

# Next Generation Biofuel: TECHNOLOGY OPTIONS FOR INDIA

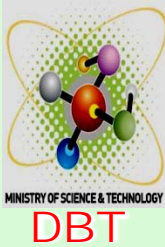
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Dr. Meenakshi Munshi, Joint Director, Department of Biotechnology, Government of India

# Indian Energy Scenario

- **India faces formidable challenges in terms of meeting its energy needs.**
- **An Expert Committee set up by the Planning Commission suggested that in order to maintain an annual GDP growth of 8% over the next 25 years to meet its goals for poverty elimination, the country needs to triple its primary energy supply and quadruple its electricity supply.**
- **The global meltdown has left its imprint on the Indian economy as well and there is already a slump in the growth rate.**
- **The country now imports 65% of its petroleum and with demands mounting this could increase to 90% by 2025.**

# 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**

# Challenge

- **Applying life sciences and biotechnology for :**
- **improving biomass production system**
  - **promoting the Bio-refinery concept aiming at the integral use of Biomass and**
  - **maximizing the cost effectiveness of final product**

## **Programme I Bioethanol**

- Re-engineered feed stock
- Re-engineered microorganisms
- Process optimization

## **Programme II Biodiesel**

- Quality planting material
- Improved feed stock
- Process optimization

## **DBT's Energy Bioscience Programme (DBT – EBP)**

## **Programme IV Energy Bioscience Centres & Capacity Building**

## **Programme III**

**Algal system for  
production of  
hydrocarbon**

# DBT – EBP Programme I

## Bioethanol

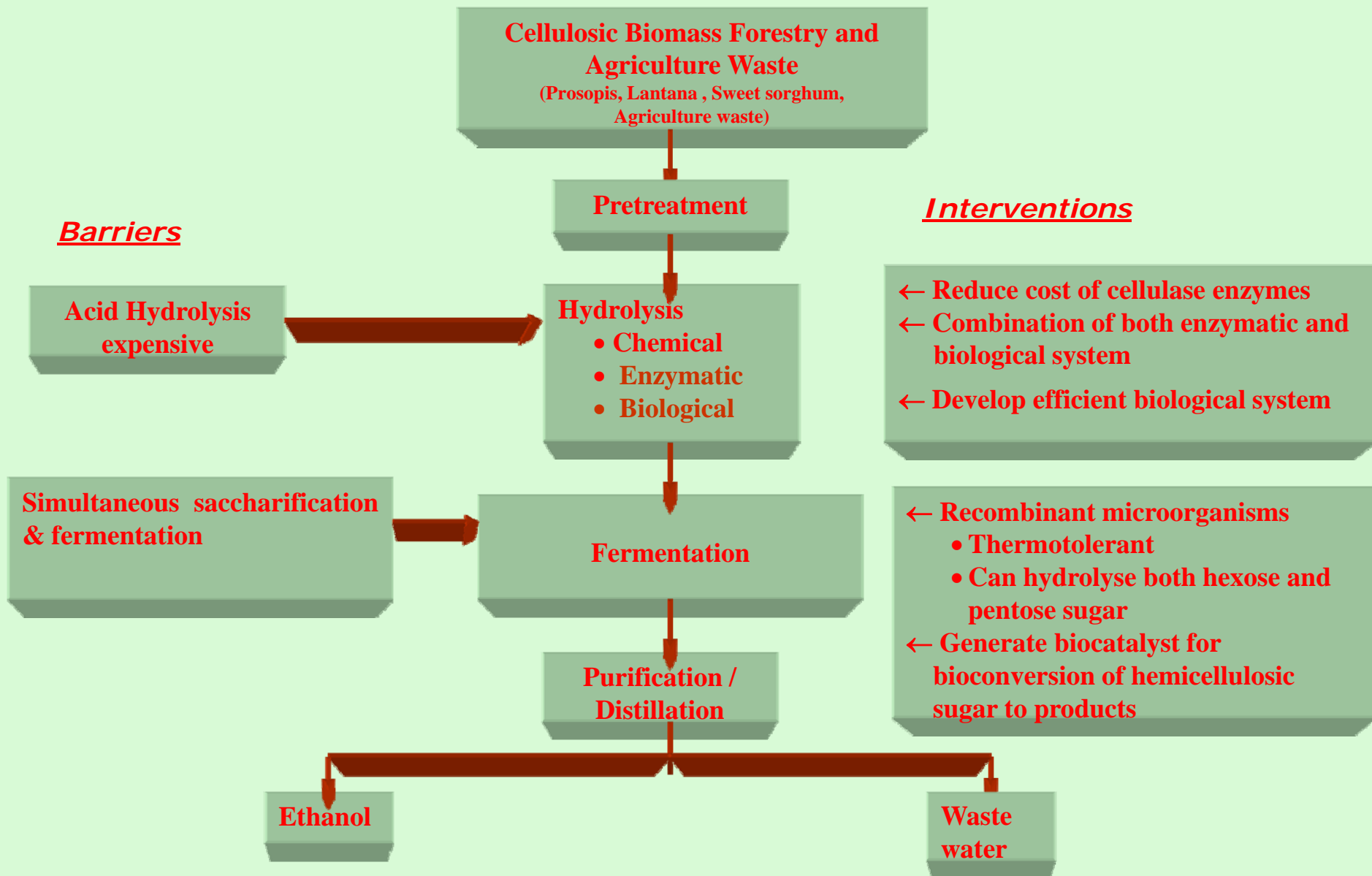
### *Concerns - Food vs Fuel*

- **Current feed stock – sugarcane, molasses**
- **Limited availability of feed stock for increased production targets**
- **Crop requirement of water and plant nutrient - Sugarcane is a water intensive crop**
- **Current process may not be competitive in global market**

# The solution ..... second generation Biofuels

- **Lignocellulosic Biomass as a feed stock – agriculture and forestry waste**
  - India has nearly 500 Mt of biomass waste available annually, only 170 Mt being used
- **Development of multi-product Biorefinery**
  - Production of value added products

# Ethanol from Cellulosic Biomass – Biotechnological Interventions



# Key tools for Bioethanol production from Lignocellulosic waste

- **Reengineer feedstock for enhanced ethanol recovery**
  - **Desired levels of lignin and cellulose to make them amenable to microbial fermentation**
  - **High in starch and sugar content**

## ➤ Reengineer Microorganisms for increased productivity

- **Microbes which ferment both hexose and pentose**
- **Expression of cellulases in fermenting microorganisms**

- **Improved Process productivity-  
*reduction in feedstock, enzyme and  
capital cost***
- **Improved cellulase production**
- **Plant architectural modification**

## Leads

- **Lab scale(10 L) process for conversion of Lignocellulosic biomass optimized; recovery rate being enhanced**
- **Two Thermo tolearnt yeast strains developed**
- **Recombinant yeast strain for converting starch to ethanol tested at pilot scale**
- **Recombinant Bacteria developed for enhanced cellulase production**

# DBT – EBP Programme II

## Biodiesel

- **Demand - 10.14 mt @20% blend by 2012**
- **Feed stock – *Jatropha***
- **Planting material requirement – 27 b plants over 11.2 mha by 2012**

(Planning commission Report 2006)

# *Jatropha* Plant

- *Jatropha curcas* is 3-4 m tall deciduous shrub.
- Found in tropical and subtropical climate.
- Plant is not browsed by cattle and goats.
- Normally grown as a live hedge.
- Found in almost all states of India.

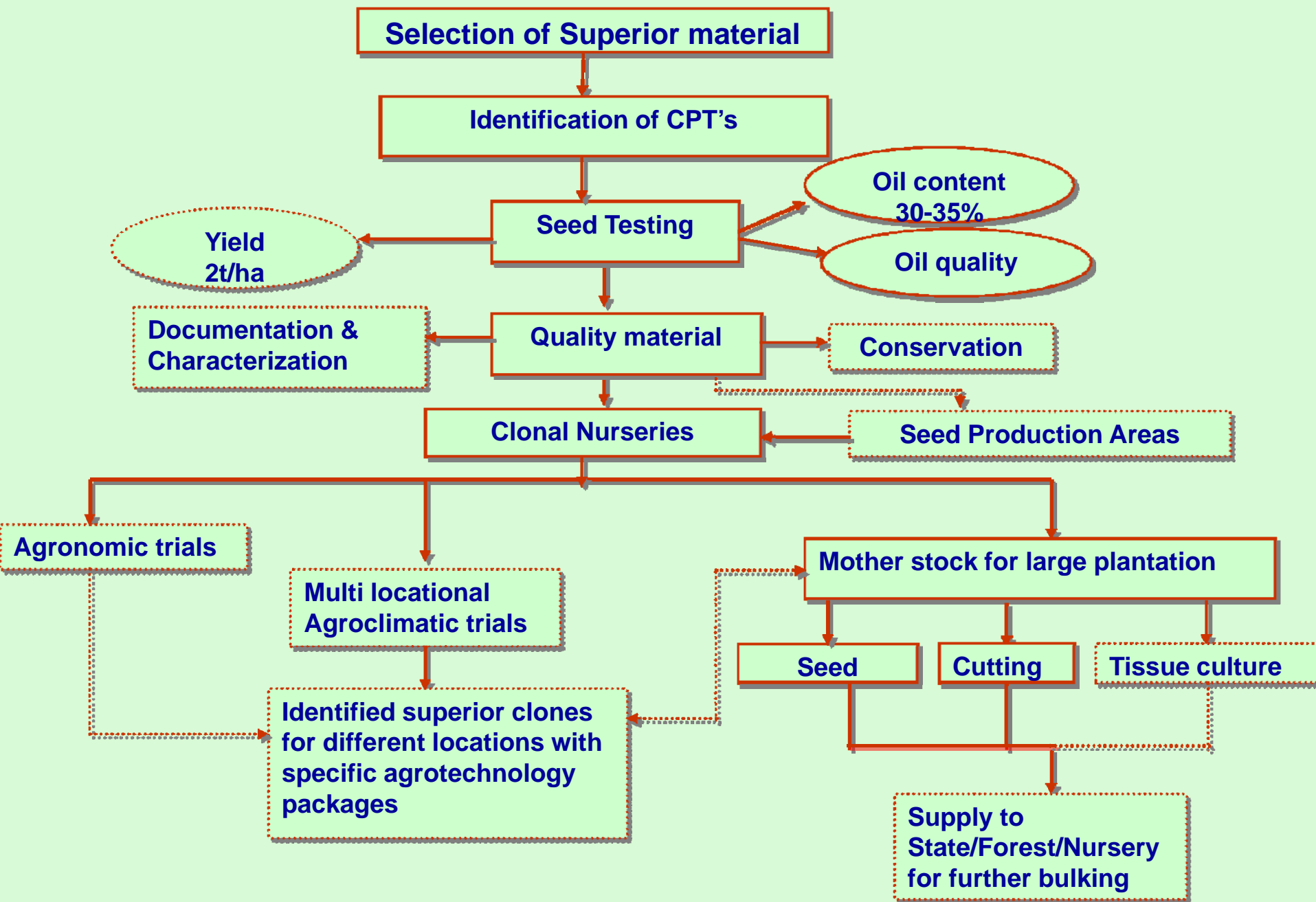


**Nursery establishment of quality material of *Jatropha* at  
Biotech Park, Lucknow**



**Field demonstration of *Jatropha curcas***

# Production of Jatropha Quality Material – Current Strategy



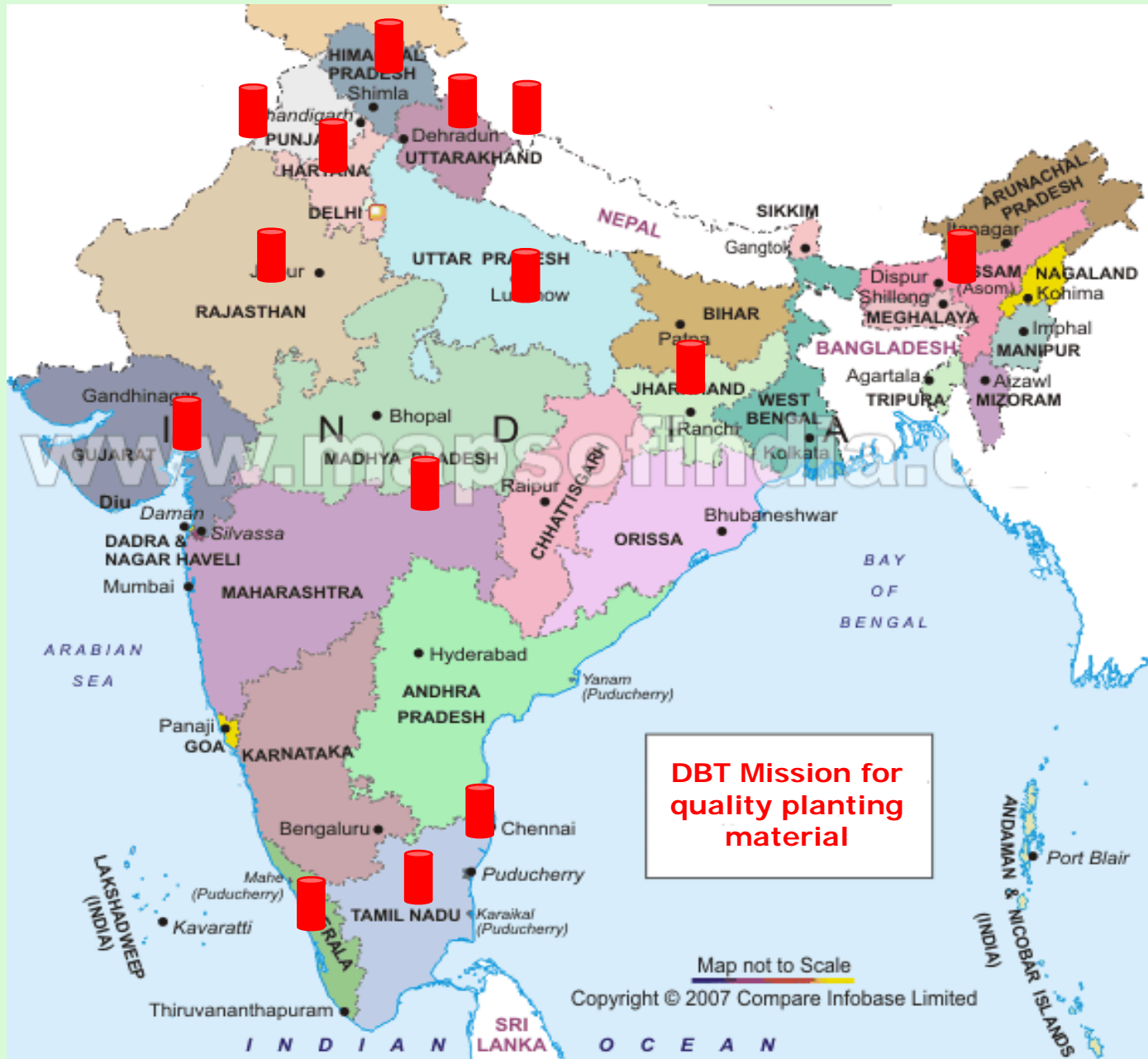
# Jatropha – Quality material

- **First systematic survey and collection of Jatropha germplasm from 12 States**
- **1500 accessions collected and characterized for oil content and quality**
- **Molecular characterisation through DNA fingerprinting for cataloguing of superior material**
- **Superior accessions being conserved at NBPGR**
- **500 ha field planted with superior material**



- **Multi-locational agronomic trials initiated at 10 locations (Himachal Pradesh, Uttaranchal, Hissar, TamilNadu, Rajasthan, Orissa, Northeast, Maharashtra, Gujarat, Uttar Pradesh) representing different agroclimatic zones**
- **20 superior accessions being tested and have been expanded to 100 accessions**
  - **Clonal trials**
  - **Clonal orchards**
  - **Half sib seed orchards**
- **Tissue culture raised plants being tested for genetic fidelity (LabLand, Mysore)**
- **A National germplasm database being developed for authenticated, superior material (NBPGR, New Delhi)**
- **15 lakhs plants being produced for demonstration**

# Multilocation trials of *Jatropha* across the country



## Locations

Shimla  
Dehradun  
Garhwal  
Hissar  
Patiala  
Lucknow  
Jaipur  
Anand  
Raipur  
Akola  
Chennai  
Madurai  
Thrissur  
Guwahati

# R&D for *Jatropha* and Biodiesel Improvement

## Genetic improvement for quality planting material

- Yield
- Oil content
- Biotic and abiotic stress

### Approaches

- Natural selection
- Breeding
- Transgenic

## Marker assisted selection for

- Oil
- Yield

## Value added products

- Glycerol
- Oil Cake

## Improved oil quality and transesterification process

- Biological catalyst
- Heterogeneous Catalyst
- Continuous process
- Mixed feed stocks

# Feed stock improvement

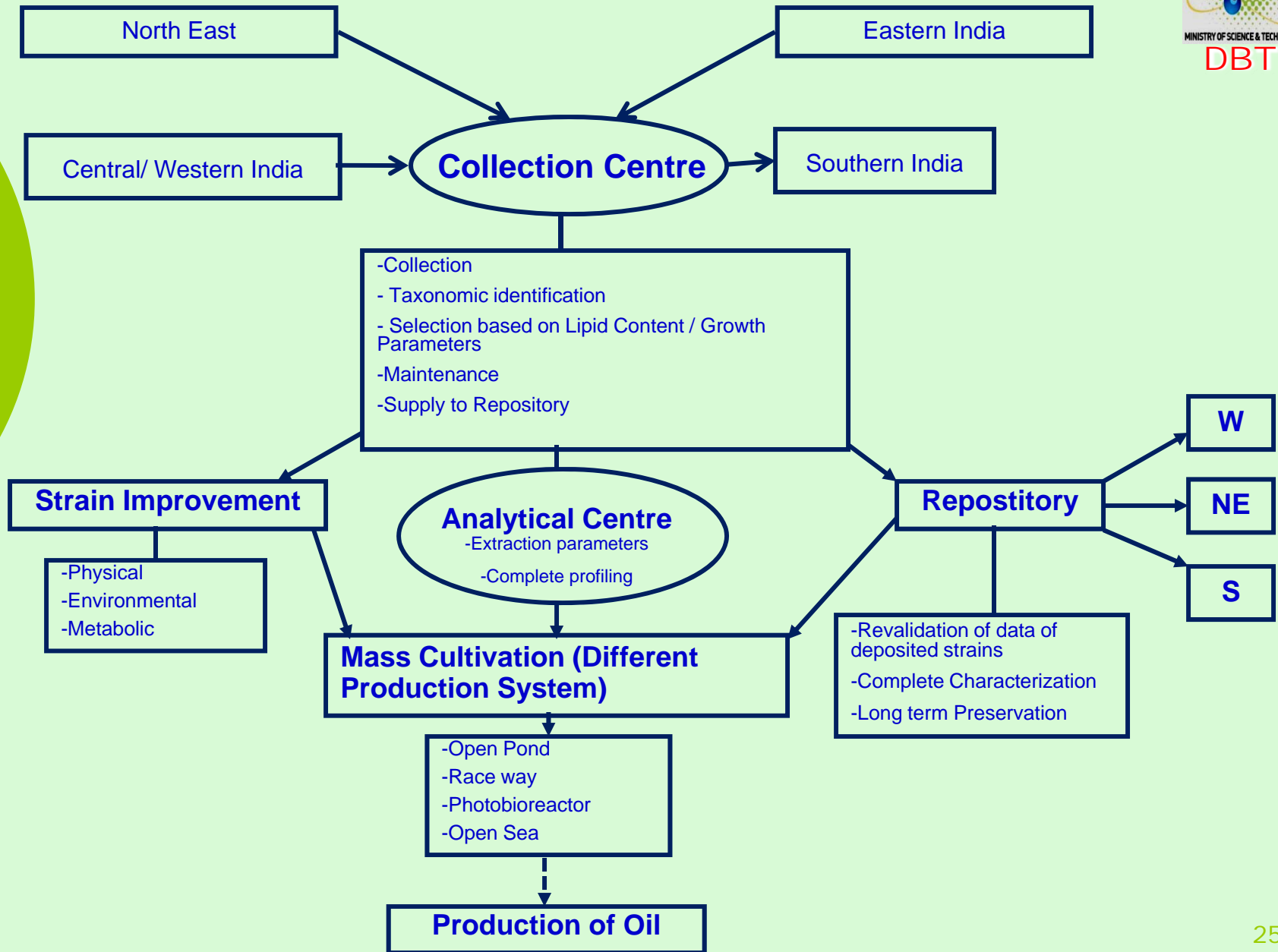
- R&D supported for plant improvement – oil quality, content, yield, biotic and abiotic stress
- Gene prospecting for increased oil synthesis
- Metabolic engineering of oil biosynthesis pathway
- Molecular markers for marker aided selection
- Pongamia, Mahua and Castor also being tested as potential feedstock

# Algae : Potential source for Biofuel

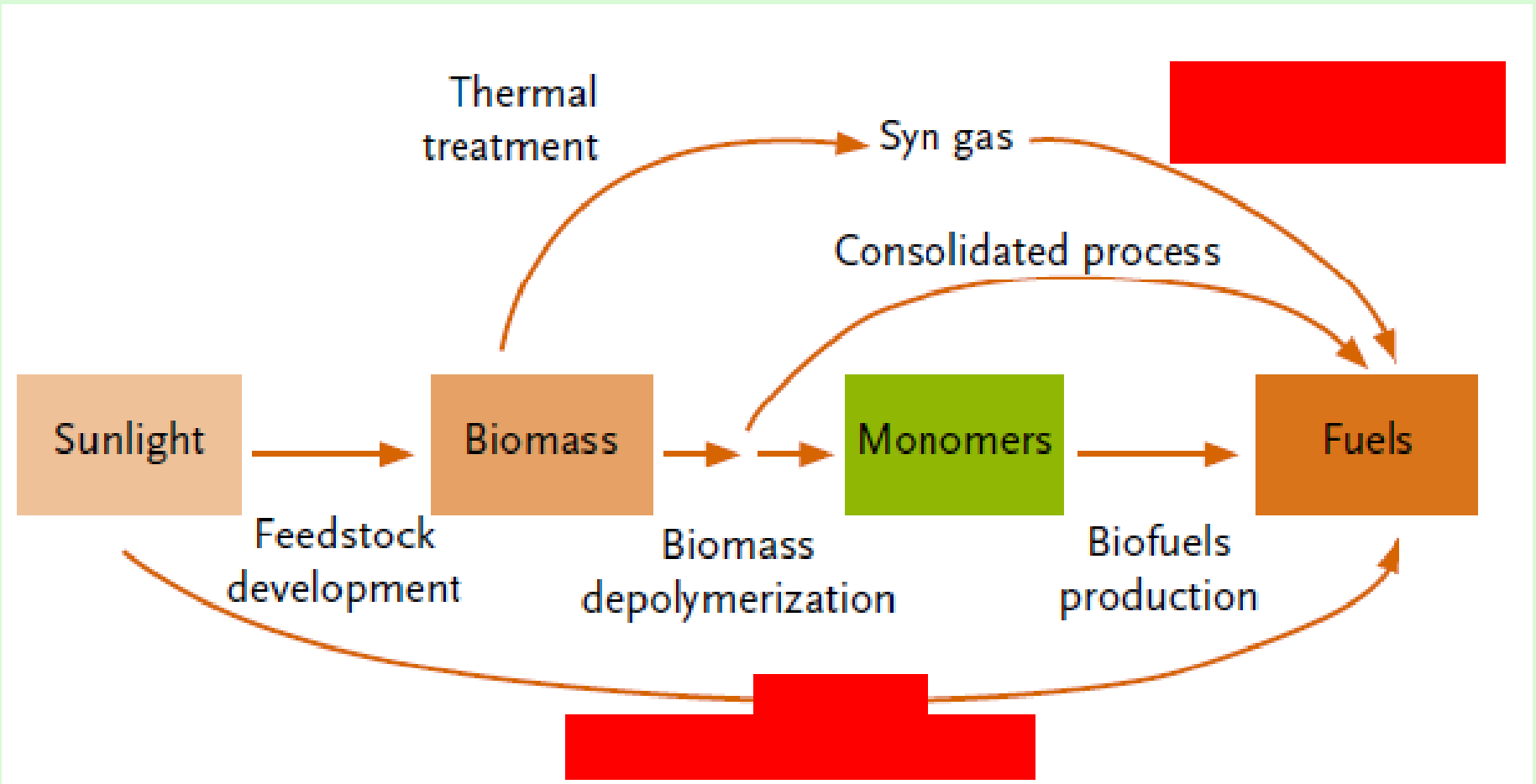
## ➤ Biofuels from micro-algae

- Aerial productivity 2 to 5 fold higher as compared to traditional agricultural crops and fast growing 'energy crops'.
- Lower quality water can be used for growing algae
- Algal systems can remove CO<sub>2</sub> (and NOX) from flue gases from power plants that can be directed through the algal bioreactor.
- Micro-algae produce many different kinds of lipids, hydrocarbons and other complex oils.

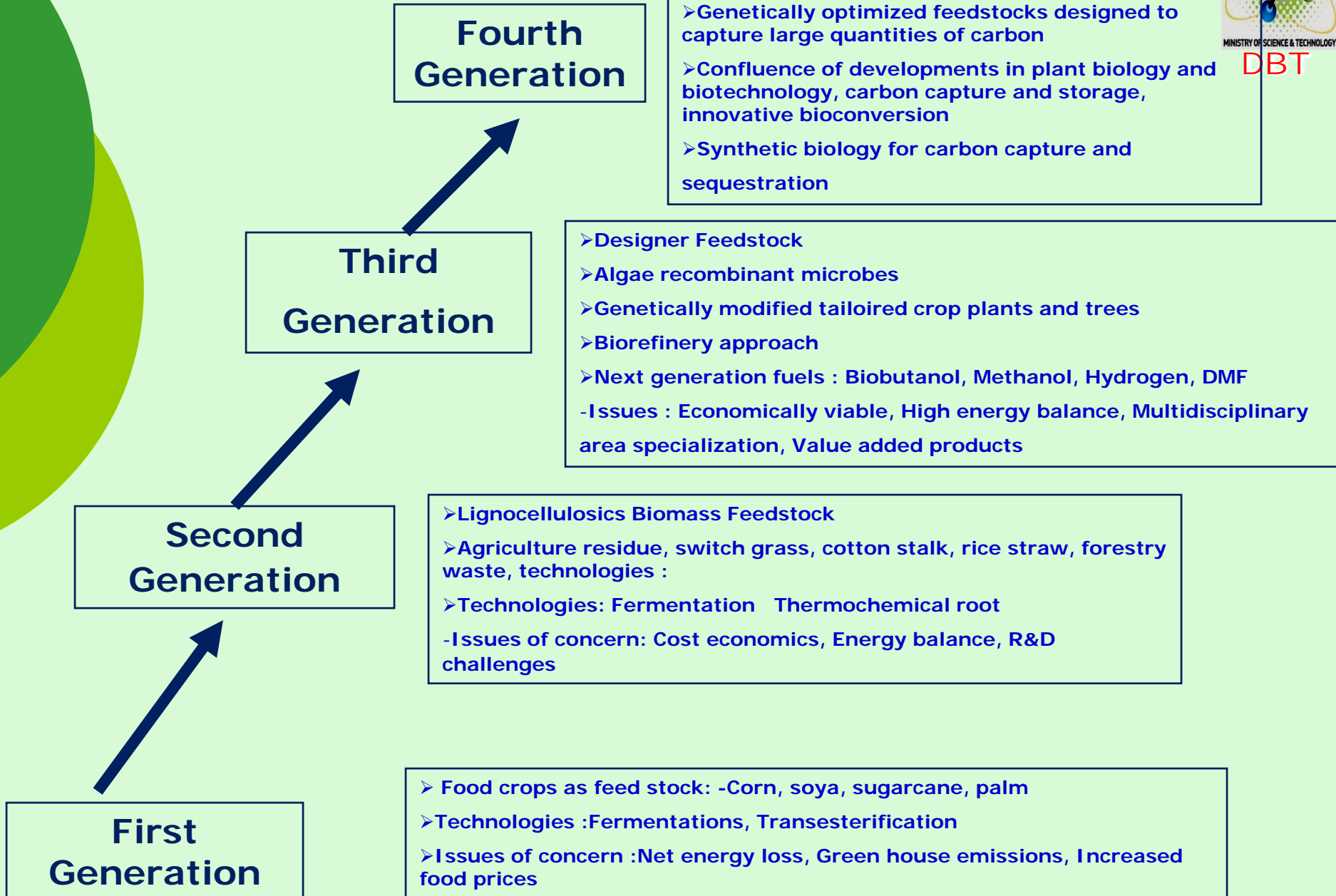
# ALGAL BIOFUEL NETWORK



# Potential Pathways for biofuel production



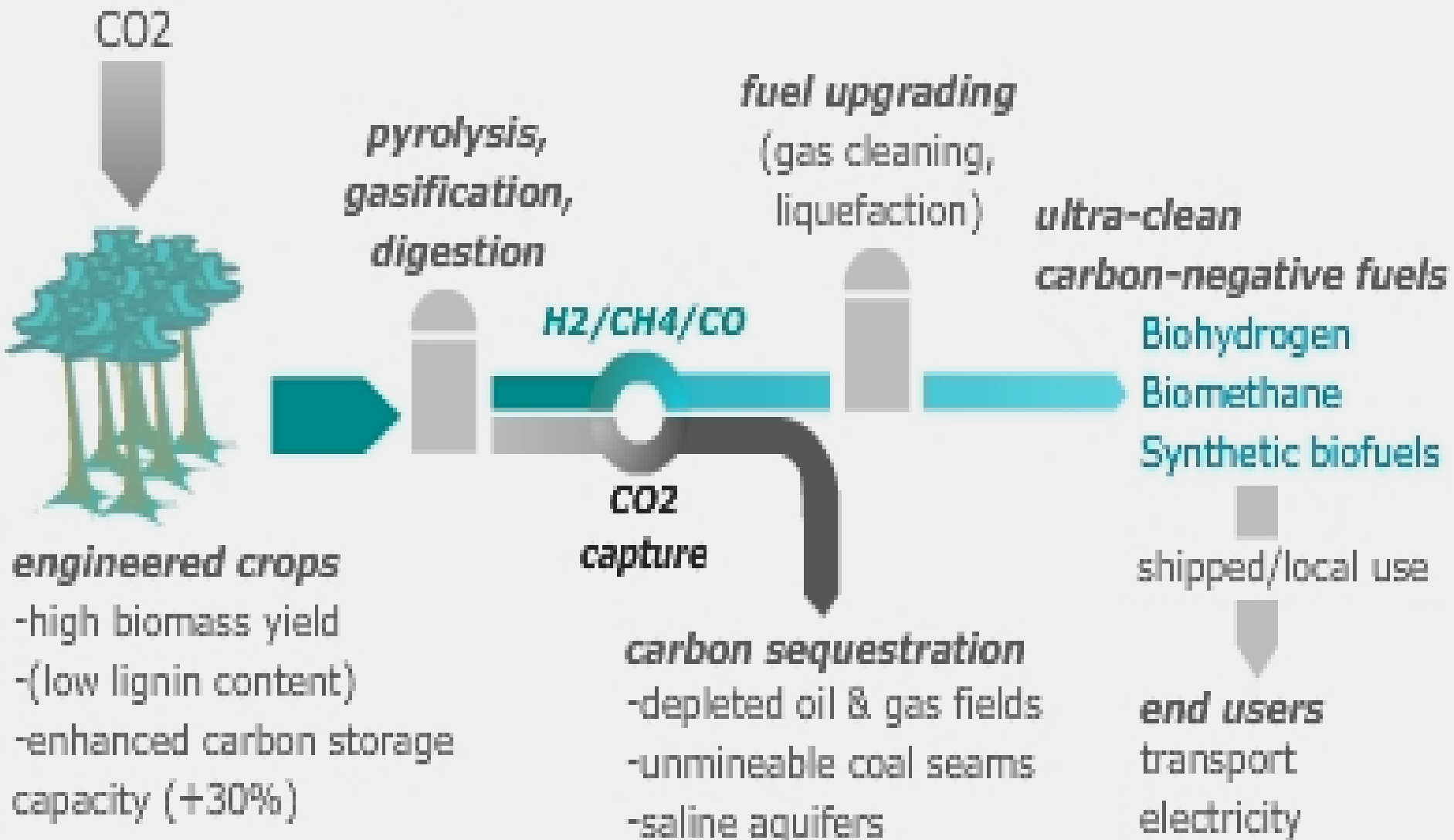
# The Biofuel Generation



## Other Fuels

- **Biobutanol**
- **Dimethyl Furfuryl**
- **Biohydrogen Diesel**
- **Biomethanol**
- **Biojet fuel**
- **Biohydrogen**

# 'Fourth generation' biofuels



# DBT – EBP Programme IV

## Energy Bioscience Center(s)

### Models

- **Public-Private Partnership**
- **Public-Public Partnership**
- **International Collaboration for Capacity Building**
  - **Ph.D.**
  - **Post-Doctorate**

# DBT-ICT Centre of Energy Biosciences

- India's first National Bioenergy Research Centre
- Being set up at an initial cost of Rs. 24.8 crore
- Multidisciplinary Centre with emphasis on cutting-edge technology development and transfer to Indian industry
- Networked with Institutions & Industry in India and abroad
- 40 PhD scholars; several Senior Research Scientists and 10 faculty in different disciplines of modern biological sciences and bioengineering



DBT-ICT  
Centre for Energy Biosciences

DBT-ICT-Centre for Energy Biosciences

The Facility at the Centre equipped for work in the following areas

- **Molecular Engineering at the interface of Biology, Chemistry and Engineering**
- **Synthetic Biology**
- **Recombinant DNA technology**
- **Microbial Proteomics**
- **Metabolomics and Metabolic Engineering**
- **Fermentation Technology**
- **Enzyme Technology**
- **Downstream processing and Separation Technologies**
- **Bioinformatics and Molecular modeling**

# Capacity Building

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

# Acknowledgement

- **This work has been possible due to hard work of dedicated scientists working at Universities, Research Institutions across the country.**
- **Nearly 50 - 60 scientists are involved in this work.**

