# Research and Development for Bio based economy


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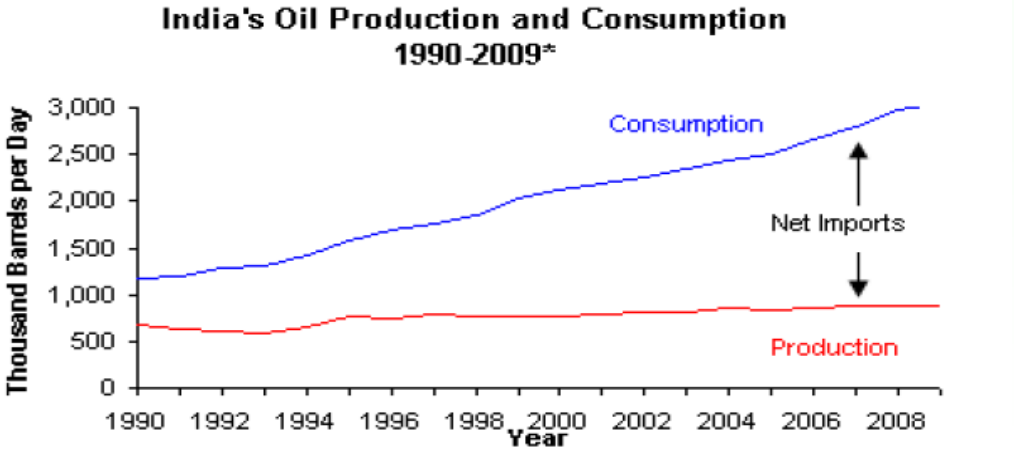
# Challenges in the Energy Sector

- Fossil fuel reserves are limited
- Fossil fuels are linked to environment pollution
- Growth is exponential with limited indigenous resources
- Alternate energy sources become exceedingly important
- Bio-energy is an important segment



# The Potential in India for Biofuels

## Strengths

- Alternate fuel source
- Energy security of the country
- Less GHG emissions, environment friendly
- Higher Cetane number and better lubricating effect for biodiesel

## Weaknesses

- Wasteland requirements
- Need for engine modifications in higher blends
- Market still in nascent stage
- Still in field trial stage in India

## Opportunities

- National Biodiesel policy
- Keen interest of private players
- R&D across the sector
- Less dependency on depleting fossil fuels

## Threats

- The discovery of huge gas reserves in India may push biofuels on the backfoot
- Food vs. fuel debate
- Cost effectiveness of Biofuels
- Raw material

# Projections for 2nd Gen biofuels

- 10-13 % of total transport fuels by 2030 from biofuels
- 26 % of total transport fuels by 2050
- By 2050, about 90 % of biofuels will be from 2nd / 3rd generation
- India & China will produce about 20 % of global production
- 10 % of global forestry & agricultural residues (2007 based ) can satisfy about 6-8 % of current transport fuel needs
- India has enough surplus residues to get about 30 % of its transport fuel

*Source : World Energy outlook 2009 . An analysis by IEA*

# National Biofuel Policy

- Goal
  - To ensure that a minimum level of biofuels become available to meet the demand.
- Target
  - 20% blending of biofuels by 2017

# Policy for R&D

- A major thrust to be given through this Policy on Innovation, Research & Development and Demonstration in the field of biofuels.
- Intensive R&D work to be undertaken in
  - Biofuel feed-stock production
  - Advanced conversion technologies for first generation biofuels and emerging technologies for second generation biofuels.
  - Technologies for end-use application
  - Utilisation of by-products

# Implementation Modalities

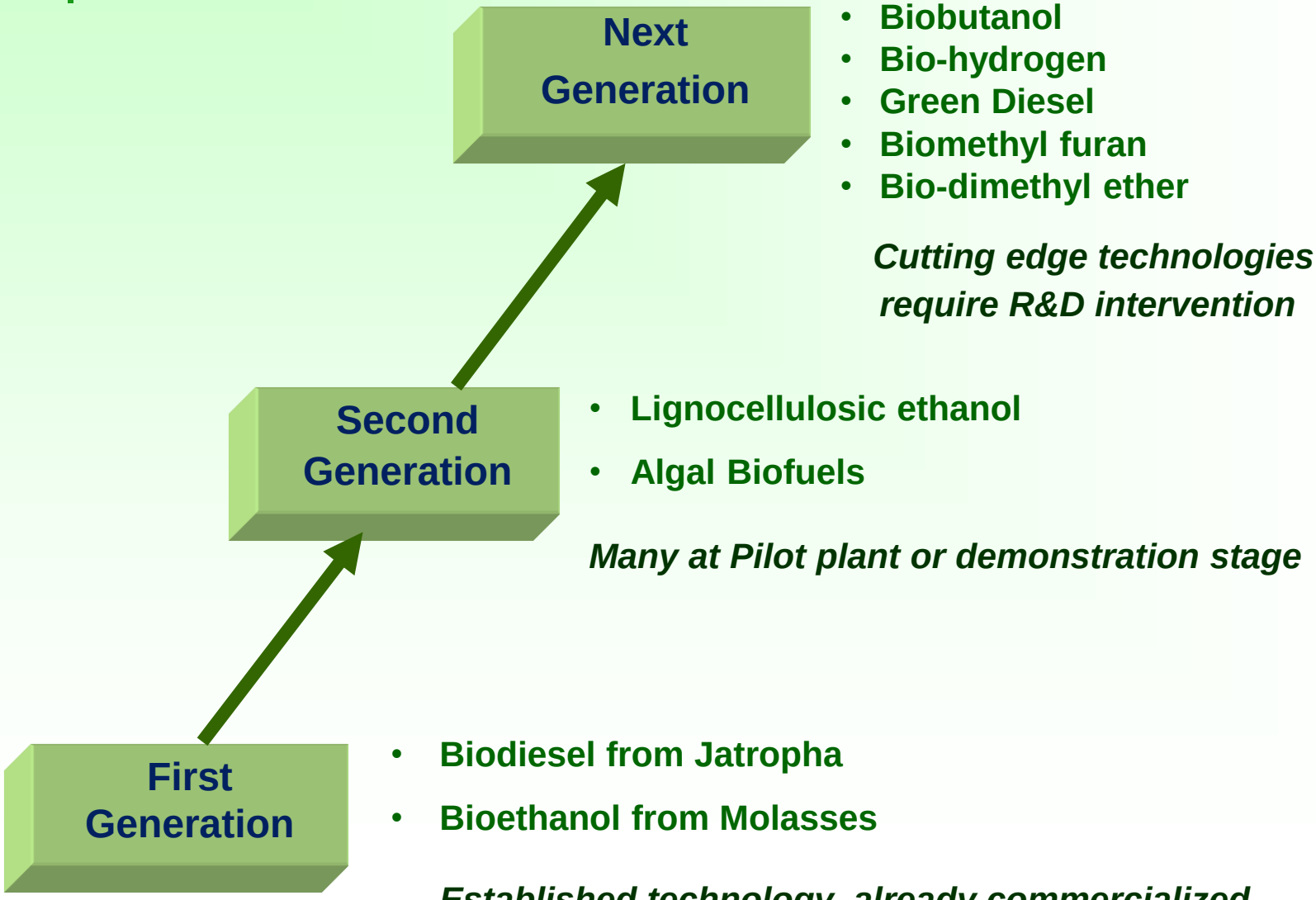
- Demonstration projects for biofuels involving academic institutions, research organizations, specialized centers and industry.
- Strengthening of existing R&D centers and setting up of specialized centers in high technology areas.
- Multi-institutional, time-bound research programmes with clearly defined goals and milestones.
- Promoting industry - academic interaction and transfer of know-how to industry.

# R&D Efforts – Agencies involved

- Ministry of Agriculture – Indian Council of Agricultural Research
- Ministry of Defence – Defence Research Development Organization
- Ministry of New & Renewable Energy (MNRE)
- Ministry of Petroleum and Natural Gas – Indian Oil Corporation
- Ministry of Science & Technology
  - Council of Scientific & Industrial Research
  - Department of Biotechnology
  - Department of Science & Technology

*Inter Agency Committee chaired by Secretary, DBT to coordinate R&D effort.*

# The Biofuel Generations



# DBT's Energy Bioscience Program

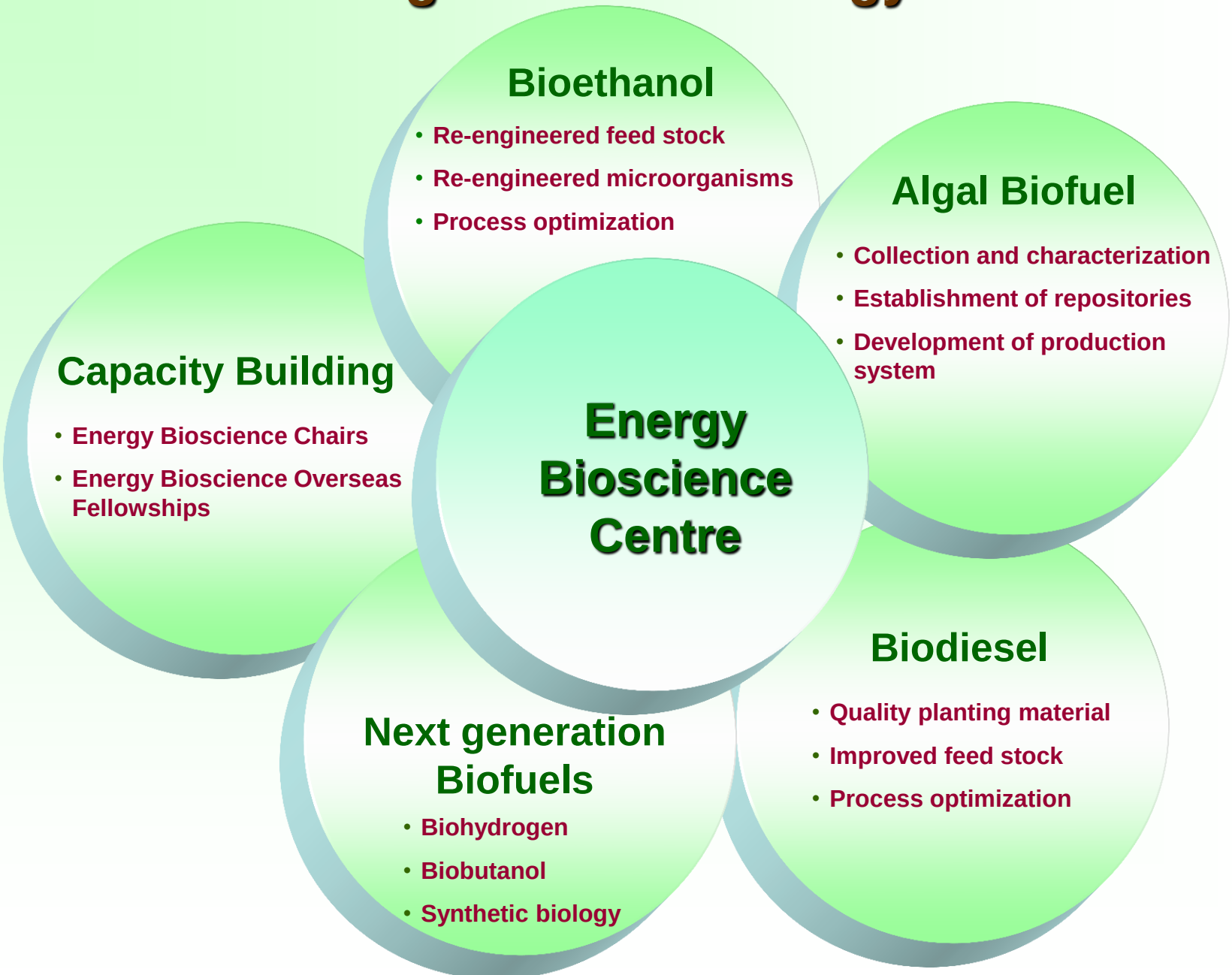
## Vision

**To make available, economically viable alternative fuel from Biomass to meet the energy deficit and national targets of biofuel blending**

# Goals and Targets

- Ethanol from cellulosic biomass by 2012 (agricultural and forestry waste)
- Biodiesel from varied feed stocks
- Harness optimally the energy potential of all natural resources for conversion to alternative fuel
- Create alternative second generation biofuels through synthetic biology

# National Programme on Energy Biosciences




***More than 60 research institutes, universities and industries involved***

# Research Priorities

- Feed stock Development and Improvement
- Improved Production Technologies
- Biorefinery based fuels and biochemicals
- Algal Biofuel
- Synthetic Biofuel

# Bioenergy Centers

1. DBT-ICT Centre for Energy Biosciences, ICT, Mumbai

2. DBT-IOC Centre for Advanced Bioenergy Research, R&D IOCL Faridabad

3. DBT-ICGEB Centre for Advanced Bioenergy Research, ICGEB New Delhi

# DBT- ICT Centre for Energy Biosciences

## India's first National Bioenergy Research Centre

**Fermentation Technology**
Extractive fermentation, Metabolomics and Metabolic Engineering for Optimized production of amino acids, Vitamins and Enzymes

**Enzyme Technology**
Design and Use of Stable, Reusable, Inexpensive Enzymes for organic and other Biotransformations

**Second and Next Generation Biofuels**
BioAlcohols, BioDiesel, BioHydrogen, BioMethane

**DBT-ICT Centre for Energy Biosciences**
*Work Areas*
*In Industrial Biotechnology*

**Synthetic Biology**
Engineering Metabolic pathways for overproduction of primar metabolites, synthesis of designer proteins and Stra improvement

**Separation Technology**
Design and Applications of selective adsorptive and chromatographic separations for small and macromolecules

**Algal Biotechnology**
Design of algal systems for production of primary and secondary metabolites, as also starch, oil for biofuels, amino acids and other natural products

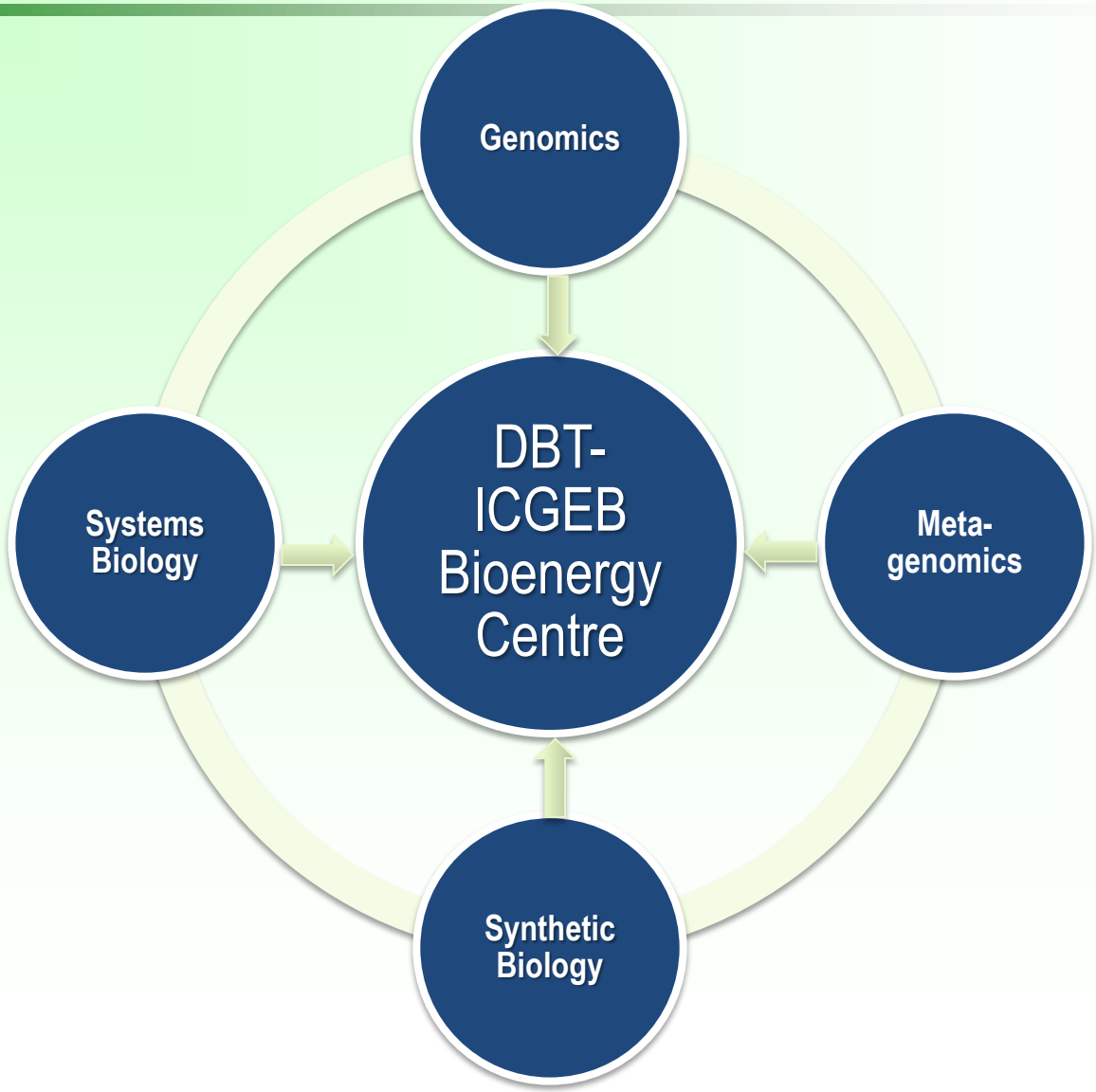
# DBT-IOC Centre for Advanced Bioenergy Research

- **Mission**: " Research, Development and Deployment of sustainable, environmental friendly and economically viable bio-assisted energy technologies"
- **Objectives**:
  - To conduct a multi-disciplinary bioenergy research involving biology, engineering, chemical and material sciences etc.
  - To provide a platform for integrating dis-jointed research activities pursued in several areas related to biofuels by various institutes.
  - Development of "institutional capability" to address the India specific bio-energy need based on "science-enterprise model".
  - Provide National capability of pilot level and scale-up of developed technologies. To be a DBT Network partner

# Research Programmes of DBT-IOC Centre

- Lignocellulosic based bio-fuels
- Algal research
- Gas Fermentation
- LCA & Economic models
- Synthetic biology
- Novel biotechnological method for CO2 mitigation
- Life cycle analysis

# 3rd Bioenergy Centre of DBT



# Research Area

Genomic and metagenomic approaches for identifying novel cellulolytic enzymes

Engineering microbes for direct conversion of biomass into biofuel

Engineering algae for higher lipid and biomass yield

Engineering microbe for production of higher value advance biofuel molecules

# Major Biofuels being researched upon

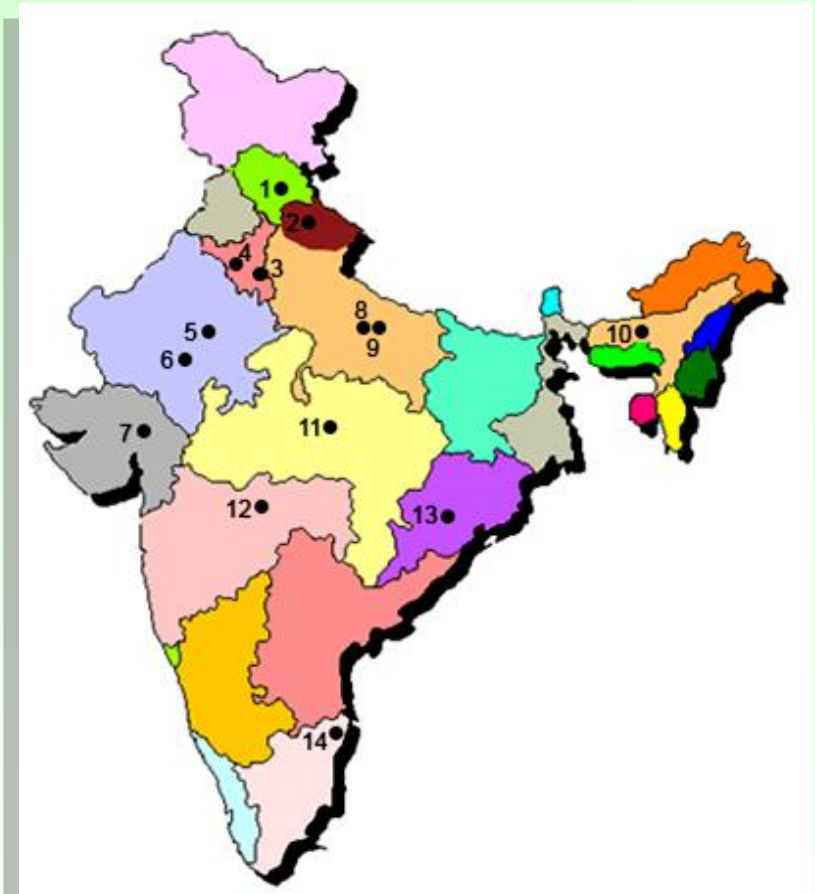
| Biofuel | FeedStock | Technology |
|---|---|---|
| Biodiesel | Jatropha, TBO | Transesterification batch / continuous process |
| Bioethanol | Cellulosic – Agricultural & forestry waste | Pre-treatment enzyme modification |
| Bio-butanol<br>Bio-hyrogen | Algae –<br>Micro & Macro | Simultaneous saccharification and fermentation |
| Bio-hydrocarbon | Biomass | Synthetic biology |

# R & D Intervention

| SNo | Biofuel Feedstock | Status | Intervention required |
|---|---|---|---|
| 1 | Biodiesel – Jatropha | Technology available | Improved feedstock quality germplasm |
| 2 | Bioethanol – Cellulose Biomass | • Technology at Pilot Plant / Demonstration<br>• Cost effective pre-treatment and fermentation technologies standardized<br>• Improved enzyme consortia<br>• Microbial strains capable of fermenting C5 & C6 sugars | • Multi feedstock pilot plant<br>• Enzyme engineering screening, expression and production of new cellulose<br>• Improved fermentation technologies – 10 fold<br>• Sustainable technologies for conversion of lignin to value added products. |

| SNo | Biofuel Feedstock | Status | Intervention required |
|---|---|---|---|
| 3. | Biobuthanol Biohydrogen | ➢ At preliminary research stage<br>➢ Metabolically engineered strains<br>➢ Process validation | ➢ Optimal strain development<br>➢ Novel fermentation method<br>➢ Butanol recovery |
| 4. | Algal Biofuel | ➢ At initial stages, scattered at various centre<br>➢ Algal repositories established, 2000 collections<br>➢ Production technologies at small scale | ➢ Identification of high yielding, fast growing strain<br>➢ Improved production system<br>➢ Harvesting and processing |
| 5. | Biohydrocarbon | Very preliminary, basic research | ➢ Strengthen research groups and infrastructure<br>➢ Build collaborations |

# Multi-location trials of Jatropha across the country



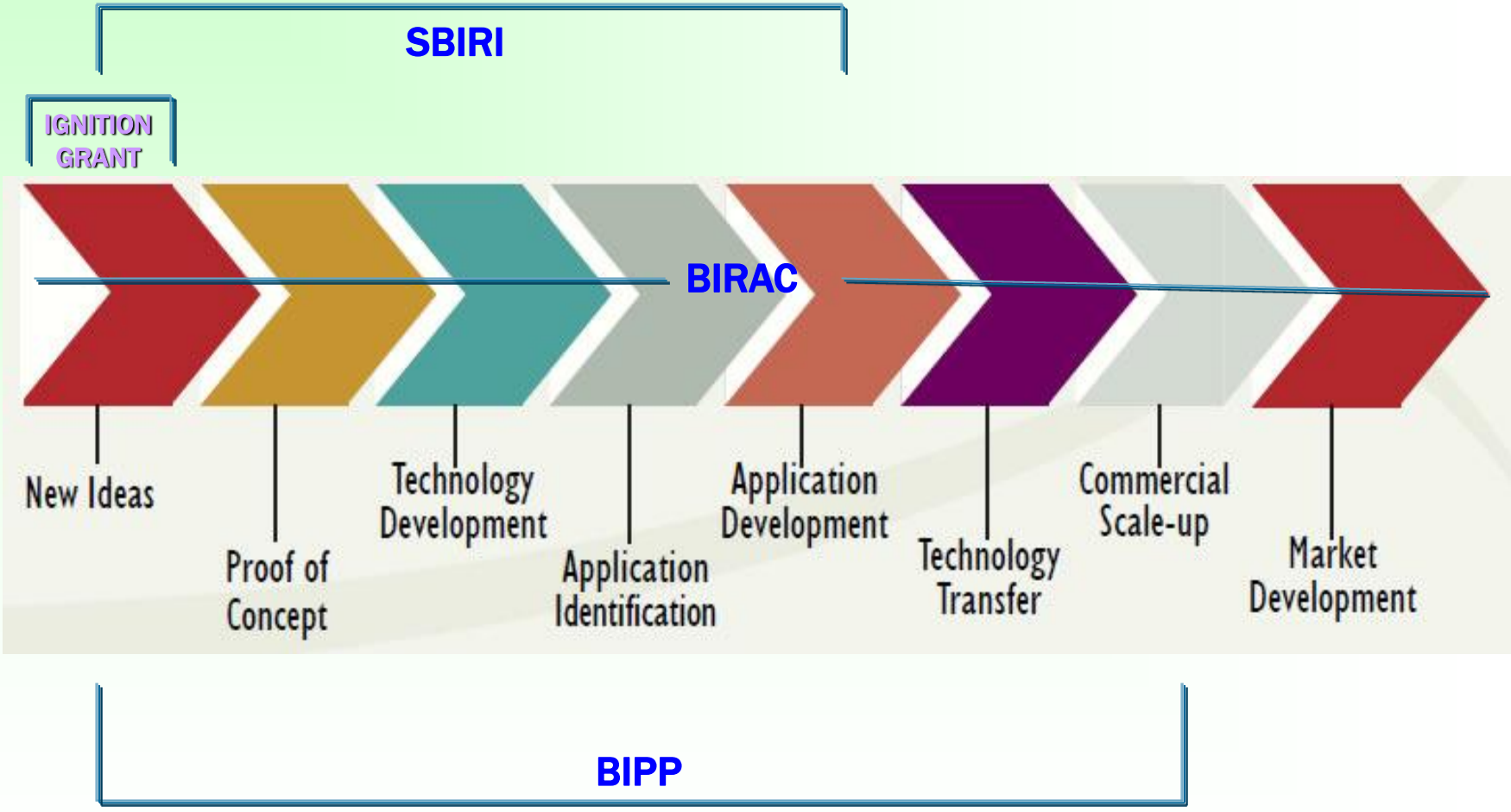

- First systematic study for morphological, chemical and molecular characterization of germplasm
- 400 accessions bulked to raise 17 lakh quality plants

| Collections made by institutes | Collections accessioned | Accessions used for trials | Institutions involved | Area under plantation | Number of plants in trials |
|---|---|---|---|---|---|
| 1261 | 890 | 349 | 13 | 317 ha | 693696 |

# Promoting Innovation

- Fostering Public Private Partnership
- Enabling IP generation and protection
- Infrastructure development
- Promoting Synergy between inter-disciplinary fields

# Promoting innovation



# Private Sector Collaboration

- A large number of private sector research groups involved in Biofuel R&D.
- Nearly 15 major private players play an important role
- Focus on Biobutanol and Biohydrogen

# Indo - U.S.

# Joint Clean Energy Research & Development Centre

# (Indo-U.S. JCERDC)

सत्यमेव जयते
Government of India

U.S. DEPARTMENT OF ENERGY

- Recognizing the need to create the clean energy economy of the 21st century. Prime Minister Singh and President Obama agreed to launch a Clean Energy and Climate Change Initiative.

- Memorandum of Understanding to enhance cooperation on Energy Security, Energy Efficiency, Clean Energy and Climate Change has signed on November 24, 2009 during Prime Minister Singh's visit to the United States.

# The Indo-US JCERDC

- 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 Nov 4, 2010 during President Obama's head of state visit to India.

- The goal for the Center is to spur truly collaborative R&D between U.S. and Indian researchers on potentially breakthrough clean energy technologies.

# JCERDC Priority Areas

- The initial priority areas covered under the Indo-US JCERDC are:
  - Solar Energy
  - Second Generation Biofuels
  - Energy Efficiency of Buildings
- The thrust is on cutting edge R&D for technology / process development leading to commercialization.
- All components of the research & development and translational chain upto commercialization are being considered.

- **The Indo-US JCERDC is the first its kind bilateral research programme between India & U.S.**

- **The process involved a joint call for proposal, joint review mechanism & joint final selection by the both government.**

- **This unique initiative involved 28 reviewers from across the country in three identified areas.**
- **Three selected consortia have involvement and participation of 48 leading institutes across the country.**
- **This programmes are led by 33 scientists.**
- **This is first public private partnership consortia model with its own management, governance and IP sharing structure.**
- **Success of this consortia model would help replicate it for other areas.**

# Capacity Building

- National Chairs for scientists of eminence
- National Energy Bioscience fellowships for Re-entry
- Niche area Overseas fellowship
- Ph.D and post doctoral fellowship at the Centers of Excellence
- Specialized short term training programmes in the identified areas
- Industrial trainings

# The Bioenergy Road Map – Strategy and Action Plan

- Launch a Strategic Research Programme towards achieving the Goal of 20% blending by 2020.
- Set up atleast 5 Joint Centres.
- Support Basic Research R&D programmes in different cutting edge science areas, which are critical to provide a detailed understanding of the process involved and modifications which are feasible. This would be networked to the energy centres.
- Work towards establishing a bio-based economy – value added bioindustrial products using biorefinery concept.

- Create a ‘Team India’ of at least 100 scientists in interdisciplinary research areas.
- Train atleast 100 Post Doctoral Overseas in specialized areas such as Synthetic Biology, Enzyme and Protein Engineering, Metabolic Engineering, Systems Biology etc.
- Attract atleast 25 overseas scientists to the centre through Energy Bioscience Fellowship and Institute atleast 5 chairs.

# In Conclusion

- Bio-energy shall be a major contributor to energy pool
- This area is in intense R&D phase and India needs to establish timely lead
- Partnered Centres and Public Private Partnership is the key to meet the challenge
- Time bound, coordinated efforts will be essential to exploit this potential optimally

# In Conclusion

- Priorities have been identified ……
  - Technologies are being researched upon ……...
    - Potential benefits have been assessed ……

# What we require

The Will to overcome the technical hurdles

The Strength to meet the challenges

and

The Determination to succeed