Advances in Bio-Energy & Bio-fuels

by

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BIOENERGY & BIOFUELS

- Bio-energy – Source of Renewable energy
- 11% of world total primary energy supply
- 7% is used in developing countries in-efficiently
- 2% electricity production worldwide from biomass
  - - 464Twh
- 4 % of world transport fuel demand met thru Biofuels

National Bio-fuel Policy

Specific mandates and incentives for bio-fuels

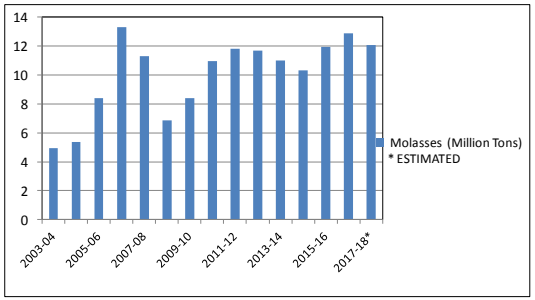
- **20% bio-fuels by 2017 (National Policy on Bio-fuels, 2009)** ***Now called an indicative target by 2020***
- **Permitted 5% blending of ethanol in gasoline . Now 10 % ethanol in gasoline is also permitted to achieve at least 5% target on all India level.**
- **Permitted 5% biodiesel in diesel & now upto 20 % biodiesel in diesel permitted.**
- **Government agreed on a prefixed price for biodiesel / ethanol to be purchased by oil companies (2005). Prices reviewed periodically.**
- **New purchase policy of ethanol & biodiesel implemented in 2014.**

  Last year Approx 3.8 % ethanol in gasoline , likely to go down to ~ 2 % this year

MOLASSES BASED ETHANOL

- Molasses production , linked to sugarcane production, varies from ~5 MMTA (2003-06) to ~13 MMTA (2016-17)
- Thus ,sustained supply of ethanol debatable
- About 40% of total ethanol production as fuel grade
- Even at peak production , it can meet only about 5-8 % blend level in gasoline
- Alternate and sustainable source of ethanol is required

Production of Molasses by the Sugar Industry



INDIAN ETHANOL PRODUCTION CAPABILITY

Fuel Ethanol –Indian Scenario

Item/Year	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17*	2017/18*
Sugar Production[2] (Million Tons)	28.40	26.40	15.30	18.9	24.39	26.34	25.14	24.5	22.6	26.2	28.2	26.5
Molasses Production (Million Tons)	13.31	11.31	6.88	8.4	10.97	11.82	11.7	11.0	10.32	11.95	12.87	12.07
Potential Alcohol Production (Million Lits)	3,195	2,700	1,650	1,950	2,633	2,838	2,808	2,640	2,477	2,868	3,089	2,897
Demand (Million Lits)												
Portable Liquor and Other Use	1,550	1,660	1,680	1,730	1,630	1,710	1,755	1,803	1,848	1,881	1,845	1,888
I: Ethanol for 5 Percent Blending	600	650	700	820	1,054	1,107	1,126	1,132	1,188	1,247	1,308	1,373
I: Total Demand (including 5% EBP)	2,150	2,310	2,380	2,550	2,684	2,817	2,881	2,935	3,036	3,127	3,153	3,260
I: Surplus/Shortfall (Million Lits)	**+1,045**	**+390**	**-730**	**-600**	**-51**	**+21**	**-73**	**-295**	**-559**	**-259**	**-64**	**-364**
II: Ethanol for 10% blend with Gasoline	1,200	1,300	1,400	1640	2,108	2,214	2,252	2,264	2,375	2,493	2,616	2,745
II: Total Demand(including 10% EBP)	2,750	2,960	3,080	3390	3,738	3,924	4,007	4,067	4,224	4,374	4,461	4,633
II: Surplus/ Shortfall	**+445**	**-260**	**-1,430**	**-590**	**-1,105**	**-1,086**	**-1,199**	**-1,427**	**-1,747**	**-1,506**	**-1,373**	**-1,736**

* Estimated

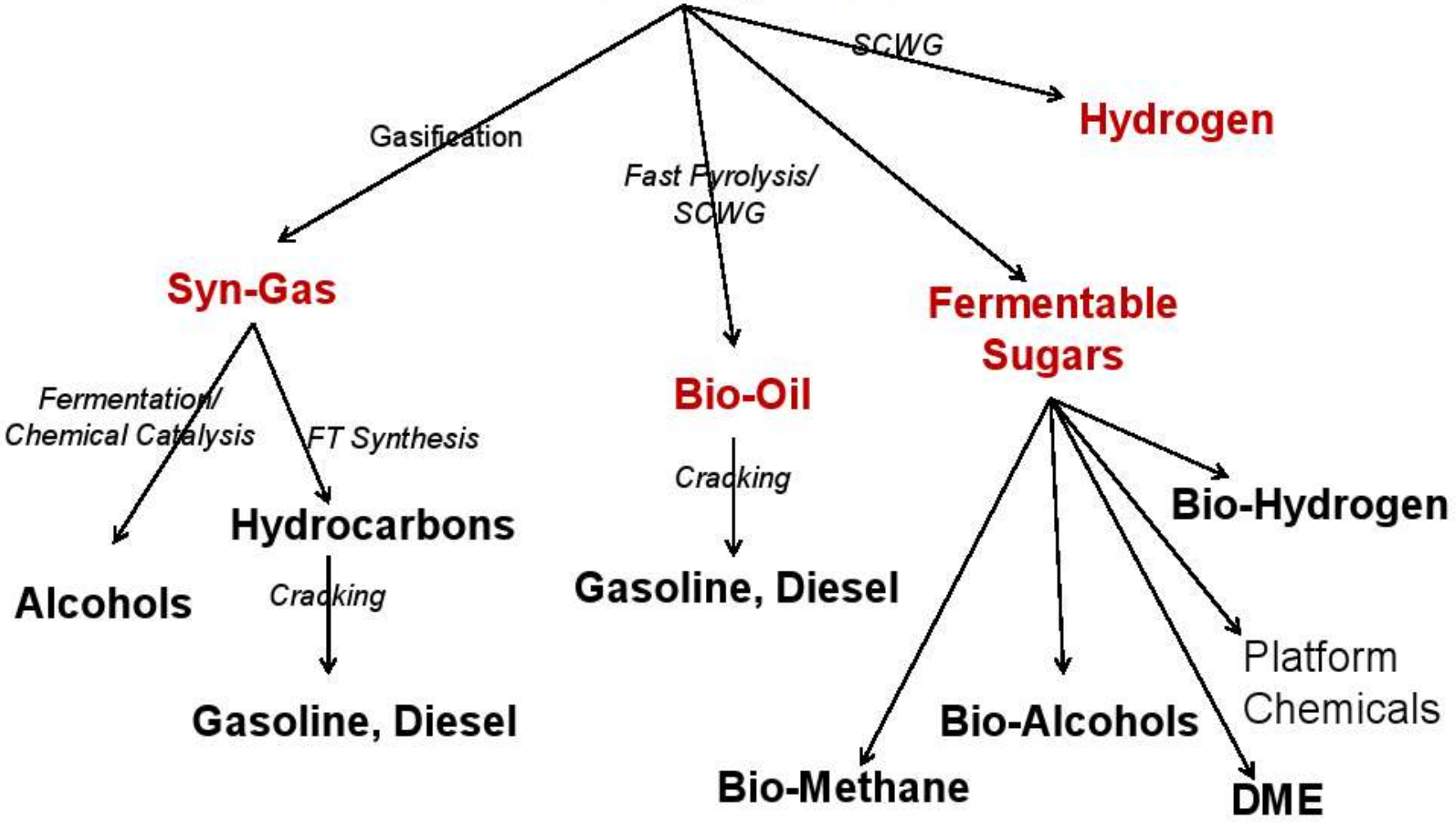
POSSIBLE SOLUTIONS

- No single feedstock or technology platform can achieve targets
- Non-edible oils will contribute but to little extent
- We need to look at all possibilities
  - Second /third generation bio-fuels
  - Bio-oils from biomass pyrolysis
  - Gasification of Biomass
  - Conversion of waste gases (CO) to ethanol
  - Biogas / ethanol from municipal waste
  - And all other options

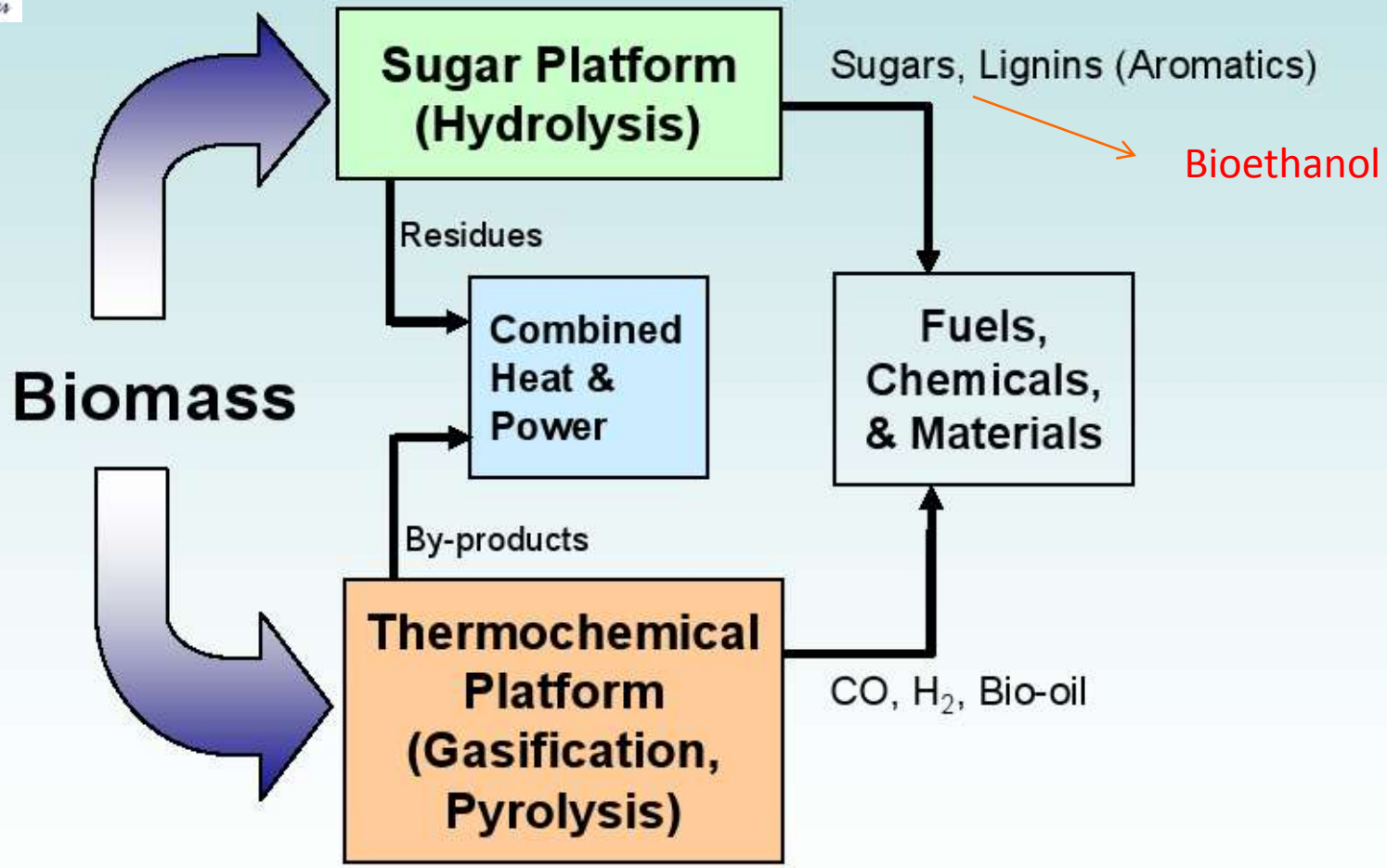
Each of above will contribute to achieve bio-fuel Mission

AGRICULTURAL BIOMASS

Biofuel Options



Biomass Conversion Technology "Platforms"



Ethanol Advantages

- Ethanol (Gen. 1st) can reduce CO_2 by 25-60 %
- Cellulosic ethanol will reduce CO_2 by 70-90 %
- Ethanol is good blend component for gasoline as it increases octane and reduces emissions

Biomass Sources

ECONOMICAL

Sugar Cane

Corn Starch

Corn Fiber

Switch Grass

Cottonwoods

MSW

Agri. residues

ABUNDANT & AVAILABLE

Biomass Availability in India

Non-food & Non-fodder/ Surplus

Lignocellulosic Biomass:

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

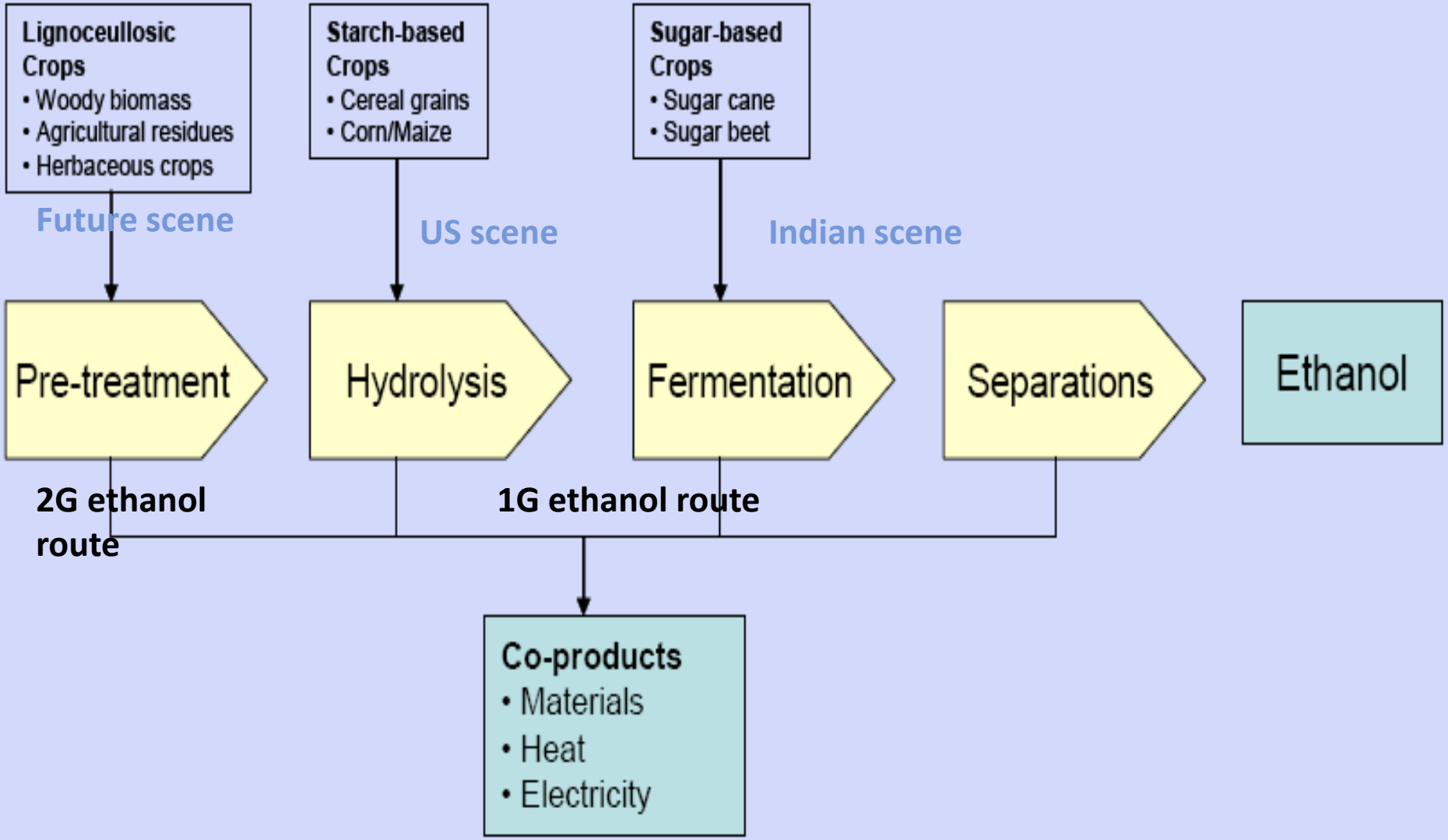
Annual availability > 300 MMT !!

Biomass biofuel potential ~ 30 MMT/y

Source : TIFAC report

Crop residues	Production Million tons	
	1994	**2010**
Field based residues		
Cotton stalk	19.39	30.79
Rice straw	214.35	284.99
Wheat straw	103.48	159
Maize Stalk	18.98	29.07
Soybeans	12.87	34.87
Jute stalk	4.58	1.21
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	0.28

ROUTES TO 1G & 2G ETHANOL



GHG EMISSION REDUCTIONS AND NER OF BIOFUELS AND CONVENTIONAL FUELS

Transportation fuel	GHG emissions (g CO2 eq./km)	reduction w.r.t gasoline	NER
Bio-ethanol, sugarcane molasses	50-75	77-70 %	3.2-4.5
Bio-ethanol, corn	100-195	**20-10%**	**0.9 -1.2**
Cellulosic ethanol	25-50	**88-77%**	**4.5 -6.0**
Biogas	50-100	77-20%	4.3-5.0
Biodiesel	80-140	63-35%	3.20
Gasoline	210-220	NA	0.80
Diesel	155-185	27-14%	**0.74**

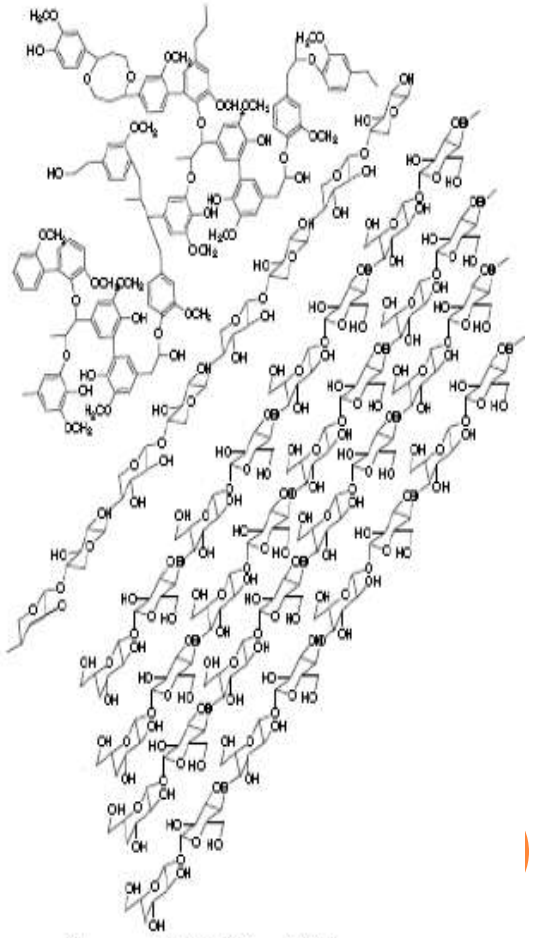
Biomass characterization

Components (% w/w)	Sugarcane Bagasse	Rice straw	Wheat straw	Cotton stalks
Cellulose	40	37	39	30
Hemicellulose	29	31	36	18
Lignin	13	16	10	30
Silica/Ash	2	12	6	2
Others	16	4	9	20

Increasing Severity Order

Bagasse < Rice Straw < Wheat Straw < Cotton Stalk

Cellulose + Hemicellose is Approx. 50-70 % which indicates ethanol potential of the feed



Source: J.D. McMillan, NREL

BIOMASS TO ETHANOL

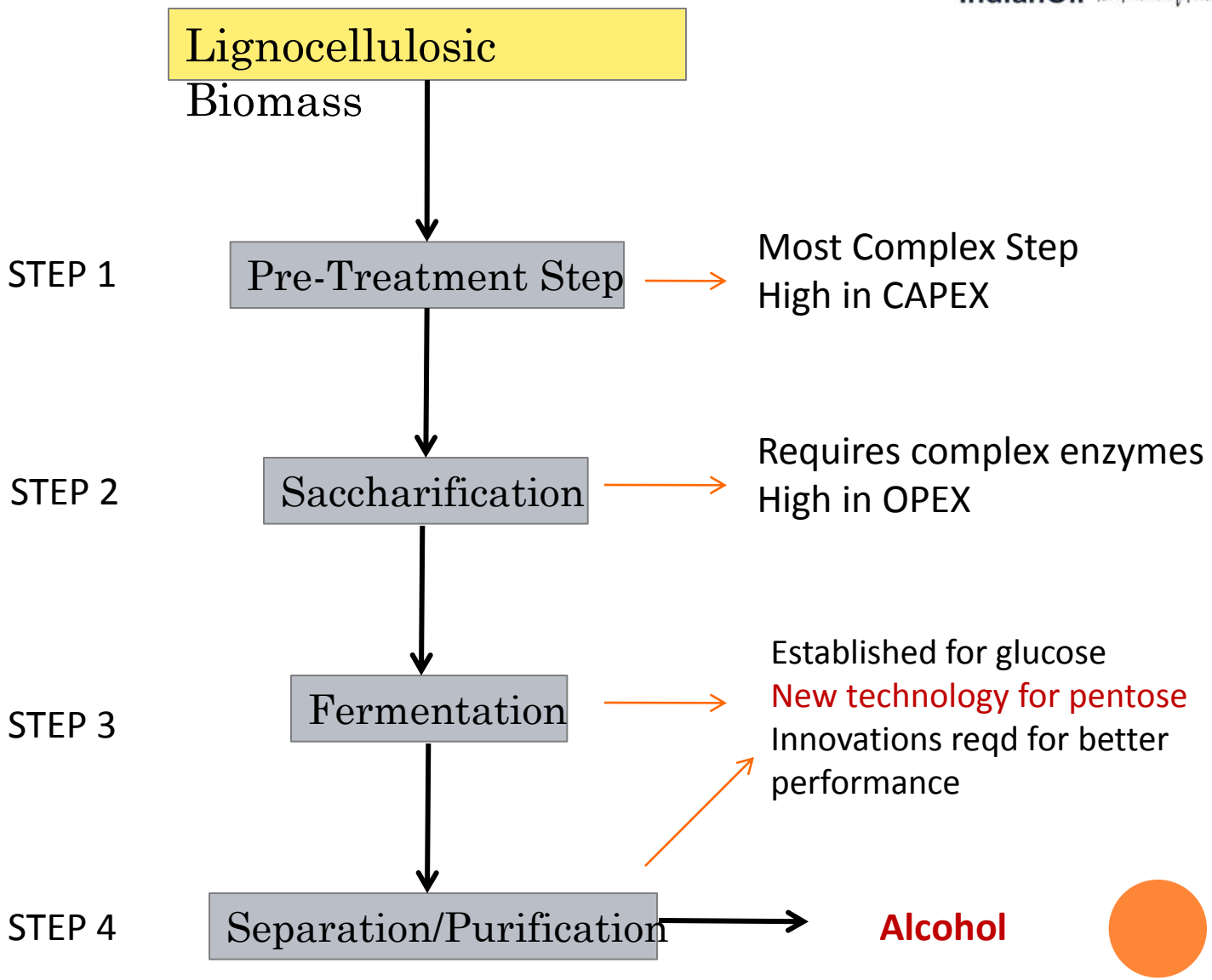
BIOMASS

SUGARS

ETHANOL

CELLULOSIC ETHANOL

TYPICAL PROCESS OUTLINE



Major Challenging Areas in 2G ethanol technology

- Pretreatment – *about 30 % of cost*

  * *Producing low toxins*

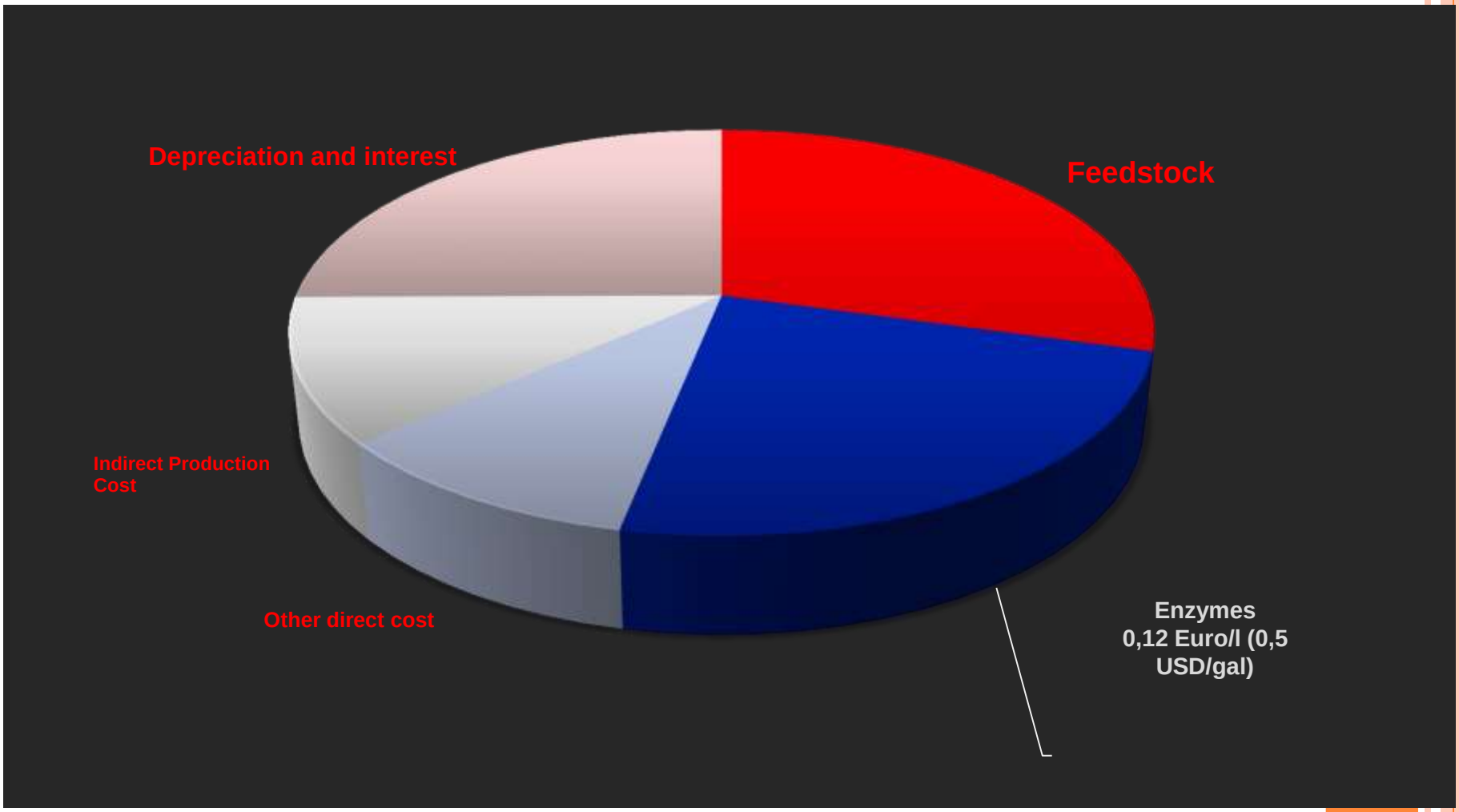
- **Enzyme Hydrolysis** – *high opex*

  * *High turn over & resistance to toxins*

- **Fermentation** - *Utilisation of both C5 & C6 sugars*

Consequence of Enzyme cost

Based on a ethanol production plant capable of approx. 100 MLPY.



"CELLULOSIC ETHANOL TO TAKE OFF FROM 2013" by Steen Riisgaard president and CEO of Novozymes
"what is next alternative for energy" Boston consulting group

©

1G ETHANOL GLOBAL SCENE

- US is largest producer and corn is used as feedstock
- US has almost all gasoline blended with 10% ethanol
- Brazil produces ethanol from sugarcane juice and blends to level of 27 % and 85 % in flexi vehicles
- European ethanol is from grains
- *Indian 1G ethanol can not follow this route*

2G ETHANOL NEED

- US uses about 1/3rd of total corn for ethanol production
- Corn ethanol reduces GHG, as compared to gasoline, only by 25-30%
- Long run the programm is unsustainable
- Huge amount of farm residue available
- 2G ethanol reduces GHG by ~70-90 %
- US thus introduced renewable Fuel Standards (RFS) where certain amount of 2G ethanol use is mandatory

CELLULOSIC ETHANOL GLOBAL STATUS

- **> 12 years of extensive R&D in US & Europe (Funded by DOE/EU)**
- Demo pilots appeared in 2005-10
- Commercial activity after 2012
- Enzyme companies (eg. Novozymes) ~ State funded for cost reduction
- **Six large plants operational**
  - **Beta Renewables (20 MG/yr) in Italy- 2013**
  - **Poet-DSM(20 MG/yr) -2014, Dupont (30 MG/yr) 2016, Abengoa (25 MG/yr) in USA-2014**
  - **Raizin (10 MG/yr)-2015 and Granbio (20 MG/yr) in Brazil- 2014**

Almost all plants faced initial teething problems before stablisation

Technology is still evolving as there are few operational and maintenance issues & mid term corrections being done

BIODIESEL

- **No Technological issue for BD production**
  - Trans-esterification/esterification
- Major Challenges to improve availability
  - Raw material
  - New raw materials required
  - Value addition of by products
  - 3rd Generation technologies
- **Production Capacity : 1.2 MMT A**
  - Low efficiency
- **OMCs started B5 blending in 2016**
  - **Very low production**
  -

CONCLUDING

- Bio Energy area is fast evolving
- Technologies are getting better & cheaper
- Production costs have dropped
- Still technical challenges are formidable
- India needs to develop best suited technology platform
- Current focus on R&D is very promising
- Large R&D funding available for promising projects

Thanks

RENEWABLE ENERGY INDICATORS 2015

		2014	2015
INVESTMENT			
New investment (annual) in renewable power and fuels[1]	billion USD	273	285.9
POWER			
Renewable power capacity (total, not including hydro)	GW	665	785
Renewable power capacity (total, including hydro)	GW	1,701	1,849
Hydropower capacity[2]	GW	1,036	1,064
Bio-power capacity[3]	GW	101	106
Bio-power generation (annual)	TWh	429	464
Geothermal power capacity	GW	12.9	13.2
Solar PV capacity	GW	177	227
Concentrating solar thermal power capacity	GW	4.3	4.8
Wind power capacity	GW	370	433
HEAT			
Solar hot water capacity[4]	GW_{th}	409	435
TRANSPORT			
Ethanol production (annual)	billion litres	94.5	98.3
Biodiesel production (annual)	billion litres	30.4	30.1
POLICIES			
Countries with policy targets	#	164	173
States/provinces/countries with feed-in policies	#	110	110
States/provinces/countries with RPS/quota policies	#	98	100
Countries with tendering / public competitive bidding[5]	#	60	64
Countries with heat obligation/mandate	#	21	21
Countries with biofuel mandates[6]	#	64	66

Bio-diesel Specification

S.No.	Characteristics (Unit)	IS15607:2005	IS-15607 - 16	ASTM D6751-15	EN 14214-14
1	Density at 15^0C ($kg/m^{3)}$	860-900	860-900	NA	860-900
2	K. V. @ 40^0C (cSt)	2.5 to 6.0	3.5-5.0	1.9-6.0	3.5-5.0
3	Flash point, PMCC (^{0}C) min	120	101	93	100
4	Sulphur (mg/kg) max	50	10	15/500	10
5	CCR* (% mass) max	0.05	0.05	0.05	-
6	Sulfated ash (% mass) max	0.02	0.02	0.02	0.02
7	Water & sediment (ppm) max	500	500	500	500
8	Total contⁿ (mg/kg) max	24	24	NA	24
9	Cu corrⁿ, 3h @ 50^0C (No) max	1	1	3	1
10	Cetane No., min	51	51	47	51
11	Acid value (mg KOH/g)	0.50	0.50	0.50	0.50

* Carbon residue shall on 100% sample

Bio-diesel Specification (cont...)

IndianOil R&D The Power of Possibilities

S.No.	Characteristics (Unit)	IS:15607:2005	IS-15607-16	ASTM D6751	EN 14214
13	**Methanol (% mass) max**	0.20	0.20	0.20	0.20
14	**Linolenic acid methyl ester, %m/m Max**	-	12	NA	12
15	**Ester content (% mass) min**	96.5	96.5	NA	96.5
16	**Free Glycerol (% mass) max**	0.02	0.02	0.02	0.02
17	**Total Glycerol (% mass) max**	0.25	0.25	0.24	0.25
18	**Phosphorous (mg/kg) max**	10	4	10	4
19	**Oxid^{n} stability @110^{0}C (h) min**	6	8	3	8
20	**Na & K (mg/kg) max**	5	5	5	5
21	**Ca & Mg (mg/kg) max**	5	5	5	5
22	**Iodine value g iodine/100gm max**	To report	120	NA	120
23	**Polyunsaturated (>-4 double bonds) methyl ester , % mass max**	-	1	NA	1

ENTS OF ANHYDROUS FOR USE IN AUTOMOTIVE FUEL AS PER IS 15464:2004

S. No.	Characteristic	Requirement
i)	Relative density at 15.6/15.6^{O} C, Max	0.7961
ii)	Ethanol content percent by volume at 15.6/15.6^{O} C, Min (excluding denaturant)	99.50
iii)	Miscibility with water	Miscible
iv)	Alkalinity	Nil
v)	Acidity (as CH_3COOH) mg/l, Max	30
vi)	Residue to evaporation percent by mass, Max	0.005
vii)	Aldehyde content (as CH_3CHO) mg/l, Max	60
viii)	Copper, mg/kg, Max	0.1
ix)	Conductivity, µS/m, max	300
x)	Methyl Alcohol, mg / litre, Max	300
xi)	Appearance	Clear & bright