Ministry of New and Renewable Energy
Proceedings of
"Conclave on RD & D in New and Renewable Energy"
held on 5th August 2014
at Vigyan Bhavan, New Delhi.

1. Inaugural Session

1.1 Ministry of New and Renewable Energy (MNRE) organized the 2nd "Conclave on R&D in New and Renewable Energy" on 5th August 2014 at Vigyan Bhawan, New Delhi. Shri Piyush Goyal, Hon'ble Minister of Power, Coal and New and Renewable Energy inaugurated the Conclave. Dr. R. Chidambaram, Principal Scientific Adviser, Government of India and Shri Upendra Tripathy, Secretary, MNRE addressed the participants during inauguration. A Compendium on R&D projects on new and renewable energy funded by MNRE was released by Shri Piyush Goyal on the occasion. The Conclave aimed to present the on-going R&D projects funded by the Ministry of New and Renewable Energy and to seek the views of researchers, scientists and eminent experts, policy makers for taking necessary steps for faster development of new and renewable energy technologies in the country. In all, about 24 Principal Investigators presented the outcomes and results of their on-going R&D projects. The programme of the conclave is given in **Annexure-I.** Around 220 participants, which included Principal Investigators, Co-PIs of R&D projects, researchers and scientists from R&D institutions engaged in research and development activities in new and renewable energy, eminent experts and policy makers from relevant government departments participated and contributed to deliberations in the Conclave. The list of participants is given in annexure-II. In addition a few media persons also participated in the inaugural session. The compendium which included a brief status of 103 on-going R&D projects and projects completed during 2013-14 in the areas of solar thermal, solar photovoltaics, biogas, biofuels, hydrogen and fuel cells and wind energy, was distributed to participants and media persons.

1.2 Shri Upendra Tripathy, Secretary, MNRE welcomed the participants, and made introductory remarks stating that the MNRE is very keen to strengthen R&D programme for faster development of technology so that full potential of New & Renewable Energy is utilized effectively and expeditiously. Shri Tripathy informed that the Ministry has set up the National Institute of Solar Energy (NISE) to give boost to R&D in Solar Energy Technologies. He further informed that in order to give impetus to R&D in bioenergy and wind energy, respectively, the National Institute of Renewable Energy, Kapurthala will be converted into the National Institute of Bio-energy and the Centre for Wind Energy Technology (C-WET), Chennai to the National Institute of Wind Energy Technology. He stressed on adopting a coordinated approach among R&D/academic institutions and industries for faster development of New & Renewable Energy Technologies. He further informed MNRE has initiated the process of setting up of a National University of Renewable Energy in Delhi to foster the R&D

in new and renewable energy. Secretary, MNRE mentioned that the MNRE has made increased outlay for R&D during the current 12th Five Year Plan, and impressed upon scientists, researchers, industries, etc for developing project proposals aiming at improved efficiency and cost reduction for faster commercialization of new and renewable energy systems/devices. He announced that the MNRE will create a provision for award to scientists for outstanding achievements from R&D Projects. Dr. R. Chidambaram, Principal Scientific Adviser to the Govt. of India in his address gave a detailed overview of R&D in renewable energy sector both at International and National levels. He appreciated the efforts made by MNRE for development & deployment of new & renewable energy in the country, and mentioned that subsidy is necessary to expand the use of New & Renewable Energy. Dr. Chidambaram pointed out to an interesting synergy between nuclear and renewables, exemplifying that Department of Atomic Energy uses solar panels with batteries to run seismometers in remote locations, the world's biggest hybrid nuclear desalination plant uses both Reserve Osmosis and Multi-stage Flash Technologies, which is used in solar desalination. He further mentioned that a 12MWp Solar PV Power plant which was laid at the Heavy Water Plant at Manuguru in November 2013, will reduce coal consumption at the plant by 15,000 tonnes per annum. He cited the examples of R&D efforts made elsewhere in developing storage systems utilizing molten salts and other materials and stressed the need for pursuing R&D in this area to enhance the reliability and availability of renewable energy. He mentioned that though R&D efforts, in solar photovoltaics, both globally and in India, have received maximum attention, and hinted that the country should also concentrate on increasing polysilicon production, if we are to prevent supply-chain disruptions in the future. At present, 90% of global polysilicon is supplied by just few companies in the U.S., Japan, Europe and China, and most solar cells are produces in China, Germany, the U.S. and Japan. Crystalline Silicon (single crystal, multi-crystalline) dominates the SPV field- 85-90% of the global market. Thin films (amorphous-Si, Cadmium-Telluride, Copper-Indium-Diselenide and Copper-Indium-Gallium-Diselenide have perhaps most of the remaining global market. Dr. Chidambaram emphasized on R&D in other advanced thin film technologies and in organic solar cells. He appreciated the initiative taken by MNRE in setting up of National Centre of Excellence and desired that these Centres should bring out the efficient and cost effective technologies and also manpower for operations and maintenance.

1.3 Shri Piyush Goyal, Hon'ble Minister of Power, Coal and New and Renewable Energy, in his inaugural address stressed on the need of strengthening R&D capabilities of the institutions for developing efficient and cost effective technologies so that the same can be deployed to realize the potential of renewable energy, contributing to achieving the goal of energy security and sustainable development. Shri Goyal stated that Hon'ble Prime Minister believes personally in indigenous development of technology and innovation, and therefore there will be no budget restrictions on R&D and that the present government is committed to it. Hon'ble

Minister further stated that MNRE has taken some concrete measures for strengthening institutional mechanism to boost R&D in solar energy through setting up of National Institute of Solar Energy (NISE) at Gurgaon. Similarly, National Institute for Wind Energy, Chennai and National Institute of Bioenergy, Kapurthala have been set up for expanding R&D, Testing and Demonstration in the fields of wind energy and bio-energy technologies and systems, respectively. He further stated that the Ministry is also working on setting up a Clean Energy Innovation centre at National Institute of Solar Energy as a Centre of Global Excellence. Hon'ble Minister mentioned that if necessary scientists working in R&D institutions should visit laboratories in the developed countries to acquire knowledge about the process and the technology and prepare collaborative programmes for technology development, and MNRE will be happy to explore the ways and means for organizing such visits. The efforts will help us to make India No.1 in the field of New and Renewable Energy Technologies in the World in next five years. He further stressed that the institutions created by MNRE should emerge as global centres for promoting the use of New and Renewable Energy. Shri Piyush Goyal, stressed on the need to expand the development and deployment of renewable energy technologies such that they are used even in the remotest place in the country. Shri A. K. Dhussa, Adviser, MNRE, while proposing the vote of thanks, acknowledged that the participants of the conclave have the key role in development and deployment of new and renewable energy in the country.

2. Plenary session

2.1 In plenary session, the over-views of developments in solar thermal, solar photovoltaics, bio-energy and new technology were presented by invited speakers. Dr. S. Srinivasa Murthy, Emeritus Professor, IISc Bangalore made a presentation on "Development in Solar Thermal Technologies-An Overview". He gave an over view of development in solar thermal technologies for water heating, industrial process heat and power generation applications. Prof. Murthy highlighted technical aspects of these technologies. He presented a few solar thermal power demonstration projects being implemented in the country. In his presentation, he emphasized on research on materials such as optical surface coating, antireflection coatings, self-cleaning glazing materials, development of medium temperature process heat solar collectors (for temperatures up to $250^{O}C$) with focus on cost reduction and durability aspects, and thermal storage systems to ensure continuous energy supply. He showed that solar thermal applications cover a wide range of temperatures and capacities. He mentioned that in certain, small to medium capacities, 'standalone' solar thermal power generation systems can be highly competitive because 'heat storage' is simpler, economical and environment friendly compared to 'battery storage'. Moreover, solar thermal systems are more amenable to "hybridization" with other forms of renewable sources, especially biomass. He stressed that 'solar polygeneration' systems, especially in food and agricultural processing, can make solar thermal applications economically viable. He mentioned that CSP/Heliostat

based very large capacity thermal power plants can yield high returns from a 'life cycle' point of view due to the recyclability of the materials.

2.2 Dr. A. K Barua,Hony. Emeritus Professor, Indian Institute of Engoneering Science and Technology, Shibpur, Howrah, made a presentation on "Developments in Solar Photovoltaic Technologies: an Overview", covering the status of various aspects of developments of solar cells and production technology including solar PV modules, balance of systems for solar pv array and storage both at international and national levels. In his presentation, Dr. Barua showed that the first generation cells which comprise crystalline silicon solar (single and multi-crystalline) cells occupied more than 85% of total PV shipment in 2013, which was 36GW. He explained that at the international level, efficiency of single crystal silicon solar cells is in the range 17-20% and for multi-crystalline in the range 15-18%, though at the R&D level the efficiency has been reported to be 25%. He mentioned that due to over production specially in China the present selling price of c-Si modules is less than USD $1.0/pW, which is lower than the cost price. This situation is not viable and the prices will increase when the excess inventory is finished and with increase in demand. He also showed that the efficiency of multi-crystalline solar modules is 2-3% lower than single crystal efficiencie. The lifetime of c-Si solar modules is claimed to be 25 years. He mentioned that India does not produce significant amount of poly-silicon. There are 20 industries making solar cells to modules and wafer to modules. He showed that though the installed capacity is about 2GW, only 1GW was produced at efficiency of 15-18%. He also showed the development and market share of second generation thin film solar cells, silicon based thin films, a Si & MICROMRPH, compound semiconductor thin film solar cells, CIGS thin films solar cells. In third generation solar cells, Dr. Barua showed that Dye sensitized solar cell has yielded efficiency 7-8% at R&D level in India. Organic & polymeric based solar cells have shown efficiency is 8-10%. He appreciated that R&D is nano material based solar cells is being pursued in India. He also presented R&D on various solar cell/module technologies being pursued in various R&D labs/industries in India. He emphasized on the need that Indian PV market has to be protected as is done in USA and Japan. He strongly stressed on the need of adopting consortium approach which worked reasonably well for a Si technology.

2.3 Prof. L. M. Das of IIT Delhi and Dr. Mathew Abraham, Mahindra & Mahindra made a joint presentation on "Developments in Utilization of Hydrogen: An Over view. Dr Das presented the work pursued in hydrogen research at IIT Delhi, which included utilization of hydrogen as fuel for engines, general properties and characteristics of hydrogen as fuel, technology for transport application under R&D projects supported by MNRE. The research activities funded by MNRE are being pursued jointly by IIT Delhi and Mahindra & Mahindra Ltd. He explained how hydrogen can be used as a clean energy fuel produced from hydrocarbons (medium term) and from renewable sources (long term). Dr. Das described how Hydrogen can be used in engines as neat hydrogen, hydrogen supplementation (i.e. hydrogen mixed with

petrol), hydrogen mixed with CNG and dual fuddling (mixing hydrogen with diesel). He showed that the performance testing for engine system at lab scale gave a maximum thermal efficiency of close to 44% at lean engine operation. He presented how the technology has been transferred from lab to land through demonstration for H_2 – Fuelled Three Wheelers in New Delhi in association with Mahindra & Mahindra and Air Products. The engine optimization and performance durability was done at IIT Delhi, field trials and maintenance by M&M and fuelling station of hydrogen supply by Air Products. The H_2 operated three wheelers were also demonstrated in exhibitions in Delhi. He showed that under a project funded by MNRE, field trials on hydrogen operated 3 wheelers for 30,000 km per vehicle is being carried out. Dr. Mathew Abraham, M&M presented the work on hydrogen vehicle integration. He presented the various aspects on safety and storage. He showed that HCNG-hydrogen enrichment with CNG has been completed in association with different business partners. Dr. Mathew highlighted the various issues such as availability of HCNG infrastructure, hydrogen fuel availability, regulations on HCNG as challenges. He also showed that a new four-cylinder hydrogen engine has been developed with 100% hydrogen substitution. He also showed that M&M is testing a 15kw fuel cell procured from Ballard. The stack was tested and fitted on vehicle, which worked successfully. He mentioned that M&M is actively making on CFCT fuel cell for operating vehicles.

2.4 Prof. Arvind Lali, DBT-ICT Centre, Institute of Chemical Technology, Mumbai made a presentation on "Recent Advances in Bio-energy Technologies: An Overview". In his presentation he talked about relevance and forms of biofuels, biomass and feedstocks showed their rich potential as source of energy in the country. He mentioned that waste is to be the next generation of wealth in India. He showed the potential of agri-residues/weeds/wild growth/forestry waste to be 40MJ /year; municipal solid waste, 20MJ/year, municipal liquid waste, 50MT/year. He also described the various options for biomass to biofuels and biomass to energy and comparisons of conversation options and showed that production of liquid fuels gives better value compared to power. He also presented the R&D activities being pursued at IICT on lignocellulosic bioethanol technology, biomass to methane and biomass to Bio-CNG.

3. Technical Sessions

3.1 Technical Session-I (Solar Thermal)

3.1.1 The session was chaired by Prof. S. Srinivasa Murthy, Emeritus Professor, IIT Chennai and co-chaired by Dr. P. Saxena, Director General, National Institute of Solar Energy, Ministry of New and Renewable Energy. Shri S. K. Singh, Director, NISE was the rapporteur of the session. Four projects were presented in the session as follows.

3.1.2 Prof. J. K. Nayak, IIT Bombay presented the progress of the project on "National Solar Thermal Power Testing, Simulation and Research Facility". It was

shown that the project had three major activities such as setting up of 1MW solar thermal power plant, creation of test facility of concentrating solar systems and development of simulation software for designing of solar thermal power plant. A grid-interactive solar thermal power plant, with a gross capacity of 1 MWe at direct normal irradiance (DNI) of 600 W/m2, has been designed and commissioned in the campus of National Institute of Solar Energy(NISE) at Gwalpahari. The unique feature of the plant is the integration of two different solar fields (parabolic trough collectors and linear Fresnel reflectors) without a fossil fuel backup. The plant combines the advantages of synthetic oil based parabolic trough collector (PTC) field and direct steam generation (DSG) of linear Fresnel reflector (LFR) field. The heat supplied for generation of steam is received from two different solar fields. The PTC field supplies about 60% (3 MWth) of the required heat, while the LFR field supplies the balance about 40% (2 MWth) of the required heat at design condition. The PTC field uses concentrated solar radiation incident on it to generate high temperature oil at 390ºC, which is fed into the heat exchanger. Simultaneously, the LFR field generates saturated steam at 44 bar and 256.1°C which is added to the steam generator. At the outlet of the LFR field a two-phase mixture is obtained. The mixture enters a drum, where the saturated steam is sent to the heat exchanger and the liquid is re-circulated to the LFR field inlet. HTF is used for both steam generation and superheating. The steam mass flow rate, pressure and temperature at the inlet of the turbine are 1.93 kg/s, 40 bar and 350ºC respectively. The plant works when reasonable quantity of solar radiation is available and uses a small amount of thermal energy storage (for about 20 min) as transient back-up. The test rig has been installed and commissioned at project site. Thermal performance of the paraboloid dish has been evaluated. Simulation software has been developed. The preliminary version of the simulator was released in 2011. Now version v2.0 of the software has been released. A few questions were asked from the audience regarding deployment of CST for power generation in the country. Prof. Nayak responded that further work will need to be done to assess the market potential of concentrator solar technologies.

3.1.3 Shri B. K. Jayasimha of WRST, Brahma Kumaris, Rajasthan presented the project on "1 MWe Solar Thermal Power Plant with 16 hrs. thermal storage for continuous operations". The configuration of power plant includes 770 nos of paraboloid reflectors of 6om3 fully automatic network enabled dual axis tracking provision, supported with static cast iron cavity receiver with thermal storage for 24 hours continuous operation. It was shown that institution has created infrastructure for manufacturing of solar dish including curving of mirrors. All the 770 paraboloidal reflector has been fabricated in their manufacturing unit and installed. The two-stage twin turbine generators has been procured from Siemens to generates 24 MWh electricity per day and 10 lakh litres hot water. A few questions were asked from the audience, which were clarified by Shri speaker.

3.1.4 Prof. L. Chandra, IIT Jodhpur presented progress under the project "Establishment of Centre of Excellence in Solar Thermal Research in IIT Jodhpur. IIT Jodhpur have initiated activities on various aspect of solar thermal technology such as mechanism of dust deposition on heliostat, effect of dust deposition in volumetric air receiver, mechanism of cleaning of volumetric air receiver, high temperature selective coating. Research has also been undertaken for development of development of glass to metal seal for vacuum receiver of parabolic trough. IIT Jodhpur have created facility for indigenous design and evaluation of sub-system for solar air tower, such as, open volumetric air receiver, thermal energy storage. Prototype open volumetric air receiver has been designed and evaluated. Centre has initiated design simulation for solar furnace for heat treatment of metal. A prototype of furnace has been designed and tested.

3.1.5 Dr. Yash Shukla, CEPT University, Ahmedabad presented the progress under the project **"Centre for Solar Passive Architecture and Green Building Technologies".** Presentation reveals that a number of building materials have been studied and have been categories in generic building materials and industrial building materials. They were further sub divided and identified as IS standard as well as for ISO ASTM testing protocol. 180 generic building materials and 190 finished sample and 30 substrates have been tested for thermal conductivity, specific heat, diffusivity, transmittance, reflectance and absorptance. Entire database have been placed in online U value calculator tools to facilitate designers to take informed decision regarding selection of materials for wall and roof. A few questions were asked from audience about the energy efficiency of such buildings. Prof. Shukla responded that it will depend on building orientation and combination of material used.

3.2 Technical Session-II (Hydrogen)

3.2.1 The session was chaired by Prof. S N Upadhyay, former Director, Institute of Technology, BHU, Varanasi and currently DAE Ramanna Fellow at Department of Chemical Engineering & Technology, IIT (BHU), Varanasi. Dr. M. R. Nouni, Director, MNRE was the rapporteur of the session. Four presentations were made in the session as described in brief below.

3.2.2 Prof. Debabrata Das, Indian Institute of Technology Kharagpur, Kharagpur presented the work undertaken in the project entitled "Mission Mode project on Hydrogen production through biological routes". It was mentioned by him that Jawaharlal Nehru Technological University, Hyderabad; Indian Institute of Chemical Technology, Hyderabad; The Energy and Resources Institute, New Delhi; University of Allahabad and Banaras Hindu University are also involved in implementation of the project as link institutions. Through the coordinated efforts of all academic and research organisations involved in the project, it is proposed to develop two pilot demonstration plants with reactor capacity of 10 m^3 each for installation at Kharagpur and Hyderabad with hydrogen generation capacity of 30,000 to 50,000

litres per day. In addition, design of a 100 m^3 bio-reactor for commercial application of the process would be another deliverable of the project. In view of the lower theoretical hydrogen yield of dark fermentation process for hydrogen production using different biological wastes, photo fermentation process has also been studied. He mentioned about the work undertaken under the project relating to: (i) identification of various microorganisms for biological hydrogen production through dark fermentation and photo fermentation processes; (ii) characterisation of various substrates like cane molasses, distillery wastes, paper mill effluents, etc. that are rich in carbohydrates and can be utilized for hydrogen production; (iii) optimization of various physico-chemical and biological process parameter for maximizing hydrogen production; (iv) development of prototype models for demonstrating the bio-hydrogen production process; and (v) maximization of gaseous energy recovery by hydrogen production followed by methane production. He concluded that hydrogen production through the biological routes will be attractive using organic wastes as substrates. Agricultural processing industry residues and de-oiled cakes are found to be most promising as nutritional supplement in the hydrogen production media for increasing the overall hydrogen yield and decreasing the production cost. Two-stage processes such as bio-hythane is a very promising concept for high energy recovery from the organic wastes. He mentioned that work relating to (a) design, fabrication, commissioning and operation of 10 m^3 reactor for bio-hydrogen production; (b) evaluation of the material and energy analysis of the process; and (c) design of a commercial plant for bio-hydrogen production are yet to be undertaken under the project.

3.2.3 Prof. S Dasappa, Indian Institute of Science, Bangalore made a presentation on R&D project on "Hydrogen and Liquid Fuels from Biomass Gasification". This R&D project is focused on two distinct areas, one dealing with hydrogen production and other on production of Liquid Fuel using Fisher Tropsch (FT) synthesis through Biomass Gasification. Air gasification is a mature and widely used technology with theoretical limit for hydrogen production as about 60 g/kg of biomass. However, about 40 g of hydrogen can be produced practically. IISc has gone in for oxygen instead of air gasification for eliminating some of the inert elements from the products of gasification. In addition, use of steam as gasifying agent enhances the hydrogen yield through water gas shift reaction. A scaled down version of about 15-20 kg/h capacity of open top down draft gasifier was adopted for the oxy-steam gasification with few modifications. In this system, about 104 g of hydrogen was produced per kg of biomass with steam to biomass ratio of 2.7 : 1 and gasification efficiency of 71%. Liquid fuel production part of the project included work relating to setting up of Fischer Tropsch reactor, to withstand pressure up to 5 MPa and temperature in the range of 300-350^oC. Catalysts for reaction were synthesized in-house due to non-availability of commercial catalysts. Preliminary results obtained for FT synthesis indicate production of diesel fraction. Detailed analysis in this regard is being carried

out. It was mentioned by him that IISc is developing a proposal for setting up about 60 kg/day hydrogen production unit for meeting the needs of PEM fuel cell bus.

3.2.4 Prof. O.N. Srivastava, Banaras Hindu University, Varanasi made a presentation covering R&D work carried out at BHU, Varanasi under the projects on "Mission Mode project on hydrogen storage materials (Hydrides): Research and Development" and "Development and demonstration of hydrogen fuelled three wheelers". He informed that the project group at BHU, Varanasi has investigated / developed 19 hydrogen storage materials / hydrides. He mentioned that BHU is focusing on development of hydrogen storage materials like AB_5 [LanNi5 (Mn)] and A_2B (Mg_2Ni) due to some favourable properties like storage capacity, activation, storage rate, cycle life, stability and cost. $La(Ni_{0.80}Fe_{0.20})_5$, developed at BHU, has provided storage capacity of 2.4wt%. The project group is focusing on MgH_2 due to favourable aspects like (a) large deposit in earth crust, (b) low cost, (c) a very light metal hydride, (d) high gravimetric storage capacity (7.6wt%), and (e) high volumetric storage capacity (110 kg/m^3). However, there are challenges relating to (a) high desorption temperature above 400^0C(desired ~150-200^0C), (b) high desorption activation energy ~97 kJ/mol, and (c) slow kinetics associated with MgH_2. By using different catalysts, success has been achieved in lowering desorption temperature and improving kinetics. A number of complex hydrides that include $LiAlH_4$ catalyzed with GNF; $NaAlH_4$ (catalyzed with Mm, Ti, TiO_2, GNF, CNT and Graphene); $Mg(AlH_4)_2$; $LiMg(AlH_4)_3$; $KAlH_4$; K_2NaAlH_6; $LiNH_2/Li_2NH$; and $NaBH_4$ have been investigated. The group has focused on those complex hydrides which promises reversibility and improvement in thermodynamics (temperature and pressure). MgH_2 and $NaAlH_4$ are among the front running candidates as solid state hydrogen storage materials for systems required for on-board storage of hydrogen in automobiles. MgH_2 and $NaAlH_4$ also have complementary properties in terms of hydrogen storage. In order to explore above properties, BHU has investigated the composite of MgH_2 and $NaAlH_4$. The progress under the project on "Development and demonstration of hydrogen fuelled three wheelers" was also presented. In the 8 three wheelers to be developed under the project $MmNi_{4.7}Fe_{0.3}$, $LaNi_{4.7}Fe_{0.3}$, Mg_2Ni and catalyzed MgH_2 are to be used for obtaining driving range of 30-90 km. These hydrogen storage materials offer different hydrogen storage capacities.

3.2.5 Prof. B. Viswanathan, Indian Institute of Technology Madras, Chennai made a presentation about an R&D Project entitled "Studies on hydrogen storage in carbon materials". He explained the need for developing carbon based materials for hydrogen storage and results of hydrogen storage capacity reported in the literature. He mentioned that hydrogen is stored in carbon and water in the nature. It was clarified by him that the project is focusing on developing appropriate and readily available carbon materials for storing about 4 to 5 wt% hydrogen. In this context, he mentioned about the efforts made for synthesis of heteroatom substituted carbon materials and evaluation of storage capacity of such materials. He also informed that nano scale carbon materials and graphene materials have been synthesized and their

hydrogen storage capacity have been evaluated. Pd nano particles decorated boron doped graphene has shown hydrogen storage capacity of about 5 wt% at room temperature and 3.2 MPa pressure. Work is in progress to achieve 5 wt% storage capacity at room temperature and 2 MPa pressure. Carbon materials up to 1770 m^2/g surface area have already been prepared and efforts are under way to prepare carbon material with surface area of the order of 3000 m^2/g. He also informed that M/s. Nano Ram Technologies, Bangalore is the industrial partner in the project and would undertake industrial production of the materials developed under the project for hydrogen storage.

3.3 Technical Session-III (Solar Photovoltaic)

3.3.1 The session was chaired by Dr. A.K. Barua, Hony Emeritus Professor, CEGESS, Bangal Engineering and Science University(BESU), Howrah(WB) and Co-chaired by Dr. Vikram Kumar, Former Director, NPL and Emeritus Professor, Department of Physics, IIT Delhi. Dr. O. S. Sastry, Director, NISE was the rapporteur of the session. The presentations made by PIs and the discussion held is briefly described below.

3.3.2 Dr. Geeta Balakrishna, Center for Nano and Material Sciences, JAIN University, Bangalore made a presentation on the project entitled "Exploitation of Unique Properties of Quantum Dots for Efficient Energy Harvesting Solar Cells". The project was sanctioned in May 2011 for three years period, and the final report has yet to be submitted. Dr. Geetha presented the work on the synthesis of nanostructured TiO_2 by sol-gel method and doping of TiO_2 with Nd, N and F, and Characterization of photo-catalyst using analytical techniques such as by XRD, SEM, TEM, BET, Spectral, AB, FTIR and DRS. DSSC are made by varying dopants, TiO_2/ N719 Dye, NF- TiO_2/ N719 and Nd- TiO_2/ N719 Dye. Highest efficiency DSSC obtained is 4.5%, however separately the maximum solar cell parameters obtained are, maximum J_{SC} of 8.7mA is observed in TiO_2/ N719, highest V_{oc} of 0.85V obtained Nd- TiO_2/ N719 and best fill factor(FF) of 0.702 observed in NF- TiO_2/ N719 solar cells. Further the synthesis of CdSe and CdTe quantum dots developed by drop cast and dip coating technique, and the characterization of the QDs, using XRD, SEM , TEM, Spectral study (PL, UV), DLS techniques are presented. CdSe Quantum dots fabricated from Octadecane solvent. X-ray diffraction studies established the crystal structure is Wurzite and PL, spectral studies to using UV-visible source are also completed. Similar studies on CdTe Q-dots using UV source are presented. Further, results on solar cells made out of TiO_2/CdSe and Nd-TiO_2/CdSe showed efficiencies less than 1%. Super-sensitized solar cells are also made out of hybrid structures **a) TiO_2/N719/CdSe/Pt and b) TiO_2/CdSe/ N719/Pt, and** efficiencies are 2.6% and 1.1% respectively, showing former structure

are better. At end of presentation a summary of all the results on different solar cell structures are listed. Finally, it was informed that, work is still under progress "to develop a prototype of solar cell with the new product and to study the maximum output characteristics of cell with respect to different parameters like film thickness, conductivity of substrates etc".

3.3.3 Dr. Shantikumar Nayer, Dean Research from Amrita Center Nano-Sciences and Molecular medicine presented the project, which aims to "Establish a Centre for Education in Integrated Nano materials based PV -Storage devices and to develop integrated panels consists of PV cells and Nanostructured, Super Capacitor cells". Accordingly, the PI aimed at developing a prototype based on three layered structured module, consisting of DSSC panel, electronics and storage layer consisting of super capacitors. The major achievements presented are :

- After a detailed lab scale research a DSSC module of 12cm X 12 cm main objective is to develop the model Thin Film based 4% efficiency was developed by spray pyrolysis of TiO_2. Further research optimization of the efficiency, temperature and long term stability is under progress.
- In the area of storage layer it is proposed to develop a Pseudo-capacitor with high energy and power density with high cycle life. After a detailed comparison study Electrophoretic-deposited MnO_2 / nanocarbon based super capacitors and battery are selected for storage purpose. A detailed study of comparison capacitance, energy density, and cycle life completed.
- The volumetric parameters such as capacity, energy density, specific energy density, power density and cycle life are compared with other conventional battery technologies. The performance is comparable in most of the parameters.
- The PI proposed that the following work to be taken up in the next phase:
  a. Making Si roof top modules (5 feet X 3 Feet)
  b. Creating the storage integrated roof-top modules (SISMs)
  c. Storage by developing cyclindrical cells (10 cm long by 2 cm dia) exhibiting a specification of 3V to 4V and 1200—1500 mAh.
  d. Cycling stability of 5000 cycles.
  e. Battery bank with pseudo capacitors and super capacitors.
  f. Characterize real time performance and stability of the system.

3.3.4 Prof. Chetan Singh Solanki of IITB, made presentation on the prestigious NCPRE project. NCPRE is established with a main thrust on education and research in field of SPV. This is a five year project with major objectives of development of 20% crystalline Si solar cells, 5% thin film sensitized cells, >90% efficiency power electronics, development of techniques for characterization, simulation and modeling, and a comprehensive education training programme in SPV. The project

was sanctioned during September 2010 with a total outlay of Rs. 47.50Crores. Following are the major achievements presented during the conclave:

a) A 1000 class and semi-clean room facilities established for preparation of materials, devices & interfaces and characterization facilities, modeling, testing and energy storage purpose as a part of the project

b) The major facilities for Si fabrication include diffusion furnace, PECVD and edge isolation, screen printer, rapid thermal processing, e-beam evaporator, ALD facility for new materials and devices. For materials and devices characterization UV-Visible, FT IR spectrophotometers, SEM, QE measurement system, solar simulator, CoRRescan and life time measurement set ups are established. For indoor and outdoor module characterization sun simulator module tester, a multichannel I-V tracer, environmental chamber, EL and IR set-ups, cell line checker, portable I-V tracer are available at NCPRE.

c) As a part of education training development programme in PV, short term and full term courses are designed and are made available through NCPRE web page: www.ncpre.iitb.ac.in . 8 class room and several short term courses recorded, 52 PhDs, 85 M.Techs are completed, 579 CEPs, 946 teachers and 693 others are trained.

d) As a part of PV crystalline Silicon solar cell research, process is developed for 14.9% efficiency Si solar cells through surface passivation and improved metal contacts, and solar cells with 17.4% efficiency over 100cm^2 and 16.4% over 156cm^2 area are developed using selective emitter, advanced light trapping and using new device structures. As a part research on new materials ALD based Sb_2S_3 sensitized solar cells of 1.8% efficiency, and Organic solar cell of efficiencies of 2.86% and 3.48% are fabricated in both conventional and inverted geometry respectively. Further, Perovskite based solar cells with 11.5% efficiency are also fabricated and reported.

e) A semi engineered product for two standalone systems 500 VA and 300 VA is developed. For irrigation application one semi engineered product has been developed for induction motor drive of 3 Hp capacity. Development of 1Hp Low Cost, High Speed Submersible BLDC Motor for deep well water pump is in progress. Hardware development for two more schemes are in progress. Semi engineered product for a single phase 5 kVA grid feeding inverter is developed. Hardware development for one three phase and one single phase grid feeding scheme is in progress. Hardware setup for analysis of transient response in micro-gird is developed. Low cost compact Solar Study Lamp based on 0.5w LED is also developed.

f) An all India survey of PV module's degradation is under taken jointly by NCPRE and NISE. As part of this survey, 56 modules from 26 sites covering 5 climatic zones are surveyed. Maximum degradation rates of

>1% are reported from Hot and humid and hot and dry. In the other zones the rates are within the specified limits.

3.3.5 Prof. H. Saha, CEGESS, BESU, Kolkota made a presentation on the project **"Advanced Research on Thin Film Silicon Solar Cells and PV systems"**. The major objectives of the sanctioned project are development of 7% stable a-Si modules of 10cm X 10cm, development of double tandem micro-marph cells of 11% over 1cm^2 area, double tandem 11% modules of 10cm^2 and 20% efficiency 3cmx3cm HIT cells. In PV systems major targets are to develop high efficiency (>80% @20% load) centralized charging system for LED/ CFL Lights, standalone inverter of 1KVA/24V of 95% @ 25% load and a GI string inverter of 10KVA, 3Ø of > 95% @ 25% load. The project was sanctioned during May 2011, with total outlay of Rs. 14.76Crores fro period of 5years. Work is still under progress as the date of completion is June 2016. Major achievements reported are:

a) World class facilities for solar cells development are established. These include wet Texturization, oxidation/ diffusion furnace, thickness profiler, SR measurement system, FESEM, Scanning microprobe, belt furnace, laser scriber, four probe measurement system, Screen printer, PECVD cluster, RF/ DC Sputtering unit, e-beam and thermal evaporation unit and a Reactive Ion etching unit.
b) The target set for single junction-Si solar cell with initial efficiency of 9% and a stabilized efficiency of 7.5% has been achieved in collaboration with HHV.
c) 13.24% efficient HIT cells on 1cm^2 area are developed. SiO_2 NPs solar cells of 8% efficiency are developed.For Micromorph cells work will start from September 2014.
d) Simulation studies on embedded silica nanoparticle, for the efficiency enhancement in superstrate type a-Si solar cell showed that, 20.94% with 200µm thick,18.75% with 20µm thick and 14.23% with 2µm thin layers are possible due to increased absorption and collection.
e) Simulation studies are also reported on Silicon nanopillars to reduce the reflection and increase the injection of incident light. The reflection measurements on actual nanopillars developed indicated that an average reflection loss reduced significantly to 5% in the spectral range of 300 to 1100nm.
f) A pre-commercial LED based Solar lantern for centralized charging system with improved efficiency of 85% and reduced cut-off current of 1.5 mA has been developed. Estimated cost reduction is ~20%.
g) A single phase Solar mains type inverter is developed with dual charging facility, >90%, high surge capacity, continuous full load operation, software settable parameters, with all protections has been developed. Similarly a Grid tied single phase transformer less inverter of 1KVA capacity with >90% efficiency, <5% THD, Islanding protection, frequency band width of 50H_Z ±

$3H_Z$, reconnection time of <10Sec and low DC injection is developed and currently under testing.

3.3.6 Due to paucity of time only a few questions could be allowed which were answered by the PIS and also addressed by Chiar/Co-chair. The Chairman and suggested that further questions could be discussed during tea/lunch/free time.

3.4 Technical Session –IV (Biofuel)

3.4.1 The session was chaired by Dr. D. K. Tuli, Executive Director and Centre Coordinator, DBT-IOC Centre for advanced Bio-energy Research, and co-chaired by Shri A. K. Dhussa, Adviser, MNRE. Shri Gangesh Updahaya, Director(Biofuel), MNRE was the rapporteur of the session. The presentations and discussions held are briefly described below.

3.4.2 Dr. R. K. Sukumaran, PI of the project made a presentation on the project "Sorghum Stover based Bio-refinery for Fuels and Chemicals", In his presentation, he described bio-refinery approach for production of fuels and chemicals from Sorghum stover, covering the following achievements;

- The availability of sorghum stover, suitability of material as a feed stock for biorefinery, details of the project and networking among the other three collaborative institutions of the project are discussed.
- Detailed information on the status of the project as per the sanctioned objectives and presentation of results on pretreatment of biomass , in house production of enzymes, pilot scale facility for enzyme production and ethanol production from sugar hydrolysates.
- The innovative efforts on development of technologies for production of aminoacids from C5 rich pretreatment liquor, cultivation of microalgae on C5 and C6 fermentation effluents, extraction of algal oil and production of biodiesel from algal oil and mentioned that upgradation of the developed technologies to pilot scale as future work of the project.
- The output of the project was disseminated through one published and two communicated papers and two patents which are under preparation for filing.

3.4.3 Dr. Piyali Das, PI of the project made a presentation on the project "Stabilization and upgradation of biomass derived bio-oils over tailored multifunctional catalysts in a dual stage catalytic process to produce liquid hydrocarbon fuels and its application studies". He presented the activities on catalytic pyrolysis of biomass under the above R&D Project as follows;

- Development of technologies like Auger and fludized bed technologies for production of stable bio-oil, and integration of this bio oil for production of alternate transportation fuels.
- The details of the developed automated pyrolysis unit (20 kg/hr) to pyrolyse five selected agro residues and testing of bio oils and evaluation of byproducts.
- Future activities under the project was mainly based on formulations of effective catalyst and production of stable bio oil with enhanced properties which can be used as Drop in fuel for petro fuel, Catalytic cracking of Stable upgraded Bio oil by selected Catalysts and production of alternate transportation fuel.
- One patent is filed and one publication was made from the outcome of the project activities.

3.4.4 Ms. Manju Sharma, PI of the project made a presentation on "Improved production of Biogas and Bio-CNG from Ligno-cellulosic Biomass". She presented the production of biogas and Bio-CNG from Biomass using modern approaches to improve the efficiency of the process as follows;

- Low yields, advantages and current draw backs of biomass to biogas technology and on need of transformation of present "Khadi'' technology to through Chemical, Engineering and Biotechnological interventions for improved modern industrially competitive biogas technology.
- Emphasis on the role of Modern Biological Engineering for improved production of Biogas through different reactor designs and less of hindrances from Waste Biomass.
- The development of optimal microbial consortium, process parameters of hydrolysis, acidification and methanogenisis and designing of substrate specific microbial consortia.
- The main outcome is the development of process to improve the production efficiency of biogas.

3.4.5 Dr. Thallada Bhaskar, PI of the project made a presentation on the project "Hydro pyrolysis of lignocellulosic biomass to value added hydrocarbons". The project mainly deals with the different approach for pyrolysis i.e Hydro-pyrolysis of the lignocellulosic biomass for production of biofuels. The presentation covered the following;

- The issues with fast pyrolysis of oils like high oxygen content and incompatibility with crude fractions for processing and emphasizing the

need and advantages of hydroconversion of bio oil to reduce the oxygen content.

- The details of the activities under the project as development of a hydropyrolysis demo unit and Hydropyrolysis Kinetics, catalyst for hydro conversion and a suitable process and optimized conditions for integrated hydropyrolysis of wheat straw, cotton residue and *Jatropha* seed deoiled cake.
- The outcome of the project activities were disseminated in the form of 5 number of papers in International journals and two papers presented in international conference and four number of manpower was trained in the project.

3.4.5 All the presentations were followed by an active interactive discussion between participants and PIs, Chai/Co-chair. The session was well attended by 30 participants from universities, R & D institutions and industries engaged in biofuel research throughout the country.

3.5 Technical Session – V (Wind Energy)

3.5.1 The session was chaired by Dr. S. Gomathinayagam, ED, C-WET and the rapporteur was Shri J.P. Singh, Director, MNRE. The presentations and discussions held are briefly descried below.

3.5.2 Shri A. D. Thirumoorthy, TEDA, Chennai made a presentation on the project "Study on Power Quality Issues in Grid Connected Wind Farms and Identification of Remedial Measures". He mentioned that the project was sponsored by C-WET with an objective to identify the key power quality issues like voltage sag, voltage swell, flicker, transients, harmonics etc., which causes operational and technical issues in the grid. The total budget outlay of the project was Rs. 37.375 lakhs. It was informed that the study was conducted both at wind turbine and sub-station levels in the State of Tamil Nadu. Actual events and waveform were captured and documented. From the monitored and captured events voltage sag, swell and transients were recorded. The simulations were conducted by using a sophisticated tool DIGSILENT and the validation was carried out with the actual events. As an outcome of the project various remedial measures like Low Voltage Ride through Technology (LVRT) and dynamic reactive capacity including soft switching were suggested. As an academic output, two papers were published in journals and three papers were presented in the conference including Asian International conference, Thailand. Also the project has helped in completing two M.Tech projects and one PhD work is underway. The project is completed.

3.5.3 Dr. Rajesh Katyal, Unit Chief, NIWE, Chennai made a presentation on the project "Health/condition monitoring at experimental/R&D wind farm at Kayathar on 2MW Wind Turbine". He mentioned that the project was sponsored by C-WET with a budget allocation of Rs. 40.89 lakhs, and the objective was to determine the appropriate condition monitoring system to determine the early failures in various components and sub-systems in order to shift from preventive and corrective maintenance to condition based maintenance. The idea was to determine the balance life of various components / sub-systems of wind turbine so as to bring down the operation and maintenance cost. As an outcome of the project the standardized monitoring is developed with fault prediction algorithm with the help of which the residual life of drive train components can be calculated. Further it was informed that the monitoring helps in providing the individual turbine health information and thereby increasing the life expectancy of various components and sub-systems thereby reducing the operation and maintenance cost. Data collection is underway and the project is ongoing.

3.5.4 Dr. A. P. Haran, Park College of Engineering & Technlogy, Coimbatore made a presentation on the project "Experimental characteristics of wind turbine blading over full 0-360 ^{o} angle of attack". The objective was to provide the aerodynamic characteristics of standard indigenously developed wind turbine covering the stall regions, post stall regimes and also the region of hysteresis to help indigenization of small wind turbines suitable for low and moderate wind regimes for a good starting and performance characteristics. Dr. Haran mentioned that as an outcome of the project good understanding has been developed for starting capacity low speed performance useful for selecting aerofoil for HAWT and VAWT by knowing the characteristics of the aerofoil at high angle of attack and the hysteresis. As an academic output one student has completed M.S (by research) and three conference papers has already been presented. Also one paper is under consideration for publication. The project is completed.

3.5.5 Dr. N. Kumarsen, National Institute of Technology, Tiruchirappli, made a presentation on the project "A novel hybrid energy system for supplying isolated loads with FPGA based energy management scheme". He mentioned that the project was sanctioned by NIWET, Chennai with a total budget outlay of Rs. 79.58 lakhs, and the aim of the project is to design and develop a micro-grid system based on various renewable energy sources such as wind, solar and biomass / biogas for reliable power supply at remote locations. Dr. Kumarsen mentioned that as a part of the project the electrical generators and appropriate power electronics controllers will be designed and fabricated. The project is to be carried out in two phases. The first phase involves the laboratory demonstration of the proposed system and the second phase is in the field implementation of the 10 kW wind-solar hybrid system. It was informed that the first milestones of the work such as development of algorithm for FPGA based inverter control and experimentation on WRIG using laboratory setup has been

completed. In addition, two research papers have been prepared based on the said work and communicated to the journals for possible publication. The project is ongoing and the programme is as per the milestones/ deliverables original mentioned in the proposal.

3.5.6 Dr. S. Ranganath Murthy, SSN College of Engineering, Chennai made a presentation on the project "Study and Control of Weak Grid connected Matrix Converter based DFIG system". He mentioned that the project was sponsored by C-WET with a budget allocation of Rs. 7.75 lakhs, and the objective was to replace the conventional Pulse Width Modulator (PWM) technique based AC-DC-AC converter with AC-AC Matrix converter. The simulations and hardware development of the DFIG using Matrix converter were briefed. As an outcome the project it was informed that a Matrix converter which works under synchronous and sub-synchronous modes of operation was developed. Also the switching algorithm was extremely complex than the back to back AC-DC-AC converters. As an academic outcome three International Journal Papers has been published and three papers has been presented in International Conference Proceedings. The project has helped in completing one PhD degree, two M.Tech degrees and four B.E. level projects.

3.6 Technical Session – VI (Biogas and Gasification)

3.6.1 In this session, the progress of four R&D projects in biogas and biomass gasification was presented by the respective Principal Investigators. The session was chaired by Prof. Arvind Lali, ICT, Mumbai and Co-chaired by Shri A. K. Dhussa, Adviser, MNRE. Dr. B. S. Negi, Director (Biogas R&D), MNRE was the rapporteur of the session. The presentations and discussion held in this session are briefly described below.

3.6.2 Prof. V. K. Vijay, IIT Delhi made a presentation on a R&D project entitled "Comparative evaluation of performance and mass emissions of an automated passenger vehicle fuelled with the enriched biogas using field trial tests". The project was completed in July 2013 and the final report submitted to MNRE. Prof. Vijay in his presentation showed the biogas upgrading facility established at CRDT, IIT Delhi and described how the enriched biogas produced from the facility has been used for operating a CNG driven vehicle under the project. He explained that the vehicle was initially tested with enriched biogas(93% methane) after a mileage built up to 6000 kms for mass emissions and power and torque and the results were compared with that of CNG fuel. After the testing, the vehicle was run successfully up to 20,000 kms in different driving conditions. The results were compared with the pre field trial results and it was found that the emissions were under the CPCB norms as prescribed for CNG. The fuel consumption was calculated with both carbon balance method and daily data reading for 20,000 Kms and it was found to be 24 km/kg. Also the cylinder retesting was done after the completion of the entire test by a government authorized CNG retesting center and it was found to be compatible. Carbon deposit

and wear and tear of engine components was checked for both pre and post field trial tests and minimal effect was found with 20,000 kms field trial of the vehicle. The proposed project has created database on various technical aspects of utilization of enriched biogas filled in the CNG cylinder for running automobile vehicles. There is no such study available in India and it will help regulatory authorities of the country to decide on various norms and regulations along with propagation of use of enriched biogas in vehicles. Prof. Vijay mentioned that the biogas up gradation technology need to developed for large scale promotion of collection of upgraded biogas from Goshala and rural areas which will not only give boost to enhancing energy availability but also will create employment opportunities.

3.6.3 Dr. Shailey Singhal, UPES and Co-PI of the project entitled "Integrated Research, Development and Demonstration of Biogas Generation from Leaves, Fruit hull & De-oiled cake of Jatropha using CSTR Digester" made a presentation on the project. The project was sanctioned to University of Petroleum and Energy Studies, Dehradun, and the duration of the project expired in March 2014. The completion report on the project has yet to be submitted. Dr. Shailey in her presentation explained that the objectives of the project have been met to a large extent. She mentioned that as they were unable to source fruit hull during the season and hence only JDOC and some leaves have been used for the production of biogas. The expected output of the study was operation and optimization of data on pilot scale for 40 m^3 CSTR type plant using Jatropha based lignocellulosic materials for biogas production, which has been achieved with the production of higher amount of biogas with approx. 70% methane in less time. She mentioned that this is the first CSTR reactor installed in the country at such a large scale, and through this successful efforts have been made for the complete replacement of cow-dung, the conventional source of biogas, by JDOC, which actually is a waste (needs care for disposal). She explained using pre-treated JDOC in CSTR helped in reducing the standard hydraulic retention time (40 days) to an appreciable extent, i.e. only 5.5 days. CSTR installed in the University is an automatic temperature control system, effective for all the seasons. She further explained that it is highly recommendable and advisable that CSTR can be adopted as technology, especially for community based biogas plants, used either for biogas or electricity production. She mentioned that future research perspectives involve the usage of inoculum chamber for the pre-treatment purpose. This will help in further reducing the HRT, in-turn increasing the productivity. In this work, pre-treatment has been done only at lab scale. This can be done and planned in-situ in the reactor. Feed stocks other than JDOC, such as agricultural wastes, fruit hull, etc. can be studied for their pre-treatment followed by production of biogas.

3.6.4 Dr. Mohan Rao, M/s Spectrum Renewable Energy Ltd., Kodoli, Kolhapur briefly described the project entitled "Decentralized project for production of 8000 kg/day Bio-CNG from press mud" at Kolhapur. In his presentation, he showed the photograph of the plant only. Dr. Rao informed that the plant is a 100 TPD press mud to biogas

and organic manure generation plant set up with 10% support by MNRE, which as was informed by him was Rs.3.5 crore. He informed that the project producing about 22000 cum of enriched biogas from press mud as well as spent wash which generates around 8000 kg Bio-CNG which is CN grade fuel. He informed that biogas produced from the plant is being sold to local people at much lower price than the LPG. He mentioned that he is not a technical person and therefore he was not able to talk about the technical detail of the project. He was also not able to make a technical presentation. The detailed status of the progress of the project was not available in the concerned division of MNRE, and therefore the same could not be included in compendium. In response to a question raised by one participant that whether any assessment on the success of such projects have been made and whether any individual can be allowed to carry out assessment as a success stories, the chairman responded that the case can be considered.

3.6.5 Dr. N. K. S. Rajan, CGPL, IISc Bangalore presented the progress of the project" Advanced Biomass Research Centre(ABRC)". The project duration expired in March 2014 and the completion report on the project has yet to be received. Dr. Rajan It was shown that R&D efforts under the project are focused on advanced on improving engine efficiency, technology package development to replace fossil fuels in industries by gasifier, development of higher capacity engine and improved efficiency, development of standards and test protocols of gasifiers, etc. He presented the outcome of the project as follows;

(i) Advanced research to address thermo-chemical conversion of biomass-Combustion & Gasification with emphasis on efficiencies and environmental compliance with multi-fuel capability demonstrated with woody biomass and agro & other residues in briquetted form.

(ii) Engine research in the area of usage of biomass derived fuels-Producer Gas, Bio Gas, Bio Oil etc. Both fundamental research and developmental activity in the area of producer gas has resulted in addressing critical issues in using producer gas for gas engines. Experimental work and modeling work on naturally aspirated engine which has been fitted with a close matching of turbocharger to producer gas has resulted in increasing the peak power output from 27kWe to about 74 kWe for the same engine. Adaptation of lean burn Indigenous engines for producer gas in collaboration with Cummins has resulted in a 500 kW capacity in India. Lean burn engines of 900kWe capacity imported engine on natural gas have been tested with producer gas without any modifications on the turbo charger. It has been able to go to a peak power of about 700 kWe. Short duration runs have been completed with specific fuel consumption is about 0.85-0.90kg/kWh. Based on the R and D in the lab related to engine, field implementation of projects is in progress.

(iii) In technology package development for replacing fossil fuels, design and adaptation for radiant tube burners with recuperation where the temperature

required is about 1100°C has been completed. Burner adaptation for aluminum melting furnaces has been developed and tested. Substitution of furnace oil with producer gas for biscuit backing industry has been demonstrated. The plant has been in operation for last three years with plant availability of more than 90%. Based on the performance about 18 industries of the same group is now going ahead with the technology package. 500°C, the required temperature for spray drying has been achieved by substituting 8 kg/hr of LPG with 32 kg/hr of biomass. Stoves for commercial kitchen have been deployed to replace LPG or fossil oil.

(iv) In emission standards for biomass energy devices, process for treating gasifier waste water has been developed. The present process for water treatment is adopted for IISc gasification system. Water treatment method developed meets the present CPCB effluent discharge standards. Engine exhaust except for CO at low loads is able to meet CPCB norms

(v) In establishing standards, a draft of manufacturing standards for gasification for recommendation to BIS has been sent to stake holders and comments have been received from academics and some manufacturers. Current test protocols have been studied and revised test protocols and qualifying standards have been established and made after discussions with the committee members. Comments were received and the document is being discussed with the stakeholder for converting to BIS

4. Concluding Session

4.1 As the Secretary, MNRE could not come to chair the concluding session, the discussion on summing up the deliberations was chaired by Shri A.K. Dhussa, R&D Coordination, MNRE. Shri Dhussa mentioned that the thrust on R&D is going to be high in the 12th Plan Period as renewables are going to be expanded. He then requested chairs/co-chairs of the respective sessions to make concluding remarks/recommendations. A few good questions/suggestions came from participants, which were considered by respective chairs/co-chairs in their concluding remarks. The recommendations are given below.

Solar Thermal - Prof S. Srinivasa Murthy

i. In low temperature applications range, R&D need to be pursued on exploring new material including examining whether aluminum is a good material for flat plate collector development. Heat pipe technology also needs to be developed for rise in flat plate collector.

ii. In concentrating solar technologies, the R&D needs to be pursued on indigenous development of receiver tubes with evacuation system. Parabolic trough and heliostats development should be pursued for reliable and cost effective technology. R&D in selective coating for temperature applications.

iii. R & D in Latent heat molten salt storage systems & chemical storages to improve the efficiencies and storage densities should be intensified.

iv. Extensive testing and evaluation need to be carried out on existing technology validation and demonstration projects on solar thermal power to study the performance and for scaling up the development and deployment. Based on the experiments and performance evaluation, manufacturing process of CST may be developed.

v. Food and agriculture applications of solar thermal technologies including 'polygeneration' integrated with various thermal processes need to be promoted.

Solar Photovoltaics - Prof. A.K. Barua and Prof. Vikram Kumar

i. R&D should be supported for development of crystalline solar cells for high efficiency with industry and academic consortia keeping in view USA is aiming at 25% efficiency.

ii. R&D should be supported for development of very highly efficient silicon based thin film solar cells which can meet the PV module demand when production reaches Terawatt range. A separated group to be set up for the purpose.

iii. Thin film technology is going to play an important role in future therefore R&D and production technology to be supported in the area.

iv. Research groups with proper networking like NCPRI at IIT Bombay need to be created to work for development of technology with efficiency and technology for production.

v. Technology need to be developed for production of raw silicon in the country. Large size plants are required for economy and therefore MNRE should support the activity.

Hydrogen Energy - Prof. S.N. Upadhyay and Prof. O.N. Srivastava

i. R&D to be supported considering both production and storage of hydrogen together and connecting application.

ii. The work of Prof. D. Das, IIT Kharagpur on bio-hydrogen production may be scaled up. This will call for use of a consortium of microbes as different wastes may be used for biological hydrogen production at different locations.

iii. In the context of production of syn-gas by gasification of biomass for hydrogen generation and production of synthetic liquid fuel by FT synthesis, it was suggested that both end products are important and therefore, both the routes are required to be supported, keeping in view the availability of biomass.

iv. So far as hydrogen production through electrolysis route is concerned, electricity is not cheap in India. So, efforts should be focused on improving the efficiency of electrolysers. It was mentioned that some experts suggest use of off-peak power for hydrogen production, but the important point is do we really have off-peak power? It was suggested that cost of production need to be worked out.

v. There is lot of similarity between fuel cells and electrolysers, used for hydrogen production, as some of the components are common. There is need for the researchers working in the area of fuel cells and electrolysers to come together for utilizing the expertise available with these two groups for developing efficient electrolysers and fuel cells. It was indicated that the technology of fuel cells and electrolysers and especially that of membrane which is used in both the products may not be made available to us by other developed countries.

vi. R&D on development of catalysts for photo-catalytic and photo-electro-chemical devices may be supported.

vii. In view of the fact that emphasis is being laid on replacing hydro-carbons by modern renewables, that excludes bio-energy, hydrogen has the potential to emerge as the ultimate green fuel. Therefore, policy decision will have to be taken for promoting use of hydrogen and curtailing use of hydro-carbons. In this context, levy of carbon tax and incentives for use of green fuel, such as hydrogen by the users were suggested.

Biogas & Biomass Gasification - Prof. Arvind Lali

i. R&D in bioenergy is need to be supported to translate the prototype systems developed in lab to the next level and tested for exploring the possibility for scaling up efforts through technology demonstration.

ii. Pilot scale projects to be supported to industry in consortia mode for technology demonstration prior to commercialization.

iii. Biomass research to be done in mission mode with certain facilities assigned to particular lab/consortia of labs.

Bio-fuel- Dr D K Tuli

i. Though R&D on biofuel has been supported in the country in last 10 years no pyrolysis unit exist in the country for production of biofuel.

ii. Cost economics and life cycle analysis need to be done in the beginning for taking up any R&D activities for development and demonstration of technology.

iii. Unavailability of indigenous enzymes is the major bottleneck of lignocellulosic ethanol technology development, and R&D aiming at addressing the issue need to be supported.

Wind Energy Technology- Dr. S. Gomathinayagam, ED, C-WET

i. Wind energy is a mature technology and therefore no research is done/sponsored in the area.

ii. Indigenous development of wind turbine is to be taken up and C-WET would like to take up this task including standardization.

iii. Hybridization of wind machine with solar has to be taken up vigorously, and a policy for hybridization is needed to support the same.

4.2 The Conclave ended with a Vote of Thanks to all the participants.

Annexure-I

R & D Conclave on New and Renewable Energy
On
5th August 2014

Venue: Vigyan Bhavan, New Delhi

Programme Schedule

09:00 – 09:30	**Registration**
09:30 -10:15	**Inaugural Session- Hall No. V** Welcome & Introductory Remarks: Sh. Upendra Tripathy, Secretary, MNRE Address: Dr. R. Chidambaram, Principal Scientific Adviser Inaugural Address: Sh. Piyush Goyal, Hon'ble Minister for Power, Coal and New and Renewable Energy **Release of "A Compendium on Research, Development & Demonstration Projects" by Hon'ble Minister for Power, Coal & New and Renewable Energy** Vote of Thanks: Shri A.K. Dhussa, Adviser, MNRE
10:15-10:45	**Tea Break**
Plenary Session- Hall No. V	
10:45-12:00	**Chairman: Shri Upendra Tripathy, Secretary, MNRE** Developments in Solar Thermal Technologies - An overview by Prof. S Srinivasa Murthy, IIT Madras Developments in Solar Photovoltaic Technologies - An overview by Prof. A.K. Baruah, Emritus Professor, BESU, Kolkata Developments in utilization of Hydrogen: An overview by Prof. L.M. Das, IIT, Delhi and Dr. Mathew Abraham, Mahindra & Mahindra Recent Advances in Bio-energy Technologies: An overview by Prof. Arvind Lali, ICT, Mumbai
Parallel Sessions	

Technical Session – I (Solar thermal)- Hall No V- 12:15-13:30	**Technical Session – II (Hydrogen and Fuel Cells Hall No-IV)- 12:15-13:30**
Chairman : Prof. S Srinivasa Murthy, IIT Madras Co-chair: Dr. Praveen Saxena, Adviser, MNRE Rapporteur: Sh. S.K. Singh, Director, NISE 1. 3.5 MW solar thermal power plant with 16 hours thermal storage for continuous operation by Mr. Golo Pilz, Adviser, WRST, Mumbai 2. Development of a MW scale national solar thermal power testing, simulation and research facility by Prof. J.K. Nayak, IIT, Bombay, Mumbai 3. Development of a Modular Central Receiver Concentrated Solar Power Plant for Decentralised Power Generation by Dr. Nitin Goel, SBET Pvt. Ltd. , Gurgaon 4. Establishment of the Centre of Excellence in solar thermal research and education at IIT, Jodhpur, Rajasthan by Prof. Rajiv Shekhar, IIT, Jodhpur, Rajasthan	Chairman : Prof. S.N. Upadhyay, Former Director, IIT, BHU, Emeritus Professor, Dept. of Chemical Energy, IIT (BHU), Varanasi Co-chair: Prof. L.M. Das, IIT Delhi Rapporteur: Dr M R Nouni, Director 1. Mission mode project on Hydrogen production through biological routes by Prof. Debarata Das, IIT, Kharagpur 2. Hydrogen and Liquid Fuels from Biomass Gasification by Prof. S. Dasappa, IISc., Bangalore 3. Hydrogen Storage Materials and hydrogen fuelled threes wheelers: by Prof. O.N. Srivastava, BHU, Varanasi 4. Mission mode Project on Hydrogen Storage in carbon materials by Prof. B. Viswanathan, IIT, Madras
13:30–14:15	**Lunch**
Technical Session-III (SPV) Hall No.V 14:15 –15:30	**Technical Session-IV (Biofuel) Hall No.IV 14:15 –15:30**
Chairman: Prof. Ashok Kumar Barua, Emeritus Professor, Bengal Engineering & Science, University, Kolkata Co-chair: Dr. Bharat Bhargav, DG, ONGC Rapporteur: Dr. O.S. Sastry, Director, NISE 1. Integrated Nano-material based PV storage Devices and Development of an Integrated panel consisting of PV cells & Nano-structured super capacitor cells by Prof. Shantikumar Nair, Cochin 2. National Centre for Photovoltaic Research And Education (NCPRE) by Prof. J. Vasi, Co-PI, IIT, Bombay 3. Exploitation of Unique Properties of Quantum Dots for Efficient Energy Harvesting in Solar Cells by Dr. R. Geetha Balakrishna, CET, Bangalore 4. Advanced research on thin silicon solar cells and photovoltaic systems by Prof. H. Saha, Bengal Engineering & Science University, West Bengal	Chairman: Dr. D.K. Tuli, Executive Director, R&D Centre, IUCL, Faridabad Co-chair: Shri A.K. Dhussa, Adviser, MNRE Rapporteur:Shri G.Upadhyay, Director, MNRE 1. Sorghum Stover based Biorefinery for Fuels and Chemicals by Prof. Ashok Pandey, NIIST, Trivandrum 2. Stabilization and upgradation of biomass derived bio-oils over tailored multifunctional catalysts in a dual stage catalytic process to produce liquid hydrocarbon fuels and its application studies by Dr. Piyali Das Fellow, TERI 3. Improved production of Biogas and Bio-CNG from Ligno-cellulosic Biomass by Dr. Arvind Lali, Head, DBT-ICT, Mumbai 4. Hydropyrolsis of lignocelulosic biomass to value added hydrocarbons by Dr. Thallada Bhaskar, IIP, Dehradun
15:30 – 15:45	**Tea**

Technical Session-V (Wind) Hall No.V **15:45-16:45**	**Technical Session-VI (Biogas and Gasification) Hall No.IV** **15:45-16:45**
Chairman: Dr S Gomathi Nayagam Rapporteur: Shri J P Singh, Director, MNRE 1. Study on power quality issues in grid connected wind farms and identification of remedial measures by Sh. A.D. Thirumoorthy, DGM (Retd.), TNAU, Tamilnadu 2. Health/condition monitoring at experimental/R&D wind farm at Kayathar on 2MW Wind Turbine by Sh. S. Shanmugam, Director, Design Desk Pvt. Ltd., Chennai 3. Experimental characteristics of wind turbine blading over full 0-360° angle of attack by Dr. A.P. Haran, Head, Dept. of Aeronautical Engg., Park College of Engg. & Technology, Anna University, Coimbaore 4. A novel hybrid energy system for supplying isolated loads with fpga based energy management scheme by Dr. N. Kumaresan, Dept. of Electrical & Electronics Engg., National Institute of Technology, Tiruchirapalli	Chairman: Prof. Arvind Lali, ICT, Mumbai Co-chair: Dr. N.P. Singh, Adviser, MNRE Rapporteur: Dr. B.S. Negi, Director, MNRE 1. Comparative Evaluations of Performance and Mass Emissions of an Automotive Passenger Vehicle fuelled with the enriched biogas using field trial tests by Prof. V.K. Vijay, IIT, Delhi 2. Integrated Research, Development and Demonstration of Biogas Generation from Leaves, Fruit hull& De-oiled cake of Jatropha using CSTR Digester by Mr. G.Sanjay Kumar, PI, UPES, Dehradun 3. Decentralization project for production of 8000kg/day Bio-CNG from Press mud by Dr.Mohan Rao, Director, M/s Spectrum Renewable Energy Ltd., Kodoli, Kolhapur. 4 Advanced Biomass Research Centre (ABRC) by Dr. N.K.S Rajan, IISc., Bangalore &
Concluding Session	
16.45:17:30 Hall No.V	Chairman: Shri A. K. Dhussa, Adviser, MNRE Panelist; 1. Prof. S. Srinivasa Murthy 2. Pro. A. K. Barua 3. Prof. Vikram Kumar 4. Prof. S.N. Upadhyay 5. Dr. Arvind Lali 6. Dr. D. K. Tuli 7. Dr. S. Gomathinayagam **Closing statement: Shri A.K. Dhussa, Adviser, MNRE**
Tea	

Annexure-II

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