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DBT: Initiatives and Schemes to Promote Innovation and RD&D in Biofuels

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Ministry of Science & Technology
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3rd EU-India Biofuel Conference
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Biofuel R&D Strategy

DBT Vision: To develop economically viable biofuel production technologies

Strategy

Promote cutting edge R&D and Innovation
Create Centre of Excellence
Capacity Building
Strengthen International Cooperation

Areas of Focus

Feedstock development, Improvement of conversion technologies, 2G Ethanol, Enzymes, Advance biofuels, Waste to Energy, Cutting edge research

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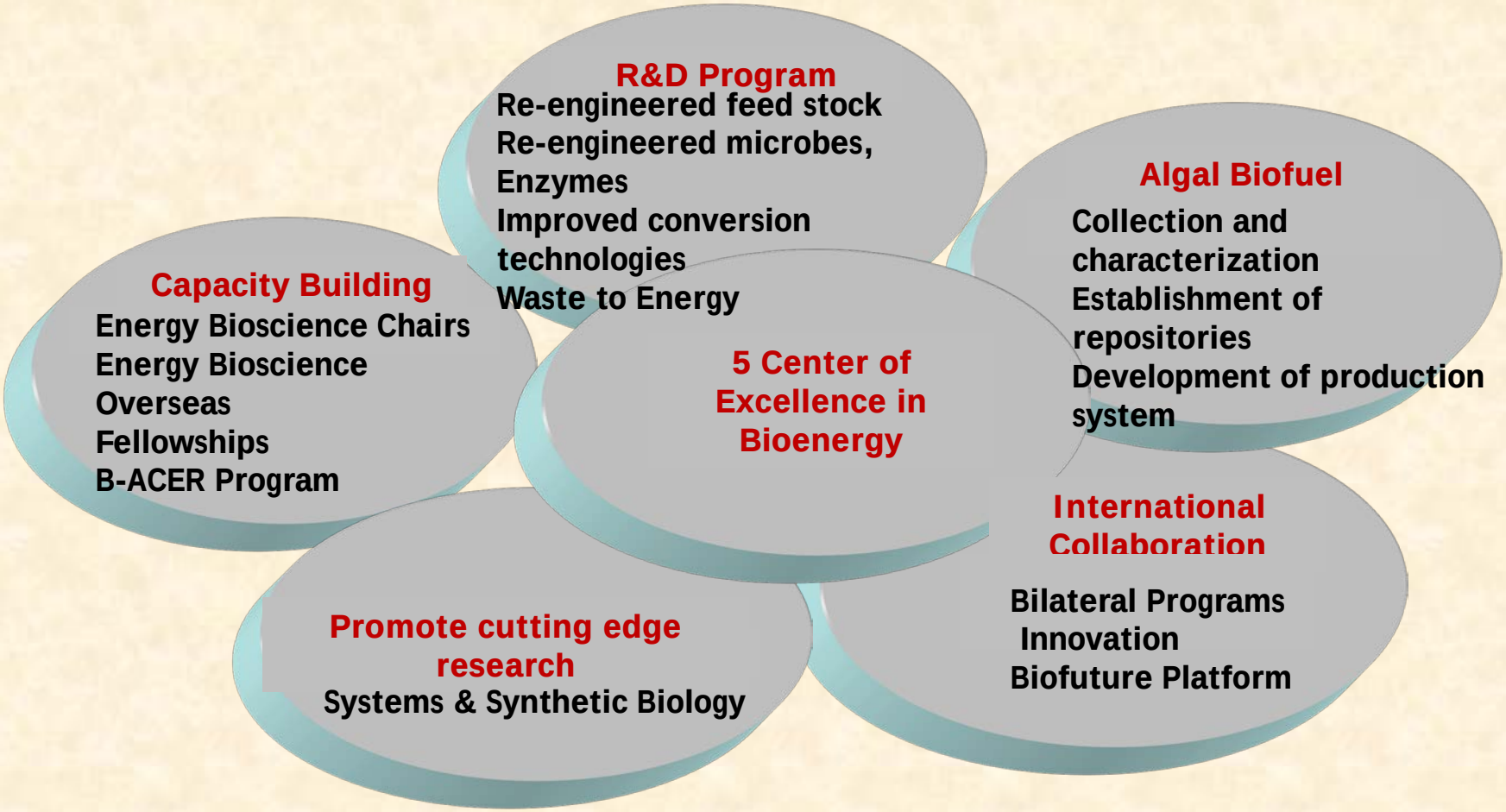
Various Schemes for Implementation in Biofuel R&D



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Centres of Excellence in Bioenergy

1. Institute of Chemical Technology, Mumbai
2. Indian Oil Corporation R&D, Faridabad (cost sharing)
3. International Centre for Genetic Engineering and Biotechnology, New Delhi
4. Indian Institute of Technology (Virtual Centre of 5 IITs)
5. The Energy and Resources Institute, New Delhi

State-of the art facilities
Interdisciplinary teams
Capacity building
Cutting edge and Translational R&D

Various Bio-refinery Platforms

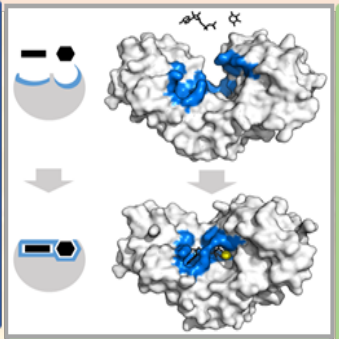
Green Chemistry and Catalysis

Processes for treating agro, agro-processing wastes

MSW & MLW & Nallah waste Treatment process optimization

Development of catalysts for efficient conversions and yields

Recycling of catalysts for better process economics



Enzyme Technology

Recycling Cellulases for sugar production in LBM wastes

Exploring new enzymes for higher efficacies and lower OPEXs associated with commercial usage

Validating enzymes and processes for higher sugar yields

Synthetic Biology

Designing microbes for utilizing sugars and phenolic monomers

High value products to support biofuel production

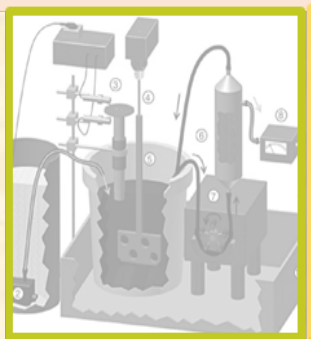
Eight different hosts being modified to suit high-value biorefineries

Algal Biotechology

Genetic Engineering for Green Algae & Cyanobacteria

Growth Engineering of Macroalgae, Green Algae & Cyanobacteria

Screening & process optimization of Macroalgae, Green Algae & Cyanobacteria for producing Value added Products



Fermentation

2G ethanol

Butanol

Biogas

Organic Acids

Microbial Lipids

Integration & Implementation

- 2G Ethanol Technology
- MSW & MLW technology
- Nallah Cleaning Technology

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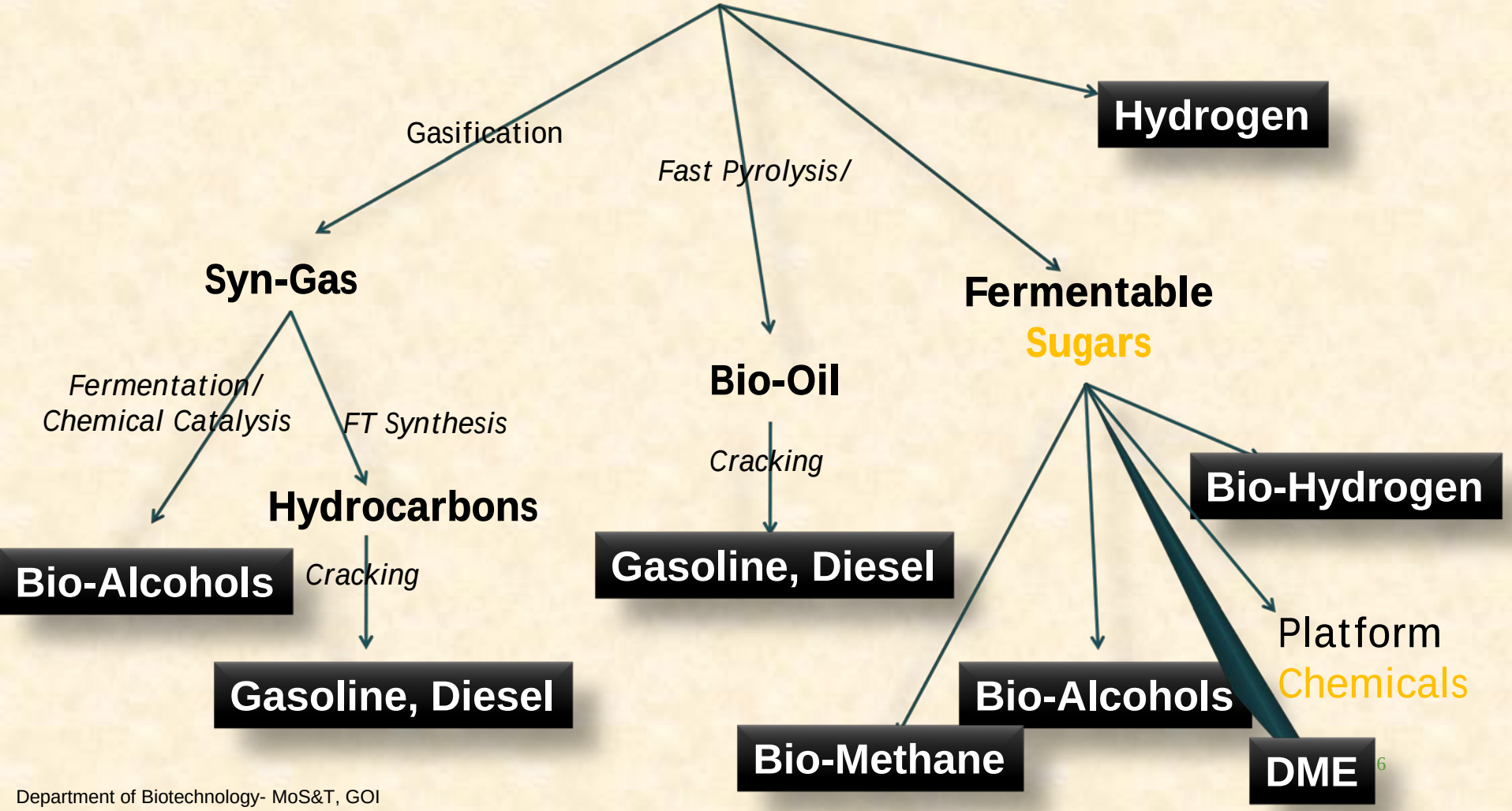
Agricultural Biomass Biofuel Options



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Biochemical Transformations

Biomass

Terrestrial
Marine/Aquatic
Waste

Engineering Microorganisms
- *E. Coli*
- *S. Cereviseae*
- *Corynebacteria*
- *Clostridia sp.*
- *Yarrowia sp.*
- *Pseudomonas sp.*
- *Lactobacilli*
- *Cyanobacteria*
- *Algae*
- *Methanogens*

Oligosaccharides
Sugars
Lignin
CTL Bio-Crude

Designing Catalysts

Chemical Catalysts
- Homogeneous
- Heterogeneous

SEPARATIONS

Alcohols
- *Methanol*
- *Ethanol*
- *Butanols*
- *Xylitol*
- *Butanediols*
- *Isopropanol*

Organic Acids
- *Acetic acid*
- *Propionic acid*
- *Butyric acid*
- *Lactic acid*
- *PHAs*
- *FDCA*

TG/Fatty Acids
Amino Acids
Biopharmaceuticals(?)
Polymers
Hydrocarbons
- Terpenes
- Methane

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Algal Biofuel

- Network Program
- Collection and Characterization
- R&D for strain improvement
- Design and development of algae production systems

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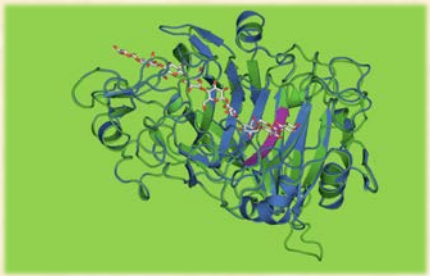
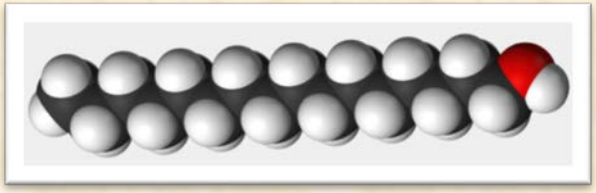
Biofuel Technology Development Status in India



2G EthanoTechnology



Biohydrocarbons

MSW to Energy-Swachh Bharat-
Novel technologies are being demonstrated

Biohydrogen- 1000 L

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Scale up process of Bio-H_2 production

Clostridium butyricum TM-9A culture as inoculum

Sugar cane molasses as feed stock

Pilot scale nitrogen generator

Scale up of hydrogen production in pilot scale

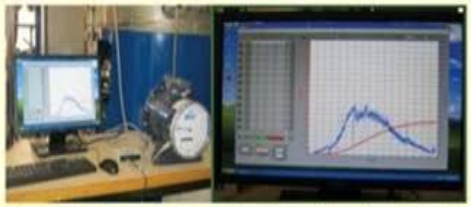
2.5 L scale bioreactor

14 L scale bioreactor

30 L scale bioreactor

150 L BIOREACTOR

1500 L BIOREACTOR



Fermentative biohydrogen production from molasses by *Clostridium butyricum* TM-9A strain, in laboratory scale & proto scale bioreactors

Biogas generated during dark fermentation process allowed to pass through gas flow meter | Quantification detection of biogas production by gas flow meter

Hydrogen production by *C. butyricum* TM-9A strain in 150 and 1500 liter scale bioreactor

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Demonstration Projects on MSW to Methane

Setting up Pilot Scale Demonstration Plant to convert 1 ton/day MSW into Energy (By DBT-ICT at BPCL Colony, Mumbai)

Rapid AD Technology – **TRL- 5**

(1 TPD MSW + 200 m3 per day Sewage)

High rate Bio-Methanation of organic fraction of MSW for the generation of biogas based power and bio-manure (By IICT Hyd at GHMC Site)
(10TPD MSW**) TRL-9**

Co-Fermentation of Kitchen Waste and Fecal Sludge-
(BITs Goa with Village Panchayat)

Food waste : 10 to 15 TPD (from 1350 Hotels)
Black water : 10 to 20 m^3 per day (from 200 community toilets)

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Waste water treatment at DBT-ICT-CEB Mumbai

International Cooperation in Sustainable Biofuels

Mission Innovation- Lead role in many activities
Accelerating innovation through 14 R&D projects in collaboration with 9 member countries

Provide ecosystem to innovators/ start-ups through Clean Energy Incubato

Biofuture Platform-
Member of Core group

Bilateral Collaboration
Brazil, Canada, Denmark, Netherlands, UK

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Mission Innovation

To accelerate innovation in clean energy

Founder Member with active participation

International Sustainable Biofuel Conference in Feb 2018 in collaboration with IC4 Co-leads and Biofuture Platform in New Delhi

Funding Opportunity Announcement 2018 for Innovation Challenges(IC4) Sustainable
14 R&D projects with 9 member countries

Established the **first International Clean Energy Incubator** – collaboration with Sweden under Avoided Emission Framework.

MI Champions Program to support individuals innovations in clean energy

1.	Renewable drop-in fuels through oleochemical route	Cananda
2.	Utilize CRISPR cas tools for redirecting metabolic flux in *Thermoanaerobacterium* sp RBIIT for biobutanol production	USA
3.	Novel concepts for developing efficient cellulolytic cocktails for hydrolysis of bio-refinery relevant pretreated lignocelluloses	Canada, USA, The Netherlands.
4.	A novel integrated biorefinery for conversion of lignocellulosic agro waste into value added products and bioenergy *(biohydrogen and methane)*	Norway, The Netherlands, USA, China, Saudi Arabia
5.	Hydrogen production from biomass through pyrolysis process followed by catalytic steam reforming of volatiles	Czech Republic
6.	Development of *Paenibacillus polymyxa* as a platform for production of branched chain alcohols *(isobutanol)*	USA, China
7.	Genetic engineering of microalgae for producing alkanes for further applications *(drop in jetfuel)*	UK
8.	Modifying the lignin composition in biomass sorghum and its deployment for enhanced ligno-cellulosic (2G) biofuel production	Australia
9.	Advanced biofuels generation from thermo-chemical conversion of biomass – Research, Demonstration and Analysis *(use of biomass and MSW to produce syn gas)*	Australia, USA
10.	Technology development for cost effective lignocellulosic bioethanol production	Brazil
11.	Catalytic aqueous-phase reforming of model compounds of microalgae and activated sludge	United Kingdom
12.	Impact of Carbon Nanomaterial based Photocatalyst on Microalgae Growth and Lipid for Improved Biodiesel	United Kingdom
13.	Membrane based prototype development for higher yield of microalgal biomass and biofuel using industrial waste resources	USA
14.	Bio-chemical and technological innovations to develop high value ‘green’ chemicals from 2G lignin and improve biorefinery sustainability	USA

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Industrial Waste Challenge (Newton-Bhabha Fund)

1. BIOREVIEW: Bio-refining Value from Industrial Waste
   fatty acids (VFAs), xylitol and microcrystalline cellulose (MCC)from bagasse and spent wash
2. Economic non-food sugar from variable mixed solid waste for high value chemical products
   Cellulose Enzyme for 2G ethanol
3. Integrated bio-refinery for converting paper mill waste into (waste-2-wealth)
   Cellulose Enzyme and industrial microorganisms for value added products
4. Reducing industrial waste from sugarcane processing in India
   Bio-butanol, succinic acid, lactic acid
5. Valorising Waste from Sugar Cane and paper mill waste
   lysine and linalool

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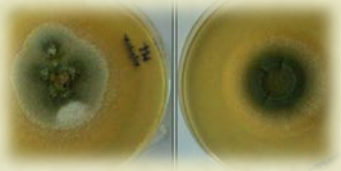
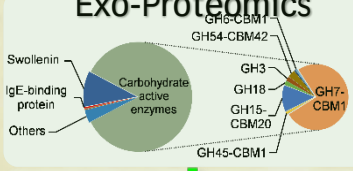
Reducing industrial waste from sugarcane processing in India" (Indo-UK program)

WP2-Enzymes
ICGEB, India
Univ of York, UK
Prozomix, UK

Hypercellulolytic In-house Fungus

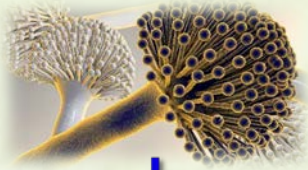


Exo-Proteomics



Genome engineering to enhance specificity

In-house engineered *Aspergillus niger/tubingensis*



fba

Genome engineering for C5/C6 fermentation

WP1-Fermentation
ICGEB, India
Univ of York, UK
BDC, UK

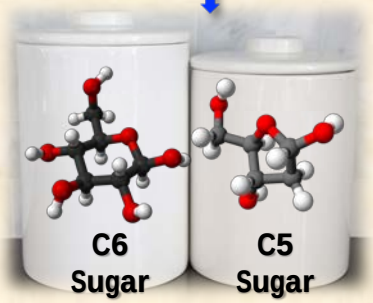
Pre-treatment development

UoY, UK

Natems Sugar Mill, India

Sugarcane Bagasse

Pre-treatment



Saccharification

Fermentation

WP3-Reactors
Natems, India
Jesmond Engineering, UK
Wilson Biochemical, UK

Reactor and Process Design & Engineering

R&D Collaboration Opportunities

- Knowledge sharing - joint R&D programs in mutual priority areas
- Connecting Researchers through Virtual R&D Center
- Capacity building- Researchers/Student Exchange programs
- Bioenergy Incubator to support start ups/innovators
- Sharing of best practices

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India-Brazil Biofuel R&D Collaboration

Bilateral Meeting on 28thFeb 2018 in New Delhi to identify common priorities and shared opportunities

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Indo-Brazil collaboration

S&T Agreement Signed on 30th May 2018

Objectives:

a) to broaden and deepen cooperation in Science & Technology in the field of Biotechnology;

b) To encourage industrial Research and Development (R&D) in biotechnology sector

b) To promote transparency through exchange in information and cooperation among relevant institutions.

Areas of cooperation

a) Biomedicine and health, b) Agriculture breeding practices; c) Bio-fuels and Bio-energy; d) Nanotechnology and Bioinstrumentation; and e) Biodiversity and Taxonomy

b) Total 11 R&D joint projects in Bioenergy supported by both countries.

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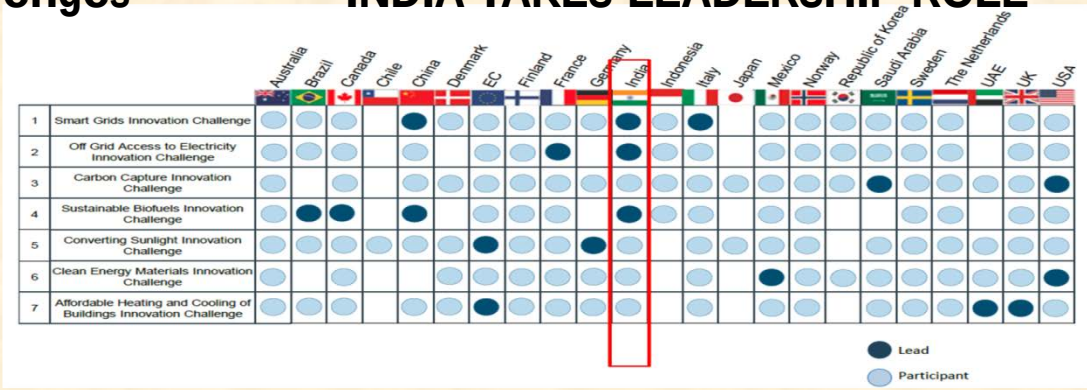
Mission Innovation

Eight Mission Innovation challenges

INDIA TAKES LEADERSHIP ROLE



INDIA'S CLEAN ENERGY AREAS OF INTEREST

- **Energy Efficiency**
  - Reduction of energy intensity in industry
  - Residential and commercial buildings, appliances and equipment
  - Transport sector through use of better fuels and automobiles
  - Energy savings through advanced traffic management protocols
- **Renewable Energy Sources**
  - Solar energy
  - On-shore & off-shore Wind energy
  - Sustainable Bio-Energy
  - Geothermal energy
  - Hydroelectricity
  - Other renewable energy sources
- **Other cross-cutting technologies**
  - Energy system analysis
  - Carbon capture, storage and utilization technologies
  - Development of advanced sun fuels
  - Basic energy research
- **Hydrogen and Fuel Cells**
  - hydrogen
  - Fuel cells
- **Other power and storage technologies**
  - Efficient electricity transmission and distribution
  - Energy storage (non-transport applications)
  - Smart Grids

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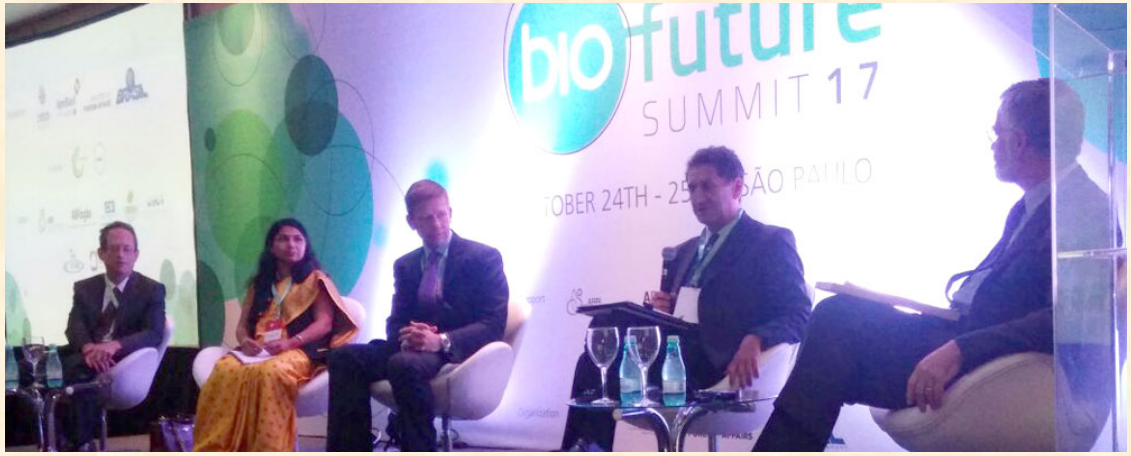
Biofuture Platform–linkage with Mission Innovation (IC4)

International Sustainable Biofuel Conference in Feb 2018



Biofuture Summit- Oct 20

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