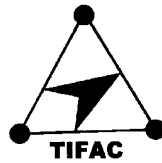


New Generation Biofuels- Technology & Economic Perspectives



Nirmala Kaushik & Soumitra Biswas

**Technology Information, Forecasting & Assessment
Council (TIFAC)**

Department of Science & Technology (DST)

biotifac@gmail.com

tifac.org.in

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Presentation Structure

- **Biomass Resources in India**
- **Biomass Conversion Routes**
- **New Generation Biofuels**
- **Biofuel Economics**
- **TIFAC Initiatives**
- **Future Perspectives**

BIOMASS RESOURCES



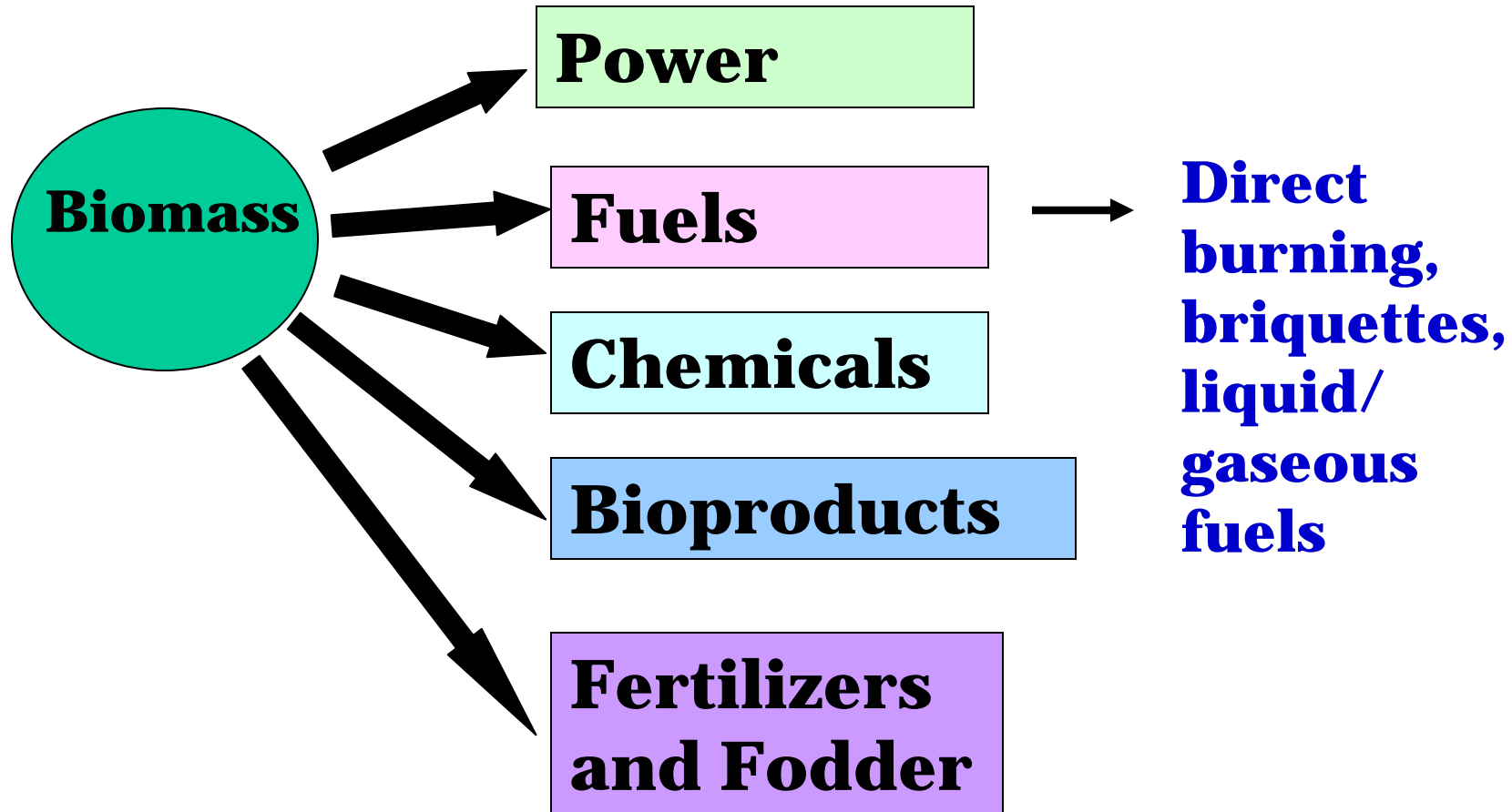
Why biomass ?

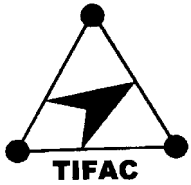
- **Fast renewable resource for primary energy (solid, liquid & gaseous fuel)**
- **Rural economy augmentation & employment generation**
- **Energy Security**
- **Mitigation of GHG emissions**
- **Technology innovation & business opportunities**



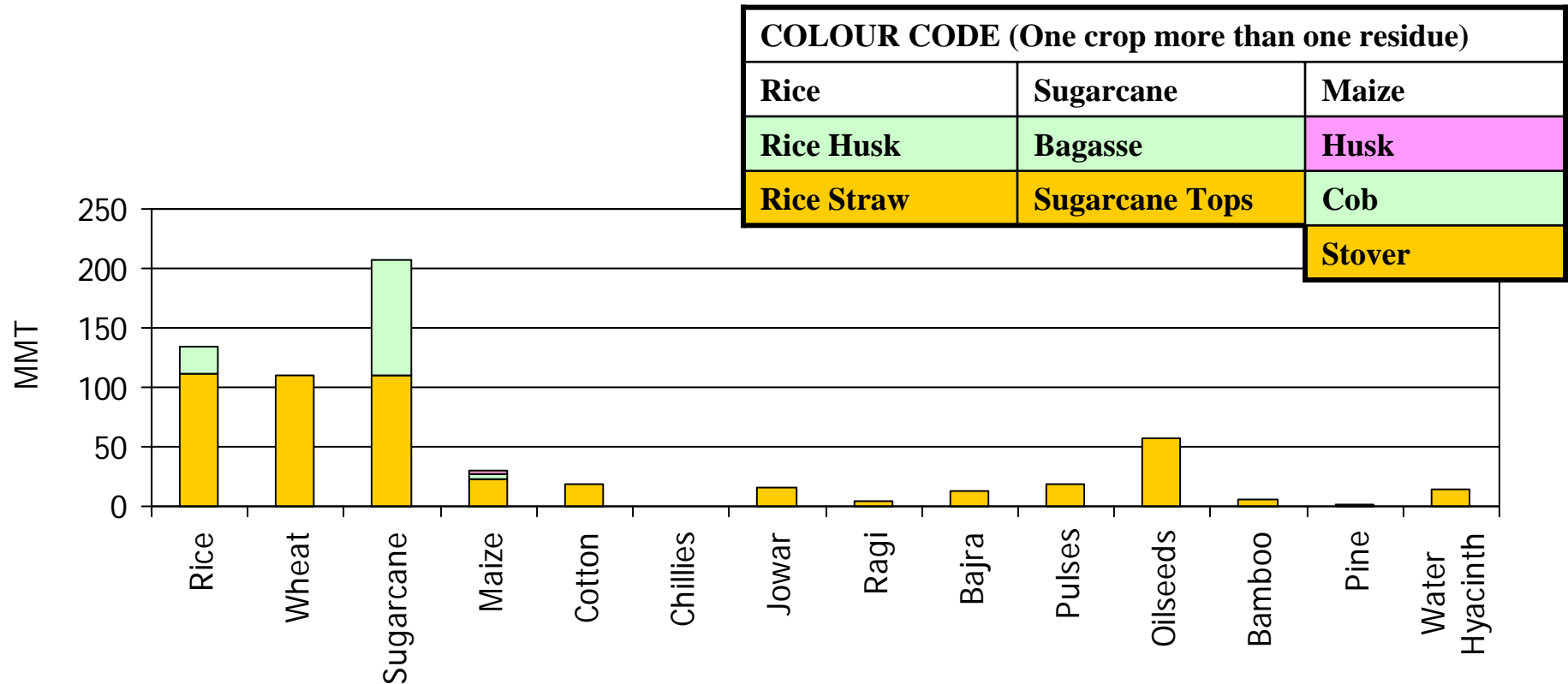


Utilization of Bio-resources





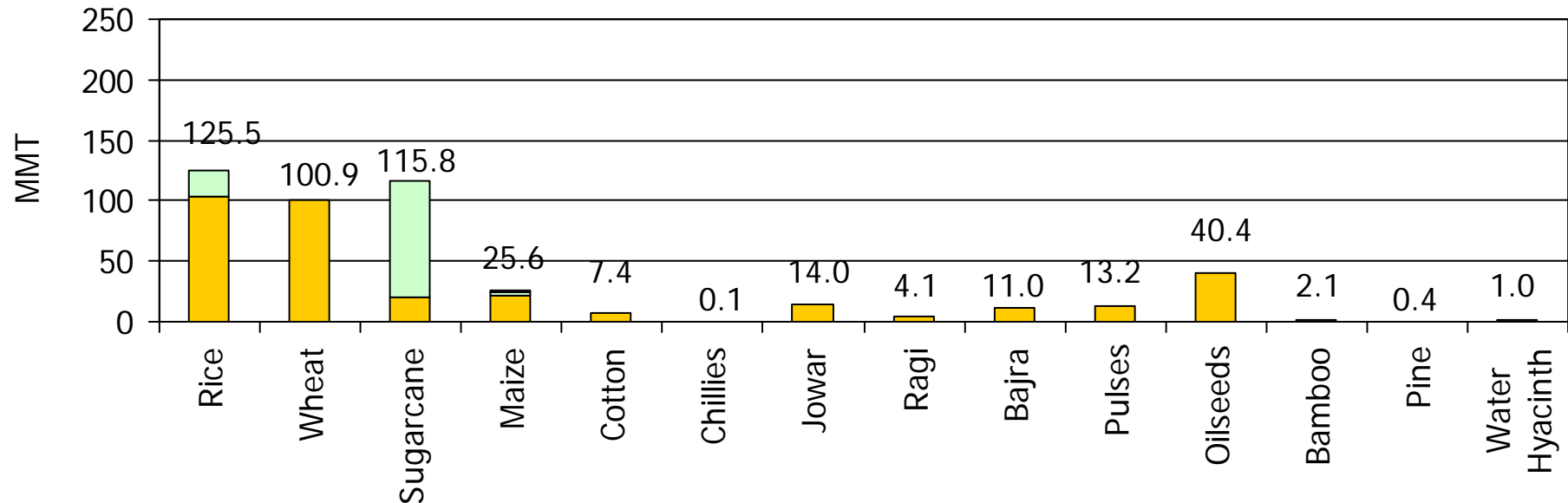
Crop Residue Generation



Rice straw, rice husk, wheat straw, sugarcane tops & bagasse main crop residues generated in India



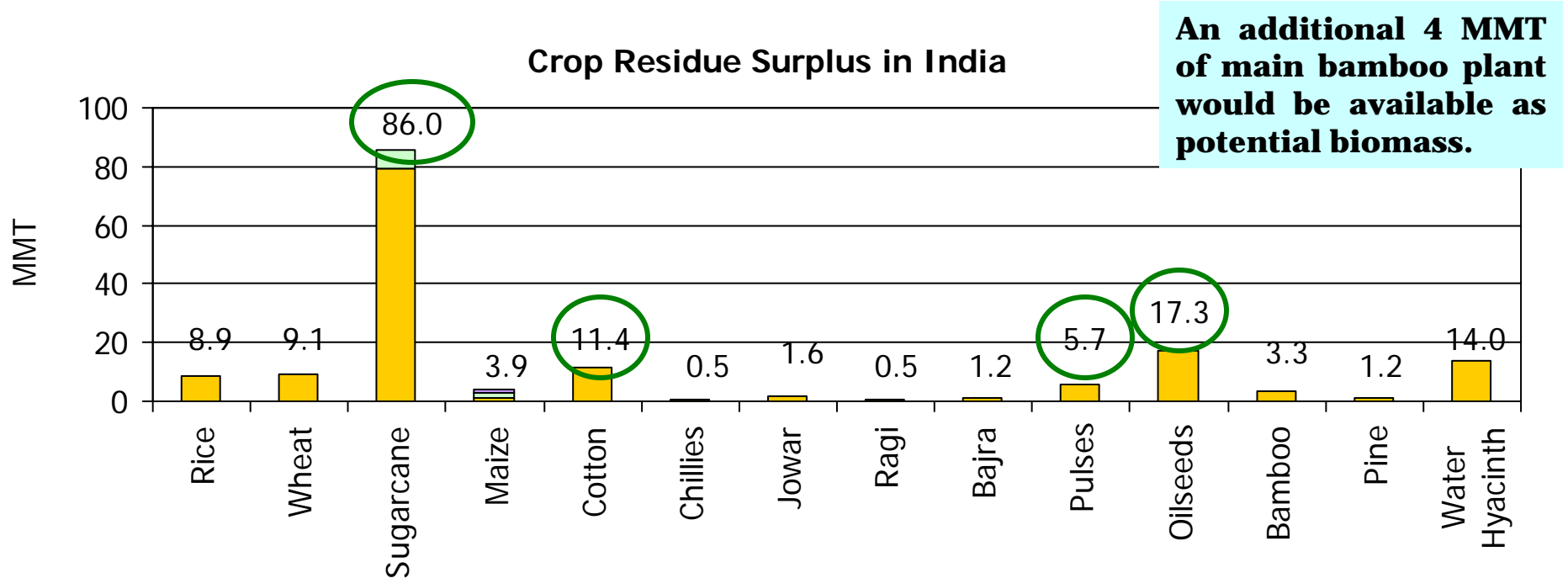
Crop Residue Consumption



- **Rice, Wheat, Maize, Jowar, Ragi & Bajra residues : cattle fodder**
- **Cotton, Chilli, Pulses, Oilseeds residues : fuel for household needs**
- **Rice husk in boilers as fuel & bagasse for power/paper production**



Crop Residue Surplus



- **Sugarcane tops** most surplus residue burnt in the fields
- **Other fuel crops like Cotton, Chilli, Pulses & Oilseeds do not have much other use apart from fuel**
- **Low surplus from fodder crops, used mostly as cattle feed**



Crop Residue Surplus Density

State	State Area	Biomass Generation Density (MT/km ²)	Biomass Consumption Density (MT/km ²)	Biomass Surplus Density (MT/km ²)
Uttar Pradesh	238,566	578.6	417.7	160.9
Haryana	44,212	669.7	554.5	115.1
Tamil Nadu	130,058	309.9	207.2	102.7
Punjab	50,362	823.7	731.0	92.7
Maharashtra	307,713	265.6	173.0	92.6
West Bengal	88,752	299.8	259.0	71.4
Karnataka	191,796	203.8	143.8	60.1
Gujarat	196,024	157.7	102.2	55.5
Andhra Pradesh	275,068	160.7	118.2	42.5
Bihar	94,164	221.6	185.4	36.1
Others	1,668,264	-	-	-
Total	3,284,979	189.8	140.4	50.1

BIOMASS CONVERSION ROUTES



Biomass Conversion



**Biomass
Feedstock**

- Trees & Grasses
- Agricultural Residues
- Forest Residues
- Animal Wastes
- MSW

**Conversion
Processes**

- Bio-chemical Platform
(Pretreatment, Hydrolysis,
Enzymatic Fermentation)
- Thermo-chemical Platform
(Combustion, Gasification,
Pyrolysis)

PRODUCTS

ENERGY

- Ethanol
- Biodiesel
- Hydrogen
- Electricity
- Heat (co-gen)

CHEMICALS

- Plastics
- Solvents
- Building block
Chemicals
- Phenolics
- Adhesives
- Furfural
- Fatty acids
- Acetic Acid
- Carbon black
- Paints
- Dyes & Pigments
- Detergents

FOOD & FEED



Biomass Conversion Products

Solid fuel

Direct incineration

**Firewood, RDF /
Pellets / Briquettes**

Gaseous Fuel

**Gasification
(Producer gas
& Syn-gas)**

**Bio-methanation /
Anaerobic digestion
(Biogas)**

Liquid fuel

**Ethanol, SVO,
Bio-diesel,
Pyrolysis oil,
Synthetic Gasoline**



Typical Biomass Composition

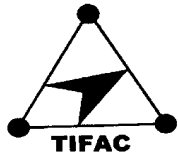
Lignocellulosic Biomass

Cellulose (35-50%) - Polymer of glucose hydrolyzed to individual glucose molecule that **can be fermented** into ethanol

Hemicellulose (20-30%) - Polymer of sugars (5 carbons xylose) that **cannot be fermented** into ethanol by conventional method

Lignin (15-25%) - Phenyl-propene polymer used as binder in cement industry and as boiler fuel in pulp & paper industry

Others (5-35%) - generally ash, extracts, fats, resins, phenolics, minerals, salt etc.



Ligno-cellulosic Ethanol - Challenges

Pretreatment

Pretreatment methods for different biomass

Cost to affect hydrolysis process cost

Small particle sizes

Pretreatment methods that support enzymatic hydrolysis

Hydrolysis

Cost effective cellulase production

Inorganic side stream

Corrosiveness – high capital cost

Focus on cost reduction

Fermentation

Fermentation to use entire pentose fraction

Genetically modified organism for fermentation of entire C5 fraction



Thermo-chemical Conversion

Gasification

Gasification of biomass ($\sim 700-1000^{\circ}\text{C}$); producer gas burnt directly for **heat/electricity generation by **steam turbine/internal combustion engine** after gas clean up**

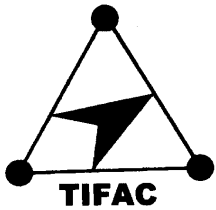
Pyrolysis /Fast Pyrolysis

Thermal depolymerisation of biomass at ($\sim 450-500^{\circ}\text{C}$) in absence of added oxygen. Products include **gases, bio-oil & char**

Fischer Tropsch Synthesis

Syngas ($\text{CO}+\text{H}_2$) generated at high temp ($1200-1600^{\circ}\text{C}$) converted at synthetic biofuels; multistage process with high capital cost thus increasing cost of products

New Generation Biofuels



Biodiesel

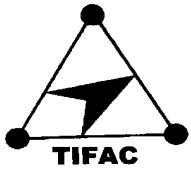
First Generation

- Batch or Continuous Trans-esterification with alcohol
- Solid or mixable catalyst
- Traditional fats – Oils, Animal, used oils

Important factors : Energy, Effluent, Specs, Food vs. Fuel, uncertain policy initiatives

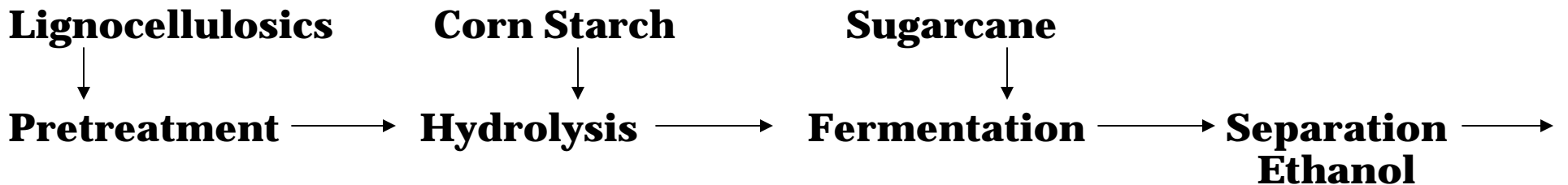
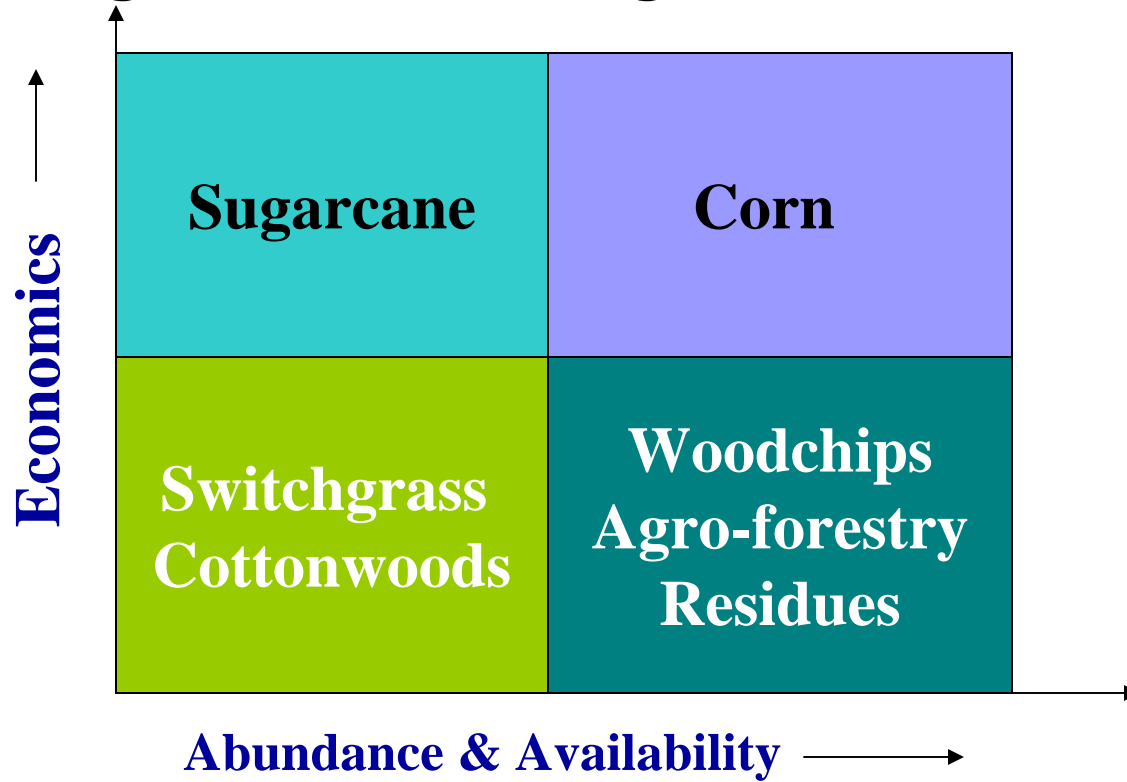
Second Generation

- Cracking – feed stock agnostic
- Reusable catalyst
- Zero effluent
- 2nd Gen fats such as Algae, water weeds etc. with Solar panels
- GM variants for traditional oil crops for energy specific needs



Bioethanol

1st Generation (Corn / Sugarcane) → **2nd Generation** (Lignocellulosics) → **3rd Generation** (Biorefineries)





Biofuels

Biohydrogen

Produced from renewable sources; fermentation of biomass by microorganisms in presence/absence of light

Also, produced by algae under anaerobic conditions.

Green Diesel

Synthesized from biomass by controlled catalytic depolymerisation ($>300^{\circ}\text{C}$); 90% of biomass converted to diesel & 10% to lighter gases ($\text{CO} + \text{H}_2$) used for DG set



Biofuels

Biobutanol

Produced from sugar, starch or cellulosic feedstocks by microbial fermentation.

High calorific value, less hydrophilic than ethanol, less corrosive, transported via pipeline for existing petroleum fuels infrastructure.

Directly used as fuel component or further processed into gasoline, diesel, jet fuel or chemicals.

Reliance Life Sciences, developed solvent tolerant strain, 20 gms. producing one litre of butanol using renewable feedstock in a single batch process

Cobalt Biofuel, US plans to build 10,000-35,000 gal/yr pilot plant by 2010.



Biofuels

Algal Biofuels

Fastest growing biomass in the world, grown year round.

Converts CO₂ in presence of solar energy & water into chemical energy via photosynthesis

Captures CO₂ emitted in power plants, cement & other chemical plants to convert into oil, thus generates carbon credits

Algae species contain ~25-30% of oil

500 Ha of algae growing area reduce 5% of CO₂ emissions

Residue de-oiled cake, a high protein matter, used as cattle feed, organic fertilizer & nutritional supplements

IOC plans to build 200,000 MTPA of biodiesel & to produce a protein byproduct for animal feed

BIOFUEL ECONOMICS



Biodiesel Economics

Basis: 100 kg Jatropha seeds

Seed price: Rs.7.50/kg

Yield: 30 kg oil/100 kg seeds

30 kg oil gives 30 kg/ 33 lit biodiesel

3 kg glycerine produced from 30 kg biodiesel

100 kg seeds	Rs.750/-
Extraction cost	Rs.150/-
Trans-esterification	Rs.240/-
Total	Rs.1140/-

Price of 33 lit biodiesel (@Rs.35/lit)	Rs.1155/-
Glycerine price	Rs.60/-
Oil seed cake price	Rs.140/-
Total	Rs.1355/
Margin	Rs.215/-



Ethanol Economics

Capital cost for 150 million litres/pa of gasoline

- **USD111 million** for **Grain ethanol** plant
- **USD854 million** for **Fischer-Tropsch synthesis** plant

Cost of Ethanol

- **Grain ethanol : USD1.90/gal** (corn – USD4.20/bushel)
- **LC ethanol : USD3.36/gal** (biomass- USD50/ton)
- Technology improvement, wide-scale deployment expected to bring down cost of 2nd gen biofuels
- Cost reduction potential higher in case of LC ethanol
- LC Ethanol expected to hit **USD1.85/gal** by 2030

TIFAC INITIATIVES



Projects Launched

Centre for Biofuels **(NIIST, Trivandrum)**

- **Cutting edge research in bio-refinery technologies**
- **Optimization of process parameters for lignocellulosics-ethanol in pilot plant for Indian biomass varieties**
- **To evolve leading centre of knowledge & pedagogy**

Detoxification of jatropha seed cake & recovery of residual hydrocarbons by enzymatic process

(Osmania University & Naturol Bioenergy Ltd., Hyderabad)

- **Removal of toxic contents (phorbol esters) by dioxygenase**
- **Cracking of higher hydrocarbons for improved recovery of oil by alkane hydroxylases**
- **Use of seed cake as fodder**



Technology Assessment Studies

A Survey of availability of Indian biomass resources for exploitation

Study carried jointly by TIFAC & NIIST for an assessment of biomass resources, their state-wise production & existing utilization to ascertain the availability of surplus resources for their conversion to energy, fuel and value-added products

Biomass Derived Bioproducts– Assessment of Technology Trends, Gaps & Opportunities for India

Commissioned by TIFAC for comprehensive understanding of current technology status in advanced countries vis-à-vis India, identification of gaps and actions required thereon. The report to emerge as *Technology Dossier* for industries planning to diversify to biotech.

Study on ‘Life cycle assessment of biofuels in Indian context’

Specialized exercise on life cycle assessment of **biodiesel & **bioethanol** for addressing **carbon & energy neutrality aspects****

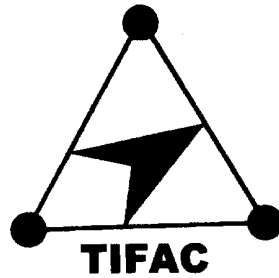
FUTURE PERSPECTIVES



Future Perspectives

- **Pretreatment & Enzymatic Hydrolysis of ligno-cellulosic biomass**
- **Conversion of Hemicellulose (C₅ sugars) into fermentable sugar for better economics**
- **Cost reduction in Cellulase & Hemicellulase enzymes**
- **Syn-gas (CO+H₂) fermentation to synthetic fuels**
- **Selective fermentation of syn-gas into value-added biopolymers (e.g. polyhydroxyalkonates)**
- **Biomass pyrolysis → bio-oil → value-added chemicals**
- **Heterogeneous catalyst for bio-diesel production**
- **Value-added chemicals from by-products**
- **Biorefinery : A spectrum of bioproducts (food, feed, materials, chemicals) and bioenergy (fuels, power/heat)**

Thank You



biotifac@gmail.com

tifac.org.in