Benefits Of The Use Of Biofuel As The Transportation And Industrial Applications: Indian Scenario

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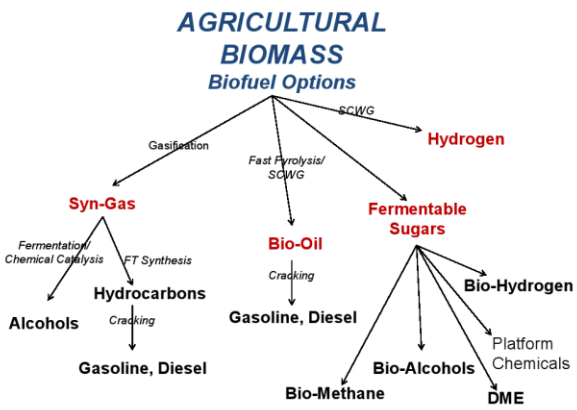
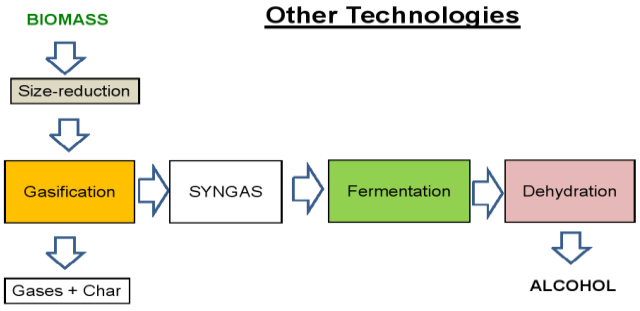
Abstract: *The world's non-renewable resources of energy like petroleum and coal are depleting at an alarming rate. After only an century of dependence on these fossil fuel man is faced with an energy crises. We are compelled to find out other alternatives. Ethanol is one of the products from biofuel that is receiving a great deal of attention these days as it is a substitute of gasoline (obtained from petroleum).*

GASOHOL ⟶ *GASOLINE + ETHANOL*

Gasohol is presently being used as a fuel in a few vehicles in U.S. Ethanol is also valuable as it can be converted to hydrocarbons such as alkanes, cycloalkanes, alkenes and aromatic hydrocarbons. Biomass is defined as living matter or its residue, and is therefore a renewable and abundant resource of energy. Biomass include all organic material obtained either directly or indirectly form the growth of plants. Biomass includes trees, grasses, grains, sugarcane, water hyacinth, algae and residue from domestic uses. The most common residue includes forest, agriculture, animal, municipal and industrial organic matter. This calls for multi-disciplinary approach. Labs specializing in Biotechnology, chemical engineering, synthetic biology need to work in a net work.





Keywords: Biomass, biofuel, ethanol, algae, thermochemical, biochemical, fermentation etc.

Introduction: Biomass can be converted into biofuels either by thermochemically or biochemically. The best known thermochemical conversion process is direct combustion. In the thermochemical method, biomass is subjected to high temperature and depending upon the quality of O_2 supplied, process such as pyrolysis, combustion and gasification occurs. Direct heating of biomass in stoves and open fire is example of combustion in which O_2 supply is generally higher than that required. Under condition of lower rate of O_2 supply, pyrolysis and gasification occurs.
In biochemical route of conversion of biomass to other useful forms is low energy process and relies upon the action of bacteria, which degrades complex molecules of biomass into simpler ones. Government is also taking interest on biofuel:

National Biofuel Policy

Specific mandates and incentives for biofuels:

20% biofuels by 2017 (National Policy on Biofuels, 2008).
Mandatory 5% blending for ethanol and biodiesel (Nov 2009).
Government agreed on a prefixed price for biodiesel / ethanol purchase by oil companies (Nov 2009).
Prices reviewed periodically.
Biofuels are Ethanol and Biodiesel.

Rather than no specific road map to achieve these targets.

Biofuel Demand in India

Year	Petrol Demand (MMTPA)	Ethanol Blending Requirement (MMTPA)			Diesel Demands (MMTPA)	Biodiesel Blending Requirements (MMTPA)		
		5%	10%	20%		5%	10%	20%
2006-07	10.07	0.5	1.01	2.01	52.32	2.62	5.23	10.46
2011-12	12.85	0.64	1.29	1.57	66.91	3.35	6.69	13.38
2016-17	16.4	0.82	1.64	3.28	83.58	4.18	8.36	16.72

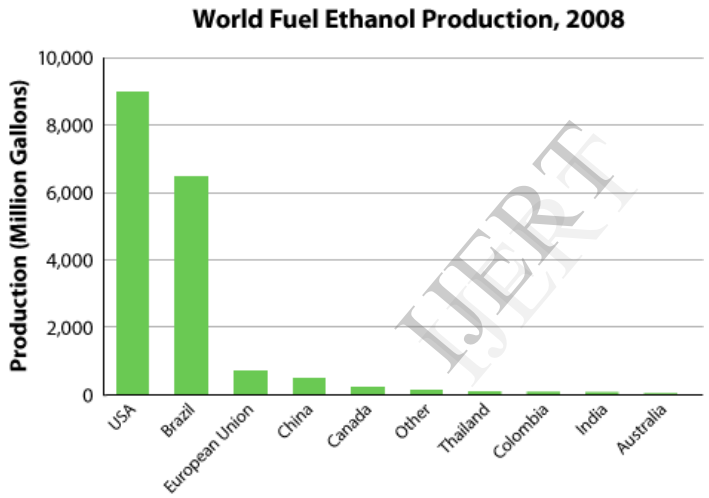
Source: *Planning commission, Report of the Committee on Development of Biofuel, 16 April 2003.*

Current Situation Inspite of Mandates & Incentives we have Fuel Ethanol - 60 million gallons in India vs. 15 billion gal worldwide in 2009 **(0.4%)** and biodiesel - 10 million gallons vs. 3 billion gallons in 2009 **(0.3%)**
•Less than 0.5% of total transportation fuel in India uses biofuels.
•We need to increase it 40 times in 6 years to meet policy targets of 20 %
It can be inferred that our performance in biofuels has been very poor.

Achieving Vision Biofuel Vision very optimistic, Huge quantity of biofuel required, New feedstocks / technology necessary, Road map and action plan necessary, Long range planning necessary, Split vision target into actionable projects.

Possible Solutions: No single feedstock or technology platform can achieve targets, Non-edible oils will contribute somewhat but will not be the only one. We need to look at all possibilities like second generation biofuels. Bio-oils from biomass pyrolysis, Gasification of Biomass, Conversion of waste gases (CO) to ethanol, Biogas / ethanol from municipal waste and all other options.
Each of above will contribute to achieve biofuel Mission.

Ethanol Advantages: Good blend component for gasoline, Ethanol (Gen. 1st) can reduce CO_2 by 30-60 % , Cellulosic ethanol will reduce CO_2 by 70-90 % and Ethanol can be converted to several chemicals

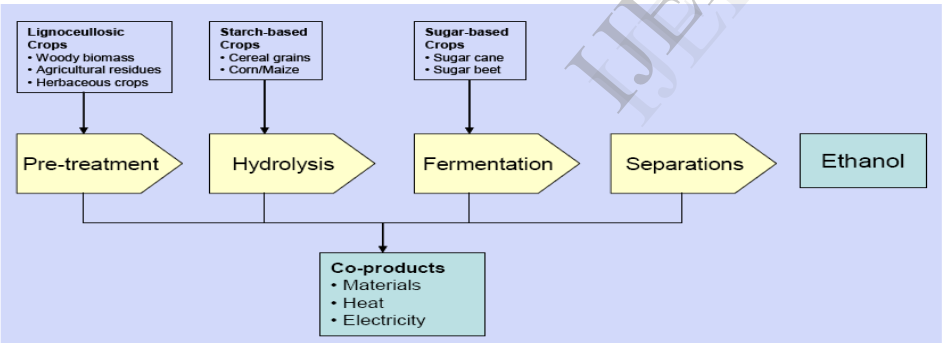


Out of which more than half is being used for fuel in US

Fuel Ethanol Scenario

Item/Year	2006/07	2007/08	2008/09	2009/10
Sugar Production/1(Million Tons)	**28.40**	**26.40**	**15.30**	**18.9**
Molasses Production (Million Tons)	13.31	11.31	6.88	8.4
Potential Alcohol Production (Million Lits)	3,195	2,700	1,650	1950
Demand (Million Lits)				
Portable Liquor and Other Use	**1,550**	**1,660**	**1,680**	**900**
I: Ethanol for 5 Percent Blending	600	650	700	820
I: Total Demand (including 5% EBP)	2,150	2,310	2,380	1720
I: Surplus/Shortfall (Million Lits)	**+1,045**	**+390**	**-730**	**+230**
II: Ethanol for 10% blend with Gasoline	1,200	1,300	1,400	1640
II: Total Demand(including 10% EBP)	2,750	2,960	3,080	3390
II: Surplus/ Shortfall	**+445**	**-260**	**-1,430**	**-590**

Route to Ethanol



Ethanol production processes

Energy security: The world according to oil

Energy security: The world according to farming

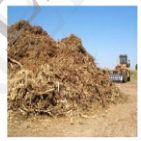
Cellulosic ethanol feedstocks

A diverse range of feedstocks can be found globally and the most common types include:

Woody biomass	Agricultural residue	Municipal waste	Energy crops
			
Hardwood Softwood Wood chips Wood waste Wood trimmings	Corn stover Sugarcane bagasse Wheat straw Rice straw	Wastepaper Solid organic waste	Switchgrass Miscanthus Arundo donax

Biomass Availability in INDIA

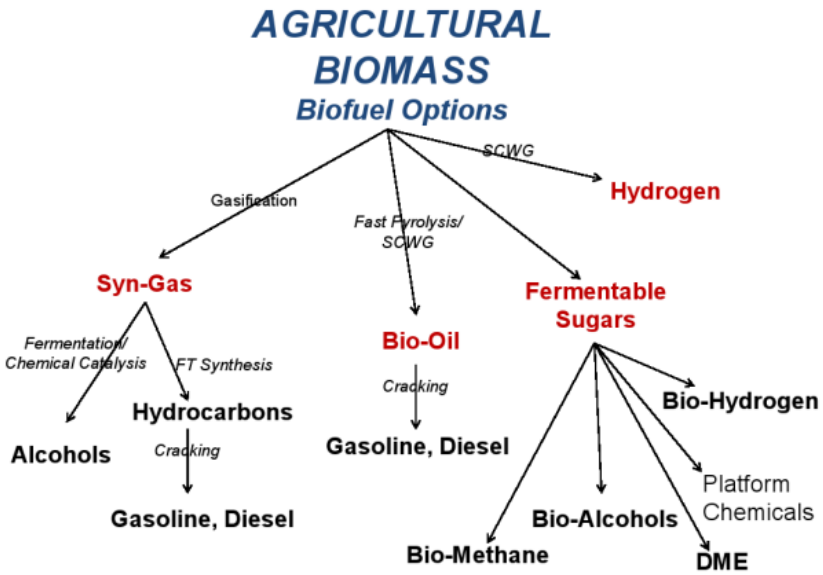
Non-food & Non-fodder/ Surplus Lignocellulosic Biomass:



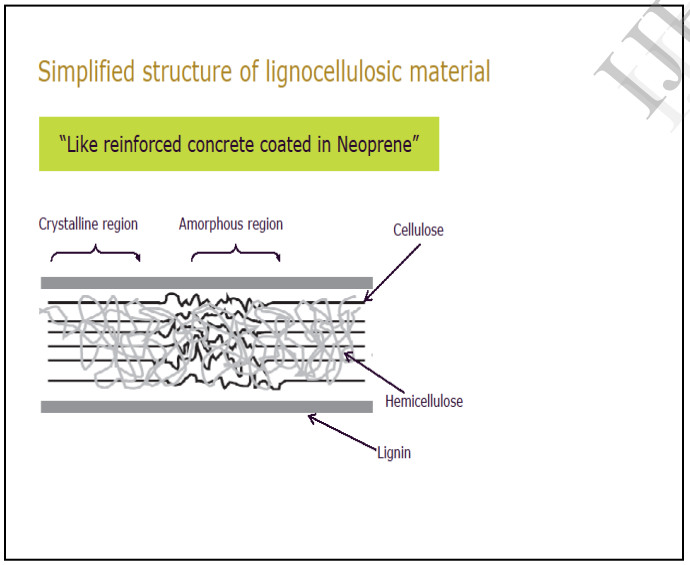
- *Cotton Stalk*
- *Wheat Straw*
- *Rice Straw*
- *Sugar Cane trash*
- *Many others !!*

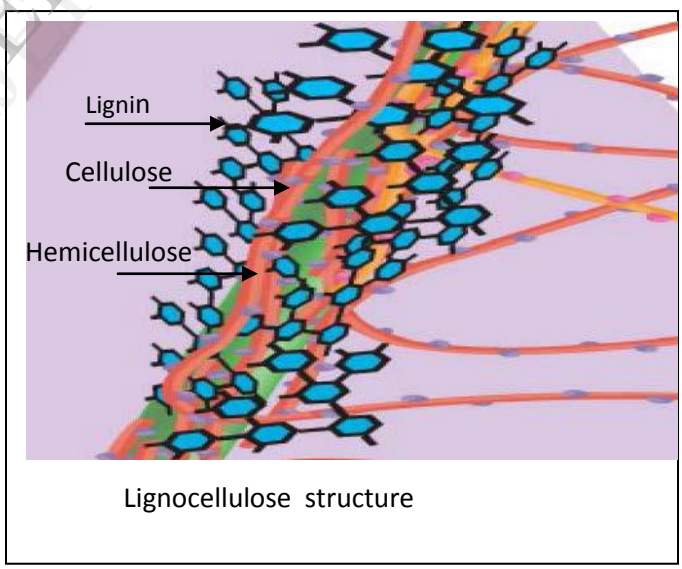
Annual availability > 300 MT !!
Biomass biofuel potential > 100 MT/year
Liquid Fuel Consumption = 50 million tons/year

Crop residues	Production Million tons	
	1994	2010 (projected)
Field based residues		
Cotton stalk	19.39	30.79
Rice straw	214.35	284.99
Wheat straw	103.48	159
Maize Stalk	10.98	20.07
Soybeans	12.87	34.87
Jute stalk	4.58	7.21
Sugarcane tops	68.12	117.97
Ground nut straw	19	23.16
Processing Based residue		
Rice Husk	32.57	43.31
Rice Bran	10.13	13.46
Maize cob	2.59	3.97
Maize Husk	1.90	2.91
Coconut shell	0.94	1.50
Coconut husks	3.27	5.22
Ground Nut Husk	3.94	4.80
Sugarcane bagasse	65	114.04
Coffee husk	0.36	0.58



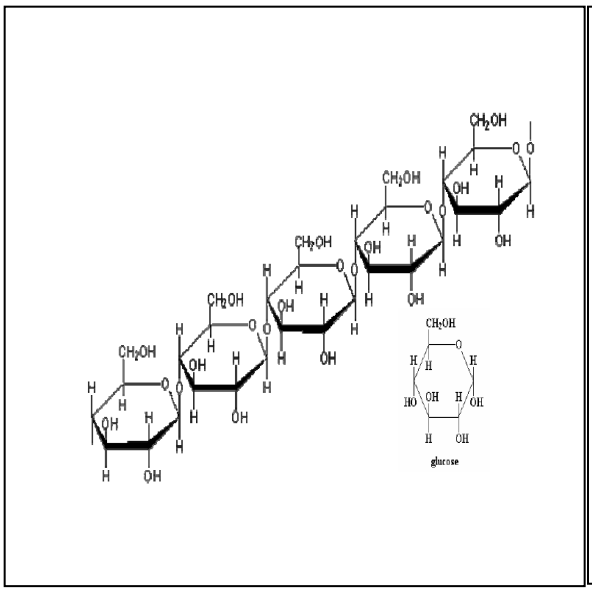
Methodology:



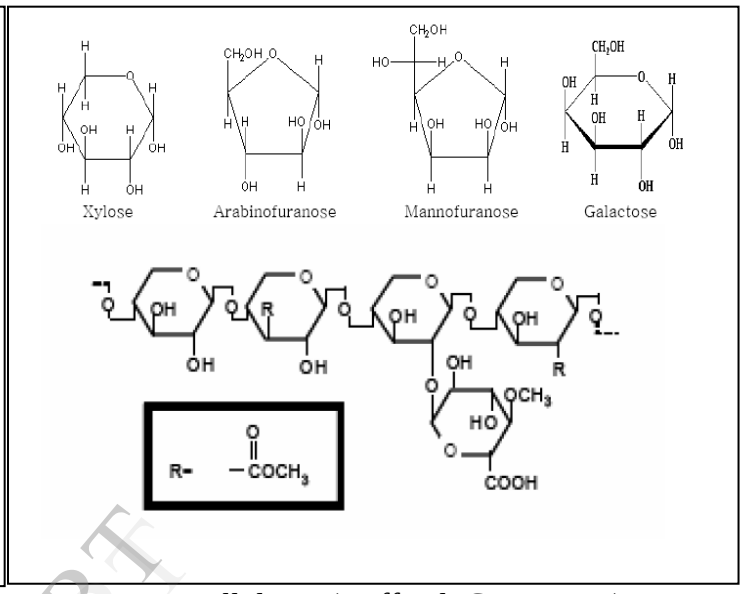


Lignocellulose structure

Major components of Lignocellulosic biomass



Cellulose (Easy conversion)

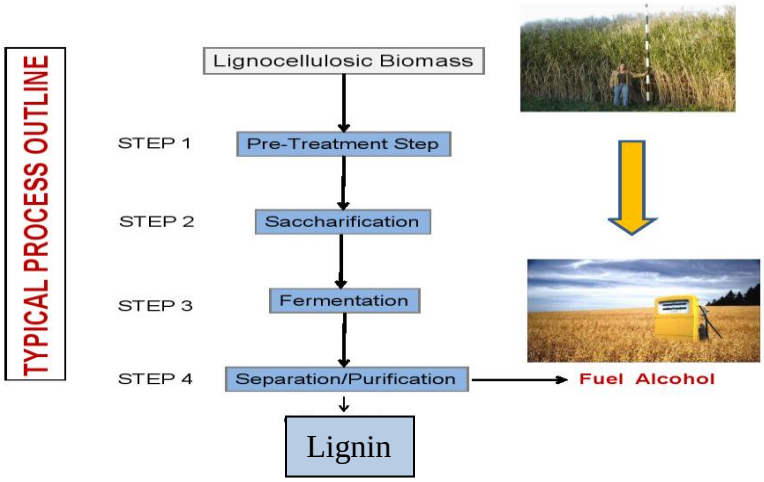


Hemicelluloses (Difficult Conversion)

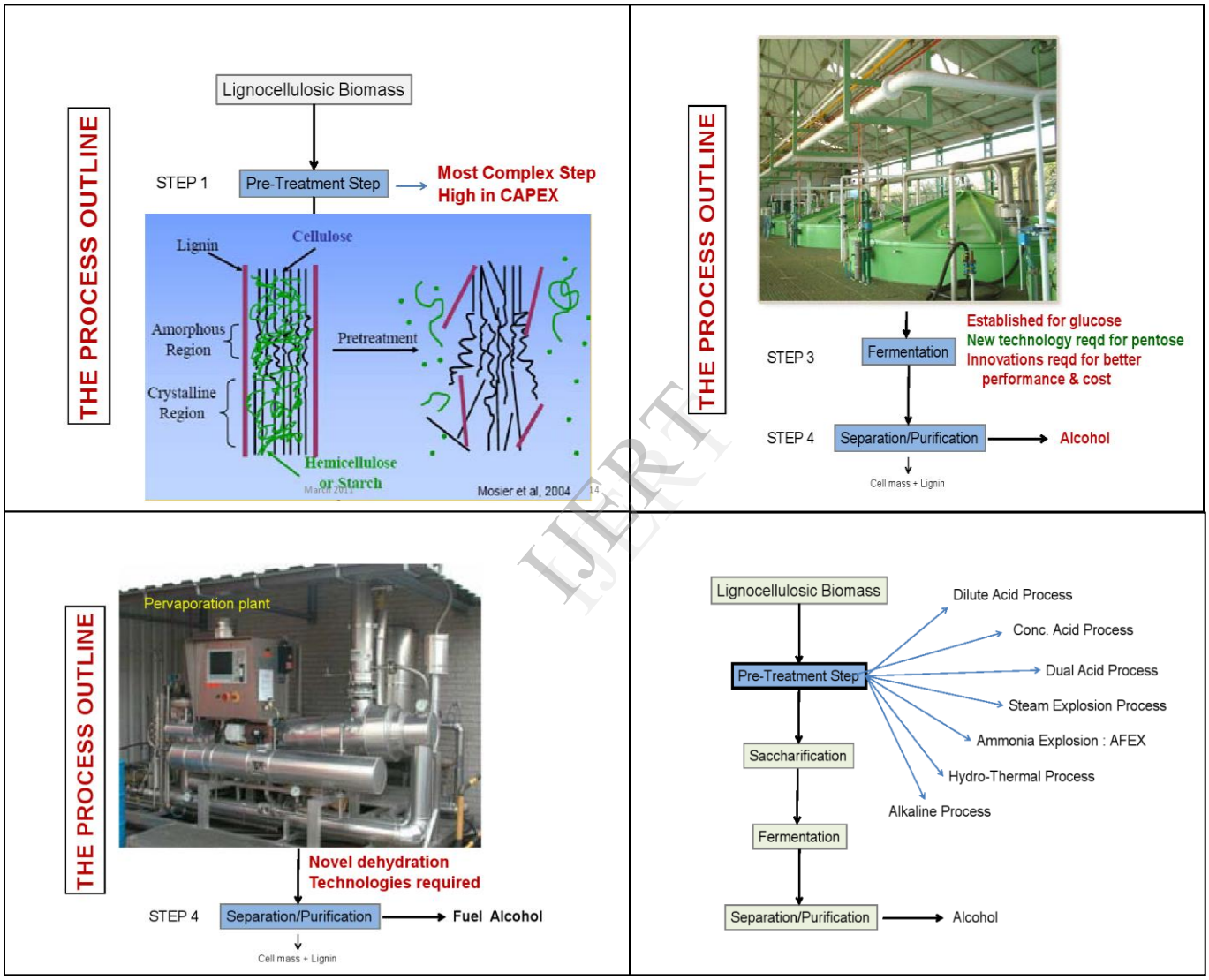
Cellulose is easy to convert ethanol but hemicelluloses are very difficult for conversion to ethanol.

Lignin structure is very complex.

Typical flow process of fuel production:



The typical process of fuel alcohol from lignocellulosic biomass is Pre treatment followed by saccharification and fermentation followed by separation where lignin is removed and purification process is done to produce fuel alcohol.



Major Challenging Areas

Pretreatment – *about 30 % of cost*

* *Producing low toxins*

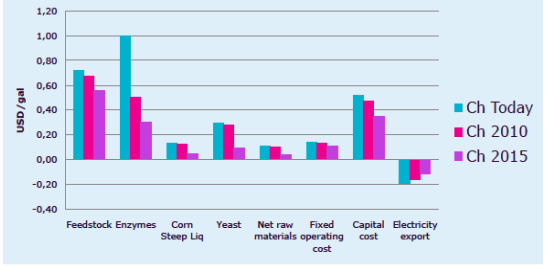
Enzyme Hydrolysis – *high opex*

* *High turn over & resistance to toxins*

Fermentation - *Utilisation of both C5 & C6 sugars*

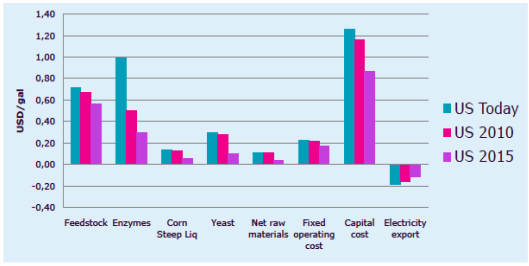
China, production cost estimate

Case	MESP (USD/gal)	Yield (gal/dry ton)
Today	2.7	70
2010	2.1	75
2015	1.4	89



USA, production cost estimate

Case	MESP (USD/gal)	Yield (gal/dry ton)
Today	3.6	70
2010	2.9	75
2015	2.0	89



Current Cellulosic Ethanol Status:

More than 70 pilot plant (1 ton /day to 100 ton/day) operational.
High yield biomass variety being developed.
Enzyme cost down significantly (from 5 USD/L to 0.5 USD/L)
Robust enzymes continuously evolving.
Fermenting strains continuously improved.
Ethanol dehydration technologies being improved.

Areas of Improvements:

Flexible multiproduct pretreatment technologies are required.

New enzymes/reaction systems should be developed.

New fermenting strains are required.

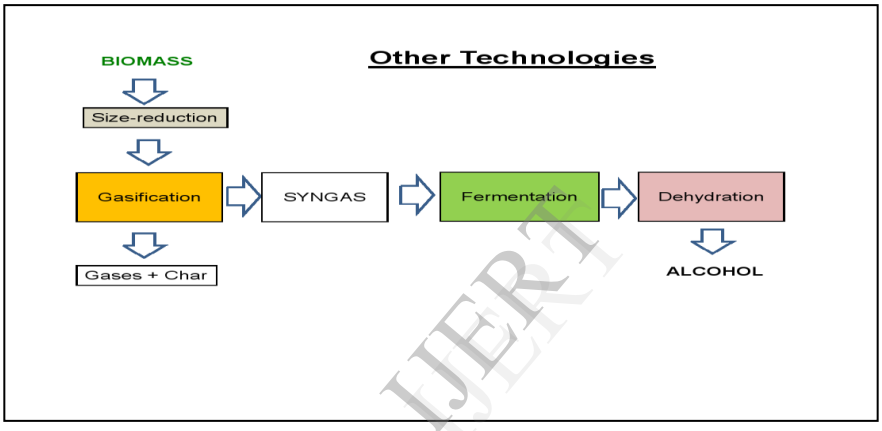
New fermenter design should be done on large scale.

New dehydration technologies are needed.

This calls for multi-disciplinary approach . Labs specializing in Biotechnology, chemical engineering, synthetic biology need to work in a net work

Comparison of Technology Platform

First Gen	Second Gen
Food vs. Fuel	Non food biomass
Needs arable land	Can grow on marginal lands & already available agri. waste
Conversion technology available	Technology still evolving
Low yields and viability	Viable- with R&D advances



Indian Efforts in Development of Cellulosic Ethanol Technology

Indian Efforts in Cellulosic Ethanol Technology:
Some basic R&D in several universities / research labs since last decade, Isolation / evaluation of natural enzymes main activity, Almost no work on enzyme characterization , modification, All efforts isolated and none was targeted at commercial level, Serious efforts , by few players, started about 5 years ago, Ms Praj Matrix ,Pune established a 1 TPD pilot with international collaborations (Qteros).
Good amount of data collected on pre-treatment , fermentation ICT-DBT centre in last 2 years has done excellent basic R&D. ICT-DBT developed a lab scale process based on enzyme recirculation , Collaboration with IGL to set up 8tpd unit at Kashipur. ICT-ICGEB-IOC combine to re-engineer micro-organisms for hydrolysis & pentose fermentation,Basic work on synthetic biology initiated.
IOC(R&D) designed country's first multi-feed multi-technology pilot with assistance of NREL,US
This facility , costing Rs 8 crores , will help generate authentic data which can be safely used in subsequent scale up, IOC-DBT centre shall in network with ICT & ICGEB develop hydrolysis & fermentation technologies. Real life data on biomass type and availability shall be priority LCA of each process

Cellulosic Ethanol – Prospects & Problems

Prospects	Problems
Effective utilization of waste biomass	Technology not yet commercial
Could take care of all India's gasoline substitute needs Basic technology platform exists	High costs of production Core biotech part missing
Some process routes highly scalable	Lack of R&D in India

Technological challenges in algae Production

Algae is not as well understood as plants, animals and microbes, large scale of algae production are still under study and third challenge is downstream processing to useful return.

Conclusion:

Cellulosic Ethanol is fast evolving.
Enzymes are getting better & cheaper
Production costs have dropped from $ 8/gallon in 2007 to $ 3 in 2010 and are expected to be ~ $ 2 / gallon by 2015
Still technical challenges are formidable
India needs to develop best suited technology platform.
Current focus on R&D is very promising.

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