving the biogas yield by 2.5 times. The performance of the horizontal reactor got influenced by low ambient temperature (20–25 °C) in winter season and the biogas yield got reduced to 75 to 90 L/kg TS. The insulation of HFAD reactor was done with glass wool to avoid the fluctuation in reactor temperature. The insulated HFAD showed increase in the biogas yields by 22–25%. The daily biogas yield is given in Figure 2.6.

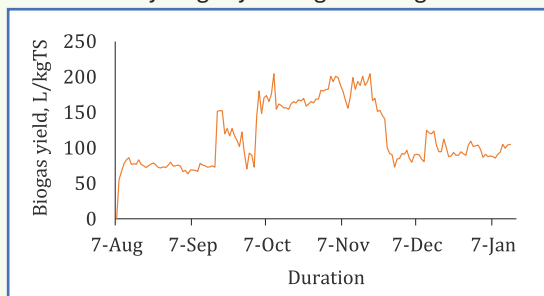


Figure 2.6: Daily biogas yield during anaerobic digestion of cow dung

2.4 Bio-methanol production from biogas

The study was conducted for conversion of methane into methanol using strain *Methylobacterium buryatense*. The bioreactors of 500 ml capacity (Figure 2.7) were used to optimize

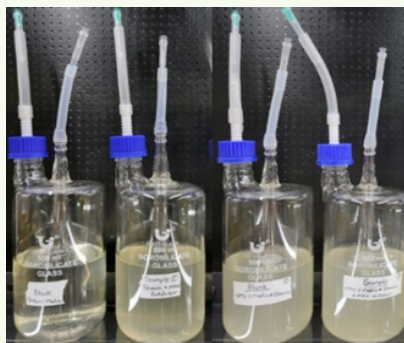


Figure 2.7: Setup for methanol production from biogas the methanol production in mineral salts (NMS-2) media containing methanol dehydrogenase (MDH) inhibitors, and gas-feeding strategies (mixture of gases and composition). The use of MDH inhibitors such as MgCl_2 , EDTA, NaCl, and sodium formate enhanced methanol production by restricting the enzymatic oxidation of methanol to downstream intermediates. The MDH inhibitor MgCl_2 (20 mM) achieved methanol production of 1.99 g/L, compared to 1.54 g/L in control conditions (without MDH inhibitor). Delayed addition of MgCl_2 (after 6 h) improved methanol accumulation compared to immediate addition, highlighting the significance of timing of inhibitor addition. Further study was conducted in 3 L bioreactor (Figure 2.8). The methanol concentrations 1.83 g/L were achieved



Figure 2.8: Methanol production in 3 L reactor

using pure methane gas at 0.5 bar pressure in 3 L bioreactor with optimized gas feeding intervals (24 h). The experiments on methanol production

using raw biogas generated from horizontal flow-anaerobic digester having methane content of 60% was conducted in 5 L bioreactor. The raw biogas was supplied continuously with periodic oxygen feeding (24 h interval) and using MgCl_2 (20 mM). The result shows methanol production of 0.54 g/L within 24 h. These results showed that concentration of inhibitor, time of addition as well as gas-feeding strategy significantly influences the methanol production.

2.5 Bio-butanol production from agri-residue

The study on biobutanol production was carried out using *Clostridium sporogenes* and rice straw & cotton stalk hydrolysate as the primary carbon source for fermentation. The hydrolysis of acid pretreated rice straw and cotton stalk were performed using cellulase (Cellic® Ctec2, Novozymes) in sodium citrate buffer (pH4.8) at an enzyme loading of 12 FPUg⁻¹ biomass at 50 °C and 150 rpm for 48 h in a shaker incubator. This saccharification process resulted in release of fermentable sugars with concentrations of 44 mgmL⁻¹ from rice straw and 29 mgmL⁻¹ from cotton stalk. The hydrolysate was analyzed using HPLC showed higher concentrations of inhibitory compounds in cotton stalk, with 9.44 mM furfural and 0.11 mM hydroxymethylfurfural (HMF). Whereas, rice straw hydrolysate showed 4.8 mM furfural and 0.089 mM HMF, indicating comparatively favorable suitability for biobutanol fermentation as compared to cotton stalk. The experiments with rice straw hydrolysate in 500 ml serum bottles resulted in a maximum butanol concentration of 3.2 g/L as compared to 2.1 g/L from of cotton stalk hydrolysate. The scale up study in a 5 L capacity fermenter with rice straw hydrolysate showed butanol concentration 2.9 g/L at 30th hour.

2.6 Development of cellulose and lignin-based nanobiocomposites from agro-waste

A lignin and cellulose nanoparticle recovery was established using Natural Deep Eutectic Solvents (Lactic acid:Choline Chloride; 9:1) from rice straw and cotton stalks. The resulting solid fraction (cellulose) was converted to Nanocellulose *via* controlled hydrolysis, while the lignin rich liquid fraction was processed into lignin nanoparticles

(LNPs) using an anti-solvent precipitation method. Particle size analysis (PSA) revealed that 98% of the synthesized LNPs using acetone-water (3:1) exhibited particle diameters in the range of 43-68 nm. The Nanocellulose production, from rice straw showed 99% nanocellulose particles in the range of 24-43 nm. The cotton stalk nanocellulose particles showed 92% in the range of 58-78 nm. The nanocomposites were fabricated with Polyvinyl alcohol (PVA) as polymer matrix using solvent casting and electrospinning techniques (Figure 2.9). Mechanical properties of the



Figure 2.9: Electrospinning equipment for nanocomposite films preparation

biocomposite films (cotton straw LNPs and rice straw LNPs with PVA) were analyzed. Tensile strength of CSLNPs/ PVA blended films increased from 2.4 MPa (5% PVA) to 3.16 MPa. Blending of RSLNPs with 10% PVA showed 2-fold enhancement in tensile strength i.e. 4.92 MPa when compared to pristine 10% PVA films (2.4 MPa). SEM analysis further confirmed the formation of uniform and interconnected network structures, particularly in nanocellulose-reinforced films (Figure 2.10). The films prepared with LNP/PVA blend for use in UV protection confirmed interfacial interactions by FTIR analysis.

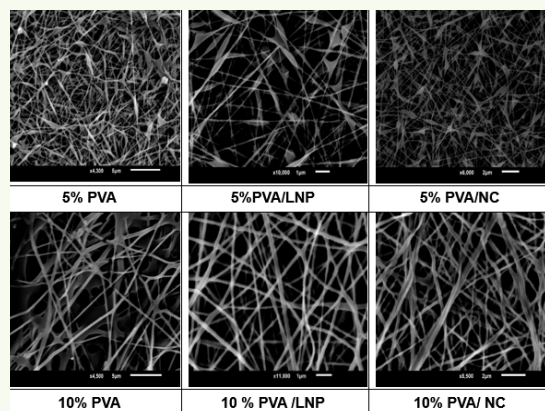


Figure 2.10: SEM images of PVA, NC and LNP blended composite films

3.1 Development & demonstration of bio-oil burner for thermal application

A bio-oil burner based on air-atomization has been developed and evaluated for thermal applications with an output thermal capacity of 200 MJ/h (Figure 3.1). The system comprises of



Figure 3.1: Combustion of bio-oil in developed burner at the user site

a bio-oil storage tank with heating and agitation arrangement, an air-assisted atomization nozzle and air compressor tank. The bio-oil generated from crop residues in slow pyrolysis process was used as fuel in developed burner. The aqueous portion of the bio-oil was removed by gravity separation and filtration process. The bio-oil temperature in the tank was maintained between in the range of 50–60 °C to improve fuel flow and its atomization. The burner was operated at flow rate of 8–10 LPH with an atomization pressure of 2–2.5 bar, and flame temperature was observed in the range of 500–580 °C. The developed system was successfully demonstrated at a user site (M/S Kismat Kathiawad, Anand), for more than 4 hrs of continuous operation multiple times. The air-atomization configuration enabled improved spray characteristics and cleaner combustion. Emission analysis of the bio-oil burning in the developed system indicated that pollutant levels are within acceptable limits (Table 3.1).

Table 3.1: Flue gases analysis during the combustion of bio-oil at Kismat Kathiyawadi Lodge, Borsad

S. No	Parameter	Present Study	Remarks
1	CO ₂ (vol.%)	9.1	Within an acceptable range
2	NO _x (ppm)	133.5	Moderate emissions
3	SO _x (ppm)	130.6	Comparable values
4	CO (ppm)	115.1	Indicates good combustion
5	O ₂ (vol.%)	11.2	Adequate excess air
6	SPM (mg/m ³)	74.3	Within limits

3.2 Automation of fuel pellet combustor for high ash pellets

An automated pellet combustor system has been developed to utilize high-ash-containing pellets for industrial thermal applications. The grate configuration of the burner was modified for wider spacing of 6–7 mm. The developed grate was integrated with a paddle-based agitation unit followed by a central axial grate rotating mechanism to achieve continuous operation of 4-5 h (Figure 3.2). These interventions ensured periodic disturbance of the fuel bed, thereby preventing ash accumulation and to make uniform combustion of pellets.

The developed system showed 90% low ash accumulation above the grate by as compared to unmodified system. The ash collection below the grate increased to 32.6%, indicating effective ash displacement. The clinker recovery below the grate reached to 92.6%, demonstrating small size clinkers formation due to the low ash accumulation above the grate. The duration of continuous operation of the modified system increased from 2.5 h to 5.5 h more than 100% enhancement. The modified combustor was demonstrated in the poha industry for continuous operation for 6 h with high ash containing pellets. The integration of paddle agitation and axial rotation significantly improved ash management, and operational reliability.

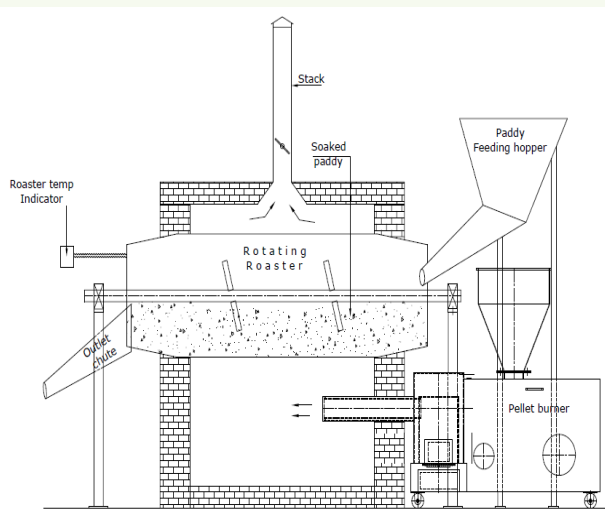


Figure 3.2: Pellet burner integrated with the roaster at the poha-making industry

3.3 Automation of green steam generation coupled with fluidized bed gasification system

A biomass-based fluidized bed gasification (FBG) system was successfully integrated with a multi-fuel steam generator to produce green steam for industrial thermal applications (Figure 3.3). The system converts agricultural biomass into producer gas, which is then directly used as fuel in the steam generator. The integrated unit operated smoothly under optimized conditions, producing stable steam at 165–168 °C at 5 bar pressure.



Figure 3.3: FBG unit with PLC-based automation for steam generation

Table 3.2 showed that the biomass-based fluidized bed gasification system significantly reduced the fuel cost for the steam generation to ₹2.1 per kg steam as compared to ₹3.6 per kg steam with use of coal as a fuel. In addition to economic benefits, the system also demonstrated lower

carbon emissions, reducing the fuel-based carbon footprint from 0.53 to 0.49 kg CO₂ per kg steam.

Table 3.2: Comparative Performance of steam generation system

Description	Producer gas-based operation	Coal-based operation
Steam generation rate (kg/h)	90	75
Steam pressure (bar)	5±0.5	
Steam temperature (°C)	165±5	165±3
Fuel consumption (kg/h)	26.1	16.6
Thermal energy input (MJ/h)	452	416
FOR of the fuel (₹/kg)	5.9	16.2
Fuel cost of steam generation (₹/kg)	2.1	3.6
Fuel-based carbon footprint (kg/kg steam)	0.49	0.53

The steam generation system coupled with fluidized bed gasifier was further integrated with a PLC-based automation for ease of operation. The automated control system regulates biomass feeding and air supply to achieve process heat demand. The developed technology demonstrates pathway for decentralized green steam generation at lower cost using available biomass resources.

3.4 Portable biochar kilns for biomass valorization

A low-cost and farmer-friendly biochar kilns have been developed and evaluated for converting



Figure 3.4: Developed vertical biochar kiln (a) 50 kg/batch; (b) 250 kg/batch and (c) 1000 kg/batch

agricultural residues into biochar at the farm level (Figure 3.4). These kilns were developed considering ease of operation, portability and minimum infrastructure requirement. These kilns allow crop residues to process and convert into biochar directly at the source, lowering storage needs, and avoiding losses. The developed models include both horizontal and vertical kilns with a biomass handling capacity of 50–250 kg per batch. Larger capacity kilns of 1000 kg/batch were also developed. Recovery of char from the kilns were in the range of 40–45%. This approach promotes value additional and income opportunities from agricultural waste.

3.5 Development of continuous horizontal type torrefaction system for agro-residues

A continuous horizontal torrefaction system of 20 kg/h capacity was developed for conversion of crop residues into torrefied biomass with improved fuel properties. The developed unit consists of a horizontal screw-conveyor reactor enclosed inside a heating chamber, where a pellet-fired burner is used to heat the reactor (Figure 3.5).

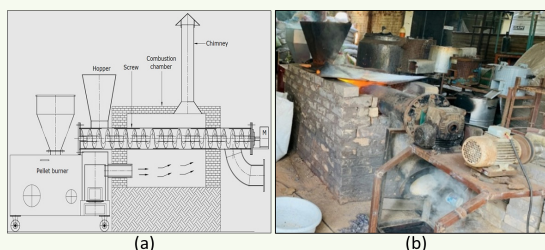


Figure 3.5: (a) Schematic arrangement of the horizontal screw-type continuous torrefaction system (b) image of the developed system

Table 3.3: Performance of small scale horizontal reactor

Parameter	Observations
Feed input rate (kg/h)	12–15
Heating chamber temperature (°C)	~550
Reactor wall temperature (°C)	320–350
Feed outlet (product) temperature (°C)	140–150

The performance of the developed horizontal torrefaction system demonstrated stable system operation, with the heating chamber temperature around 550 °C and reactor wall temperature in the range of 320–350 °C. Torrefied biomass temperature at outlet observed in the range of 140–150 °C (Table 3.3).

3.6 CO₂ capture in bio ash: An integrated CCS approach for biogas plant

A pilot-scale carbonation reactor with a handling capacity of 2 kg ash per batch was designed and developed (Figure 3.6). The mineralization of ash at 4 bar pressure, 90 °C temperature, and 1:15

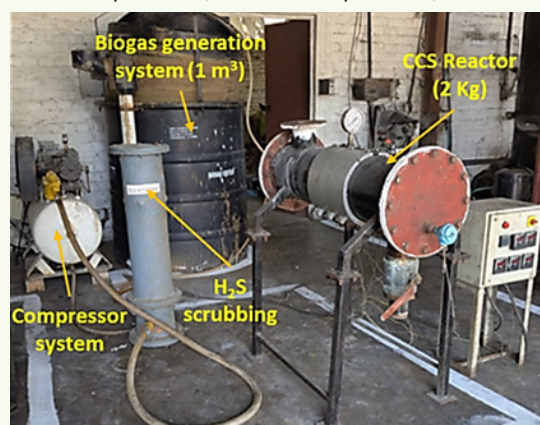


Figure 3.6: CO₂ capture reactor integrated with the portable biogas unit of capacity 1m³ per day

ash-to-water ratio showed capturing of 128.6 g CO₂/kg ash. Further improvement was achieved through Bishophite (Mg-based salt) impregnation, increasing the CO₂ capture capacity to 168.2 g/kg ash. A cow dung-based biogas plant of 1 m³ capacity was integrated with the developed CO₂ mineralization system. The integrated setup first compress the raw biogas and pressurized biogas is supplied to the carbonation reactor, where CO₂ reacts with slurry of bioash for sequestration of CO₂ into carbonated ash. Experimental trials are currently underway to evaluate continuous capturing of CO₂ and simultaneous biogas upgrading under real operating conditions.

3.7 Development and field testing of biochar-based BMC effluent treatment system

Wastewater generated from Bulk Milk Chillers (BMCs) is often discharged directly onto agricultural fields without adequate treatment, leading to soil and environmental pollution. To address this issue, SPRERI has developed a biochar based effluent treatment system of 50 LPH capacity for treatment of Bulk Milk Chiller wastewater. The system was evaluated and the quality of the treated water is found irrigation quality standards. The performance of the system is given in Table 3.4.

Table 3.4: Characterization of the untreated and treated BMC effluent from Devrajpara village

Parameter	Un-treated Effluent	Treated Effluent	Reduction (%)	Norms of Irrigation Water
TDS (mg/L)	839.0	462.0	44.9	450–2,000
COD (mg/L)	1855.4	128.0	93.1	<250
BOD (mg/L)	89.0	27.0	69.7	<30
pH	9.1	8.0	12.1	6.5–9.0
Turbidity (NTU)	93.5	4.2	95.5	1–5
Total Hardness (mg/L)	1000.0	328.0	67.2	100–600
TSS (mg/L)	28.0	12.2	56.4	0–50

The BMC effluent treatment system has been up-scaled to a 100 LPH capacity to meet the wastewater treatment requirements of typical bulk milk chilling centers (Figure 3.7). The up-scaled unit has been installed at the Mujkuwa Dairy of Amul for

field evaluation and demonstration. The system successfully treated BMC effluent, reducing the COD from approximately 3,000 mg/L to 500 mg/L, thereby validating the technology under real operating conditions. Further work is underway to automate the system for minimal manpower requirements and ease of operation to enhance operational reliability for commercialization.



Figure 3.7: Bio-char-based bulk milk chiller effluent treatment system (100 LPH) site

3.8 Mapping of regional variability & availability of crop residues in Gujarat

The biomass availability data was collected as per the guidelines of the Indian Agricultural Research Institute (IARI), New Delhi. A sample size of 605 farmers were selected for each of the five major crops grown in the state. In addition, 605 crop residue samples collections were planned to characterize for their variability. The zonewise selected village (450) across State for the survey is shown in Figure 3.8. The biomass assessment has been completed for 17 districts. The district-wise surplus biomass availability is summarized in the Table 3.5.

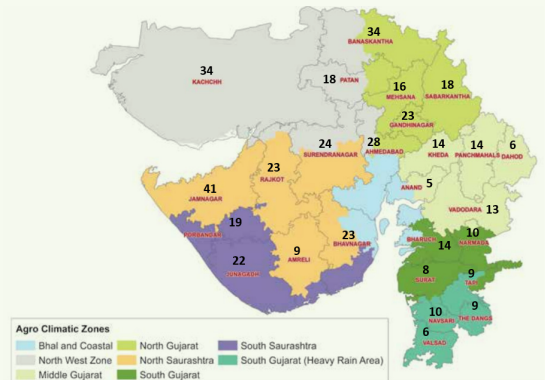


Figure 3.8: Location of villages for survey in eight agro-climatic zones of Gujarat

Table 3.5: District-wise biomass production and surplus availability of major crops

District	Total Biomass (MT/annum)	Surplus Biomass (MT/annum)	Major Crops
Navsari (Zone 1)	8,23,950	4,76,243	Sugarcane and Paddy
Valsad (Zone 1)	8,11,960	516569	Sugarcane and Paddy
Bharuch (Zone 2)	16,45,402	7,52,822	Sugarcane, Cotton, Pigeon Pea, & Paddy
Anand (Zone 3)	32,38,096	20,58,861	Banana, Paddy, Wheat and Tobacco
Kheda (Zone 3)	15,64,613	5,90,074	Paddy, Banana, Wheat, and Tobacco
Mahisagar (Zone 3)	7,41,853	2,35,565	Cotton, Paddy, Wheat, Bajra and Maize
Panchmahal (Zone 3)	6,81,932	2,19,037	Cotton, Paddy, Wheat, Maize
Vadodara (Zone 3)	15,10,869	7,25,430	Banana, Paddy, Cotton, and Castor
Gandhinagar (Zone 4)	10,33,159	3,46,108	Potato, Wheat, Paddy, and Groundnut
Mehsana (Zone 4)	15,00,342	6,00,137	Cotton, Castor, Groundnut, and Bajra
Ahmedabad (Zone 5)	26,47,928	13,98,106	Paddy, Wheat, Cotton, Castor, and Gram
Surendranagar (Zone 6)	10,47,986	4,08,599	Paddy, Bajra, and Groundnut
Rajkot (Zone 6)	31,51,585	13,12,635	Bajra, Cotton, Groundnut, and Paddy
Amreli (Zone 6)	12,57,343	5,13,943	Cotton, Groundnut, Wheat, and Sesame
Botad (Zone 6)	7,86,897	3,29,582	Cotton, Wheat, Gram, and Groundnut
Junagadh (Zone 7)	26,79,224	9,40,943	Cotton, Groundnut, Wheat, and Mung
Gir Somnath (Zone 7)	14,39,090	6,02,925	Cotton, Groundnut, Wheat, and Jowar
Total	2,65,62,229	1,20,27,579	

The analysis of the biomass data shows that the selected districts of Gujarat produces about 26.6 million tonnes of agricultural biomass every year, out of which 12.0 million tonnes (56%) is available as surplus biomass after meeting requirements such as animal fodder, domestic fuel, and other agricultural uses. The Kharif season contributes the highest amount of biomass, producing 55.1%,

followed by the Rabi season with 38.0%. The Zaid season contributes only 7.0%. In terms of surplus biomass, Anand ranks first with 2.06 million tonnes, followed by Rajkot (1.31 million tonnes). The results indicate that Kharif crop residues are the major source of biomass, while Rajkot and Anand are the most promising districts for biomass resources.

4.1 Bio-hydrogen production from agri-waste residues

The study was conducted in 5 L anaerobic reactor with established strain *Staphylococcus epidermidis* SPS3 for hydrogen-production in dark fermentation. The sugars generated from 100 g rice straw (40-43 g) was used to prepare 4 L media for hydrogen production. More than 90% sugar was consumed by *Staphylococcus epidermidis* SPS3 strain within 48 h. The results of hydrogen generation from rice straw sugar shows 36-40 L H₂/kg rice straw in batch mode and 65-70 L H₂/kg rice straw in fed-batch mode. The reactor effluent obtained after dark fermentation was analyzed for volatile fatty acid (VFA) profiling using HPLC. The progressive accumulation of organic acids, with total VFA concentration of 1780.2 mg/L by 48 h, with lactic acid identified as the dominant metabolite (1016.0 mg/L), followed by significant accumulation of propionic acid (515.0 mg/L). The VFA-rich effluent produced in the dark fermentation has a potential for utilization as a substrate for photo-fermentative hydrogen production. Studies were initiated using *Rhodopseudomonas palustris* under nitrogen-limited conditions for photofermentative hydrogen production. The culture was successfully acclimatized under photoheterotrophic conditions, exhibiting characteristic pink-brown pigmentation indicative of active growth (Figure 4.1). Continuous



Figure 4.1: *Rhodopseudomonas palustris* in DSMZ Medium 27

illumination was provided using tungsten lamps positioned 20 cm from the culture vessels. Three nitrogen-limited media formulations were tested and one of them (described by Craven *et al.* 2019) showed comparatively higher hydrogen production with 20% hydrogen detected by gas

chromatography (GC) under preliminary serum bottle-based experiments.

4.2 Bio-hydrogen production using water gas shift reactor

The project focuses on the optimization of developed a two-stage Water Gas Shift Reactor (WGSR) integrated with a biomass gasification system for hydrogen generation. A High-Temperature Reactor (450–550 °C) and a Low-Temperature Reactor (200–300 °C) were integrated with steam generation with pressurized pure CO. In-house catalysts Fe/Al₂O₃ and Cu/Al₂O₃ were synthesized for the HTR and LTR, respectively. The WGSR was optimized using pure CO gas and resulted in hydrogen concentrations of 62 vol. % confirming the effectiveness of in-house developed catalysts. The WGSR system was subsequently integrated with a downdraft gasifier (DDG) to generate CO enriched producer gas (Figure 4.2).



Figure 4.2: WGSR integrated with DDG for hydrogen generation

The integrated system (DDG + WGSR) was evaluated with producer gas-to-steam ratio of 1:2.2. The in-house developed catalysts showed enhancement in hydrogen concentration by 55% as compared to hydrogen concentration present in raw producer gas. Further, comparative performance of WGSR with commercially available catalysts and in-house developed catalysts are being assessed for their catalytic efficiency and hydrogen yield.

4.3 Oxy-steam catalytic gasification system for enhanced hydrogen production

An oxy-steam catalytic gasification system for enhanced hydrogen production has been designed & developed (Figure 4.3). The system consists of a reactor, oxygen supply unit, steam injection

system and control instrumentation. Provision for simultaneous injection of oxygen (5–10 Nm³/h) and steam (2–4 kg/h) into the reduction zone has been incorporated to facilitate intensified thermochemical conversion. The developed system was tested with wooden blocks and briquettes of groundnut shell at feed rate of 12–16 kg/h. The preliminary results indicate an increase in hydrogen concentration in gas stream from 8–12% (air gasification) to 28–35% under oxy-steam catalytic conditions. The system demonstrated improved carbon conversion efficiency in the range of 75–82% with stable reactor operation.



Figure 4.3: Downdraft oxy-steam gasification system under stable operation

4.4 Hydrogen production from wastewater using photocatalysis

Development of TiO₂-biochar composite photocatalysts for hydrogen production from

wastewater was carried out. Biochar was prepared from sugarcane bagasse, groundnut shell, and cotton stalk through controlled pyrolysis under nitrogen atmosphere at 450 °C. The produced biochar was characterized for UV-Vis absorption at different concentrations (0.02–0.06% w/w) as shown in Figure 4.4. The results indicated strong absorption in the ultraviolet region (200–250 nm), followed by a gradual decrease in absorbance across the visible spectrum. Absorbance was observed to increase proportionally with biochar concentration, indicating stable dispersion behavior without formation of additional electronic transitions. However, the absence of a distinct absorption edge suggested that biochar behaves primarily as a broadband carbonaceous light absorber rather than an efficient standalone semiconductor photocatalyst. The development of a photoreactor system for photocatalytic hydrogen production is underway.

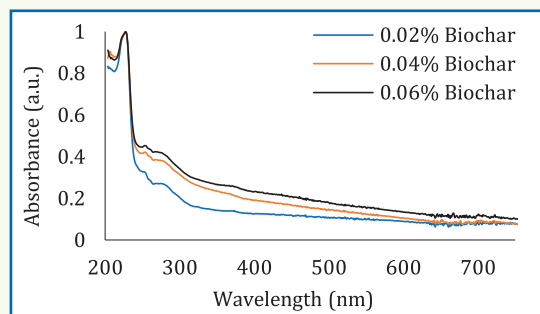


Figure 4.4: UV-Vis absorbance characteristics at different biochar concentrations

5.1 Energy assessment of banana cultivation in Gujarat state

An Energy assessments study was conducted to evaluate energy consumption pattern and productivity in Banana cultivation across major district of Gujarat. The study analyzed input energy required in banana cultivation in various farm operations from land preparation to harvesting to assess energy efficiency and specific energy for banana cultivation practices. Banana cultivation

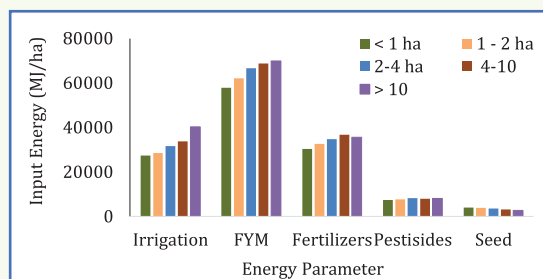


Figure 5.1: Energy use for different cultivation practices for different land categories

in Gujarat requires an average total energy input of 155,874 MJ/ha and yields an energy output of 887,945 MJ/ha (Figure 5.1). Among all cultivation practices for farmers based on different land categories, major energy consuming practices are in farm yard manure (FYM, fertilizer application and irrigation application. The input energy was examined as direct and indirect energy needs. The direct energy needs include energy required by Human/labor for various operations, electricity consumption, water uses and diesel consumption. Indirect energy needs are met through the sequestered energy from seeds, fertilizers, herbicides, pesticides, and insecticides. For banana cultivation process, the required direct energy is 29% and the indirect energy is 71% for Gujarat state. Major share of total energy input was constituted by the indirect energy, such as by fertilizers, farmyard manure (FYM), machinery, and other inputs (seeds and Pesticides), as listed in Table 5.1.

Table 5.1: District wise indirect input energy consumption pattern

Sr. No.	District	Indirect Energy				Total Indirect Energy (MJ/ha)
		FYM (MJ/kg)	Fertiliser (MJ/kg)	Machinaries (MJ/ha)	Other Input Energy (MJ/ha)	
1	Anand	68356	63962	755	28578	161650
2	Vadodara	65905	44072	1240	19791	131008
3	Narmada	105482	15417	2039	7562	130501
4	Chhotaudepur	79471	30970	1148	3315	114904
5	Surat	61767	30209	648	3497	96121
6	Tapi	40319	24814	597	4125	69855
7	Bharuch	48660	26061	824	4275	79821
8	Kutch	58401	41400	754	20385	120940

Anand recorded the highest indirect energy use (161,650 MJ/ha). Direct energy consumption in banana cultivation varied across districts, ranging from 30,041 MJ/ha in Vadodara to 70,621 MJ/ha in Kutch (Table 5.2). Higher energy use in Kutch, Narmada, and Bharuch was mainly due to greater electricity and irrigation requirements.

Table 5.2: District wise different energy trends

Sr. No.	District	Direct Energy				Total Indirect Input Energy (MJ/ha)	Total Input Energy (MJ/ha)	Output Energy (MJ/ha)	Energy Ratio	Specific Energy (MJ/kg)
		Electricity (MJ/ha)	Irrigation (MJ/ha)	Other Direct Input Energy (MJ/ha)	Total Direct Input Energy (MJ/ha)					
1	Anand	20733	19095	1516	41344	161650.4	202994	1090360	5.4	2.2
2	Vadodara	22320	3783	3938	30041	131007.9	161049	1113700	6.9	1.7
3	Narmada	14683	2682	31636	49001	130500.5	179501	812569	4.5	2.6
4	Chhotaudepur	15190	3406	17422	36018	114904	150922	953953	6.3	1.9

Sr. No.	District	Direct Energy				Total Indirect Input Energy (MJ/ha)	Total Input Energy (MJ/ha)	Output Energy (MJ/ha)	Energy Ratio	Specific Energy (MJ/kg)
		Electricity (MJ/ha)	Irrigation (MJ/ha)	Other Direct Input Energy (MJ/ha)	Total Direct Input Energy (MJ/ha)					
5	Surat	20229	3444	10405	34078	96120.65	130199	810849	6.2	1.9
6	Tapi	24277	4176	8421	36874	69855.05	106729	628163	5.9	2.0
7	Bharuch	25736	16331	2145	44212	79821.01	124033	959340	7.7	1.5
8	Kutch	44858	23286	2477	70621	120939.8	191561	734625	3.8	3.1

The energy output/input ratio ranged from 3.8 to 7.7, with Bharuch recording the highest energy-use efficiency. Kutch showed the lowest energy ratio, indicating higher energy input requirements for banana production. Specific energy varied between 1.5 and 3.1 MJ/kg.

5.2 Energy assessment in rice-based poha industries of Gujarat

The institute initiated an energy assessment of poha processing industries of different capacity to identify opportunities for improving energy efficiency and promoting cleaner production. The survey revealed that poha industries primarily use a single thermal process for roasting of soaked paddy. Electrical energy consumption is mainly associated with milling and flaking machines, while additional energy is used for material conveying, screening, and handling (Figure 5.2). Three industries viz.

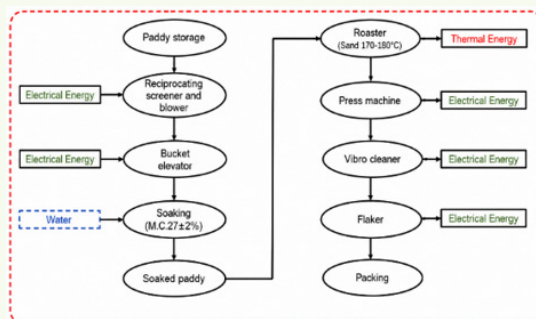


Figure 5.2: Process flow diagram for poha industries M/s Swastik Industry, Anand, M/s Krishna Agro Industry, Mahisagar, and M/s Mahalakshmi Food Products, Godhra, were studied for energy auditing. All three plants were assessed for electrical, thermal energy consumption and manpower involvement. The surveyed data is summarized in Table 5.3.

Table 5.3: Details of three surveyed poha industries of different capacities

Sr. No.	Particular	M/s Swastik Industry, Anand	M/s Krishna Agro Ind, Mahisagar	M/s Mahalakshmi Food Products, Godhra
1.	Paddy processing capacity (TPD)	2.0	10.5	12.2
2.	Production capacity (TPD)	1.1	6.5	7.2
3.	Water consumption (liter/batch)	4,000	22,000	27,000
4.	Production yield (%)	50-55	60-62	58-60
5.	Annual operational days (No.)	200	300	300
6.	Daily operational hours (h)	8	10	8
7.	Number of thermal applications (No.)	01	01	01
8.	Thermal load (lakhs kcal/h)	2.8	5.5	4.5
9.	No. of electrical motors (No.)	08	23	27
10.	No. of press mills (No.)	03	05	-
11.	No. of flakers (No.)	01	02	08
12.	Connected electrical load (hp)	36	125	160
13.	Electricity consumption (kWh/batch)	216	460	610
14.	Mode of material Conveyance	Manual	Manual+ Mechanized	Mechanized

The lowest specific electricity consumption was found in case of process used by M/s Mahalakshmi Food Products (49.8 kWh/ ton) whereas M/s Swastik Industry exhibits the highest specific energy consumption (108 kWh/ ton of paddy). Further, the specific water consumption remains uniform across all units. The paddy husk is the primary fuel source at M/s Mahalakshmi Food Products and M/s Krishna Agro Industry, whereas M/s Swastik Industry uses sawdust as a fuel. The thermal efficiency of the roasting process of surveyed industries were observed in the range of 12-16% which indicates the scope of improvement in thermal efficiency.

5.3 Establishment of value chain of cow dung management in a village

A feasibility survey was conducted in Bhadrasa village of Kheda district, and the results indicated that the village has significant potential for establishing a cow dung-based value chain. The details of the proposed value chain are presented in Figure 5.3 (top). The construction of a 100 m³ biogas plant has been completed (Figure 5.3 (bottom)). A Memorandum of Agreement (MoA) has been signed with the Gram Panchayat and local farmers for the collection of cow dung. The biogas generated from the plant will be utilized for thermal

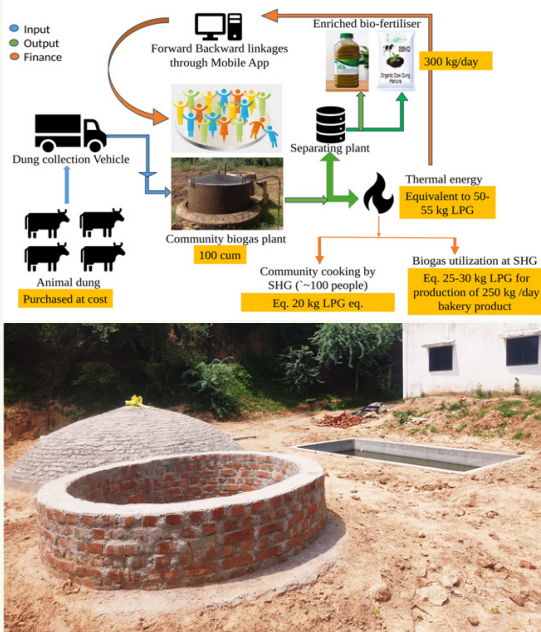


Figure 5.3: Manure based value chain for cow dung management (top); and construction of 100 m³ biogas plant (bottom)

applications in Gruh Udyog units operated by Self-Help Groups (SHGs) and adjoining households.

5.4 Development of compost turner for rice straw composting

SPRERI has developed a batch-mode composting technology capable of producing compost within 21 days using the SPRERITECH consortium. The process typically requires 15-18 man-days for heap formation and turning of the straw at seven-day intervals. To address this challenge, a mechanized compost turner was developed for turning and remixing the biomass heap, as shown in Figure 5.4. The developed turner consists of a rotating drum fitted with blades that uniformly mix the biomass by breaking the compacted rice straw heap, thereby improving aeration. The system is also equipped with a sprinkler arrangement for spraying microbial culture and water on the straw to maintain uniform moisture content during the compost mixing process.



Figure 5.4: SPRERI developed compost turner

6.1 Demonstration and awareness creation program

The Demonstration, Training, and Awareness Program for the year 2025-26 was successfully conducted across both rural and urban regions to ensure wider accessibility and active participation of farmers, academia, and industry stakeholders. The initiative covered diverse geographic locations within Gujarat as well as across other states, thereby significantly enhancing its outreach and

impact.

(a) Field-level demonstrations

A series of village-level demonstration programmes were conducted to ensure effective dissemination and adoption of improved renewable energy technologies among rural households. Total of twelve demonstration programmes were organized across four districts of Gujarat, namely Narmada, Bharuch, Kheda, Anand, and Panchmahal districts, the details are given in Table 6.1.

Table 6.1: Details of field-level demonstrations

Sr. No.	Name of Village	Taluka	District	Date	No. of beneficiaries
1.	Shuklatirth	Bharuch	Bharuch	July 01, 2025	18
2.	Krushnapuri	Jhagadiya	Bharuch	July 08, 2025	23
3.	Panetha	Jhagadiya	Bharuch	July 08, 2025	26
4.	Mota vasana	Jhagadiya	Bharuch	July 08, 2025	15
5.	Gamdi	Anand	Anand	July 08, 2025	24
6.	Khandhali	Anand	Anand	November 12, 2025	21
7.	Agas	Petlad	Anand	November 19, 2025	100
8.	Sunav	Petlad	Anand	November 29, 2025	22
9.	Palaj	Petlad	Anand	November 29, 2025	47
10.	Alindra	Nadiyad	Kheda	December 03, 2025	39
11.	Amda	Dediapada	Narmada	December 11, 2025	45
12.	Bamangam	Ankalav	Anand	December 22, 2025	32

These demonstrations facilitated direct interaction with approximately 260 farmers and 145 women participants (Figure 6.1).



Figure 6.1: Cookstove demonstration on field

During these programmes, key renewable energy technologies such as SPRERITECH improved biomass cookstoves, micro solar domes and rice straw composting were demonstrated. The demonstrations emphasized practical, hands-on engagement, enabling participants to understand the operational aspects, benefits, and applicability of these technologies in their day-to-day activities.

(b) In-house demonstration for students and farmers

SPRERI conducted inhouse technology demonstration programs for farmers, and students of schools and colleges as a regular activity throughout the year (Figure 6.2). These demonstrations provided exposure to about 750 students from various institutions who visited SPRERI. (Table 6.2).



Figure 6.2: Students/farmers visit to SPRERI

Table 6.2: List of school/college visited SPRERI

Sr. No.	Name of School/College	Date	No. of students
1	BBIT, Anand (Mechanical Engg.)	April 08, 2025	125
2	BBIT, Anand (Computer Engg.)	May 08, 2025	50
3	V and C Patel School, Anand	August 22, 2025	120
4	GEMI, Vadodara	August 22, 2025	6
5	Dharmsinh Desai University, Nadiad	September 20, 2025	40
6	V and C Patel school, Anand	September 25, 2025	125
7	B. A. College of Agricultural, AAU, Anand	October 01, 2025	145
8	BBIT, Anand (Mechanical Engg.)	October 06, 2025	45
9	Participants of Farmer Training programme at AERC, Anand.	November 15, 2025	35
10	Sardar Patel Education Campus, Anand (Electrical Engg.)	January 04, 2026	65
11	CAET, JAU, Junagadh (Agricultural Engg.)	March 18, 2026	40

(c) Technology showcasing

Institute participated in various invited events (Table 6.3 and Figure 6.3) with the objective of creating awareness among a wider audience, including urban communities, academic institutions, and industry representatives. During these events, SPRERI showcased its technologies and outreach initiatives that received an enthusiastic response on sustainable energy technologies, and enhancing environmental consciousness, while motivating participants to adopt sustainable energy practices in their daily lives.

Table 6.3: SPRERI's participation at invited events

Sr. No.	Event title and Organizer	District	Date	No. of Beneficiaries
1	Livelihood-Centric Technologies for Promotion of Women-Led Entrepreneurship in Uttar Pradesh, organized by TAP-RISE Lucknow	Lucknow, Uttar Pradesh	December 18, 2025	100
2	Gyanotsav 4.0 organized by CVM University, Vallabh Vidyanagar	Shastri Maidan, Anand	February 04–08, 2026	5000
3	Gram-samvad organized by The Foundation for Ecological Security	Samtarampur, Panchmahal	March 11, 2026	2500
5	सह-SANKALP -National Exhibition-cum-Technical Meet organized by Department of Science and Technology (DST), New Delhi	New Delhi	March 18, 2026	125
5	Industrial Meet and Start-Up Conclave, organized by ICAR-DMAPR, Anand	DMAPR, Anand	March 24, 2026	120

During these events, SPRERI's demonstration received media recognition, with the institute's display stall being featured on Doordarshan Girnar on March 11, 2026.



Figure 6.3: Demonstration at Women-led Entrepreneurship Program, Lucknow (*top left*); Demonstration at Exhibition-cum-Technical Meet (सह-SANKALP) in Delhi (*top right*); Participation in Gyanotsav 4.0 at CVM, Anand (*bottom left*) and Coverage in Doordarshan Girnar (*bottom right*)

(d) Awareness program for school students

An awareness programme on “Renewable Energy Technologies for Sustainable Development” was organised for about more than 100 students at Gojosharda Mandir School on September 25, 2025 to educate about sustainable energy solutions and their importance for a clean future, as shown in Figure 6.4.



Figure 6.4: Awareness programme conducted in a School

6.2 Training programs

During the year five training programmes focused on the use of renewable energy interventions and skill development for SHG women and farmers were organized. Two trainings focused on Banana fiber and its product development, and the remaining three on solar dryer and torrefaction system.

(a) Training on extraction and combing of banana fiber

A training programme on “Use of Banana Pseudostem for Extraction and Combing of Banana Fiber” was conducted on August 19, 2025. The participants (20 numbers) from Roshani Sakhi Mandal, Petlad, Anand (Figure 6.5) participated in training. The expert from M/s Unifab India Pvt. Ltd. Er. Sanket Kumar provided hands-on skills for banana fiber extraction and combing machines installed at SPRERI under the DST-SUNIL project. Participants were trained on the complete process of banana fiber processing, including pseudostem sheathing, fiber extraction, combing, washing, and drying techniques.



Figure 6.5: Combing machine operations by participants

(b) Training on solar drying of agro produce

A training and awareness programme on “Solar Thermal Technologies” was organized on December 22, 2025 (Figure 6.6). The participants (30 number) from Shree Mahakali Sakhi Mandal, Ankalav participated in the programme. Participants were trained on drying of ginger using SPRERI double glazed solar dryer and its other applications. The



Figure 6.6: Solar dryer operations demonstration

improvement in quality and hygiene with solar dryer were also explained to fetch a high market value.

(c) Training on handicrafts from banana fiber

A training programme titled “Weaving Sustainability: Training in Banana Fiber Crafts” was organized on March 27, 2026 for 10 women members of Roshani Sakhi Mandal (Figure 6.7). Ms. Dharti Dave an entrepreneur was invited as the resource person for hands-on training on banana fiber, conversion into value-added handicrafts. Participants were trained in braiding techniques and the preparation of decorative mirror frames, including shaping, fixing, polishing, and embellishment processes.



Figure 6.7: Braiding of banana fiber by SHG women participants

(d) Training on biochar production from agrowaste and its applications

A training programme on “Value Addition of Agricultural Waste: Biochar and its Applications” was organized on March 27, 2026 for farmers (20 numbers) from Kheda district (Figure 6.8). The programme focused on decentralized production of biochar using portable kiln. The production of biochar using locally available biomass are shown in Figure 6.8. The farmers were also made aware about the importance of biochar and its application for soil improvement and other benefits.



Figure 6.8: Participants during training of biochar

(e) Training on solar technologies at SPRERI

The Solar Energy Division organized a one-day training programme on “Operation and Maintenance of Solar Drying and Refrigeration Technologies” on March 30, 2026 for farmers and rural women from a village Manjipura, Kheda district (Figure 6.9). The programme focused on the role of solar drying,

extending shelf life, and enhancing the market value of agricultural produce. Participants were provided hands-on training on the operation of the Double Glazed Portable SPRERITECH Solar Dryer and engaged in drying of potato, banana, methi, and tomato. Demonstrations were also conducted for solar cold storage and refrigeration systems for storage of perishable commodities.



Figure 6.9: Training and discussion on solar dryer utilization

6.3 Technology-based livelihood generation program for strengthening of economically weaker section

(a) Socio-Economic survey

A socio-economic survey of economical weaker section was undertaken in Anand District (Figure 6.10) to assess the socio-economic status,



Figure 6.10: Survey in Anand district, Gujarat

livelihood patterns of households and their readiness for the adoption of renewable energy technologies. The survey aims to establish a reliable baseline for evaluating the impact of Renewable Energy Technology Interventions under DST SEED-SUNIL project. To ensure systematic assessment, a tool was developed to capture key indicators such as income sources, landholding size, occupation patterns, etc. The survey covers households from both registered Economically Weaker Sections (EWS) and non- registered EWS categories. A total of 917 households were surveyed across Anand district. The survey findings indicate that agriculture remains the primary occupation for approximately 52% of the households. However, landholding patterns reveal a significant constraint: nearly 90% of families own less than 0.50 hectares (2 bigha)

of land, which limits agricultural productivity and income potential. As a result, many households diversify their livelihoods. The families engaged in non-agricultural occupations, such as salaried jobs and small businesses, earn 80% more income than agriculture-dependent households. This highlights a growing shift towards non-farm income for EWS sources in the district. Overall, the survey underscores the need for targeted renewable energy interventions integrating livelihood strategies to ensure sustainable socio-economic development.

6.4 Promotion of green livelihood opportunities for SC community

A community-focused program titled “Promoting Green Livelihood Opportunities for SC Community through Renewable Energy Innovation” was organized on March 21, 2025 by SPRERI, supported by ICAR-AICRP on EAAI (SCSP) at Bhadrasi in Kheda district. The event witnessed participation from approximately 150 beneficiaries of SC community, including farmers and women. Renewable energy technologies i.e. solar dryers, biogas plants, biochar kilns, and improved cookstoves, were disseminated during the event as technology grant certificates. The program also included awareness sessions on the adoption of Renewable Energy, health & hygiene, and financial literacy, contributing to holistic community development. A glimpse of the event has been given in Figure 6.11.



Figure 6.11:Inauguration of the event (*top left*); speech by Chief Guest-Dr. Vinod Kumar Bhargava, Program Coordinator- ICAR - AICRP on EAAI (*top right*); participants (*bottom left*) an distribution of technology grant certificates (*bottom right*)

SPRERI successfully organized its flagship event, the 17th Open House, on February 25–26, 2026, to showcase a diverse range of renewable energy technologies developed by the institute. The two-day event witnessed an enthusiastic footfall of around 1,800 participants, including students, researchers, industry professionals, and other stakeholders. Visitors were engaged through guided tours and live demonstrations, providing practical insights into sustainable energy solutions. The inaugural session was graced by Er. Bhikhubhai Patel, Chairman of SPRERI and CVM, Dr. Manish Das as Chief Guest, and Mr. Vishal Patel, Joint Secretary CVM as Guest of Honour (Figure 7.1). Several engaging sub-events enriched the Open House.



Figure 7.1: Inauguration and technology visit during Open House

Sub-events of Open House

(a) Poster paper competition

A poster paper competition on the theme “Renewable Energy Technologies for Energy Security, Sustainability and Climate Resilience” was organized for college students (Figure 7.2), with participation from around 48 contestants from 16 colleges such as Gujarat biotech university, Ganpat University, B&B institute of technology, Atmiya university, Sardar Patel University. The presented posters were evaluated by Dr. Vishal Singh, Principal ADIT and Dr. Vina Chauhan, Prof. B.V.M. College of Engineering. Prizes were awarded to the first, second and third rank poster prizes.



Figure 7.2: Poster assessment (left) and Prize distribution (right)

(b) Inter school quiz competition on renewable energy

The “Green Spark” inter-school quiz competition on Renewable Energy was organized (Figure 7.3) and teams from six schools of Vallabh Vidynagar participated in the programme. A team of two students represented the school. The competition comprised multiple rounds designed to assess participants’ knowledge and aptitude. It provided an engaging platform to promote awareness and learning among students. The winners and runner-up team were awarded with medals and cash prizes in recognition of their performance.



Figure 7.3: Quiz session (left) and prize distribution (right)

(c) Technology exhibition by industries and enterprise

Renewable Energy technology exhibition was organized featuring six stalls from invited organizations (Figure 7.4), including Agro Economic Research Institute Centre, M/s Sattva Organic, M/s Adarsh Plant Protection Ltd., and M/s Esha Biodegradable. The exhibition showcased a range of innovative and sustainable products. It served as an effective platform for knowledge sharing and stakeholder interaction. The participants of open house showed interest in the exhibition and interacted with technology providers.



Figure 7.4: Technology exhibit during the program

8.1 Consulting Services

(a) Impact study for increased agriculture power consumption in agriculture sector in Gujarat state

SPRERI conducted a comprehensive, data-driven assessment of agricultural electrification under Paschim Gujarat Vij Company Limited (Figure 8.1), based on a large-scale field survey of over 2,400 farmers under PGVCL jurisdiction. The study reveals that the rise in agricultural (AG) connections is driven not by land expansion but by family land division and increasing demand for independent irrigation access. High accessibility, affordable tariffs (99.25% manageable), and strong service reliability have made electrification highly inclusive and widely accepted. The study highlights that solarization under PM-KUSUM offers a highly viable solution. For PGVCL's 83,704 new pumps, shifting from grid supply to solar (₹1,730 crores one-time subsidy) can generate savings of ₹1,061 crores per annum. Overall, PGVCL's agricultural electrification model has delivered significant socio-economic benefits and improved productivity.

(b) Impact study for increased agriculture power consumption in agriculture sector in Gujarat state

SPRERI conducted a comprehensive, data-driven assessment of agricultural electrification under Uttar Gujarat Vij Company Limited (Figure 8.2), based on a field survey of 1,500 farmers across North Gujarat. The study shows that the rise in agricultural (AG) connections is primarily driven by family land division and the need for independent irrigation access rather than land expansion. High accessibility, affordable tariffs, and reliable service delivery have made electrification inclusive and widely adopted. The analysis highlights strong potential for solarization under PM-KUSUM. For UGVCL's 61,388 new pumps, grid supply would result in a ₹1,724.2 crore subsidy burden over 25 years, whereas solarization requires a one-time subsidy of ₹1,353.5 crore yielding savings of ₹370.7 crore per annum. Solarization also ensures reliable daytime power and eliminates recurring energy costs. Overall, UGVCL's agricultural electrification model has significantly improved rural productivity and livelihoods. Solarization of feeders and pumps emerges as the next logical step offering a scalable, farmer-centric, financially viable, and sustainable pathway for Gujarat's future agricultural energy transition.

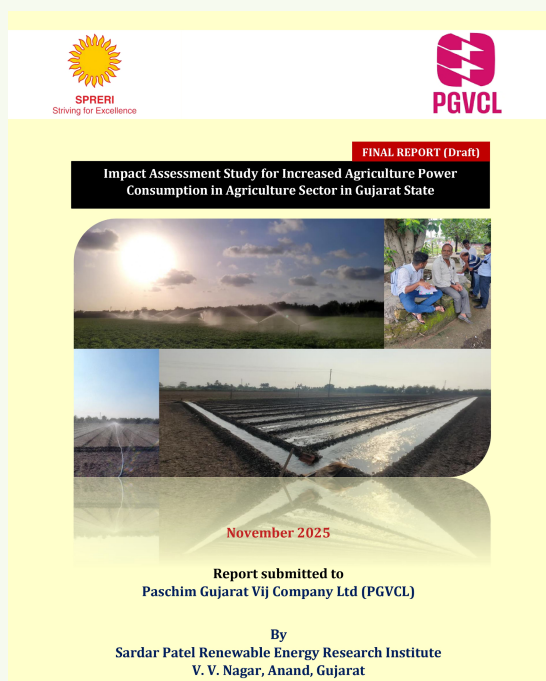


Figure 8.1: Report submitted to PGVCL

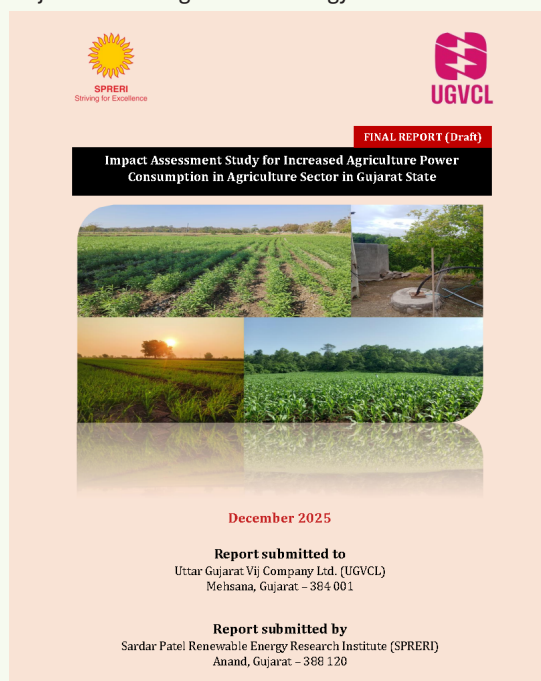


Figure 8.2: Report submitted to UGVCL

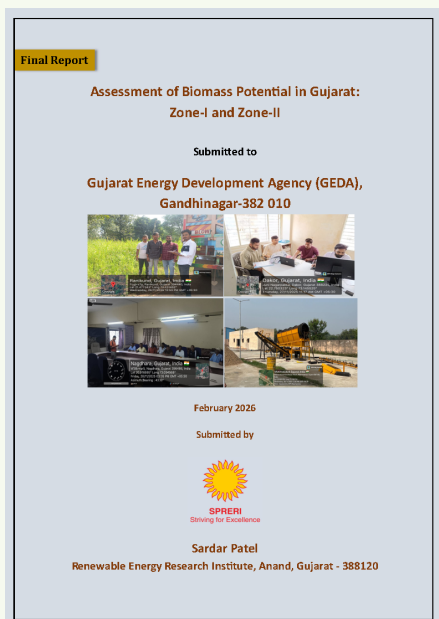
(c) Capacity building programme on operation & maintenance of solar rooftop systems on government buildings

The Gujarat Energy Development Agency (GEDA) has undertaken a state-wide initiative to strengthen the operational efficiency and long-term sustainability of solar rooftop installations on government buildings through a structured “Capacity Building Programme on Operation & Maintenance of Solar Rooftop Systems.” Under this initiative, the Sardar Patel Renewable Energy Research Institute (SPRERI) has been awarded the responsibility of designing and executing comprehensive training programmes across 17 districts of Gujarat. This work encompasses the development of standardized training modules, hands-on technical sessions, and field-level demonstrations aimed at equipping engineers, technicians, and facility managers with practical expertise in system operation, preventive and corrective maintenance, of solar rooftop systems.

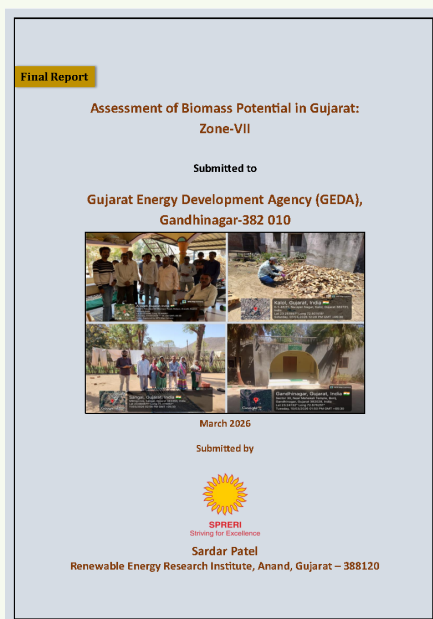
(d) Assessment of biomass potential in selected thirteen districts of the central and south Gujarat regions (Supported by: Gujarat Energy Development Agency (GEDA), Gandhinagar)

A comprehensive assessment of biomass potential was carried out across the selected thirteen

districts of the Central and South Gujarat regions. Among these regions, Ahmedabad, Anand, Aravalli, Bharuch, Botad, Gandhinagar, Kheda, Narmada, Navsari, Surat, Tapi, and Valsad were covered with GEDA support (Figure 8.3). The study involved extensive field surveys covering 783 villages, 51 forest ranges, 11 gaushalas and panjrapoles, 314 agro-processing and timber industries, and 30 municipalities/municipal corporations across the selected zones. More than 30 registered gaushalas and panjrapoles were also assessed for livestock-based biomass potential. The study was focused in three different Zones; i.e., Zone-I (Bharuch, Navsari, Surat, Tapi, and Valsad), Zone-II (Anand, Botad, Kheda, Narmada, and Vadodara) and Zone-VII (Ahmedabad, Aravalli and Gandhinagar). Zone-I demonstrated an annual biomass availability of 10.67 million metric tonnes (MMT), Zone-II contributed 13.62 MMT and Zone-VII is 5.76 MMT annually. In Zone-I, sugarcane, banana, rice, and cotton are the dominant crops. In Zone-II, major biomass-generating crops are cotton, banana, rice, wheat, and sugarcane. In Zone-VII, major crops include Cotton, Groundnut, Wheat, Paddy, Jowar, Bajra, Maize, and Soybean. The study also carried out district-wise surplus biomass quantification and analysis of biomass-rich clusters to support decentralized bioenergy planning and biomass supply-chain development.



(a)



(b)

Figure 8.3: Report submitted to GEDA, Gandhinagar (a) Zone-I and Zone-II and (b) Zone-VII

9.1 Business meet on SPRERI's patented hybrid biomethanation technology

A business meet titled “Kitchen & Mandi Waste to Watts: Technology Demonstration and Collaboration Event” was organized on June 21, 2025, to highlight SPRERI's patented bio-methanation technologies for converting kitchen and mandi waste into biogas generation for thermal application. The technology has specific features that the retention period of plant is 3.5 days and it also saves 50% water as compared to the other commercial technologies. The event highlighted economic benefits and carbon offset and payback period through decentralized waste-to-energy systems. The event attracted 30 number of participants from a diverse group of stakeholders, including industrialists, representatives of housing societies, ashrams, etc. The technical session followed by live demonstrations of 3.5 TPD bio-methanation plant and the mechanism of waste collection and gas distribution at user site are shown in Figure 9.1.



Figure 9.1: Technical session (top) and biomethanation plant visit (bottom)

9.2 SPRERI's Foundation Day celebration

The Sardar Patel Renewable Energy Research Institute commemorated its 48th Foundation Day on January 27, 2026, celebrating 47 years of sustained contributions to renewable energy and sustainable development (Figure 9.2). SPRERI's journey over

the past four decades and key achievements were highlighted to the participants. The celebration was graced by Prof. Indrajit Patel, Provost of CVM University, as the chief guest; Dr. V. Siva Reddy, Director (Technical), National Institute of Solar Energy (NISE); Dr. Saji Philip, former Deputy Director as guest of Honor; and Special Invitee Dr. A. Mahesh, Board Member SPRERI. Their addresses emphasized the role of SPRERI as an institute that contributed in growth of renewable energy in the state. A key highlight of the event was the felicitation of retired employees and recognition of long-serving scientists for their invaluable contributions. The announcement of the SPRERI Alumni Chapter to be formed, marked an important step toward strengthening engagement and collaboration.



Figure 9.2: Participation of SPRERI alumni during the event

9.3 National seminar at SPRERI on microalgae

Sardar Patel Renewable Energy Research Institute, organized a National Seminar on “Advances in Microalgae for Carbon Capture, Biofuels and Value-Added Products” on January 09, 2026, bringing together 130 participants from academia, research institutions, and industry. The seminar was support by Gujarat State Biotechnology Mission. The participants also attended the event in online mode also. The seminar focused on emerging opportunities in microalgae-based carbon capture, biofuel production, and development of value-added bioproducts, highlighting microalgae as a promising solution for climate action and circular bioeconomy initiatives. The programme was inaugurated by Prof. Indra Mani, Vice-Chancellor, VNMKV Parbhani as chief guest, and Dr. Anasuya Bhadalkar, Joint Director GSBTM- and Dr. Vinod K Bhargava, PC – ICAR-AICRP on EAAI as Guests of Honour. Seminar Souvenir was released by dignitaries during the inauguration programme

(Figure 9.3). Other eminent scientist present during the seminar were Dr. Mohanty, IIT Guwahati Dr. Nirupama Malik, IIT Kharagpur, Prof. Kaustubha Mohanty IIT Guwahati, Dr. Manish Das, ICAR-DMAPR, Dr. Gangil, CIAE Bopal delivered their expert keynote during three technical sessions on carbon sequestration, algal biorefineries, and commercialization pathways for algae-based products. The thematic areas covered were on carbon capture by microalgae and scale-up, and Engineering of Bio-refinery Systems and Technologies for Microalgal based products. The panel discussion was also held based on Harnessing Algae for Climate Action and Bio-economy: Policy, R&D Potential and Pathways. The seminar emphasized the need for innovation, industry collaboration, policy support, and market-driven product development to accelerate large-scale adoption of microalgae technologies for sustainable energy and bioeconomy growth.



Figure 9.3: Release of souvenir during the inauguration of the National Seminar

9.4 AICRP workshop on Energy in Agriculture and Agro-Industries (ICAR) at SPRERI

SPRERI hosted 29th Annual Workshop of the ICAR–All India Coordinated Research Platform on Energy in Agriculture and Agro-Industries (AICRP-EAAI) from January 29-31, 2026 (Figure 9.4). The workshop was inaugurated by Shri Jitubhai Vaghani, Hon'ble Minister of Agriculture & Farmers Welfare, Gujarat, GoG, as the Chief Guest, with Shri Yogesh Patel (MLA, Anand) as Guest of Honour. The session was chaired by Dr. S. N. Jha, DDG (Engineering), ICAR, New Delhi, in the presence of Dr. K. B. Kathiria, Vice Chancellor, Anand Agricultural University, Dr. K. P. Singh, ADG (Farm Machinery), ICAR, along with Shri Bhikhubhai B. Patel, Chairman CVM and SPRERI, Dr. V. K. Bhargava, Project Coordinator for ICAR, AICRP-EAAI and Dr. Anil Kumar Dubey, Director SPRERI. The inaugural session witnessed

participants over 250 delegates including scientists from different part of country, academicians, entrepreneur, industrialist and farmer. The technical sessions on Solar Energy, Thermo-chemical, Bio-conversion of biomass, Energy management in Agriculture and Renewable energy programme were carried out during the three days' event. Sixteen centres of the project participated in the technical session and presented the progress of the projects. The workshop emphasised to focus on national priority in collaboration with industries on a fast track mode.



Figure 9.4: Inauguration of workshop by Shri Jitubhai Vaghani - Hon'ble Minister of Agriculture & Farmers Welfare, Gujarat, Govt of Gujarat

9.5 Workshop on NABL accreditation

A workshop on National Accreditation Board for Testing and Calibration Laboratories Accreditation Process was conducted on August 12, 2025, with Mrs. Bhumi Rajguru from NABL head office, Ahmedabad, as the resource person (Figure 9.5). The programme aimed to provide comprehensive guidance on accreditation requirements, procedures, and quality standards for laboratories. A total of 30 participants from various research institutes attended the workshop. The session covered key aspects of documentation, compliance, and best practices for achieving NABL accreditation.



Figure 9.5: Expert address during the workshop

10.1 Strengthening research infrastructure: Installation of FDM 3D printer

A Fused Deposition Modelling (FDM)-based 3D printer (Figure 10.1) has recently been installed for additive manufacturing and advanced materials research. The facility is being utilized for the development of agri-residue-based polymer composite materials, enabling value addition to agricultural biomass through sustainable and eco-friendly products. Research activities will focus on formulating bio-based composite filaments and fabricating customized components for applications in sustainable packaging, consumer products, and functional engineering components.

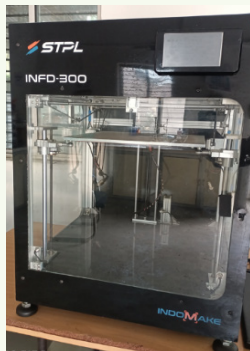


Figure 10.1: FDM based 3D Printer

10.2 Renewable energy Tech Park at SPRERI

SPRERI has made an effort to develop “Renewable Energy Tech Park” (Figure 10.2) to create awareness about different renewable energy technologies appropriate for demonstration. The Tech Park will serve as a technology hub, showcasing a range of renewable energy technologies developed by institute.



Figure 10.2: Renewable energy tech park

10.3 Quiz competition on renewable energy for school students

A new initiative was undertaken to organize quiz competitions with the objective of creating awareness about renewable energy and energy conservation among school students (Figure 10.3). Six such competitions were conducted across different schools. The details of the participating schools have been given in Table 10.1. The winning teams were awarded prizes in recognition of their performance. In addition to the participants, the audience members were also engaged through interactive questions asked between the rounds.

Table 10.1: Details of Green Spark Quiz competitions organized

No.	Name of School	Date	No of Participants
1	Gojo Sharda-mandir	October 11, 2025	55
2	V & C Patel School	November 11, 2025	120
3	M.S. Mistri School	November 25, 2025	42
4	I.B. Patel School	December 11, 2025	55
5	Gyanganga Vighaylay	January 23, 2026	42
6	M. U. Patel School	February 18, 2026	50



Figure 10.3: Green spark quiz competition conducted in different schools

Memorandum of Understanding

Marking a year of collaboration and growth, SPRERI strengthened its activities through a series of strategic partnerships and MoUs. These collaborations reflect SPRERI's continued efforts to foster innovation, promote sustainable technologies, and enhance institutional linkages across academia, research institutes, industry, and rural communities.

(a) MoU with academic institutions

During the year, SPRERI strengthened its academic partnerships by entering into strategic Memoranda of Understanding (MoUs) with two academic institutions (Figure 11.1) in Gujarat. These collaborations were aimed at promoting academia–research linkages through joint projects, knowledge exchange, and capacity-building initiatives. They are expected to enhance research outcomes, foster innovation, and provide valuable academic as well as practical exposure to students and faculty. The MoUs were signed with the following institutes:

- Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar (SDAU), Dantiwada on May 28, 2025.
- Birla Vishvakarma Mahavidyalaya (BVM), Vallabh Vidyanagar, Anand, Gujarat on March 24, 2026.



Figure 11.1: MoU signing events with SDAU (top) and BVM (bottom)

(b) MoU with research institutions

During the year, SPRERI also strengthened its linkages with research institutes by entering into strategic Memoranda of Understanding (MoUs). These collaborations were aimed at fostering research–research partnerships through joint projects, technology development, knowledge sharing, and capacity-building initiatives. Such engagements are expected to enhance the quality of research outputs, promote innovation, and facilitate the exchange of technical expertise and best practices among institutions. The MoUs were signed with the following research institutes:

- ICAR-Directorate of Medicinal and Aromatic Plants Research(DMAPR), Anand on March 24, 2026.
- Gujarat Ecology Society, Vadodara on April 11, 2026.



Figure 11.2: MoU signing event with DMAPR

(c) MoU with industries

During the year, SPRERI strengthened its engagement with industry by entering into strategic collaborations for technology transfer and joint initiatives. These partnerships were aimed at



Figure 11.3: MoU signing event with Prime Advance Polishing System Pvt. Ltd. Vadodara

facilitating the commercialization and field-level adoption of developed technologies, while promoting industry–research linkages through collaborative projects and technical support. The collaborations were established with the following industry partners:

- Satyajeet Green Tech Pvt. Ltd. for Torrefaction system on March 23, 2026.
- Prime Advance Polishing System Pvt. Ltd., Vadodara, for cookstoves on March 24, 2026

(d) MoU with rural organizations

During the year, SPRERI strengthened its outreach by collaborating with rural organizations such as Self-Help Groups (SHGs), NRLM units, and Gram Panchayats for the implementation of its technologies at the grassroots level. These

partnerships were aimed at promoting community-based adoption through capacity building, hands-on training, and local institutional support. Such collaborations are expected to enhance livelihood opportunities, empower rural

communities, and ensure effective dissemination and sustainable use of technologies. The collaborations were undertaken with the following rural organizations:

- Roshani Sakhi Mandal, Agas, Petlad, Anand on August 19, 2025 for developing a paper making unit using banana fibers.
- Bhadrasa Grampanchayat, Kheda on July 24, 2025 for community biogas plant
- Cluster Level Foundation (CLF), Anand on March 10, 2026 for Banana Waste Valorisation.



Figure 11.4: MoU signing event with Roshani Sakhi Mandal (*left*); Bhadrasa Grampanchayat, Kheda (*Centre*) and Cluster Level Foundation (*right*)

Recognition & Achievements

1. Dr. Anil Kumar Dubey chaired the session on “Green Technologies” on November 11, 2025, in the 59th Annual Convention of Indian Society of Agriculture Engineers (ISAE) at ICAR–Central Institute of Agricultural Engineering (ICAR-CIAE), Bhopal during November 10-12, 2025.
2. Er. Milan Sojitra, Associate Scientist, SPRERI has been awarded first prize certificate for oral presentation on “Optical and Photo-thermal performance of a cost-effective Nanofluid derived from waste engine oil for solar application” presented in International Symposium during the 59th Annual Convention of Indian Society of Agricultural Engineers (ISAE), at ICAR-CIAE Bhopal during November 10-12, 2025.
3. Dr. Anil Kumar Dubey was invited as the Chief Guest and addressed the students in Deeksharambh 2025, an Induction Program for newly enrolled students at Marwadi University, Rajkot, on July 17, 2025.
4. Dr. Mukund G. Adsul invited by Ganpat University (Gujarat) to be the distinguished jury member to assess the innovative ideas submitted under, “Green Energy Challenge 2.0” on June 28, 2025.
5. Dr. Mukul Dubey was honored with an invitation to Chair a technical session on Plasma Coatings, Surfaces, and Interfaces at the 4th International Online Conference on Coatings and Interfaces, USA from May 21–23, 2025.

1. Borah, M. J., Das, A., Rohit, M. V., Singh, N., & Mohanty, K. (2026). Catalytic hydrothermal liquefaction of *Chlorella sorokiniana* for high quality biocrude production over Mg modified activated red mud catalyst. *Journal of Analytical and Applied Pyrolysis*, 107384.
2. Chandekar, B., Rohit, M. V., & Patel, S. K. (2026). Green bioprocess development using sawdust hydrolysate for efficient hydrogen production by novel *Staphylococcus epidermidis* SPS3. *Fuel*, 404, 136335.
3. Doshi A., Lanjekar P.R., Patel A., Dubey A.K., Suman S.K., Patel S.K.N., (2026) "On-Field Valorization of Rice Straw by Microbial SPRERITECH Consortia: A Novel Approach to Agricultural Waste Management and Resource Recovery" *Journal of Material Cycle and Waste Management*. Vol 28, pp1389–1400.
4. Drishya, P. K., Reddy, M. V., Mohanakrishna, G., Sarkar, O., Isha, Rohit, M. V., Aesha, P., Chang, Y. C. (2025). Advances in microbial and plant-based biopolymers: synthesis and applications in next-generation materials. *Macromol*, 21 ,(2)5.
5. Sojitra M., Joshi A., Dubey M., Mehta J. (2025), "Optical and Photo-thermal Performance of a Cost-effective Nanofluid Derived from Waste Engine Oil for Solar Application". Research paper presented at the International Symposium during the 59th Annual Convention of the Indian Society of Agricultural Engineers (ISAE), held at the ICAR-Central Institute of Agricultural Engineering, Bhopal, from November 10–12, 2025.
6. Joshi A., Sojitra M., Dubey M., (2025), Solar-Powered Standalone Thermal Energy Storage Integrated Refrigerator for Remote Areas". Research paper presented at the International Symposium during the 59th Annual Convention of the Indian Society of Agricultural Engineers (ISAE), held at the ICAR-Central Institute of Agricultural Engineering, Bhopal, from November 10–12, 2025.
7. Dr. Mukund G Adsul presented work titled "High-Rate Biomethanation of Napier Grass Juice with Integrated Valorization of Residues" during 59th Annual Convention on Engineering Innovations for Agriculture 5.0 and International Symposium on Mechatronics and Robotics in Pre and Post Production Agriculture, organized by Indian Society for Agricultural Engineers (ISAE) and ICAR-CIAE, Bhopal on November 10–12, 2025 at ICAR-Central Institute of Agricultural Engineering, Bhopal
8. R. K. Singh, B. Soni, G. Kumari, and S. Makwana, "Development of a High- and Low-Temperature Shift Reactor System for Efficient Hydrogen Production," presented at Engineering Innovations for Agriculture 5.0 and the International Symposium on Mechatronics and Robotics in Pre- and Post-Production Agriculture, November 10–12, 2025, ICAR-CIAE, Bhopal.
9. B. Soni, A. Pawar, R. K. Singh, and G. Kumari, "Feasibility Study on CO₂ Capture using Biomass Ash: A Carbon Capture Approach," presented at Engineering Innovations for Agriculture 5.0 and the International Symposium on Mechatronics and Robotics in Pre- and Post-Production Agriculture, November 10–12, 2025, ICAR-CIAE, Bhopal.
10. Doshi A., Dubey A.K., Lanjekar P., (2025). "Decentralized Waste-To-Energy Solution: A Case Study on A 3.5 TPD Bio-Methanation Plant for Renewable Thermal Applications". Research paper presented at 59th Annual Convention on Engineering Innovation for Agriculture 5.0 organized by Indian Society for Agricultural Engineers (ISAE) and ICAR-CIAE, Bhopal, November 10-12, 2025.
11. Doshi A., Dubey A.K., Pandya S., (2025). "Energy Utilization trend and efficiency metrics for banana cultivation in Anand, Gujarat". Research poster presented at 59th Annual Convention on Engineering Innovation for Agriculture 5.0 organized by Indian Society for Agricultural Engineers (ISAE) and ICAR-CIAE, Bhopal, November 10-12, 2025.

12. B. Soni, R. K. Singh, A. K. Dubey, and G. Kumari, "Steam Generation using Syngas Generated from Fluidized Bed Gasification System," presented at the 5th International Conference on Recent Advances in Bio-Energy Research (ICRABR 2025), October 6–9, 2025, Sardar Swaran Singh National Institute of Bio-Energy (SSS-NIBE), Kapurthala, Punjab.
13. B. Soni, R. K. Singh, and G. Kumari, "Continuous Torrefaction of Agro-Residues for Solid Biofuel Upgrading: Process Performance and Energy Densification," presented at the 5th International Conference on Recent Advances in Bio-Energy Research (ICRABR 2025), October 6–9, 2025, Sardar Swaran Singh National Institute of Bio-Energy (SSS-NIBE), Kapurthala, Punjab.
14. Doshi A., (2025). "Advancing Banana Fiber Value Chain: From Technical Advancement to Rural Employment Generation". Research paper presented at National Conclave on Weaving India Together at Delhi organized by Central Agricultural University, Imphal, October 06, 2025.
15. Doshi A., Dubey A.K., Narayanswamy A., (2025). "SPRERI's Patented Biomethanation Technology: A Decentralized Scalable Pathway to Socio-Technical Transition". Research paper presented at 5th International Conference on Recent Advance in Bioenergy Research (ICRABR) organized by National Institute of Bioenergy Kapurthala, October 06 - 09, 2025.

Patents

Sr. No.	Name of design	Application/ Patent No.	Applicants	Filing date	Status
1	Double-Glazed Solar Dryer for Drying Agricultural and Food Products	463151-001	1. Sardar Patel Renewable Energy Research Institute 2. ICAR-AICRP on Energy in Agriculture and Agro-based Industries, CIAE, Bhopal	23/06/2025	Patent granted Certificate issued Date of Issue: 08/10/2025
2	Fluidized Bed Gasification Apparatus to convert Agro-Industrial Residue to Thermal Energy	475156-001	1. Sardar Patel Renewable Energy Research Institute 2. ICAR-AICRP on Energy in Agriculture and Agro-based Industries, CIAE, Bhopal	27/09/2025	Patent granted Certificate issued Date of Issue: 29/01/2026
3	Solid State Rotary Drum Reactor for Enzymatic Hydrolysis of Agri-Residues	473716-001	1. Sardar Patel Renewable Energy Research Institute 2. ICAR-AICRP on Energy in Agriculture and Agro-based Industries, CIAE, Bhopal	16/09/2025	Application Under Process (examination report submitted)

Invited Talks

1. Dr. Geeta Kumari delivered a keynote address in the National Seminar on “Recent Trends in Renewable Energy: Innovations, Challenges and Opportunities,” held on November 26, 2025, organized by Vadodara Institute of Education and Research (VIER), Vadodara, and supported by Gujarat Council on Science and Technology (GUJCOST).
2. Dr. Anil Kumar Dubey delivered a keynote address on “Clean and Green Energy Technologies: Energy Transition” on November 11, 2025, in the 59th Annual Convention of Indian Society of Agriculture Engineers (ISAE) at ICAR–Central Institute of Agricultural Engineering (ICAR-CIAE), Bhopal during November 10-12, 2025.
3. Dr. Anil Kumar Dubey delivered an invited talk on “Smart Cities Need Smart Solar: Role of Technology in Urban Solar Integration” at the Solar Contractors Meet held in Surat, Gujarat, on September 16, 2025.
4. Dr. Mukul Dubey was invited to the Solar Contractors Meet held in Surat on September 16, 2025, to discuss emerging trends, implementation challenges, and best practices in solar project deployment and maintenance.
5. Dr. Anil Kumar Dubey delivered a podcast on “Technological Advancements in Renewable Energy” at Birla Vishvakarma Mahavidyalaya (BVM) Engineering College, Vallabh Vidyanagar, on September 15, 2025.
6. Dr. Mukul Dubey delivered an invited lecture on “New Developments in Energy Management of Food and Dairy Operations” at Vidya Dairy, Anand, on August 21, 2025 with a special focus on the application of solar energy technologies in the dairy and food processing industries.
7. Dr. Anil Kumar Dubey delivered an invited lecture on “Energy Scenario and Global Environmental Concerns” at Vidya Dairy, on August 19, 2025.
8. Dr. Anil Kumar Dubey delivered an invited lecture as a speaker during the Training Programme on “Empowering Sustainable Energy: Indian Standards for Solid Biofuels”,

organized by the Bureau of Indian Standards (BIS) at BIS Branch Office, Chandigarh, on April 15, 2025.

9. Dr. Amrita Doshi delivered a lecture on “Crafting Winning Research Proposals: From Idea to Approval” during the three-day workshop on Research Proposal and Report Writing” under ‘Promotion of Research and Facilities’, by Knowledge Consortium of Gujarat, Ahmedabad, held at Argo-Economic Research Centre, on March 16-18, 2025.

Exhibition / Workshops

1. Organized a training workshop on “Biochar production from Agro-residue using SPRERITECH kilns” held at SPRERI on March 27, 2026.
2. Er Asim Joshi and Dr Pranay Lanjekar participated in the National Exhibition-cum-Technical Meet (सह-SANKALP), a flagship event focused on “Bridging Gaps, Building Future: Tech for Rural Prosperity”, organized under the aegis of the Office of the Principal Scientific Adviser to the Government of India and 15 different Ministries of Govt. of India, ICAR and CSIR on the March 18, 2026. At the exhibition, SPRERI showcased its innovative, field-ready technologies aimed at promoting sustainability, clean energy, and rural livelihoods.
3. Dr. Anil Kumar Dubey, Dr. Mukul Dubey, Dr. Mukund Adsul, Dr. Geeta Kumari, Dr. Amrita Doshi, Er. Asim Joshi, Dr. M. V. Rohith, Dr. Rohit Singh, Er. Bhavin Soni, Er. Milan Sojitra, and Dr. Anand Narayanasamy attended the ICAR – AICRP on CRP Annual workshop on March 16, 2026.
4. Various scientists and technical staff of SPRERI have participated in Gyanotsav 4.0, organized by CVM University during February 4-8, 2026 at Shastri Maidan, Vallabh Vidyanagar, Anand, Gujarat. At the Exhibition Pavilion, SPRERI showcased a range of renewable energy technologies, demonstrating practical solutions that promote sustainable energy access, rural development, and circular economy pathways. The stall attracted a vibrant audience of students, innovators, start-

ups, and industry representatives, making the event a valuable platform for knowledge exchange and networking.

5. Dr. Anil Kumar Dubey, Dr. Mukul Dubey, Dr. Mukund Adsul, Dr. Geeta Kumari, Dr. Amrita Doshi, Er. Asim Joshi, Dr. M. V. Rohith, Dr. Rohit Singh, Er. Bhavin Soni, Er. Milan Sojitra, and Dr. Anand Narayanasamy attended the ICAR – AICRP on EAAI XXIXth Annual workshop from January 29–31 2026.
6. Dr. Amrita Doshi, and Dr. Bhautik Gajera participated in a 4-day training on “Pulp and Paper Technology”, organized by ICAR - Central Institute for Research on Cotton Technology (CIRCOT), Mumbai from November 24 -27, 2025.

Meetings

1. Dr. Anil Kumar Dubey participated in the Second Brief Meeting of the Bureau of Indian Standards (BIS) Sectional Committee PCD 7 on Torrefied Pellets and Briquettes, held on March 18, 2026.
2. Dr. Anil Kumar Dubey, Dr. Mukul Dubey, Dr. Mukund Adsul, Dr. Geeta Kumari, Dr. Amrita Doshi, Er. Asim Joshi, Dr. M. V. Rohith, Dr. Rohit Singh, Er. Bhavin Soni, Er. Milan Sojitra, and Dr. Anand Narayanasamy attended the ICAR – AICRP on EAAI meeting on December 23, 2025.
3. Dr. Amrita Doshi held a meeting with the Resident Addl. Collector - Shri R. K. Bhagora, Chhota Udepur on November 27, 2025 requesting registered EWS data for an ongoing project.
4. Dr. Anil Kumar Dubey, Dr. Mukul Dubey, Dr. Mukund Adsul, Dr. Geeta Kumari, Dr. Amrita Doshi, Er. Asim Joshi, Dr. M. V. Rohith, Dr. Rohit Singh, Er. Bhavin Soni, Er. Milan Sojitra, and Dr. Anand Narayanasamy attended the ICAR –AICRP on EAAI meeting on October 6, 2025.
5. Dr. Amrita Doshi held a meeting with the Bhadrassa Sarpanch - Shri Deepak Bhai Parmar, on October 5, 2025 for site location for community biogas plant.
6. Dr. Anil Kumar Dubey, Dr. Mukul Dubey, Dr. Mukund Adsul, Dr. Geeta Kumari, Dr. Amrita Doshi, Er. Asim Joshi, Dr. M. V. Rohith, Dr. Rohit Singh Er. Bhavin Soni, Er. Milan Sojitra, and Dr. Anand Narayanasamy attended the ICAR – AICRP on CRP meeting on September 19, 2025.
7. Dr. Anil Kumar Dubey and Dr. Amrita Doshi held a meeting with the District Development Officer (DDO) Ms. Devahuti, IAS, on August 18, 2025 to discuss the REI and discuss the scope of working in collaboration with NRLM.
8. Dr. Amrita Doshi held a meeting with the Collector - Shri Amit Prakash Yadav, I.A.S, Kheda on July 23, 2025 requesting registered EWS data for an ongoing project.
9. Dr. Anil Kumar Dubey attended the Industry Meet & Start-up Conclave 2025, organized by ICAR at Boriavi, from July 14–15, 2025.
10. Dr. Anil Kumar Dubey participated in the Bureau of Indian Standards (BIS) FAD 34: P11 Committee Meeting on Energy in Agriculture, held on July 10, 2025.
11. Er. Asim Joshi participated in the of 31st virtual meeting of MED 04 Sectional Committee of BIS on June 13, 2025
12. Dr. Anil Kumar Dubey participated in an online deliberation meeting on the progress review of work allocated for the respective sub-chapters, organized by the Bureau of Indian Standards (BIS), Manak Bhawan, New Delhi, on May 29, 2025.
13. Dr. Anil Kumar Dubey, Dr. Mukul Dubey, Dr. Mukund Adsul, Dr. Geeta Kumari, Dr. Amrita Doshi, Er. Asim Joshi, Dr. M. V. Rohith, Dr. Rohit Singh, Er. Bhavin Soni, Er. Milan Sojitra, and Dr. Anand Narayanasamy attended the ICAR –AICRP on EAAI meeting on May 27, 2025.
14. Dr. Anil Kumar Dubey and Dr. Amrita Doshi held a meeting with the District Collector, Anand - Shri Praveen Chaudhary, IAS, on May 13, 2025 requesting registered EWS data for an ongoing project and also discussed the research areas of SPRERI.
15. Dr. Mukul Kumar Dubey participated in the online meeting of BIS National Agriculture Code Sectional Committee (FAD 34/Pane XI) on April 17, 2025.
16. Dr. Anil Kumar Dubey attended the Conference on “Water and Livelihoods in Viksit Bharat 2047” held at the National Dairy Development Board (NDDB), Anand, on April 12, 2025.
17. Dr. Anil Kumar Dubey and Dr. Amrita Doshi participated in a meeting with NDDB Chairman – Shri Maneesh Shah to discuss the scope of collaboration projects.

Training/Internships/Dissertation

- Chaudhary Krunal, B. Tech. student of Mechanical Engineering Department, Birla Vishvakarma Mahavidyalaya Engineering College, Vallabh Vidyanagar, Gujarat has completed his industrial project on “Testing of cold thermal energy storage integrated solar refrigerator for transient storage” in Solar Energy Division, SPRERI
- Vekariya Abhay, B. Tech. student of Mechanical Engineering Department, Birla Vishvakarma Mahavidyalaya Engineering College, Vallabh Vidyanagar, Gujarat has completed his industrial project on “Testing of cold thermal energy storage integrated solar refrigerator for transient storage” in Solar Energy Division, SPRERI
- Vasavada Meet, B.Tech. student of Mechanical Engineering, Faculty of Technology, Dharmsinh Desai University, Nadiad, completed a one-month internship on “Solar Energy Technologies” in the Solar Energy Division, SPRERI.
- Yadav Dev, B.Tech. student of Mechanical Engineering, Faculty of Technology, Dharmsinh Desai University, Nadiad, completed a one-month internship on “Solar Energy Technologies” in the Solar Energy Division, SPRERI.
- Valvi Priyadarshani, B.Tech. Student of the College of Agricultural Engineering and Technology, Anand Agricultural University (AAU), completed a four-month internship on “Solar Energy Technologies” in the Solar Energy Division, SPRERI.
- Khandelwal Jayshree, B.Tech. Student of the College of Agricultural Engineering and Technology, Anand Agricultural University (AAU), completed a four-month internship on “Solar Energy Technologies” in the Solar Energy Division, SPRERI.
- Chauhan Krishna, B.Tech. Student of the College of Agricultural Engineering and Technology, Anand Agricultural University (AAU), completed a four-month internship on “Solar Energy Technologies” in the Solar Energy Division, SPRERI.
- Er. Bhavin Soni, Er. Akanksha Pawar, Er. Drishya P. Kannan, Dr. Rohit Kumar Singh, and Dr. Geeta Kumari attended a training programme on “SimaPro Software for Life Cycle Assessment (LCA) Analysis,” organized by AICRP on Energy in Agriculture and Agro-based Industries.
- Dharmi Borsadiya, B.Tech. student of Agriculture Engineering, College of Agricultural Engineering and Technology, Junagadh Agricultural University, Junagadh completed three-month internship on “Socio-Economic study of selected district of Anand” in the Extension and Technology Transfer Division, SPRERI.
- Abhay Chhuchhar, B.Tech. student of Agriculture Engineering, College of Agricultural Engineering and Technology, Junagadh Agricultural University, Junagadh completed three-month internship on “Socio-Economic study of selected district of Anand” in the Extension and Technology Transfer Division, SPRERI.

Visitors

- Mr. Yagnesh Bhatt, HR Manager, and Mr. Deval Patel, Production and Planning Manager, HLE Glascoat Pvt. Ltd., Anand, visited on March 24, 2026 for discussion on biogas plant inquiry with the Director.
- Mr. Utsav and Mr. Minesh, Owners, Dfurn Modular Systems Pvt. Ltd., Kheda, visited on March 23, 2026 for discussion regarding establishment of a biogas plant.
- Mr. Praveenkumar Kulkarni, Chairman, KK Nesar Projects Pvt. Ltd., Vadodara, visited on March 20, 2026 regarding collaboration with SPRERI.
- Dr. Anuraddha Ganesh, Board Member, visited on March 12, 2026 to discuss the ongoing research activities of the institute.
- Dr. Dipa Galvi and Mr. Jayendra, Gujarat Ecological Society, Vadodara, visited on March 5, 2026 for research collaboration.
- Dr. Ulpa Patel, Assistant Professor; Dr. Kamlesh Jethwa, Associate Professor; and Dr. J.P. Rathod, SRF, AAU, Anand, visited on February 15, 2026
- Mr. Nikunj Usadadia and Mr. Ajay Barod, IWMS, Anand, visited on February 13, 2026 for a meeting regarding collaboration between IWMS and SPRERI.
- Mr. Bharath Raj, Engrow, Erode, visited on February 2, 2026 for discussion regarding fast pyrolysis system for bio-oil production.
- Er. Nirali Dudharejiya, Environmental & Safety Manager, Navneet, Mumbai, visited on January 20, 2026 for scope of implementation of REI.
- Dr. Paresb Budh, Retired Scientist, visited on January 20, 2026.
- Mr. Anant Awasthi, Area Manager, Design Tech Systems Pvt. Ltd., Ahmedabad, visited on September 11, 2025 to propose and demonstrate GIS software.
- Mr. R.P. Mehta, Anupam Mission, ITC, visited on August 11, 2025
- Er. Satish B. Patel, Executive Director, Kisan Drip Irrigation Pvt. Ltd., Vadodara, visited on July 11, 2025
- Mr. V. B. Harani and Er. V.K. Pandya, Joint Secretary and Retired Additional Chief Engineer (GETCO), visited on June 21, 2025 regarding waste-to-energy initiatives.
- Dr. S.K. Philip, Ex-Deputy Director, SPRERI, visited on June 17, 2025 to visit the institute and extent support SPRERI's research activities.
- Mr. Sanjay Mittal, Sankhya & Mr. Vinay Patel, NDDDB Team, visited on June 05, 2025 for a meeting on developing a biochar system.
- Mr. Harish Aanchan & Other Members, Arth Fit Solutions, Pune, visited on May 26, 2025 for an torrefaction system
- Mr. Pankaj Macwan, Stuti Industry, visited on March 20, 2025 for scope of installing Pelletizer Plant

Director

Dr Anil Kumar Dubey

Solar Energy Division

- Dr Mukul Kumar Dubey, Principal Scientist and Head
- Er Asim Kumar Joshi, Senior Scientist
- Er Milan Sojitra, Associate Scientist
- Mr Mahendra Padhiyar, Jr. Lab Assistant
- Mr Mukesh Jadav, Helper
- Mr Divya Nagar, Helper

Bio-conversion Technology Division

- Dr Mukund G. Adsul, Principal Scientist and Head
- Dr Maku Venkata Rohith, Senior Scientist
- Dr Anand Narayanasamy, Associate Scientist
- Mrs Aesha Patel, Senior Research Fellow
- Ms Drishya P K, Senior Research Fellow
- Ms Mareena Jose, Senior Research Fellow
- Ms Aditi Suthar, Project Associate
- Mr Ashok Harijan, Lab Attendant
- Mr Ashok Mochi, Helper
- Mr Harman Parmar, Helper
- Mrs Manjula Vadhel, Helper
- Mr Karan Jadav, Helper
- Dr Neha Singh, Senior Scientist (till August 31, 2025)

Thermo-chemical Conversions Technology Division

- Dr Geeta Kumari, Principal Scientist & Head
- Dr Rohit Kumar Singh, Senior Scientist
- Er Bhavin Soni, Associate Scientist
- Dr Aanand Lakhani, Research Associate
- Er Akanksha Pawar, Senior Research Fellow
- Er Shivam Makawana, Project Associate
- Mr Ashok Patel, Helper
- Mr Sachin Parmar, Helper

Technology Transfer & Extension Division

- Dr Amrita Doshi, Senior Scientist & Head
- Dr Pranay Lanjekar, Senior Program Officer
- Er Shradhdha Pandya, Senior Research Fellow
- Er. Ravindrasinh Gohil, Program Professional
- Er Shivam Thakar, Project Associate
- Mr Minesh Suthar, Jr. Technician
- Mr Shailesh Solanki, Helper
- Dr Bhautik Gajera (till December 04, 2025)

Administration & Finance Division

- | | |
|---|----------------------------------|
| • Mr Bipin K Patel, Account & Admin Officer | • Mr Dahya Harijan, Jr. Mechanic |
| • Mr Hashmukh Vaghela, Jr. Office Assistant | • Mr Suresh Bhoi, Jr. Welder |
| • Mr Mayur Parmar, PA to Director | • Mr Rajesh Machi, Driver |
| • Mr Chetan Parmar, Sr. Account Assistant | • Mr Bhupendra Parmar, Helper |
| • Mr Bhupendra Prajapati, Electrician | • Mr Jitesh Solanki, Helper |

Balance Sheet

S.S. Choudhary & Associates
Chartered Accountants

SF 208/2029, Nilkanth Square,
Opp. Seva Sadan,
New Ganesh Chowkadi

SARDAR PATEL RENEWABLE ENERGY RESEARCH INSTITUTE - VALLABH VIDYANAGAR
BALANCE SHEET AS ON - 31 - 03 - 2026

FUNDS & LIABILITIES	31/03/2025	31/03/2026	ASSETS	31/03/2025	31/03/2026
CAPITAL FUND	10 82 669.20	10 82 669.20	FIXED ASSETS		
PROJECT FUND			1. Furniture & Fixtures	2 49 808.62	2 49 808.62
Balance from last year	1 50 90 846.67	1 85 00 161.67	2. Electric Fittings	1 62 350.85	1 62 350.85
Add / Less during the year	34 09 315.00	1 09 71 036.00	3. Mobile Phone	19 600.00	19 600.00
(As per Schedule - 5)	1 85 00 161.67	2 94 71 197.67	4. Institute Equip.(R & D / Others)	10 71 372.00	10 71 372.00
PROJECT EQUIPMENT			5. Car - GJ-23 AF-0282	5 85 597.00	5 85 597.00
Depreciated value of Equipment	13 03 02 244.51	13 39 13 614.51	6. New Jeep - GJ-23-GA-0488	8 34 000.00	8 34 000.00
Add : During the year	36 11 370.00	39 38 840.00		29 22 728.47	29 22 728.47
(As per Schedule - 1)	13 39 13 614.51	13 78 52 454.51	PROJECT EQUIPMENT	13 39 13 614.51	13 78 52 454.51
Gratuity Fund	65 14 125.57	68 14 637.87	INVESTMENT		
EAR MARKED FUND			Fixed Deposit (As per Schedule -2)	3 87 99 712.00	4 38 71 475.00
1. Building Fund Provision	35 32 595.00	35 32 595.00	Deposit in LIC - Gratuity Scheme	65 14 125.57	68 14 637.87
2. Research & Development Fund	1 04 60 434.83	1 04 60 434.83		4 53 13 837.57	5 06 86 112.87
3. Contingent Development Fund	1 40 070.00	1 40 070.00	LOANS & ADVANCES		
4. Depreciation Fund (As Per Sh -7)	70 77 841.30	71 53 829.30	1. Tax Deduction at Source	2 90 894.00	24 38 810.00
5. Endowment Fund (Hari Om Ashram)	15 14 118.75	15 14 118.75	2. Telephone Deposit	20 313.00	20 313.00
6. Share & Care Fund	1 60 477.00	1 60 477.00	3. CGM Deposit(Oil Diesel & Petrol)	42 400.00	42 400.00
7. Maint. Fund (Core Grant)	7 62 173.00	7 62 173.00	4. Indian Oxyzen Ltd., Deposit	4 252.94	4 252.94
8. Depreciation Investment Fund	4 78 006.00	4 78 006.00	5. Mobile Phone Deposit	4 680.00	4 680.00
9. Staff Welfare Fund	17 44 896.95	17 46 687.95	6. Broad Band Security Deposit	3 000.00	3 000.00
10.Quiz Prog. Fund	61 175.00	61 175.00	7. Gas Cylinder Deposit	10 350.00	10 350.00
11.Donation (Gen.)	25 03 454.00	27 54 954.00	8. Security Deposit(GEB - New DP)	1 00 920.00	1 00 920.00
(As per Schedule - 6)	2 84 35 241.83	2 87 64 520.83	9. Loan to Staff & Advance to Project (As Per Schedule - 4)	9 43 466.00	14 02 128.00
			10.Intrest Accrued	41 15 847.00	10 61 385.00
				55 36 122.94	50 88 238.94
Balance as per last Balance Sheet			BALANCE :		
Balance as per last Balance Sheet	19 97 924.33	48 79 497.06	Bank Balance (As per Schedule - 3)	56 21 965.35	1 26 07 596.77
Add/ Less : - As per Inc.& Exp. A/c	28 81 572.73	3 19 511.42	Cash Balance	17 041.00	27 357.00
Add:- Surplus	48 79 497.06	51 99 008.48		56 39 006.35	1 26 34 953.77
TOTAL	19 33 25 309.84	20 91 84 488.56	TOTAL	19 33 25 309.84	20 91 84 488.56

Date :- 23/07/2026
Place :- Vallabh Vidyanagar.


Accounts Officer




Director



For, S. S. Choudhary & Associates
Chartered Accountants


CA Satish S. Choudhary
(Partner)
M.No. 171726

Acronyms & Abbreviations

AHR	Anaerobic Hybrid Reactor	NABL	National Accreditation Board for Testing and Calibration Laboratories
AgNP	Silver Nanoparticle	NGO	Non-Governmental Organization
AICRP	All India Coordinated Research Project	NMS	Nitrate Mineral Salts Medium
BEE	Bureau of Energy Efficiency	NPG	Neopentyl Glycol
BIS	Bureau of Indian Standards	PCM	Phase Change Material
COD	Chemical Oxygen Demand	PE	Pentaerythritol
CSLNP	Cotton Stalk Lignin Nanoparticle	PLC	Programmable Logic Controller
CTec2	Commercial Cellulase Enzyme Preparation	PSA	Particle Size Analysis
DC	Direct Current	PTC	Parabolic Trough Collector
DSMZ	German Collection of Microorganisms and Cell Cultures	PV	Photovoltaic
DST	Department of Science and Technology	PVA	Polyvinyl Alcohol
EAAI	Energy in Agriculture and Agro-based Industries	rpm	Revolutions Per Minute
EPD	Electrophoretic Deposition	RSLNP	Rice Straw Lignin Nanoparticle
FAD	Food and Agriculture Division	SC	Scheduled Caste
FDM	Fused Deposition Modelling	SEM	Scanning Electron Microscopy
FPO	Farmer Producer Organization	TES	Thermal Energy Storage
FTIR	Fourier Transform Infrared Spectroscopy	TMP	Trimethylolpropane
HMF	Hydroxymethylfurfural	TS	Total Solids
HFAD	Horizontal Flow Anaerobic Digester	UV	Ultraviolet
HPLC	High Performance Liquid Chromatography	VS	Volatile Solids
HRT	Hydraulic Retention Time	WEO	Waste Engine Oil
ICAR	Indian Council of Agricultural Research	XRD	X-Ray Diffraction
ISO	International Organization for Standardization		
LNP	Lignin Nanoparticle		
LPH	Litres Per Hour		
MCC	Microcrystalline Cellulose		
MDH	Methanol Dehydrogenase		
MNRE	Ministry of New and Renewable Energy		
MoU	Memorandum of Understanding		

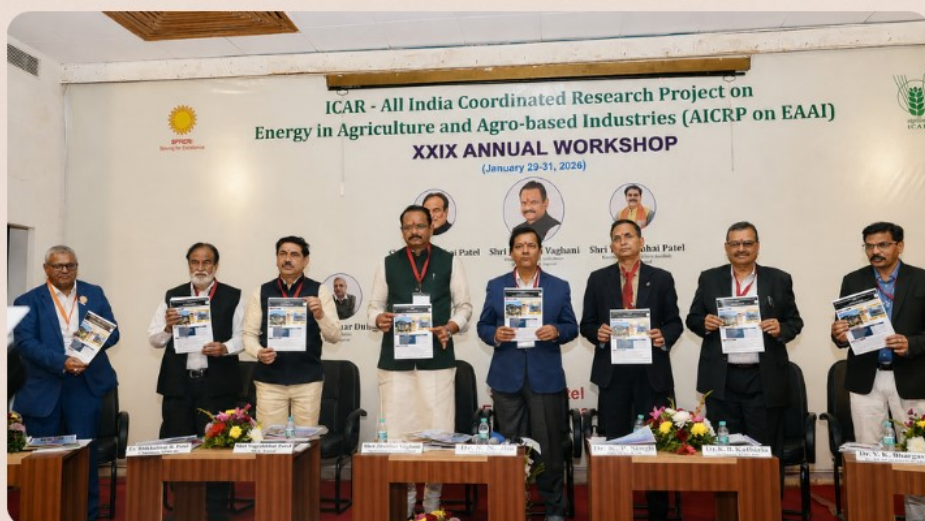
Technologies for Commercialization

- Hybrid solar dryer with thermal storage (scalable)
- Portable solar dryer (up to 20 kg/batch)
- Low-tunnel solar dryer (up to 50 kg/batch)
- Indirect solar dryer with solar air heating collectors (scalable)
- Walk-in-type solar tunnel dryer (scalable)
- Solar PV-powered cold storage with thermal storage (up to 10 MT)
- Solar refrigerator with thermal storage (up to 200 L)
- Solar-biogas hybrid vapor absorption cold storage system (scalable)
- Solar PV-based cooking system with thermal storage (scalable)
- ETC-based solar cooking system (scalable)
- ETC-based solar desalination system
- Solar still for water purification and desalination
- Solar Scheffler dish with cavity receiver for green steam generation (scalable)
- Solar photovoltaic-thermal (PVT) hybrid collector for space heating
- Nanofluid-based heat transfer fluid for high-efficiency solar thermal applications
- Single-axis solar tracking system for photovoltaic modules
- Odorless Bio-methanation technology for Mandi and kitchen waste of 4 days HRT
- Process for high yield and pharma grade Micro crystalline cellulose production from agro-residues
- Microbial Consortia for rapid Bio-composting of agro-residues
- Bioremediation process of waste effluent using microalgae
- Process for higher biogas production from rice straw
- Bio-lubricant production process from algal lipids
- Hybrid Horizontal flow anaerobic reactor for biogas production at high TS
- Process for bio-methanation of Napier grass along with residue valorisation
- High yield lignin extraction method from agro-residues
- Biogas technology for agro-industrial effluent
- Bio-methanation technology for dairy effluent and scum
- Continuous biochar production system
- Fast pyrolysis system for bio-oil production
- Activated carbon production system
- Bulk milk chiller effluent treatment system
- Fluidized bed gasifier for agro-residues (up to 100 kg/h)
- Biomass gasifier-based power generation system (up to 125 kVA)
- Biomass-based gasification system for thermal applications (up to 500 kg/h)
- Waste heat utilization system for biomass drying
- Biomass combustor for air and water heating
- Biomass cookstoves for domestic and commercial applications
- Bio-oil combustion system for thermal applications

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