DBT-IOC Integrated Technology for 2G Ethanol

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Rationale for Bio-fuels development

Bio-fuels Options:

- Ethanol for Gasoline
- Biodiesel for Diesel

❖ **Huge Demand supply gap – Production & Raw material constraints**

➢ Ethanol presently from sugarcane molasses only (First Generation Technology)- ~3-4 % v/v of gasoline

➢ Oilseeds for biodiesel (First generation technology) (~0.001%) **– oilseed raw material not available at required scale**

Possible Answers- Technology based upon alternate Feedstocks

- Ligno-cellulosic Biomass (LCB) – Agri /forest waste abundantly available in India
- Municipal bio-waste, MSW
- Micro-algae and marine plants
- Carbon sources like CO / CO2 from waste gases

2nd /3rd Generation Bio-fuels technologies from alternate raw materials essentially required to meet 20 % bio-fuels mandate of National Biofuel Policy

Annual surplus Biomass residue & Ethanol potential in India

- Gasoline consumption in 2016-17 : 23.77 Million Tons (~32 MKL) hence 10% blending shall require 3.2 Billion Lt & 20% shall require 6.4 Billion Lt of ethanol

Biomass	**Annual availability**	**Theoretical ethanol potential***
	(Million metric tons/yr)	**(Billion Lt /yr)**
Cotton stalk	52.9	13.2
Maize cob	27	6.7
Mustard stalk	8.7	2.2
Rice straw	170	42.5
Sugar cane bagasse	12.1	3.0
wheat sraw	112	28
Total	382.7	95.7 **(75.2 MMT)**

*1 ton dried biomass gives approximately 250 lit of cellulosic ethanol

** Source: TIFAC

*** Rice straw disposed off in various ways **such as burning which release Greenhouse gases**. Rich in carbohydrates having ~ 60% fermentable sugars.

Advanced Bio-Fuels

Bio-Energy Research Centres of DBT, Ministry of Science & Tech., Government of india

- 1st centre at ICT Mumbai (2008) to develop separation technologies and processes in cellulosic ethanol
- 2nd centre at IOC(R&D) in 2012 to research scale up issues and develop pre-treatment technology
- 3rd centre in 2012 at International Centre for Genetic Engineering & Biotechnology (ICGEB) to develop genetically modified enzymes / yeast
- 4th PAN IIT Centre (2014)
- All centres working on bio-refinery concept

DBT IOC Centre
Current Main Focus Area

Lignocellulosic Ethanol Technology Development

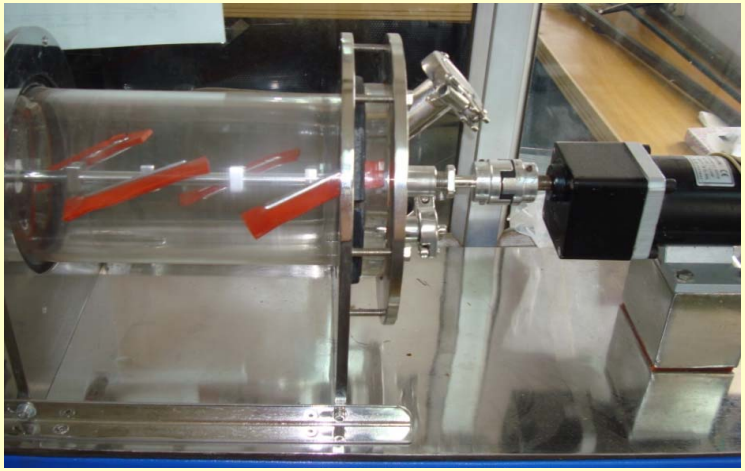
- Pre-treatment of biomass on pilot scale
- Development of reliable analytical methods
- Feedstock storage issues
- Understanding costing elements
- Bio-refinery integration
- Enzymes and yeast developments

PILOT SCALE UP TO 10 TONS FEED/DAY for CELLULOSIC ETHANOL

Capabilities- Pretreatment

Pretreatment

Saccharification



Multi Feed/ chemical Lignocellulosic ethanol pilot plant build with technical assistance from NREL, USA

Capabilities- Fermentation

Bench scale fermenters from 1-20 litre

150 litre Fermenter

Cellulosic Ethanol - Typical Process Outline

Lignocellulosic Biomass

STEP 1 — Pre-Treatment Step → **Most Complex Step**
High in CAPEX

STEP 2 — Saccharification → **Requires complex enzymes**
High in OPEX

STEP 3 — Fermentation → **Innovations reqd for better Performance & time reduction**

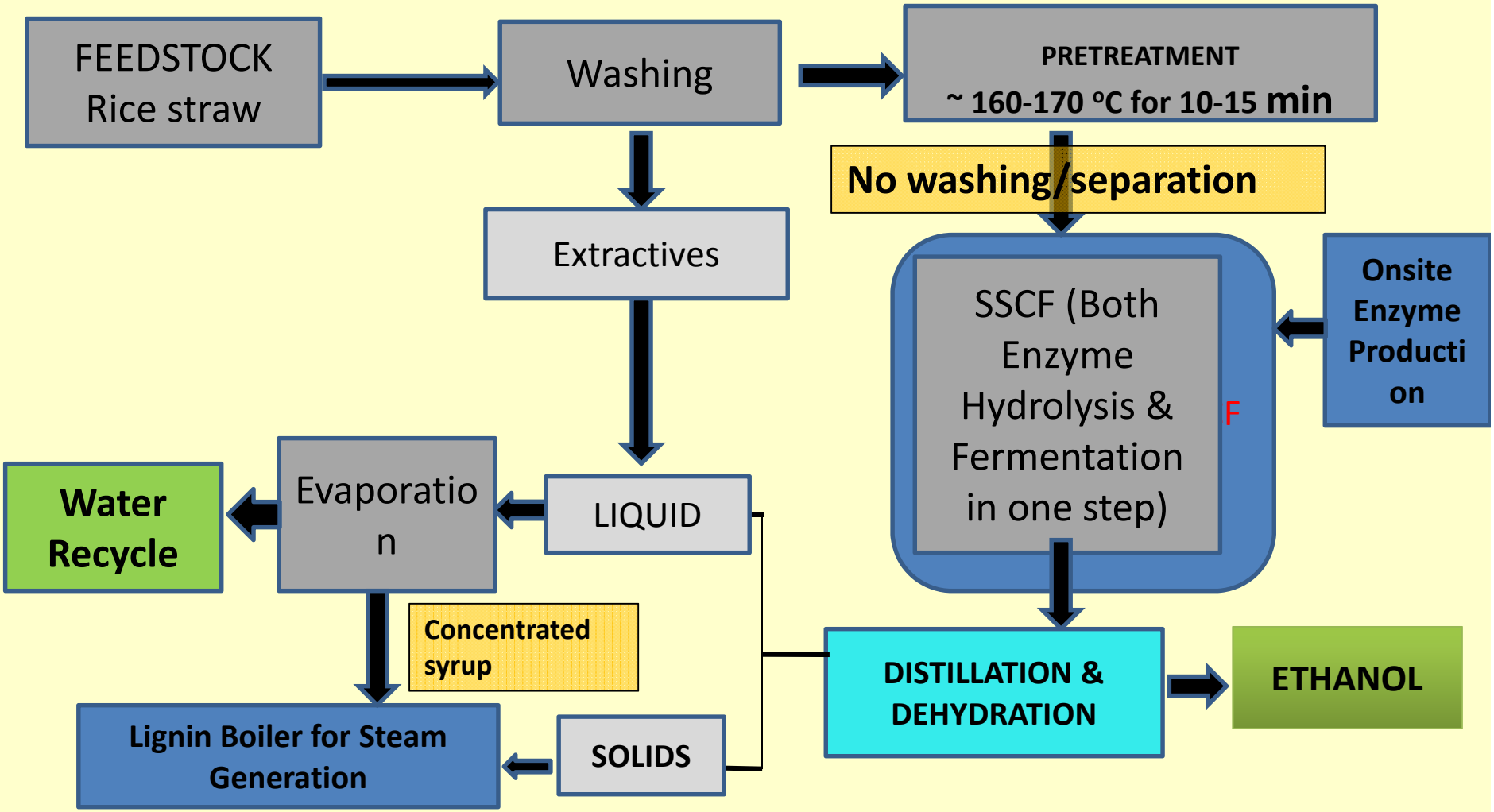
STEP 4 — Separation/Purification → **Alcohol**

Our efforts are directed to reduce cost & process time

DBT-IOC R&D 2G Ethanol Technology

- Work started in 2012
- 0.25 ton Pretreatment Pilot Plant unit in 2013
- Technology : **Acid based finalized on pilot scale & SSCF**
- Raw material : Rice straw & Baggase
- Enzyme recipe developed indigenously
- Yeast by Belgium, Europe

DBT-IOC R&D 2G Ethanol PFD



Low Capex, Low Opex, Less Time

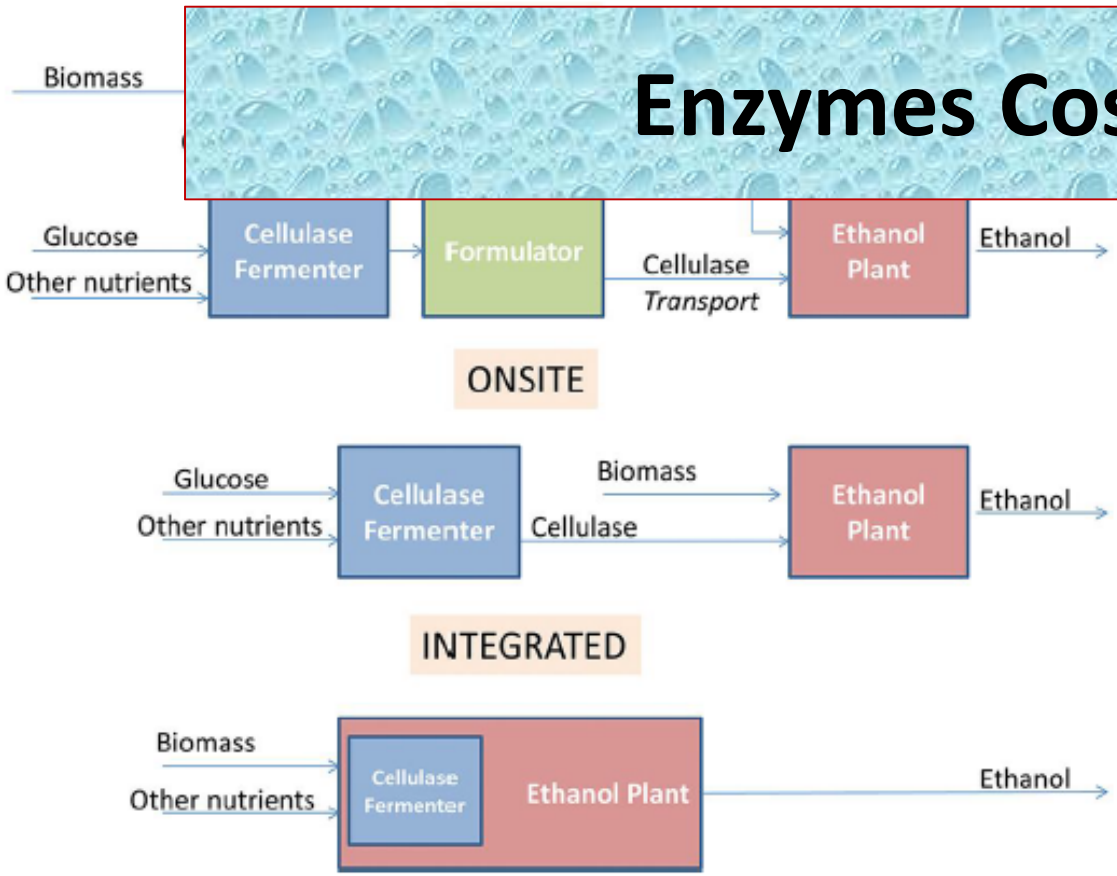
Enzyme Technology Development

- Developed two high activity producing fungal strains
  - **Media & C source optimization for lower cost**
- Performance almost at par with commercial enzyme
- Enzyme scale up in 250 litre fermenter done
- Scale up trials to 5 KL underway
- Industry tie-up for toll manufacturing initiated
- Supply enzymes to forthcoming 2G ethanol plants

Our Enzyme costs ~50% of the existing enzyme & has activity of 85-90% of world's best commercial enzymes

Enzyme Cost

Integrated enzyme production lowers the cost of cellulosic ethanol



Enzymes Costs

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Off-site	28%
On-site	22%
Integrated	10%

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OPEX Comparison with Similar Technologies (acid based)

Sl. No	Parameter	DBT-IOC Process	Competitors (Similar technologies)	Advantages IOC process
2	Chemical cost	Low	High	Lower OPEX
3	Enzymatic Hydrolysis & Fermentation	SSCF ~ 60 hrs	SHCF >120 h	Lower Opex & Lower Time
4	Enzyme cost	Low	High	Lower OPEX as indigenous enzyme cost is half of commercial enzyme cost
5	Ethanol titre	5% V/V	4% V/V	More productivity

Our OPEX will be about Rs 10 lower than the commercial technologies

IOC– Process demonstrated at Pilot scale (Pretreatment-250 kg/day, SSCF- 150 kg per batch)

SSCF-Simultaneous Saccharification & Co-Fermentation

SHCF- Separate Hydrolysis & Co-Fermentation

IOC Future Plans

- 10 TPD demo plant based on IOC R&D Technology work in progress
- Demo plant shall have integrated enzyme technology developed by IOC R&D
- Demo Plant expected in 2019 at Mathura
  - BDEP prepared
  - Land Finalised
- Future commercial plants based on IOC R&D technology upon its successful demonstration

DBT-IOC
BIO-ENERGY RESEARCH CENTRE

इंडियनऑयल R&D
IndianOil The Power of Possibilities

THANKS