Current biotechnological interventions for residue utilization from Indian perspective

Ashok Pandey
Centre for Biofuels
National Institute for Interdisciplinary Science and Technology, CSIR
Trivandrum, India

Indo-EU Second Stakeholder Meeting- *Biotechnological interventions in Biomass and Bio-waste availability for sustainable bio-economy*
TERI, India Habitat Centre, New Delhi
November 7, 2012

Alternate energy sources – Indian Scenario

Power Generation Technologies

Wind Power
Small Hydro
Biomass Power
Biomass Cogeneration
Biomass Gasifiers
Energy from Wastes

Solar Energy Technologies

Solar Photo-voltaics
Solar Thermal
Stand-alone Wind Energy and Hybrid Systems
Rural Energy Technologies - Biogas

New Technologies

Chemical Sources of Energy
Hydrogen Energy
Geothermal Energy
Alternative Fuels for Transportation - Biofuels
Tidal Energy

Alternate energy sources – Indian Scenario

Power Generation Technologies

Wind Power
Small Hydro
Biomass Power
Biomass Cogeneration
Biomass Gasifiers
Energy from Wastes

Solar Energy Technologies

Solar Photovoltaics
Solar Thermal
Stand-alone Wind Energy and Hybrid Systems
Rural Energy Technologies
Biogas
Improved Cookstoves

New Technologies

Chemical Sources of Energy
Hydrogen Energy
Geothermal Energy
Alternative Fuels for Transportation - Biofuels
Tidal Energy

Bioenergy- Biofuels

-1st Generation of biofuels: ethanol from sugar, corn, molasses, starchy biomass, etc

- 2nd Generation of biofuels: biodiesel from vegetable oils and bioethanol from lignocellulosic biomass

- 3rd Generation of biofuels: algal biofuels

- 4th Generation of biofuels: biohydrogen

Bioenergy- Biofuels

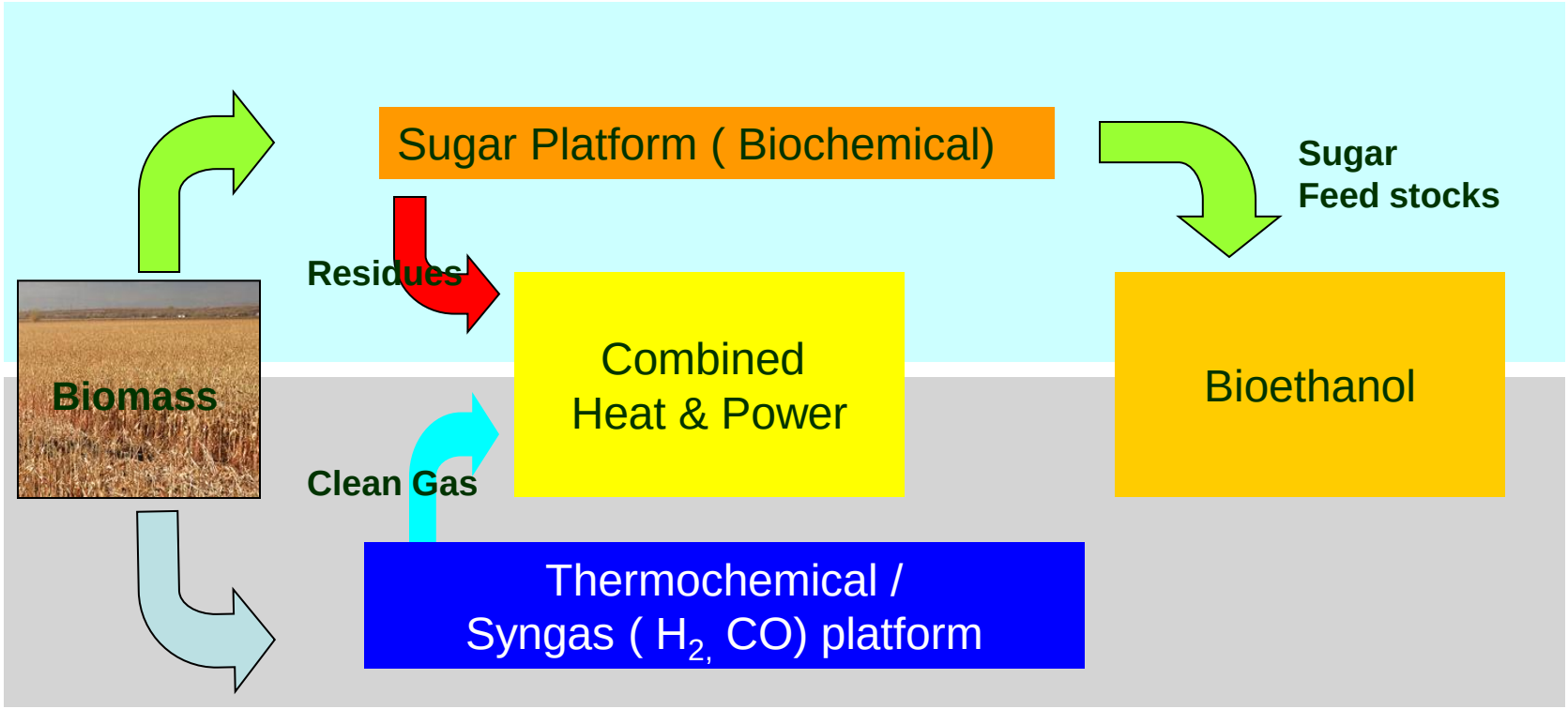
-*1st Generation of biofuels: ethanol from sugar, corn, molasses, starchy biomass, etc*

- *2nd Generation of biofuels: bioethanol*

- *3rd Generation of biofuels: algal biofuels*

- *4th Generation of biofuels: biohydrogen*

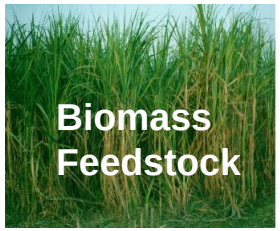
The concept and approach



The conceptual biorefinery is built on two platforms

1. **Sugar Platform which uses biochemical conversion of biomass to fermentable sugars, followed by subsequent fermentation to yield useful products.**
2. **Thermo-chemical platform where biomass is gasified using thermo-chemical reactions to generate fuels and the byproducts are utilized.**

Biorefineries for lignocellulosic bioethanol



Lignin to energy

pretreatment

Processed Biomass

Sugars to products

Fermentable sugars

Ethanol

Cellulases, Hemicellulases

Alcohol fermenting microbes

Infrastructure
Collection,
Storage,
Composition variability,
Sustainability

Process Chemistry
Role of biomass structure and composition,
High solids processing

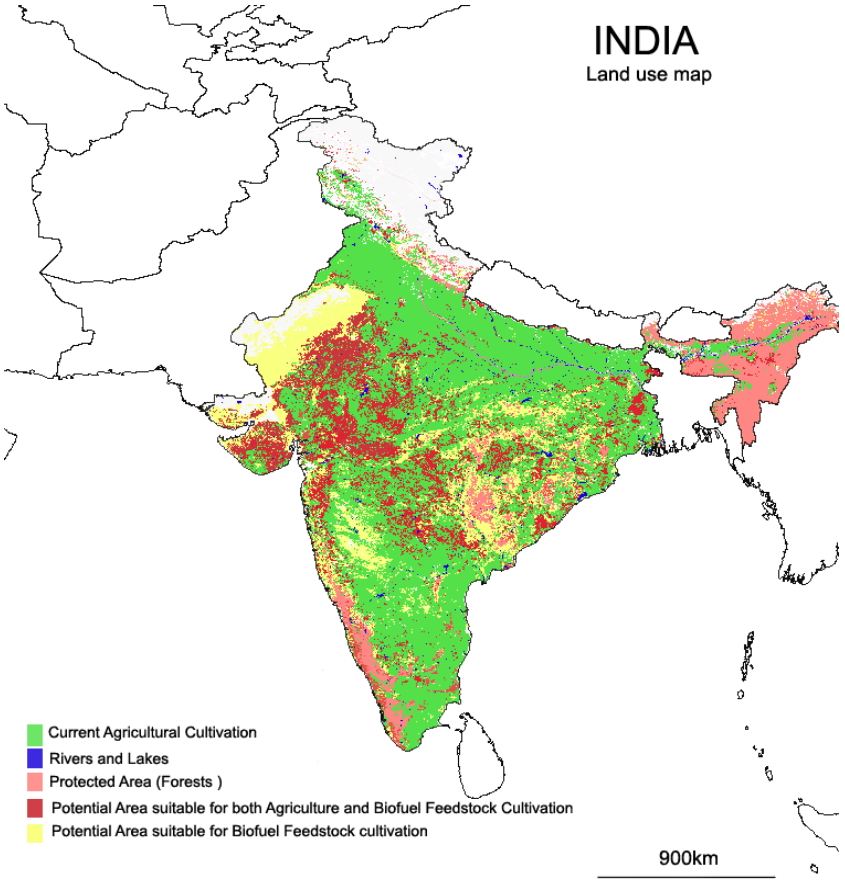
Improve specific activity,
Reduce cost of production,
Role of biomass composition on reactivity,
Fundamental enzyme biochemistry

C5 fermentation
Improved alcohol production,
Lesser product inhibition

Ethanol recovery
Dewatering of ethanol,
Storage,
Transportation

Process integration: High quality performance data, kinetic models, separation requirements, understanding key process interactions

Why bioethanol from agro-residues?



- India do not have surplus vegetable oil and biodiesel production should depend on imported oil !
- The nation does not have land resources to support the cultivation of oil crops or any energy crops at levels which can meet the production demand !
- India generates ~600 MMT of agricultural residues annually and this could be a potential feedstock for fuel production.

Sukumaran & Pandey 2010, India Country report, In: Eisentraut A (ed), Potential for sustainable production of 2nd generation biofuels, IEA 2010

~51 % of the land surface in India is cultivated and the cultivated lands are mostly rain-fed !!!!

Feedstocks for bioethanol production

Availability of feedstocks in India?

Feedstock for bioethanol production

Availability of feedstocks in India?

For the purpose of understanding the feasibility and sustainability of producing biofuels from biomass in India, a clear understanding of the production, current uses and excess availability ('surplus') of biomass was needed.

Further, the storage, transportation and procurement practices of such biomass resources also need to be understood.

2nd generation bioethanol

NIIST-TIFAC study on the sustainable availability of potent biomass resources for bioethanol production in India

The scope of study

- Identification of top biomass resources available in India with state-wise/geographical distribution.
- Assessment of the total quantity of biomass generation (state-wise and national)
- Assessment of current consumption of the identified biomass resources and usage pattern (state-wise and national).
- Assessment of current practices in storage and transport, if existing for agro-residues/biomass resources.

NIIST-TIFAC study on the sustainable availability of potent biomass resources for bioethanol production in India

The scope of study (cont…)

- Generation of data on feasibility of collecting the feedstock other than agro-residues (inclusive of forest biomass resources such as bamboo and pine needles, and aquatic biomass such as water hyacinth). Estimates on the cost of collection, drying (if applicable as in the case of water hyacinth), storage and transport have to be prepared.

- Cost assessment for the biomass when procured at small-scale and at large-scale.

NIIST-TIFAC study on the sustainable availability of potent biomass resources for bioethanol production in India

The scope of study (cont…)

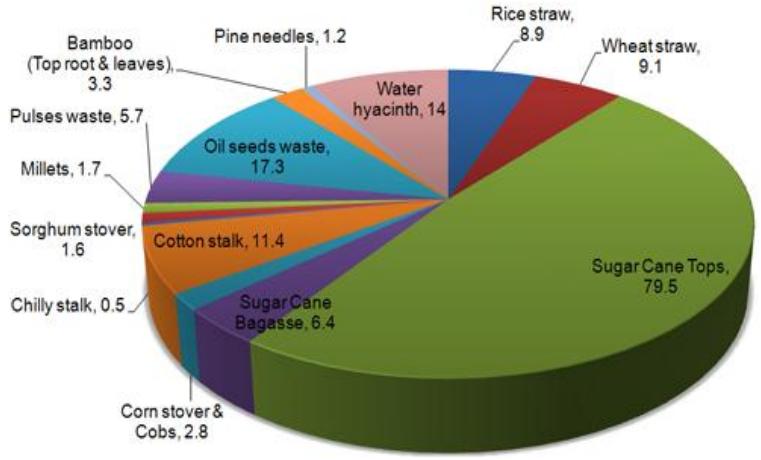
- Identification of major locations in the country with highest concentration of the 5-6 feedstocks.
- Sources of procurement of biomass and agro-residues.

2nd generation bioethanol

NIIST study on the sustainable availability of potent biomass resources for bioethanol production in India

- Primary data sources
- Secondary data sources
- National scale

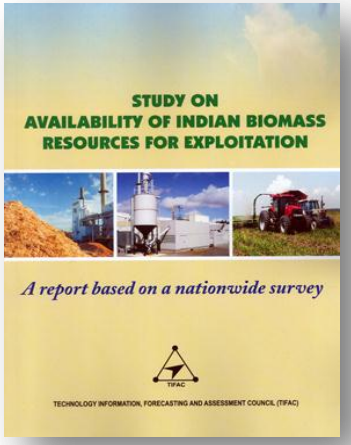
Identification of feedstock to work-on



Annual surplus availability of biomass residues in India (MMT)

- **More than 90% of the cereal crop residues are used domestically !**
- **Surplus residues are sufficient to support projected demand for 2020 even with the most pessimistic conversion figures (Projected Demand for 2017 at 10% Blending = 2.2 Billion L)**

Agro residue	Annual Availability (MMT)	Cellulose (%)	Alcohol - Theoretical Max (Billion L)	Alcohol - Estimated @35% efficiency (Billion L)
Rice Straw	8.9	33	2.11	0.737
Wheat Straw*	9.1	33	2.15	0.754
Bagasse	6.4	40	1.84	0.643
Corn Stover*	1.1	35	0.28	0.097
Sugar Cane Tops	79.5	35	19.96	6.985
Chili PHR	0.5	47	0.17	0.059
Cotton PHR	11.4	31	2.53	0.887
Bamboo	3.3	42	0.99	0.348
TOTAL			**30.03**	**10.51**



NIIST-TIFAC survey report, 2009

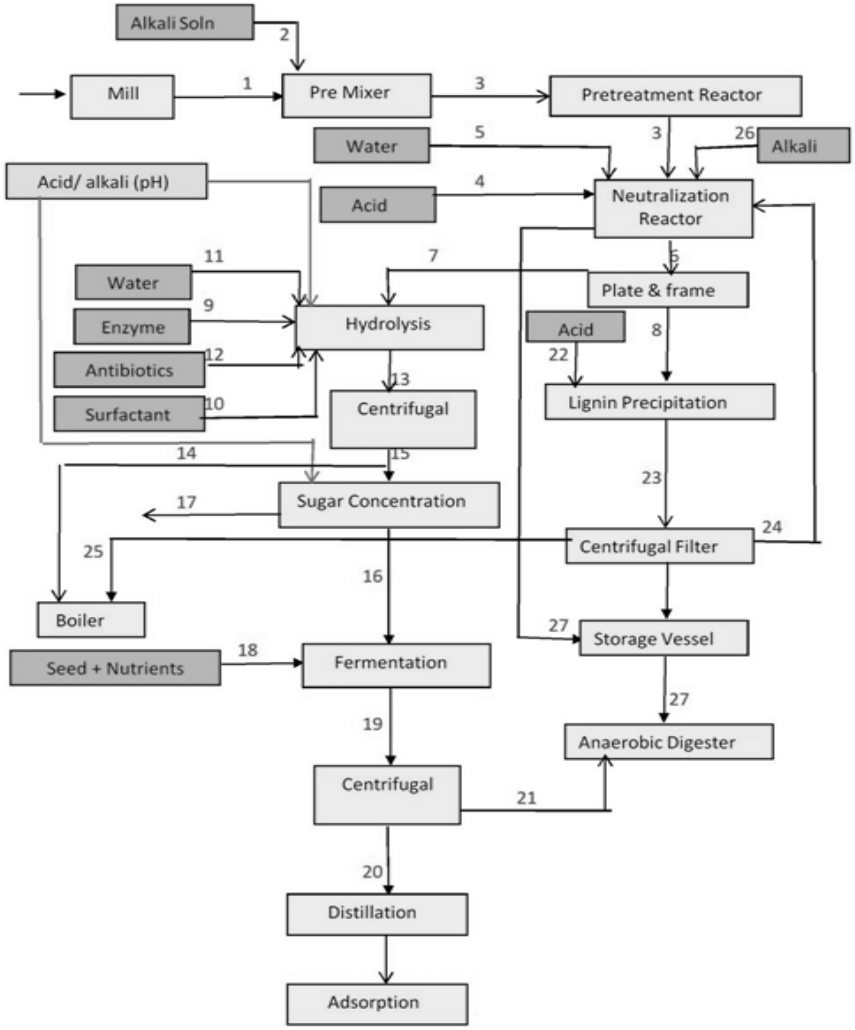
Feedstock for bioethanol production

Theoretical estimates of LC bioethanol in India

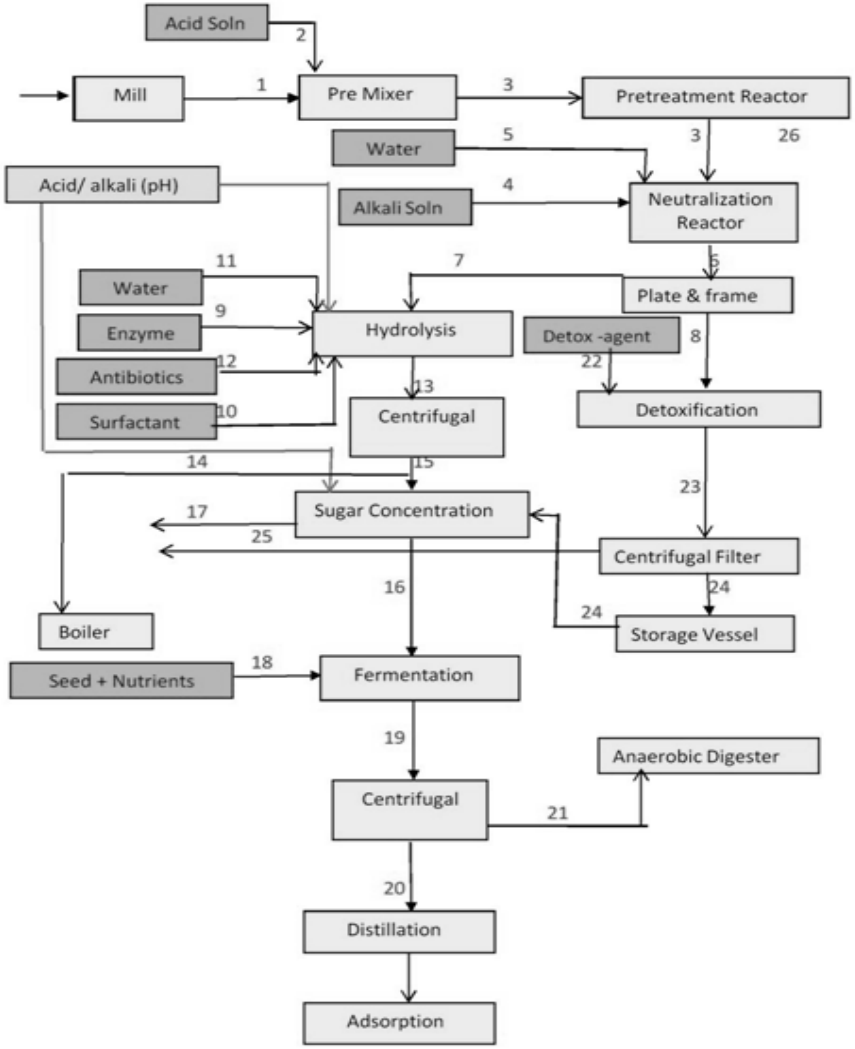
With 10% of the major feedstocks (wheat straw, rice straw and SCB) being used for the production, and at 75% theoretical yield, the projected ethanol yield will be 5.4 billion liters annually.

Lab to Plant: Design of process-flows and volumes

Alkali pretreatment scheme

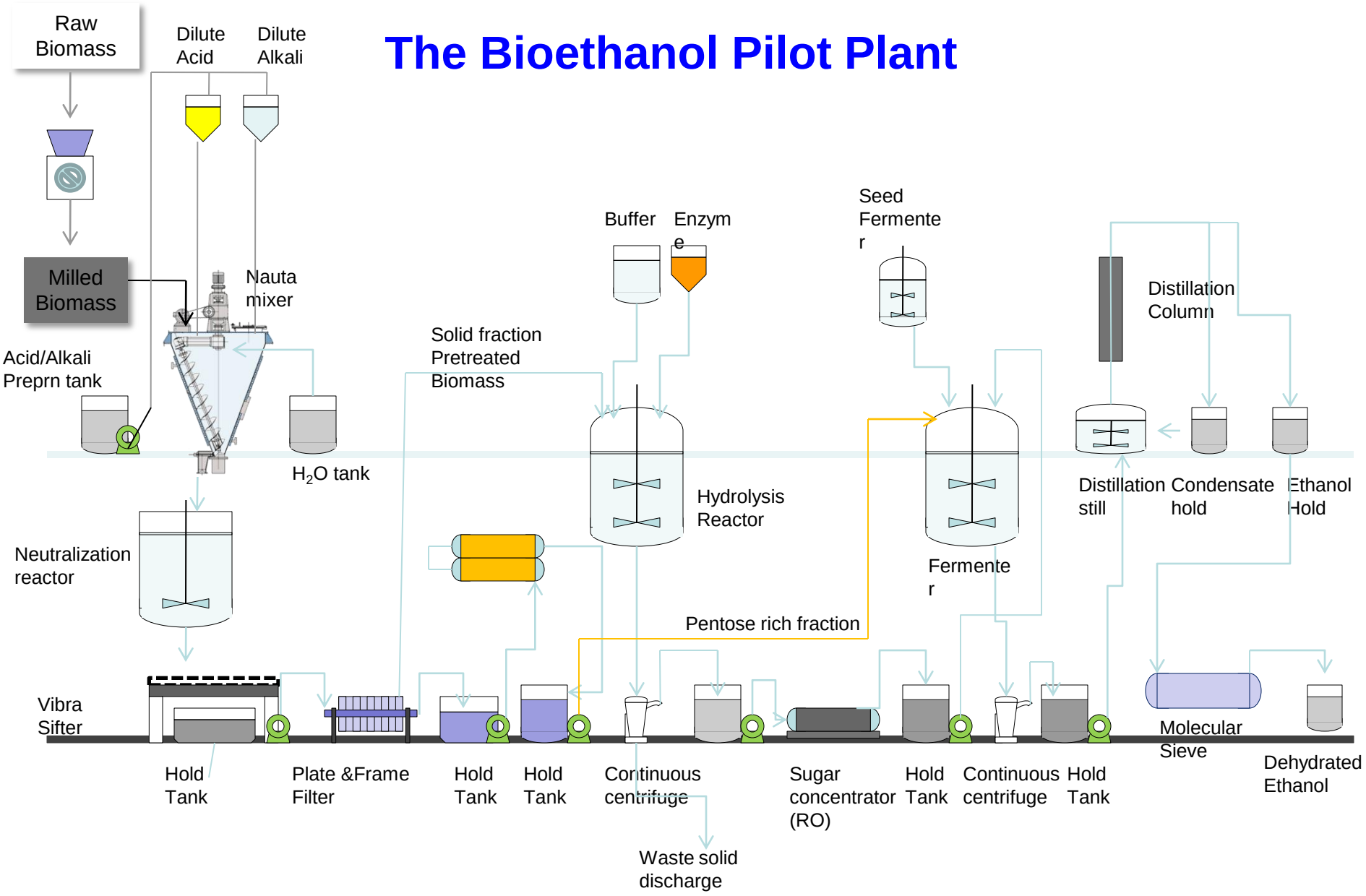


Acid pretreatment scheme



Centre for Biofuels

The Bioethanol Pilot Plant








Pilot plant

Centre for Biofuels

CBF - Achievements

Design copyright	**1**
Papers in SCI journals	**20**
Conference papers	**25**
Book chapters	**10**
Books	**2**
Special issues of journals	**5**
Reports	**2**
Consultancy project	**1**
Patent (in pipe-line)	**1**

Centre for Biofuels

Our partners, collaborators and facilitators

TIFAC

सत्यमेव जयते

Department of Science & Technology
Government of India

CSIR-INDIA

CSIR

NATUROL

Naturol Bioenergy, Hyderabad

Somaiya GROUP

Godavari Biorefinery, Sameerwadi

Kerala State Bamboo Corporation

MAPS

MAPs Enzymes Pvt Ltd

CSIR-NCL , Pune; CSIR-IICT, Hyderabad; UBP, France; EPFL, Switzerland; HTBS, Pune; Scigenics India Pvt Ltd, Chennai

Acknowledgements

Dr Priyangshu M Sarma and the Oraganizers

TIFAC, New Delhi

Dr Rajeev K Sukumaran, Dr K Madhavan Nampoothiri, Dr P Binod,

Dr R Sindhu, Vikram Surender, M Kiran Kumar, Vani Sankar,

Dr Reeta Rani Singhania, KU Janu, M Kuttiraja, Preeti Varghese, Sandhya Varier, KP Rajasree, Abraham Mathew, Aravind Madhavan, Lalitha Devi G, Gincy Marina Mathew, Mr PN Sivankutty Nair, Mr Prakash KM

CSIR -NIIST

Centre for Biofuels

Questions?

Contact: pandey@niist.res.in