Indo-U.S. Joint Clean Energy Research and Development Center

Setting the pace








सत्यमेव जयते
Ministry of Science and Technology
Government of India

Recognizing the need to address climate change, ensure mutual energy security, and build a clean energy economy that drives investment, job creation, and economic growth; Prime Minister Manmohan Singh and President Barack Obama launched the U.S.-India Partnership to Advance Clean Energy (PACE) under the U.S.-India Memorandum of Understanding to enhance cooperation on Energy Security, Energy Efficiency, Clean Energy and Climate Change. This MoU was signed on November 24, 2009 during Prime Minister Singh's visit to the United States.

As a priority initiative under the PACE umbrella, the U.S. Department of Energy (DOE) and the Government of India signed an agreement to establish the **Joint Clean Energy Research and Development Center (JCERDC)** on November 4, 2010 during President Obama's head of state visit to India. The JCERDC is the first bilateral initiative designed specifically to promote clean energy innovation by teams of scientists and engineers from India and the United States.

Joint Clean Energy Research and Development Center

The **Joint Clean Energy Research and Development Center** (JCERDC) is funded by the **Indian Ministry of Science & Technology** and the **U.S. Department of Energy (DOE)**. The overall aim of the JCERDC is to facilitate joint research and development on clean energy to improve energy access and promote low-carbon growth.

To achieve this objective, the Indo-US JCERDC will support multi-institutional network projects using a public-private partnership model of funding.

Funding Mechnisms and Priorities

As agreed the center would be a virtual center which has consortia in each identified priority area.

- **Solar Energy** encompassing solar electricity production, nanoscale designs of interfaces and cells, advanced photovoltaic technologies, concentrating solar power technologies, etc.
- **Second Generation Biofuels** covering conversion technologies for advanced biofuels, optimal characterization for ligno-cellulosic feedstock, algal biofuel, standards & certification for different biofuels and co-product with end-use applications, etc.
- **Energy Efficiency of Buildings** including building heating and cooling, cool roofs, advanced lighting, energy-efficient building materials, software for building design and operations, building-integrated photovoltaics, etc.

Government of India and US Department of Energy have committed $25 million each (over five years, subject to appropriations) for supporting projects in the priority areas of solar energy, buildings efficiency, and second generation biofuels.

Project funding is in Public-Private Consortia mode with the Consortia partners providing matching funds to achieve approved project goals.

S.No	Priority Areas	Amount
(i)	Solar Energy	US$12.50 million over five years from each side
(ii)	Second Generation Biofuels	US$6.25 million over five years from each side
(iii)	Energy Efficiency of Buildings	US$6.25 million over five years from each side

The Program is being coordinated by the Ministry of Science & Technology – Department of Biotechnology and Department of Science & Technology and is administered in India by the Indo-US Science and Technology Forum (IUSSTF)

Management

PARTICIPATING CONSORTIA MEMBERS

The virtual center has involvement and participation of consortia members who have the knowledge and experience to undertake first-rate collaborative research programs and would leverage existing resources and physical infrastructure. The applications were jointly submitted by the U.S. and Indian researchers based on their mutual interests, priorities and strengths. These consortia consisted of entities or individuals from academia, national laboratories, non-governmental R&D institutions along with at least one partner from the private sector. Each consortium has a self-governed management structure. The sharing of Intellectual Property is also a critical

"Our two great democracies share an enduring commitment to innovation. For decades, scientists, engineers, and social innovators from India and the United States have worked side-by-side.

We also want our governments to embrace the spirit of innovation to improve our own work and strengthen our partnership."

Hillary Rodham Clinton
U.S. Secretary of State

"Our bilateral relationship today is a true partnership that uses the soft progress of science and technology and innovation for the benefit of people, the priority in both our countries.

When the most powerful, large economies of the world join and develop their innovation agenda, it is bound to deliver values of global good."

Late Shri Vilasrao Deshmukh
Former Minister for Science & Technology, Govt. of India

and well worked out process. Each consortium will have common objectives for India and the U.S. and will be managed by a Joint Project Management Committee.

The **Indo-U.S. Steering Committee on Clean Energy Science and Technology Cooperation** is co-chaired by India's Deputy Chairman of the Planning Commission and the United States Secretary of Energy. This committee provides high-level review and guidance for the activities of the JCERDC. A Joint High-Level Experts Panel of twelve preeminent private and public sector academic experts would provide the JCERDC with critical suggestions and insights and also act as an advisory body for the Steering Committee.

Review Process

On 22nd October 2010, a Pre-Stakeholder meeting was held in New Delhi to provide potential applicants with an overview on the JCERDC and also engage the stakeholders in an open-house discussion and Q&A session. A draft Funding Opportunity Announcement (FOA) was posted online in February 2011 to garner queries/suggestions/comments from potential applicants. The Final FOA was posted online on 16th May 2011 and the call for proposals (with a submission deadline of 16th August 2011) was advertised in national dailies and journals.

For the first call for proposals with the submission deadline of 16th August 2011, IUSSTF and DOE received a total of 21 applications. After completing the compliance review of the applications, a total of 19 proposals were accepted for further review (Solar Energy: 3; Second generation Biofuels: 9; Energy Efficiency of Buildings: 7).

Three Joint Merit Review Panels (JMRP) (one for each priority area) each consisting of three U.S. and three Indian merit reviewers evaluated the

applications in accordance with the following criteria identified in the Joint FOA:

- Scientific and Technical Merit (35%)
- Technical Approach, Management Plan, Understanding of Project Objectives (35%)
- Applicant /Team Capabilities, Experience, Organization, Facilities, Management Capabilities (30%)

These evaluations were discussed in three JMRP meetings in India– Second Generation Biofuels (19th January 2012), Solar Energy (27th Jan 2012) and Building Efficiency (4th February 2012). The JMRP recommendations were shared with the U.S. side. To supplement and facilitate the reviews by the JMRP, additional reviews were requested from Guest Evaluators.

The JMRP then provided their recommendations and scores to the Joint Appraisal Committee (JAC). The composition of the JAC was as follows:

INDIA	USA
• **Dr. Renu Swarup** Department of Biotechnology	• **Dr. Phyllis Yoshida** Office of Policy and International Affairs
• **Mr. Sanjay Bajpai** Department of Science & Technology	• **Dr. Linda L. Horton** Office of Science - Basic Energy Sciences
• **Dr. N.P. Singh** Ministry of New & Renewable Energy	• **Mr. Rob Sandoli** Office of Energy Efficiency and Renewable Energy
• **Mr. Sanjay Seth** Ministry of Power	

The JAC held discussions through a DVC on 22nd February 2012 to discuss the recommendations of the JMRP's and based on these deliberations; three consortia were selected for award. The awards were announced as a press-release by the Press Information Bureau on 16th April 2012.

"JCERDC is a big step towards exploring the potential of clean energy technologies for the benefit of humankind.

This is a first-of-its-kind initiative, bringing about 90 Indian and US academic and industry teams together, for joint research and development on clean energy technology.

When the finest scientific capabilities of our two nations meet, we can be sure that our needs for clean energy would be fully met."

Montek Singh Ahluwalia
Deputy Chairman, Planning Commission
Government of India
Co-Chair, Indo-U.S. Steering Committee on Clean Energy Science and Technology Cooperation

"Developing and investing in new technologies is a key component to meeting the goals of a clean energy future.

This innovative approach to collaborative research is a testament to the special relationship shared by the two countries.

By working with our partners in India and sharing a strong commitment to building a clean energy economy, we can get further, faster, than by working alone."

Dr. Steven Chu
Secretary of Energy
United States of America
Co-Chair, Indo-U.S. Steering Committee on Clean Energy Science and Technology Cooperation

Based on the JAC recommendations, part or whole of the projects would be funded through agreements between the Indo-U.S. Science and Technology Forum on behalf of the Government of India, and all consortia partners, subject to the successful completion of award negotiations.

Intellectual Property Management

Intellectual Property Rights (IPR) are subject to Annex I- Intellectual Property (IPR Annex) of the Agreement on Science and Technology Cooperation between the Government of the United States of America and the Government of the Republic of India (S&T Agreement; 2005), the respective standard IPR provisions of the Parties and the project annexes of the participants to the extent it is not in contravention with the IPR annex and the associated IP framework allocation document.

Dr. M. K. Bhan
Secretary
Department of Biotechnology
Govt. of India

"The Centre's work will be conducted in existing facilities by consortia with the knowledge and experience to first-rate collaborative research programmes between the United States and India. something that has not been tried before. The Centre will involve the active participation of academic and private sectors of both the countries working in a consortia mode. This is a novel and ambitious approach to creating a truly joint process that we hope will result in real collaboration"

पत्र सूचना कार्यालय, भारत सरकार

Press Information Bureau, Government of India

16-APRIL, 2012 13:51 IST

US $25 MILLION PLEDGED FOR JOINT INDO-US CLEAN ENERGY RESEARCH

The Ministry of Science and Technology has announced the selections for three consortia projects under the Indo-US Joint Clean Energy Research and Development Center (JCERDC). The JCERDC is being established under an agreement signed between the Governments of India and the United States of America which commits an amount of Rs 125 crore (US$ 25 million) in funding over five years to institutions in India by the Government of India with equal amount of grants to organisations in the United States by the US Department of Energy for taking up collaborative research in the fields of advanced biofuels, energy efficiency in buildings and solar energy. In addition, Indian and US consortia partners from industry have pledged matching funds for this program.

These consortia – led in India by the Indian Institute of Science-Bangalore, Indian Institute of Chemical Technology-Hyderabad and CEPT University-Ahmadabad will bring together experts from national laboratories, universities, and industry in both India and the US to leverage their expertise and resources to unlock the huge potential of clean energy technologies that can reduce energy use and dependence on fossil fuel, and accelerate the deployment of renewable energy sources. The three lead Indian institutions have partnered with three lead US institutions –National Renewable Energy Laboratory (NREL), the University of Florida, and Lawrence Berkeley National Laboratory (LBNL). The program would be administered in India by the bilateral Indo-US Science and Technology Forum and in the US by the Department of Energy.

The Joint Clean Energy Research and Development Center is part of the US-India Partnership to Advance Clean Energy announced by Prime Minister Dr Manmohan Singh and President Barack Obama in November 2011, which aims to accelerate the transition to high performing, low emissions, and energy secure economies. As two of the world's largest economies, the United States and India have a special role to play in addressing global energy and environmental sustainability challenges. Details of the three winning consortia can be accessed at: http://www.indousstf.org/JCERDC.html.

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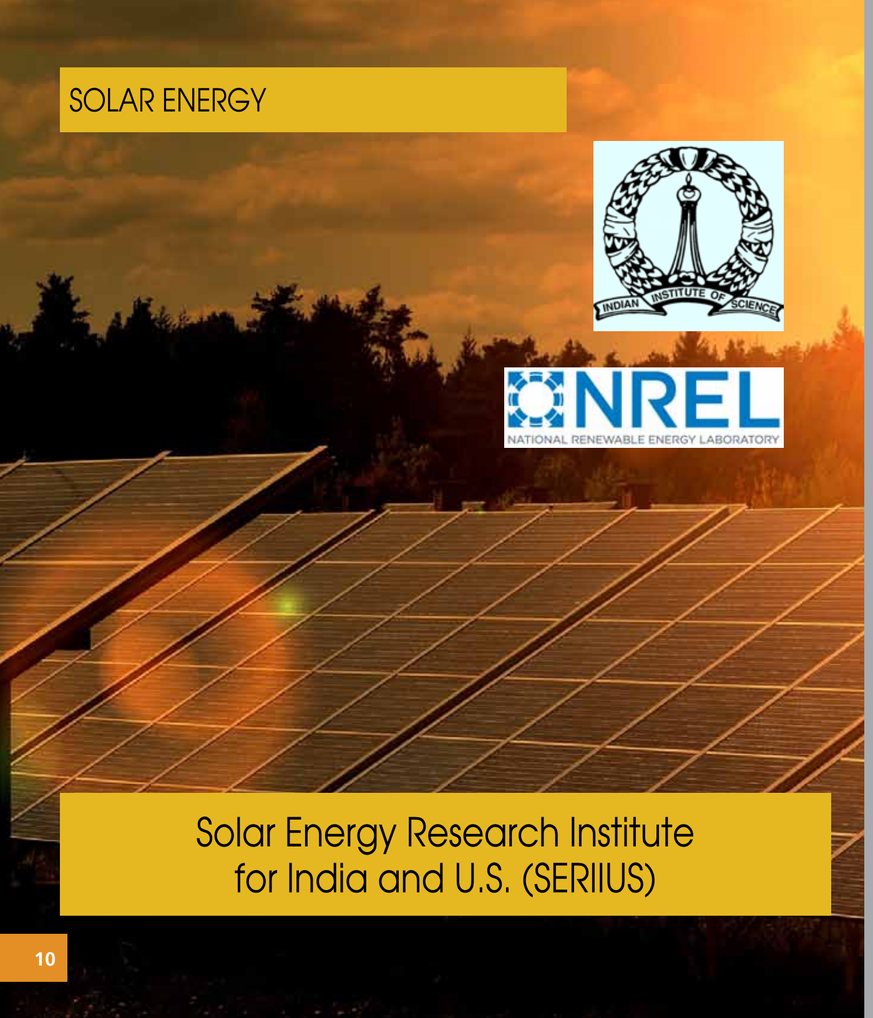
"Low carbon energy generation with greater share of renewables is a common goal that US and India share. Indo-US collaboration in this area will greatly contribute to achieving energy efficiency in this importance sector. It is for the first time that large consortia from both the countries representing the best of industries, institutions and other stakeholders are engaging in pre-competitive research and partnering to deliver near commercial technologies, which is highly commendable."

Dr. T. Ramasami
Secretary
Department of Science and Technology
Govt.of India

And the winners are :

Area	Title of the Project	Lead Partner (India)	Lead Partner (USA)
Solar Energy	SOLAR ENERGY RESEARCH INSTITUTE FOR INDIA AND THE UNITED STATES (SERIIUS)	Indian Institute of Science, Bangalore, Karnataka **LEAD PI** **Kamanio Chattopadhyay** kamanio@materials.iisc.ernet.in	National Renewable Energy Laboratory Golden, Colorado **LEAD PI** **Lawrence Kazmerski** kaz@nrel.gov
Second Generation Biofuels	US-INDIA CONSORTIUM FOR DEVELOPMENT OF SUSTAINABLE ADVANCED LIGNOCEL-LULOSIC BIOFUEL SYSTEMS	Indian Institute of Chemical Technology Hyderabad, Andhra Pradesh **LEAD PI** **Ahmed Kamal** ahmedkamal@iict.res.in	University of Florida Gainsville, Florida **LEAD PI** **Pratap Pullammanappallil** pcpratap@ufl.edu
Energy Efficiency of Buildings	UNITED STATES-INDIA JOINT CENTER FOR BUILDING ENERGY RESEARCH AND DEVELOPMENT	CEPT University, Ahmedabad, Gujarat **LEAD PI** **N. K. Bansal** nkbansal43@gmail.com	Lawrence Berkeley National Laboratory Berkeley, California **LEAD PI** **Ashok Gadgil** AJGadgil@lbl.gov



Solar Energy Research Institute for India and U.S. (SERIIUS)

SERIIUS Vision

"to create an environment for cooperation and innovation "without borders" to develop and ready emerging and revolutionary solar electricity technologies toward the long-term success of India's Jawaharlal Nehru National Solar Energy Mission and the U.S. DOE Sun Shot Initiative."

SERIIUS Thrust Areas

- **Sustainable Photovoltaics:** Develop next-generation materials, devices,and manufacturing processes tailored to India's needs, environment, and resource availability
- **Multiscale Concentrated Solar Power:** Overcome critical science and engineering challenges for reliable multiscale (including small 25–500 kW) CSP systems
- **Solar Energy Integration:** Identify and assess key technical, economic, environmental, and policy barriers to enable a research agenda for technical readiness in India and to benefit the United States.

SERIIUS Consortium Leadership

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Dr. Lawrence L. Kazmerski
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Dr. Pradip Dutta
Indian Institute of Science (IISc)
Bangalore

Dr. William Tumas
National Renewable Energy Laboratory (NREL)
Golden

Co-led by the Indian Institute of Science at Bangalore (IISc) and the National Renewable Energy Laboratory (NREL), the overall goal of SERIIUS is to accelerate the development of solar electric technologies by lowering the cost per watt of photovoltaics (PV) and concentrated solar power (CSP) through a binational consortium that will innovate, discover, and ready emerging, disruptive, and revolutionary solar technologies that span the gap between fundamental science and applied R&D, leading to eventual deployment by sustainable industries.

SERIIUS seeks to address critical issues in fundamental and applied research, analysis and assessment, outreach, and workforce development. Throughout this joint effort, a key element is engaging a significant base of Indian and U.S. industry that is dedicated and committed to developing solar energy for both countries.

Project Structure

The project structure is two-tiered, and consists of:

- **Consortium projects** are pre-competitive multi-institutional research projects focusing Indian and U.S. capabilities and personnel on disruptive technology development to address key technical barriers.
- **Core projects** are industry driven and largely industry funded to meet specific company objectives for promoting technology development and commercialization.

Binational Collaboration

A key SERIIUS objective is to implement an effective and efficient management plan overseen by highly experienced scientific leaders to enable high-impact R&D, as well as coordination and communication among diverse teams across the three research thrusts. The consortium will establish a **SERIIUS Council**—comprising the directors, research thrust leaders, competency coordinators, and industry board members—to monitor, review,and recommend adjustments of technical activities.

Collaborative Culture and Outreach

SERIIUS aims to develop an innovative cyber infrastructure to enable functional research teaming across a number of institutions and to provide an efficient method to communicate SERIIUS activities, findings, and partnering opportunities to the external community. This web-based collaboration tool will also provide secure intra-SERIIUS communications and will supplement face-to-face meetings and regular tele- and video-conferencing at the project and consortium level. Additional outreach objectives include focused workshops, public forums, publications, and e-learning, as well as the development of an affiliates program to engage abroad audience.

Workforce Development

SERIIUS aims to help develop the future work force through online education, workshops, and a sizable **Fellowship Program** that will involve exchange of students and postdocs among SERIIUS partners.

Consortium Management

The SERIIUS management plan has been developed and designed to encourage and facilitate partnering between Indian and U.S. institutions—from management and administration through the activities of the co-led research projects and cross-cutting competencies. The underlying fundamental principle is that all work and responsibilities are co-shared by individuals and organizations from both India and the United States. Empowered India-U.S. partnering is the culture of SERIIUS.

The organization and management structure is designed to facilitate the successful execution of the vision, objectives, and strategy. The scientific leaders of SERIIUS are empowered by an energetic, leading-edge research and problem-solving environment within an organizational structure that assures that research is focused, flexible, and agile.

SERIIUS Research Thrust Activities

SUSTAINABLE PHOTOVOLTAICS		
Earth-Abundant PV	Novel Process Technology	Multiscale Modeling and Reliability
MULTISCALE CONCENTRATED SOLAR POWER		
High Temp, Closed-Cycle CO_2 Brayton Cycle	Low Temp Organic Rankine Cycle (ORC)	Thermal Storage and Hybridization
SOLAR INTEGRATION		
Road-mapping, Analysis and Assessment	Grid Integration and Energy Storage	

SERIIUS Consortia Partners

INDIA	U.S.
LEAD INSTITUTION	**LEAD INSTITUTION**
Indian Institute of Science-Bangalore	National Renewable Energy Laboratory
OTHER PARTNERS	**OTHER PARTNERS**
Indian Institute of Technology – Bombay (IITB); Center for the Study of Science, Technology and Policy (CSTEP); International Advanced Research Centre for Powder Metallurgy and New Materials (ARCI); Solar Energy Centre (SEC); Indian Institute of Technology-Madras (IITM); Indian Association for the Cultivation of Science (IACS)	RAND Corporation; Lawrence Berkeley National Laboratory (LBNL); Arizona State University (ASU); Carnegie Mellon University (CMU); Colorado School of Mines (CSM); Massachusetts Institute of Technology (MIT); Purdue University; Stanford University; University of Central Florida (UCF); University of South Florida (USF); Washington University in St. Louis (WU)
INDUSTRY PARTNERS:	**INDUSTRY PARTNERS:**
S Clique Developments Ltd.; Hindustan Petroleum Corporation Ltd. (HPCL); Moser Baer India Ltd.; Thermax Ltd.; Turbo Tech Precision; Engineering Ltd.; and Wipro Ltd.	Corning Incorporated; General Electric Company (GE); Cookson Electronics; MEMC Corporation; and Solarmer Energy Inc.

SERIIUS has an Executive Oversight Board composed of the leadership of the key organizations engaged in the consortium. This Board ensures that the consortium operations conform to the standards, ethics, legalities, and environmental, safety, and health quality of those organizations—as well as providing a commitment to excellence, cooperation, and facilities use from those key entities. SERIIUS governance has an empowered management component (SERIIUS Council) within the central leadership framework that ensures conformity with the SERIIUS objectives and shared, transparent, and equitable decision-making.

The Industry Board is composed of core industry partners to provide their expert guidance toward accelerated commercialization of relevant industry-driven research, and to establish and co-fund projects of interest directly. The Technical Advisory Board of research authorities is the independent technical review and guidance arm of the Institute. Research and development is organized under Research Thrusts, with cross cutting competencies under the Competency Gateway, both of which report directly to the Co- Directors. The research projects are coordinated by Project Leads, who are accountable to the Thrust Leaders.

Deliverables

- Sustainable Photovoltaics: Develop next-generation earth-abundant materials, devices, and manufacturing processes tailored to India's needs, environment, and resource availability
- Multiscale Concentrated Solar Power: Overcome critical science and engineering challenges for reliable multiscale (including small 25–500 kW) CSP systems
- Solar Energy Integration: Identify and assess key technical, economic, environmental, and policy barriers to enable a research agenda for technical readiness in India and to benefit the United States.
- Carry out world-class applied and fundamental R&D to develop or enhance concepts, materials, processes, and systems to facilitate pre-competitive R&D for accelerating technology transfer in the areas of for solar energy conversion.

SECOND GENERATION BIOFUELS

U.S.-India Consortium for Development of Sustainable Advanced Lignocellulosic Biofuel Systems

Consortium Leadership

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The Energy Independence and Security Act (EISA, 2007) mandates that the United States must use 21 billion gallons of second generation biofuels per year by 2022, while the National Biofuels Policy of India approved on December 24, 2009 proposes an indicative target of 20% blending of biofuels by 2017.

This can be made possible with the sustainable production and use of biofuels from non-food based feedstock which can increase energy independence, reduce greenhouse gas (GHG) emissions, and promote healthier land-use while providing additional jobs and income to both rural American and Indian communities. In order to achieve the common goals on development of sustainable, replicable feedstock production, logistics, processing, and biofuels distribution systems in these two countries, a well-coordinated and synergistic approach is needed.

The present project addresses this through the **U.S.-India Consortium for development of Sustainable Advanced Lignocellulosic Biofuel Systems**, emphasizing sustainable feedstock cultivation and supply, biochemical conversion technologies for production of second generation biofuels with minimal environmental impact, and analysis of overall sustainability and supply chain of feedstock.

The major goal of this project is to develop and optimize selected non-food biomass (high yielding biomass and bmr varieties of sorghum, sweet sorghum, pearl millet, bamboo and switch grass)-based advanced biofuels systems and bio-based products like biogas and lignin-based byproducts for the U.S. and India.

The successful completion of the project is expected to benefit both nations by delivering a working model for feedstock production and supply, biochemical conversion approaches and technologies that have been validated on pre-commercial scale systems, and the overall economics and sustainability of biofuel production and supply systems.

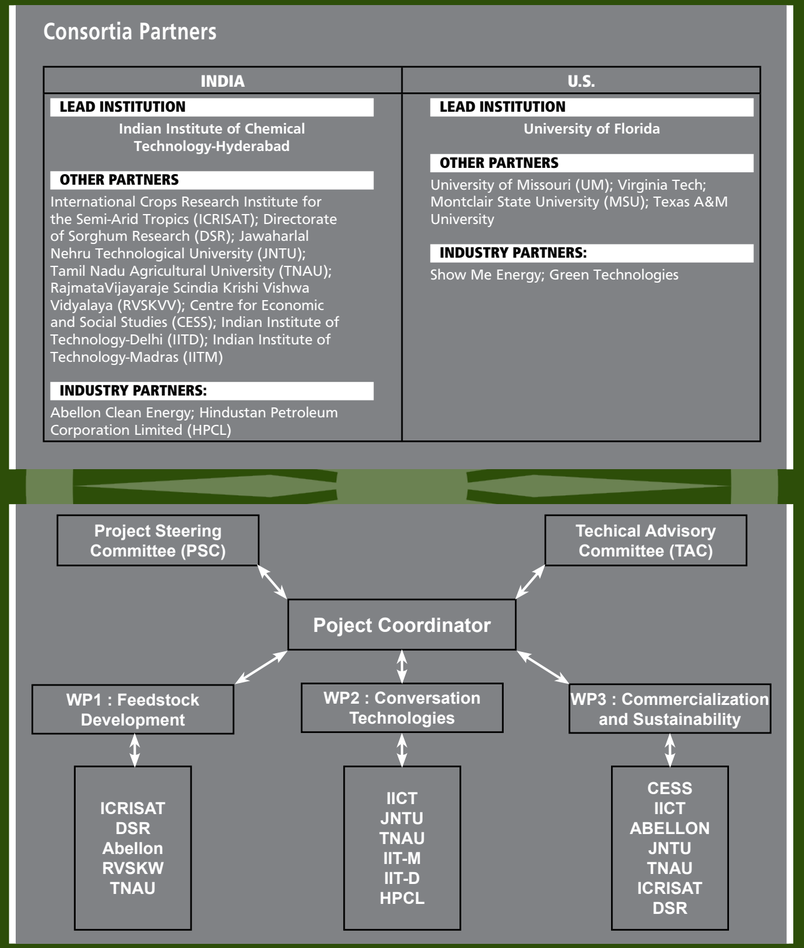
CONSORTIUM OBJECTIVES

1. Improve feedstock (production potential and feedstock quality) using genomics and breeding tools and identify locally adapted cultivars and their optimization for large-scale production.
2. Develop production logistics and identify soil and environmental criteria to ensure a commercially successful advanced feedstock production system.
3. Development of biocatalysts for production of advanced biofuels and co-products and optimization of pretreatment and fermentation processes.
4. Minimizing environmental impact and maximizing revenues from bio-refinery waste streams.
5. Analysis and development of certification protocols and sustainability standards.
6. Assessment of energy requirements and emissions.
7. Supply chain management analysis.

CONSORTIUM MANAGEMENT

The Indo-U.S. Consortium for development of sustainable advanced lignocellulosic biofuel systems is being led by CSIR-Indian Institute of Chemical Technology (IICT), Hyderabad, India, which will be responsible for the smooth functioning of the project to achieve the targets with the help of a three-tier management system including an administrative setup, consortium leader and the individual partnering institutes.

The administrative setup comprises of a Technical Advisory Committee (TAC) and a Project Steering Committee (PSC). The TAC would meet at least once a year (or more if required). The TAC will review the project work execution and render technical inputs to achieve the approved milestones and deliverables. The TAC consists of Dr. David Hoisington (Deputy Director General-Research, ICRISAT), Dr. B.D. Kulkarni (Scientist DG Grade, National Chemical Laboratory), Dr. Pankaj Patel (President and Member on the Board, Abellon Clean Energy), Dr. B. Ramachandran (Professor, IIT-Madras) and Dr. K. Ramaswami (Vice Chancellor, Tamil Nadu Agricultural University). The PSC consists of Dr. David Hoisington (Deputy Director General-Research, ICRISAT),



Dr. B.D. Kulkarni (NCL), Dr. Pankaj Patel (Abellon CleanEnergy) and Dr. P. Gunasekaran (Madurai Kamraj University). The PSC would meet once a year to review the overall progress and suggest suitable opinions to meet the proposed milestones.

The Project Coordinator, Dr. Ahmed Kamal will coordinate the project implementation, while the task leads - Dr. P. Srinivasa Rao (Work Package 1), Dr. C Ganesh Kumar (Work Package 2), and Dr. Beena Patel (Work Package 3) will coordinate the execution of the respective Work Packages by closely interacting with the investigators. Each principal investigator would be responsible for meeting the deliverables/ milestones defined in their respective work package(s).

DELIVERABLES

- Identify locally adapted high biomass abiotic stress tolerant sorghum, pearl millet and bamboo cultivars identified (>18 t/ha dry biomass)
- Develop a low input advanced feedstock production system
- Optimize efficient pretreatment method and identify biomass-based enzyme formulation for saccharification
- Develop efficient fermentation process for high ethanol and butanol recovery
- Develop standard and certification protocol and prepared energy, emission, economic analysis and supply chain management report for lingo-cellulosic biofuel production commercialization

U.S.-India Joint Centre for Building Energy Research and Development (CBERD)

Consortium Leadership

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India is an emerging giant with an expanding economy, and a quest for an improved quality of life. The commercial buildings and high-density residential construction industry is experiencing explosive growth. India will add approximately 700 to 900 million square meters of built floor space each year (McKinsey, 2010). The United States is one of the largest energy consumers in the world; with buildings accounting for over 70% of the nation's total electricity use.

The potential for building energy savings in both nations is immense - studies have demonstrated that systems-level integration through innovative design and technologies can reduce energy consumption by at least 60% in new construction in India, and at least 10-30% in retrofits in the U.S. relative to local norms and practices. By drawing on the research and technological capabilities of the U.S. and India, substantial energy savings can be achieved.

CONSORTIUM OBJECTIVES AND ACTIVITIES

The **U.S.-India Joint Centre for Building Energy Research and Development (CBERD)** will conduct collaborative research and promote clean energy innovation in the area of energy efficiency in building with measurable results and significant reduction in energy use in both nations. CBERD will focus on the integration of information technology with building controls and physical systems for commercial/high-rise residential units. The R&D tasks are intended for technology acceleration and include:

Building energy modeling and simulation	Thermal comfort
Monitoring and benchmarking of buildings	Grid responsive buildings
Communication and controls integration	Renewable energy source integration in buildings
Building envelope and passive design	Scientific collaboration between U.S. and India
Advanced HVAC and lighting technologies	

This outcome-based R&D will result in significant energy savings by driving development of cost-effective technologies and their implementation across buildings. CBERD's vision is to build a foundation of collaborative knowledge, technologies, human capabilities, and relationships that position the U.S. and India for a future of high-performance buildings, with accelerated, measurable and significant energy use reduction. The focus on the highest growth sectors, i.e., commercial and high-rise multi-family buildings, targets primarily new construction in India and retrofits and operations in the U.S. While this will create the maximum impact, the results will have spill-over benefits to other building sectors. CBERD will draw from its partners' collaborative R&D and commercial experience to meet the goals of the JCERDC, aligning it to the vision of DOE (U.S. DOE Multi-year Plan, 2011–2015) and GOI (IPC, 2011) as well as to larger industry interests.

CBERD will gain an in-depth analysis of how buildings in India and the U.S. use energy, and create a Lifecycle Performance Assurance Framework (LPAF) that supports building system integration throughout the building's design, construction, and operation. The overall R&D strategy is structured and prioritized to provide guidance on the selection of key technologies and components for each major building system to meet the desired performance levels, and cost-effective solutions.

CONSORTIUM MANAGEMENT

CBERD Consortia management is structured to achieve project objectives and quality at every stage of technology development while minimizing management and travel costs. The Consortia's expertise exists at different levels, which helps to provide flexibility for changes in priorities over the five-year project. The technologies and systems will be evaluated during each stage of the CBERD project to meet performance requirements and make sure that the R&D success is achieved through scientific collaboration and creating deployment pathways.To coordinate and manage this project, LBNL and CEPT will form joint Management Offices led by the CBERD Directors and Deputies (Principal and CoPrincipal Investigators), and supported by the Project Directors. The Office would be called the CBERD Management Office or CMO. The administrative, fiscal, contracting, and R&D responsibilities for the U.S. side will be conducted by LBNL, and CEPT would assume parallel responsibilities for the Indian partners.

Consortia Partners

INDIA	U.S.
LEAD INSTITUTION CEPT University-Ahmedabad	**LEAD INSTITUTION** Lawrence Berkeley National Laboratory
OTHER PARTNERS International Institute of Information Technology (IIITH) Hyderabad; Malaviya National Institute of Technology (MNIT); Indian Institute of Technology Bombay (IITB); Indian Institute of Management Ahmedabad (IIMA); Auroville Center for Scientific Research (ACSR); Indian Green Building Center/Confederation of Indian Industries; Indian Society of Heating Refrigeration and Air Conditioning Engineers; Rajasthan Electronics and Instruments Limited; Indian Society of Lighting Engineers	**OTHER PARTNERS** Oak Ridge National Laboratory (ORNL); University of California Berkeley; Carnegie Mellon University (CMU); Rensselaer Polytechnic Institute (RPI)
INDUSTRY PARTNERS Asahi India Glass; Biodiversity Conservation India (Pvt.); Infosys Technologies; Neosilica Technologies; Oorja Energy Engineering Services; Paharpur Business Centre/Green Spaces; PLUSS Polymers; Philips Electronics India; Saint Gobain Corp.; Schneider Electric India; Sintex Industries Limited; Skyshade Daylights; Wipro EcoEnergy; Glazing Society of India; Indian Green Building Council; India Society of Heating Refrigerating Air-Conditioning Engineers; Indian Society of Lighting Engineers	**INDUSTRY PARTNERS** Autodesk, Inc.; California Energy Commission; Delphi; enLighted, Inc.; Honeywell; Infosys Public Services; Ingersoll-Rand/Trane; Lighting Science Group Corp.; Nexant; Saint Gobain Corp./SAGE Electrochromics; Synap Sense; The Weidt Group; Bay Area Photovoltaic Consortium; City of San Jose; HOK Architects; Natural Resources Defense Council

DELIVERABLES

CBERD's approach for applications-specific transfer and transformation of technologies will improve both adaptation and adoption of technological solutions. The technologies will be evaluated in test beds and field-studies in both India and the U.S., and refined through collaborative exchanges amongst the consortium members, thereby improving energy efficiency in both India and the United States. Some of the innovative, prioritized tools and technology solutions that CBERD research and development will generate are:

- Development of new building energy simulation tools and extension of existing ones, geared toward building energy code compliance, critical input data (materials and weather databases) and early-stage design tools.
- Application of actionable benchmarking to (i) set appropriate performance targets, (ii) provide a technical foundation for national-scale monitoring/benchmarking programs, and (iii) develop advanced training guides and new tools to address data scarcity.
- Establishment of new technical solutions for sensing, monitoring, and controlling building operations by creating platforms for electric devices and building components.
- Development of technical solutions for grid-connected and responsive buildings and building-integrated photovoltaic that accelerate Smart Grid and renewable integration.
- Identification of guidelines for best practices in envelope design, passive/hybrid cooling systems, windows/ daylight techniques and occupant comfort that will lead to a scientific-measurable basis for their widespread application and adoption, to achieve energy savings.
- Development of modular HVAC and lighting systems, equipment, and technologies that offer superior energy efficiency and individual climate controllability. These will be made relevant for different applications taking into account the weather, material-construction, localization, and building characteristics that support commercialization.
- Providing a bridge to commercialization of advanced building materials for cool roofs, insulation, and glazing, with the aim of minimizing energy loads.
- Direction of positive and powerful outcomes of the R&D research thrusts toward cost optimization, test bed/field-tests, and scientific staff training and collaboration.

RESEARCH GAPS OR CRITICAL BARRIERS	PROJECT OBJECTIVES	CBERD METHODOLOGIES
RESEARCH AND DEVELOPMENT INNOVATION		
Lack of building systems integration throughout the design, construction, and operation processes	Evaluate and optimize the integration of building systems using the whole-building approach across the building lifecycle to advance high-performance buildings	Develop a Lifecycle Performance Assurance Framework that stakeholders can use to ensure optimal integration of building IT systems with building physical systems through a building's lifecycle
Lack of specific energy efficiency solutions that will apply to diverse building types	Formulate Building EE R&D strategies targeted to the wide diversity of building types in the commercial including new construction and retrofits	Conduct research and develop guidelines and best practices for building prototypes
Lack of efficiency technologies and applications customized for regional application	Develop a suite of R&D strategies customized for U.S. and Indian applications to help leapfrog transitional technologies while developing and advancing appropriate regional and local low-energy practices and technologies	Develop bilateral transfer of technologies and products between the U.S. and India to help speed the development of regional practices normalized to weather, materials-construction techniques, systems and occupant comfort
Lack of universally accepted, standardized processes for achieving building energy performance targets for technology R&D	Enhance pathways to meet or exceed building standards and codes through decision tools, design specification algorithms, and best practices that are supported by measured data	Establish milestone-driven, short-term, tangible results and long-term goals using comprehensible, actionable data from emerging technologies and their integration
TEAM INNOVATION		
Building energy researcher, designer, and developer knowledge limitations in the U.S. and India	Boost the knowledge and capability levels of building energy stakeholders through documentation, education/ training, and demonstration	Facilitate and enable collaboration and information exchange among key academic and research institutes to disseminate building efficiency knowledge broadly among stakeholders
Building industry fragmentation inhibits energy efficiency	Accelerate building efficiency R&D and deployment through a solid, functioning consortium with bilateral public-private partnerships	Establish on-going, sustainable joint consortia that draw on core research and commercial strengths of both nations, with well-defined cooperative responsibilities and roles

Moving Ahead

Keeping in mind the fact that science and technology has since long been an important cornerstone of cooperation between India and the United States, both nations recognize the fact that further collaboration would enhance our shared understanding of the planet's climate. The activities of the Indo-U.S Joint Clean Energy Research and Development Center would contribute greatly to the sustainability and prosperity of not only our two countries but the world at large by helping diversify energy supply and accelerate the transition to a low-carbon economy.

This new and unique initiative of both Governments to set up a joint bilateral virtual centre through a joint call, review, funding and management process can serve as an excellent model for other such consortia.

Principal Investigators and Co-Principal Investigators of the Indian Consortia with Dr. M.K. Bhan (Secretary, Dept. of Biotechnology, Govt. of India) on 17 September 2012

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