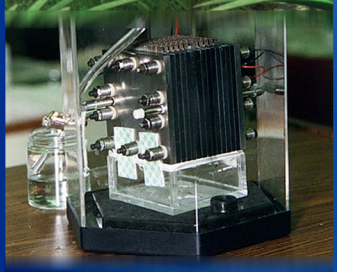

RENEWABLES IN SCIENCE AND ENGINEERING (RISE-2014)

(Under TEQIP - II and MNRE Solar RTC Project)

ABSTRACT BOOK

SESI STUDENTS' CHAPTER,
NATIONAL INSTITUTE OF TECHNOLOGY
SILCHAR-788010, ASSAM, INDIA

SOLAR ENERGY SOCIETY OF INDIA

RISE14

Renewables In Science and Engineering-2014

10-14th January,2014

ABSTRACT BOOK

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Prof. N. V. Deshpande
Patron, RISE-2013

We at NIT Silchar, Assam are glad to be associated with Solar Energy Society of India (SESI) for organising a one week short term course on Renewables In Science and Engineering (RISE-2014) from January 10th to 14th 2014 at NIT Silchar.

The rapid advancement of human civilization undoubtedly faces certain challenges and scarcity of resources is a major one. In such a scenario the renewables are the alternative and play a significant role in enhancing the quality of life of millions. Introduction of renewables in to the energy mix will definitely influence positively the future energy trends, environment and bestow health benefits.

It is indeed the need of the hour to exchange deliberations and brainstorming towards up-scaling and mainstreaming renewables in achieving Energy Security and Economic Development in India. I hope the week long course will be a catalyst for spreading awareness among all the stakeholders of this event and motivate them to innovate, implement and lead in the wide spread field of renewables.

I wish the event a grand success and the organising team all the best!

N. V. Deshpande
Director

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Rabindra Kumar Satpathy
President

4th January, 2013

MESSAGE

I am very happy to know that National Institute of Technology, Silchar and Solar Energy Society of India (SESI) are jointly organizing one week short term course on RENEWABLES IN SCIENCE AND ENGINEERING (RISE-2014) during 10-14 January, 2014 at National Institute of Technology, Silchar, Assam.

Developing countries like India, where nearly 300 million people do not have access to electricity and modern energy forums, need enhanced supply of energy to advance their social and economic development, but the key challenge lies in being able to do so in a clean and sustainable manner. The need for diversifying towards alternative energy choices is increasingly being recognized particularly to enhance energy security.

I am confident that the above short term course will provide the participants the requisite knowledge and training in the renewable energy sector.

I wish the above course a grand success.

Rabindra Kumar Satpathy
President

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Prof. R. D. Misra
Chairman, RISE-2014

4th January,2014

Message

In today's climate of growing energy needs and increasing environmental concern, demand for harnessing of renewable energy sources is increasing as alternatives to the non-renewable and polluting fossil fuels. The most common renewable energy sources available for use today are solar, wind, micro-hydro power etc. These freely available sources are all non-emission power sources having non-toxic or non-radioactive waste products. Power generated from these sources can be stored in a battery bank to provide backup power if utility power fails.

This one week short term course on "Renewable in science and engineering (RISE-14)" would provide an unique opportunity for dissemination of information in this field. This is an effort to publish a brief but comprehensive report in the form of abstracts.

The workshop would achieve its objective if each of us carries forward even a small part of the shared knowledge and use it to meet the challenges that confront us.

Rahul Dev Misra

Solar Energy Society of India

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Jagat S Jawa
B.E. TECH., P.G.D.P.M., M.TECH.
Director General

4th January, 2013

MESSAGE

We at Solar Energy Society of India (SESI) are glad to be associated with National Institute of Technology, Silchar for holding one week short term course on RENEWABLES IN SCIENCE AND ENGINEERING (RISE-2014) during 10-14 January, 2014 at National Institute of Technology, Silchar, Assam.

Renewables in India are being viewed increasingly as a means for providing millions of peoples with a better quality of life. It is also recognized that a higher share of renewable energy in the energy mix can have a significant impact on future energy trends, environmental as well as health benefits.

Our country has been taking steps towards development of renewable energy which has resulted in installed capacity of more than 29,000 MW in the various sector such as wind, solar, small hydro, biomass, etc. However, there is need for accelerated development and deployment of renewable energy systems and technologies specially in rural areas.

NIT, Silchar already has a SESI Student Chapter and I am sure this one week programme will enhance in the skills of participants in the renewable energy sector.

Wishing all the best for the above event.

Jagat S Jawa
Director General

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Dr. A Roy
Co-Chairman, RISE-2014

Message

3 January 2014

It is a privilege to be associated with "RISE-2014". I am immensely happy that our NIT Silchar is organizing a short term course "Renewables in Science and Engineering (RISE-2014)". This one week course will be highly beneficial to all participants, as leading experts of the country will deliver the lectures and will share their thoughts on state-of-art situation of energy crisis and its possible solutions. I am sure that this short term course will point out the need of renewable energy as the alternatives energy sources for our future and universe as a whole.

I extend my heartiest congratulations and best wishes for all the members of RISE-2014 and I wish the RISE-2014 a grand success.

(Asim Roy)

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Dr. Ranjith G. Nair
Coordinator, RISE-2014

Message

2 January 2014

In the current scenario per capita energy consumption is increasing day by day and the conventional energy sources are depleting. Recent trend of research shows that the whole globe is searching for an efficient alternative source of energy to meet our needs in which Renewable Energy definitely plays a major role to address the energy challenges. The wide scope of renewable energy lures researchers from all kinds of backgrounds and is a concern in almost all the sectors of the economy. The future, which demands renewables, has certainly a lot to offer to the stakeholders too.

RISE-2014 is an initiative to increase the pool of stakeholders and to update the ones who are already into the field. We expect this short term course not only to be a platform for the exchange of ideas rather we expect it to lead to their creations. We hope that we would end up with a fruitful and hence successful RISE-2014.

We heartily welcome everyone to RISE-2014 and wish a pleasant stay at NIT-Silchar.

(Ranjith G Nair)

FROM THE EDITORIAL DESK

It was in 1950's when a geologist named M King Hubbert created a curve, in which he had predicted that the oil reserves globally would be reaching a crest and then would get into the trough, never to return back. This prompted a lot of concerns across the globe with a big question mark over the future of humanity. Since then there have been a myriad of predictions related to the running out of fossil fuels. With a quick search on the web one can find that many of the theories predict an extinction of all the fossil fuels (viz. Coal, Oil and Natural Gas), by the end of the 21st century. Though the predictions have been shrouded with ambiguities, still no one can deny the fact that sooner or later, the fossils are certainly going to last. But, is it that the clock ticking in reverse would stop only when the final ounce of the fossil is consumed? Well, the problem palpably would start surfacing much before that. A rise in fuel prices is already evident. World's global warming graphs are buzzing the alarm. The "Carbon Trading" route to abide the Kyoto protocol won't remain for long, as soon the countries exporting their carbon dioxide emissions are going to touch the production limits of their own and hence would stop the trading of their CO_2 limits. Nobody wants the development to stop (rather, nobody wants the development to even get slower). But the development itself comes at some costs. Paying the cost in terms of fossils has a negative implication on society as it stands as the major culprit in harming the environment and hence they owe us a larger social cost (negative Externality). As is quite evident, the future global geopolitics is going to be shaped by the concerns of energy as well as environment security.

Renewables happen to be a promising detour to meet our energy as well as environmental demands, till eternity. With the present scenarios, one can doubtlessly declare that the ones taking the lead in overhaul of present energy systems from conventional fossils to non-conventional renewables would be the ones taking their development graphs to new levels. Thankfully, the Indian picture is satisfactory, as the ambitious schemes like Jawaharlal Nehru National Solar Energy Mission have been initiated. With the government taking its step ahead, it's now our turn, as the budding technocrats, to take the onus on our shoulders. It's now our turn ….to RISE!!!

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PHOTOVOLTAIC POWER: FROM EVOLUTION TO REVOLUTION

B. Ghosh
School of Energy Studies, Jadavpur University, Kolkata 700032

The exploitation on natural resources has caused a controversy since the industrial revolution in the nineteenth century. Questions about who controlled these resources, which benefited from their explorations, and what are the environmental consequences of this exploitation have been raised repeatedly. Energy resources and fossil fuels in particular, have been the focus of intense and protracted controversy throughout the industrialized world. Providing of power to the industrialized society, energy resources have to be converted into useful form of work. In fact that the technical wonders of the modern world, by and large, depend on the handful of what we call the conventional energy conversion technologies, the principle of which has been known for a century or more ago. Most of these technologies are heat engines. In fact, energy technologies have been based primarily conversion of thermal energy i.e. heat into other forms of energy. The conventional heat engines includes two particularly important varieties; the steam power plants for generating electricity, and the internal combustion engine for powering the transportation systems in the modern society. The conventional heat engines are running through the burning of fossil fuels. The burning process imposed two major constraints to our mother earth and her environment. The first one is resource depletion with characteristic degradation and emission from end products of burnt items that causes a great threat for sustenance of the world. Thus, for bringing sustainability for this globe there are the efforts in search of clean and safe energy sources in addition to their hassle free conversion technologies. The solar power is the ultimate source of almost all the world's energy, including coal, oil, natural gas, wood, food, wind and waves, as well as direct heating by the incoming solar radiation. It is not a truly eternal source as all astronomical evidence indicates that the sun will eventually suffer a catastrophic end. However, it is all but certain that it will last rather longer than mankind. Thus, it can be

regarded as an eternal source. Furthermore, the rate at which the solar power reaches the earth's surface is fairly constant, and will probably remain so for the next several millennia. Thus, solar power is truly inexhaustible nature of supply and beyond privatization. Conversion of solar power into the useful form of energy is a possible solution for supplying clean and safe power to this world. The important aspect that solar energy enables vegetation to grow and it is using to produce electricity through photovoltaic systems. Photovoltaic (PV) systems convert sunlight into electricity by means of photovoltaic effect; the effect took its birth 1839. When sunlight shines on photovoltaic cells, it is absorbed and converted directly into electricity without any moving parts. Although each cell produces only a small amount of electricity, cells can be linked together into solar modules to make solar arrays until the desired electrical output is met.

PV is an increasingly important energy technology. Deriving energy from the sun offers numerous environmental benefits. It is an extremely clean energy source, and good matching to the ecology. As it quietly generates electricity from light, PV produces neither any air pollution nor hazardous waste. Moreover, it does not require any land and water when integrating in the buildings. Thus, building integrated PV (BiPV) system is a Zero Land Zero Water power plant. As its input energy source is sunlight, which is free and abundant, indicted that PV systems can offer virtually guaranteed access to electric power market. Initiatives since 1954 has taken in fabricating milli watt peak (mWP) and today it reached to the Mega watt peak (MWP) level and participated in the power budget. Many of such power plants were emerged in our country which are generating with the capacity like conventional power plants. All these aspects will be presented in the text of the paper.

Dr. Biswajit Ghosh M.Sc, PhD, C.Engg., D.Sc(Engg.) is an eminent scientist and technologist made original scientific and outstanding technological contributions in the various fields of science and technology. He contributed in the field of electrical contacting technology to electronic devices in general and solar photovoltaic cells in particular. In addition to these he contributed in power generation from agricultural wastes for conserving conventional fuels and green house gasses. His expertise in electroless coating technology and defect induced contact fabrication beard the stamp of originality in research.

He is distinguished in providing leadership for implementing solar power from mili watt to mega watt level both in India and abroad. Implementation of gasification technology in the industries for conventional fuel conservation is another dimension of his contribution.

The achievement started from fundamental work in 1978 in developing electrical contact to photovoltaic (PV) cells in general and later on electrifying rural remote island villages in using PV power systems and integrating PV systems the urban buildings with the perception of onsite generation and conservation for sustainability in particular.

He played a pivotal role in implementing Energy Science and Technology education in India and abroad. He is credited with directing the ascent of the School of Energy Studies of Jadavpur University, Kolkata, India. His contribution led School of Energy Studies at the global forum and also becoming the topmost school in the University.

He credited many award of funding from national bodies as well as international organization like Commission of European Communities, Royal Society, British Council for carrying research in the frontier areas of technologies. Recently he has been offered by the Leverhulme Trust Research Chair of Visiting Professor at Newcastle University, UK.

He has achieved significant global recognition through contributions to novel electroless deposition process for various

scientific and industrial applications and successful implementation of megawatt level solar PV power both in India and also United Nation's Industrial Development (UNIDO) program in the countries of central Asia and West Africa in enhancing Human Development Index.

BIOHYDROGEN: A GREEN FUEL FOR THE FUTURE

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Although crude oil production is predicted to peak soon, it is unreasonable to assume that conventional fossil fuel sources can continue to meet society's increasing energy demands for many decades to come. The United Nations estimates the population to be around 9 billion by 2050. This predicted human population explosion without renewable energy technology will be a major threat to this planet due to the increasing levels of carbon dioxide (CO_2) in the Earth's atmosphere. Besides, the excessive use of fossil fuels is one of the primary causes of global warming and acid rain, which have started to affect the earth's climate, weather, vegetation and aquatic ecosystems. Such rising global concerns coupled with national energy security considerations have urged the need for the development of non-polluting, renewable energy sources. Hydrogen has emerged as a promising alternative since it can be derived from a variety of energy sources and used in fuel cells with high efficiency. Biological H_2 production has an edge over its chemical counterpart mainly because it is environmentally benign. Despite having simpler technology, higher evolution rate of H_2 and the wide spectrum of substrate utilization, the major deterrent of anaerobic dark fermentation process stems from its lower achievable yields.

Theoretically, the maximum H_2 yield is 4 mol H_2/mol glucose when glucose is completely metabolized to acetate or acetone in the anaerobic process. But it is somewhat difficult to achieve the complete degradation of glucose to carbon dioxide and H_2 through anaerobic dark fermentation. Moreover, this yield appears too low to be economically viable as an alternative to the existing chemical or electrochemical processes of hydrogen generation. Intensive research work has already been carried out on the advancement of these processes, such as the development of

genetically modified microorganism, improvement of the reactor designs, use of different solid matrices for the immobilization of whole cells, development of two-stage processes, etc. for higher rate of H_2 production. Maximum H_2 yield is found to be mol H_2/mol glucose. However, major bottlenecks for the commercialization of these processes are lower H_2 yield and rate of H_2 production. Competent microbial cultures are required to handle waste materials efficiently, which are usually complex in nature. This will serve dual purposes: clean energy generation and bioremediation. Scale-up studies on fermentative H_2 production processes have been done successfully. Pilot plant trials of the photo-fermentation processes require more attention. Use of cheaper raw materials and efficient biological H_2 production processes will surely make them more competitive with the conventional H_2 generation processes in near future.

Prof. Debabrata Das has pioneered the promising research and development of biohydrogen production process by applying fermentation technology. This is a major area of green technology whereby the future world will be rewarded with the boons of a dream fuel-hydrogen! He is actively involved in the research of hydrogen biotechnology for a period of last eleven years. His commendable contributions towards development of a commercially competitive and environmentally benign bioprocess began with the isolation and characterization of high-yielding hydrogen producing bacterial strain *Enterobacter cancerogenus (cloacae)* IIT-BT 08, which, as of today, is known to be the highest producer of hydrogen by fermentation. He has conducted basic scientific research on the standardization of physico chemical parameters in terms of maximum productivity of hydrogen by fermentation and made significant contribution towards enhancement of hydrogen yield by redirection of biochemical pathways. Prof. Das has also conducted modeling and simulation study of a continuous immobilized whole cell hydrogen production system using lignocellulosic materials as matrix.

Prof Das is involved in Pilot Plant studies (800 L and 10,000 L) for the commercial exploitation of the process using cane molasses, sewage sludge and industrial wastewater such as distillery effluent and cheese whey. The aim was to synchronize the bioremediation of wastewater with clean energy generation. He has various sponsored projects on different aspects of hydrogen biotechnology under the aegis of DST (India), DBT(India), MNES(India), NSF (USA), DAAD (Germany), DTU (Denmark), Norwegian Foreign Ministry. He associated with international collaborative research work with University of Miami & Southern Illinois University, USA; Ruhr University & Aachen University, Germany; Technical University, Denmark; University of Berger, Norway. He is the Editor-in-Chief of *American Journal of Biomass and Bioenergy*. He is the member of the Editorial Board of the journals: *International Journal of Hydrogen Energy, Biotechnology*

for Biofuels, Indian Journal of Biotechnology. Recently, he has been awarded *IAHE Akira Matsui Award 2008*. Prof. Das has published one top cited paper in the *International Journal of Hydrogen Energy* (present citation no. is 1214). He is the one of the authors of the book entitled "Biohydrogen Production: Fundamentals and Technology Advances" published by CRC Press, USA. Presently, he is the 'MNRE-Renewable Energy Chair Professor' of IIT Kharagpur.

ISSUES AND CHALLENGES FOR WIND POWER INTEGRATION INTO POWER SYSTEMS

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Wind power has been proved as one of the potential sources of electricity generation with minimal environmental impact and is the fastest-growing source of new electric generation in the world. With the advancement of aerodynamic designs, wind turbines that can capture several megawatts of power, are available. When such wind energy conversion systems (WECSs) are integrated with the grid, they produce a substantial amount of power, which can supplement the base power generated by thermal, nuclear, or hydro power plants. Harnessing wind energy for electric power generation is an area of research interest and at present, the emphasis is given to the cost-effective utilization of this energy resource for quality and reliable power supply.

In the past, when the wind power penetration was not high, wind turbines were treated by and large as embedded generators, which were not to contribute to power system control and therefore requirements for wind turbines were focused primary on protection of the turbines themselves and did not consider the impact of these on the power systems. However, with the increasing share of wind turbines in power generation and with connection of wind farms directly to the high voltage grid, loss of a considerable part of the wind generators cannot be accepted. Therefore, power system operators revise their grid connection requirements, and issue grid code requirements (GCR) specifically made for wind turbines and wind farms. Hence wind turbines were required to take part in actively to control voltage and/or frequency. In addition, wind turbines are required to remain in connection from the grid even during the abnormal operating conditions. That is, if, wind power substitutes conventional power plants, it also has to take over the power system control and stabilization tasks, which the substituted conventional power plants are accomplished.

To analyse the impact of wind power in meeting the existing GCR as well as GCR's required in future, suitable models of wind power generation are required reflecting the technological development. Wind farms must fulfil almost the same technical requirement as conventional power plants. According to the German grid code, wind farms have to supply not only active power but also reactive power into the grid. The requirements are defined with respect to the power factor as a function of the voltage at the point of common coupling (PCC) with the main grid. Thus, the reactive power management becomes an integral issue in the grid connected offshore/onshore wind parks having long cables/transmission lines. The available reactive power sources such as switched reactors, switched capacitors, transformer taps along with switching of cables, flexible ac transmissions systems (FACTS) devices, etc. must be utilized properly during both steady-state and dynamic conditions.

Integration of wind power into the competitive electricity market presents challenges to power system planners, policy makers and operators. In many countries around the world it is being discussed how to combine the introduction of competitive electricity markets with the implementation of renewable energy sources (RES) targets. This is due to the existence of several types of barriers to the penetration of renewable energy. Specifically, several barriers that have prevented penetration of wind power generation have been listed in the literatures. These include cost-effectiveness, technical barriers, and market barriers such as inconsistent pricing structures, institutional, political and regulatory barriers, and social and environmental barriers. Some barriers may be specific to a technology, while some may be specific to a country or a region.

This talk will discuss the various issues and challenged in grid connected wind power generation.

Prof. S. N. Singh obtained his M. Tech. and Ph. D. in Electrical Engineering from Indian Institute of Technology Kanpur, in 1989 and 1995, respectively. Presently, he is a Chair Professor in the Department of Electrical Engineering, Indian Institute of Technology Kanpur, India. Before joining IIT Kanpur as Associate Professor, Dr Singh worked with UP State Electricity Board as Assistant Engineer from 8-8-1988 to 13-6-1996, with Rookree University (Now IIT Rookree) as Assistant Professor from 14-6-1996 to 1-1-2001 and with Asian Institute of Technology, Bangkok, Thailand as Assistant Professor from 2-1-2001 to 4-4-2002. Dr Singh received several awards including Young Engineer Award 2000 of Indian National Academy of Engineering, Khosla Research Award of IIT Roorkee, and Young Engineer Award of CBIP New Delhi (India), 1996. Prof Singh is receipt of Humboldt Fellowship of Germany (2005, 2007) and Otto-monsted Fellowship of Denmark (2009-10).

His research interests include power system restructuring, FACTS, power system optimization & control, security analysis, wind power, etc. Prof Singh is a Fellow of Institution of Electronics and Telecommunication Engineers (IETE) India, a Senior Member of IEEE, USA, a Fellow of the Institution of Engineering & Technology (UK) and a Fellow of the Institution of Engineers (India). Recently he received 2013 IEEE Educational Activities Board Meritorious Award in Continuing Education which is very prestigious award, first time won by a person of R10 region (Asia-Pacific).

Prof Singh has published more than 350 papers in International/national journals/conferences. He has also written two books one on Electric Power Generation, Transmission and Distribution and second is Basic Electrical Engineering, published by PHI, India.

He is Chairman, IEEE UP Section.

ANALYSIS OF DIFFERENT TYPE OF HYBRID PHOTOVOLTAIC THERMAL AIR COLLECTORS: A COMPARATIVE STUDY

S. Agrawal
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A hybrid PVT system is a combination of photovoltaic (PV) and solar thermal components/systems which produce both electricity and heat from one integrated component or system. A comparative analysis of different type of photovoltaic thermal (PVT) air collector namely: (i) unglazed hybrid PVT tiles, (ii) glazed hybrid PVT tiles and (iii) conventional hybrid PVT air collectors have been carried out for the composite climate of Srinagar (India). It has been observed that overall annual thermal energy and energy gain of unglazed hybrid PVT tiles air collector is higher by 27% and 29.3% respectively as compared to glazed hybrid PVT tiles air collector and by 61% and 59.8% respectively as compared to conventional hybrid PVT air collector. It has also been observed that overall annual energy efficiency of unglazed and glazed hybrid PVT tiles air collector is higher by 9.6% and 53.8% respectively as compared to conventional hybrid PVT air collector. On the basis of comparative study, it has been concluded that CO_2 emission reduction per annum on the basis of overall thermal energy gain of unglazed and glazed hybrid PVT tiles air collector is higher by 62.3% and 27.7% respectively as compared to conventional hybrid PVT air collector and on the basis of overall exergy gain it is 59.7% and 22.7%.

Dr. Sanjay Agrawal was born on July 01, 1976 at Obra, Shonbhadra (U.P.), India. He did B.E. in Electrical Engineering from Madan Mohan Malviya Engineering College, Gorakhpur (U.P.), M. Tech. in V.L.S.I. Design from Uttar Pardesh Technical University, Lucknow (U.P.) and PhD from Indian Institute of Technology Delhi. Mr Agrawal has 11 year of teaching experience. He joined as a Lecturer in Department of Electrical & Electronics Engineering in G.L.A. Institute of Technology and Management, Mathura (U.P.) in 2002. Presently, Mr. Agrawal is holding the post of Reader, Electrical Engineering, School of Engineering and Technology, Indira Gandhi National Open University, New Delhi.

He has worked for Industrial Project entitled "Automatic power factor correction" sponsored by Applied Electro-Magnetic Pvt Ltd, Noda and Project entitled "Clean drying technology for locally available medicinal plants and seasonable vegetables of IIT Delhi" Sponsored by "Ministry of food processing industries (MOFPI)". He has visited Sweden and Spain and presented many papers in an international conferences. He has published 15 papers in international journals and authored two books.

His areas of research interest are solar thermal, photovoltaic, exergy, carbon trading, power system and circuit theory. He has expertise in designing of transmission line and substation up to 220KV.

BIOMASS AND BIO-ENERGY AS VIABLE ALTERNATIVE TO CONVENTIONAL ENERGY SOURCES: SOME ISSUES ABOUT RESOURCES AND TECHNOLOGY

D.C. Baruah
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Biomasses can produce energy through six distinct routs *viz.*, (i) combustion (*domestic heat for cooking, lighting & space heating; industrial process heat, steam and electricity*); (ii) gasification (*heat, fuel and electricity*), (iii) fermentation (*ethanol*), (iv) pyrolysis (*charcoal & bio oil*), (v) anaerobic digestion (*biogas*) and (vi) extraction (*bio-diesel*). These are more of less technologically matured options and have wide ranges of applications. Biomass used for domestic cooking and space heating through traditional combustion devices comes under traditional category. On the other hand, uses of biomass for energy conversion through efficient conversion devices are called as modern biomass. There has been some visible move worldwide to utilize biomass as a viable alternative to the conventional sources of energy.

Modern biomass, as a source of renewable electricity, has also developed in many countries. For example, modern biomass accounts for 11% of the Austria's national energy supply. Similarly, biomass accounts for about a third of the energy supply in Brazil, main applications being (i) ethanol for automobile from sugar cane (about 14 billion litres a year) and (ii) use of biomass charcoal in steel industry. Danish renewable energy programme is formulated to utilize about 1.2 million tonnes of annual crop straw as well as forest residues for generating thermal and electrical energy. Modern biomass provides about 20% and 17% of primary energy demand in Finland and Sweden, respectively. It is also planned to acquire 40% of the Sweden's energy supply in 2020 through modern biomass. Similarly, Zimbabwe produces about forty million litres of ethanol per year making share of biomass up to 75% of national energy demand. Besides production of about 4 billion litres of ethanol per

year, USA has about 10.7 GW biomass fired power plant. However, there are many issues, concerning the material (biomass) and conversion technology requiring appropriate attention. Knowledge on the (i) availability of biomass material in sustainable manner, (ii) biomass characterisation ensuring efficient and economic utilization, (iii) selection of appropriate technology suiting the specific biomass material and ensuring minimum possible life cycle emission are some of the issues highlighted in this lecture. A special reference of geospatial tool techniques used for planning biomass based renewable energy programme to handle space and time varying parameters is also made in this lecturer.

Prof D.C Baruah is currently Professor in the Department of Energy, Tezpur University, Assam. Before joining Tezpur University, Prof. Baruah served Assam Agricultural University (AAU) for about 17 years (1989 to 2006) in various teaching and research positions. Major research involvement of Prof Baruah during that period has been farm mechanization and energy management. He taught courses on Agricultural Engineering and led numbers of field demonstration programmes on modern farm machinery in various parts of Assam. He also handled number of sponsored research projects concerning Energy Requirement in Agricultural, Farm Implements & Machinery and Renewable Energy during his engagement in AAU. Prof. Baruah joined Tezpur University in March 2006 as Reader and promoted to the post of Professor in September 2009. Some of his current interests are renewable energy planning and management, renewable energy intervention in industries, GIS-LCA analysis for Rural Energy planning etc.

An Agricultural Engineering Bachelor Degree holder from Rajasthan Agricultural University in 1988 completed his M. Tech. from IIT, Kharagpur in 1990. He got his Ph.D. from Punjab Agricultural University, in 2000.

There are about 50 research publications to his credit and has attended numbers of national and international conferences and seminars in various places in the country and abroad. Currently three externally funded research projects with international and national partners are carried out by Prof Baruah. Four of his 12 Ph. D. students have already received degree under his guidance. He was offered Indian Distinguished Visiting Fellowship by University of Nottingham, UK in 2010. He is also the recipient of Commendation Medal offered by Indian Society of Agricultural Engineering (ISAE), New Delhi. He is a life member of Indian Society of Agricultural Engineers and Fellow of Institution of Engineers (India). In addition to the academic responsibilities he is holding various other responsibilities in the University. He served as

the Head of the Department of Energy during 2010 to 2013 and Coordinator of Tezpur University Intellectual Property Cell during 2009 to 2012 and currently he is the Dean of Students Welfare, Tezpur University

SOLAR CELL MATERIALS AND ITS APPLICATIONS

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In this communication different generation of solar cells materials, their efficiencies, life, and cost have been discussed. Further the type of solar cell based PV module available in the market has also been discussed. Working principle of silicon base PV module, the different applications of hybrid PVT systems namely solar distillation, dryers, water/air heating system have also been discussed. Some of the analytical expressions have also been derived.

Prof. Gopal Nath Tiwari born on July 01, 1951 at Adarsh Nagar, Sagerpali, Ballia (UP), India. He had received postgraduate and doctoral degrees in 1972 and 1976, respectively, from Banaras Hindu University (B.H.U.). Over several years since 1977, he has been actively involved in the teaching programme at Centre for Energy Studies, IIT Delhi. His research interests are Solar distillation(water purification), Water/air heating system , Greenhouse technology for agriculture, aquaculture and crop drying, Earth to air heat exchanger , Passive building design and Hybrid photovoltaic thermal systems for greenhouse, solar house and drying. He has guided about 70 Ph.D. students and published over 500 research papers in journals of repute. He has authored twenty books associated with reputed publishers namely Pergaman Press UK, CRC Press USA, Royal Society of Chemistry (RSC), UK, Pira International, UK, Alpha Science, UK, Narosa Publishing House, Anamaya Publisher, New Delhi etc. He is a co-recipient of 'Hariom Ashram Prerit S.S. Bhatnagar' Award in 1982. He has been recognized both at national and international levels. His contribution for successful implementation of hot water system in the IIT campus has been highly appreciated. He had been to the University of Papua, New Guinea in 1987-1989 as Energy and Environment Expert. He was also a recipient of European Fellow in 1997. He had been to the University of Ulster (U.K.) in 1993. Besides, he had been nominated for IDEA award in the past. He is responsible for development of "Solar Energy Park" at IIT Delhi and Energy Laboratory at University of Papua, New Guinea, Port Moresby. He has organized many QIP (Quality Improvement Program) at IIT Delhi.

Professor Tiwari had visited many countries namely Italy, Canada, USA, UK, France, Australia, Greece, Thailand, Singapore, Sweden, Hong Kong, PNG and Taiwan etc. for invited talks, chairing international conferences, expert in renewable energy, presenting research papers etc. He has successfully co-coordinated various research projects on Solar distillation, water heating system, Greenhouse technology, hybrid photovoltaic thermal (HPVT) etc.

funded by Govt. of India in past. He is an Associate Editor *Solar Energy Journal (SEJ)*, USA (2006- Present) and *Int. J. Agricultural Research*, USA (2006- Present) and Editorial board member of Int. *J. of Energy Research*, Canada (2006- Present) and *The Open Environment Journal* (2007-present). He was organizing secretary "SOLARIS 2007", and SOLARIS-2012 at IIT Delhi and BHU, Varanasi.

Professor Tiwari has also been conferred "Vigyan Ratna" award by Government of Uttar Pradesh in the year 2007 on his work in the area of SOLAR ENERGY APPLICATIONS. Currently he is President of Bag Energy Research Society (BERS-2007) (www.bers.in) form to disseminate energy education in rural areas.

AN ASSESSMENT OF PHOTOACTIVITY OF OPTIMIZED MIXED LATTICE METAL OXIDE NANOMATERIALS FOR SOLAR ENERGY AND ENVIRONMENTAL APPLICATIONS

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Search for high potency nano-technological alternatives for solar, energy and environmental applications is being vigorously pursued specially for photovoltaic energy conversion, photocatlytic hydrogen production, piezoelectric nano-generation, and environmental remediation including carbon valorization.

From a host of nanomaterial systems of inorganic/organic origin being investigated for these applications, metal oxides find a much wider attention due to their favourable physico-chemical properties, non-toxicity and cost effectiveness. For direct photocatalytic solar hydrogen production as well as solar photocatalytic detoxification and disinfection applications investigation of these materials is being pursued around the globe. The trend shows that the third generation photovoltaic devices will be completely dominated by nano-materials of different origins, morphology, crystallinity, etc.

A number of studies on pristine titania based systems have concluded that the pristine titania phases, which have limited photoactivity in the Ultra-violet(UV) range only, can be improved. For this different approaches such as doping, sensitization, multi-phase complexation, size/shape modification, specific surface area enhancement and morphological variations have yielded some positive results.

These isolated approaches have resulted in improvement of the performance attributes of the photoactive nano-structured systems such as enhanced light harvesting, extended absorption spectrum,

efficient charge separation and complementary carrier transport characteristics along with apposite sorption characteristics for photocatalytic applications. The report presents the improvement in the most of the aforementioned attributes through approaches aimed at having desired impact through nano-structuration / complexation of the photoactive metal-oxide system.

Prof. S.K. Samdarshi, Head, Centre for Energy Engineering, and Dean, School of Engineering, Central University of Jharkhand(CUJ), Ranchi, Jharkhand(India) is an alumnus of Indian Institute of Technology Delhi, India. He has been actively associated with the Solar Energy research in the country and has made substantial contribution in design, simulation, materials, applications and systems' research and development in the diverse area of solar and renewable energy technologies. These resulted in a number of important research publications (45 International, 22 National), two books(edited) and one national patent. He has guided six Ph.D.s and four more are working under him. He has executed 07 research and 04 developmental projects in different areas of solar energy. Some of his significant contributions in the area of visible photocatalysis include development of highly active homojunctions of titania and zinc oxide nanosystems and their consolidation under doped, sensitized and composited conditions. He has also done a collaborative work in the development of bio-mimicked hierarchical morphology of the photocatalyst systems at nanoscale. He has a number of national and international collaborations. His current research interests are in upstream technologies related to solar photocatalytic, new generation photovoltaic materials and solar thermal systems performance parameters, and in downstream issues such as energy security and renewable energy education. He has contributed substantially at national and international level as member of different bodies and also as Head of the Deptt of Energy, Tezpur Central University, Tezpur Assam, India. A former Governing Council member of the Solar Energy Society of India(SESI), Prof Samdarshi was convener of ICORE 2011(International Congress on Renewable Energy 2011), the first SESI flagship event to be held in NE India.

AN OVERVIEW OF POLYMER ELECTROLYTE MEMBRANE FUEL CELL COMPONENTS: RESEARCH AND DEVELOPMENT

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Polymer electrolyte membrane fuel cell (PEMFC) is one of the fuel cells that operate at low temperature and found suitable for stationary and automotive applications as well as for power generators ranging from a few Watts to kilo Watts. Despite the fact that PEMFC have many advantages such as relatively low operating temperature, convenient fuel supply, longer lifetime, high power density, and its modularity, their marketability will depend heavily on whether it can compete with the conventional technologies on performance, cost, and reliability in a specific application. For example, the cost of automotive fuel cells should be competitive with today's internal combustion engines for successful commercialization. The DoE's cost target for commercialization of a fuel cell system in 2010 was 45 $\$\cdot kW^{-1}$ for production volume of 5,00,000 units. This target was divided between the fuel cell stack (30 $\$\cdot kW^{-1}$) and the supporting balance of plant (15 $\$\cdot kW^{-1}$). However, the ultimate goal for replacing the internal combustion engine is 30 $\$\cdot kW^{-1}$ by 2017. Due to the pressing need to overcome these issues, the researchers and scientists are attracted to research and development of efficient PEMFC components such as bipolar plate, electrocatalyst support, polymer electrolyte membrane (PEM), and gas diffusion layer (GDL). Therefore, the material selection for the PEMFC components plays a pivotal role on the performance of a fuel cell. In particular, electrical conductivity and excellent chemical stability in acidic and redox environment are a few of the most important requirements.

Graphene has attracted a great deal of attention in a variety of applications in the fuel cell components including bipolar plate and electrocatalyst support material due to its unique properties.

Graphene is one of the most exciting nanomaterials being explored during recent years, not only out of academic interest but also for its potential applications. Graphene is an atomically thin sp^2 hybridized 2D sheet of carbon atom, packed in a hexagonal lattice structure. This distinct structure of graphene has received considerable attention because of its fascinating properties including very high surface area (around 2630 $m^2 \cdot g^{-1}$), highest electrical conductivity (around 10^6 $S \cdot cm^{-1}$), excellent mechanical strength, inherent flexibility, high aspect ratio, and unique basal plane structure. Therefore, the lecture would provide basics of fuel cell with emphasis on PEMFC along with its components. Moreover, glimpse of the research work focusing on the use of graphene in the fuel cell components would also be discussed.

Dr. Anil Verma holds Ph.D. in Chemical Engineering, from IIT Delhi. He was a visiting fellow to Newcastle University, U.K. in 2008. Prior to joining IIT Guwahati in 2005, he worked with Asian Paints (India) Limited. His research work covers the various aspects of Energy and Environment Systems focusing on Fuel Cells and CO_2 Conversion to Fuel using electrochemical techniques. He is recipient of various national and international awards. A few of them are UK India Education and Research Initiative (UKIERI) Research Award, Amar Dye-Chem Award for Excellence in Research and Development from IIChE, and served as All India National Council Member for IIChE. Till date, he has published 46 papers in International journals having high impact factors such as Journal of Power Sources, International Journal of Hydrogen Energy, Fuel Cells, and Carbon etc. He has undertaken various projects and consultancies from different organization such as CSIR, BRNS, DST, KFUPM Saudi Arabia, and MHRD etc.

TEST PROCEDURES FOR SOLAR THERMAL COLLECTORS AND SYSTEMS – THE BASIC CONSIDERATIONS

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A solar thermal conversion system, inevitably, is an integration of a number of sub-systems which, invariably, are tailor-made with minor variations in the basic design for an application and purpose and are, accordingly, named differently. For example a solar water heatersystem is used for heating water, solar air heater for air, a solar cooker for food material, solar dryer for materials with water content, solar still for evaporating water, solar power systemfor heat transport fluid, and solar refrigeration and cooling system for absorbent-refrigerant mixture. All of them haveone and the most important sub-system in common, that is the collector-absorber sub-system which itself may not only be isolated but different also such as - flat plate/evacuated absorber with a concentrating/non-concentrating collector.

Thus the test procedure for the collector-absorber subsystem is isolated from the test procedure of the complete solar thermal systems for a given application. Hence the present report essentially discusses the test procedure for these subsystems and the complete system separately keeping in mind that the issues to be addressed may differ considerably whether it is related to the thermal performance parameters, material, structure, support system, long term stability, compatibility, weather, installation or handling. The collector-absorber sub-system is the heart/prime-mover of a solar thermal system. Hence the measure thrust has been given on thermal performance testing of these in addition to performance of its optical components.

Prof. S.K. Samdarshi, Head, Centre for Energy Engineering, and Dean, School of Engineering, Central University of Jharkhand(CUJ), Ranchi, Jharkhand(India) is an alumnus of Indian Institute of Technology Delhi, India. He has been actively associated with the Solar Energy research in the country and has made substantial contribution in design, simulation, materials, applications and systems' research and development in the diverse area of solar and renewable energy technologies. These resulted in a number of important research publications (45 International, 22 National), two books(edited) and one national patent. He has guided six Ph.D.s and four more are working under him. He has executed 07 research and 04 developmental projects in different areas of solar energy. Some of his significant contributions in the area of visible photocatalysis include development of highly active homojunctions of titania and zinc oxide nanosystems and their consolidation under doped, sensitized and composited conditions. He has also done a collaborative work in the development of bio-mimicked hierarchical morphology of the photocatalyst systems at nanoscale. He has a number of national and international collaborations. His current research interests are in upstream technologies related to solar photocatalytic, new generation photovoltaic materials and solar thermal systems performance parameters, and in downstream issues such as energy security and renewable energy education. He has contributed substantially at national and international level as member of different bodies and also as Head of the Deptt of Energy, Tezpur Central University, Tezpur Assam, India. A former Governing Council member of the Solar Energy Society of India(SESI), Prof Samdarshi was convener of ICORE 2011(International Congress on Renewable Energy 2011), the first SESI flagship event to be held in NE India.

SOLAR ENERGY MATERIALS

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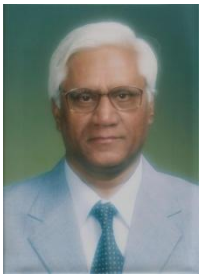
Solar energy is converted into useful form by using either Photothermal or Photovoltaic effect. In a photothermal conversion of solar energy, solar radiation is converted into heat by using absorber which essentially is a copper plate coated with selective coating. The selective coating used for photothermal conversion has a unique property that it has high absorptance for solar radiation and low emmittance for thermal radiation. There are several materials such as Black Nickel, Black Chrome, Cobalt Oxide, Aluminum Nitride, etc which can be deposited on the metal surfaces and tailored to give desired properties. The structured surfaces of the absorber also act as a selective coating. Recently, it has been shown that nano-materials also have high solar absorptance and low thermal emmittance and are useful selective coatings for high temperature applications. The structural and optical properties of these materials are dependent on the substrate and the deposition technique used.

In a photovoltaic conversion of solar radiation, solar energy is directly converted into electricity by using a device called "Solar Cell". Solar cells are made from semiconducting materials such as silicon, gallium arsenide, copper sulphate etc. Solar cell is essentially a p-n junction made from suitable semiconducting materials which absorbs solar radiation and converts them into charge carriers. These charge carriers flow through the load and generate the current. This is the most attractive way to convert solar energy into useful form. The most widely used material for making solar cell is silicon either in single crystal, polycrystalline or amorphous form. Besides silicon, gallium arsenide, copper indium disulphide, cadmium telluride, cadmium sulphide, etc are other materials used for fabricating solar cells. The highest efficiency of solar cell which one can get for single junction solar cell depends on the band gap of the material. Ideally band gap of the material to get highest efficiency is 1.55 eV. The researchers all over the world are

trying to develop cost effective technology to achieve highest possible conversion efficiency by using novel materials.

In recent times, instead of single junction solar cells, multi-junction solar cells have been developed. These cells are called as "Tandem Solar Cells" and are made from gallium arsenide, cadmium telluride, copper indium diselenide, amorphous silicon, etc materials. In the tandem solar cells, band gap of each layer is tailored to use entire solar spectrum to generate charge carriers and increase the overall efficiency of the solar cell. Researchers have already achieved efficiency of about 36% without using solar concentrator.

Now nano-structured materials are being used to fabricate solar cells. These cells have higher efficiencies due to higher absorption of solar radiation, efficient charge transfer, and efficient collection of charge carriers. All these efforts are directed to achieve higher conversion efficiency and lower cost of production of solar cells so that Solar energy can compete with conventional energy sources.



Dr M G Takwale was Professor of Energy Studies (State Bank Energy Chair) and Director of School of Energy Studies, University of Pune from 1988 to 2000. Dr Takwale completed his M. Sc. Physics (1967) degree from University of Pune and Ph. D (1974) degree from National Chemical Laboratory, Pune. Then he joined Department of Physics, University of Pune as Lecturer and taught Solid State Physics, Surface Science, Materials Science and Solar Energy to postgraduate students. He actively participated in establishing Interdisciplinary Schools in Science Faculty. Under the ULP program of UGC (1974), he developed 20 experiments of Solid State Physics for undergraduate students. He has 35 years of teaching and research experience. His major field of research are Material Science, Surface Science, Solar Energy and Energy Management. He has published 125 research articles in international Journals and has guided 30 students for Ph. D. degree and 42 students for M. Phil. Degree.

Dr Takwale developed "Test Center" for testing solar thermal systems which has been recognized by MNRE, Govt of India as "BEST TEST CENTER" in India. He also developed and installed Solar Steam Cooking System at Shri Saibaba Temple's Prasadalaya, Shirdi. This system produces on an average 2600 Kg steam per day which is sufficient to cook 1400 Kg rice. This system has been selected by MNRE, as "Prestigious solar system in India".
Dr Takwale was Vice-Chancellor of Shivaji University (2000 – 2004), Kolhapur and Pravara Institute of Medical Sciences (2004 – 2012), Loni, Ahmednagar, Dean of Science Faculty and Director of Board of College and University Development, Pune University. He has worked as technical expert on several committees of MNRE and MEDA.

Dr Takwale is member of Physical Society of Japan and Indian Physics Association and Fellow of Maharashtra Academy of Sciences. He was given "Surya Award" (2002) by Indian Institute of Social Sciences, New Delhi, "DSK Energy Award" (2006) by Institute of Engineers for his contribution to the field of solar energy. For his contribution to the higher education, he was awarded

"Guruwarya Baburao Jagtap Award" (2004) by Maratha Mahasangh.

For his higher studies and research collaboration, he visited Nagoya University (Japan), Swedish University of Agricultural Sciences (Lund), and International Center for Theoretical Physics (Trieste, Italy).

ORGANIC SOLAR CELLS FOR A BRIGHT FUTURE

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Nature has created sun and it is now human turn to harness solar radiation energy for generation of electricity in a cost effective and eco-friendly way. Photovoltaic is the answer to this. Currently used photovoltaic technologies are based on crystalline Si (single, multi -crystalline, thin films), thin film based on amorphous Si, CIGS, CdTe, etc. All these technologies suffer from high cost. Efforts are in progress to make these conventional technologies more cost effective and efficient. However, there is a strong need to find alternate technologies which can address both the problem of cost and efficiency and is commercially viable. One of the alternatives that stores a promise is the organic photovoltaic (OPV) technology. Global R &D efforts are in progress to achieve better efficiencies in organic solar cells based on various approaches such as small molecule, polymer, hybrid organic-inorganic composites, etc. Power conversion efficiency > 10.0 % has already been achieved in polymer solar cells using donor: acceptor interpenetrating bulk heterojunction (BHJ) with suitable interface layers, thermal treatments, inverted and tandem configurations, etc. It clearly shows polymer BHJ solar cells based on a composite of an electron –donating conjugated polymer and an electron- accepting fullerene offer promise for the realization of a low-cost, printable, portable and flexible renewable energy source. Recently new developments have taken place in the area of organic solar cells where efficiencies in excess of 8% have been obtained based on solution proccessable small molecules in combination with PCBM .These options make the OPV technology more commercially viable and holds a bright future. CSIR-NPL has also made significant fundamental and applied contributions in the area of OPV especially towards enhancement in efficiency of these solar cells.

Dr. Suresh Chand is an internationally known scientist having more than 37 years of research and development experience in the area of polymers and their applications in opto-electronic and organic electronics devices. He had all his education from Delhi University and has always been a ranked holder. After receiving his Ph D in Physics in 1981from Delhi University he joined as scientist 'B' in National Physical Laboratory (NPL), New Delhi, India.

Presently he is holding a senior position of Chief Scientist and is the Head of many R&D activities at NPL such as (i) Physics of Energy Harvesting Division (ii) Nodal officer CSIR-NPL TAPSUN Program (iii) Head Organic and hybrid solar Cell Group Head Organic and inorganic LED Group

Throughout his research carrier Dr. Suresh Chand has been very creative and innovative and has made significant fundamental, applied and technological contributions in the area of polymers, selenium, polymer-selenium combinational x-ray imaging materials and devices, organic electronic materials viz. small molecules, conducting/conjugated polymers, hybrid organic-inorganic nano-composites and their application in organic solar cells. He has more than 100 international publications in highly reputed innovative international journals and a few patents to his credit. He has guided and guiding many Ph.D and M. Tech. Students.

Currently he is leading many multi crore international and national projects in the area of organic photovoltaics. He is also chairman, advisor, member of various monitoring committees of projects from UK, France, USA, etc in polymer solar cells.

Dr. Suresh Chand is recipient of ***"NPL** outstanding scientist award for the year 2007- 2008".* Besides this he is a member of various scientific bodies and a reviewer on various internationally reputed scientific journals. He is widely internationally travelled and has participated in various international meets and delivered invited talks. He is a vibrant scientist and inspiration to youth who wish to pursue a scientific career.

SYNTHESIS AND APPLICATIONS OF PHOTO-CATALSIS IN SOLAR ENERGY UTILIZATION

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It is known that nearly 400 different semiconducting oxides and other mamaterials and many other variations in each of them like doping, coupling have been employed for three important photo-catalytic decomposition of water, photo-catalytic reduction of carbon dioxide and also reduction of di-nitrogen. In addition to these energy conversion or chemicals formation reactions a variety of decontamination reactions have also been studied for the purication of water and air. In spite of these extensive studies, the success and reported conversion efficiency has not yet reached the desired levels of success due to various inherent problems. In spite of these concerted attempts to evolve and identify a material that can produce solar energy to chemical energy conversion to a desired level, the success appears to be eluding and the reasons could be many. However, these attempts have led to variety of spin off technologies like thin film coating, understanding of defect science of semiconductors and development of efficient solar collectors. The presentation attempts to review and bring forth the possible fallacies in our search for suitable materials for solar energy conversion.

One of the main reasons is the anxiety to develop materials which will be active in the visible region of the solar spectrum. The validity of this attempt will be analyzed from the point of view of the energy needs of earth and the available energy from sun.

Among the materials that have been examined for solar energy conversion, TiO2 occupies an unique place accounting for more than 50 percent of the studies dealing with this system. In spite of this situation the exact positions of the band edges in the two of the active phases of TiO2, namely anatase and rutile are not yet clearly established. In Fig 1, the most recent study on this system is

shown schematically. There are a variety of postulates correlating the photo-catalysis activity with descriptors like the d electron configuration of the transition metal ion of the semiconductor, the extent of ionicity of the metal oxygen bond and a variety of other inherent parameters of the semi-conducting materials including the crystal structure. The presentation will examine all these postulates with a view to evolve future directions for this search.

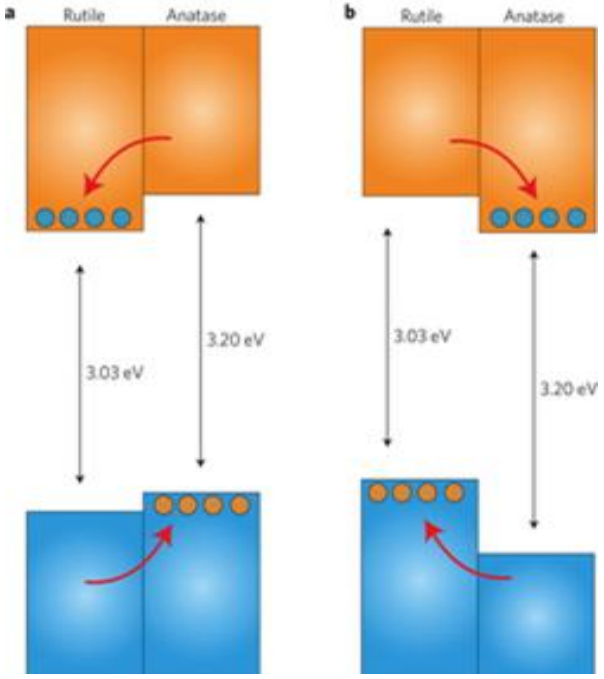

Figure 1: Two proposed valence and conduction band alignment mechanisms for the anatase/rutile interface

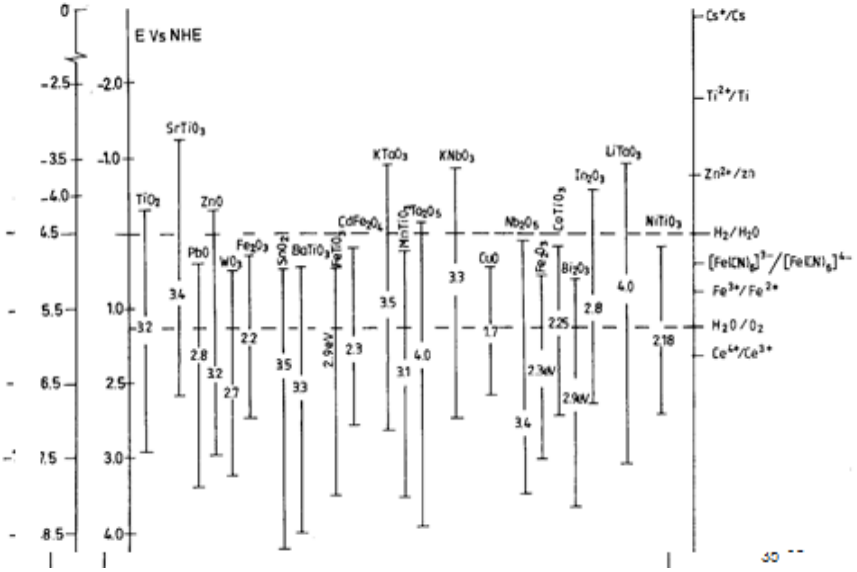

Figure 2: Positions of bands of semiconductors relative to the standard potentials of several redox couples.

Dr. Balasubramanian Viswanathan, Emeritus Professor in dept. of Chemistry, IIT Madrass. He published more than 600 research papers in international and national journals and has made over 400 presentations and has over 30 books and an equal number of patents in the areas of Fuel Cells, Hydride Batteries, Electrochemistry, Hydrogen Energy, Microporous and Mesoporous Materials, Solid State Chemistry, Molecular Catalysis, Materials Science, Theoretical Chemistry, Applied Catalysis, Chemical and Electrochemical Energy Sources.

He did his Master of science, M Sc, University of Madras, 1964; Doctor of philosophy (Ph.D) Indian Institute of Technology, Madras 1969. He has a vast experience in teaching and administration. Faculty in the Department of Chemistry, Indian Institute of Technology, Madras from 1970 to 2004. (various positions like lecturer, assistant professor, professor, head of the department (2001-2003), Head of the material research centre (2 terms) 1995-1998; 2001-2003) Dean, Students(1998-2001), advisor cultural (1991-1994), Advisor Guidance and Counseling unit, Secretary, GATE(Graduate aptitude test for engineering) 1995, warden,(1985-1988) Chairman council of wardens(1995-1998) and many other student activities in this period (1970-2001).

He is a member of the Royal Institute of Chemistry, London over 25 years; Secretary and president of the
Catalysis Society of India for many terms each two years; Member of the Materials Research Society of India; Member of the Chemical Research Society of India; member of the Indian Association of solid state chemists and allied Scientists, Member of the International association of hydrogen Energy; Research advisory committee member of National Chemical laboratory (1999-2002) and also Indian Institute of Chemical Technology, Hyderabad (2008-2010).

He is a fellow of the Tamil nadu Academy of Sciences. Member of the Editorial Board of Applied Catalysis 1977-1999, Fellowship of the Max Planck Society 1977, 1982-1983, Alexander Von Humboldt Foundation Fellowship 1976-1977, JSPS fellowship

1984, Deputy leader of the Indian delegation to USSR for long term scientific collaboration in 1988, Member of the scientific delegation to France 1994, Held a number of positions in the national societies like the Catalysis Society of India, Member of the international Congress on Catalysis 1992-1996.1998-2016, UNDP expert for evaluation of projects in the field of catalysis, Project Advisory committee member for DST in ILTP programme, Research advisory committee member of CFRI on fundamental studies for 5 years, Secretary and president of the Madras section of the Royal Society of Chemistry, Editorial board member of Indian journal of Chemistry Section A (1999-continuing), Editorial board member of Indian Journal of Chemical Technology, 1999-2001, Editor of the Bulletin of the catalysis society of India (for over 25 years), Received Eminent Scientist award of the Catalysis Society of India – 1992, Hari Om S S Bhatnagar Endowment Award for Catalysis – 1988, MRSI medal in the year 1998, CRSI medal for the year 2001, PEPEEF Research Award 2006, Member of the Tamilnadu Science Forum, Member of the APCAT council.

SILICON SOLAR CELLS: MATERIALS AND DEVICES

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There is worldwide resurgence in the research and development programmes related to solar cells as devices for generating electricity from sun light. The most common solar cells are made from crystalline silicon. The solar cells in commercial panels have efficiency of about 15 % and a projected life of about 25 years. The initial cost of setting up the electrical power generation based on crystalline solar cells is still high. So, that provides motivation for innovations. There are several options. One is to make the silicon cells more efficient. The laboratory record efficiency of crystalline silicon solar cells stands at 25%.The key area of improvement, which led to this was minimisation of recombination. While, this was a big achievement, theoretical maximum being about 30%, the processes used to fabricate high efficiency silicon cells in laboratory are not suitable for manufacturing cheaper cells. So, there are attempts to evolve simpler/cheaper processes for manufacturing high efficiency silicon solar cells. Since silicon is indirect band gap material, it requires thick silicon wafer to fully absorb sunlight upto the band gap of silicon. Present day crystalline silicon cells are about 200 microns thick. There is great effort being made to reduce the thickness without degrading performance. Hetero-junction silicon solar cells using a-Si:H and c-Si have reached efficiency of 24.7% . This structure is also associated with choice of materials for the preparation of cells at considerably lower temperatures to minimise the energy used in the manufacturing. In this talk , I will try and give a brief overview of these exciting developments.

Prof. Brij Mohan Arora received B.Tech. degree in electronics and electrical communication from the Indian Institute of Technology, Kharagpur in 1965 and M.S. and Ph.D. degrees in electrical engineering from the University of Illinois, Urbana-Champaign in 1968 and 1972 respectively. Since 1972, he was with the Tata Institute of Fundamental Research, Mumbai, from where he retired as Professor in the Department of Condensed Matter Physics and Materials Science in July 2008. From Dec 2008, he is Professor in the Department of Electrical Engineering at IIT Bombay. B M Arora has worked in the areas of plasma display panel, semiconductor materials and optoelectronic devices, particularly Semiconductor lasers and infrared detectors , based on III-V compound semiconductor quantum structures. During the last part of his stay at TIFR, he worked on properties of III- nitride semiconductors. Since joining IIT Bombay, he has been working on several aspects of silicon solar cells. In addition, he has taken active part in designing experiments for education of solar cells, and disseminating them.

SYNTHESIS OF CARBON NANOTUBES FROM PLANT BASED PRECURSORS AND THEIR APPLICATION IN BIODIESEL STORAGE

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The present work aims to explore a natural renewable precursor for the synthesis of carbon nanotubes CNTs, conforming to the principles of green chemistry. CNTs were synthesized by chemical vapor deposition using a natural renewable GREEN precursors followed by process optimization. The pre-requisite for process optimization is to set an objective parameter. For the synthesis of CNTs it is necessary to optimize the process for the objective parameter such as better yield or quality. This needs to be done for each precursor type. To achieve the twin objective of physical optimization of the process parameters for better yield and acceptable quality for each precursor type poses almost an impossible task because of time and cost involved. However, a statistical technique such as Taguchi robust technique is expected to be an efficient and effective tool to do this. The process needs to be optimized for each of the precursors selected for CNT synthesis for higher yield and acceptable relative quality conforming to requirement of applications. In this paper, a few parameters that influence the yield and quality of CNT have been identified. Taguchi robust technique is employed which not only helps to optimize the parameters but also analyse the extent of effect of each parameter on the synthesis.

The precursors however, themselves are not very stable and tend to get oxidized in air. This problem was faced during CNT synthesis and the related problem of biodiesel storage extracted from the literature resulted in the current work. Biodiesel technology that has evolved in past decade has enormous potential and hence considered to be the future fuel which will power next generation vehicles. Though the technology is reasonably matured, its

commercialization is still not possible due to its low shelf life. Biodiesels are chemically synthesized from plant based oils and hence start getting oxidized (degraded) within six hours. The antioxidants hitherto used are homogeneous in nature. The addition of such antioxidants can check the oxidation but at the cost of engine performance. This inhibits their widespread use due to recurring consumption cost as well as contribution to enhancement in emission. This work is an attempt to engineer magnetically separable heterogenous antioxidants for biodiesel storage using CNT as a substrate.

Dr. S Paul, received Ph.D. (Energy) and M.Tech. (Energy Technology) from Department of Energy, Tezpur University. He is currently heading the Department of Energy Engineering at North-Eastern Hill University, Shillong. He started the department with B. Tech. program in Energy Engineering at NEHU. Dr. Paul has also served in the Centre for Energy Engineering, Central University of Jharkhand, Ranchi. He is presently engaged in material research and their applications in energy systems which include green synthesis of Carbon Nanotubes and their applications in Organic Solar Cell, Biodiesel storage and Fuel Cell. His work is recognized at national and international level and has produced a national patent and publications in peer reviewed reputed International and National Journals. Dr. Paul is also a recipient of the prestigious ISCA Young Scientist Award and NASI Swarna Jayanti Puraskar. He is Member of professional bodies like ISCA and SESI in India. He has broadly contributed in the area of applications of nanomaterials for renewable energy devices and systems.

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Abstracts of Presentations by Participants

STUDIES ON POLYMER-BASED NOVEL ELECTRODE BINDER MATERIALS FOR DIRECT BOROHYDRIDE FUEL CELLS

Nurul A. Choudhury, Jia Ma, YogeshwarSahai, Rudolph G. Buchheit
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Novel, cost-effective, high-performance, and environment-friendly electrode binders, comprisingpoly(vinyl alcohol) chemical hydrogel (PCH) andchitosan chemical hydrogel (CCH), are reported for directborohydride fuel cells (DBFCs). PCH and CCH binders-based electrodes have beenfabricated using anovel, simple, cost-effective, time-effective, and environmentally benign technique. Morphologies andelectrochemical performance in DBFCs of the chemical hydrogel binder-based electrodes have beencompared with those of Nafion® binder-based electrodes. Relationships between the performance ofbinders in DBFCs with structural features of the polymers and the polymer-based chemical hydrogelsare discussed. The CCH binder exhibited better performance than a Nafion® binder whereas the PCHbinder exhibited comparable performance to Nafion® in DBFCs operating at elevated cell temperatures.The better performance of CCH binder at higher operating cell temperatures has been ascribed to thehydrophilic nature and good water retention characteristics of chitosan. DBFCs employing CCH binder-basedelectrodes and a Nafion®-117 membrane as an electrolyte exhibited a maximum peak power density ofabout 589mWcm^{-2} at 70^{o}C.

Nurul Alam Choudhury completed his B.Sc. with Chemistry (Hons.) from Cachar College (Silchar) in 1997, M.Sc. in Chemistry from University of Delhi in 1999, Ph.D. in Materials Electrochemistry from Indian Institute of Science (IIScBangalore) in 2009. During April (2009) - September (2013), he did his Post-doctoral studies in Ohio State University (USA), Washington University in St. Louis (USA), and Queen's University (Canada). He has been working as an Assistant Professor (on contract) in Chemistry Department of Nagaland University since October 30, 2013. His research interests include polymer electrolytes, polymer-based electrode binders, and electrode materials for fuel cells, supercapacitors, batteries, regenerative fuel cells etc. He has so far co-authored 15 research papers and 2 review articles in reputed peer-reviewed journals. He is co-inventor of 2 US patent publications.

SCOPE OF ENERGY PRODUCTION FROM WASTE WATER AND AQUATIC WEEDS

Sourav Sarkar[1], P.Ramarao[2], Yogalakshmi K.N [2] and *Tapati Das[1]
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One of the major problems the modern societies facing today is waste water generation, may it be from industries, agriculture and municipalities and households, and more challenging are the methods to manage this problem.

It is also observed that most of the aquatic systems and wetlands are facing the problem of invasion by nuisance aquatic plants. The rapid growth of these plants accelerates the build-up of sediment, nutrients and organic matter, which leads to eutrophication. Subsequently, the water gets choked with vegetative mats and there is development of anaerobic conditions which is detrimental to the native flora and fauna in those systems that ultimately lead to the decline in biodiversity of the region. Moreover, the death and subsequently the decomposition of the aquatic plants in the degraded water bodies also leads to emission of methane which has 21 times higher potential than carbon dioxide in terms of global warming.

In order to combat these major environmental problems i.e. eutrophication and global warming, energy extraction from waste may be a feasible method, be it from wastewater or nuisance aquatic plants.

On the other hand, it may be mentioned here that the high-energy demands of our modern society in combination with the predictable depletion of fossil fuels (which is a non-renewable resource) hints for the development of sustainable and green forms of energy.

Trapping renewable energy from waste organic sources will facilitate energy production and at the same time the task of treatment of wastewater and management of nuisance aquatic plants shall be accomplished.

In this context a study was made to evaluate the feasibility of microbial electrolysis cells (MEC) in biohydrogen production while treating fertilizer wastewater. The wastewater was collected from National Fertilizer Limited, Bathinda and was characterized for its water quality parameters namely pH, BOD, COD, ammonia, nitrate and nitrite. The analysis of the characterization of fertilizer wastewater showed that the wastewater was highly acidic. It contained much higher amount of total solids, total dissolved solids, suspended solids, volatile solids, COD and BOD. Wastewater was fed to the MEC which includes a cathode and anode which transmits charged particles from one chamber of the apparatus to the other while connected externally to an ammeter. The study revealed that the microbial biofilm at the electrodes produced biohydrogen and treated the wastewater under anaerobic conditions.

Keywords: Waste water, aquatic weeds, microbial electrolysis cells, bio-hydrogen production

DARRIEUS ROTOR: A REVIEW IN ITS VARIOUS DESIGN AND PERFORMANCE PARAMETERS

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Wind energy converters harness the kinetic energy contained in following air masses. Since decades, attempts have been made to extract this energy through diverse means, Vertical axis wind turbines (VAWTs) being one of them.

VAWTs were originally considered as very promising before being superseded by the present, horizontal axis wind turbines (HAWTs). For various reasons, there is now resurgence of interest for VAWTs, in particular Darrieus turbine due to its compact and simple design especially when small applications in urban agglomerations are considered. Using modern design tools, analytical models and computational approaches, it should be possible to considerably enhance the performance of traditional rotors. The use of BE-M (Blade element-Momentum) models for design and analysis has aroused a large credit in the field of research and academic communities.

In the present work, a detailed review on Darrieus rotor is made, transpiring the impact of it in the field of research. Many factors like blade geometry, aspect ratio, pitch angle, tip speed ratio, dynamic stalling that directly affects the efficiency and power coefficient are also discussed in this paper.

CFD ANALYSIS OF HYDRODYNAMIC CONDITION OF DESIGNED SPIRAL COLUMN PHOTOBIOREACTORS

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Microalgae are able to accumulate significant amounts of lipids. They are therefore seen as promising candidates for the production of biodiesel. To expand this as well as to cut down the cost parameter involving with biodiesel production from algae, we need to increase the growth rate of algae for which closed cultivation is the best option for maintaining the proper condition which is necessary for their growth, for which different types of reactor are used one of them is bubble column reactor, with increase in mixing rate of algae with nutrients, growth rate increases, so in the present paper we will be designing spiral column reactor which will have better mixing rate than conventional bubble column reactor in turn more mass transfer due to more turbulence which can be seen by analyzing the gas hold up for both the reactors , for that CFX solver is been used

NON-EDIBLE VEGETABLE OIL-BASED BIODIESEL AS A ALTERNATIVE FUEL FOR DIESEL ENGINE: A REVIEW

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The rapid escalation of fuel prices, shortage of conventional petroleum based fuels coupled with environmental pollution have forced us to look for alternatives fuels. This paper review the non-edible vegetable oil based bio-diesel as a substitute fuel for diesel engine. The current status of bio-diesel production, engine emissions and performance has been discussed. From the literatures review, it is concluded that the physical and chemical properties of biodiesel produced are comparable with diesel fuel. There is significance improvement in engine performance and emissions while using non-edible vegetable oil- based biodiesel in compression ignition engine. Thus biodiesel produced form non-edible vegetable oils can be used in existing conventional diesel engine satisfactorily without any significant hardware modifications.

Keywords: Non-edible vegetable oil, biodiesel, performance, emission

A REVIEW STUDY ON EXPERIMENTAL AND NUMERICAL INVESTIGATIONS INTO THE PERFORMANCE AND MODIFICATIONS OF SAVONIUS WIND ROTOR

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Savonius wind rotor is a drag type vertical axis wind turbine (VAWT). The performance of this rotor is lower than that of the other conventional wind rotors but it is having a number of advantages over the others such as simple in structure, omni-directional, self starting at lower wind speeds and has a high starting torque. A number of investigations have been carried out experimentally and numerically to improve the performance of the Savonius wind rotors. The use of guide vanes, deflector plate and curtain arrangement infront of the rotor and also placing the rotor inside guide-box tunnel (GBT) are the techniques adopted by many researchers to increase the performance of Savonius rotor. In some investigations researchers modify the conventional Savonius rotor and proposed new modified Savonius rotor by varying the various design parameters. The results of the investigations showed that the modified Savonius rotor is better in performance than conventional Savonius rotor under identical working conditions. In this paper a review study is done on the various techniques adopted by many researchers to improve the performance of Savonius wind rotor. The modifications done on the basic structure of Savonius rotor for increase in coefficient of power and coefficient of torque is also reviewed thoroughly and presented in this paper.

"AQUATIC FLORA AND OILSEED SHELL"- A FUTURE PROSPECTS OF BIODIESEL RESOURCE

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The fossil fuel reserves are diminishing rapidly but the demand of energy in the world is increasing. The petrochemical sources are finite and at current usage rates will be consumed shortly. Diesel fuel is the largely consumed fuel in transport, agriculture and industrial sector. So there is a demand of a renewable energy to substitute the conventional diesel. Biodiesel is one of the reliable and technically feasible fuel which can substitute the petrodiesel. Vegetable oils can be used directly as fuel but their high viscosity and low volatility causes problems to the diesel engine. So their esterified form is used as biodiesel in diesel engine which has similar properties with petro-diesel.

In the present work aquatic floras from NIT Silchar campus and oilseed shells are taken as biodiesel feedstock. The climate of North Eastern India favors the growth of aquatic floras. These non edible feedstocks will not create a food versus fuel problem as it is not covering the agricultural land. With the help of Biotechnology Department, Assam University, the oil content in this aquatic flora is estimated. Our objective of present is experimental investigation to extract oil from indigenous biomass using solvent extraction technique and obtain the alkyl ester of triglyceride which could be obtained by trans-esterification of the non-edible biomass oil. In the initial stage we have got analytical result of 1% and 4% of oil content in wet biomass of aquatic flora by "*Bligh and Dyer"* method.

CATERING THE ENERGY NEED OF SOCIETY THROUGH RENEWABLE ENERGY SOLUTIONS: ISSUES AND CHALLENGES

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Electrification in India as well as other developing countries has been a challenging task for all the governments throughout. It has remained a top priority agenda for all of them, though the success rate is dabatable. The lack of clean and safe lighting for these people makes their life extremely difficult, it limits their productivity and is an obstacle to development opportunities in core necessities of modern life such as health, education, infrastructure and upgradation of living standards. Our country has a large number of distant located villages which doesn't get sufficient electricity supplies, if connected to a power grid. Pathetically still there are large areas which do not even have this luxury! Linking the rural areas to electricity grid would be very difficult because it would need a lot of time and budgetary investments. However, technologies to use energies like solar energy, wind, biomass, hydro, ocean, etc. might be the lower cost options in rural villages to meet out their basic needs, where population is very low. This study is limited to the direct use of non-conventional, alternate and renewable energy sources. The case study has been helpful in removing the myths associated with usability of non-conventional energy sources and highlights their benefits over other conventional sources. Researcher has focussed on pragmatic implementations and as a outcome discussed the prominent issues and challenges faced during implementation of thses solutions for meeting the needs of a small village/ home, which could be useful for such implementations elsewhere.

PHOTOELECTROCHEMICAL BEHAVIOR OF ZNO NANORODS

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Vertically aligned ZnO nanorods grown on flexible ITO using hydrothermal method. In this paper we demonstrate the photoelectrochemical property of ZnO nanorods. Donor concentration and flat-band potential of ZnO nanorods has been determined by mott-schottky plot. Hydrothermally grown ZnO nanorods sample presents a 6×1017 cm-3 donor concentration. In linear sweep voltammagrams we have seen that in light ZnO nanorods exhibits significantly large current compare to the dark current. ZnO nanorods show excellent photosensing behavior with high on/off ratio ~ 100.

Appendix

NIT SILCHAR AT A GLANCE

National Institute of Technology (NIT) Silchar, an Institute of National Importance under the NIT Act was established in 1967 as Regional Engineering College (REC) Silchar in Assam. In year 2002, it was upgraded to the status of an NIT from REC. Right from its inception, the institute has envisioned establishment of unique identity by development of high quality human and knowledge resources in diverse areas of technologies to meet local, national, and global economic and social need and human society at large in self-sustained manner.

It is situated on the banks of river Barak and with a sprawling campus spread over 600 acres of land on the outskirts of Silchar. NIT-S has strength of more than 2500 students and 153 faculty members. Institute offers myriad of courses in engineering, sciences, humanities and management at UG, PG and PhD level. Various research & development activities undertaken by the institute puts the students on busy schedules enabling them to get molded as per the modern industry requirements. Though fledgling at present, the infrastructure would soon be matured enough to be at par with the best in the country with the completion of various visionary projects which have already been started. Adding flavor to all this is the naturally aesthetic surroundings with beautiful lakes and tea gardens in and around the campus.

SESI AT A GLANCE

The Solar Energy Society of India (SESI), established in 1976, and having its Secretariat in New Delhi, is the Indian Section of the International Solar Energy Society (ISES). SESI is a multi-faceted national membership organization.

With its long history and extensive technical and scientific expertise provided by its members, the Society is a modern, future oriented non-governmental organization (NGO). SESI has been serving the needs of the renewable energy community and the Society supports its members in the advancement of the renewable energy technology, implementation and education.

The objectives of the Solar Energy Society of India are to advance, promote and propagate the use of renewable energy by encouraging basic and applied research in renewable energy by doing following activities:

- Collecting, compiling and dissemination information relating to renewable energy
- Organizing seminars and conferences, by publishing books, memoirs, journals and proceedings in the field of renewable energy
- Instituting awards
- Establishing formal education curriculum in collaboration with other institutions
- Establishing renewable energy centers in collaboration with Corporates, NGOs, Foundations, individuals and government bodies
- Collaborating and co-operating with other scientific societies, institutions and academies in the country and abroad for research, development and furtherance of renewable energy utilization

SESI STUDENT CHAPTER AT NITS

SESI students' chapter was set up on 31st March, 2012 with a vision to encourage the budding technocrats towards the field of solar energy. Within an year of its inception, the society has gained a membership of over 200 students. It has organized various training courses within the institute to persuade the students to take up their profession and research in the field of solar energy.

Rohit Thakwani, former SESI S/C secretary and a UG student at department of mechanical engineering, patented a design of a solar wheel-chair and got awards from EUREC (European Renewable Energy Congress) and INAE (Indian national academy of engineering) for his achievement. SESI members have also undertaken various research projects related to solar energy with a funding from research promotion cell (RPC) at NIT-S.

RENEWABLE ENERGY INITIATIVES AT NITS

Men's desire to live a better and luxurious life, right from the beginning of civilization, has led to innumerable breakthrough inventions and discoveries and in the present era, one cannot deny the importance of energy. High demand of power and the environmental hazards caused by fossil fuels in the present day world has led to the development of advanced and more efficient green methods of power generation. In the past few decades, due to the rapid depletion of fossil fuel reserves, renewable sources of energy, such as solar, wind, biogas, hydel, tidal to name a few have gained wide acceptance across the globe. In India, Jawaharlal Nehru National Solar Mission (JNNSM) was launched on 9th October 2012 under the brand name "Solar India" in order to avail optimum utilization of solar power which is a self sustainable source of energy. The immediate aim of the mission was to set up an enabling environment for solar technology both at centralized and decentralized levels. The mission recognizes the applications particularly for meeting rural energy needs and has set an ambitious target of adding 20 GW of grid connected and 2 GW of off-grid capacity by 2022. Biomass is the fourth highest primary energy resource in the world after oil, coal, and gas, contributing about 10.6% of the global primary energy supply. In Assam, Bamboo Dust Gasification Project by HPCL of capacity 2×4.5 MW successfully commissioned in September 2007 for thermal application is the world's largest biomass gasifier installation and the first in India of its kind. The gasifier runs on the waste materials (bamboo dust) generated from Nagoan and Cachar paper mills of Assam. A hybrid system can be generated by having various combinations of renewable energy sources. In India, a 1 MW-scale PV-diesel hybrid solar power plant has been installed in Tirupar, Tamil Nadu.

Solar Energy

Based on hourly estimates of radiation by National Renewable Energy Laboratories (NREL), the daily average of solar radiation in different places of north-east India including Silchar is in the range of 3-6 kWh/m^2/day. It is evident from this data that

solar power has the potential to act as a substitute to the conventional power generating sources. However, it is yet to set its marks as an efficient and economic power source in north-east. With an objective to become a paradigm of applications in renewable, NIT Silchar has taken an appreciable initiative in this regard and is privileged to successfully complete two major installations; 100 kW solar power plant and solar streetlights within the campus.

SPECIFICATIONS:

Wattage: 100 kW.

PV module :
Make: Central Electronics Limited.
Capacity: 360
No. of PV modules: 360.

Battery:
Make: HBL
Capacity: 120/600 Ah; 240/450 Ah; 240/750 Ah.

Installation date: 12.09.2013

Solar power plant at NIT Silchar

Photovoltaic (PV) technologies with longer lifetimes can be the cheapest source of electricity in some member states, when compared to the costs of building a new traditional power plant as stated by Brinkerhoff, 2010, a technical report. Unlike conventional systems, PVs demand few operational expenses, allowing for a relative accurate estimate of lifetime costs for the electricity produced. NIT Silchar requires an average power of 2 MW/day. In May 2012, three solar power plant installations of 20 kW, 30 kW and 50 kW were made by Central Electronics Limited to take care of the energy demands of the institute and some neighbouring areas. The project was completed in about four and a half months (01-05-2012 to 12-09-2012). 360 numbers of PV modules, each of capacity 280 W power were installed on the roof tops of the institute buildings. The 2.7 crores project which has been funded 90% by the central government (Ministry of New and Renewable Energy, MNRE) and remaining 10% by the institute itself was inaugurated

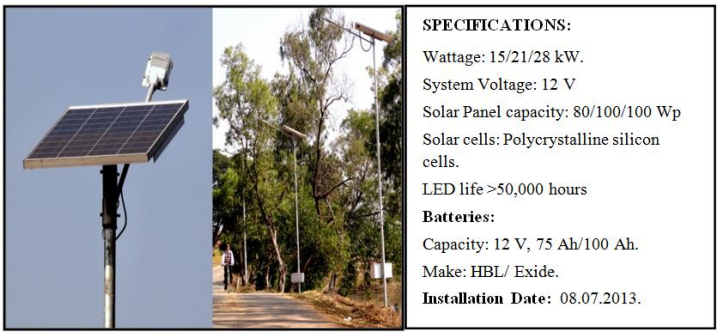
by Assam government's Commissioner of Hills and Barak Valley Division Dr. Mahammed Ariz Ahammed on 1st October 2012.

Like incandescent lamps and unlike most fluorescent lamps (e.g. tubes and CFLs), LED lights come to full brightness without need for a warm up time and is usually used as lighting source of modern street lights. These lights require almost zero maintenance and have good aesthetic value. Solar street lights powered by PV modules have been installed along the streets within the institute campus as well as in the hostels. The installations that were successfully accomplished are as follows:

The solar PV cells that are utilized in the installation are made of polycrystalline silicon cells having a minimum efficiency of 14% and are manufactured in India. The whole project took around two weeks (22-06-2013 to 08-07-2013) for completion.

Sl. No.	No. of street lights	Wattage (W)
1.	48	15
2.	15	21
3.	12	28

A few more projects based on renewable sources are under process such as 10 more solar power plants in 10 different locations within the campus each of 10 kW power capacity. The project will be handled by the agency Agni Power & Electronics Pvt. Ltd. The total cost estimation is about 1.93 crores, of which 70% will be borne by the institute and the remaining by MNRE.



Solar powered street lights at NIT Silchar

Biogas plant

In modern world, along with other renewables, biogas generation from biomass is also gaining momentum due to its high potential as an energy resource. Energy can be recovered from biomass either by direct combustion of the fuel or through initial gasification and subsequent combustion. NIT Silchar has taken a step in this regard to boost its significance by installing the 'Nisargruna' biogas plant within the campus. 'Nisargruna' technology from the Bhaba Atomic Research Centre (BARC), Mumbai is an indigenous and appropriate technology developed for small scale application to convert municipal organic solid waste into biogas and manure.

Here at NIT Silchar, the biogas produced with the current capacity of 'Nisargruna' project generates 75-80 kg of cooking gas per month which is sufficient enough to cook breakfast for 15 days for 600 persons. The raw material for power generation comprises cow dung apart from leftovers at the students' hostels. Around 40-50 kg of hostel garbage is fed everyday to run the gasifier. Although the electricity consumption by the plant costs Rs. 147 per month, but there is a considerable saving of Rs. 2000 approximately. The total cost of installation of gasifier is Rs. 13,69,500. The plant has been operating satisfactorily for about one year since the date of installation.

Biogas power plant at NIT Silchar

Technical Specifications & Components:

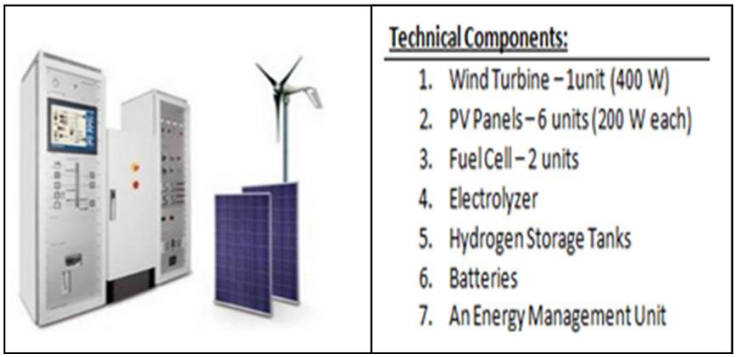
1. Plant Capacity – 100Kg/Day organic waste processing
2. Primary Digester Cum Gas storage Dome: - SS-316(high chrome) 1 m^3 capacity
3. Main Digester: - SS-316(high chrome) body with water seal. 4 m^3
4. Compressor ----2 sets (One for air & another for Biogas)
5. Biogas stove
6. Biogas storage balloon - 5 m^3 with safety shelter
7. Bio gas water scrubber
8. Manure collection- plastic drum

Hybrid system

The unique New Energy Lab addresses all aspects of integrated renewable energy systems: generation, storage and management of energy. Its flexible energy management unit enables the quick modification of the system's setup, making it possible to combine multiple renewable inputs with different energy storage options.

The off-grid hybrid system allows studying each technology individually or in combined set-ups. It combines solar and wind power with energy storage in batteries or through the generation of hydrogen powering a fuel cell. The system can further

be connected to the grid. Typical scenarios, such as night-time operation, periods of no wind or the combined use of renewable and conventional energy sources like a diesel genset, can be simulated and analyzed (smart grid education and training). Various types of loads can be connected to the system or be simulated with its electronic load. Students gain a fundamental understanding of each technology and the interrelationships between the different system components. This enables them to dimension smart and efficient hybrid systems in line with supply requirements. Extensive measuring technology and the monitoring and control software allows for data logging and analyzing. Energy flows are visualized in real time.



Hybrid system test set-up

ESTABLISHMENT OF REGIONAL TEST CENTER (RTC) - CUM TECHNOLOGY BACK UP UNIT FOR SOLAR THERMAL DEVICES

Sanctioning Authority : Ministry of New and Renewable Energy (MNRE), Govt. of India
Date of Approval : 26th March 2013
Project Duration : 5 Years
Project Investigator : Dr. A. Biswas, Assistant Professor
Project Co-Investigator : Dr. R. D. Misra, Professor

Project Deliverables:

a) To obtain MNRE and NABL accreditation for the solar RTC of NIT Silchar.
b) To establish complete test facilities for solar thermal devices.
c) To generate money and deposit in the account of MNRE by conducting tests thereby giving BIS certification to the stakeholders.
d) To conduct workshops, symposiums and awareness programs on solar thermal devices for the people.
e) To carry out research on solar thermal devices using the test facilities.

Description of the Project:

An NABL accredited Regional Test Centre is to be established at Mechanical Engineering Dept., NIT Silchar for the entire northeast India. This test centre will facilitate the manufacturers and technocrats of solar thermal devices, like solar water heater, solar cookers, and evacuated tube collectors, especially of this part of the country, to test their devices at the centre. All such stakeholders will earn BIS certifications of their devices after their devices pass through all the tests to be conducted using the test facilities. The test centre will be helping the PhD scholars and other researchers to innovate new and efficient designs of solar thermal devices. Thus it will provide state-of-the art of solar thermal technology in the northeast India.

NITS SOCIAL RESPONSIBILITY INITIATIVES

NITS believes in giving back to the society. GYANSAGAR is a society (soon to be a registered NGO) of NIT Silchar volunteered by the students of institute encouraged and approved by Director, NIT Silchar. Since last three years Gyansagar has put its effort towards the development of the society. The development is in terms of general education, IT education, agricultural awareness, health awareness, job-opportunity awareness, exploring the inherent qualities of kids in villages, etc.

Gyansagar was started in the year 2009 by a group of students led by Mr. Aditya Choudhary, a 2012 pass-out student from NITS. Since then, it has taken huge leaps to become a social organization which benefits the nearby villages and communities near NIT Silchar. Gyansagar currently has more than 250 student volunteers, who cover 7 neighbouring villages covering more than 500 children.

The major objectives of Gyansagar as an organization are as follows:

- To become a scalable model of college-centric student-run social work enterprise.
- To provide the people of surrounding villages a standard education which they are not getting at school that tends to eradicate ignorance and illiteracy.
- To help bringing the drop out students back to school.
- To provide computer education to the villagers through the NITS-CIT program (A 3-month weekend classroom program for the youth).
- To carry out various awareness drives in Financial, Agriculture, Government Jobs and Health sector and to make them aware about the best opportunities.
- To provide vocational training to the villagers on various techniques by conducting various workshops for them.

RISE' 14 – PROGRAMME SCHEDULE

DAY 1, 10th January 2014 (Friday)

Sl. No.	Time	Events
1.	09:00am to 09:30am	Registration
2.	09:30am to 10:55am	Inauguration
3.	10:55am to 11:05am	High Tea
4.	11:05am to 12:30pm	Invitee talk- 'Photovoltaic power: from evolution to revolution' by **Prof. B. Ghosh, Jadavpur University.**
5.	12:30pm to 1:30pm	Lunch Break
6.	01:30pm to 02:55pm	Invitee Talk- 'Biohydrogen: a green fuel for the future' by **Prof. Debabrata Das, IIT Kharagpur**
7.	02:55pm to 03:05pm	Tea Break
8.	03:05pm to 04:00pm	Oral presentation by applicants
9.	04:00pm to 05:00pm	Interaction with experts

DAY 2, 11th January 2014 (Saturday)

Sl. No.	Time	Events
1.	09:30am to 10:55am	Invitee talk- 'Issues and challenges for wind power integration into power systems' by **Prof. S. N. Singh, IIT Kanpur.**
2.	10:55am to 11:05am	Tea and Snacks
3.	11:05am to 12:30pm	Invitee talk- 'Analysis of different type of hybrid photovoltaic thermal air collectors: A comparative study' by **Dr. Sanjay Agarwal, IGNOU,** New Delhi.
4.	12:30pm to 01:30pm	Lunch Break
5.	01:30pm to 02:55pm	Invitee Talk- 'Biomass and bio-energy as viable alternative to conventional energy sources: some issues about resources and technology' by **Prof. D. C. Baruah, Tezpur University.**
6.	02:55pm to 03:05pm	Tea Break
7.	03:05pm to 04:00pm	Oral presentation by applicants
8.	04:00pm to 05:00pm	Interaction with experts

DAY 3, 12th January 2014 (Sunday)

Sl. No.	Time	Events
1.	09:30am to 10:55am	Invitee talk- 'Solar cell materials and its applications' by **Prof. G. N. Tiwari, IIT Delhi.**
2.	10:55am to 11:05am	Tea and Snacks
3.	11:05am to 12:30pm	Invitee talk- 'An assessment of photoactivity of optimized mixed lattice metal oxide nanomaterials for solar energy and environmental applications' by **Prof. S. K. Samdarshi, Central University, Jharkhand.**
4.	12:30pm to 01:30pm	Lunch Break
5.	01:30pm to 02:55pm	Invitee Talk- 'An overview of polymer electrolyte membrane fuel cell components: research and development' by **Dr. Anil Verma, IIT Guwahati.**
6.	02:55pm to 03:05pm	Tea Break
7.	03:05pm to 04:00pm	Invitee talk- 'Test procedures for solar thermal collectors and systems – the basic considerations' by **Prof. S. K. Samdarshi, Central University, Jharkhand.**
8.	04:00pm to 05:00pm	Interaction with experts

DAY 4, 13th January 2014 (Monday)

Sl. No.	Time	Events
1.	09:30am to 10:55am	Invitee talk- 'Solar energy materials' by **Dr. Murlidhar G. Takwale, Pune University.**
2.	10:55am to 11:05am	Tea and Snacks
3.	11:05am to 12:30pm	Invitee talk- 'Organic solar cells for a bright future' by **Dr. Suresh Chand, CSIR- National Physical Laboratory, New Delhi.**
4.	12:30pm to 1:30pm	Lunch Break
5.	01:30pm to 02:55pm	Invitee Talk- 'Synthesis and applications of photo-catalysis in solar energy utilization' by **Prof. B. Viswanathan, IIT Madras.**
6.	02:55pm to 03:05pm	Tea Break
7.	03:05pm to 04:00pm	Oral presentation by applicants
8.	04:00pm to 05:00pm	Interaction with experts

DAY 5, 14th January 2014 (Tuesday)

Sl. No.	Time	Events
1.	09:30am to 10:55am	Invitee talk- 'Silicon solar cells: materials and devices' by **Prof. B. M. Arora, IIT Bombay.**
2.	10:55am to 11:05am	Tea and Snacks
3.	11:05am to 12:30pm	Presentation- 'Studies on polymer-based novel electrode binder materials for direct borohydride fuel cells' by Nurul A. Choudhury.
4.	12:30pm to 01:30pm	Lunch Break
5.	01:30pm to 02:55pm	Invitee Talk- 'Synthesis of carbon nanotubes from plant based precursors and their application in bio-diesel storage' by **Dr. Samrat Paul, NEHU, Shillong.**
6.	02:55pm to 03:05pm	Tea Break
7.	03:05pm to 05:00pm	Valedictory function

Renewable Initiatives at NIT Silchar

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