ISO 9001:2008

18th Annual Report

2015-2016

SARDAR SWARAN SINGH
NATIONAL INSTITUTE OF BIO-ENERGY
(Formally Sardar Swaran Singh National Institute of Renewable Energy)
(An Autonomous Institution of Ministry of New and Renewable Energy)

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Executive Summary

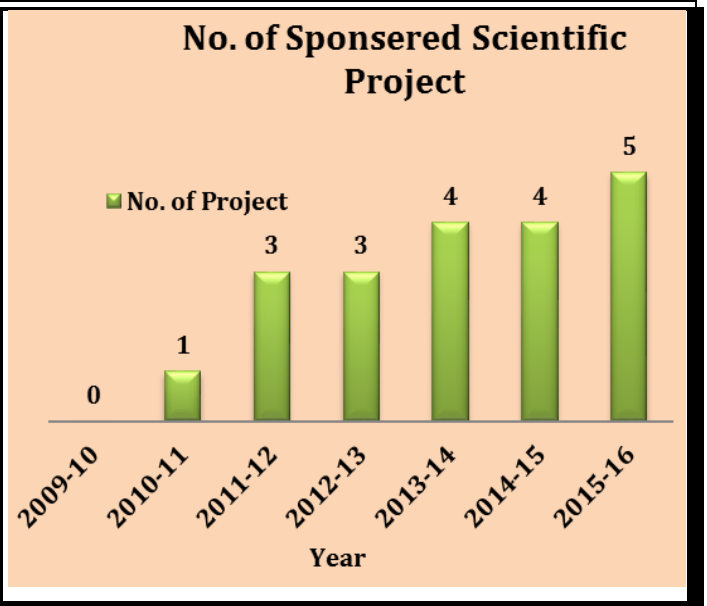
Sardar Swaran Singh National Institute of Bio-Energy (SSS-NIBE), Kapurthala is an autonomous institution under the Ministry of New and Renewable Energy (MNRE), Govt. of India, set up with the vision "to become an apex institution for carrying out state-of-the-art research and developmental activities in the area of bioenergy and human resource development at all level for promotion of bio-energy in the country. The institute formerly known as Sardar Swaran Singh National Institute of Renewable Energy (SSS-NIRE) was renamed as Sardar Swaran Singh National Institute of Bio Energy (SSS-NIBE) following the approval of the 23rd G C Meeting held on 31st October 2014. In the meeting, GC desired to make the institute a Centre of Global Excellence in Bio Energy. During the year 2015-16, R&D activities were taken up in the frontier areas such as Bio-crude Production, Lignocellulosic Bioethanol Production, Biogas Production from Agro-residue, Biomass Cookstove Testing and Certification. The research findings in the frontier bioenergy areas, deposition of gene sequence of new consortia, microalgae etc., from the in-house R&D were published in reputed journals.

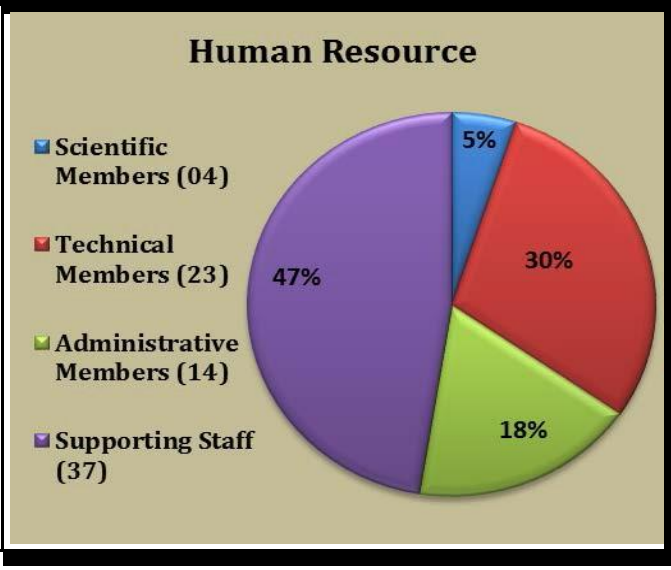
The Institute conducted short term trainings for around 300 fellows, starting from undergraduate to postdoctoral level and updating their knowledge towards development and applications of bioenergy. The second International Conference on Recent Advances in Bioenergy Research (ICRABR -2016), was successfully organized by the institute during February 22-27, 2016 that provided an opportunity for interaction for R&D collaboration with several leading R&D Institutions and Universities around the world. A Bio-Energy Alliance was also formed during the conference to play pivotal role in bringing the stakeholders, researchers, policy makers, and industry to the same platform for discussion and suggesting ways and means for promoting research and bioenergy applications.

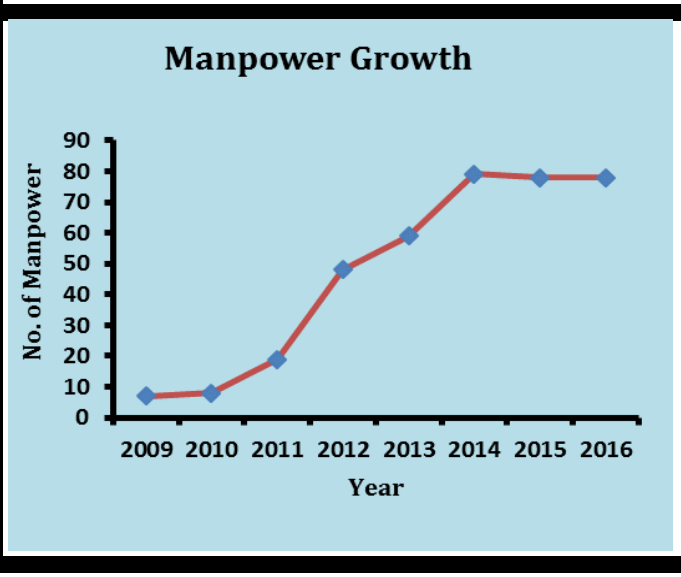
The institute took leading role in preparing all technical documents related to Biofuel and Bioenergy as entrusted by the Ministry of New and Renewable Energy, Govt. of India from time to time. Its officials participated in all technical programs and meetings of MNRE, particularly related to Bioenergy Sector, for discussion on R&D, strategy and policy, progress and dissemination of knowledge and technology.

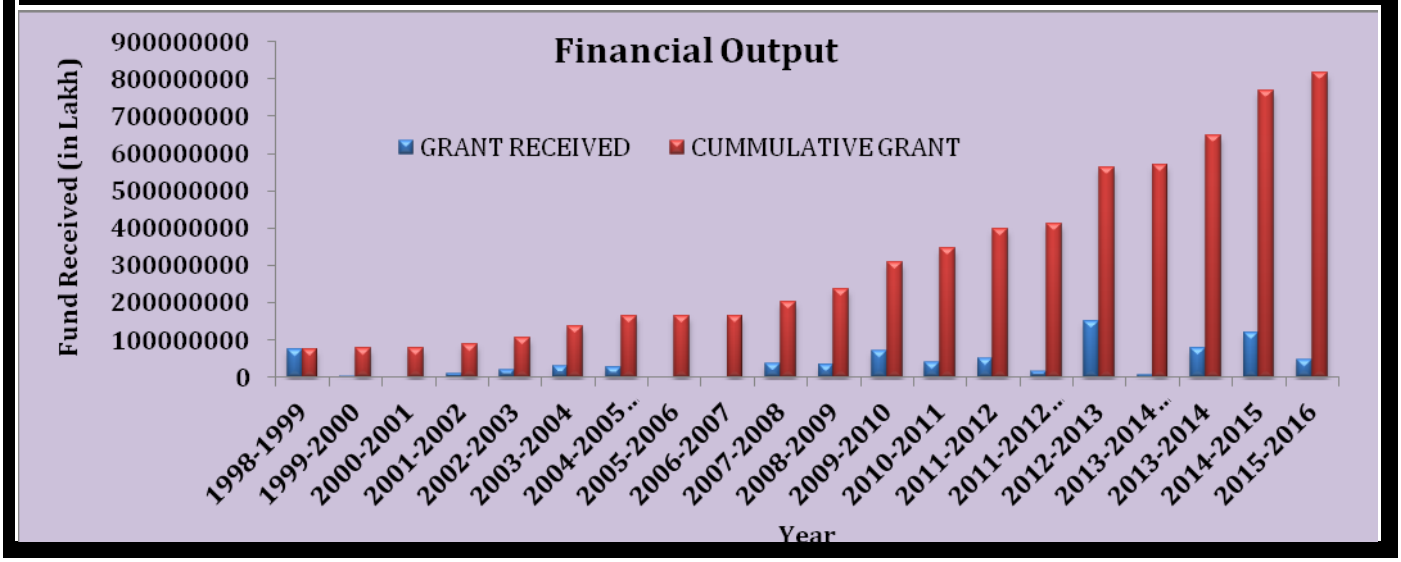
The institute took initiative in recruitment of scientific/technical and research manpower. All efforts were made to implement activities assigned to institute. A total grant-in-aid of 5.60 Crore INR was received from the Ministry of New and Renewable Energy, Govt. of India in the financial year 2015-16, out of which 3.4 Crore INR was spent from the budget allocated under different heads and Rs. 2.68 Crore INR has been allocated for committed expenditure.

Institute Growth: At A Glance









1. INTRODUCTION

Sardar Swaran Singh National Institute of Bio-Energy (SSS-NIBE), Kapurthala is an autonomous Institution of the Ministry of New and Renewable Energy (MNRE), Govt of India devoted to research, design and development and demonstration for promotion of bioenergy in the country. The institute has 10 nos. of sanctioned posts for various identified activities. The institute has an approved vision documents for 5 years (2013-2017) for research plan and accordingly created five research divisions including all aspects of biofuel and bioenergy research. The broad spectrum of bioenergy covers biomass resource assessment & management, biomass characterization, Biomass conversion technologies (gasification, combustion, pyrolysis),solid waste/state biomethanation, liquid biofuels (biodiesel, bioethanol, bio-oils, green diesel), algal biomass production, biohydrogen production, solid waste treatment & management, life cycle analysis/assessment of bioenergy system, 1st, 2nd and 3rd generation of biofuels, etc. The overall progress of the institute is monitored by the Governing Council comprising experts in the field under the Chairmanship of Secretary, MNRE, Government of India.

The 16th meeting of the Governing Council approved the vision document and creation of 16 nos. of new scientific posts for smooth implementation of the R&D activities under different divisions. The proposal has been approved for approval by the Ministry of Finance, and process has been initiated for recruitment. The institute was certified by Intertek as an ISO 9001:2008, under R&D institution. The institute has 75 acres of land with green carpet and unique buildings at the 12th KM Stone, Jalandhar-Kapurthala national highway with plentiful research infrastructure and an eco-friendly research environment.

The institute is in the process of strengthening its capacity for pursuing R&D, testing, evaluation and standardization in bioenergy. Several vital equipment facilities are required to be created at the Institute for further strengthening the R&D activities, creating state of the art laboratory facilities and centre of excellence in Bioenergy Research, Design, Demonstration and Development activities. The institute has five (5) R&D divisions created for carrying out research, design and demonstration of bioenergy sector. In addition to dedicated equipment facility, skilled technical and manpower will also be required for handling these vital equipment and safe operation.

2. OBJECTIVES AND FUNCTIONS

VISION

To become a Centre of Excellence for carrying out state-of-the-art research and developmental activities in the area of bioenergy.

MISSION

- To be a knowledge based R&D institution of high quality and dedication.
- To impart the training to professionals of bioenergy sector
- To provide the services and optimum solutions for the major stakeholders across the entire spectrum of the bioenergy sector.
- To support bioenergy sector in developing the knowledge for promoting new technologies.
- To develop Human Resources for the bioenergy sector at all levels.

OBJECTIVES

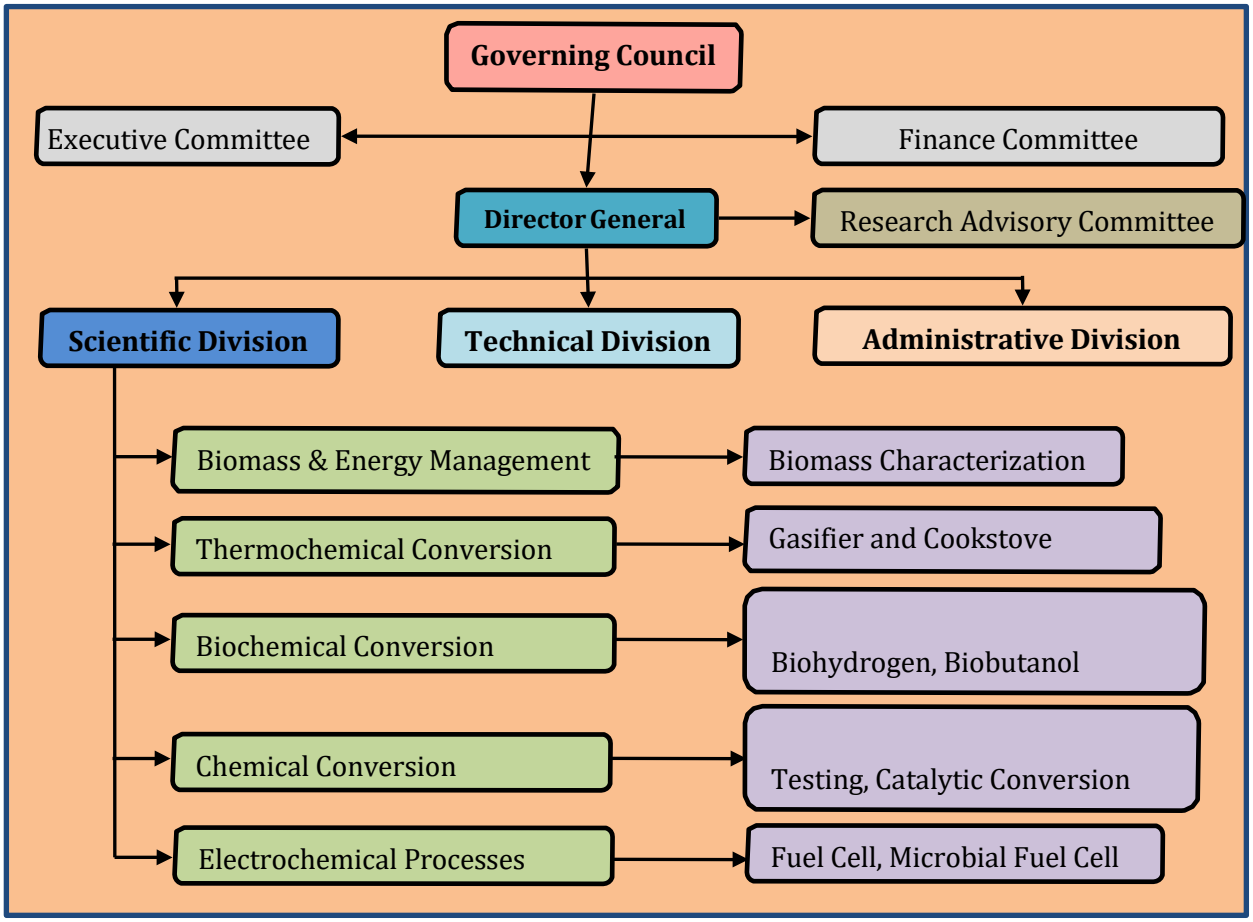
- To carry out and facilitate research, design, development, testing, standardization and technology demonstration eventually leading to commercialization of RD&D output with a focus on:
  a. Bioenergy, biofuels and synthetic fuels in solid, liquid and gaseous forms for transportation, portable and stationary applications; and
  b. Development of new technologies for effective utilization of different type of wastes and production of value added products
- To undertake and facilitate human resource development and training including post-doctoral research in the area of bioenergy.
- To create facilities for operationalization of the Institute.

FUNCTIONS

- Conduct resource surveys and assessment of potential across the country in the bioenergy sector.
- In-house R&D programmes in all emerging fields of bioenergy.
- Joint technical programmes with other national institutions and testing centres.
- Testing and certification of devices and systems.
- Techno-economic evaluation of bioenergy equipments and systems.
- Creating data base for bioenergy including information on patents.
- Compilation and dissemination of information on resources, technologies, products and applications.
- Providing technical support to industry on new product design and development and up-gradation of products and manufacturing processes.
- Providing technical support to the biomass energy project in achieving and sustaining quality such that systems of highest quality and reliability are installed.
- Organization of training programmes, seminars and workshops.
- Cooperation with scientific and technical Institutions abroad under bilateral and multilateral agreements and MoU.

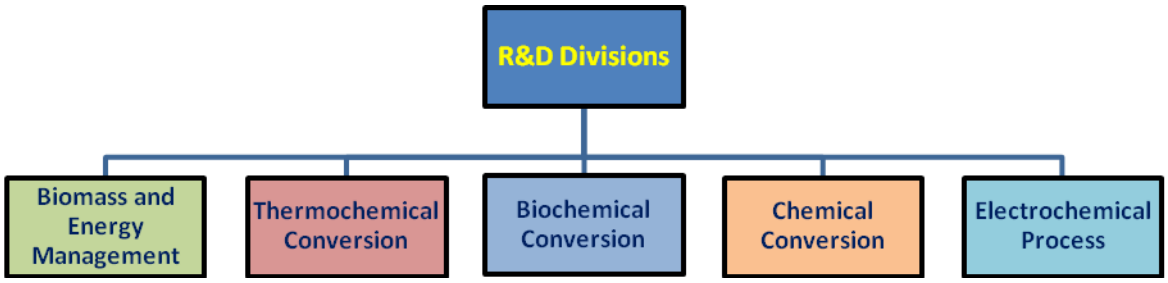
- Assistance in curriculum development in renewable energy and undertaking concrete programmes for human resource development.
- Consultancy and advisory services in the bioenergy sector.
- Providing technical support to MNRE in policy planning and implementation.
- Cookstove dissemination projects through Carbon Financing (CDM).
- Information, Communication and Education (ICE).

3. ORGANIZATION CHART



4. RESEARCH DIVISIONS AND LABORATORY SETUP

There are total five R&D divisions as given below:



The R&D laboratories of the Institute and facilities are subdivided under the following headings as per application point of view.

i R&D Block-I (Chemical and Electrochemical Conversion Laboratory, viz. Biodiesel, Hydro processing, Catalysis and Fuel Cell).

ii R&D Block-II (Biochemical Conversion Laboratory viz. Bioethanol, Biobutanol, Biogas, Biohydrogen, Algal biomass, Metabolic Engineering).

iii R&D Block-III (Thermochemical Conversion Laboratory, viz. Biomass Characterization, Gasification, Pyrolysis, Cookstoves, New and Hybrid Energy Systems).

iv Common Facility Building (Computer Lab, Library, Conference Hall and Canteen).

v Workshop (Common Workshop Machines & Tools and Test Engines).
vi Gasifier shed (Biomass Gasification and Testing Facilities).

5. CHARTER

With a view to manage, administer, direct and control the affairs of SSS-NIBE, an environment and culture conducive to achievement of excellence, will be created by ensuring:

i Commitment to the mission: sense of purpose and direction to policies, programmes & activities to achieve the aims and objectives;
ii Commitment of staff members: liberal, positive and people-sensitive personnel policies, training and management development with special reference to advance technologies equipment and result orientation;
iii Commitment to excellence: professional competence, encouragement to creativity, innovation, initiative and career development; and
iv Commitment to society: application of the state-of-the-art research and development to national/social priorities.

6. LABORATORY DEVELOPMENT

The state-of-the-art research facilities are being developed for biodiesel, bioethanol, gasification, biogas, cookstoves research & testing and for other areas in bioenergy. The consumables including chemicals, glass wares and plastic wares have also been procured for experimental work in the laboratories. The following divisions were created in the Institute:

•Biomass and Energy Management
•Thermochemical Conversion
•Biochemical Conversion
•Chemical Conversion
•Electrochemical Process

Division-wise progress

6.1 Biomass and Energy Management Division

Few biomass samples (wood, pellets, etc.) are being tested and the generation of database is going on as per the requirements of the scientists and the mandate of the division in particular and the Institute in general. Few more equipments required for the complete characterization of biomass samples are likely to be procured shortly. At present all the vital equipments are functional and basic characterization of biomass samples are ongoing with the help of various precious, equipment like CHNS-O analyzer, Bomb calorimeter etc.

6.2 Thermochemical Conversion Division

The basic testing facilities for biomass gasification and cookstove testing, etc, have been created for thermochemical conversion of biomass including gasification, combustion, etc. and some of the important equipments like Differential Scanning Calorimeter, Online Gas analyzer, Stack Monitoring System (for SPM Measurement) and Testing Hood for biomass cookstove, pots of different size and dimensions, besides, few important instruments such as, moisture analyzer, microbalance etc. have been procured and installed in the biomass cookstove laboratory.

6.2.1 Biomass Cookstove Testing Laboratory

The institute has set up the testing and R&D facilities for improved biomass cookstove. The design and development of low cost durable and locally acceptable biomass cookstoves has been initiated. The test facility is as per standard of BIS. Performance testing of improved biomass cookstoves which are received from industry is done as per Indian standard.

Improved biomass cookstove models developed/modified

The cookstove models (Modified natural draft gasifier cookstove, and Modified natural draft traditional cookstove) have been designed and fabricated in the Institute during previous years using standard design principles. These all are unique models developed so far in the country. One of the cookstove models has an option to cook Chapati (Roti) with direct contact to the fire coming from the combustion chamber. Using the basic heat transfer and cookstove design principles available in the literature, the improved cookstoves were designed and fabricated in the workshop with different possible modifications using locally available materials. These are some unique models developed so far in the country. The first cookstove model (Modified natural draft gasifier cookstove) was designed on the principle of down-draft gasifier where pyrolysis, gasification and combustion of biomass are taking place simultaneously, modifications having air gap between the inner structure and outer one so as to reduce the heat loss and utilizing this hot air for combustion through the secondary holes.

The photographic view of a particular model is shown in Table1. For regulating the air supply through the combustion chamber, an extra plate was provided at the bottom, through which the supply of air for gasification of woody biomass can be adjusted from minimum (0%, by fully closed) to maximum (100% by fully opened). These cookstoves were designed based on the gasification principal so as to get a better performance and the combustion temperature by means of controlled air/fuel ratio. Several design principles were applied using a thorough literature survey and three best designs were selected for fabrication of different models using mild steel, whereas, for insulation clay and wheat straw mixture in a specific portion was used. The performance parameters such as, energy efficiencies, power output, and emission of exhaust gases and particulate matter etc. of each cookstove was calculated according to the water boiling test following the standard test protocols.

Table 1: Improved Biomass Cookstove developed at SSS-NIBE

S. No.	Developed Cookstove model with specification	
1.	**Modified Natural Draft Gasifier Cookstove**	
		**Material of Construction:** GI/SS **Weight** (kg)**:** 9.3 **Height** (cm)**:** 30 **Diameter** (cm)**:** 11 **Thermal Efficiency (%):** 30.25 **Power output (kW):** 2.2 **TPM (mg/MJ$_d$):** 332.2 **CO (g/MJ$_d$):** 3.2 **Body Temprature (°C):** 41.83
2.	**Modified Natural Draft Traditional Cookstove**	
		**Material of Construction:** GI/SS **Weight** (kg)**:** 26.5 **Diamention** (cm)**:** 52*24*24 **Thermal Efficiency (%):** 27 **Power output (kW):** 3.6 **TPM (mg/MJ$_d$):** 394.31 **CO (g/MJ$_d$):** 4.68 **Body Temprature (°C):** 67.17

During the experiments, the data were recorded on a finite interval of 5 minutes time and the performance of different types of cookstoves has been evaluated using standard water boiling test. On the other hand, the proximate and ultimate analyses were carried out through different equipments, such as Bomb Calorimeter, CHNO-S analyzer, Muffle furnace, etc. by crushing the woody samples in powder form using available tools and the data.

The schematic diagrams of newly fabricated model are shown in Table 1. Cast iron, Galvanized Iron sheet and rod were used as a material of construction for biomass cookstove and for insulation purpose simply mixture of mud and wheat husk was used. All the experiments were carried out according to BIS protocol and it was found that all the cookstove models show a good performance in terms of thermal efficiency, power output, value of emission of CO and total particulate matter (TPM).

As per the burning capacity of the cookstove the quantity of water in each pot was optimized and it was different for each cookstove. The experimental data for each pot was collected. The temperature of water, pot, lid, ambient, dry, flame and outer surface temperature of cookstove were measured at an interval of 5 minutes. The energy efficiency with other parameters was evaluated for each experiment.

(i) Modified Natural Draft Gasifier Cookstove

The photographic view of this particular model can be seen from at serial number 1 of the Table 1. Mild steel and galvanized iron sheets were used in the manufacturing of this model. The testing of

this model was done as per the revised (BIS, 2013) protocol and the various results obtained from standard Water Boiling Test (WBT), Emission and Particulate matter measurement

are shown in the Table 1. This one of the unique model modified based on the gasification principle. All the parameters of this cookstove model are in the set limit of the BIS. The values of thermal efficiency (30.25%), CO (3.2 g/MJd), TPM (332.2 mg/MJd) are in the set limit of standard testing protocol. The further modifications and testing is going on for better performance.

(ii) Modified Traditional Cookstove (Natural Draft, Two burner)

The photographic view of this particular model can be seen from at serial number 2 of the Table 1. Mild steel and galvanized iron sheets were used in the manufacturing of this model, mud and wheat straw mixture was used for insulation. The testing of this model was done as per the revised (BIS, 2013) protocol and the various results obtained from standard Water Boiling Test (WBT), Emission and Particulate matter measurement are shown in the Table 1.This one of the unique model modified based on the gasification principle. All the parameters of this cookstove model are in the set limit of the BIS. The values of thermal efficiency (26.84%), and CO (4.68 g/MJ_d), are in the set limit of standard testing protocol, whereas the value of TPM (394.31 mg/MJ_d) and surface temperature (67.17 °C) are little bit here as the set value. The further modification and testing to reduce the TPM and surface temperature is going on as per BIS protocol.

6.2.2 Biomass Cookstove Testing and Certification Centre

The development of cookstove testing facilities under the R&D project sanctioned by MNRE with an outlay of Rs. 97.908 lakhs in March, 2014. The purchase of necessary equipment required for the testing and certification centre is to be done as soon as the reallocation of budget is approved by MNRE. However, testing of cookstove is ongoing per new BIS (BIS, 2013) while taking help and support from other test centres viz. IIT, Delhi.

6.3 Biochemical Conversion Division

Biochemical Conversion Division has been established in R&D-II with the facilities of Analytical, Bioprocess, Microbiology and Molecular Biology Laboratories. Analytical laboratory contains the equipments such as HPLC, Gas Chromatography, UV-vis spectrophotometer and Fibretech; Bioprocess laboratory contains the equipments such as Bioreactor (3.0 & 7.5 L), Refrigerated Centrifuge, Water Purification System, Lyophilizer, Microdisintegrator, Water Bath, Autoclaves, etc.; Microbiology laboratory contains the equipments such as Environmental Shaker, Microscope with camera, Incubator, CO_2 Incubator-cum-shaker, BOD Incubator, Hot Air Oven, Horizontal Laminar Flow, Automatic Colony Counter, Deep Freezer, Refrigerators and Molecular Biology laboratory contains the equipments such as Gradient PCR, Real Time PCR, Biophotometer, SDS-PAGE, 2-D gel Electrophoresis, Horizontal Gel Electrophoresis, Gel Documentation and Electroporation Unit.

6.3.1 Process Development for Ethanol Production from Agricultural Residues

An MNRE funded project entitled 'Process development for bioethanol production from agricultural residues, Phase-I: Development of process for co-fermentation of hexose and pentose sugars of agricultural residues' has been completed on Oct 31, 2015. The report has been submitted to MNRE. The following work has been completed under the project:

Medium composition of two isolated thermotolerantethanologenic yeast strains, *Kluyveromycesmarxianus* NIRE-K1 and *K. marxianus* NIRE-K3 have been optimized for both growth and fermentation, using RSM with Design-expert software. Enhancement of ethanol production was carried out by optimization of medium components for both growth and fermentation for both the isolates, using FCCD. After numerical optimization, growth medium containing (g l^{-1}) yeast extract

4.81, K_2HPO_4 1.10, NaH_2PO_4 1.05, $MgSO_4$ 0.95 and $(NH_4)_2SO_4$ 1.99 was found optimal, whereas for fermentation, the optimized medium composition were (g l-1) yeast extract 2.93, K_2HPO_4 1.99, NaH_2PO_4 0.24, $MgSO_4$ 0.42 and $(NH_4)_2SO_4$ 1.34 using the isolate *K. marxianus*NIRE-K3. In case of *K. marxianus* NIRE-K1, the optimized medium compositions (g l-1) were yeast extract 5.0, K_2HPO_4 1.35, NaH_2PO_4 1.05, $MgSO_4$ 1.0 and $(NH_4)_2SO_4$ 1.23 for the optimized growth and yeast extract 3.71, K_2HPO_4 0.11, NaH_2PO_4 1.51, $MgSO_4$ 0.84 and $(NH_4)_2SO_4$ 2.0 for the fermentation. Studies on batch fermentation kinetics using the optimized values of the medium composition for *K. marxianus* NIRE-K1 and NIRE-K3 revealed an increase in ethanol yield by 11.36 % and 10.42 %, respectively.

Studies on flux balance analysis were carried out for both the isolates in glucose/xylose mixture (4:1 and 1:1) with the objective of maximization of bioethanol production. The results predicted by the software were found to be in close agreement with the experimental values, thereby, suggesting that both the isolates could be used for maximum bioethanol production in glucose/xylose mixtures. The flux balance analysis also revealed the active role of pentose phosphate pathway for xylose utilization in both the isolates. A comparison between the cultivations of 4:1 and 1:1 g l^{-1} glucose/xylose mixture revealed that the flux from glucose-6-phosphate to ribulose-5-phosphate was almost 2.56-fold and 3.75-fold higher in 1:1 mixture in *K. marxianus* NIRE-K1 and *K. marxianus* NIRE-K3, respectively. Overall, the fluxes towards ethanol formation in *K. marxianus* NIRE-K3 were found to be higher than *K. marxianus* NIRE-K1 by 2 % and 1.8 %, in 4:1 and 1:1 glucose/xylose mixtures, respectively. Tri Carboxylic Acid cycle was found to be incomplete for both the isolates.

After pretreatment of paddy straw with sodium hydroxide under optimized conditions, it was subjected to scarification and fermentation in two different configurations, viz. separate hydrolysis and fermentation (SHF) and simultaneous scarification and fermentation (SSF) by using CellicCtec 2 and *K. marxianus* NIRE-K3 cells using bench-scale bioreactor at 45^{0}C, which resulted in 38.30 g ethanol per kg of raw paddy straw in SHF configuration, whereas in SSF configuration, 182.22 g ethanol/ kg of raw paddy straw was obtained.

Future Recommendations

Thermo tolerance of the isolates facilitate the in-situ ethanol recovery of ethanol, which minimizes product inhibition, simultaneous scarification and fermentation (SSF) with the celluloses which have optimum temperature of 50°C. However, the rate of xylose utilization is very low (0.47 g l^{-1} h^{-1}) as compared to glucose (8.33 g l^{-1} h^{-1}), which makes the yeast strain non-competitive for complete utilization of lignocelluloses. Apart from the slow xylose uptake, the yeast utilizes xylose for xylitol production. This yeast requires modification at genetic level for xylose transporter and other metabolic enzymes, which participate in the assimilation of xylose. The presence of genes for XR, XDH and xylulose kinase (XK) in this yeast make the genetic modification easier as compared to S. cerevisiae. Therefore, the further research is required for the development of robust yeast for complete utilization of lignocellulosic sugars to ethanol.

6.3.2 *Biogas production and utilization for heat and power generation applications using potential alternative feed-stocks*

An MNRE funded project entitled 'Biogas production and utilization for heat and power generation applications using potential alternative feed-stocks' is going on since Nov 2014.

6.3.2.1 Optimization of parameters for anaerobic digestion of vegetable waste

The effect of Seed (inoculum) and Moisture on biogas production for Biohydrogen and Biomethane from vegetable waste using anaerobic digestion (AD) process on a batch scale at thermophilic condition (52°C) was quantified. The optimized conditions for biogas production for both methane and hydrogen were found to be 30% seed and 97% Moisture. Cumulative yield of

biogas for methane and hydrogen was 1026.5 L/Kg dm and 430.4 L/Kg dm respectively. Average methane content and carbon dioxide are 62.4% and 27.4%. Average Hydrogen content and Carbon dioxide content was 30.7% and 50% respectively. The HRT for Hydrogen was 5 -10 days and for methane HRT was 20-25 days. Biomass conversion in all the batches was 50%-84% with maximum (84%).

6.3.2.2 Biogas production from Garden Grass

The effect of Seed (inoculum) and Moisture on biogas production for Biohydrogen and Biomethane from Garden Grass using anaerobic digestion (AD) process on a batch scale at thermophilic condition (52°C) was quantified. The optimized conditions for biogas production were found to be *30% seed and 97% water*. Cumulative yield of biogas on basis of consumption of dm (dry matter) was 1070.5 L/Kg dm against predicted value was 1071.90 L/Kg dm. Average methane content and carbon dioxide content in this batch was 54.9% and 36.1%.The HRT of all batches was 16-20 days. Biomass conversion in all the batches was 50%-72%.

6.3.2.3 C/N ratio Optimization for Paddy Straw

On lab scale, study has been done for optimization of C/N ratio for paddy straw. The C/N ratio has kept in five sets as 10, 15, 20, 25, and 30 to check the working efficiency of micro-organisms in terms of biogas yields (ml/g). The experiment has been conducted with 5% solid loading and 10% seed on wet biomass basis (w/w) at 52°C with HRT of 12 days in batch. The biogas yields obtained from the above mentioned five sets of C/N ratios were 223.75, 249.5, 281.75, 316.50 and 305.50 ml/g of dry paddy straw, respectively. The results have shown that the biogas yields increased as the C/N ratio increases till 25 and declines at 30. Therefore, C/N ratio, 25 has been considered as optimized ratio at which biogas yield was highest.

6.3.2.4 Optimization of Biomass (Paddy Straw) Size

Another lab-scale study is going on paddy straw to optimize its size in terms of effect on biogas yield. The size range has been considered for the above planned experiment are- 5.6mm, 2.8mm, 1mm, 710µm, 300µm and 75µm. However, the other conditions were similar to the previous ones i.e. 5% solid loading, 10% seed (w/w) C/N ratio, 25 at 52ºC for 12 days of HRT.

6.3.2.5 Study of Biogas Pilot Plant (1m^3/day)

Cow dung based biogas pilot plant installed in the Biochemical Conversion Division, SSS-NIBE Campus was studied for daily biogas production and methane content. The biogas production was observed to be 0.4-0.6 m^3/day. Methane content varied from 50%-65%. The produced biogas was tested for its cooking potential based on time in comparison to liquid petroleum gas (LPG). It was observed that 1 L water took about 18-20 min to boil, when biogas was used as a fuel at STP as compared to 10 min, when LPG was used as a fuel through cylinder.

Study have been done on 1cum capacity biogas plant (floating drum) working on institute's waste garden-grass for one month. Thermophilic consortium has been used as inoculum in the plant. Daily 2 kg of grass was fed to the digester and 0.3 cum biogas per day has been obtained. The body of the biogas digester is made up of PVC material which doesn't have any thermal conduction property in it. Therefore, to run the plant at thermophilic conditions the design of the digester has to be modified. Hence, the designing part has been done and given to procure the required materials for further experimentation on the present plant.

6.3.2.6 Molecular Study of Isolated thermophilic consortia

The study of identification of methanogens and other bacteria such as hydrolytic, acidogenic and acetogenic which are present in the isolated thermophilic consortia was performed. Primer designing for all the bacteria was done and amplified in PCR after DNA extraction from the

consortium. During the experiment the extracted DNA fragments got successfully amplified with the designed primers for Hydrolytic bacteria, Acidogenic bacteria, Acetogenic bacteria except the methanogenic bacteria. The amplified genes were run on the agarose-gel. Further, primers for methanogens have to be designed again due to the previous failure and that work is going on.

6.3.3 *Process development for enhanced biobutanol production using butanol-tolerant isolate*

A start up research grant project entitled "Process development for enhanced biobutanol production using butanol-tolerant isolate" has been sanctioned by Science and Engineering Research Board (SERB), DST to Dr. Shuvashish Behera, Young Scientist cum Project Principal Investigator to work at SSS-NIBE vide File No. YSS/2015/000295 dated 13 November 2015 at a total cost of Rs. 32,30,000/- (Rs. Thirty Two Lakh Thirty Thousand Only) for a duration of three years. The first instalment of the grant for Rs. 10,50,000/- (Rupees Ten Lac Fifty Thousand Only) for F.Y. 2015-2016 under the above mentioned project has been received by the Institute.

Butanol production through acetone-butanol-ethanol (ABE) fermentation using some microbial species has regained much attention recently. The major challenges in biobutanol production are solvent toxicity, availability of compatible feedstocks, low butanol titer, anaerobic nature, slow growth rate of microorganisms and product inhibition. Despite their importance at a biofuel production platform, a limited number of butanol-tolerant bacteria have been identified so far. Therefore the current project aims to make an attempt for the isolation of butanol tolerant microorganisms and further application for the development of a process for the enhancement of high concentration of biobutanol production. Isolation of butanol tolerating mesophilic/thermophilic microorganisms was carried out using laboratory designed anaerobic system aerobically/anaerobically from the collected samples after butanol treatment for the production of biobutanol. Positive results were obtained in two samples so far for the biobutanol production at 37^{o}C anaerobically. The screening of cultures is going on.

6.3.4 *Identification and characterization of algal species for power generation*

Algal samples collected from natural water bodies were grown in BG11- broth under optimum growth conditions. These cultures were maintained in laboratory by sub-culturing. The purity of cultures was also checked periodically. The isolated strains (Scenedesmus, Chlorella, Anabaena, and Phormidium) were mass cultured in photobioreactor up to 50L volume. The TGA analysis showed the lipid content of 22% in Chlorella, 20% in Anabaena, 15% in Phormidium, 24 % in Scenedesmus. The analysis of protein, carbohydrate and chlorophyll contents is in progress.

The trials of biogas up-gradation were also done and results were promising. The algal cultures (Chlorella and Scenedesmus) purged with biogas at a constant flow rate showed higher growth as compared to control. Significant changes were noticed in the biogas composition by GC analysis before and after the experiment. Decrease in nitrogen and carbon dioxide percent with increase in methane percent along with increased level of oxygen was observed. The growth profile of microalgae cultivated was also analyzed. Chlorella exhibited approximately 26% increase in methane percentage while CO_2 was decreased by 20%. Similarly, in case of Scenedesmus there was an increase of 30% methane percentage with reduction of CO_2 by 33%. The results demonstrate a high tolerance of microalgae cultures to upgrade biogas by increasing the efficiency of methane in the biogas. The growth in terms of optical density indicated comparatively higher biomass in biogas supplemented reactor than the control. The optical density reached 0.5 at 5th day of cultivation in Chlorella and 0.7 in Scenedesmus in biomass treated culture which was comparatively higher than the control. Therefore, it can be concluded that algae can be utilized for increasing the purity of biogas by generating huge biomass at the same time. The CO_2 sequestered in this way, not only

contributes to a cleaner environment but also the biomass produced can also be utilized further in various applications.

6.3.5 *Development of yeast strain with enhanced xylose utilization and ethanol production*

6.3.5.1 Fermentation and gene expression analysis of adapted *Kluyveromycesmarxianus* NIRE-K1 and NIRE-K3.

The isolated cultures named *K. marxianus*NIRE-K1 and NIRE-K3 were successfully developed for the xylose utilization and ethanol production through the evolutionary adaptation approach. However the utilization rate is slow under anaerobic condition. *K. marxianus*NIRE-K1 and NIRE-K3 were adapted in YEPX medium containing 20 g/l xylose up to 80 batches followed by the evaluation of culture progress was determined. After a maximum metabolism of xylose was achieved and no more increment was observed the culture was again adapted in the salt medium containing 20 g/l xylose. The evaluation of the culture was done every 10 batches and after the 54 batches the cultures *K. marxianus* NIRE-K1 were completely utilizing the 20 g/l xylose within 22 h, whereas *K. marxianus* NIRE-K3 was utilizing the same, within 18 h. The cultures were evaluated in terms of their metabolic enzyme activity, gene expression level, co-enzyme quantification and the fermentation capacity.

6.3.5.2 Growth analysis

Native *K. marxianus* NIRE-K3 vs Adapted *K. marxianus* NIRE-K3- The growth analysis on both the adapted and native *K. marxianus* NIRE-K1 was carried out in 3-L bioreactor under controlled condition. As resulted, the native strain finished 20 g/l xylose in 22 h whereas the adapted strain utilized the same concentration in only 18 h. The dry cell weight of the strain was measured where native and adapted *K. marxianus* NIRE-K1 obtained 7 g/l DCW (Fig. 3.1).

Native *K. marxianus* NIRE-K1 vs Adapted *K. marxianus* NIRE-K1- The growth analysis on both the adapted and native *K. marxianus* NIRE-K31 was carried out in 3-L bioreactor under controlled condition. As resulted, the native strain finished 20 g/l xylose in 28 h whereas the adapted strain utilized the same concentration in only 22 h. The dry cell weight of the strain was measured where native *K. marxianus* NIRE-K1 obtained 8 g/l DCW and adapted strain obtained 5.93 g/l DCW (Fig. 3.2).

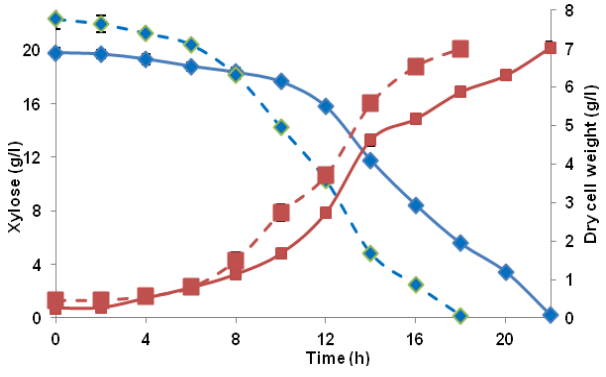


Fig. 3.1. Comparison of growth pattern between native (---) and adapted (54 batches) *K. marxianus*NIRE-K3 (—) using xylose as a carbon source, (♦) Residual xylose; (■) Dry cell weight.

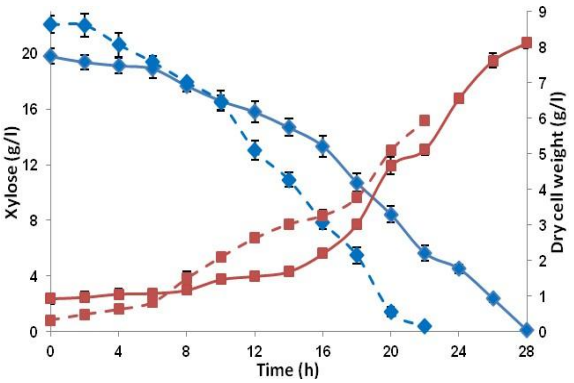


Fig. 3.2. Comparison of growth pattern between native (---) and adapted (54 batches) *K. marxianus* NIRE-K1 (—) using xylose as a carbon source, (♦) Residual xylose; (■) Dry cell weight.

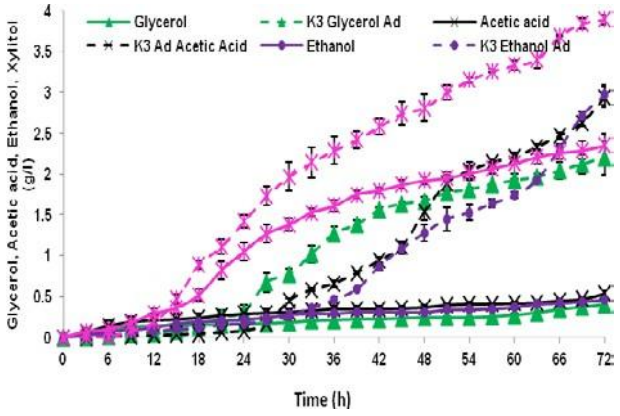


Fig. 3.3.Fermentation analysis of native and adapted *K. marxianus* NIRE-K3.

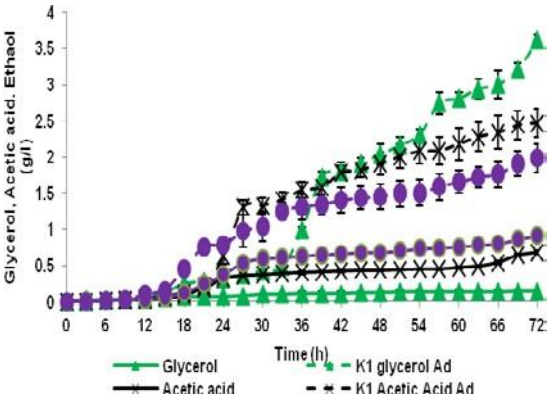


Fig. 3.4. Fermentation analysis of native and adapted K. marxianus NIRE-K1.

6.3.5.3 Fermentation analysis

Native *K. marxianus* NIRE-K3 vs Adapted *K. marxianus* NIRE-K3- The fermentation analysis of both native and adapted strain was carried out to determine the xylose utilization rate on anaerobic condition. As resulted, the adapted strain utilized 20.18 g/l xylose out of 30 g/l xylose initial and produced 2.97 g/l ethanol with 2.2 g/l glycerol, 2.94 g/l acetic acid and 3.89 g/l xylitol. On the other hand, native strain utilized only 8.31 g/l xylose out of 30 g/l xylose initial and produced 0. 46 g/l ethanol with 0.4 g/l glycerol, 0.54 g/l acetic acid and 2.35 g/l xylitol (Fig. 3.3).

Native *K. marxianus* NIRE-K1 vs Adapted *K. marxianus* NIRE-K1- The fermentation analysis of both native and adapted strain was carried out to determine the xylose utilization rate on anaerobic condition. As resulted, the adapted strain utilized 20.26 g/l xylose out of 30 g/l xylose initial and produced 1.94 g/l ethanol with 3.61 g/l glycerol and 2.47 g/l acetic acid. On the other hand, native strain utilized only 6.38 g/l xylose out of 30 g/l xylose initial and produced 0.94 g/l ethanol with 0.14 g/l glycerol and 0.68 g/l acetic acid (Fig. 3.4).

6.3.5.4 Gene expression analysis

Native *K. marxianus* NIRE-K3 vs Adapted *K. marxianus* NIRE-K3- The expression level of metabolic genes xyl1 and xyl2 was measured for both the native and adapted strain. As resulted, the adapted *K. marxianus* NIRE-K3 showed 2.53-folds and 6.99-folds higher expression level of xyl1 and xyl2 genes as compared to the native strains (Fig. 3.5).

Native *K. marxianus* NIRE-K1 vs Adapted *K. marxianus* NIRE-K1- The expression level of metabolic genes xyl1 and xyl2 was measured for both the native and adapted strain. As resulted, the adapted *K. marxianus* NIRE-K1 showed 2.23-folds and 7.73-folds higher expression level of xyl1 and xyl2 genes as compared to the native strains (Fig. 3.6).

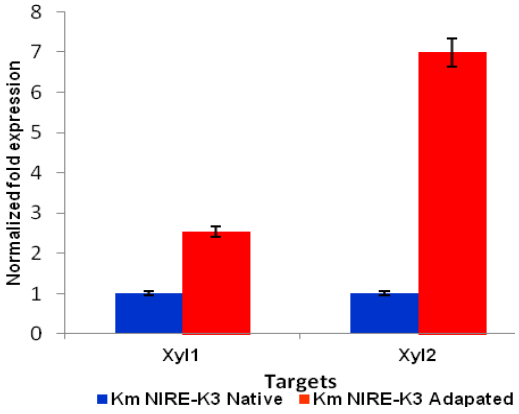


Fig. 3.5.Gene expression analysis of native and adapted *K. marxianus* NIRE-K3.

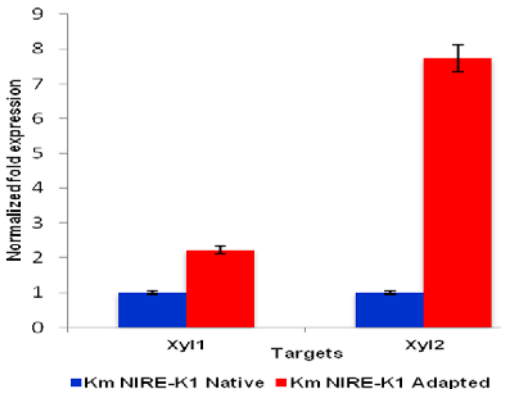


Fig. 3.6. Gene expression analysis of native and adapted *K. marxianus* NIRE-K1.

6.3.6 Pretreatment of paddy straw

Utilization of agricultural wastes (agro-waste) for biofuel production is widely advocated as it covers opportunities for both proper disposal of wastes and energy benefits. Nearly, 623.4 MMT/ Year (Million metric tons) of biomass generated in India of which, Punjab state contributes 40-45 MMT. Generation of paddy straw in Punjab is nearly 23 MMT/year of which most burnt in the field and creates air pollution. Paddy straw is lignocellulosic waste which consist of cellulose 43.32%, hemicellulose 17.5% lignin 21.57 % and silica 8% having more potential to generate ethanol however pretreatment became a necessary step. Therefore, by considering huge availability, potential of ethanol generation and need of pretreatment, the work is focused on the study of efficient pretreatment and their impacts on ethanol production from paddy straw.

Various pretreatment has been carried out such as alkali-MW, Urea-NaOH, Glycerol-NaOH and Glycerol thermal pretreatment (GTT). All the studied pretreatment shows positive effects on reducing sugar yield which, nearly *4-5* times more over control. Glycerol is a waste from biodiesel industry with high thermal capacity and could be a better choice for paddy straw pretreatment. GTT completely replace the requirement of chemical in pretreatment with conserving energy in the form of heat. GTT also shows one more advantage that there is very low generation of inhibitor and liquid extract of GTT could be converted into biogas.

6.3.7 *Biogas upgradation through membrane technology*

There are different techniques for the upgradation of biogas like water scrubbing, chemical absorption like amine scrubbing, pressure swing adsorption, cryogenic separation, biological technique and membrane separation. In literature survey of these techniques, shows their advantages, disadvantages, cost effectiveness and biogas upgradation through membrane technology are very effective and easy to operate.

Membranes are becoming a competitive technology for the separation process as compared to conventional methods like cryogenic distillation, chemical and physical absorption. Membrane gas separation method has played very important role in many environmental and energy processes such as CO_2 separation, natural gas sweetening, volatile organic compounds (VOC) recovery, hydrogen production and biogas upgradation. Membranes have been found to be suitable for the wide scale application in biogas industries due to their reasonable cost, inertness, good selectivity and easily engineered design. Gas separation with membranes has emerged into a commercially viable method in these days. Due to increasing efficacy of the membrane in industrial process, the

membrane now evolved from laboratory tools to industrial processes. Now a days, several hundred membrane technology based plants were used for the separation of gases. Membrane based module was used for enrichment of methane and 96-98% of methane enrichment occurred using membrane technique. It is very effective for the complete removal of CO_2. As CO_2 contents in the biogas is the main cause of reducing its calorific value as well as not to directly use biogas as vehicle fuel. The main emphasis of this work is to upgrade the biogas through membrane technology up to that level, that it will meet the standards required for its use as vehicle fuel.

6.4 Chemical Conversion Division

The equipment facilities available under this division includes Gas Chromatograph dedicated for biodiesel analysis viz. % Fatty acid methyl ester conversion, monoglyceride, diglyceride, free glycerol content in biodiesel, and hydrocarbons up to the boiling range 380^0C, Rams bottom Carbon Residue, Oxidation Stability Apparatus, High Pressure High Temperature Reactor, True Boiling Point Distillation Apparatus, Automatic Density Meter, Flash point apparatus(automatic open cup), Radleys Reactor, Rotary Vacuum Evaporator, Computerized Diesel Engine Test Rig and Exhaust gas analyser, FTIR, low temperature autoclave, Irox diesel etc. A few equipments are in the pipeline of procurement to complete the analysis facility as per ASTM or BIS Standards for green diesel and biodiesel testing. Several in-house R&D projects have been initiated under this division as elaborated under:

6.4.1 *Silica extraction form rice husk*

In continuation to our previous report on extraction of silica from rice husk ash (RHA) a novel protocol have been investigated for extraction of silica from husk and ash obtained from M/s Jagjit Industry which uses 100% rice husk for power production. In contrast to the reported literature for extraction of silica using strong acids weak organic acids were used and found some appreciable results. The objective is to substitute the acids from biomass precursor in due course of time. Some important findings of the process are as under:

Work Done:

- RHA washing with weak acids (inorganic and organic) of various molarities has been attempted to remove mineral impurities.
- Silica extraction is based on its PH based solubility i.e., alkali extraction followed by acid precipitation.
- Weak inorganic and organic acids are effective as like strong acids reported so far.
- Silica yields as high as 93.7% and 87.6 % has been achieved, silica presence is confirmed with predominant peak at 1060 cm-1 in FTIR spectra.

Work to be done:

- Optimization of silica extraction process.
- Characterization of silica using BET, XRD and EDX / XRF for better understanding of its quality, the facility for which is not available at the Institute and may be carried out in collaboration with some other university and Institution where such facilities are available.

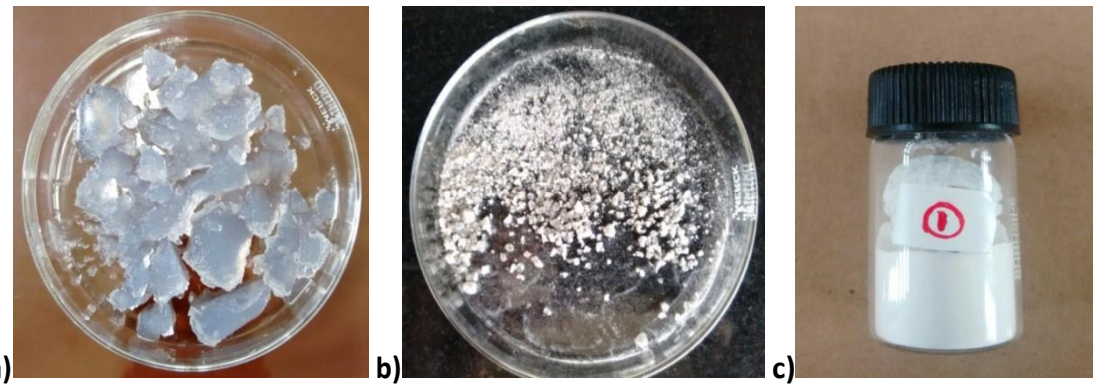


Fig. 4.1. a) Silica gel **b)** Silica after drying at 110°C for 24h **c)** Silica powder

6.4.2 Characterization and testing of different bio fuels on a stationary four stoke single cylinder D.I compression ignition engine for farm machinery applications:

The objective of the experimental study was to test of green diesel in automobile engine and compare these results with other tested results because the results of previous studies were not satisfactory (greendiesel tested in stationary CI engine). The test results are mentioned in this report and due to the improved quality of Green Diesel (high calorific value) it is not suitable for stationary engine without modifications. The other objective is to prepare the microemulsion of oil with low cost/easily available alcohols.

To validate the effects of Green diesel on engine performance it was tested with low compression ratio of CI engine. Brake thermal efficiency, brake specific fuel consumption, carbon monoxide emission, unburnt hydrocarbon and oxide of nitrogen results are mentioned for proper understanding and compare these results with petrodiesel.

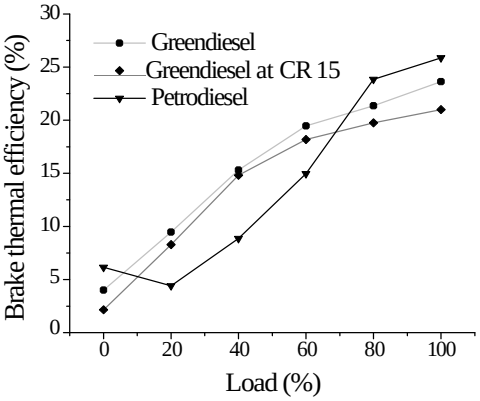


Fig. 4.2. Variation of BTE v/s load

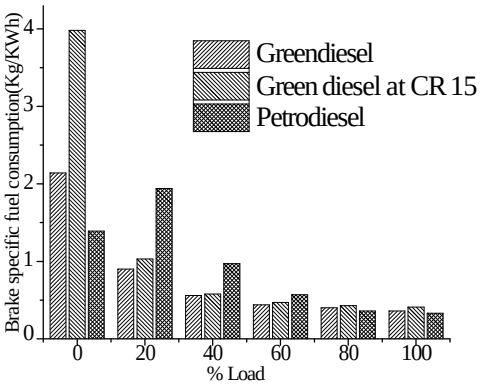


Fig. 4.3. Variation of BSFC v/s load

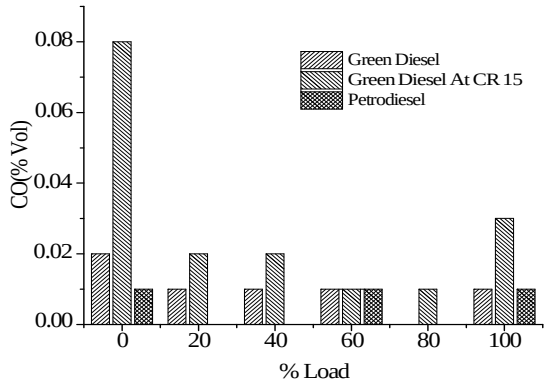


Fig. 4.4 Variation of CO v/s load

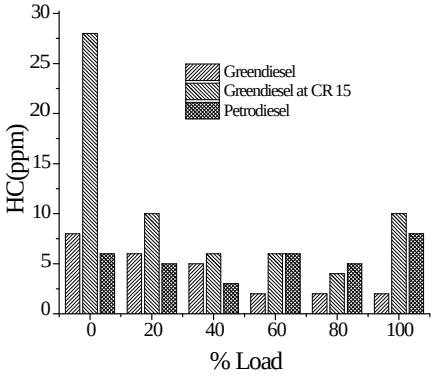


Fig. 4.5. Variation of HC v/s load

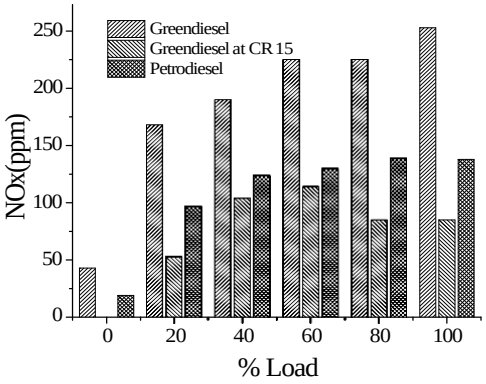
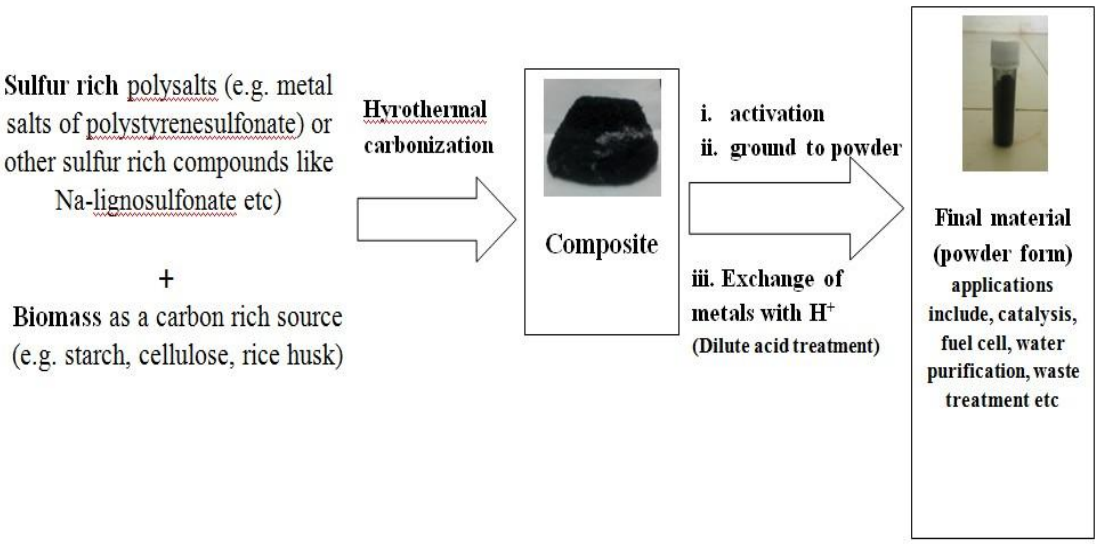


Fig. 4.6. Variation of NOx v/s load

It is clearly seen from the figures 4.2 to 4.6 that green diesel test results are unfortunate with petro diesel results. Although the green diesel properties are superior to petro diesel but due to unsupportive system (stationary CI engine), its results are not good. So, it is decided to test this fuel on automobile engine for better experience.

Process development for valorization of glycerol into fuel additive using solid acids



Scheme 1. Novel scheme developed for the conversion composites of (sulfur rich organic compounds or wastes)/ (sulfur rich organic compounds or wastes + biomass) to high value acidic carbon materials with potential application as solid catalysts, ion exchange resin etc.

In continuation to the work on the ketalization reaction for conversion of crude glycerol into value added products, sulfonic acid (-SO3H/ PhSO3H) functionalized and phosphoric activated biochar (HTPS or Cat0, PACS or Cat1, PACS2 or Cat 2 from de-oiled seed cake) shows catalytic activity for the ketelization of glycerol to solketal (a fuel additive and industrially important commodity product). Maximum glycerol conversion of 84% with 99% solketal selectivity could be obtained in multiple reaction cycles (resulting from the presence of highly stable C-PhSO3H bonds). The reaction is exothermic and optimization results with Cat2 show 30 °C to be favorable for highest yield. The observed activity is superior to equimolar amount of conc. H2SO4 (Figures 1-4), but further comparison with commercial acidic catalysts (e.g. zeolites: H-ZSM-5, H-Y, H-beta, ion exchange resins: Amberlyst 15, Amberlyst 35) are still need for publication of the results. Although, an increased reaction temperature (30-60 °C) favored higher rates, a reduced yield was observed due to equilibrium sifting in backward direction (characteristic of exothermic reaction). Further the obtained product demonstrated significantly reduced viscosity, density and was found to be suitable for blending with biodiesel, diesel and gasoline.

6.4.3 Synthesis of supported catalyst for efficacy improvement of hydroprocessing of vegetable oil

Biomass based thermal power plant fly ash (BBTPFS) was used as catalyst support for hydro processing of non-edible vegetable oil. A few conventionally used catalyst was used for hydroprocessing as reported in our previous work. But the results obtained with respect to % conversion of oil to bio crude and distillates are not encouraging and less than BBTPFS or Na_2CO_3. In view of the above the reactions have been shifted to some other catalyst such as increased %age of CaO, to that with BBTPFS.

The catalyst BBTPFS was also used as support for enzyme immobilization for transesterification to work at room temperature with Mesuaferrea L oil. The result was very encouraging and upto 82% oil having high %age of free fatty acids could be converted.

7. RESEARCH AND DEVELOPMENT (R&D) PROJECTS

7.1 Completed Projects:

- **Process development for bioethanol production from agricultural residues, Phase-I: Development of process for co-fermentation of hexose and pentose sugars of agricultural residues (PI: Dr. Sachin Kumar) (MNRE, Govt. of India)**.

MNRE funded research project on 'Process development for bioethanol production from agricultural residues, Phase-I: Development of process for co-fermentation of hexose and pentose sugars of agricultural residues' is undergoing since May 2012. The total cost of the project is INR 132.19 Lakhs for three years. Two thermo tolerant yeasts namely NIRE-K1 and NIRE-K3 were isolated from the soil samples and screened for ethanol fermentation with high ethanol yield and ability to utilize both pentose and hexose sugars. Both the isolated yeasts have been identified by Microbial Type Culture Collection and Gene Bank, Institute of Microbial Technology, Chandigarh as *Kluyveromyces marxianus*. Both the strains have been found to be

distinct characteristics as genetically as well as functionally. Both *K. marxianus* NIRE-K1 and NIRE-K3 showed the diauxic growth on hexose and pentose sugars. Both the strains are able to utilize the sugars present in the crop residues including paddy straw after enzymatic saccharification at 45^{0}C.

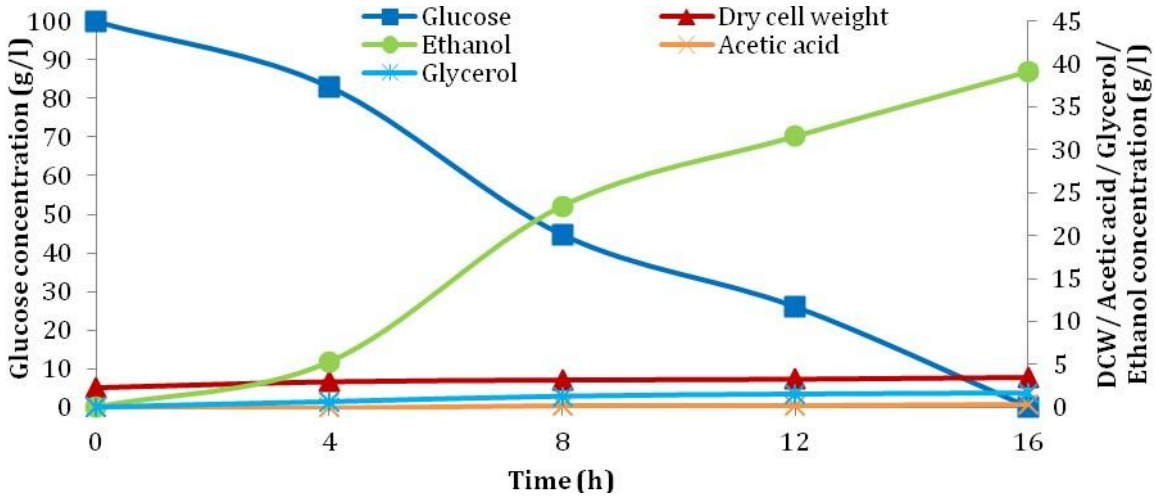
A study was carried out for the optimization of medium components (yeast extract, di-potassium hydrogen phosphate, sodium di-hydrogen phosphate, magnesium sulphate, ammonium sulphate) using RSM using Design-Expert Software Version 8.0 software for both the isolates *K. marxianus* NIRE-K1 and NIRE-K3 to increase ethanol production. Face-centered Central Composite Design (FCCD), with quadratic model was employed to study the combined effects of the salts. Dependent variable or response was maximum specific growth rate (h^{-1}) for optimization of growth. Equations were calculated with the statistical package (Stat-Ease Inc, Minneapolis, MN, USA) to estimate the response of the dependent variable. To validate the authenticity of software generated model, a confirmation experiment with duplicate set was performed under optimized concentrations of all the salts. The results were very close to the predicted value. Data indicates that the established model is reliable. The optimized media parameter (in g/L) for *K. marxianus* NIRE-K1 (yeast extract-4.3, di-potassium hydrogen phosphate-1.98, sodium di-hydrogen phosphate-0.15, magnesium sulphate-0.27, ammonium sulphate-1.9) and *K. marxianus* NIRE-K3 (yeast extract-2.78, di-potassium hydrogen phosphate-1.22, sodium di-hydrogen phosphate-0.18, magnesium sulphate-0.12, ammonium sulphate-1.97) have been obtained. Fermentation Profile of K. marxianus NIRE-K1 and NIRE-K3 in a Bench-scale bioreactor is shown in Fig. 1.

A comparative study was carried out between two thermotolerant yeast such as *Kluyveromyces marxianus* NIRE-K1 and NIRE-K3 and two mesophilic yeast such as *Saccharomyces cerevisiae* MTCC 170 and *Candida tropicalis* MTCC 230 through an assay showing xylose transporter for the transportation of xylose sugar. An assay was done at 5^{0}C temperature intervals to know the optimized temperature using the xylose analog p-nitrophenyl-β-D- xylopyranoside (pNPX) to detect the expression of β-xylosidase activity in its intact, intracellular and extracellular cell. Out of all type of yeasts, S. cerevisiae MTCC 170 showed very little growth in xylose containing medium without any utilization of xylose sugar and further showed zero xylosidase activity with intact, extracellular and intracellular cells. All the strains showed optimized temperature for the highest xylosidase activity which was higher than that of the growth temperature (Table 1).

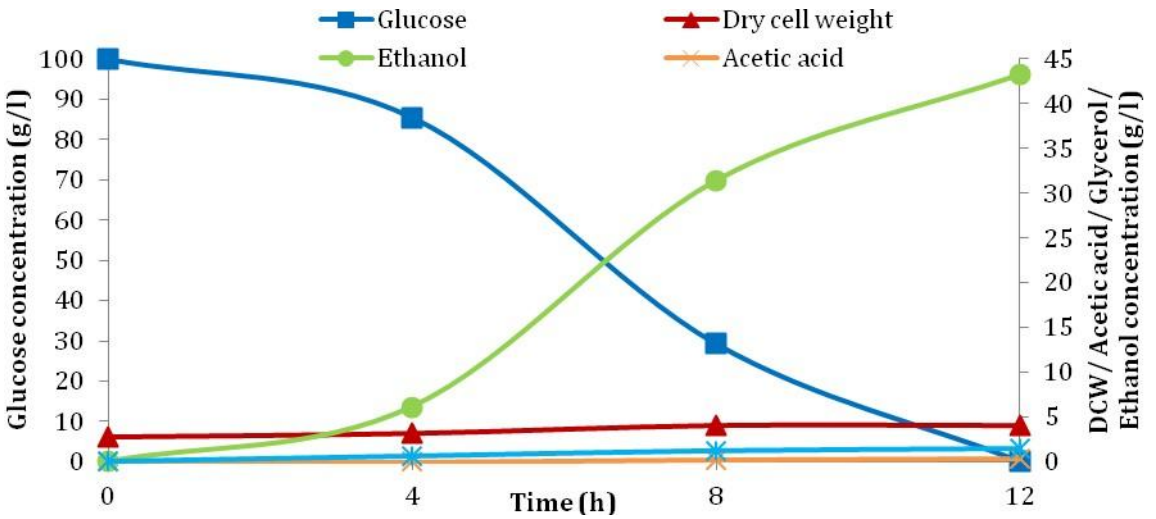
Table 1. Optimized temperatures of three types of yeast showing xylosidase activity

Strain	Cell Type	Optimized temperature (^{0}C)	pNP (nmol/mg DCW)
Kluyveromyces marxianus NIRE-K1	Intact	50	138
	Intracellular	50	1.54
	Extracellular	60	2.09
Kluyveromyces marxianus NIRE-K3	Intact	50	148.6
	Intracellular	50	1.76
	Extracellular	60	2.33
Candida tropicalis MTCC 230	Intact	45	85.56
	Intracellular	35	0.48
	Extracellular	35	1.66

The activity of xylose transporters for both the isolates has been carried out and comparison has been made between wild and adapted strains. A comparative study was carried out using adapted and wild cells of *K. marxianus* NIRE K1 and *K. marxianus* NIRE K3 through an assay showing xylose transporter activity. An assay was carried out using the xylose analog p-nitrophenyl-β-D-xylopyranoside (pNPX) to detect the expression of β-xylosidase activity in its intact cells. In general, pNPX is absorbed by the cell through transporter and is cleaved into p-nitrophenol (pNP) by xylosidase in vivo. The yellow compound pNP is then secreted and detected outside the cell. In this study, the intact cell xylosidase activity (the conversion rate of pNPX to pNP) of the strain was measured showing the expression of xylosidase gene. The amount of pNP secreted by the yeast cells showed time-dependent linearization even in 120 min. The result revealed that the intact cell activity of adapted *K. marxianus* NIRE K1 yeast was higher than wild yeast as 0.23 ± 1.26 and 0.19 ± 0.2 U (g DCW)$^{-1}$, respectively as shown in Fig. 1. Similarly, adapted cells of *K. marxianus* NIRE K3 yeast was higher than the wild one as 0.19 ± 0.02 and 0.18 ± 0.29 U (g DCW)$^{-1}$, respectively (Fig. 2). However, the wild and adapted cells of *K. marxianus* NIRE K1 showed 5.3 and 17.4% higher xylosidase activity than the *K. marxianus* NIRE K3 yeast cells.



(A) *K. marxianus* NIRE-K1



(B) *K. marxianus* NIRE-K3

Fig. 1: Fermentation profile of thermotolerant ethanologenic yeast *K. marxianus* NIRE-K1 and NIRE-K3 developed at SSS-NIRE in a bench-scale bioreactor

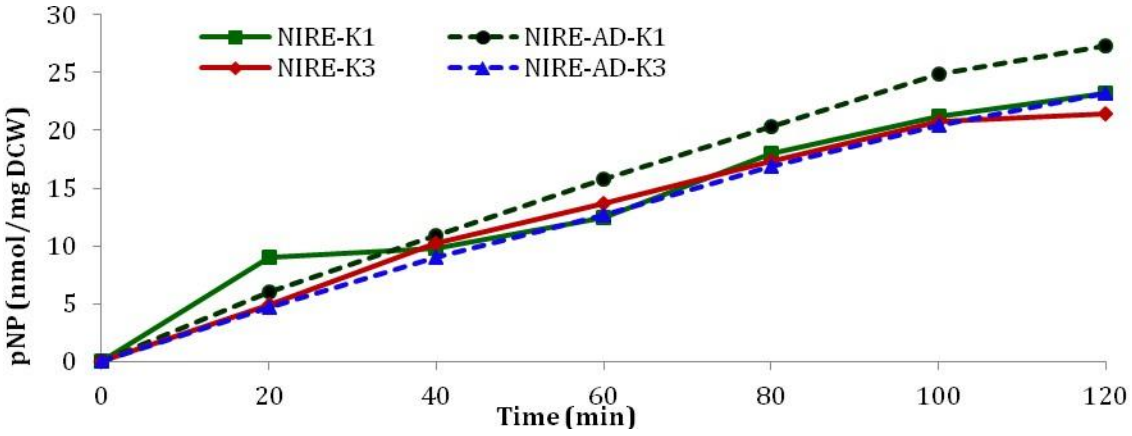


Fig. 2. Xylose transporter activity among adapted and wild isolates

7.2 Ongoing Projects:

➢ **Biogas production and utilization for heat and power generation applications using potential alternative feed-stocks (PI: Dr. Sachin Kumar) (MNRE, Govt. of India).**

A consortium of thermophiles was isolated from the soil samples. The thermophilic consortium of microbes was able to digest water hyacinth and crop residue such as paddy straw anaerobically at 50-55^{0}C and able to produce with 60-65% methane composition. The consortium has been applied for the digestion of paddy straw and kitchen wastes anaerobically for biogas production in a temperature range between 50-55^{0}C. The paddy straw was digested in a short period of time i.e. 12-20 days as compared to conventional digestion with cow dung as 40-50 days for producing same amount of biogas (Fig. 3). The biogas yield was found to be 350 L/kg of paddy straw with methane composition of 60%. A comparative study of developed consortium with other reported is shown in Fig. 4. The optimization of different conditions/operating parameters such as temperature, seed concentration, urea concentration, pH, solid loading, etc. is going on using RSM using Design-Expert software Version 8.0 software. The screening and identification of different bacteria in consortium is also going on.

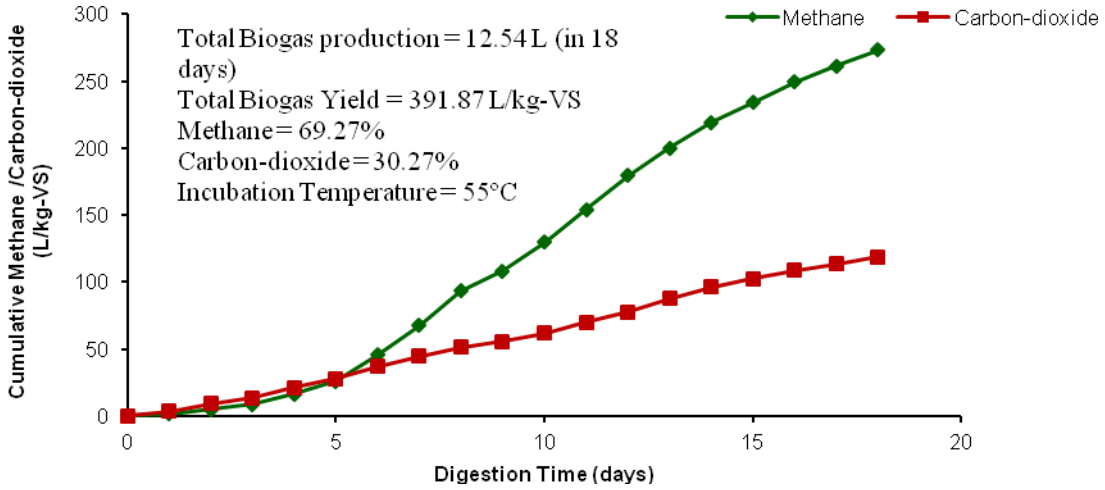


Fig. 3 Biogas production from rice straw using thermophilic consortium developed at SSS-NIBE

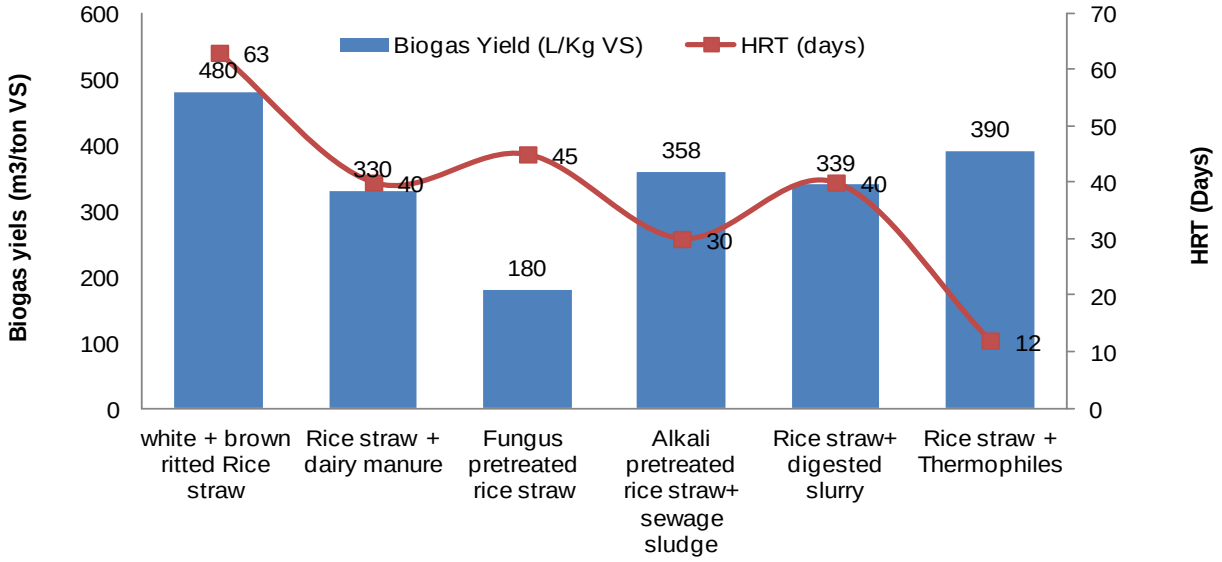


Fig. 4. Biogas production potential from rice straw using different inoculums

- **Biomass Cookstoves Testing and Certification Center at NIRE, Kapurthala (PI: Dr. S. K. Tyagi) (MNRE, Govt. of India).**

A project entitled "Biomass Cookstoves Testing and Certification Center at NIRE, Kapurthala" has been sanctioned with an outlay of Rs. 97.908. The work in this direction has started with the main objective is to develop a Testing and Certification Center for the State of Punjab, Haryana, HP and J&K and also to carry out the basic RD&D activities in the area of biomass cookstove with higher efficiency besides, to provide necessary technical assistance to different stakeholders in this region of the country. The detailed objectives of the project are as follow:

i) Establishment of well-equipped laboratory facility for carrying out performance testing of biomass improved cookstove per latest BIS norms (August 2013).
ii) Development of standards and test protocols for cookstove and fuel.
iii) Technical assistance/testing to biomass cookstove stakeholders in the region.
iv) To conduct training on operation and maintenance for SNA's, NGO's, Project developers, Industry etc. engaged in the implementation and promotion of cookstove in consultation with MNRE.
v) To carry out random field performance monitoring and evaluation biomass cookstove including indoor air quality near the kitchen space in the consultation with MNRE.
vi) Any other activities assigned by MNRE.

The establishment of the testing and R&D facilities for improved biomass cookstove is completed (Fig. 5) and the design and development of low cost durable and locally acceptable biomass cookstoves is on-going. BIS testing procedures are being followed for biomass cookstove (Fig. 6).

Fig.5. Biomass cookstove testing & certification centre at SSS-NIBE

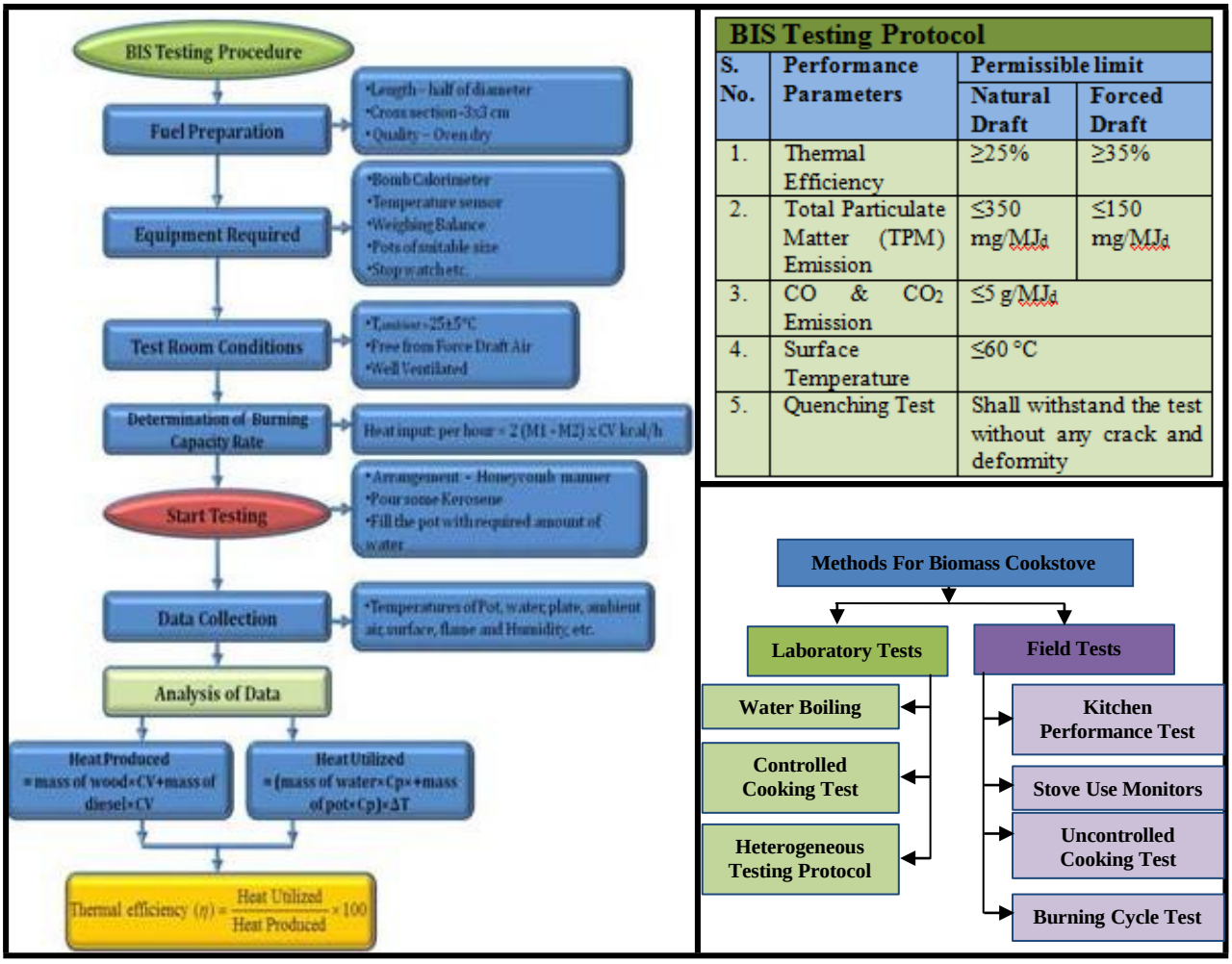


Fig. 6. Testing and certification procedure for biomass cookstove

Four cookstove models were received from different part of the country and all of the cookstoves were tested during the above said period. The details about each of the cookstove model is shown in Table 2.

Table. 2: Detail of cookstove tested during FY 2015-16

S. No.	Cookstove Model	Manufacturer	Address
Force Draft, Domestic size Cookstove			
1.	TERI-SPF1114SX	M/S Trues Steels Pvt. Ltd.	Village Kuranwala, Derabassi, Distt. Mohali, Punjab-140507
Natural Draft, Domestic size Cookstove			
2.	High Altitude Chulha	Pashupati Sheet Metal Industry	Sarwari Baajr Kullu-175101-(H.P)
3.	Natural Draft Biomass Burner (Modified)	AOV International	AOV International C-22/25, Sector-57, Noida-201301 (UP) India.
	Natural Draft Biomass Burner (Original)*		
4.	Premium Pragati Unnat Chulha	M/s B&G Renewables	M/s B&G Renewables, Solan, Himachal Pradesh

*Based on the testing results, the model was modified and resubmitted for testing as per MNRE's guidelines. The modified stove were again tested and the results are given here.

7.3 In-House Projects:

7.3.1 Biodiesel Production Testing Centre

The R&D activities on biodiesel production and application in CI engine for performance and emission characteristics using some other varieties of nonedible oil such as neem, moringaoleferia, bitter apricot and karanja were conducted. The experimental investigation under variable load condition with karanja biodiesel having B10 to B40 shows that B30 is most suitable blend for CI engine due to its high 1st and 2nd law efficiency. Also, oxygen content in the blends helps in better combustion. Exhaust analysis also showed that emission profile with respect to CO is less as compared to other tested fuels. Further the performance of B30 is comparable to petroleum diesel in all respect at full load condition. However, with neem biodiesel B10 was found to be the best fuel with respect to emission at maximum compression ratio and at highest load condition. The other performance parameters were comparable to petroleum diesel.

Similarly, the biodiesel obtained from moringaoleifera seed oil showed properties that meet ASTM D 6751 and En14214 with respect to % conversion, flash point, density, viscosity, carbon residue etc. Performance of the engine at all compression ratios showed a nominal overall decrease in the brake power with increase in blend ratio. Brake power was higher at higher compression ratio. The brake thermal efficiency in the blends decreased with the increasing % biodiesel in the blend.

The biodiesel production and process optimization was carried out for bitter apricot oil. Biodiesel production and glycerol separation with this oil is very easy and could be achieved in a single step with alkali catalyst. The biodiesel obtained was also properly characterized for fatty acid composition, fuel properties and subsequent engine performance analysis upto B40.

B10 and B20 blends showed highest 1st and 2nd law efficiency which is also higher than petroleum diesel at maximum compression ratio (1:18). All these observations showed that neem, karanja, moringa and bitter apricot oil can be effectively used for biodiesel production and utilization at domestic level because these oilseeds are locally available in Punjab, Himachal and Haryana.

7.3.2. Power generation using algal fuel cell in a biorefinery approach

Water samples were taken from the Kanjli Lake, Kapurthala and neighbouring paddy fields. Some samples were also collected from soil, digs, stones, tanks within SSS-NIRE premises. These were inoculated into Erlenmeyer flasks with appropriate growth medium (BG11). The flasks were kept in culture racks under proper illumination and temperature. When growth was observed, serial dilution technique was employed for isolation of monoalgal cultures. Streaking and spreading was also done, wherever needed. To maintain the purity of cultures, appropriate dosage of different antibiotics were used. Cultures were observed under microscope regularly and some pure colonies were obtained as shown in Fig. 8. The algal strains isolated so far, are *Anabaena*, *Chlorella*, *Phormidium* and *Scenedesmus*. These were maintained in laboratory by proper sub-culturing. *Chlorella* was mass cultured up to 50L volume and the biomass was harvested as shown in Fig. 9. Biochemical characterization of this alga is in progress along with other isolated strains. The efforts are to isolate more strains which can prove to be beneficial for the experiment.

7.3.3. Development of Biomass Gasifier Testing Centre

The comparison of three different biomass feed stocks has been investigated for 10 kW Downdraft Gasifier. The biomass feed stocks such as, mango seed, eucalyptus and melia wood stalks were selected. Mango seed was selected as it is a waste material available in abundance in India and also possesses high dry density, high HHV value and high fixed carbon content. Eucalyptus and Melia wood stalks are also selected because of their availability in bulk, high calorific value and comparatively low activation energies.

The gasifier system was operated as close as possible to the typical operation conditions with Mango seed, Eucalyptus and Melia feedstock as the fuel. The operation of Ankur WBG-20 gasifier was quite smooth and easily manageable with minimum man power requirement. Steady state syngas composition for each feed stock was determined by GC.

An R&D project entitled "Establishment of Gasifier Testing & Certification Centre at NIRE, Kapurthala" is being prepared and likely to be submitted to MNRE for funding.

8. COLLABORATION WITH OTHER ORGANIZATIONS

The Institute already has MoU with:

i. National Institute of Technology (NIT), Jalandhar

A MoU was signed on 16th August 2010 between SSS-NIBE, Kapurthala and NIT, Jalandhar to exchange the following activities on mutual interest which was later renewed in 2014:

- Joint guidance of students for PhD programme (completed 3, ongoing 3)

- Joint guidance of students for M. Tech programme (Completed 8 Nos)
- Mutual visits for academic exchange and intellectual enrichment
- Cooperation in conduct of short term course and dissemination of knowledge.
- Mutual sharing of infrastructure etc.

ii. Punjab Agriculture University, Ludhiana

A MoU was signed on 12th January, 2012 renewed on 8th June 2015 between SSS-NIBE, Kapurthala and PAU, Ludhiana to facilitate interaction between the Scientific, Academician, Research fellows and Students through the following arrangement:

- Joint R&D activities in the area of bio-energy research.
- Exchange of students pursuing their PhD.
- Joint organization of Conferences, Seminar, Workshop and Training programmes in the field of bio-energy sector.
- The library of both the institute may be availed by the staff, student, Scientists/Academicians.

iii. IKG-Punjab Technical University, Jalandhar

A MoU was signed on 4th March 2014 between SSS-NIBE, Kapurthala and IKG-Punjab Technical University, Jalandhar to have collaborative academic, research and faculty development programme in the area of Bio-energy and related field. A PhD program in Bioenergy is in continuation with IKG-PTU, for SSS-NIBE bioenergy promotion fellows.

iv. Tezpur University, Tezpur (Assam)

A MoU was signed on 22nd July 2014 between SSS-NIBE, Kapurthala and Tezpur University, Tezpur (Assam) as a gesture of goodwill between the two institutions, which may see the development of links in the areas of:

- Learning and teaching including the development of a programme leading to an award of doctoral and post-doctoral research in the area of bioenergy.
- Exchange of students/scientists for a given period through a recognized exchange programme.
- Exchange of documentation, research material and facilities.
- Co-ordination through their respective office in joint or collaborative research project.

The Insitute has signed the following MoU's during 2015-16:

i. Indian Institute of Technology, Ropar

A MoU was signed between SSS-NIBE, Kapurthala and Indian Institute of Technology, Ropar on 14th March 2016 to have collaborative academic, research and faculty development programme in the area of Bioenergy and related field.

ii. Panjab University, Chandigarh

A MoU was signed on 23rd May 2016 between SSS-NIBE, Kapurthala and Punjab University, Chandigarh to encourage interaction between the Scientist, Research Fellows, Faculty members and Student through the following arrangements:

- Exchange of personnel through deputation for limited period are mutually agreed upon.
- Both the institute can prepare and submit joint research project for funding to the funding agencies like MNRE, DST, CSIR, DBT, UGC, AICTE, etc. on mutually agreeable term and conditions.
- Joint guidance of student project/thesis in Bio-energy, Environment, Renewable Energy and other area of national interest at PUC by SSS-NIBE on mutually terms and Conditions.
- Joint M Tech / PhD programs in Renewable Energy with Bioenergy specialization.

iii. Guru Nanak Dev University, Amritsar

A MoU was signed on 16th June 2016 between SSS-NIBE, Kapurthala and Guru Nanak Dev University, Amritsar initially three years to have collaborative academic, research and faculty development programme in the area of Bioenergy and related field.

iv. Indian Renewable Energy Development Agency Ltd. (IREDA), New Delhi

A MoU was signed between SSS-NIBE, Kapurthala and (IREDA), New Delhi on 6th April 2016 in order to promote innovation, research & development, manufacturing, developing & harnessing bio energy at the state and national levels and to motivate individuals/companies to strive to perform even better in the above field, their contribution should be recognized and rewarded. The award aimed to celebrate the sprite of excellence & innovation in the bioenergy sector.

v. South Dakota School of Mines & Technology (USA)

Under Process

vi. Peninsula University of Technology, Cape Town, South Africa

Under Process

9. Scientific Events Organized

9.1 2nd International Conference on "Recent Advances in Bio-energy Research" ICRABR-2016 held during Feb 25-27, 2016 at SSS-NIBE, Kapurthala

The 2nd International Conference on "Recent Advances in Bio-energy Research" ICRABR-2016 was organized by SardarSwaran Singh National Institute of Bio-Energy, Kapurthala during Feb 25-27, 2016. The conference was started with a scintillating inaugural function on Feb 25, 2016. Prof. A.S. Brar, Vice Chancellor, Guru Nanak Dev University, Amritsar inaugurated the event as Chief Guest by lighting up the lamp followed by Shri K.S. Popli, Chairman & Managing Director, Indian Renewable Energy Development Agency as Guest of Honour and Prof. Igor Polikarpov, IFSC, Brazil as Distinguished Guest, while, Prof. Y.K. Yadav, Director General, SSS-NIBE presided over the conference as Chairperson. The prominent personalities among delegates from overseas

were Prof. Ravindra N. Chibbar, University of Saskatchewan, Canada, Dr. Lalini Reddy, CPUT, South Africa, Prof. Cecilia Laluce, UNESP, Brazil, Dr. Héctor A. Ruiz, Autonomous University of Coahuila, Mexico and Dr. T.M. Yunus Khan, University of Malaya, Malaysia. Other eminent personalities present in the inaugural function were Prof. B.S. Chadha, Guru Nanak Dev University, Amritsar, Dr. M.V.R. Prasad, Director & Chief Scientific Officer, VAYUGRID, Bangalore, Prof. RintuBanerjee, IIT Kharagpur, Dr. S. Kamaraj, Director, International Institute of Renewable Energy, Coimbatore, Dr. TusharPatil, Praj Industries, Pune, Mr. Venugopal Nair, Praj Industries, Pune, Prof. M.K. Jha, NIT Jalandhar, Dr. R.K. Sukumaran, NIIST, Trivandrum. Dr. Sachin Kumar, Organizing Secretary, ICRABR-2016, introduced the audience regarding the conference and emphasized on the objective of the conference. The vote of thanks was delivered by Dr. A.K. Sarma, Convener, ICRABR-2016.

The plenary speeches were conducted after the inauguration function during the three days event. The eminent speakers including Prof. Igor Polikarpov, Prof. Ravindra N. Chibbar, Dr. Lalini Reddy, Prof. Cecilia Laluce, Dr. Héctor A. Ruiz, Prof. Rintu Banerjee, Dr DK Adhikari, Prof. B.S. Chadha, Dr. S. Kamaraj, Dr. M.V.R. Prasad, Mr. TusharPatil, Prof. Anil Kumar, Dr. S. Pugalendhi, Dr. D. Muruganand, Mr. ParikshitDhingra and Mr. N.K. Sehgal delivered the plenary speeches. Two plenary speeches were conducted through video conferencing by Prof. Lee R. Lynd, Thayer School of Engineering, Dartmouth College, USA and Prof. Vijay Singh, University of Illinois, USA. On last day of event, a special plenary session for industry-research interaction was conducted where the issues of industries were undertaken and how the research can play the role to solve these issues.

Prof Polikarpov enlightened the knowledge about second generation bioethanol technologies: their current and future perspectives. He gave a detail discussion about different pretreatment techniques, which are beneficial to the biofuel industries. Dr Hector intensified our knowledge how to integrate the biorefinery in the proceses of 2nd and 3rd generation bioethanol production. DrLalini Reddy gave her presentation on sea weeds. She explained the different aspects of sea weeds and their role in bioethanol and other value added products. DrRavindraChibbar gave brief discussion how to modify the grain storage carbohydrates to produce value added products genetically. He gave the brief idea about how to increase the amylase and amylopectin by genetic modification and how to use them in biorefinery industries. Prof. Cecilia gave the brief discussion how to improve the lignocellulosic ethanol production with different culture, which enhance the biofuel production and what is the main requirement the worldwide in biorefinery industries. Prof. Chadha briefly explained the different strategies for identification of novel cellulase/hemicellulase from thermophilic fungi for the bioconversion of lignocellulosic materials. He briefly explained different techniques to isolate these thermophilic enzymes and how these enzymes are beneficial in the biofuel sectors.

Dr. Tushar Patil explained the current status of biofuel industries and what they need to achieve for the current requirements. He sparked motivated to commercialize the technique to achieve it. Prof. Rintu Banerjee briefly explained the different strategies of lignocellulosic bioethanol production and harmful effects of conventional techniques used in this process. She also gave the alternative techniques to overcome the limitation of conventional techniques. Prof. Vijay Singh introduce new bioenergy crop (i.e.) lipidcane as a sustainable bioenergy source. He gave a new insight how to increase the cold tolerance of sugar cane, so that it can be grown in tropical region and explained how to enhance the biodiesel production from these lipidcanes. He also gave the comparative of different crops for producing bioethanol and how lipidcane is better than other crops. Prof. Anil Kumar briefly explained the use of lignocellulosic biomass for the

production of bioethanol. He briefly explained 1st to 4th generations of biofuels. DrPugalendhi gave a brief explanation about different renewable energy technologies. He gave brief insight of the different biogas plants and their functioning. Dr. MVR Prasad talked about energy potential of Elite Clones of Pongamiapinnata. He briefly elaborated the different conditions required in the plants used in bio-energy process, which enhance the energy production. Dr. D. Muruganand gave his talk on recent advances in biofuel production. He elaborated the different generation of biofuel and mainly concentrated on the 3rd generation biofuels. He talked about the major challenges in the process development and how we overcome these hurdle.

Dr. D.K. Adhikari gave his talk on different challenges and prospectus in the biofuel sector. He briefly explained different biomass conversion processes, issues concerned with biochemical conversion, effective pretreatment processes, efficient saccharification process, advanced fermentation processes and process engineering design which enhance the biofuel production. Mr. ParikshitDhingra talked about the cellulosic ethanol. He briefly explained the enzymatic bioconversion in a commercial way and the different techniques which are used commercially to improve the enzyme potency. Dr. N.K. Sehgal gave a new insight to generate energy from the waste with zero emission and zero discharge. He talked about how to dispose and utilize all kinds of waste and the different techniques to treat the emission from these waste and how to utilize this waste in the energy sector. Prof. Lee Lynd briefed the genetic tools being developed for the conversion of cellulosic material using thermophilic bacteria. He briefly explained the different processing techniques of cellulosic biomass conversion using thermophilic bacteria. He also talked about how to develop the thermophilic strain.Twelve technical sessions were conducted in four parallel sessions each day with the different themes such as Biomass & Energy Management; Thermo-chemical Conversion; Biochemical Conversion; Algal Biomass, Chemical Conversion; Electrochemical Processes; and Integrated/Waste to Energy. About seventeen invited speakers delivered their research findings and review papers. More than thirty participants read their findings through oral presentation whereas more than forty participants through poster presentations. Six posters were selected as best poster in six different categories and conferred the award sponsored by Springer.

More than two hundred abstracts were published in the souvenir under the different sections including 47 in plenary and invited speakers, 23 biomass and energy management, 20 thermochemical conversion, 44 biochemical conversion, 11 algal biomass, 27 chemical conversion, 3 electrochemical processes, 17 waste to energy and 11 integrated processes. Due to Jaat Agitation in Haryana, the road and rail transportation was blocked during the event and hence, some of the speakers/participants could not manage their participation in the conference.

On the last day of event, 2nd meeting of 'Bio-Energy Alliance' was conducted. During the meeting, the representatives of different organizations including academic and research institutions, universities, industries and foreign delegations were present. A Founder Governing Body was constituted to get the alliance registered under the society. Several agenda were discussed and approved by the members.

The conference was come to an end with the valedictory function under the Chairmanship of Dr. Y.K. Yadav, Director General, SSS-NIBE. Prof. Ved Raj Sharma, Vice Chancellor, SBBS University, Jalandhar as Chief Guest and Dr. V.S. Hans, Director, School of Energy Studies, Punjab Agricultural University, Ludhiana as distinguished guest. Other dignitaries including Prof. Igor Polikarpov, Prof. Ravindra N. Chibbar, Prof. Cecilia Laluce, Dr. Héctor A. Ruiz, Dr DK Adhikari, Dr. S. Kamaraj, Dr. M.V.R. Prasad, Mr. Tushar Patil, Mr. Parikshit Dhingra and Mr. N.K. Sehgal were

also present. All the invitees and participants shared their experiences during the conference and gave their feed-back, while appreciating the function as a grand success.

Finally, the Chairperson of the Conference Prof. Y. K. Yadav, Director General, SSS-NIBE expressed his full satisfaction for the successful organization of the 2nd International Conference on "Recent Advances in Bio-energy Research" (ICRABR-2016). He appreciated the hard work of the NIRE staff for making the necessary arrangements for the successful organization at the Institute. He also announced the organization of Second International Conference next year at the Institute.

Few Photographs of 2nd International Conference ICRABR-2016

Recommendations

1. The following recommendations were noted based on presentations and discussions held during the conference by eminent scientists and academicians:
2. Agricultural residue was considered as the most important biomass material and biochemical routes for conversion of paddy straw to either bioethanol; biogas or value added chemicals have been recommended for R&D and industrial scale applications. Government of India may consider this issue on priority in coordination with respective state government machinery.
3. Fast growing lignocellulosic biomass such as bamboo, poplar, karanja, sugarcane, etc. should be cultivated as energy plant in degraded and forest lands for different applications.
4. Biogas production technology from food wastes and agro-residues should be integrated with cattle dung for rural applications. Toilet based biogas collection and application for boiler and power production may be prioritized in the recently announced smart cities. Ministry of Urban Development may take this issue with attention.
5. All types of non-edible oil seeds such as Jatropha, Karanja, Nesuaferrea, Mahua, Bitter apricot, etc. should be planted in degraded and forest land, suitable for agro-climatic condition for the biodiesel, and green diesel production. Industry may be set up the plants in

coordination with State Government. This will be helpful for rural employment generation.

6. Large scale high oil yielding algal biomass cultivation may be considered at pilot scale level to establish biorefinery and economic evaluation may be taken up. Both biochemical and thermo-catalytic routes of conversion of algae to biofuel may be taken up. R&D support and provision should be made for such studies.
7. Genetic modification for high oil yielding algae, oil seed and cane for lipid production may be taken up initially for R&D and pilot scale studies and later on for industrial applications as per economic feasibility.
8. Direct application of biomass for cooking should be promoted, only in efficient cookstove fulfilling BIS norms because about 60% of rural inhabitant of the country, even today, use biomass as primary source of fuel. Appropriate devices (improved cookstove) indoor air quality monitoring devices may be made available for rural community.
9. Financial incentives and support should be provided for industry, entrepreneur, who shows direct interest in setting up Biorefinery in rural areas and Government should pay appropriate attention for them.
10. R&D thrust is very import in bio-fuel and bioenergy. However, there should be collaboration among different R&D organizations, active industries working in the sector and ministries of the central and state Government. Working in isolation will not provide any solution to the emerging energy crises. Some priority R&D areas are: feed stock solution, characterization, conversion to fuel & chemicals in a bio-refinery mode, integration of different processes and setting up pilot and demonstration scale unit, use of waste water for algae production or biofuel cell application, may be initiated.

    Further bioenergy roadmap may be prepared by the Bioenergy Alliance constituted during the ICRABR – 2015.

9.2 Training Programs

9.2.1 Practical Hands for Processes of biofuel production and catalysis, characterization and engine applications

Chemical Conversion Division of the Institute organized a one-week National Training Program from 30th November, 2015 to 4th December, 2015 on "**Practical Hands for Processes of biofuel production and catalysis, characterization and engine applications**". Prof. Yogender Kumar Yadav, Director General, SSS-NIBE was the Guest of honour and inaugurated the event at 10:30 am on November 30, 2015. He informed the participants about the different activities carried at the Institute and the future scope of its expansion as the Global centre of excellence. Prof. Yadav pointed out the exhausting and polluting nature of fossil fuels and stated that 27 % of our countries energy share comes from Biomass energy and Waste to Energy as per International Energy Agency report. He however pointed out that appropriate biomass to biofuel conversion technology; their proper characterization facilities and trained manpower are yet to be created in the country. He expressed satisfaction over the expansion of bioenergy sector, however, pointed out that bio-energy alone cannot address all the issues of energy security, environment and upliftment of society in India. However, as pointed out by the inventors of diesel engine and petrol engine, in the years to come biofuels viz. vegetable oil based biodiesel and ethanol will as the major supplement of fossil fuels. Prof. Yadav appeals everyone to think in a big way for successful implementation of biofuel policy in the country and enthusiastic vision of the Govt. of India to supplement 10% ethanol with gasoline and 5% biodiesel with diesel by, 2017. Dr. A. K. Sarma, Senior Scientist, and Organizing Secretary of this training course informed

that during the training programme, the chemical processes for biomass to advanced biofuels such as biodiesel, green diesel and other hydro-processed fuels will be demonstrated. Handling of high-pressure, high temp, TBP distillation of biocrude, Biodiesel Production, GC etc will be demonstrated. He informed that the objective of such training is to train the young industrialists, scientists and research scholars in the use of advance research techniques and instrumentation for conducting world class quality research in the country itself in the field of bioenergy in general and chemical conversion technologies for advanced biofuels in particular.

About 25 participants from different Universities and Institutes across the country including Institute fellows participated in this one week training programme. Prominent among them are Dr. KariyappaKatagi, Professor, University Science College, Karnataka, Dr. AbhitoshGoyal, Industrialist from Ludhiana, Dr. Krishna Kumar Jaiswal, Pondicherry University etc. All the equipments and ongoing R &D activities and processes were demonstrated during the week including invited lectures from eminent scientist working in this field. DrThalandaBhaskar, IIP Dehradun; Dr R K Maurya, IIT Ropar; and Dr R S Bharj delivered invited speech during the training on various emerging issues of the lipid based biofuels and R &D importance on the subject.

9.2.2 Hands on Analytical and Molecular Techniques: Biochemical based Biorefineries for Advanced Biofuels and Value-added Products

One week national training program **'Hands on Analytical and Molecular Techniques: Biochemical based Biorefineries for Advanced Biofuels and Value-added Products'** was inaugurated on March 14, 2016 by Prof. S.K. Das, Director, Indian Institute of Technology Ropar in presence of Prof. Y.K. Yadav, Director General, SSS-NIBE.

The institute hosted the 35 participants for this national training program from different organizations of the country such as Sukhjit Starch &Chem Ltd., Phagwara, PESO, Kolkata, IIT Guwahati, Institute of Microbial Technology, Chandigarh, Motilal Nehru NIT, Allahabad, NSIT, New Delhi, MANIT, Bhopal, SPRERI, VV Nagar, Central University of Jammu, Central University Bathinda, Baba BhimraoAmbedkar University, Lucknow, Guru Jambeshwar University, Hisar, LPU, Phagwara, Adhiparasakthi Engineering College, Tamil Nadu, Kerala University of Fisheries and Ocean Studies, Kerala, BCET, Gurdaspur, Continental Institute for International Studies, Fatehpur Sahib.

During this program, the process for bioethanol production from agricultural waste mainly paddy straw, biogas production from agricultural and kitchen wastes, algal biomass production and its utilization in biorefinery manner were discussed and demonstrated to the participants. Molecular techniques such as DNA isolation, gene insertion, electrophoresis, etc. to improve the product yield and quality were also demonstrated. The analytical techniques for analysis of sugars, alcohols, organic acids, biogas compositions using HPLC, GC, UV-Vis Spectrophotometer,

biophotometer, etc. were demonstrated. During this program the expert lectures on xylitol, biohydrogen, bioethanol, algal biomass and biogas upgradation by Dr. D.K. Sahoo, Chief Scientist, CSIR-IMTech, Chandigarh, Prof. S.K. Soni, Punjab University, Chandigarh, Dr. NitaiBasak, NIT Jalandhar, Dr. MadhulikaShukla and Dr. Saruchi were also organized to make participant understand about the different facets of bioenergy.

The program was closed on March 18, 2016 at 05:30 pm after Valedictory Function in presence of Mr. Ashok Mittal, Chancellor, LPU as the Chief Guest and Mrs. Rashmi Mittal Pro Chancellor, LPU as the Guest of Honour. During the function, the certificates of participation will be distributed to all the participants on successful completion of the national training program.

9.3 Vigilance awareness week observed at SSS-NIRE

Vigilance Awareness Week 2015(from 26-31 October 2015) concluded at SSS-NIRE Kapurthala a function held at conference hall of the Institute. Prof. Yogender Kumar Yadav, Director of the Institute was present as the chief guest on this occasion. The programme started with an intensive oath taking on Vigilance Awareness Theme on 26th October, 2015 and banners and posters were displayed on at the Institute in all the primary locations so as to disseminate the information among all-level-workers.

"Honesty is the best policy",
"Corrupt Derail- Honest Prevail",
"Corruption is Anti-Development",
"Polluted by Corruption leads to our Destruction",
"Corruptions robs us all"

The concluding ceremony was organized at 11.00 am on 3rd November, 2015 in the conference hall. Prof. Yadav in his address stressed on the need of being vigilant for better life and governance. He pointed out that vigilance is not the sole duty of vigilance department rather it is the duty of everyone to be vigilant. The role of transparency, accountability and integrity are the basic feathers of good governance and it would lead the organization towards a more profitable, efficient and effective direction. Above all, self-discipline is more important for all concerned in public service. Prof. Yadav also emphasized that the Institute has taken initiative to become a plastic free green campus within this year. Thus everyone of the Institute is equally responsible for good works, time management and vigilant in all respect. He emphasized on self-vigilance for one's own improved performance and also of external environment to bring better competitive capabilities. Earlier discussions were held among all level workers about the need of vigilance in office and the vigilance officer welcoming the guest briefed the gathering about the different activities held during the week and greeted everyone for being alert in their respective work area.

Few photographs of Vigilance Awareness Week, 2015 at SSS-NIBE

9.4 Swachh Bharat Abhiyan

The Swachh Bharat Abhiyaan Pakhwada was initiated at the Institute with the formal program started at 9:30 AM on 17th June, 2016 as per the office order Ref: 101/1/2016-NIBE/305 dated 14-06-2016. It has been celebrated in accordance with campaign started by the Hon'able Prime Minister, Sh. Narendra Modi Ji on 2nd October 2014, viz. on the 145th birth anniversary of Mahatma Gandhi, the Father of the Nation. On this day, he emphasized people about "Clean India". This mission has targeted its completion till 2019, the 150th birth anniversary of Mahatma Gandhi. This mission has targets to fulfill the sanitation facilities to all as well as eliminate all the unhealthy practices of people in the country.

Few photographs of cleanliness drive under Swachh Bharat Abhiyan at SSS-NIBE

The event was started with addressing lecture of coordinator of the campaign, (Dr. S. K Tyagi, Scientist E) who emphasized on cleanliness to be started from our inner soul. As we can clean our house, the same way this whole country is like our house and shall be cleaned up to make the environment free from diseases. He also emphasized on the team work to make it successful mission of the Govt. of India which was a long awaited activity by involving the masses and shared his views on the cleanliness of other countries. The guest of the function Prof. M. K. Jha, Dr. B. R. Ambedkar National Institute of Technology (NIT), Jalandhar explained the difference between the cleanliness behavior of the civilian of other country and the Indian and shared his experiences of different countries. He also told what to do to improve the cleanliness. He appreciated the effort of Swachh Bharat Abhiyan started by SSS-NIBE and suggested way forward.

Finally the Director General Prof. Y. K. Yadav shared his thought on Swachh Bharat Abhiyaan and explained that SSS-NIBE is more responsible for this campaign, as we are working on Bio- Energy sector, which is basically the energy from wastes including Municipal Solid Wastes. The waste produced can be utilized for generating bioenergy and this improve India's economy as well as clean the environment. They recalled the dream of Mahatma Gandhi about "Swachh Bharat - Swasth Bharat" and told that this campaign is a footprint of Mahatma Gandhi's thought. His thought reflected cleanliness is next to GOD and it was really true and motivates the other audience for cleanliness.

The cleaning of different places started after taking the pledge at around 11:00 AM and continued till 13:30 PM. It was also emphasized that every (Saturday) weekend from 8:00 AM to 10:00 AM, all the staff of the Institute shall jointly participate in the clean drive to make the purpose and objective of the mission successful, besides, to motivate the people around for the same. The staff of the Institute takes the pledge and committed to devote at least two hours weekly to achieve the target of Swachh Bharat Abhiyan and to virtually fulfill the dream of the Bapuji's and present Prime Minister of the Nation.

9.5 Hindi Divas and Pakhwada

The Institute observed Hindi Divas and Pakhwada from 14th-28th September 2015. The program was coordinated by Hindi Officer, Dr. Abhishek Gupta. Prof. (Dr.) Yogender Kumar Yadav, Director of the Institute chaired the function.

Few Photographs of Hindi Divas & Pakhwara at SSS-NIBE

APPRECIATION AWARD

Appreciation award was given to all regular staff of SSS-NIBE, Kapurthala by the Hon'ble Ministry of New and Renewable Energy, Govt. of India, New Delhi on 9th May 2016. The Director General, distributed the appreciation award among the scientist, administrative and other regular staff of SSS-NIBE, Kapurthala. Notable that Sh Rupesh Kumar Verma, Jr Executive Asst., Admin was awarded the certificate directly by the Hon'ble Minister of New and Renewable Energy in the function held in New Delhi.

Few photographs of Appreciation award at SSS-NIBE

10. PUBLICATIONS

REFEREED JOURNALS

- Behera S, Sharma NK, Arora R and Kumar S Effect of evolutionary adaption on xylosidase activity in thermotolerant yeast isolates *Kluyveromycesmarxianus* NIRE-K1 and NIRE-K3. Applied Biochemistry and Biotechnology. DOI: 10.1007/s12010-016-2055-2 (Accepted, in press) (IF: 1.74)
- Sharma NK, Behera S, Arora R and Kumar S (2016) Enhancement in xylose utilization using *Kluyveromycesmarxianus* NIRE-K1 through evolutionary adaptation approach. Bioprocess and Biosystems Engineering. DOI: 10.1007/s00449-016-1563-3 (In press) (IF: 2.0)
- Kumar S, Dheeran P, Singh SP, Mishra IM and Adhikari DK (2015) Continuous ethanol production from sugarcane bagasse hydrolysate at high temperature with cell recycle and in-situ recovery of ethanol. Chemical Engineering Science, 138, 524-530. (IF: 2.34)
- Kumar P, Sarma A K, Bansal A, Jha M K, Srivastava V, Utilization of Renewable and waste material for biodiesel production as catalyst, Bulletin of Chemical Reaction, 10(3), 2015 221-229.
- Kumar P, Sarma A K, Bansal A, Jha M K, Formulation of SrO-MBCUS agglomerates for esterification and transesterification of high FFA vegetable oil, 2016 (http://dx.doi.org/10.9767/bcrec.0.x.8969.xxx-xxx, in press)
- Singh N, Kumar D, Sarma A K, Jha M K, An exergy conceptual based study for comparative thermodynamic performance of a CI engine fuelled with petroleum diesel and biodiesel blends, Journal of Energy Engineering, (http://ascelibrary.org/doi/10.1061/%28ASCE%29EY.1943-7897.0000380, in press).
- K. Pal, M. K. Jha, P. Gera and S. K. Tyagi, Experimental study on the performance evaluation and emission reduction potential of different cookstove models using standard design parameters and testing protocols, Biofuels Journal.
- Sunil Kumar, Y.K. Yadav and Yadvika (2015), Effect of Innoculum Concentration and Co-digestion of Kitchen Waste and Cattledung, Journal of Agricultural Engineering 52(3):39-45.

CONFERENCE PROCEEDINGS

- Mahajan R, Kaur H, Rao R, Kumar S (2016) Pre-treatment of paddy straw to improve biogas yield. In: Kumar S, Khanal SK and Yadav YK (Eds.) Conference Proceedings on the First International Conference on Recent Advances in Bioenergy Research. Springer Proceedings in Energy. Springer India, pp. 43-61.
- Sharma NK, Behera S, Arora R, Singh R, Kumar S (2016) Potential role of xylose transporters in industrial yeast for bioethanol production: a perspective review. In: Kumar S, Khanal SK and Yadav YK (Eds.) Conference Proceedings on the First International Conference on Recent Advances in Bioenergy Research. Springer Proceedings in Energy. Springer India, pp. 81-93.

BOOKS/JOURNAL PUBLISHED

- Kumar S, Khanal S K, Yadav Y K (2016) Proceedings of the First International Conference on Recent Advances in Bioenergy Research. Springer Proceedings in Energy. Springer India (eBook ISBN 978-81-322-2773-1; Hardcover ISBN 978-81-322-2771-7).

- Souvenir, 2ndInternational Conference on Recent Advances in Bio-energy Research (ICRABR-2016) (ISBN 978-93-84935-73-3).
- Journal of Bio-Fuels and Bio-Energy published by SSS-NIBE and Indianjournals.com, Diva Enterprises Pvt. Ltd. (online- ISSN: 2454-8618, Print-ISSN: 2454-860X).

ARTICLES IN NEWS LETTERS

- Rao R, Yadav Y K and Kumar S (2015) Production of biological hydrogen in India: potential source for the future. AkshayUrja, 9(2), 16-21.

PAPERS PRESENTED IN NATIONAL CONFERENCES

- Arora R, Yadav Y K, Kumar S, Simultaneous saccharification and fermentation of paddy straw at high solid loading by a novel thermotolerant isolate K. marxianus NIRE-K3 for bioethanol production. TEQIP-II sponsored National Conference on 'Application of Biotechnology in Industry and Society', Apr 12-14, 2016, Dr B.R. Ambedkar National Institute of Technology, Jalandhar.
- Sharma N K, Kumar S, Effect of evolutionary adaptation on metabolic enzyme activity of thermotolerent Kluyveromycesmarxianus NIRE-K3. TEQIP-II sponsored National Conference on 'Application of Biotechnology in Industry and Society', Apr 12-14, 2016, Dr B.R. Ambedkar National Institute of Technology, Jalandhar.
- Hans M, Yadav Y K, Kumar S, Comparative study of Biogas production from vegetable waste under mesophilic and thermophilic conditions. TEQIP-II sponsored National Conference on 'Application of Biotechnology in Industry and Society', Apr 12-14, 2016, Dr B.R. Ambedkar National Institute of Technology, Jalandhar.

PAPERS PRESENTED IN INTERNATIONAL CONFERENCES

- Singh I, Arora R, Behera S, Srivastava N K, Kumar S. Optimization of alkaline pretreatment of rice straw, structural characterization for enhancing glucose yield after enzymatic hydrolysis by application of FCCD in RSM. 2nd International Conference on 'Recent Advances in Bio-energy Research' (ICRABR-2016), Feb 25-27, 2016 at SSS-National Institute of Bio-Energy, Kapurthala, India.
- Shukla M, Kumar S, Biogas upgrading and carbon dioxide sequestration using microalgae. 2nd International Conference on 'Recent Advances in Bio-energy Research' (ICRABR-2016), Feb 25-27, 2016 at SSS-National Institute of Bio-Energy, Kapurthala, India.
- Saruchi, Kumar S, Biogas upgradation through membrane based technology. 2nd International Conference on 'Recent Advances in Bio-energy Research' (ICRABR-2016), Feb 25-27, 2016 at SSS-National Institute of Bio-Energy, Kapurthala, India.
- Hans M, Harmanjot Kaur, Kumar S, A study of biogas pilot plant. 2nd International Conference on 'Recent Advances in Bio-energy Research' (ICRABR-2016), Feb 25-27, 2016 at SSS-National Institute of Bio-Energy, Kapurthala, India.
- Kaur H, Hans M, Kumar S, Biogas production from co-digestion of cattle dung and paddy straw. 2nd International Conference on 'Recent Advances in Bio-energy Research' (ICRABR-2016), Feb 25-27, 2016 at SSS-National Institute of Bio-Energy, Kapurthala, India.

- Behera S, Yadav Y K, Kumar S, Recent advances in biobutanol production: problem and challenges. 2nd International Conference on 'Recent Advances in Bio-energy Research' (ICRABR-2016), Feb 25-27, 2016 at SSS-National Institute of Bio-Energy, Kapurthala, India.
- Gabhane J, Kumar S, Evolution of pretreatment for economical production of ethanol using paddy straw as a feedstock. 2nd International Conference on 'Recent Advances in Bio-energy Research' (ICRABR-2016), Feb 25-27, 2016 at SSS-National Institute of Bio-Energy, Kapurthala, India.
- Arora R, Behera S, Kumar S, Bioethanol production from paddy straw by a novel thermotolerantisolate K. marxianus NIRE-K3. 2nd International Conference on 'Recent Advances in Bio-energy Research' (ICRABR-2016), Feb 25-27, 2016 at SSS-National Institute of Bio-Energy, Kapurthala, India.
- P. Yadav and S. K. Tyagi, Prospects perspective and challenges of biomass densification in India: A review. 2nd international conference on recent advances in bio-energy research (ICRABR-2016, 25-27 Feb 2016, SSS-NIBE, Kapurthala, Punjab.
- S. K. Sansaniwal, K. Pal and S. K. Tyagi, Biomass Pyrolysis for sustainable development of bio-products: An Overview. 2nd international conference on recent advances in bio-energy research (ICRABR-2016), 25-27 Feb 2016, SSS-NIBE, Kapurthala, Punjab.
- K. Pal, S. K. Sansaniwal, and S. K. Tyagi, An assessment to biomass based combustion systems. 2nd international conference on recent advances in bio-energy research (ICRABR-2016), 25-27 Feb 2016, SSS-NIBE, Kapurthala, Punjab.

11. AWARDS & HONOURS

- Prof. Yogender Kumar Yadav, Director General, SSS-NIBE appointed as distinguished expert on the Panel of Experts for the fourth annual project cycle of International Renewable Energy Agency and Abu Dhabi Fund for Development (IRENA / ADFD) project facility, Abu Dhabi, UAE.
- Prof. Y.K. Yadav received the JAE Best Paper Award (2015) for Energy in Agriculture from Indian Society of Agriculture Engineers (ISAE).
- Dr. Sachin Kumar, Scientist 'C', SSS, NIBE has been selected as the Bioenergy-Awards for Cutting Edge Research (B- ACER) Fellow 2016 by the Department of Biotechnology, Govt. of India and the Indo-U.S. Science and Technology Forum (IUSSTF) to visit the USA for 12 months.
- Dr. Sachin Kumar, Scientist 'C', SSS, NIBE has been selected for ASM-IUSSTF Indo-US Research Professorship 2016 by the American Society for Microbiology (ASM) and the Indo-US Science and Technology Forum (IUSSTF) to visit the USA for 6 weeks.
- Dr. Madhulika Shukla has been conferred the Best Paper Award in poster presentation for the paper entitled "Biogas upgrading and carbon dioxide sequestration using microalgae" presented in ICRABR-2016 during Mar 25-27, 2016, at SSS-NIBE, Kapurthala, India.

12. DOCUMENTATION CENTRE

A documentation centre has been established, having collection of large number of recently published books, journals, periodicals, newsletters, reports, conference proceedings, etc. on various aspects, relating to renewable energy. The further strengthening of the documentation centre is in progress. About 50 Books and 50 Scientific Journals have been purchased for Documentation Centre in this FY.

13. HORTICULTURE ACTIVITIES

With a 'GO GREEN" motto, SSS-NIRE follows an integrated approach towards development of Forestry & horticulture by paying attention technically as well as institutional issues and targeting social causes as global warming etc to support the horticulture. More than two hundred ornamental and forestry plants have been planted during the year. Around the campus office, hostel block, housing 3500 sq mtr area has been developed with selection no. 1 and Korean grass. The Institute has also purchased the necessary fertilizers, machinery and agricultural tools for the development of campus to meet the objectives of GO GREEN campus.

Bamboo and Jatropha for biofuel applications

Bamboo plantation: Near about 300 bamboo saplings were planted along the boundary wall near Jatropha field. In the year 2011 the Bheema bamboo saplings were provided by Ms/ Grow More Pvt. Ltd. Bangalore based company. Bamboo plants are growing at a good pace and many plants have attained the height of 20-24 feet. The foliage of bamboo plants is also lush green in colour. Diameter of bamboo trunk is also healthy. Sprouting of new bamboo saplings takes place in each season. Sprouting of new bamboo from the plants are looked very healthy.

Jatropha plantation

In continuation to the decision taken in the FY 2013-14, about 1000 jatropha plants were studied under extreme care with proper water supply and fertilizer for growth, seeding and maturation. Experts from Punjab State Agriculture Department were also consulted. It was confirmed that the agro-climatic condition of Kapurthala, is not suitable for economic production of jatropha seeds.

14. ADMINISTRATIVE ACTIVITIES

Administrative/Purchase Committee/Finance Committee Meetings: Administrative meeting to discuss the plans of development and progress of R&D activities being carried out in the Institute were organized at regular intervals.

- 12th Finance Committee meeting of SSS-NIBE was held at MNRE in 2016
- 25nd Governing Council Meeting was held at MNRE in 2015.
- 26rd Governing Council Meeting was held at MNRE in2016.
- Administrative Meetings was held at SSS-NIRE on 22ndJanuary, 2016.

Other Administrative meetings during the year.

- Republic Day was celebrated in the Institute on 26thJanuary 2016.
- Appreciation Awards to NIBE staff distributed on 09th May 2016 in the Institute.

15. ANNUAL AUDITED ACCOUNTS FOR THE FINANCIAL YEAR 2015-16

The annual audited accounts of the Institute for the year 2015-16 has been prepared and duly audited by Internal Auditors M/s. Arora Vikram & Associates, Jalandhar and Statutory Auditor M/s. K. Bhagat & Co., Jalandhar. The detailed Auditor's Report, Balance Sheet, Income, Expenditure, Receipts & Payment Accounts Schedules are attached herewith.

Appendix

K. BHAGAT & CO.
Chartered Accountants
16-Brij Nagar
Jalandhar.

Phone : (O) 0181-2282829
(M) 98142-03435
99142-03435

FORM NO. 10B
[See rule 17B]

Audit report under section 12A(b) of the Income-tax Act, 1961

We have examined the balance sheet of SARDAR SWARAN SINGH NATIONAL INSTITUTE OF RENEWABLE ENERGY (SSS NIRE), KAPURTHALA as at 31.03.2016 and Income & Expenditure account for the year ended 31.03.2016 which are in agreement with the books of accounts maintained by the said Institute.

We have obtained all the information and explanations which to the best of our knowledge and belief were necessary for the purposes of the audit. In our opinion, proper books of account have been kept by the Society so far as appears from our examination of books, subject to the notes to accounts annexed herewith.

In our opinion and to the best of our information, and according to information given to us, the said accounts give a true and fair view.

(i) In the case of the balance sheet, of the state of affairs of the abovenamed society as at 31.03.2016 and

(ii) In the case of the Income & Expenditure account, of the Income and Expenditure of its accounting year ending on 31.03.2016.

For K. Bhagat & Co.
Chartered Accountants
MEM. No. 17902 JALANDHAR
Partner

Place : Jalandhar City

Dated : November 09, 2016

SARDAR SWARAN SINGH NATIONAL INSTITUTE OF RENEWABLE ENERGY

(An Autonomous Institution of Ministry of New & Renewable Energy)
Kapurthala (Punjab)- 144601

BALANCE SHEET AS AT 31ST MARCH 2016

(Amount in Rs.)

PARTICULARS	SCHEDULE	31st MARCH, 2016	31st MARCH, 2015
A. CAPITAL FUND AND LIABILITIES			
Corpus/Capital Fund	I	24,40,69,066.00	22,97,79,413.00
Reserve & Surplus	II	40,31,72,312.14	40,90,75,344.88
Current Liabilities & Provisions	III	67,79,298.00	1,98,01,286.50
TOTAL		65,40,20,676.14	65,86,56,044.38
B. ASSETS			
Fixed Assets	IV	26,72,25,002.00	29,76,06,229.00
Current Assets. Loans & Advances	V	14,04,49,399.14	13,50,39,557.38
Investment (Corpus Fund)	VI	24,63,46,275.00	22,60,10,258.00
TOTAL		65,40,20,676.14	65,86,56,044.38
Contigent Liabilities And Notes on Accounts	VII		

For SARDAR SWARAN SINGH NATIONAL INSTITUTE OF RENEWABLE ENERGY

As per our Audit Report Attached
For K.Bhagat & Co.
Chartered Accountants
Firm Reg. No.- 006797N

Place: Jalandhar
Date: 09.11.2016

SARDAR SWARAN SINGH NATIONAL INSTITUTE OF RENEWABLE ENERGY

(An Autonomous Institution of Ministry of New & Renewable Energy)

Kapurthala (Punjab)- 144601

INCOME & EXPENDITURE ACCOUNT FOR THE YEAR ENDING 31.03.2016

(Amount in Rs.)

PARTICULARS		31st MARCH, 2016	31st MARCH, 2015
INDIRECT INCOME			
Grant Received from MNRE during the year			
for Salaries		1,00,00,000.00	1,30,00,000.00
for General Expenses		3,68,58,799.00	10,70,00,000.00
Interest Received from FDRs (Corpus Fund)		1,42,89,653.00	
Less: Transferred to Corpus Fund		(1,42,89,653.00)	-
Interest Received from Bank		1,38,91,001.76	91,41,201.15
Other Interest		1,09,562.00	-
Sponsorship Received		2,70,000.00	1,95,000.00
Licence Fees		73,307.00	51,719.00
Tender Fees		28,500.00	26,900.00
Registration Fees		4,32,051.00	3,60,500.00
Hostel Fees		3,31,895.00	5,32,410.00
Grant for Conference		4,50,000.00	-
Other income		4,32,093.00	8,430.00
TOTAL	**A**	**6,28,77,208.76**	**13,03,16,160.15**
INDIRECT EXPENSES			
Advertisement		4,11,698.00	70,959.00
Audit & Legal Fees		1,86,105.00	87,130.00
Bank Charges		-	9,969.00
Consumable Laboratory Workshop Exp.		13,35,349.00	17,96,487.00
Depreciation		3,14,82,173.00	3,45,73,315.00
Electricity & POL		26,84,819.00	24,95,443.00
Function Expenses		8,306.00	17,592.00
Hiring of Prof. Services		1,16,59,368.00	1,03,25,476.00
Horticulture Expenses		1,21,473.00	1,57,879.00
Insurance Exp.		15,523.00	18,144.00
Misc. & Unforeseen Exp.		-	20,685.00
Meeting, Seminars, Workshop & Conference		17,13,868.00	15,03,882.00
Office/Guest House Exp.		89,020.00	26,421.00
Other Expenses		14,802.00	-
Printing & Publications		1,93,994.00	64,947.00
Refreshment		1,36,479.00	1,52,437.00
Repair & Maintenance		3,61,139.00	2,88,061.00
Salaries		1,00,42,835.00	72,60,033.00
Stationary (Including Software Exp.)		1,46,558.00	3,04,377.00
Stipend		48,70,852.00	19,56,804.00
Telephone & Internet Exp.		3,56,329.50	3,30,036.50
Travelling Exp.		6,06,660.00	4,38,187.00
TOTAL	**B**	**6,64,37,350.50**	**6,18,98,264.50**
Surplus Transfer to Reserve & Surplus	**A-B**	**(35,60,141.74)**	**6,84,17,895.65**

For SARDAR SWARAN SINGH NATIONAL INSTITUTE OF RENEWABLE ENERGY

As per our Audit Report Attached
For K.Bhagat & Co.
Chartered Accountants
Firm Reg. No.- 006797N

Place: Jalandhar

Date: 09.11.2016

SARDAR SWARAN SINGH NATIONAL INSTITUTE OF RENEWABLE ENERGY

(An Autonomous Institution of Ministry of New & Renewable Energy)
Kapurthala (Punjab)- 144601

RECEIPTS AND PAYMENTS ACCOUNT FOR THE YEAR 2015-16

	RECEIPTS	31st MARCH, 2016	31st MARCH, 2015
A.	**OPENING BALANCES**	**33,51,56,246.89**	**23,70,00,373.74**
	Cash in Hand	19,869.00	2,912.00
	Bank Balances		
	In Saving A/c	3,93,23,218.44	3,45,919.16
	In Deposit A/c	7,58,75,415.75	8,86,58,952.88
	In Current A/c	2,04,458.70	2,17,330.70
	Investments	21,97,36,210.00	14,74,66,375.00
	Interest Accrued on FDR & Securities	62,92,627.00	55,32,838.00
	TDS Recoverable	11,28,587.00	
	Add: Cheque deposited but not credited	1,00,05,000.00	13,625.00
	Less: Cheque issued but not presented	(1,74,29,139.00)	(52,40,533.00)
	Stamps	-	2,954.00
B.	**GRANT RECEIVED**	**4,81,33,797.00**	**12,27,52,000.00**
	From Govt. of India	4,68,58,799.00	12,00,00,000.00
	Bio- Mass Cook Stove Project	60,000.00	-
	Bio-Gas Production Project	-	24,52,000.00
	Bio- butanol Project	10,50,000.00	
	Bio Mass Energy Tech. Project	1,64,998.00	3,00,000.00
C.	**INTEREST RECEIVED**	**2,81,80,654.76**	**2,42,67,825.15**
	On Saving/Bank Deposits	1,38,91,001.76	89,47,624.15
	Interest on FDR Corpus	1,42,89,653.00	1,53,20,201.00
D.	**OTHER INCOME**	**24,34,408.00**	**21,39,959.00**
	Grant of Conference	4,50,000.00	-
	Tender Fees	28,500.00	26,900.00
	Licence Fees	73,307.00	51,719.00
	Hostel Fees	3,31,895.00	5,32,410.00
	EMD	3,07,000.00	9,65,000.00
	Registration Fees	4,32,051.00	3,60,500.00
	Sponsorship	2,70,000.00	1,95,000.00
	Misc. Income	5,41,655.00	8,430.00
E.	**OTHER ADJUSTMENTS**	**34,63,121.00**	**21,00,020.50**
	Expenses Payable/Creditors Outstanding During the Year	23,43,959.00	14,49,484.50
	Advances of Last Year Adjusted During the Year	11,19,162.00	6,50,536.00
		41,73,68,227.65	**38,82,60,178.39**

For SARDAR SWARAN SINGH NATIONAL INSTITUTE OF RENEWABLE ENERGY

As per our Audit Report Attached
For K.BHAGAT & CO.
Chartered Accountants

Place: Jalandhar
Date: 09.11.2016

SARDAR SWARAN SINGH NATIONAL INSTITUTE OF RENEWABLE ENERGY

(An Autonomous Institution of Ministry of New & Renewable Energy)
Kapurthala (Punjab)- 144601

RECEIPTS AND PAYMENTS ACCOUNT FOR THE YEAR 2015-16

	PAYMENTS	31st MARCH, 2016	31st MARCH, 2015
A.	**PAYMENT MADE AGAINST FUNDS FOR VARIOUS PROJECTS**		
	Out of Capital Grant		
	Revenue Expenditure	**3,49,55,177.50**	**2,73,24,949.50**
	Expenditure During the Year	3,49,55,177.50	6,18,98,264.50
	Less: Depreciation	-	(3,45,73,315.00)
	Capital Expenditure	**11,00,946.00**	**1,79,36,079.60**
	Fixed Assets	11,00,946.00	1,79,36,079.60
	Out of Grant for Projects	**36,17,889.00**	**20,64,074.00**
	Expenses Under Bio- Diesel Poject	-	-
	Expenses Under Bio- Ethenol Project	8,56,454.00	6,25,556.00
	Expenses Under Bio Mass Cookstove Project	7,40,260.00	6,09,105.00
	Expenses Under Bio- Crude Project	9,38,284.00	6,68,729.00
	Expenses Under Bio- butanol Project	1,28,860.00	-
	Expenses Bio-Gas Production Project	9,54,031.00	1,60,684.00
B.	**OTHER PAYMENTS**	**18,95,948.50**	**57,78,828.40**
	EMD Refunded	1,92,000.00	9,32,500.00
	Advance Given During the Year	1,06,019.00	7,69,795.00
	Expenses Payable/Creditors of Pre. Year Paid During The Year	15,81,136.50	40,76,533.40
	Creditors of Pre. Year Adjusted During The Year	16,793.00	-
C.	**CLOSING BALANCES**	**37,57,98,266.65**	**33,51,56,246.89**
	Cash in Hand	4,057.00	19,869.00
	Grant Receivable	4,00,000.00	-
	Bank Balances		
	In Saving A/c	81,31,594.20	3,93,23,218.44
	In Deposit A/c	12,37,54,120.75	7,58,75,415.75
	In Current A/c	2,08,908.70	2,04,458.70
	Investments	24,01,62,255.00	21,97,36,210.00
	Interest Accrued on FDR & Securities	62,12,567.00	62,92,627.00
	TDS Recoverable	4,65,104.00	11,28,587.00
	Add: Cheque deposited but not credited	5,000.00	1,00,05,000.00
	Less: Cheque issued but not presented	(35,46,121.00)	(1,74,29,139.00)
	Stamps	781.00	-
		41,73,68,227.65	**38,82,60,178.39**

For SARDAR SWARAN SINGH NATIONAL INSTITUTE OF RENEWABLE ENERGY

As per our Audit Report Attached
For K.BHAGAT & CO.
Chartered Accountants

Place: Jalandhar
Date: 09.11.2016

Member of Governing Council for the Sardar Swaran Singh National Institute of Bio Energy (SSS-NIBE), Kapurthala (Punjab)

S. No.	Name/Designation and Address	Status
1.	**The Secretary,** Ministry of New and Renewable Energy, Government of India, Block-14, C.G.O. Complex, Lodhi Road, New Delhi-110003	Chairman
2.	**Financial Adviser,** Ministry of New and Renewable Energy, Government of India, Block-14, C.G.O. Complex, Lodhi Road, New Delhi-110003	Member
3.	**Incharge (SSS-NIBE),** Ministry of New and Renewable Energy, Government of India, Block-14, C.G.O. Complex, Lodhi Road, New Delhi-110003	Member
4.	**Principal Secretary,** Government of Punjan, Department of Power, Room No. 423, 4th floor, Punjab Civil Secretariat-2, Sector-9, Chandigarh-160017	Member
5.	**Vice-Chancellor,** Punjab Agriculture University, Ludhiana-141004	Member
6.	**Vice-Chancellor,** Punjab Technical University, Jalandhar-Kapurthala Road, Kapurthala.	Member
7.	**Director (R&D),** R&D Centre, IOCL, Sector-13, Faridabad-121007	Member
8.	**Dr. M. Ramachandran,** IAS (Rtd), Former Secretary, Urban Development, Govt. of India anf Former Chief Secretary, Uttarakhand, House No. A-36. Ranjit Singh Block, Asian Games Village, New Delhi-49.	Member
9.	**Director,** Indian Institute of Technology, Ropar, Nangal Road, Rupnagar-144001 (Punjab)	Member
10.	**Dr. S. Dassapa,** Centre for Sustainable Technology, Indian Institute of Science, Bangalore-560012	Member
11.	**Secretary,** Indian Biomass Power Association (IBPA) & managing Director Transtech Green Power P. Ltd., D-199, Pushpak Vihar, Hanuman Nagar Extension, Queen Road, Vaishali Nagar, Jaipur-302021	Member
12.	**Director General,** SSS-NIBE, Kapurthala-144601 (Punjab)	Member Secretary

SSS-NIBE STAFF

Dr. Yogender Kumar Yadav
(Director General)

Outsource Staff
01 PS to Director
01 Office Assistant (PA)
01 Office Attendant

Scientific Staff					Administrative Staff	Technical Staff
Thermochemical Conversion Division	**Biomass & Energy Management**	**Chemical Conversion**	**Electrochemical Processes**	**Biochemical Conversion**		
Dr. S. K. Tyagi (Scientist-E)		**Dr. A. K. Sarma** (Scientist-E)		**Dr. Sachin Kumar** (Scientist-D)	**Dr. Abhishek Gupta** (Admin cum Account Officer)	**Sh. R A Singh,** Assistant Engineer (Civil)
03 SRF 01 Project Assistant 01 Lab Facilitator 01 Driver Cum Mechanic 01 Helper		02 PDF 02 SRF 01 Lab Facilitator (02 Ph.D. students)		1 Young Scientist 03 PDF 2 SRF 01 JRF 1 Lab Facilitator 2 Project Assistant	**Sh Rupesh K Verma** (Jr Executive Asst, Admin) **Sh. Sanjay B Chauhan** (Jr Executive Asst., Accounts) **Outsource Staff** 1 Sr. Office Assistant 03 Office Assistant 2 Deputy Supervisor 01 IT Facilitator 1 Junior Supervisor 2 Office Attendant **Other Outsource Staff** 01 Staff Car Driver 01 Cook-cum-Attendant 07 Sweeper 16 Mali	**Mr. Vijay Bajala** (Jr. Technical Assistant) **Mrs. Shuchi Sahu** (Technical Assistant) (Not on duty since May, 2014) **Outsource Staff** 01 Sr. Office Assistant 02 Electrician 01 Plumber 1 Tractor Driver 2 Welder 01 Care Taker-Maintenance