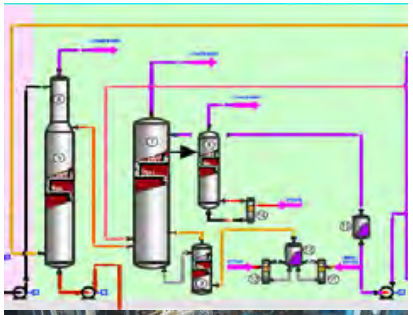
BIOETHANOL FROM NON-FOOD ENERGY RESOURCES: A POTENTIAL FUEL FOR FUTURE



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BIOETHANOL :
A Burning Issue to Green Energy

Bioethanol production from starch rich crops (fermentation of sugars) is gaining global attention as a promising approach for sustainable development as well as energy security due to increased demand/ consumption and dwindling fossil fuel resources.

BIOETHANOL

Ethanol can be :

First Generation bioethanol –

- Produced by using sugar crop and corn. Currently, 60% is produced from sugar crop and 40% is from corn.

Second generation ethanol –

- Produced by using lignocellulosic raw material (most abundant organic mass in the biosphere, acounting for approximately 90% of the biomass).

BIOFUEL SOURCES

- Biofuels from **food energy resources**:
  Brazil, USA, Korea, India & Other Countries
- Oil based Biofuels – Jatropha seeds
- Smokeless Biomass (Pyrolysis)
- Advanced Biofuels –Biochar
- **Cellulosic Biofuels**
- Microbes and Enzymes
- Photobiological Biofuels from Algae

Overall Sustainability / Process Economics/ Environmental concerns

CONCERNS ???

- Biofuel production is currently done utilizing **resources which otherwise can be put to better use** e.g. sweet sorghum, corn, maize, oils soybean, mustard, waste vegetable oil, palm, rapeseed, sunflower, soybean, jatropha, groundnut and cotton seed
- **This causes more problems than solving** w.r.t. food security and environment- possible deforestation, biodiversity loss, land degradation and water pollution.
- Countries around the globe are now beginning to recognize the **potential pitfalls** of Biofuels and finding **appropriate alternatives.**

Solution ???

Non-Food Energy Resources

- Biofuels with great promise to contribute to several urgent problems such as energy security, greenhouse gas reduction, poverty reduction, and to help promote sustainable development

Non-Food Energy Resources

- An **innovative way to convert this resource into bioethanol through use of advanced biotechnological processes utilizing enzymatic hydrolysis.**
- This will :
  - **Reduce the use of chemicals,**
  - Provide agro-based industries a **techno-economically viable option** for recycling the waste, and
  - **Ease pressure on fossil fuel reserve** due to its use as potential fuel for transportation.

Production of enzyme

Raw Material source

- Nature – Crops, residues, wastes
- Industry waste in bulk
- Pulp and paper industry – One of the oldest industrial sectors Globally including India having a long history is one of the new sources for lignocellulosic raw material.

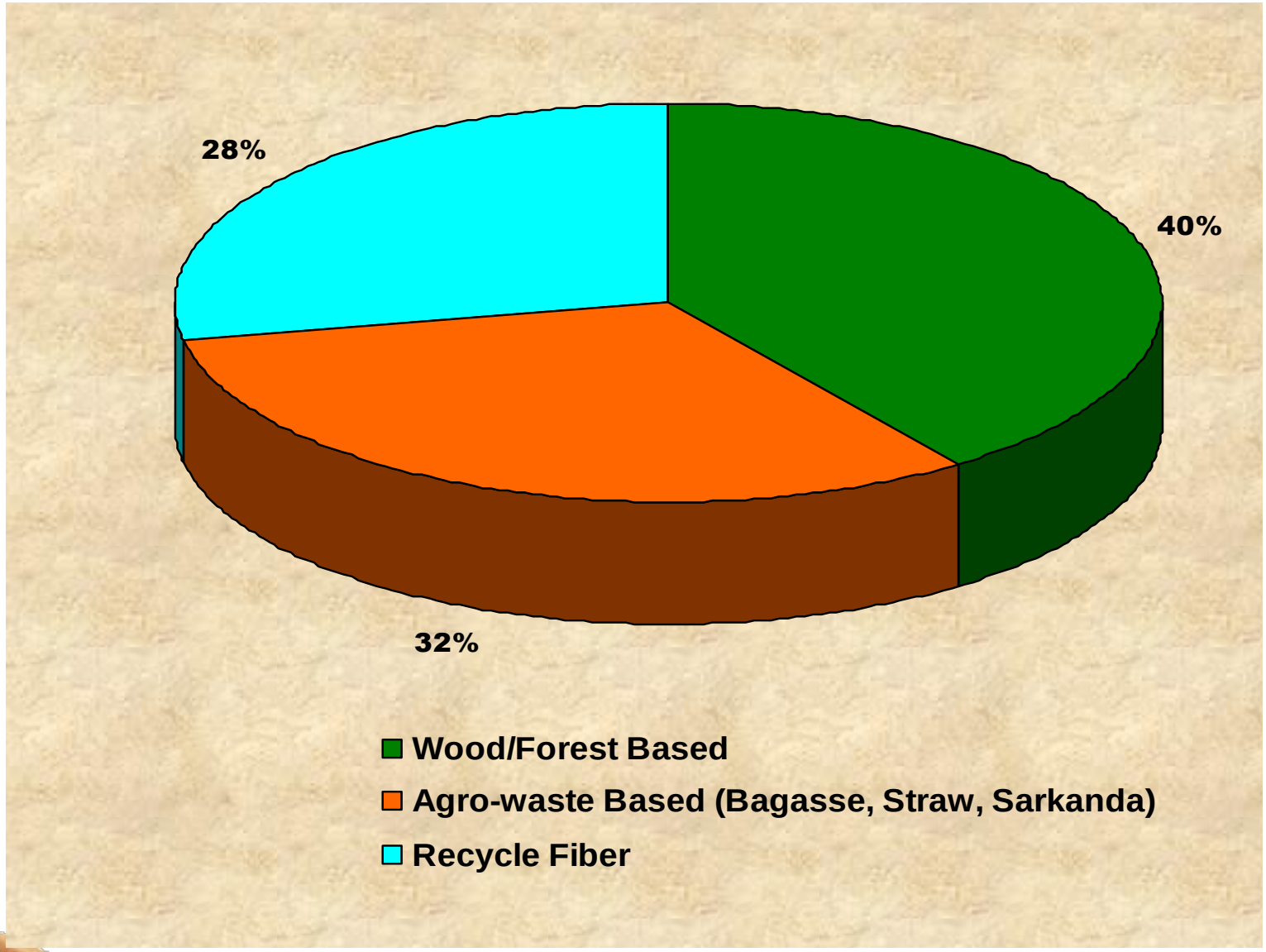
- After first mill commissioned in 1812 in the eastern state of West Bengal in India,

- Indian Paper Mills:
  1950 – >20 mills (0.137 million ton Cap.)
  Today– 594 mills (8.5 million ton Cap.)

Demand for paper has been growing continuously both in developing and developed countries due to reasons specific for each individual sector.

It is the population increase and rising standard of living, which is increasing the demand for paper in the developing countries

The future demand of paper in the country is expected to grow from current 9.5 Mt to 13 MT by 2015.


28%
40%
32%
Wood/Forest Based
Agro-waste Based (Bagasse, Straw, Sarkanda)
Recycle Fiber

CASE STUDY

Kuantum Paper Mills Ltd., Punjab – India

RAW MATERIAL : SARKANDA GRASS (Saccharum munja) in wild

RAW MATERIAL (Sarkanda) STORAGE IN THE STOCK YARD

RAW MATERIAL: Wheat Straw – Storage in the Stock Yard

Digester

PULP WASHING SECTION: Brown Stock Washers

PULP WASHING SECTION : Enzyme Dosing at Decker Washer Outlet (ABC Paper Mill)

ENZYME BLEACHED PAPER ROLL AT MACHINE OUTLET (ABC Paper Mill)

Modified Lignosulphonate Recovery Plant

COMPANY PROFILE

Kuantum Papers Ltd.

- (*earlier known as Amrit Paper or ABC Paper Mill*) was set up to produce writing and printing paper from Agricultural residues (Non-wood Biomass) like Rice & Wheat Straw, Sweet Munj Cane etc.

> 30 Years in the business of manufacturing Paper

Publicly Listed on BSE

Major R&D focus area:

- Extraction and fermentation of Glucosamine from sec. sludge;
- Algal treatment of waste – Zero Discharge and Pollution control;
- Extracting Hemi-cellulose prior to pulping to make ethanol as an added by-product to paper;
- Recovery of CaO from waste lime sludge;
- Co-incineration of secondary sludge with conventional fuel;
- **Ligno-cellulosic Ethanol** from **Agri-Biomass**;

CURRENT INITIATIVE

- To establish the Patented Technology to produce Ligno-cellulosic Ethanol from Rice Straw based
- To Setup a prototype Pilot Plant to process 3-4 MT/Day of Rice Straw to yield 1000 Litres of Ligno-Cellulosic Ethanol of >99.90% purity
- To establish micro-organisms and processes to efficiently digest Rice Straw and Cellulose
- Bio-refining of Ligno-cellulosics to produce other value added chemicals like Acetic Acid, Furfural, Butanol etc. for wider application of technology
- To establish the Techno-Economic feasibility of producing Ligno-Cellulosic Ethanol from Rice Straw for commercialization

DELIVERABLES : OUTPUTS

S. No.	Particulars	Theoretical Maximum	UICET Results Actual	EXPECTATION	
				1 MT per Shift Capacity Pilot Plant	
				PILOT PLANT - Target	PILOT PLANT - Minimum
1	ETHANOL (Liters)	370	260	290	260
2	LIGNIN (Kgs)	140	75	130	100
3	Carbon Dioxide (Kgs)	280	–	200	
4	Calcium Sulphate(Kgs)	400	225	250	225

RATIONALE : RICE STRAW

- Punjab the "Rice Bowl" of India contributes 9 – 10 % to the country's annual production
- 2.5 Million Hectares under Rice Cultivation
- 8.9 Million MTs Rice produced Annually
- 13.3 Million MTs Paddy Straw Generated Annually
- Conventional disposal of Paddy Straw – Burning in Fields

1 MT Paddy Straw Contains

PROXIMATE ANALYSIS

- 370 Kgs Cellulose
- 240 Kgs Hemi - cellulose
- 140 Kgs Lignin
- 167 Kgs Inorganic Matter
- 83 Kgs Others

1 MT Paddy Straw Contains

ULTIMATE ANALYSIS

- 5 – 8 Kgs Nitrogen
- ~ 1 Kg Phosphorous
- ~ 20 Kgs Potassium
- ~ 40 Kgs Silica
- ~ 400 Kgs Carbon

1 MT Paddy Straw Burning Releases

POLLUTANTS

- 1500 Kgs CO_2
- 60 Kgs CO
- 2 Kgs SO_2
- 3 Kgs Soot
- 200 Kgs Silica as ash

IMPORTANCE: AGRI – RESIDUE DISPOSAL

Paddy Straw Burning

Harness Biomass Potential for Green Renewable Energy

THE IMPERATIVE

To Find a Green and Viable Solution for Disposal of Paddy Straw

EPCA Directive: Eliminate Paddy Burning; Make it a cognizable offence

Farmer's Dilemma

State's Challenge

Conventional Solutions no longer 'VIABLE'

Why BURN? When it can EARN

NOVELTY

- Cellulosic ethanol is a radical game-changing technology, but the basis for the technology draws upon valuable experience from related industries.
- Because it pulls from more established technologies, this limits the technology novelty of cellulosic ethanol to be mainly around the biomass pre-treatment (which accounts for a third of the total cost), the hydrolysis part, the bio-refining part and most importantly dealing with non-organic components present in the biomass which hinder processing.
- Above all, the technology should have

NOVELTY

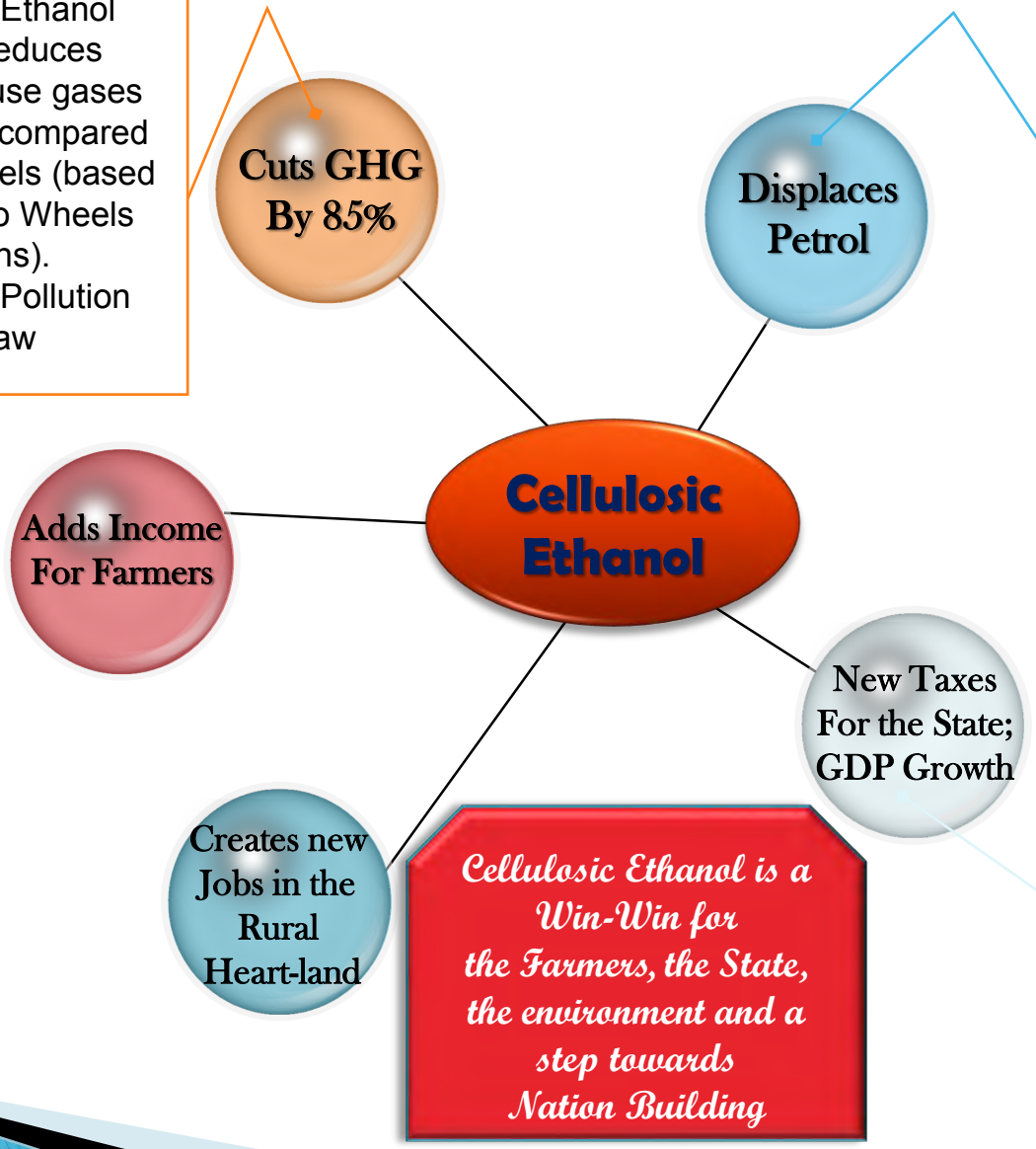
- There are 53 known Pilot-Demo plants active in the field of Ligno-Cellulosic Ethanol
- Most are working on mainly Corn Stover, Wood etc. as raw material
- The applicability of the technology is not universal and has to be customised to establish efficacy for each raw material
- Only one i.e. ICT technologies has claimed that it has worked on Rice Straw as raw material to produce Cellulosic ethanol

SOCIETAL RELEVANCE

1) **ENERGY SECURITY**: Reduced dependence on imported petroleum oil, reduction in fuel prices, reduction in CAD (current account deficit)
2) **IMPROVED ENVIRONMENT**: Reduction in Green House gas generation, Reduction/ elimination of burning of Agricultural residues in the fields
3) **CONTRIBUTES to NATIONAL Farm Subsidy Program**: By giving value for hitherto wasted by-product, farmers will earn for what they presently burn
4) **NEW JOBS**: Creates a new economy with new employment opportunities

CELLULOSIC ETHANOL – BENEFITS

Cellulosic Ethanol (Biofuel) reduces Green house gases by ~ 85% compared to fossil fuels (based on Farm to Wheels Calculations). Alleviates Pollution due to Straw Burning.



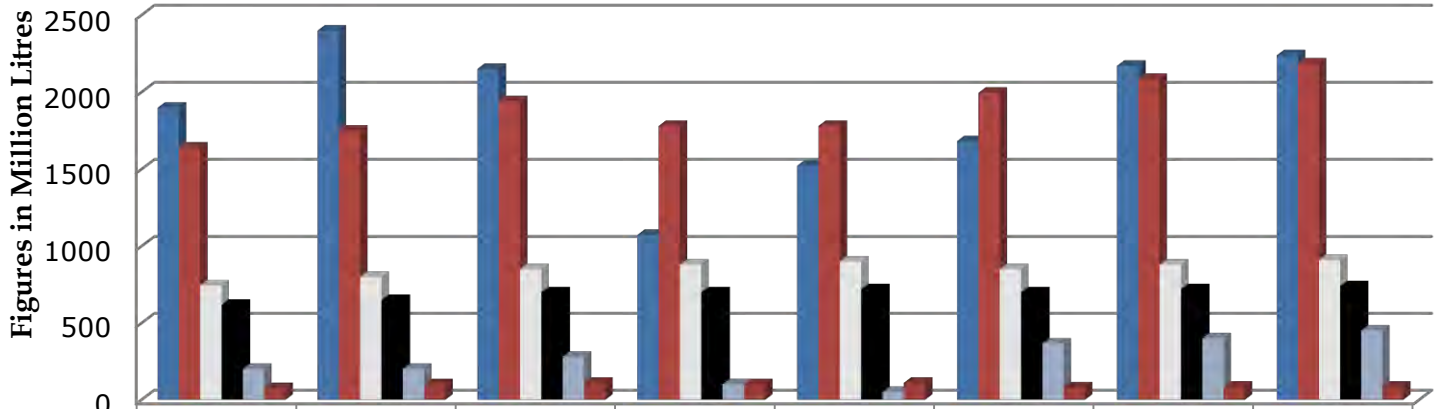
Ethanol blends upto 10% in Petrol without any modification to the existing supply chain. Is a cheaper and greener transport fuel. Reduces import bill for crude oil (saving precious Forex) and above all creates Energy Security & independence

Cellulosic Ethanol production will generate additional State Excise and other taxes. It will create increased household incomes with commensurate spends and expansion of the economy

SCOPE : ETHANOL – MARKET

- Conventional Ethanol (from Sugarcane) has reached its potential and only marginal increases can be expected
- Other known raw materials for conventional ethanol are primarily food based and eat into the scarce resource needed for human consumption

Production & Consumption of Conventional Bio-Ethanol : INDIA



	2006	2007	2008	2009	2010	2011	2012	2013
Production	1898	2398	2150	1073	1522	1681	2170	2239
Total Conumption	1639	1750	1940	1780	1780	1995	2085	2185
Potable Use	745	800	850	880	900	850	880	910
Industrial Use	619	650	700	700	720	700	720	740
Biofuel - EBM	200	200	280	100	50	365	400	450
Other Use	75	100	110	100	110	80	85	85

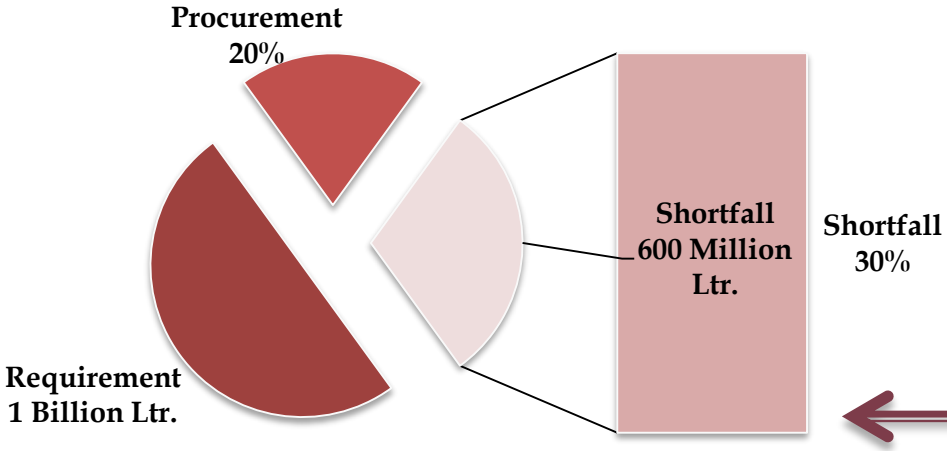
Production Total Conumption Potable Use Industrial Use Biofuel - EBM Other Use

Source: USDA Foreign Agriculture Service DTD 20/06/2012

SCOPE : ETHANOL – POTENTIAL

STATUS OF ETHANOL BLENDING PROGRAM (EBP) – INDIA

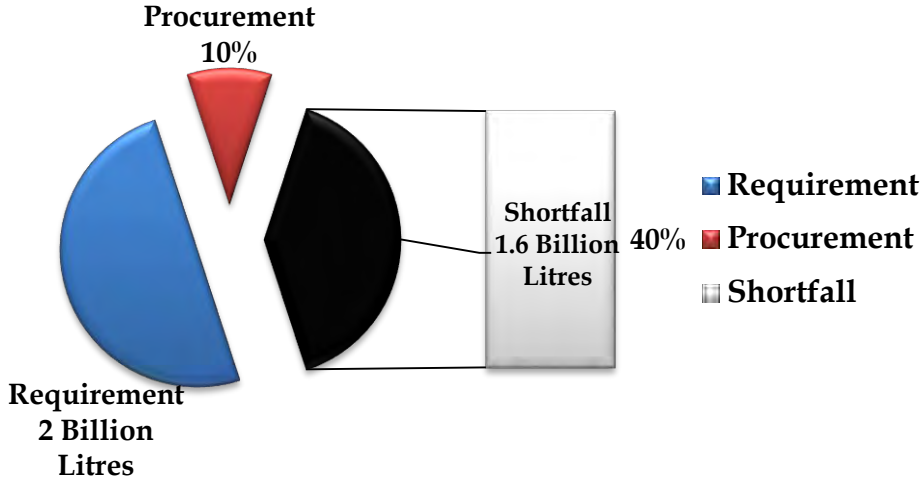
To IMPLEMENT EBP - 5%



Huge gap exists in existing Supply demand equation In meeting the Biofuel Requirement for blending 5% Ethanol with Petrol as Presently mandated

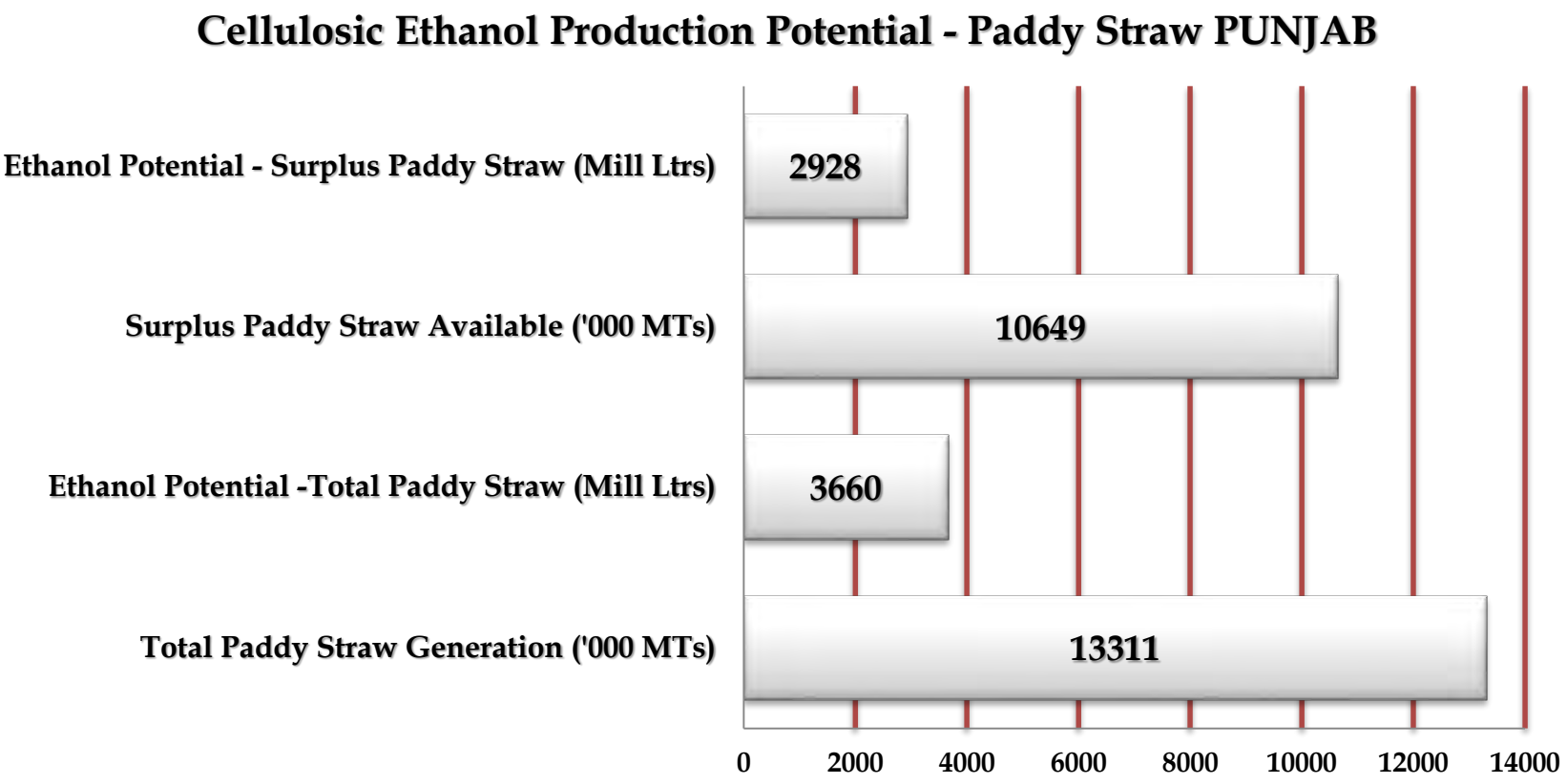
The mandate to meet 10% Biofuel blending requirement Is very challenging and would Provide sufficient impetus in Attracting large investments For production of a proven Cellulosic Ethanol Technology

To Implement EBP - 10%



Commercial Potential : Ethanol (Ricc Straw)

The answer lies in tapping hitherto untried resources i.e. LIGNO-CELLULOSIC material which are although available in abundance but due to lack of established technology and inventiveness remain untapped.



COMMERCIAL POTENTIAL

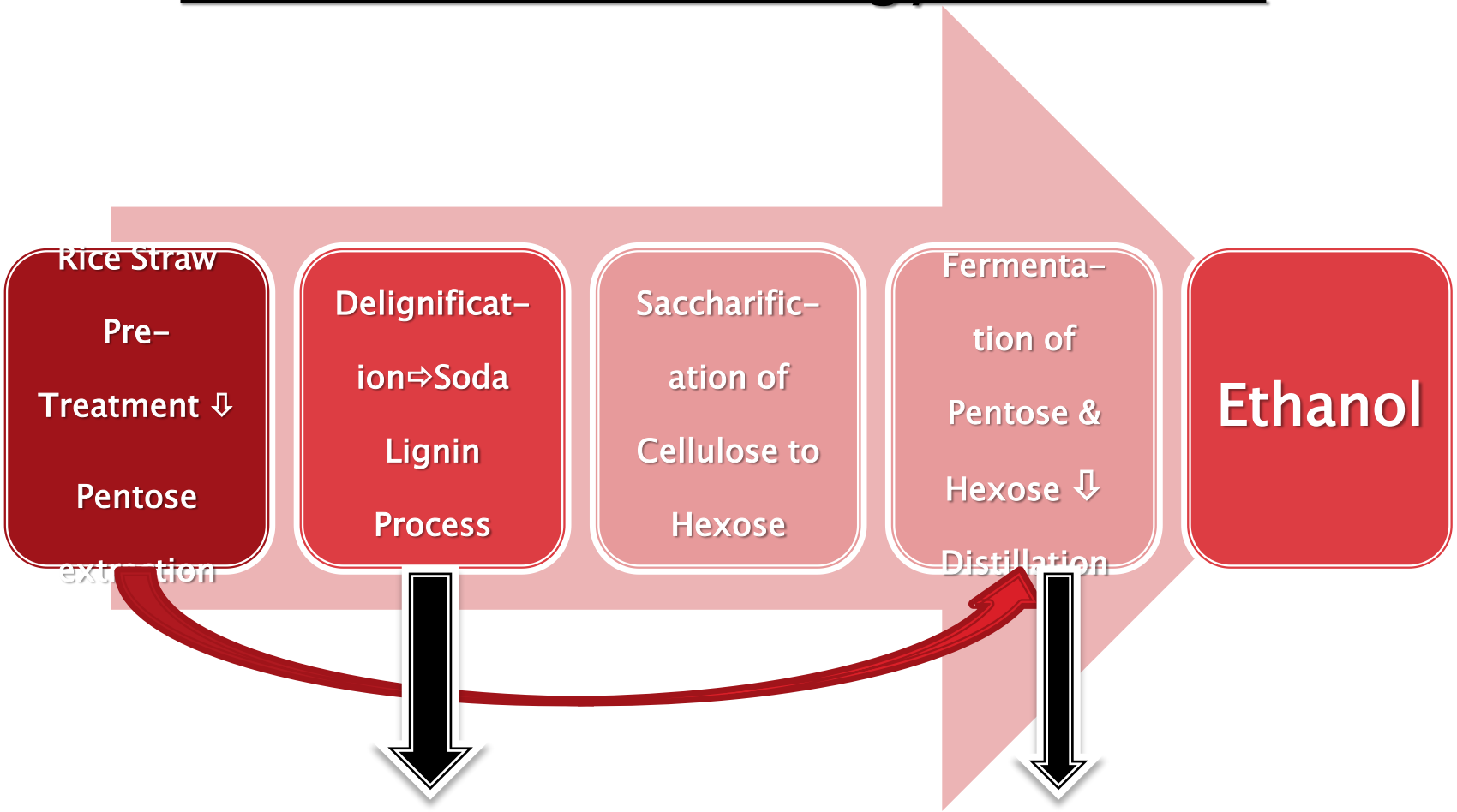
- Ethanol has 5063 Kcal/ Litre compared to petrol's 7594 thus providing 67% of its energy
- The highest potential for cellulosic ethanol lies in its use as transportation fuel
- Ethanol blending upto 85% with petrol is now well established world-wide and acceptable motor spirit
- The total potential of ethanol as bio-fuel alone is thus 15-17 Billion Litres or 17 Million Kilolitres (KL) per annum
- A 50 KL/day bio-refinery has an annual capacity of 17000 KL or 0.0017 Million KL per annum
- Thus commercialization potential exists for setting up 10,000 such bio-refineries across India
- In Punjab alone, potential exists for setting up Bio-refineries having a combined annual capacity of **3 Million KL per annum** or **a fifth of India's requirements**

RAW MATERIAL AVAILABILITY

Biomass Class	Area (kHa)	Crop Production (kT/Yr)	Biomass Generation (kT/Yr)	Biomass Surplus (kT/Yr)
Forest & Wasteland	229.1	NA	398.5	263
Agro Crops	6249.6	25072.2	44491.7	19422.3

Crop	Residue	Area (in '000 ha)	Crop Production (in '000 MTs/Yr)	Biomass Generation (in '000 MTs/Yr)	Biomass Surplus (in '000 MTs/Yr)
Paddy	**STRAW**	**2502.7**	**8873.7**	**13310.6**	**10648.5**
Wheat	**STALKS**	**3433.8**	**15563.8**	**23345.7**	**4669.1**
Wheat	Pod	3433.8	15563.8	4669.1	2334.6
Paddy	Husk	2502.7	8873.7	1774.7	1419.8
Maize	Stalks	165.3	451.9	903.9	180.8
Mustard	Stalks	46	54.9	98.8	49.4
Maize	Cobs	165.3	451.9	135.6	40.7
Mustard	Husk	46	54.9	49.4	46.9
Others	Crop Residues	101.8	127.7	204.1	32.5
Total		**6249.6**	**25072.2**	**44491.7**	**19422.3**

The Patented Technology : Overview



Black Liquor to Lignin Recovery or Recovery Boiler *Distillation Sludge Incineration*

Hemi-Cellulose Hydrolysis

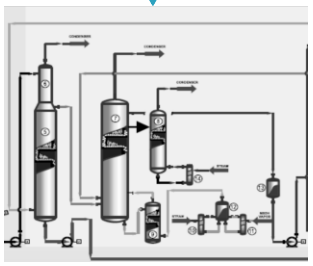
Raw Material

Pre Treatment

Stage II

This is the **first stage** of the process where hemi-cellulose hydrolysis takes place in the **Hydrolyser** and the resultant Xylose sugar(C_5) solution is separated for fermentation

Stage V



Stage IV

Stage I

INPUT

Pretreated Raw Material

+

Sulphuric Acid + Lime + Steam + Power

HEMI-CELLULOSE HYDROLYSIS

OUTPUT

Xylose or **C_5** Sugar Solution (to be fed in **Stage IV**)

Fermentation & Distillation

Raw Material

Pre Treatment

Stage I

Stage II

Stage III

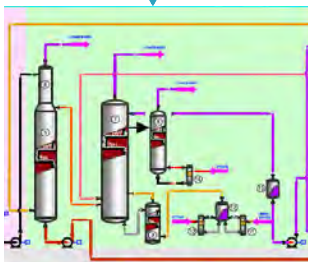
INPUT

Xylose Sugar Solution

+

Glucose Sugar Solution

Stage V



Stage IV

OUTPUT

ETHANOL

+

Carbon Dioxide + Stillage

This stage produces commercially tradable **ETHANOL** and **CO_2** produced as by-product can also be bottled and sold in the market

FERMENTATION & DISTILLATION

PRELIMNARY WORK DONE

Rice Straw

Cellulosic Pulp

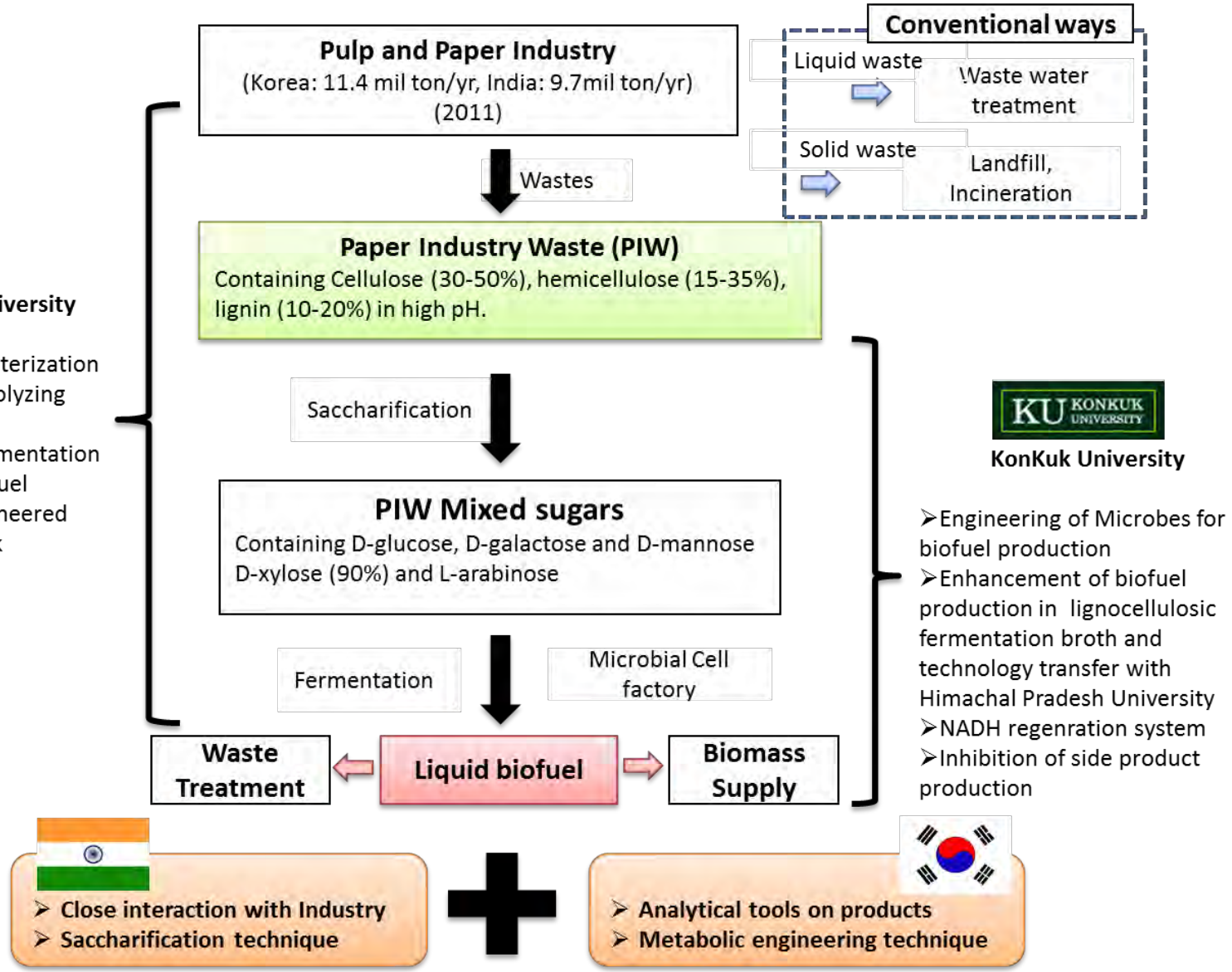
Ethanol

Laboratory

CASE STUDY

International Collaboration

Indo – Korea Initiative


Conventional ways
Liquid waste
Waste water treatment
Solid waste
Landfill, Incineration
Pulp and Paper Industry
(Korea: 11.4 mil ton/yr, India: 9.7mil ton/yr) (2011)
Wastes
Paper Industry Waste (PIW)
Containing Cellulose (30-50%), hemicellulose (15-35%), lignin (10-20%) in high pH.
Saccharification
PIW Mixed sugars
Containing D-glucose, D-galactose and D-mannose D-xylose (90%) and L-arabinose
Fermentation
Microbial Cell factory
Waste Treatment
Liquid biofuel
Biomass Supply
Himachal Pradesh University
➢Isolation and characterization of lignocellulose hydrolyzing microbes
➢Development of fermentation process for liquid biofuel production using engineered Microbes from konkuk university
➢Scale up of process
KonKuk University
➢Engineering of Microbes for biofuel production
➢Enhancement of biofuel production in lignocellulosic fermentation broth and technology transfer with Himachal Pradesh University
➢NADH regenration system
➢Inhibition of side product production
➢ Close interaction with Industry
➢ Saccharification technique
➢ Analytical tools on products
➢ Metabolic engineering technique

Thank You !

ONWARDS TO A BLUE REVOLUTION