Biomass to Biofuels - Bio-Mobility™ Platform

Ghansham Deshpande

President – Technology and Engineering

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Praj Corporate Overview

Core Competencies

Technology and Process Knowhow

Integration and Projects

Quick Scale-Up and Commerciali-zation

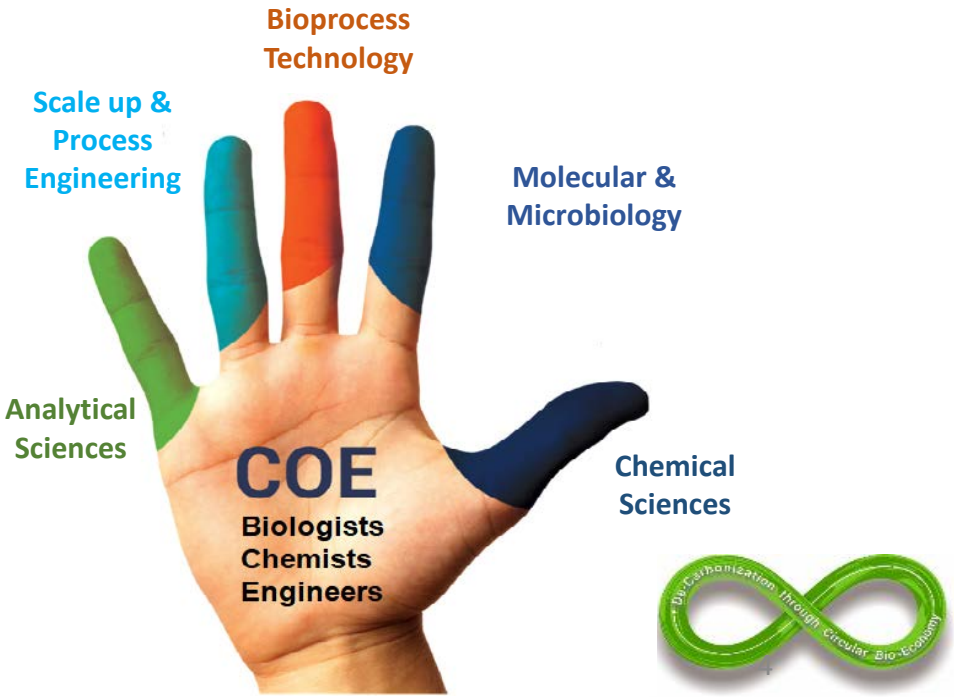
Engineering and Manufacturing

Focus on Bio-Process Engineering and Solutions in Energy, Environment and Agri-processing

Praj Matrix: The R&D Centre

- First of its kind R&D with Bench and Pilot scale facilities which enable validation of scientific assumptions and rapid commercialization
- Focus on “Green technologies’ with emphasis on sustainability
- Continuous Design & Development (D&D) endeavor to improve water and energy footprint
- Devoted to developing Bio-fuels and Renewable chemicals using advanced biotechnology tools.
- Certification by DSIR*, Govt. Of India

Ph.D.’s: 19
Masters: 55



*Department of Scientific and Industrial Research

Drivers for Biofuels

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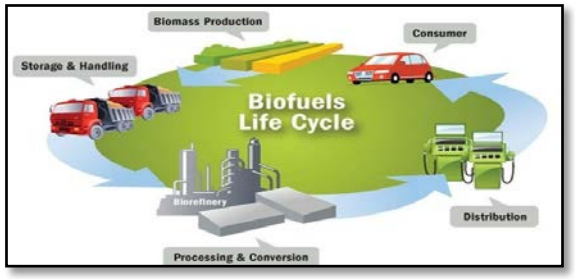
Energy

- Heavy reliance on imports
- Energy Mix skewed to fossil
- Energy Security



Environment

- Global warming -Rising GHG emissions
- Pollution due to rapid industrialization
- Climate change – COP 21

Economy

- Demand -Supply energy gap
- Accelerate Rural Economy
- Huge Forex /import bill

Social

- Job opportunities in rural areas
- Health issues due to pollution
- Eco-system under - developed

Biofuels has potential to address most of the issues.

De-Carbonization through Circular Bio-Economy

India Energy and Biofuel: Some facts

3rd Largest Consumer of Primary Energy

3RD

Indigenous Crude Oil Production in 2019-20

32.16

MMT

Crude Oil Imports in 2019-20

270

MMT

Self Sufficiency in Petroleum Products

15%

India's CO_2 Emission

2.29

Billion Ton

Contribution of Transport Sector to GHG Emissions

20-22%

Reduction in Emission Intensity by 2030

30-35%

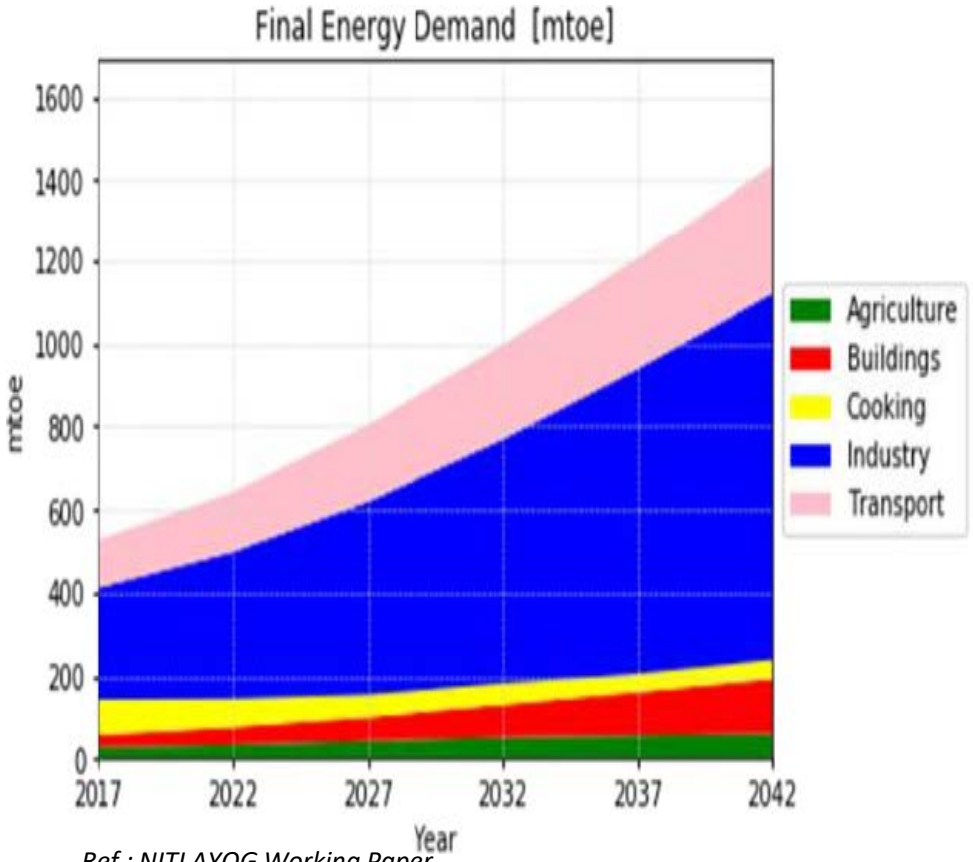
Intended Nationally Determined Contribution

Ethanol Blending Achieved in 2019-20

5 %

Sustainable Biofuels for Transportation is Need of the hour

India's Energy Scenario



Ref.: NITI AYOG Working Paper

Fossil Fuels	Production in India	Import	% Import	Import Bill $ Bln
Crude Oil	32.16 (MMT)	270 (MMT)	85%	102
LNG	33,680 (MMSCMD)	30,257 (MMSCMD)	51%	9

Source: https://www.ppac.gov.in/WriteReadData/Reports/202011230915290355175SnapshotofIndiasOilGasdataOctober2020.pdf

As per IEA India will be importing 90% of its consumption by 2040

India's energy consumption has more than doubled since 2007

Rising level of vehicle ownership keeps transport fuel demand on an even steeper upward curve

Need for Sustainable Alternate Import Substitute

Global Share of Biofuels

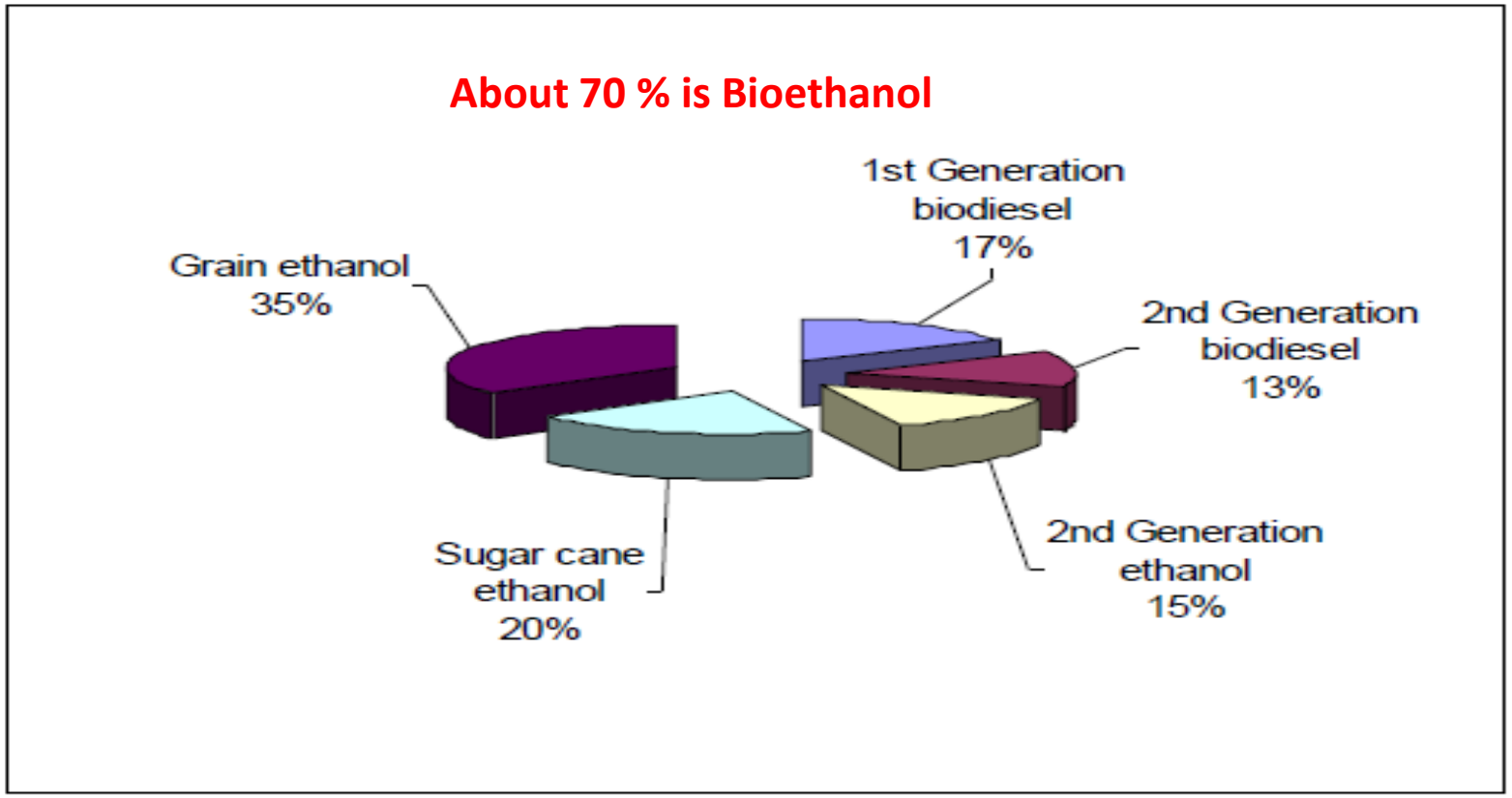
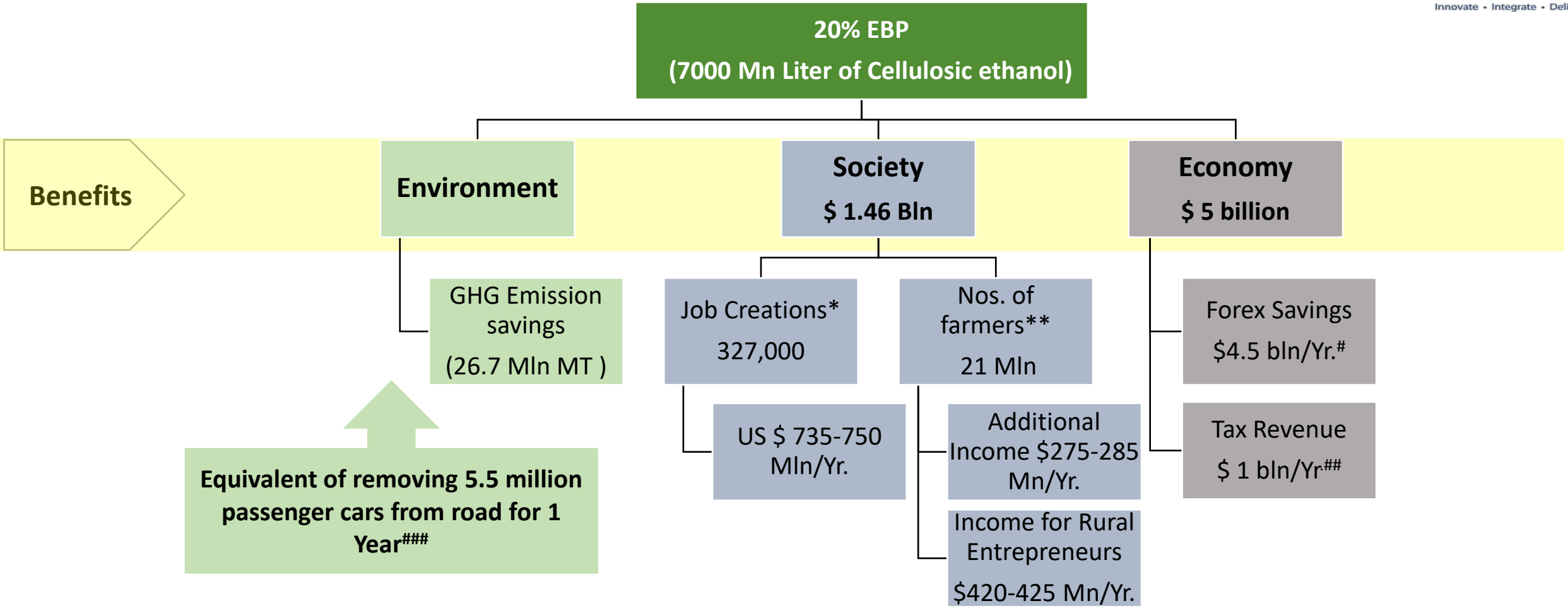


Figure 6: Likely global share of different biofuels type for 2020. Based on US Department of Energy data.

Bio-Ethanol :Bio-Economy Contributor



Bio based Technologies spinning wheels of Bio-Economy

*Note: 1) GHG emission saving from farm (by avoiding burning) – 19000 MT CO2 equivalent 2) GHG emission saving from ethanol production process – 42700 MT CO2 equivalent 3) GHG emission saving from ethanol blending – 60000 MT CO2 equivalent 4) Total GHG emission saving from farm to fuel for 100 KLPD plant is 121000 MT CO2 equivalent/year
#1USD = 66 INR ## Average tax revenue to government from 100 KLPD rice straw to ethanol plant is INR 30 Crores/ Annum
*Assuming 1500 Jobs for 100 KLPD plant covering (50 jobs for plant operations + 100 Village Level Entrepreneurs + 1350 Unskilled labor for biomass sourcing & supply chain) & 1.5 Lac income / Job **Assuming yield of 1.15 MT/Ha Rice Straw & Total land required for 100 KLPD plant will be 120000 MT/Year ***Assuming INR600/MT of rice straw realization to farmer ****Assuming INR 900/MT of rice straw realization to rural entrepreneurs

Frontier In Bioeconomy

Leveraging
Feedstock, Technology and Product Expertise

Bio-Mobility™

Bio-Prism™ (RCM)

Positive IMPACT

1 Environment

- Climate Change
- Global Warming
- Cop-21 Commitments

2 Economy

- Huge Forex / import Bill
- Bolster Rural economy
- Bridge gap in Demand-supply of energy

3 Social

- Job Creation in farming community
- Rural Entrepreneurship
- Health issue due to pollution

Building on global track record in Bio-fuels industry

Bio-MobilityTM: Reconfiguring transportation fuel mix

Bio-Mobility™ denotes carbon neutral renewable transportation fuel produced from Biological resources

- **Demand** for transportation fuel is **ever rising**
- Transportation sector the **major contributor** to rising **GHG** emission
- Both, major cause for **environmental Pollution** and major **health hazard**
- **Bio-Mobility™** based transportation helps minimize **carbon footprint**

*SAFs- Sustainable Aviation Fuels

Bio-mobility : Technology Perspective

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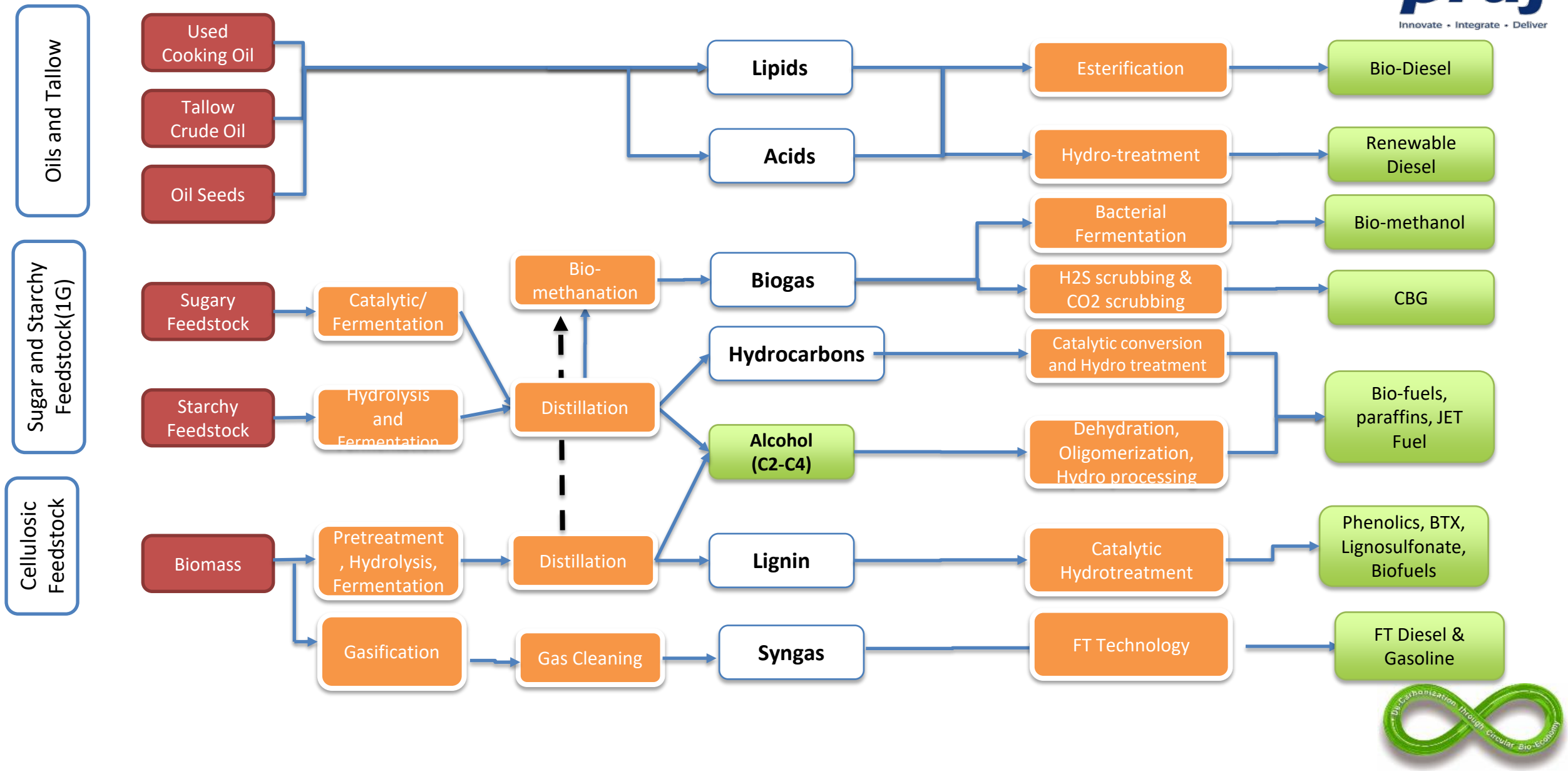
- Process Intensification in 1G – Energy reduction
- Low Carbon Technologies-LC Ethanol
- High Energy Density Bio-Fuels – BioJet ,Renewable diesel
- Negative Carbon Technologies – Carbon Capture
- Low Carbon Bio-Chemicals and Biomaterials

Carbon Neutral to Carbon Negative Technologies

Bio-mobility - Pathway



Bio-MobilityTM Bio-fuels

1st Gen ethanol

Produced from Sugary and Starchy feedstock .

2nd Gen ethanol

Produced from agri-residues such as Bagasse, Corn Cob, Rice Straw, Wheat Straw etc

Bio-methanol

Produced from Agri bio-mass like bagasse, paddy straw, wheat straw, etc

Compressed Bio-gas (CBG)

Produced from renewable feedstock such as Bio-mass, Press mud etc

Bio-Diesel

Efficient and cost effective Enzymatic technology

Sustainable Aviation Fuel (SAF)*

Bio based jet fuel produced using sugars, starch & biomass

Marine Biofuels*

Produced from Lignin based feedstock

Facilitate energy self reliance, economy & growth of farming community

* Under commercialization

Bio-Mobility™: Reconfiguring transportation fuel mix

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Bio-Mobility™ denotes carbon neutral renewable transportation fuel produced from Biological resources

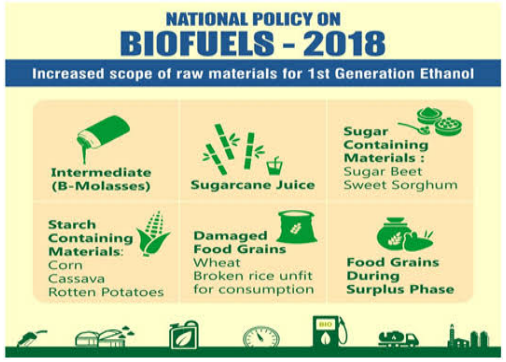
- **Bio-ethanol**

*SAFs- Sustainable Aviation Fuels

De-Carbonization through Circular Bio-Economy

Vision for Bioethanol in India

COP21·CMP11
PARIS2015
UN CLIMATE CHANGE CONFERENCE

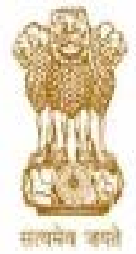


Target set to achieve

10% Ethanol blending by 2022

20% Ethanol blending by 2030

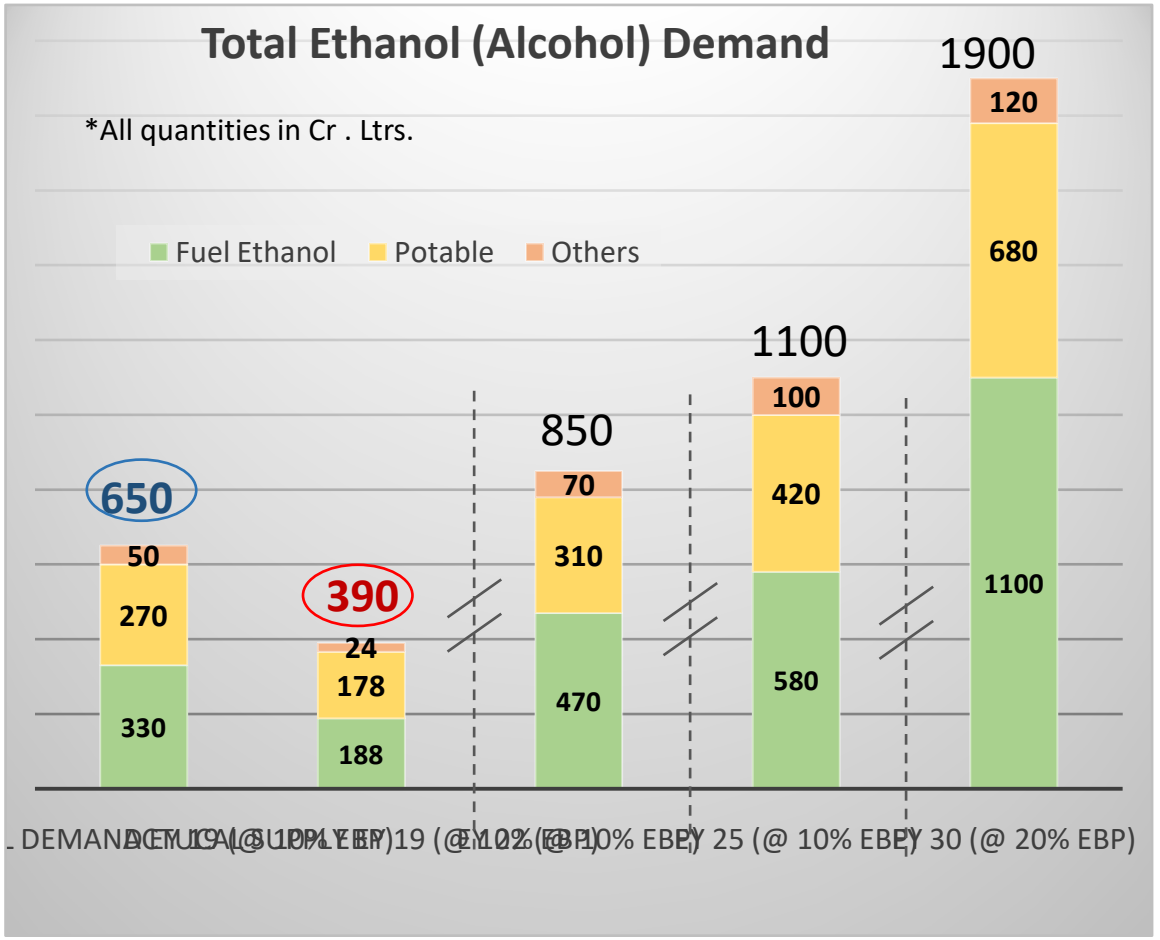
- Retain employment and additional employment generation in rural India.
- Strengthening rural economy.
- Enhanced and sustainable income for farmers.
- Ensuring energy security and self-reliance by enhancing biofuels production.
- Reducing import bill pertaining to fossil fuels.
- Reduction in carbon emission.

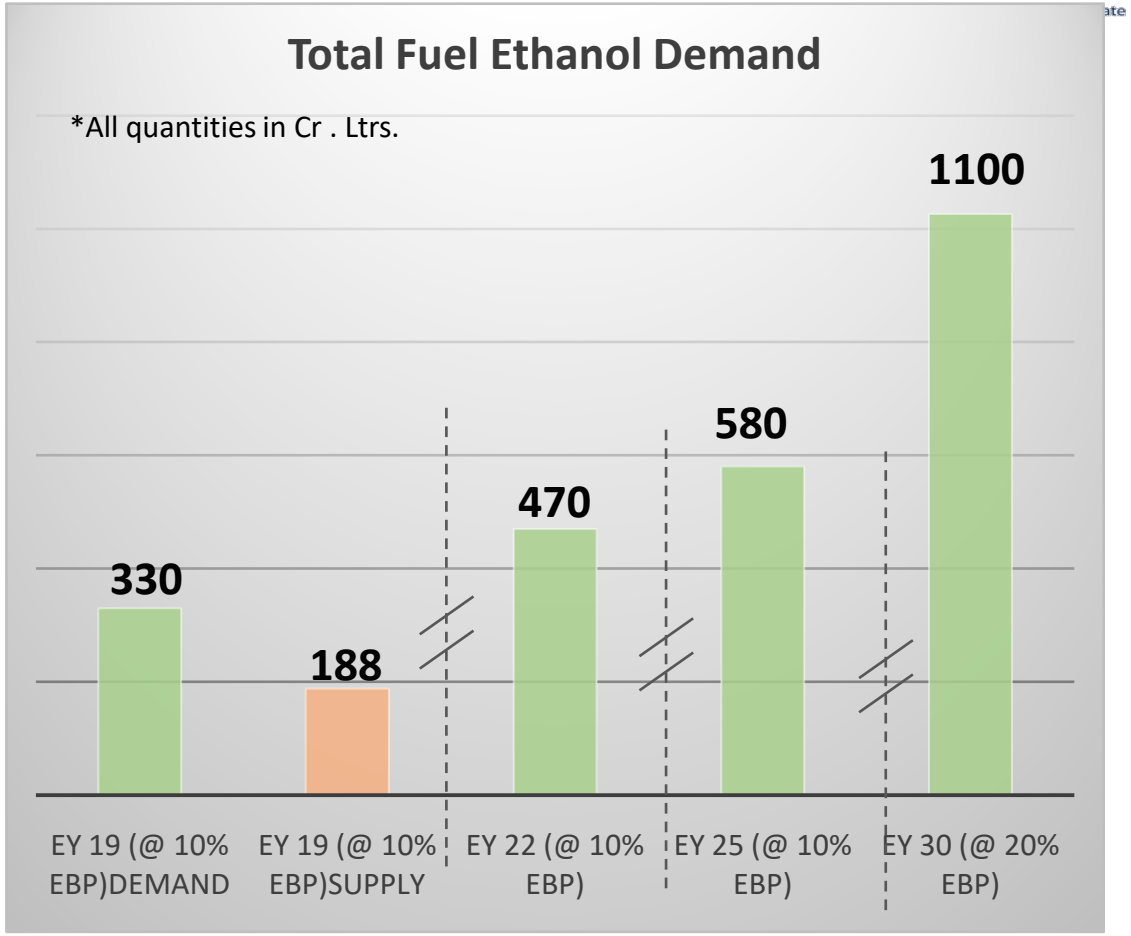


DOUBLING FARMERS' INCOME
Rationale, Strategy, Prospects and Action Plan

Progressive vision Supported by Strong Policy Environment

Total Ethanol Demand Scenario up to 2030





Others Alcohol demand includes industrial and pharma based requirements

Source of information: For potable Ethanol - Market research reports (imarc) For fuel Ethanol – EY 2022 and 2025 Fuel Ethanol tender document

EY-Ethanol Year (Starts from Dec to Nov)

E20+ will demand 1100 Cr. lit (11 Bl. Lit per yr) of Ethanol by 2030

Feedstock Availability Scenario: 1G

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Surplus Sugar Availability

Sugar Season	Opening stock	Sugar Production	Sugar Consumption	Export Expected	Buffer	Excess Sugar
	MMT	MMT	MMT	MMT	MMT	MMT
20-21	11.5	32	26	4	3	10.5
21-22	10.5	30	26.5	4	3	7
22-23	7	29	26.5	3	0	6.5
23-24	6.5	29	27	3	0	5.5
24-25	5.5	28	27	3	0	3.5
25-26	3.5	30	27.5	2	0	4
26-27	4	31	27.5	2	0	5.5
27-28	2	31	28	1	0	4
28-29	4	30	28	1	0	5
29-30	5	31	28	0	0	8

Avg. Excess Sugar Availability of **6 MMT P.A.**

Surplus Grain Availability

- New rice grain arrival 2020-21(E): 117 MMT
- Expected consumption of rice grain: 98 MMT
- Expected surplus Rice grain: 19 MMT
- Last year surplus carry forward: 15 MMT
- Estimated surplus Qty. of Wheat around 8 MMT.

Avg. Surplus grain availability **23 MMT P.A.**

Source for Sugar: VSI , Industry and mathematical assumptions

Source for Grain*: FCI,* https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1602455, DFPD

Adequate feedstock to achieve E20 by 2030

De-Carbonization through Circular Bio-Economy

Feedstock Availability Scenario: 2G

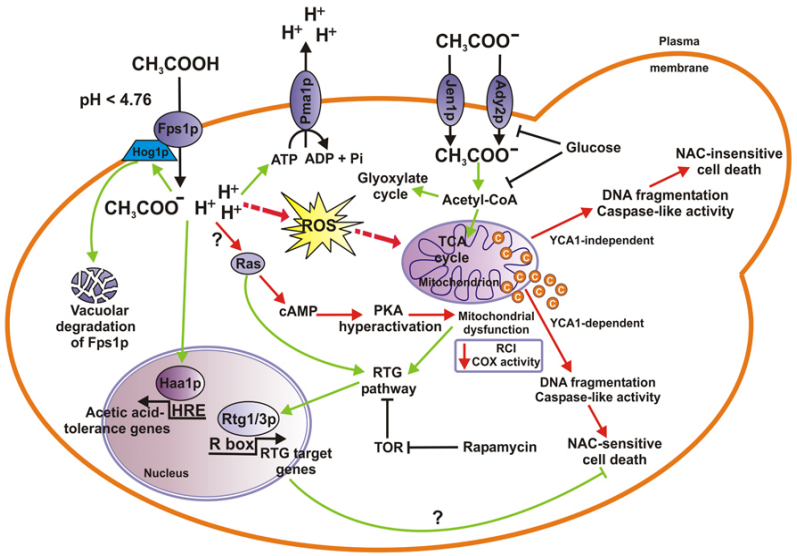
Surplus Biomass Availability

Sr. No	Biomass	Generation (MMT)	Surplus (MMT)
1	Rice Straw	112	8.5
2	Rice Husk	22.4	0.4
3	Wheat Straw	109.9	9.1
4	Sugar Cane Tops	97.8	79.5
5	Sugar Cane Bagasse	101.3	6.4
6	Maize Stover	22.7	1.1
7	Maize Cob	4.2	1.7
8	Maize Husk	2.7	1.1
9	Sorghum Stover	15.6	1.6
10	Bajra Stalk	12.2	1.2
11	Cotton Stalk	18.9	11.4
12	Chillies Stalk	0.6	0.5
13	Ragi Stalk	4.6	0.5
14	Pulses Wastes	18.9	5.7
15	Oil Seed Wastes	57.7	17.3
16	Bamboo (Top, Root and Leaves)	5.4	3.3
17	Pine needles	1.6	1.2
18	Water Hyacith (Whole)	15	14
	Total	623.4	164.5

Forest residues are not included

Excess Biomass Availability of ~**165 MMT P.A.**

Sugar to Bioethanol



$(C_5H_8O_4)_n + n\ H_2O \longrightarrow (C_5H_{10}O_5)_n$

132 kg HC + 18kg Water → 150 kg Sugars

$(C_6H_{10}O_5)_n + n\ H_2O \longrightarrow (C_6H_{12}O_6)_n$

162 kg Starch + 18kg Water → 180 kg Sugars

$n\ (C_6H_{12}O_6)n \longrightarrow 2n(C_2H_5OH) + 2n\ CO_2$

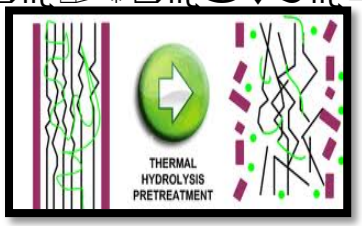
180 kg Sugars → 92 kg Ethanol + 88 kg

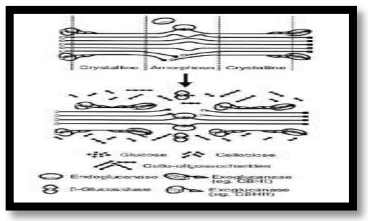
1 MT of Molasses (45 % w/w FS) yield 250 lit

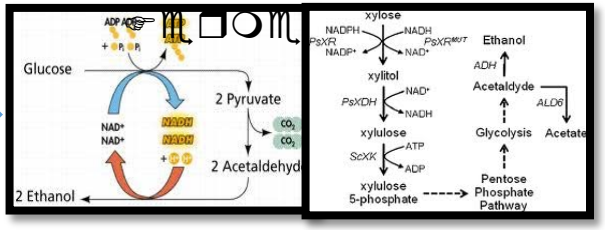
1 MT of Grain (65 % w/w starch) yields 400 lit

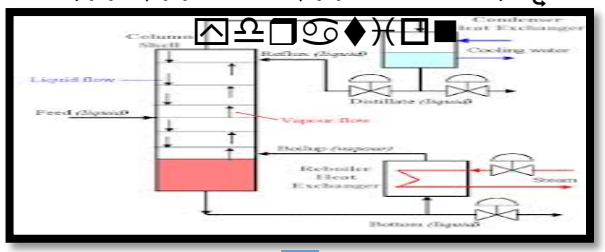
1MT of Biomass (50% carbohydrates) yield 250 lit

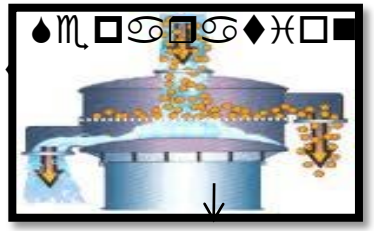
Biomass to Bio-Ethanol : Process

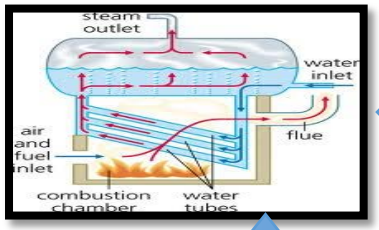


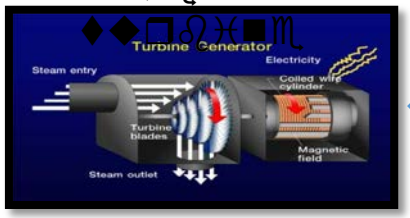












Biomass to Bio-Ethanol- Technology Development

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2009 - 16
1 BDTPD Pilot Plant Operations

2016 - 18
12 BDTPD Industrial Demo Scale Cellulosic Ethanol Biorefinery

2019 - 20
Process Optimization and Value Engineering

2020 - 21
425 BDTPD Commercial Scale Cellulosic Ethanol Bio-refinery

Feedstocks Handled

Agro Residues

Forest Residues

enfinity
Biomass to Ethanol Technology

1 ton of dry bagasse yields 250-260 lit of Ethanol

De-Carbonization through Circular Bio-Economy

enfinity – Demo Facility ,Pune, India

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enfinity
Biomass to Ethanol Technology

Our technology brings **infinite possibilities** to the environment and energy challenges confronting mankind… by making use of nature's **endless** resources. That's why we proudly call it…..**enfinity**.

De-Carbonization through Circular Bio-Economy

Viability Improvement Plan: Biomass to Bio-ethanol

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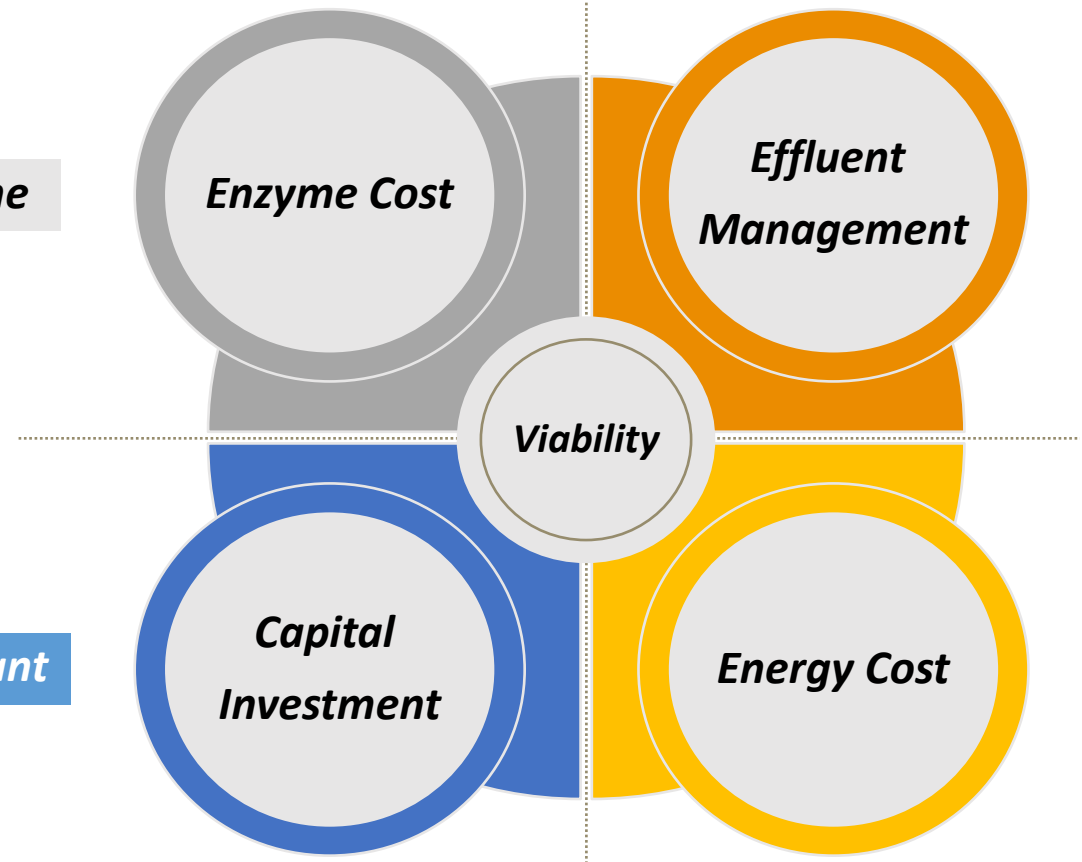
Integrated Onsite Enzyme

Lignin Based Co-products



Bolt-on to existing 1G Plant

Combined Heat & Power & POI

De-Carbonization through Circular Bio-Economy

Enzyme Cost Reduction

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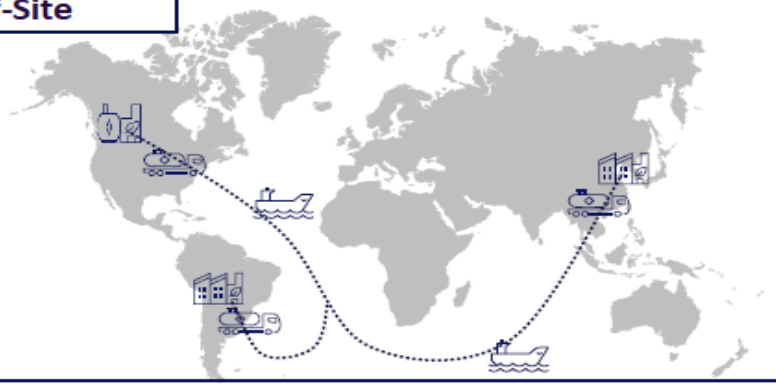
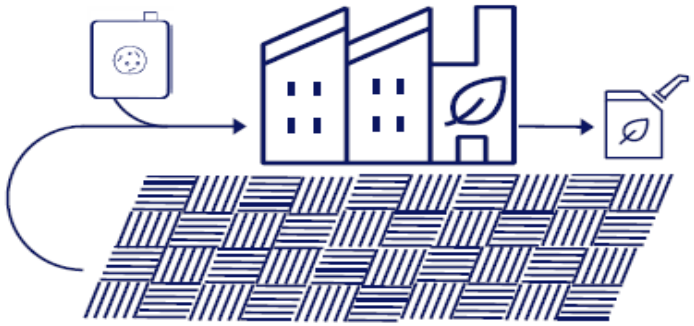
Off-Site



On-site



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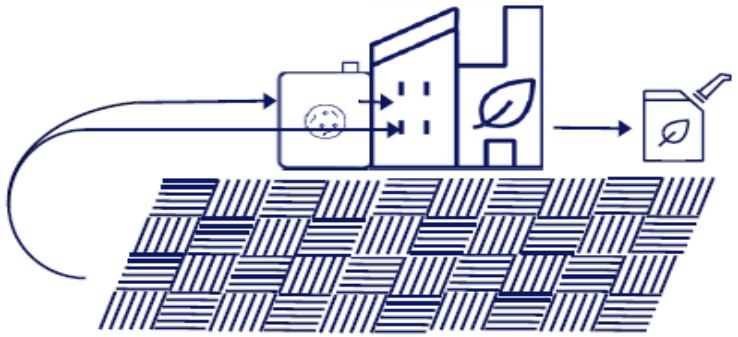

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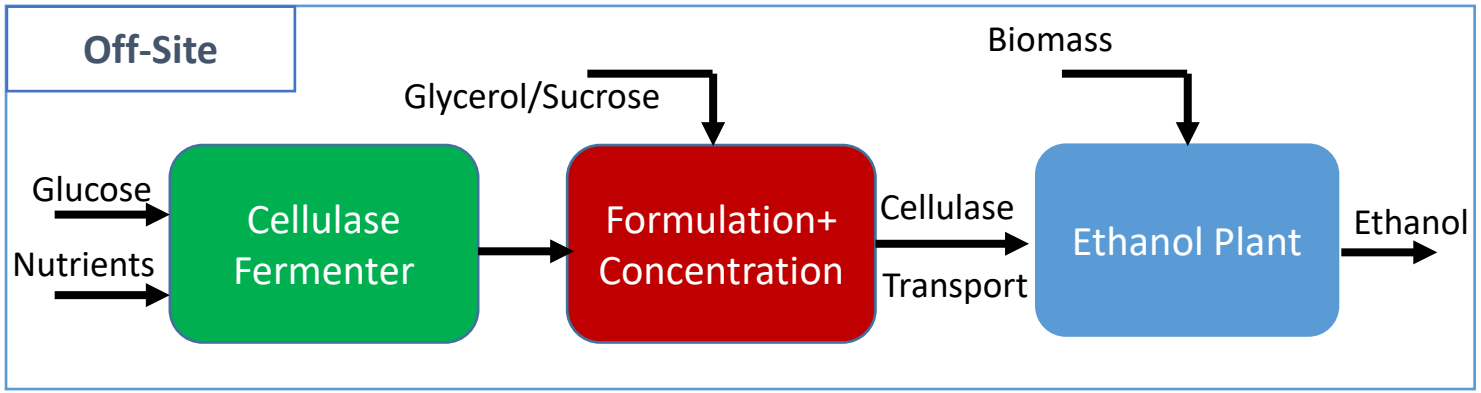

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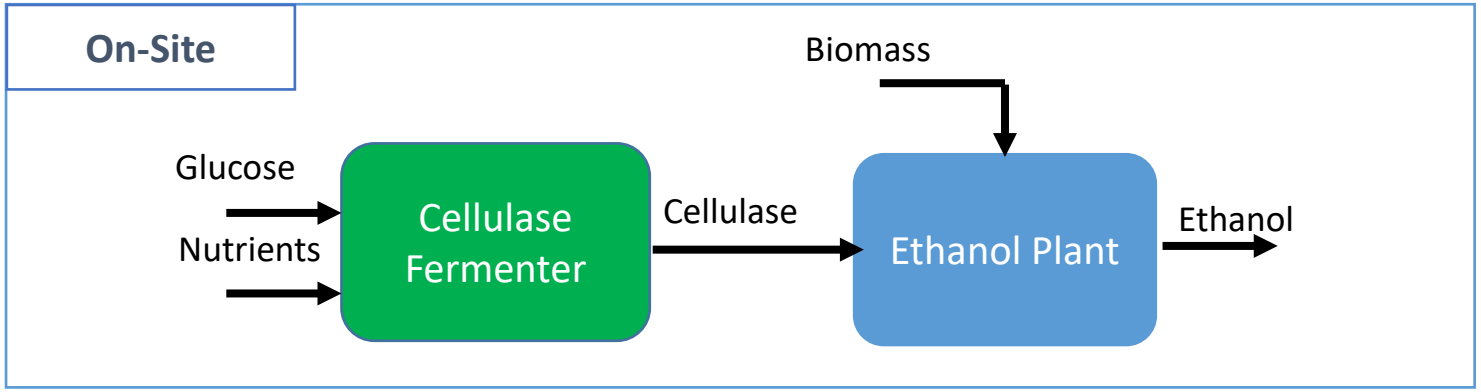

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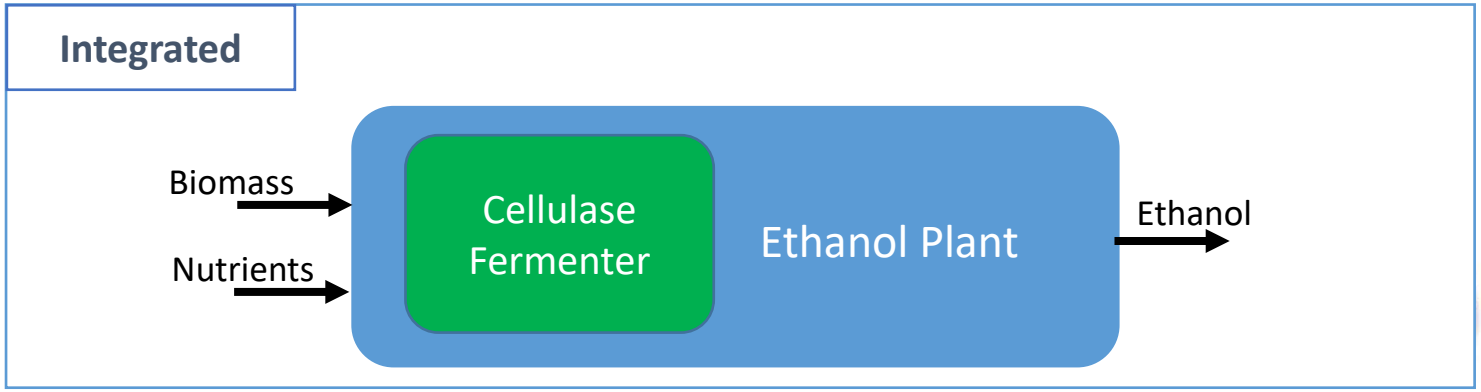
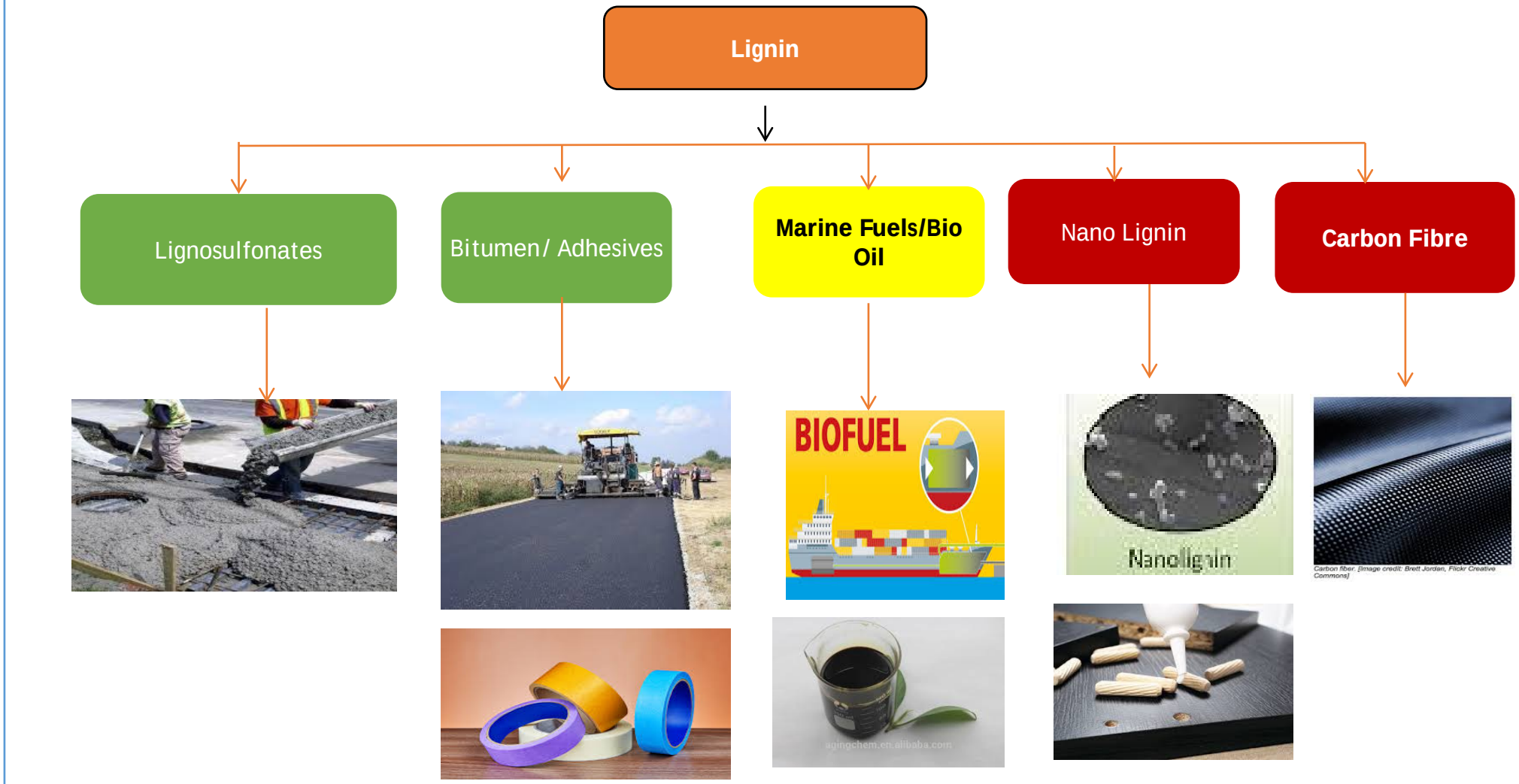


Lignin based value added co-products



Polymers, Adhesives, Roads, cement admixture applications, composites

Applications

Ligno-sulphonates

Applications:

- Plasticizers in concrete admixtures
- Additive in oil drilling
- Pesticides and surfactants
- Stabilizers in colloidal suspensions
- Additive in animal feed

Bitumen

Applications:

- Road-making
- Roofing
- Water proofing: Emulsion primer or membrane
- Tack coat application
- Tar Felt

Update on enfinity Commercial Projects in India

Sr. No.	Client	Feed-Stock	Plant Capacity	Location in India	PRAJ's Scope	Status	Exp. Mech. Completion
1	IndianOil	Rice Straw	100 m3/day Fuel Ethanol (9 GPY)	Panipat - Haryana	Technology License, BEDP, Proprietary equipment, Supervision Services, DFR & **EPCM (Overall Project Mgt)**	BEDP, DFR, Majority of Detailed Engg & Tendering completed	Q4 CY 2021
2	Bharat Petroleum	Rice Straw	100 m3/day Fuel Ethanol (9 GPY)	Bargarh - Odisha	Technology License, BEDP, Proprietary equipment, Supervision Services	BEDP Completed, EPC Project Execution started by EPC (Tata Projects)	Q1 CY 2022
3	HP	Rice Straw	100 m3/day Fuel Ethanol (9 GPY)	Bhatinda – Punjab	Technology License, BEDP, Proprietary equipment and Supervision Services	BEDP in progress, EPCm to be appointed	Q4 CY 2022
4	ONGC MRPL	Rice Straw / Corn Cobs	60 m3/day Fuel Ethanol (5 GPY)	Davangere - Karnataka	Technology License, BEDP, Proprietary equipment and , Mandatory Services	BEDP completed	-

Enfinity: Lower Carbon Footprint

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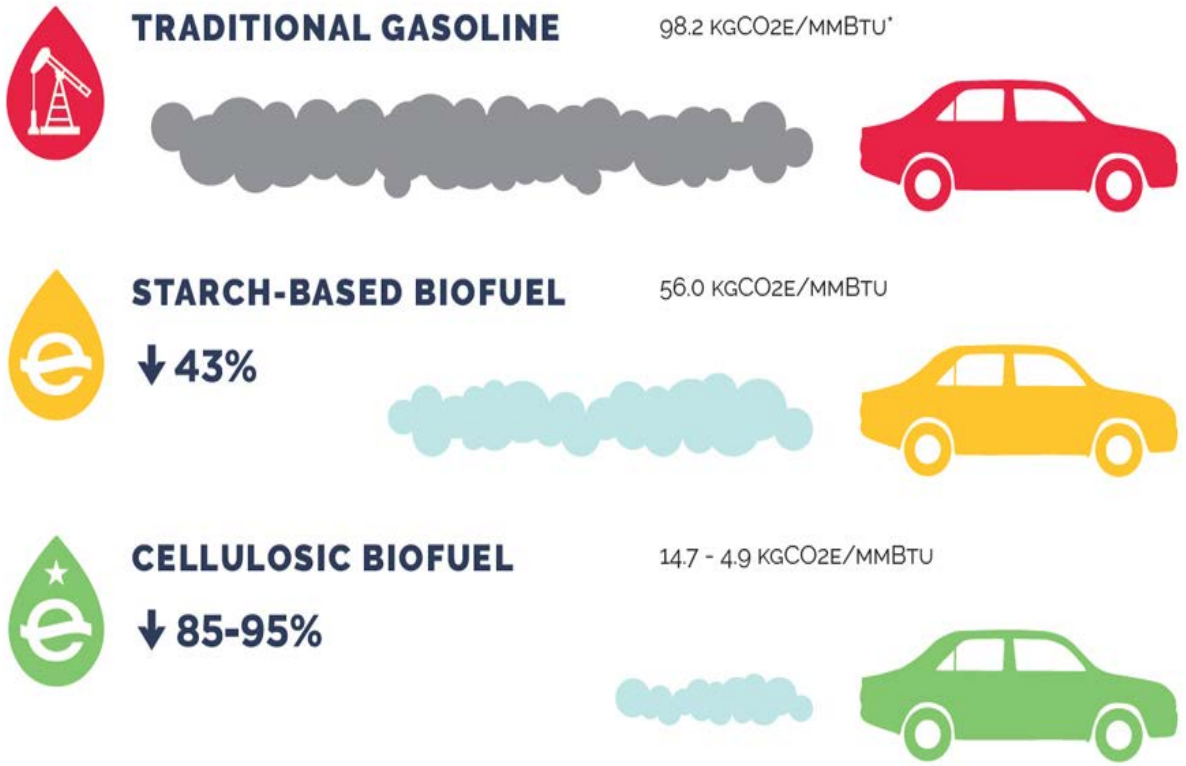
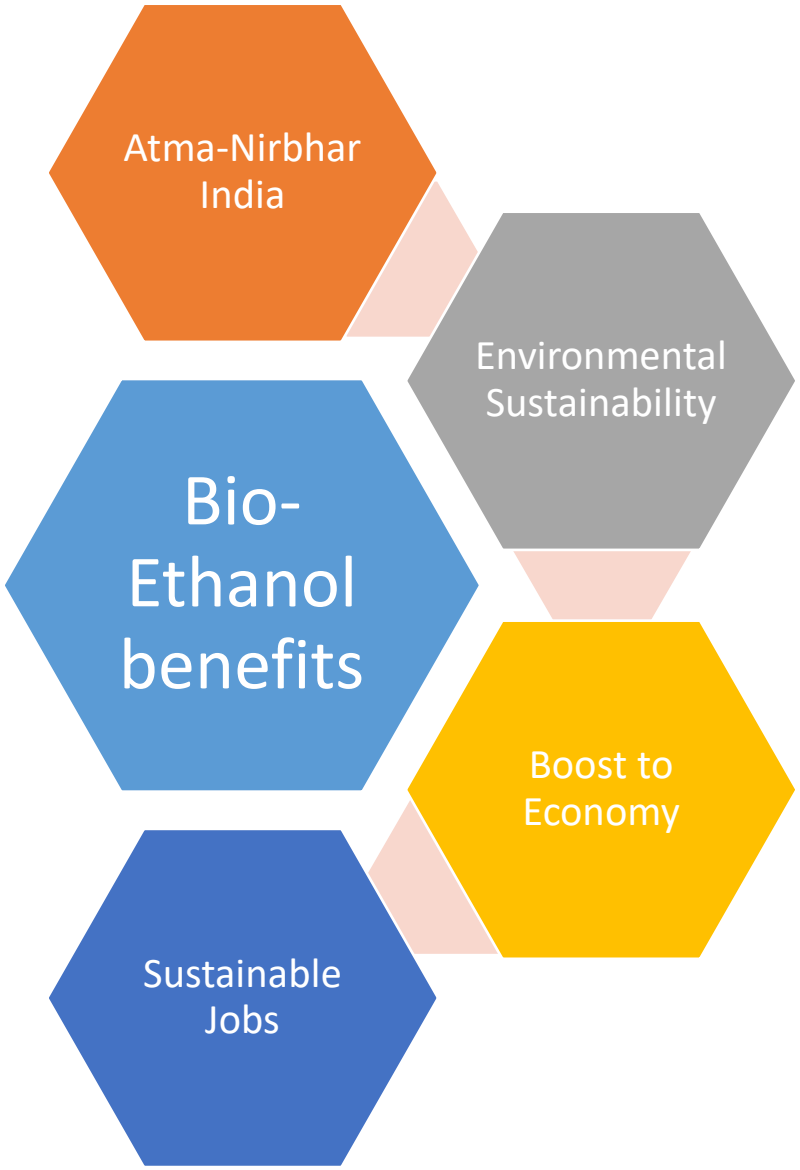


**kilograms of carbon dioxide-equivalent emissions per million british thermal units of finished fuel*

Source: Vital winter I2018 ssue

Praj's enfinity Technology : >90% GHG savings

Bio-Ethanol: Socio-Economic-Environmental Benefits - India



- **Less dependence on foreign countries for import of oils**
- **India is a sugar surplus country and producing ethanol from surplus sugar will ensure that the sugar prices do not plummet**
- **Agricultural waste which would have otherwise been burned, would be used as source for 2G ethanol**
- **Excess food grains estimated at 20-25 Mn is potential feedstock for ethanol**
- **Ethanol when blended with petrol lowers down the overall GHG emissions**
- **Creates a lot of jobs across the value chain throughout the country**
- **Farmer will get value for agricultural waste**
- **Decreased pollution will reduce economic cost of associated health risks**

Bio-Mobility™: Reconfiguring transportation fuel mix

Bio-Mobility™ denotes carbon neutral renewable transportation fuel produced from Biological resources

- **CBG/RNG**

*SAFs- Sustainable Aviation Fuels

CBG Production: Feedstock

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Pre-treatment → **Anaerobic digestion** → **Up-gradation** → **CBG Distributions**

Spent wash from Distilleries (2 BCM/yr of CBG):
- About 400 distilleries – 300 already have biogas facility

Press mud from Sugar Industry (0.5 BCM/yr of CBG):
- 526 active sugar mills.
- Use press-mud as substrate along with RSW if distillery present.

Biomass waste (37 BCM/yr of CBG) :
- Aggregation of biomass waste from fields.
- Agro processing units – rice mills (husk), fruit juice units, oil extraction units.

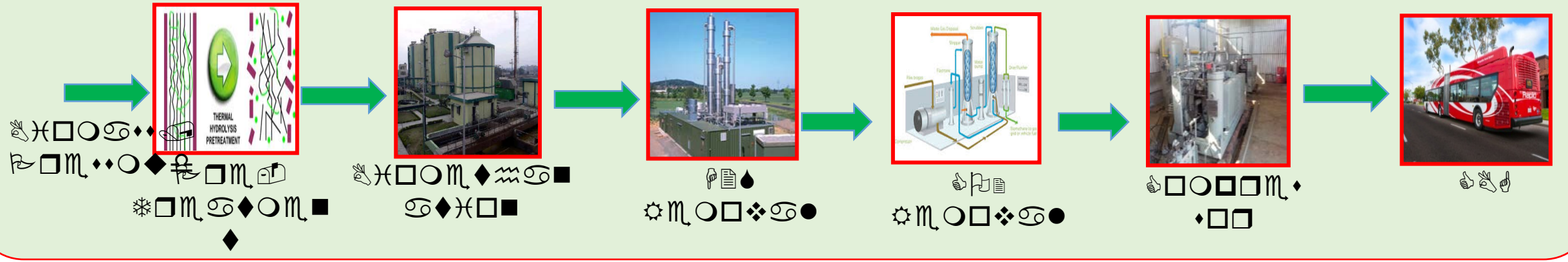
Organic MSW/ Food waste (1 BCM /yr of CBG):
- Segregation of organic waste from MSW.
- Aggregation of food waste from canteen/ hotels/ restaurants

STPs (0.3 BCM/yr of CBG):
- 84 potential customers of 152.
- Spread is Pan India

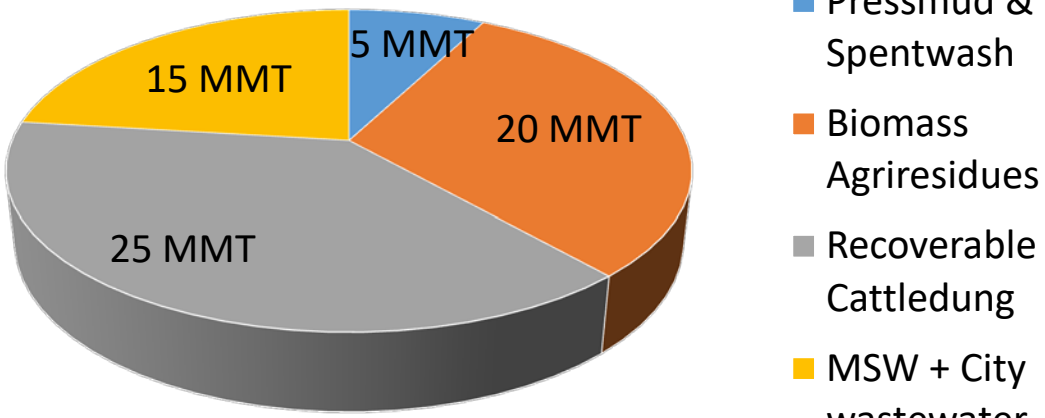
Total potential : ~ 40 BCM /yr of CBG

De-Carbonization through Circular Bio-Economy

Low Carbon Technologies: Compressed Biogas (CBG)



Feedstock Potential Million MT / Yr CBG



- **MoPNG's SATAT scheme for Support to CBG Production**
- 2022: Replace 40 MMT / Yr CNG –by Indigenous BioCNG
- Potential opportunity for ~ 5000 Plants InR 1.5 L Cr CAPEX
- Attractive Price InR 46 / Kg & 100 % Offtake -10 Years
- Various Subsidies for CBG Plant Capex

Biomass to CBG plants are under execution

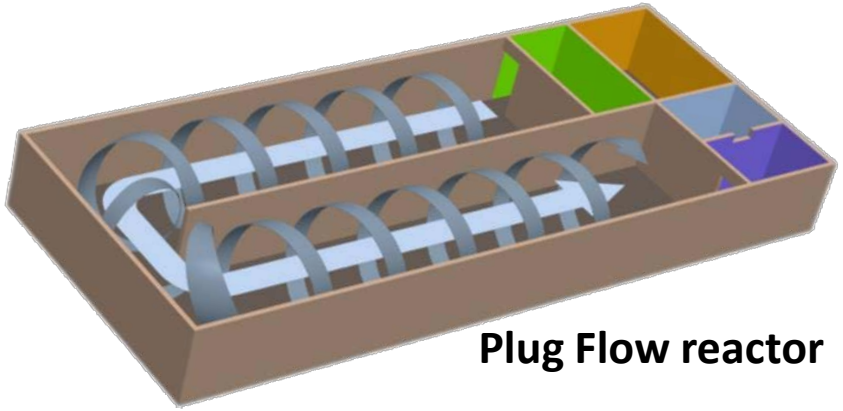
CBG Technology: A game changer

PRAJ has developed unique technology that produces Compressed Biogas from multi feedstock including agri waste such as Rice straw, Wheat Straw, corn stover, cotton stock, grass and other organic waste

CBG technology Key Features

- **Best in class technology**
- **Multi feedstock** processing capability
- **Co product** in the form of **high value organic manure** for farmers
- Advanced Biogas Purification for automotive applications
- Partnering with global leader on plug flow reactor

Complete Commercially Ready Offering: 10 to 25 MT/day modular Gas Plants



Plug Flow reactor

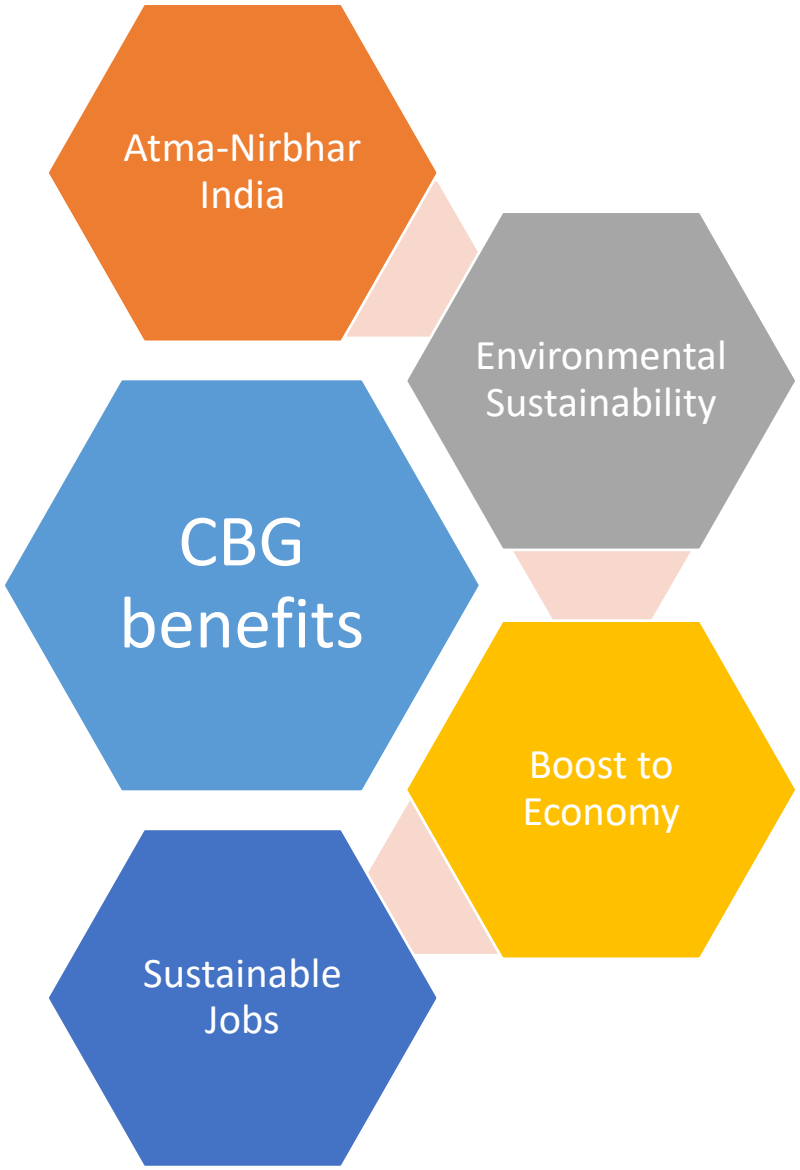
CO2 removal system

Poised to commission India's 1st Commercial plant in UP based on press mud by Jan. '21

Praj's CBG Demonstration Plant

- **Location: Praj Matrix R&D Center Pune**
- India's **first-of-its-kind** CBG demonstration facility using **agri-residue** as feedstock
- **Processes agri waste/ industrial co-products / organic wastes** like straws, agri waste, grasses, press mud, food waste and MSW
- **Automated facility** can produce up to 35000m^3 of raw biogas annually
- To be **utilized for demonstration, testing, improving, and optimizing technology** on different feed stocks.

CBG: Socio-Economic-Environmental Benefits - India



- **India has sufficient feedstock having potential >45 MMT CBG**
- **In India, CBG is estimated to replace two-thirds of India's Natural gas imports**
- **Potential opportunity for ~ 5000 Plants (INR 1.5 L Cr CAPEX)**
- **Attractive Price INR 46 / Kg & 100 % Offtake -10 Years under SATAT Scheme**
- **Various Subsidies for CBG Plant Capex announced by the MoPNG**
- **Lowers down the GHG emission**
- **Will create jobs across the value chain**
- **Farmer will get value for agricultural waste**

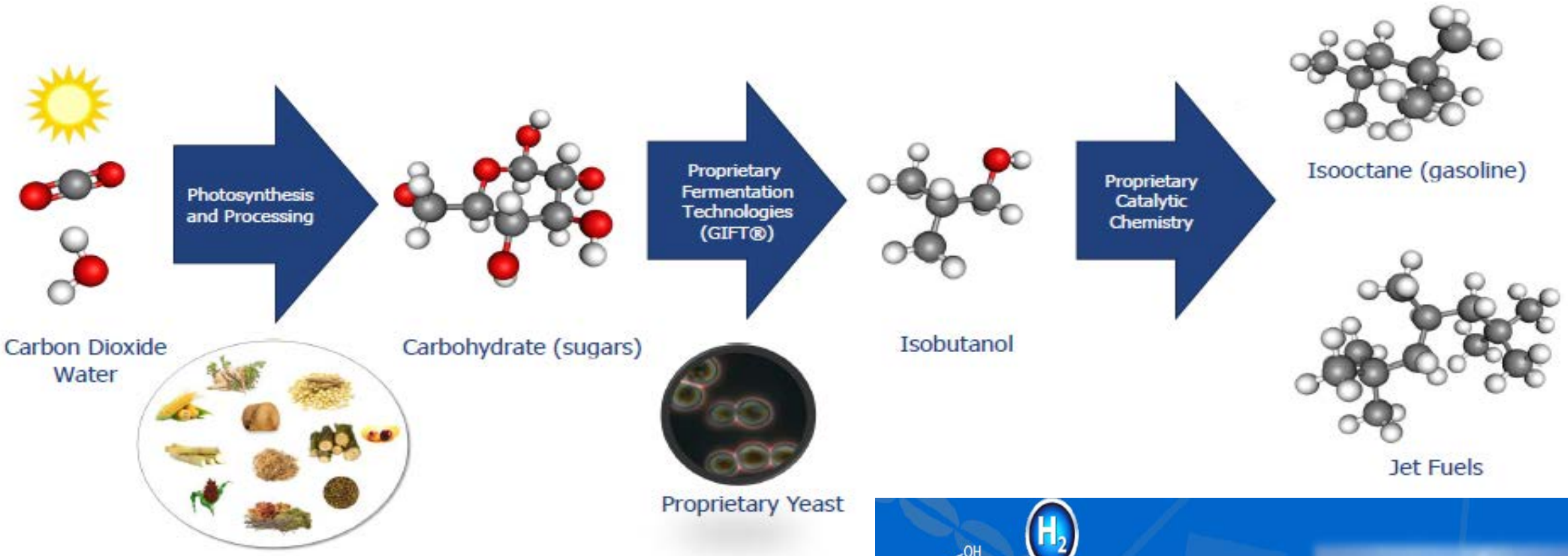
Bio-Mobility™: Reconfiguring transportation fuel mix

Bio-Mobility™ denotes carbon neutral renewable transportation fuel produced from Biological resources

- **SAFs**

*SAFs- Sustainable Aviation Fuels

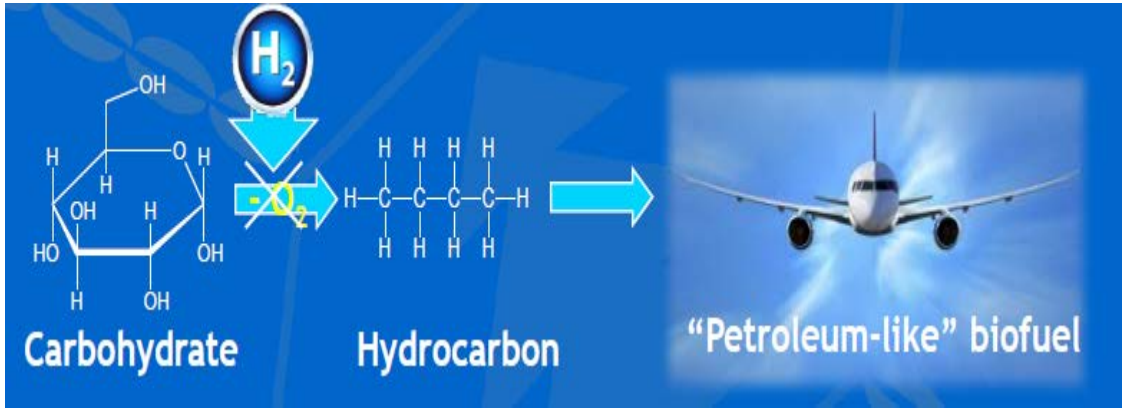
Praj – Gevo : ATJ Technology / Pathway



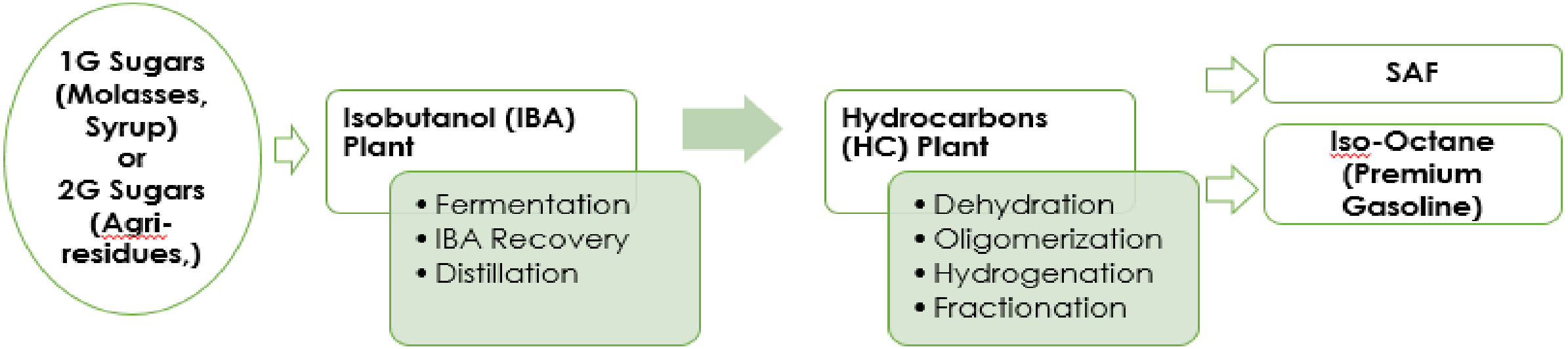
$C_6H_{12}O_6$ (glucose) → C_4H_9OH (butanol) + 2 CO_2 (carbon dioxide) + H_2O (water)

180	74	48	18

Theoretical Yield : 411 kg /MT of Glucose



ATJ Pathway / Process



1 ton Cane Molasses (45% w/w FS)	185 Ltrs IBA (96% v/v)	106 Ltrs SAF + 26 Ltrs Iso-Octane
1 dry ton Rice Straw	130 Ltrs IBA (96% v/v) + 100 Ltrs Ethanol (99.8% v/v)	75 Ltrs SAF + 20 Ltrs Iso-Octane + 100 Ltrs Ethanol

Low Carbon Technologies: Bio-jet (Sustainable Aviation Fuel)

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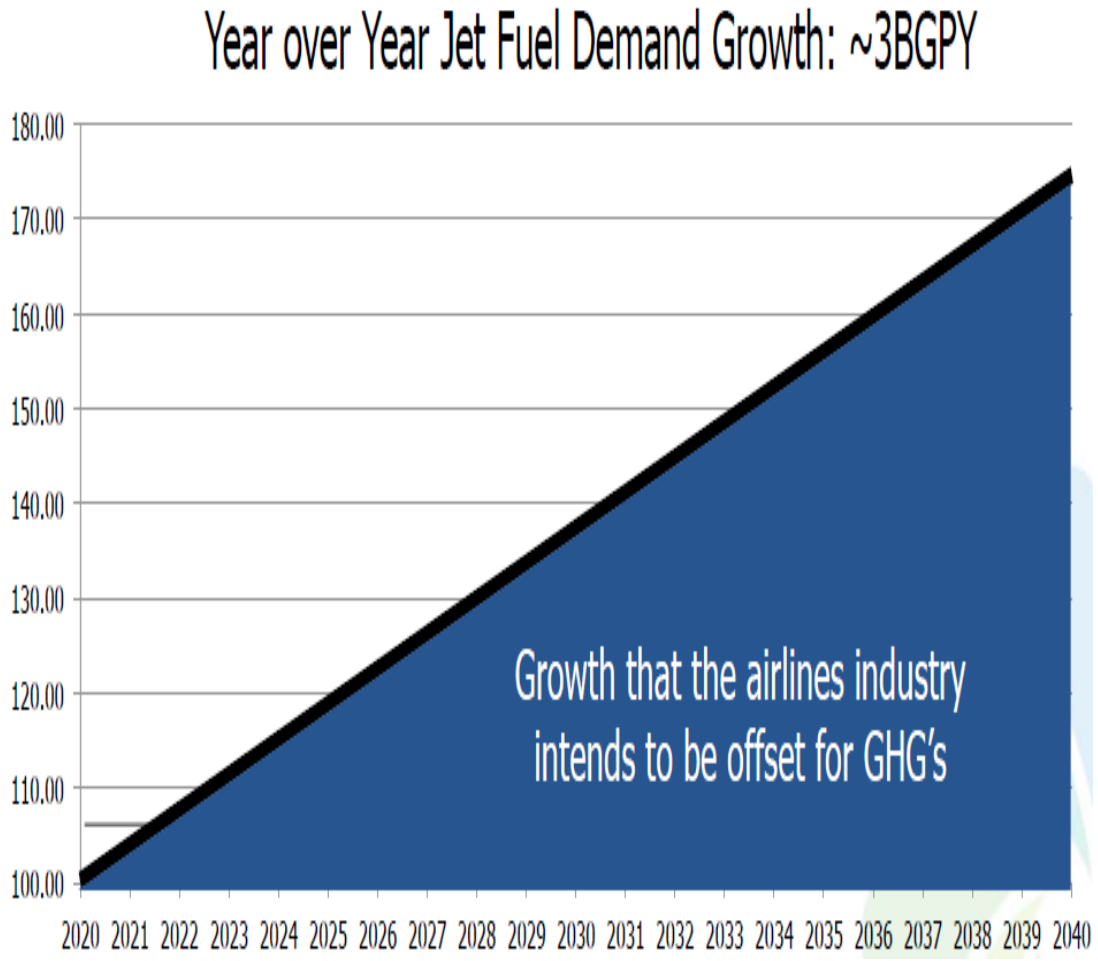
Sustainable Aviation Fuel- ASTM Approved Pathways			
Abbreviation	Certification	Conversion Process	Blending Ratio
FT-SPK	ASTM D-7566 (Annex A1)	Fischer-Tropsch hydroprocessed synthesized paraffinic kerosene	50%
HEFA-SPK	ASTM D-7566 (Annex A2)	Synthesized paraffinic kerosene produced from hydroprocessed esters and fatty acids	50%
SIP-HFS	ASTM D-7566 (Annex A3)	Synthesized kerosene isoparaffins produces from hydroprocessed fermented sugars	10%
SPK/A	ASTM D-7566 (Annex A4)	Synthesized kerosene with aromatics derived by alkylation of light aromatics from non-petroleum sources	50%
ATJ-SPK	**ASTM D-7566 (Annex A5)**	**Alcohol-to-jet synthetic paraffinic kerosene**	**50%**

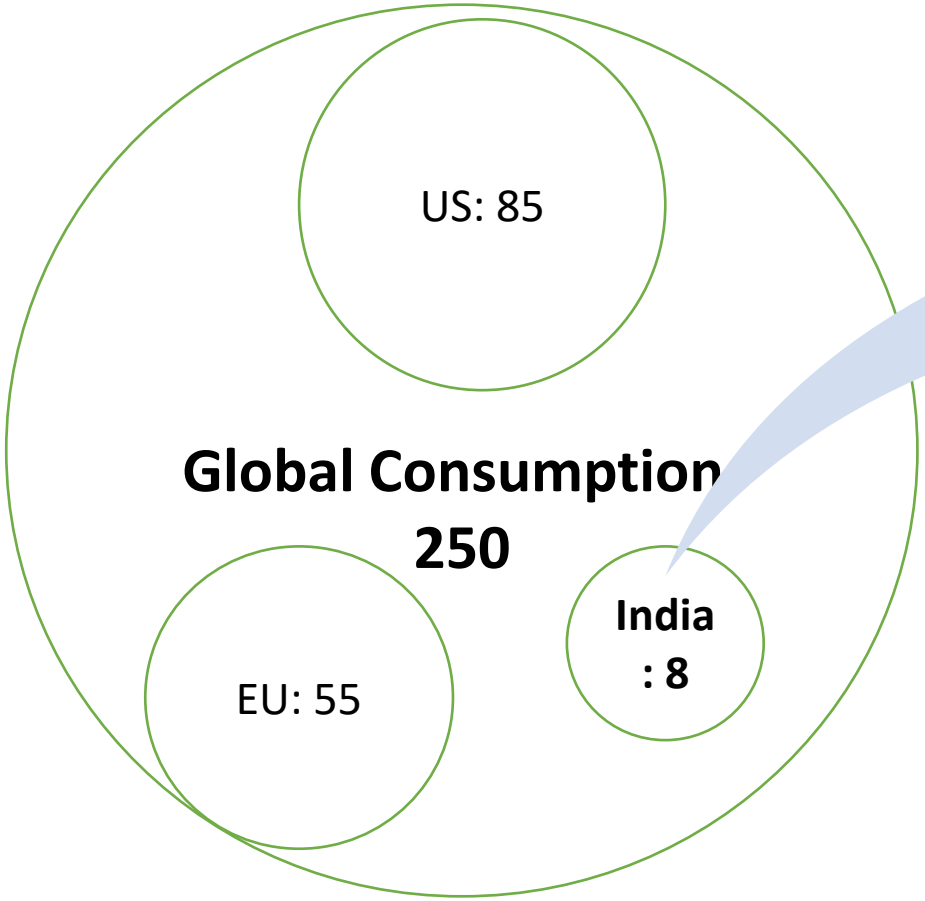


Bio-Jet Technologies are ready for commercialization

SAF Market

Current ATF Consumption

(million metric tons per year)



2030:

Est. ATF Consumption (India):

15 MMT/yr

SAF requirement with 10% blend:

200 Cr. Ltrs (1.5 MMT) per year

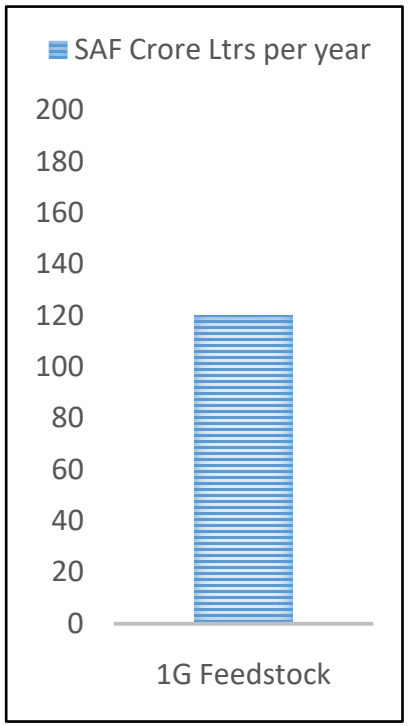
Indian Air Force

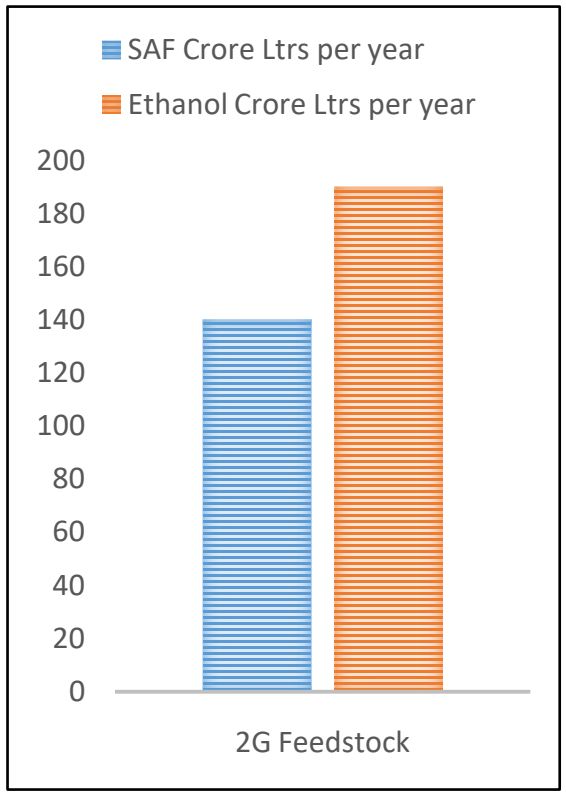
Requirement: **~40 Cr. Ltrs (0.3 MMT) per year** by 2025

SAF Market Drivers (India)

- Energy Security
- Possibility of India joining CORSIA (Commercial aviation)

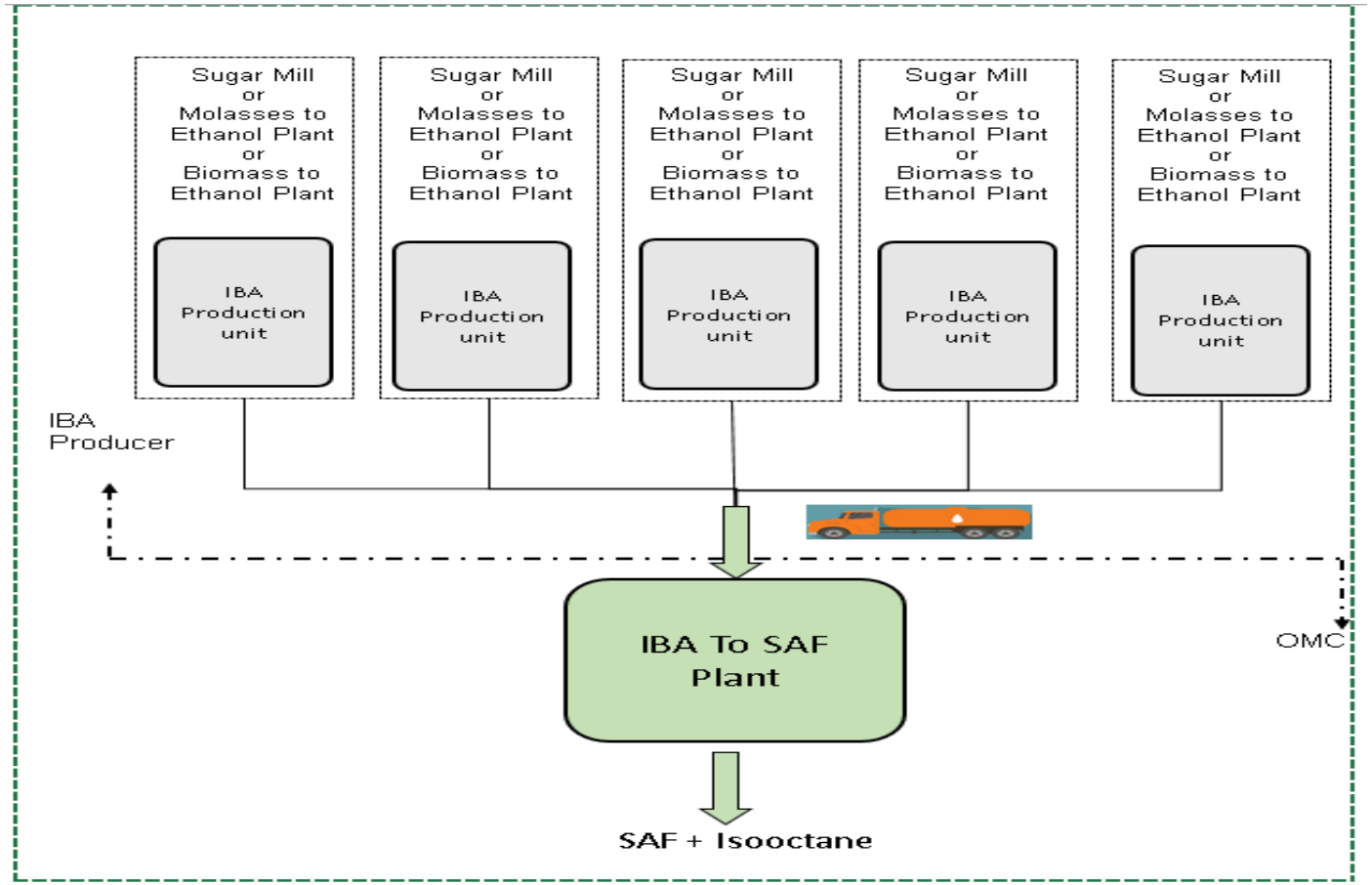
Feedstock Perspective: SAF



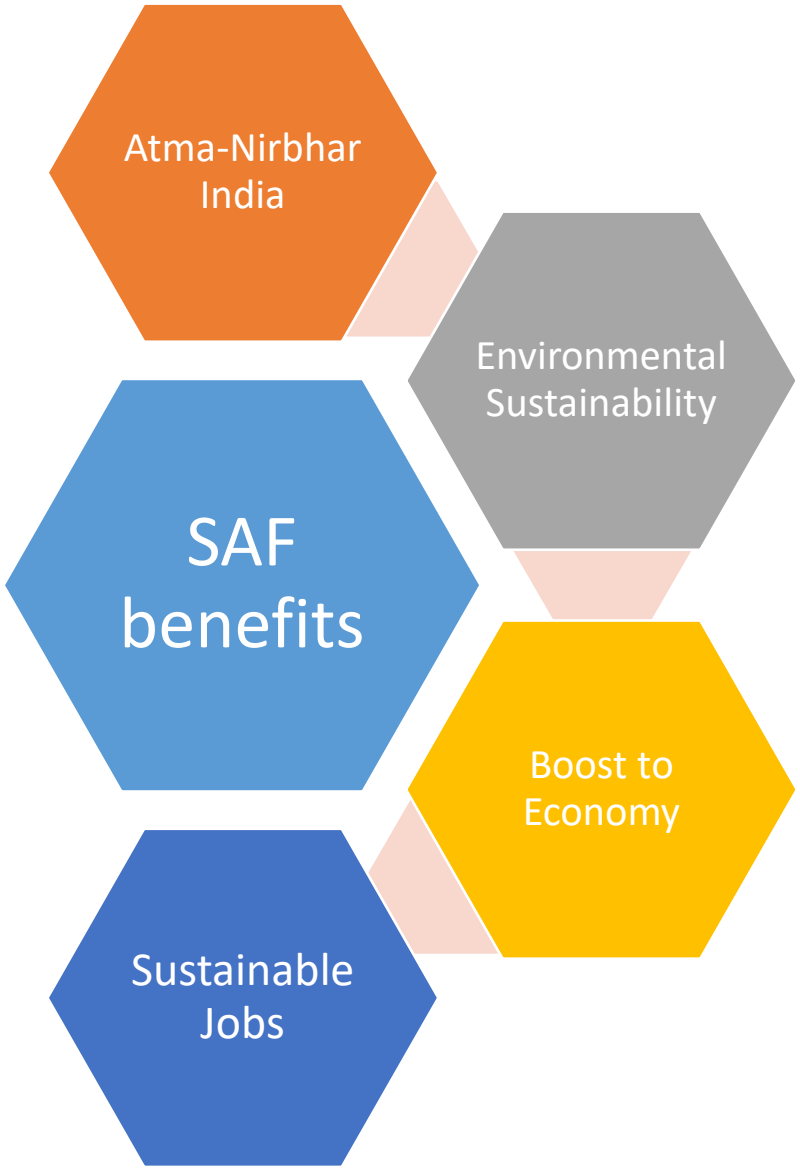


- **1G** : Cane Molasses (existing Ethanol plants) +Cane Syrup (Average Surplus sugar production ~ **5 MMT per year** + Growing yields of sugar / new varieties)
- **2G: ~19 Million MT/year** Surplus Agri-residue / Biomass (Rice Straw, Wheat Straw, Bagasse)

Distributed IBA production & Centralized SAF Production



SAF : Socio-Economic-Environmental Benefits - India



- **Less dependence on foreign countries for import of oil**
- **Savings of roughly INR 4000 Cr. annually**
- **Reduce roughly 3 million tons of carbon emissions**
- **Will create 100,000 to 120,000 sustainable jobs across the value chain**
- **Bring investment of around INR 20,000 to 25,000 crores**
- **Farmer will get value for agricultural waste**
- **Co-products such as Iso-Octane fetch high value and help to derisk the project**
- **Instead of burning in the field, agricultural waste will be diverted for production of SAF resulting in less pollution**
- **Decreased pollution will reduce economic cost of associated health risks**

Technology Adaptation & Scalability

Technology of Isobutanol adapted for Indian feedstock (Molasses & Cellulosic Sugars)

Lab & Bench scale trials of SAF production are complete

Engineering of commercial scale Isobutanol & SAF plants is complete

Ready for commercialization

Demo & Commercial Scale facilities based on ATJ Pathway

IBA & Ethanol Facility, USA
18 MGPY

SAF Facility, USA
0.1 MGPY

Operational since 2011…35000+ hours of operating experience

Bio-Mobility™: Reconfiguring transportation fuel mix

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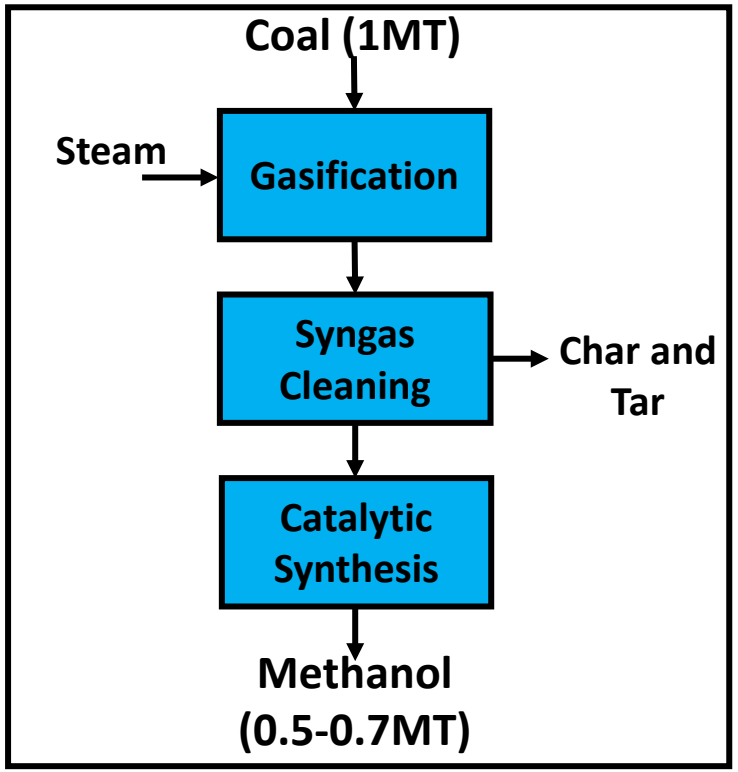
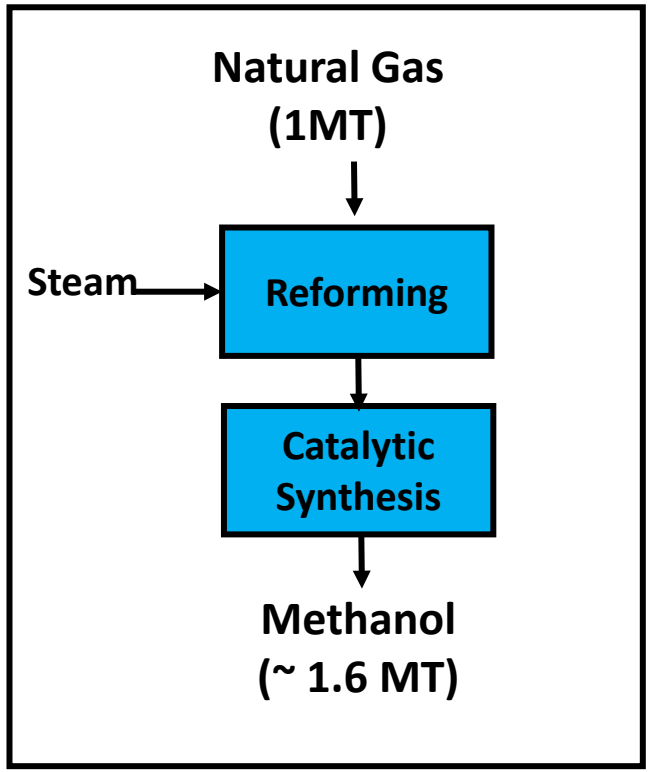
- **Bio-Methanol**

*SAFs- Sustainable Aviation Fuels

De-Carbonization through Circular Bio-Economy

Methanol: Present Scenario





Conventionally, the Methanol is produced from the syngas platform worldwide

The predominant feedstock are coal and natural gas

China is the leading producer of Methanol

Majority of China's Methanol is produced from Coal

<1% of Methanol globally is produced using biomass

Bio-methanol Market

Current Methanol Consumption 2019 data

(million metric tons per year)

China: ~80

Global Consumption: 150 MMT

ROW ~ 70

India : ~2

Source: Statista (Global), IHS Markit Report (China), India (Niti Aayog)

2030:

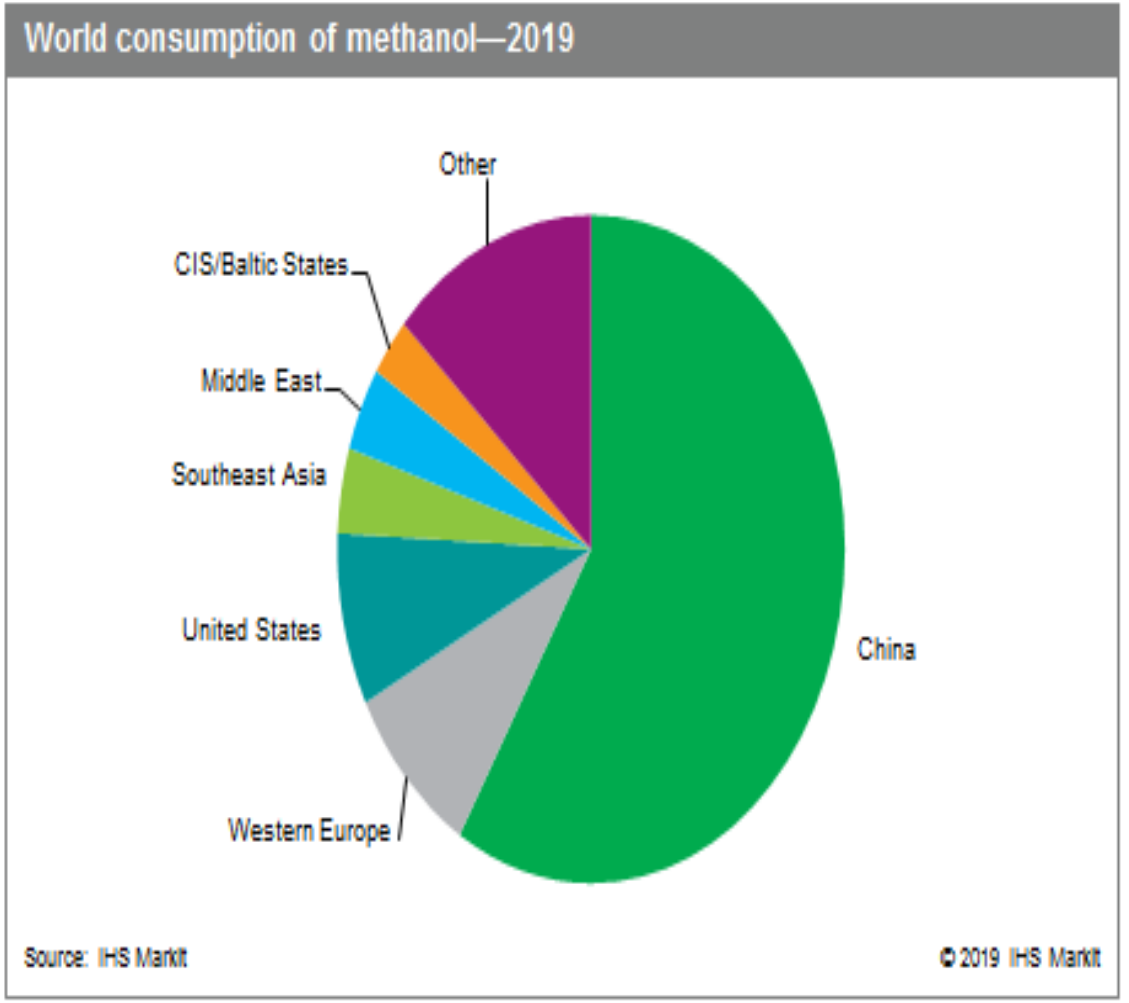
Est. Methanol Consumption (India):

4.5 MMT/yr

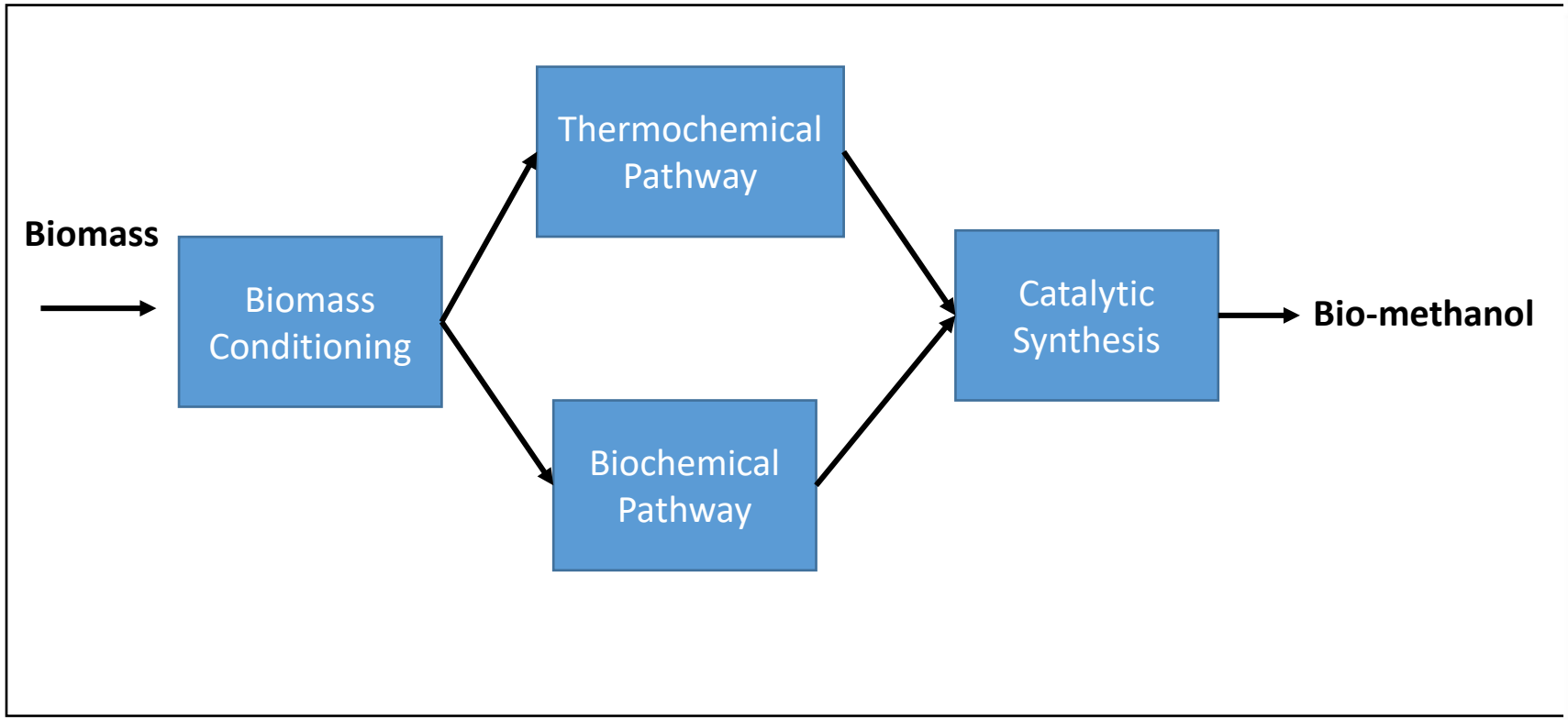
Current Indian Methanol Production:

0.2 MMT/yr

Source: researchandmarkets.com



Bio-methanol Technology pathways



Molecular Formula

CH_4O

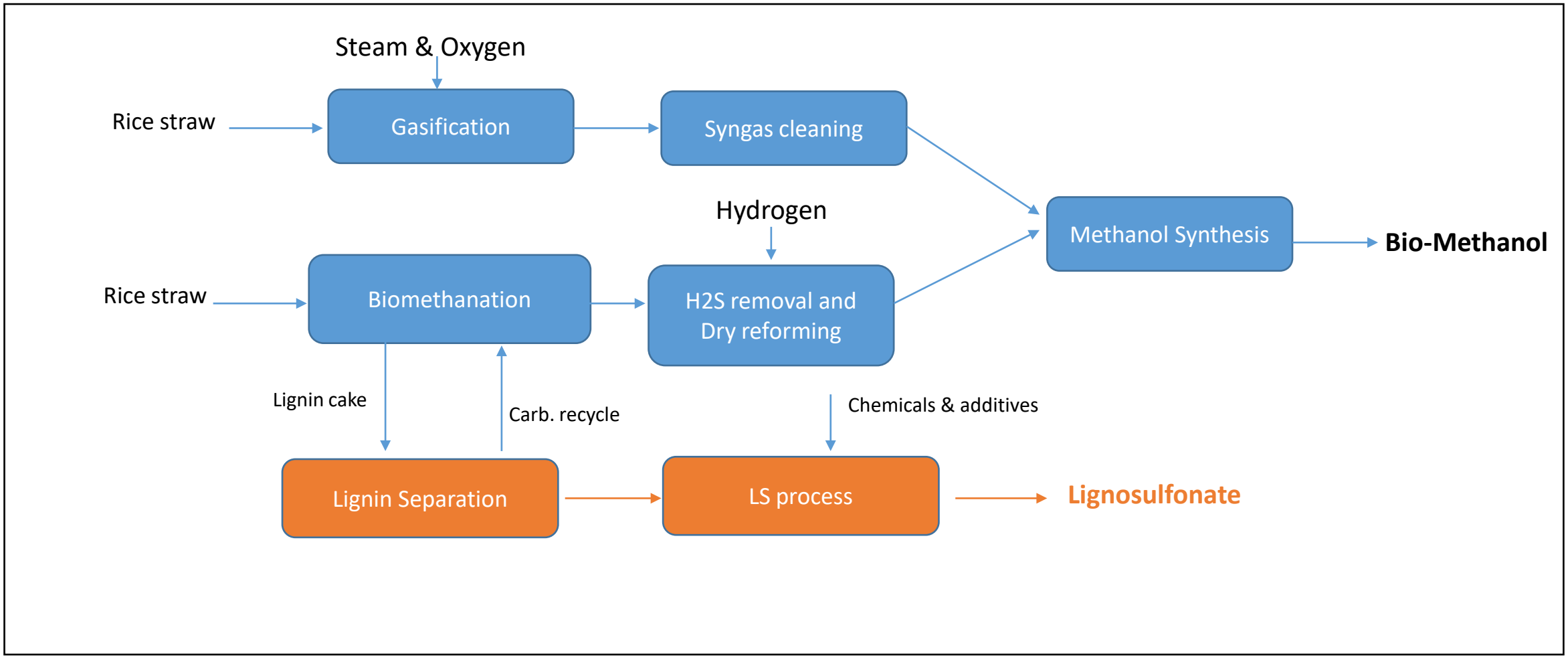
Comparison of Fuel Properties

Property	Methanol	Petrol
Density at 20 °C [kg/l]*	0.79	0.74
Lower heating value [MJ/kg]*	19.7	43.9
Octane number	>110	92
Fuel equivalence	0.48	1
GHG [gCO_2eq/MJ]**	Waste wood methanol: 5 Farmed wood methanol: 7	

*Source: *FNR 2012. Median values are used for simplification. Please refer to standards for ranges. ** Directive 2009/28/EC, total for cultivation, processing, transport and distribution*

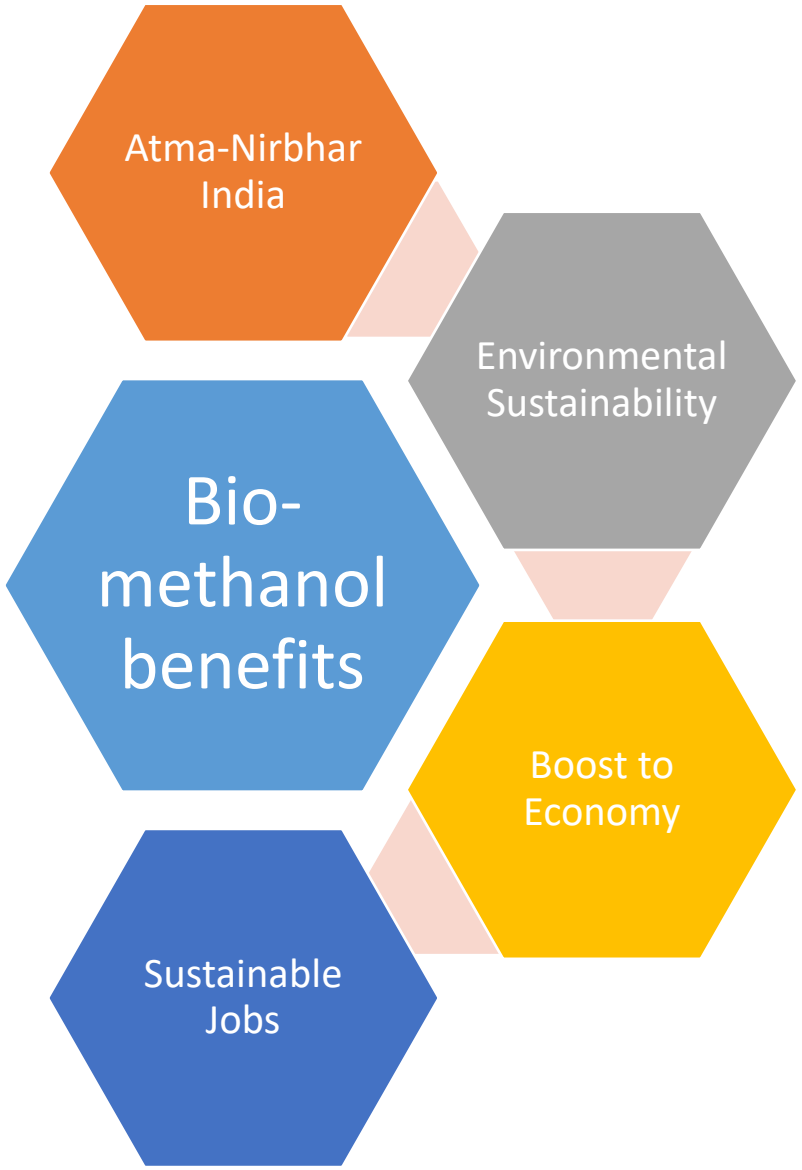
Sstimated yield of 0.3-0.5 MT of Bio-methanol per ton of Biomass

Viability Improvement through Integration of Pathways



Variable cost of production reduction upto 30% due to LS

Bio-methanol: Socio-Economic-Environmental Benefits - India



Less dependence on foreign countries for import of oils

As per Niti Aayog "Methanol Economy will result in minimum 15% of reduction in fuel bill annually for the country by 2030"

Methanol will be useful biofuel for fuel cells

Diesel replacement by methanol will reduce pollution by more than 80%

Will create close to 5 million jobs across the value chain

Additionally, Rs. 6000 Crore can be saved annually by blending of 20% DME in LPG

Farmer will get value for agricultural waste

Instead of burning in the field, agricultural waste will be diverted for production of Methanol resulting in less pollution

Bio-Mobility™: Reconfiguring transportation fuel mix

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Bio-Mobility™ denotes carbon neutral renewable transportation fuel produced from Biological resources

- **Bio-diesel**

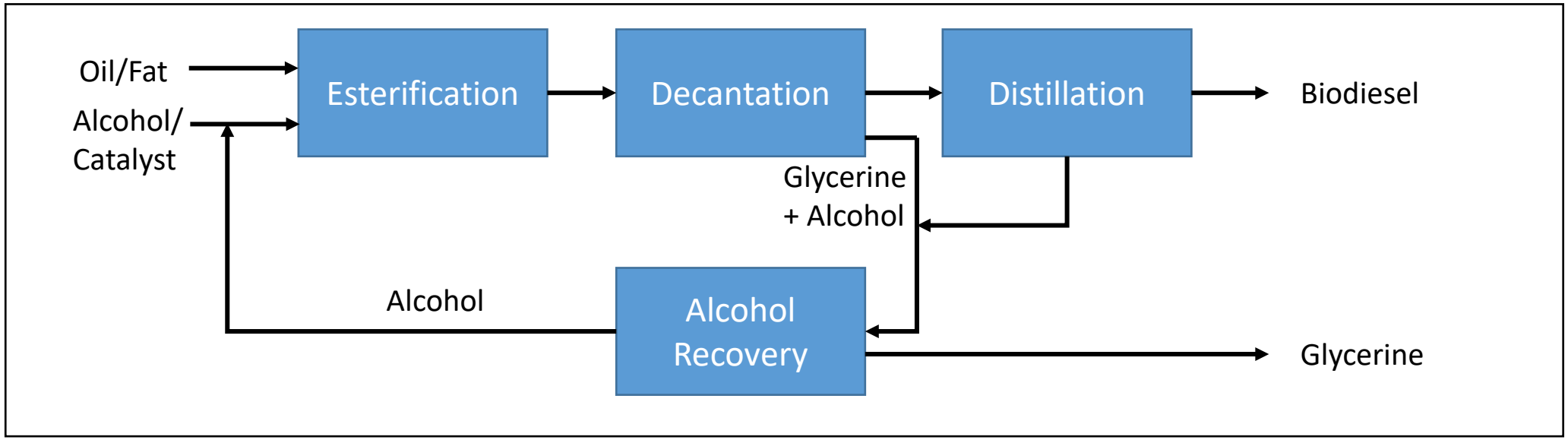
*SAFs- Sustainable Aviation Fuels

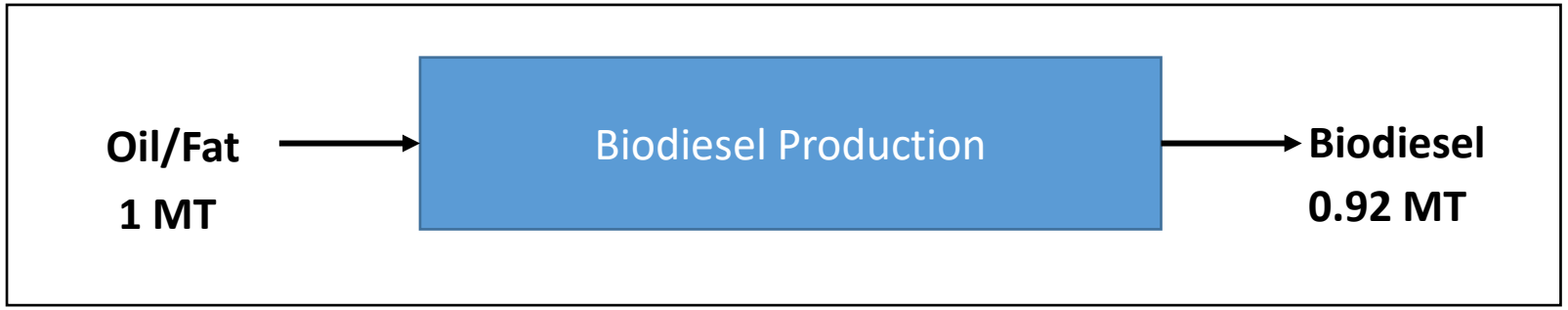
De-Carbonization through Circular Bio-Economy

Feedstock perspective: Biodiesel

Feed Stock for Bio-diesel	Availability in India (KTPA)
UCO - India	~2000
Palm Stearin, PFAD	~330
Acid Oil & TALO	~50

Bio-Diesel Process





Bio-Diesel Market

Biodiesel Consumption 2019 data

(billion liters per year)

Indonesia: ~8

Global Consumption 40

USA ~ 6.5

India : 0.2

Source: Statista

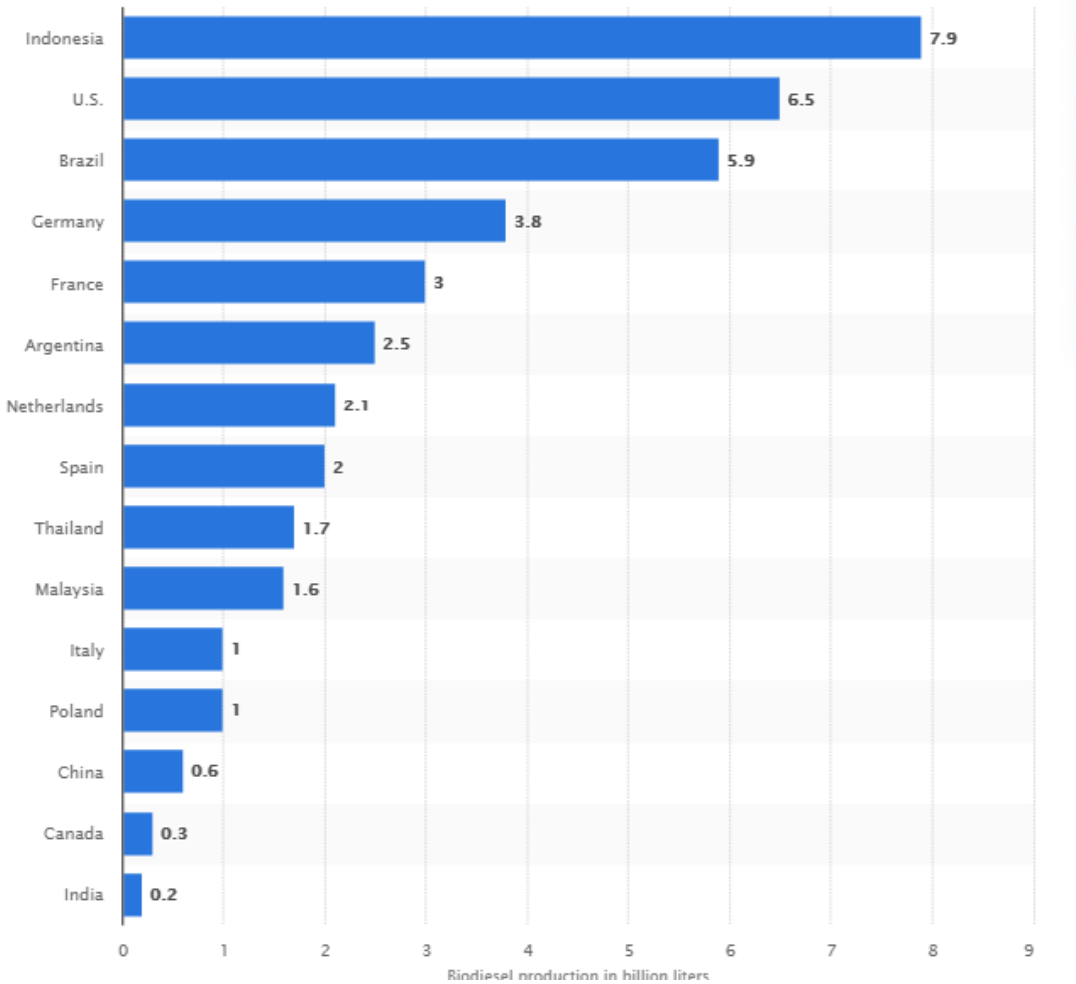
2030:

Est. Diesel Consumption (India):

50 billion liters/yr

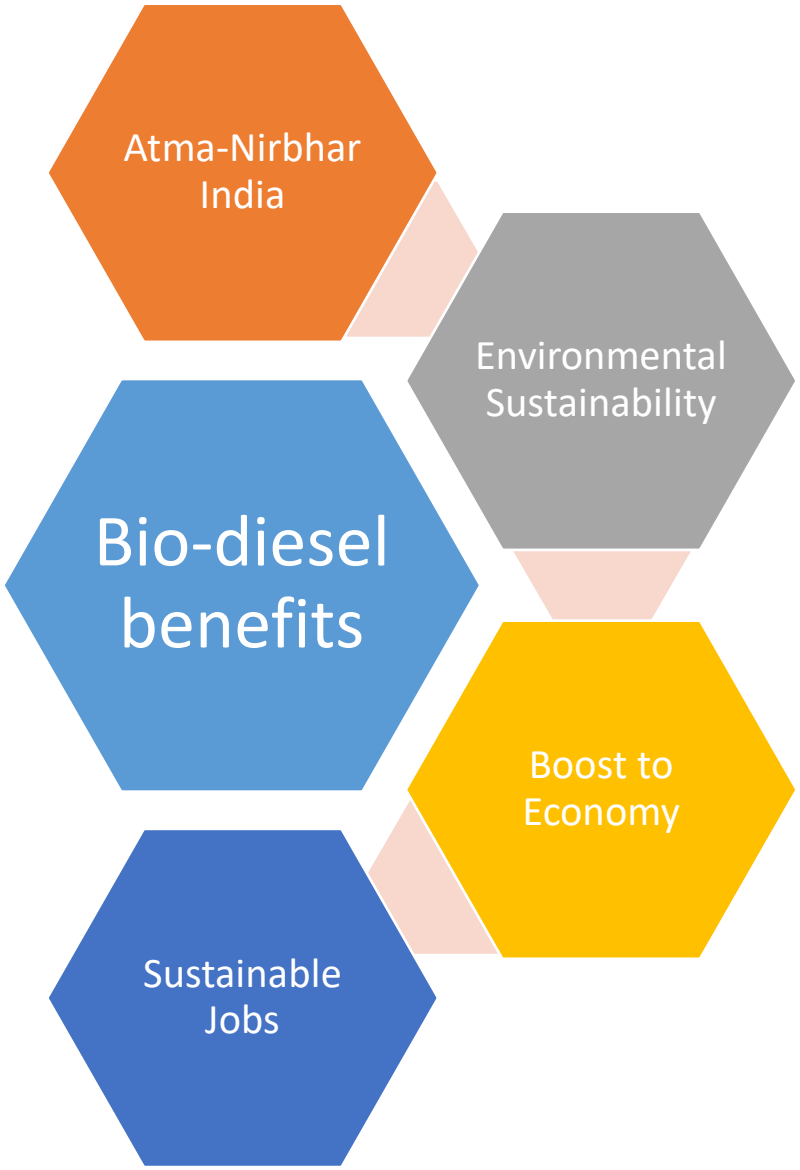
Bio-diesel requirement for 5% blending*:

2.5 billion liters/yr



* The ministry has proposed to blend 5% biodiesel in diesel by 2030

Bio-Diesel : Socio-Economic-Environmental Benefits - India



Less dependence on foreign countries for import of oils

Use of Waste Cooking Oil ensures environmental as well as economical benefit

India is the largest consumer of vegetable oil and has a potential to recover 220 crore liters of UCO to produce biodiesel by the year 2022 through coordinated action

Biodiesel reduces emissions of carcinogenic compounds by as much as 85% compared with petrodiesel

Diesel blending with BD (B20) will reduce SOx emission by 20% , and PM by around 15%

Will create significant jobs across the value chain

Decreased pollution will reduce economic cost of associated health risks

Bio-Mobility™: Reconfiguring transportation fuel mix

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Bio-Mobility™ denotes carbon neutral renewable transportation fuel produced from Biological resources

- **Marine Biofuels**

*SAFs- Sustainable Aviation Fuels

De-Carbonization through Circular Bio-Economy

Marine Fuel: Present Scenario

>80 % Trade by volume via Maritime Transport

Marine transport is one of the major contributor to GHG emissions

IMO law demands fuel sulfur conc. at 0.5% (eff Jan'20)

The conventional marine fuels are:
1) Heavy Fuel Oil (HFO)
2) Marine Diesel Oil (MDO)
3)Marine Gas Oil (MGO)
4) Liquefied Natural Gas (LNG)

Conventional crude oil derived fuels have upto 3.5% fuel sulfur content

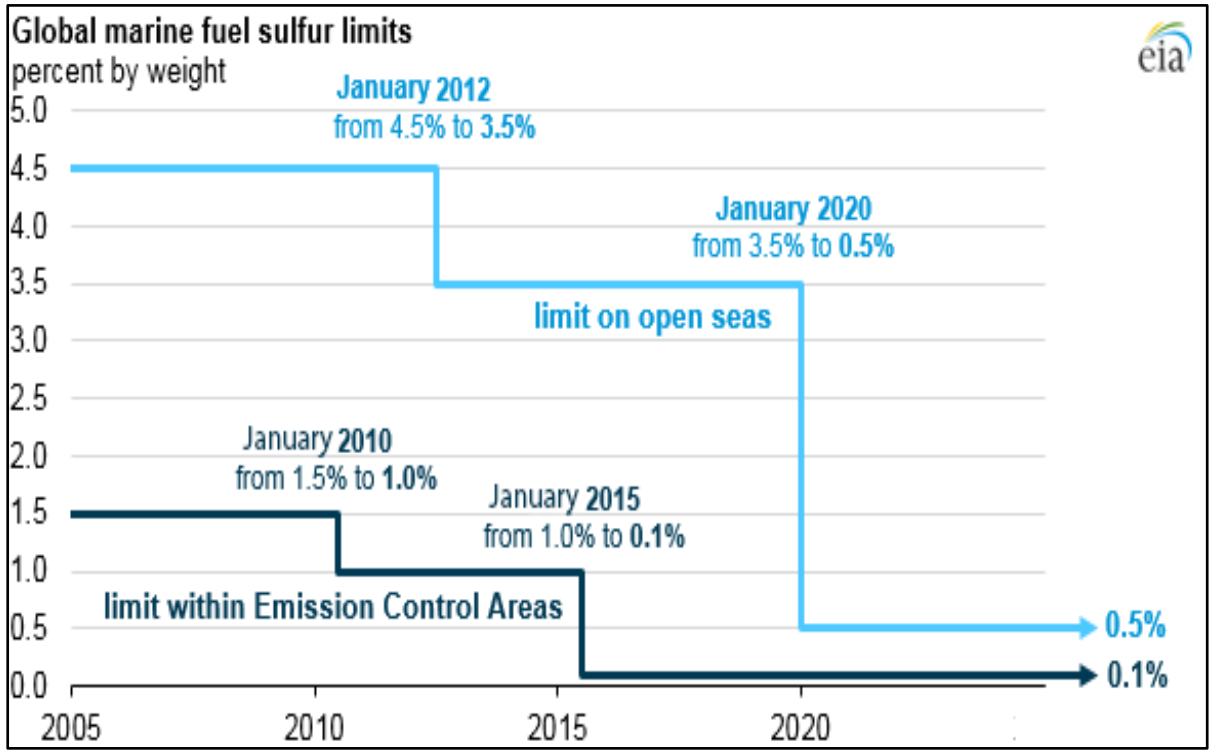
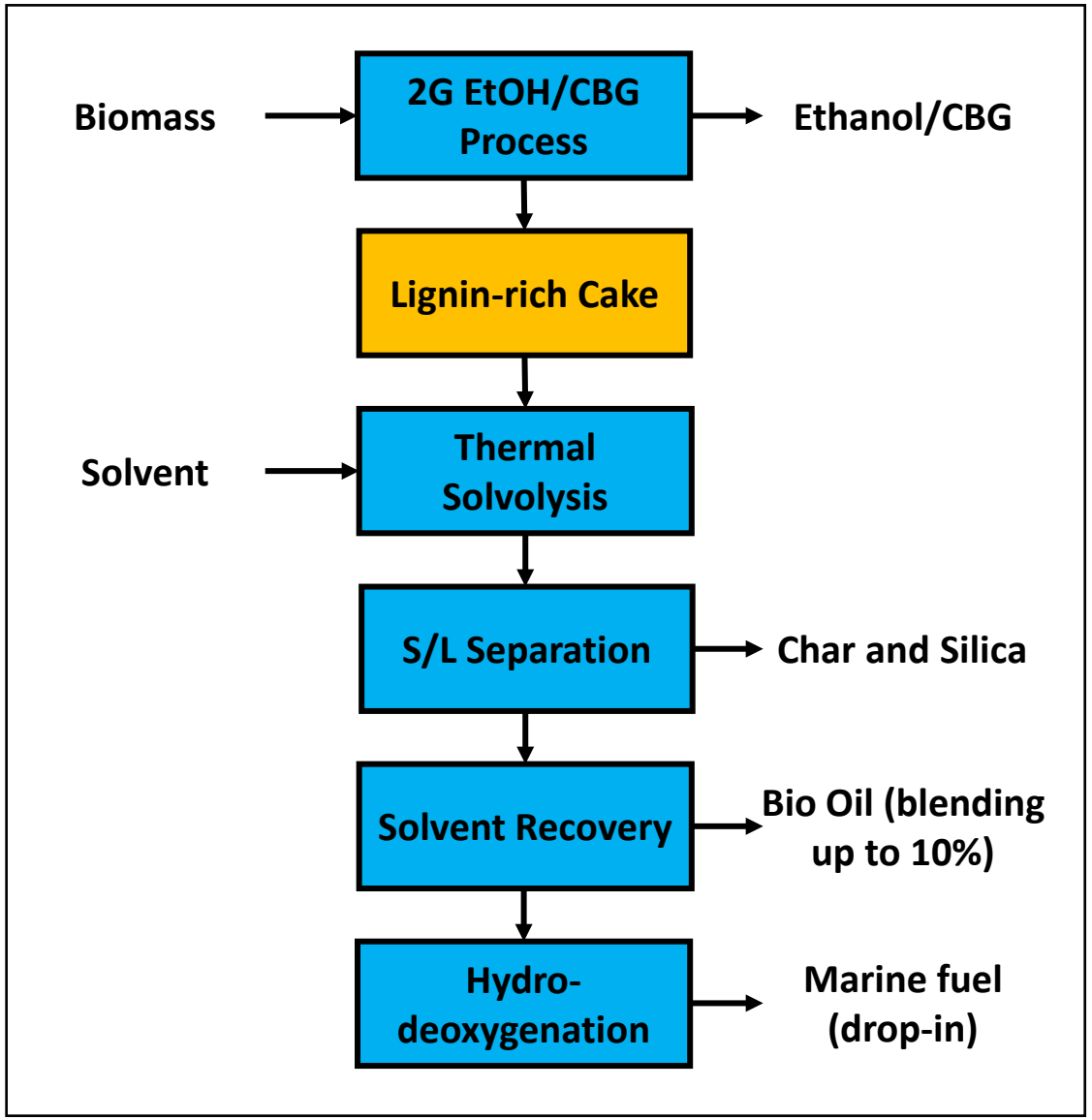
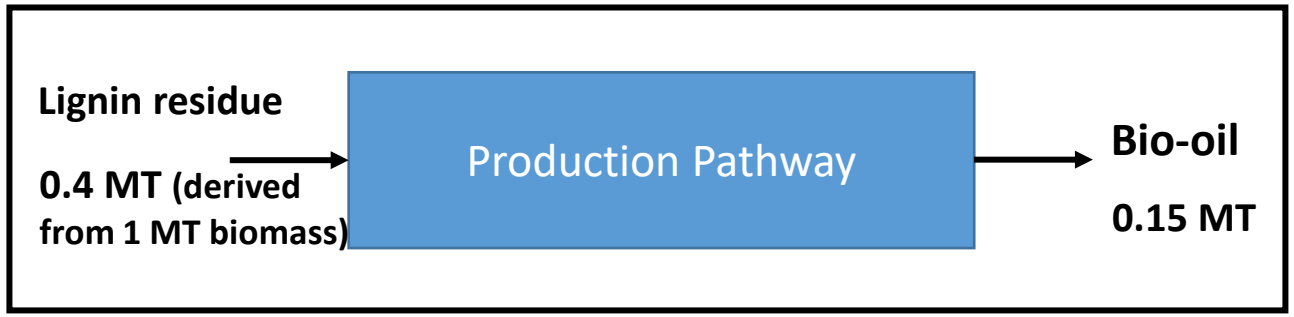


Figure: Global marine fuel sulfur limits.
Source: EIA

Marine Sector looking for solutions to meet the new fuel standards

Marine Biofuel Production Process

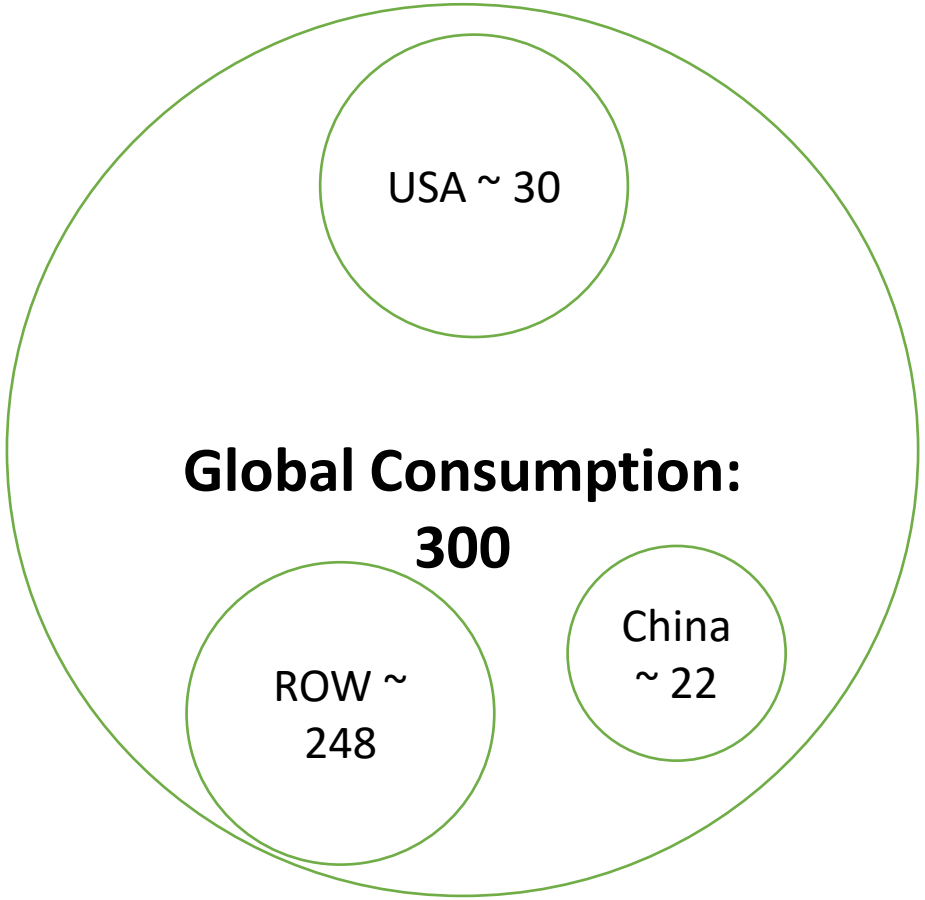




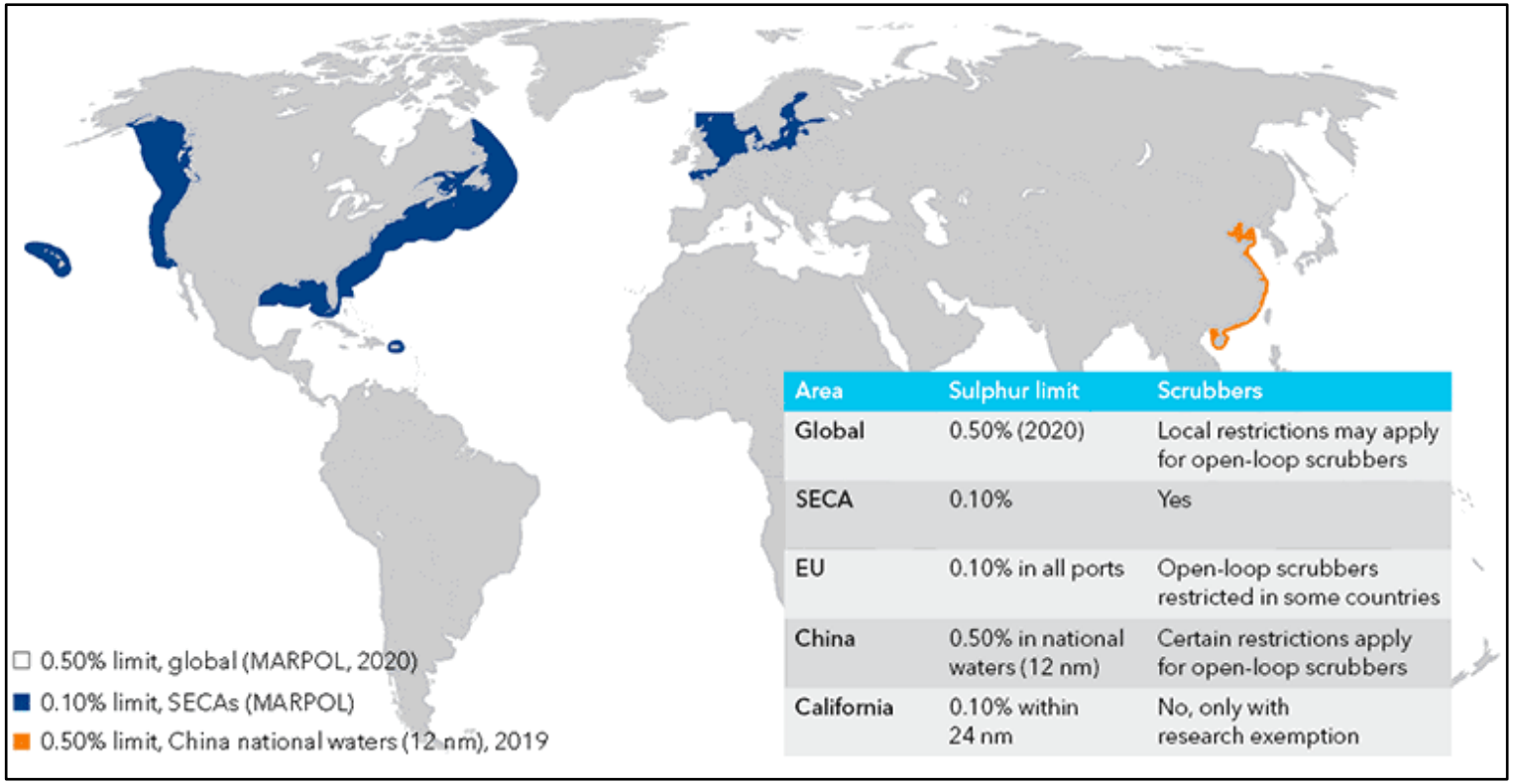
Marine Fuel Market

Marine Fuel Consumption 2018 data

(million metric tons per year)



Source: Oak Ridge National Laboratory & IEA

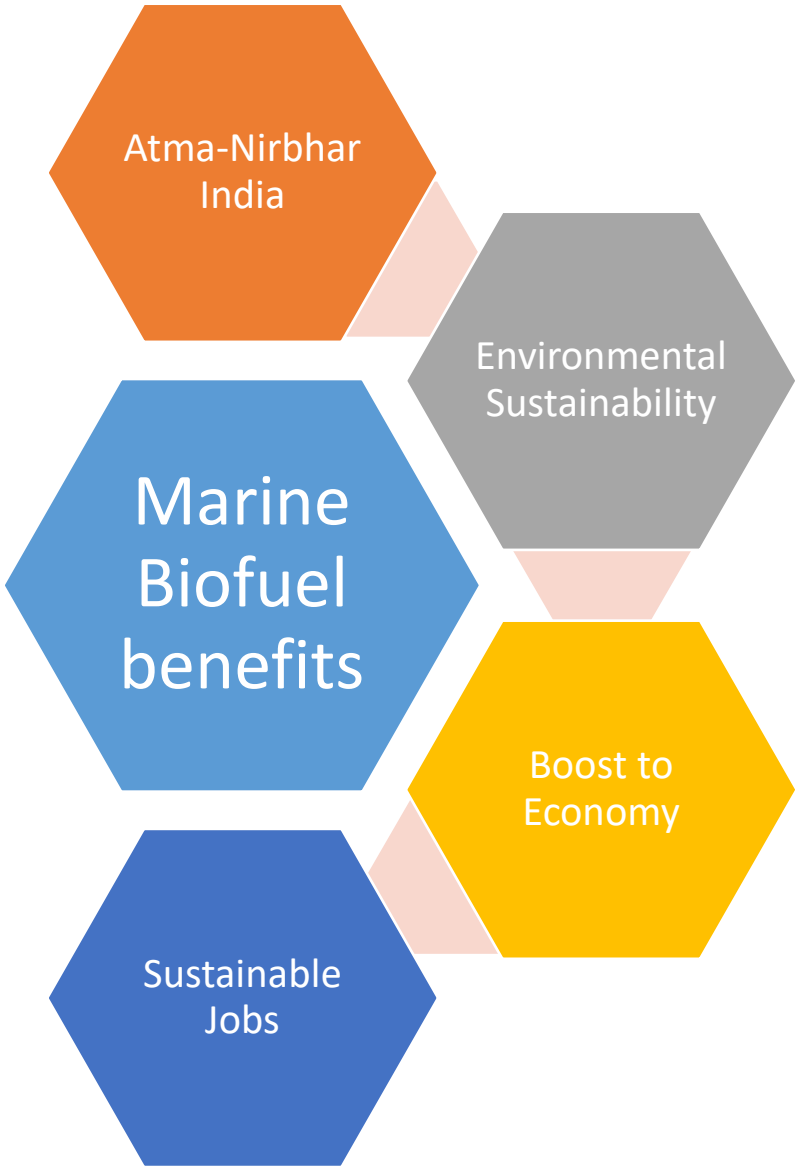


Area	Sulphur limit	Scrubbers
Global	0.50% (2020)	Local restrictions may apply for open-loop scrubbers
SECA	0.10%	Yes
EU	0.10% in all ports	Open-loop scrubbers restricted in some countries
China	0.50% in national waters (12 nm)	Certain restrictions apply for open-loop scrubbers
California	0.10% within 24 nm	No, only with research exemption

Figure: The IMO has enacted regulations to lower the fuel sulfur content from 3.5% to 0.5% by 2025. There are various Special Emission Control Areas which have placed 0.1% as the Limit.

Source: IEA

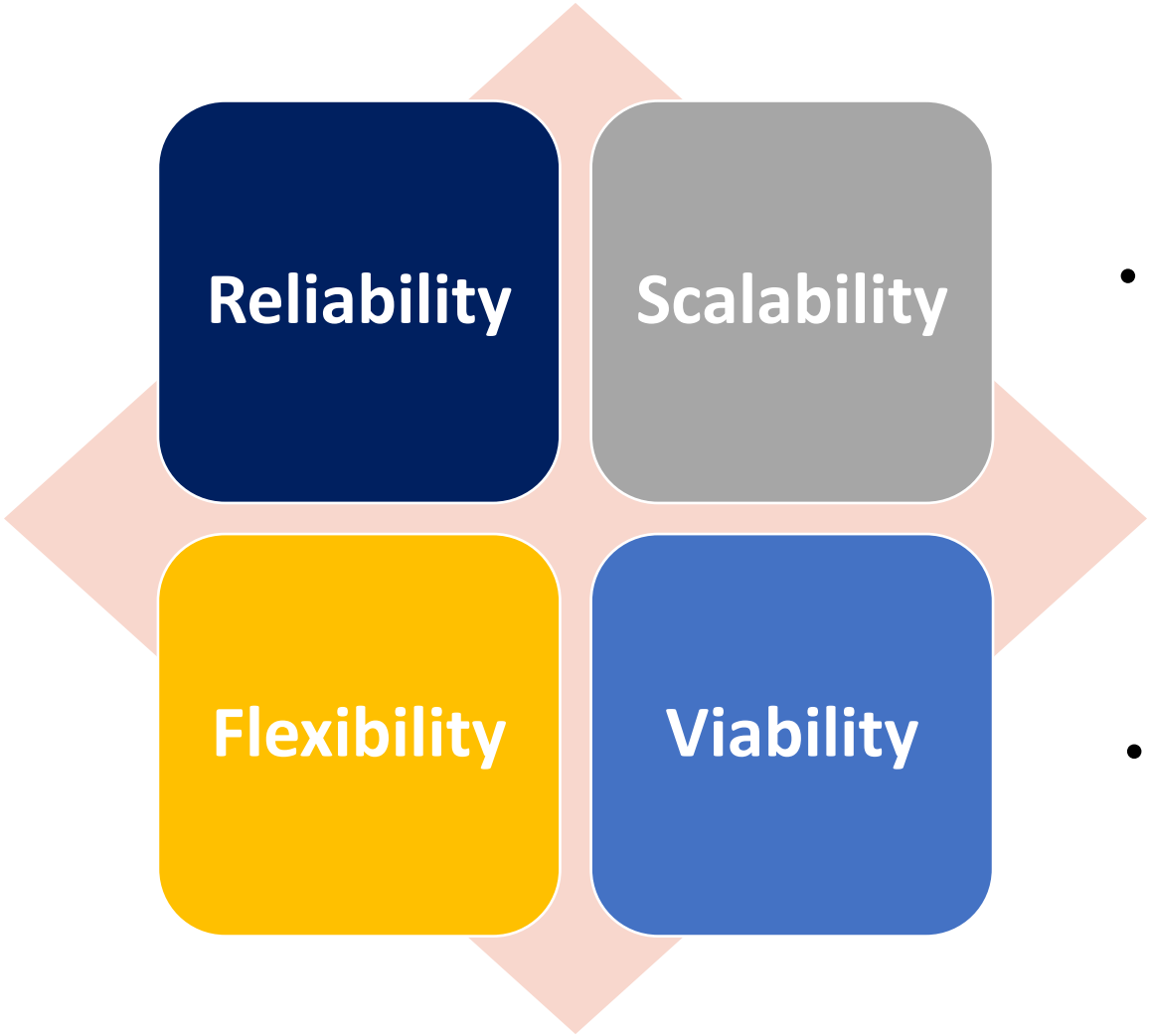
Marine Biofuel : Socio-Economic-Environmental Benefits - India



- **Less dependence on foreign countries for import of oils**
- **Use of Bio-oil can ensure 0.5% fuel sulfur content**
- **Blending or Drop-in of Bio-oil in HFO lowers down the SOx, NOx and carbon emissions**
- **Will create jobs across the value chain**
- **Farmer will get value for agricultural waste**
- **Viability improvement of biomass-based biogas & 2G ethanol plant**

Market Expectations: Advanced Biofuels

- 24X7 round the year Operation
- Multi Feed Multi product



- Established Feedstock Logistics
- Improved IRR

Sustainable production is key to success

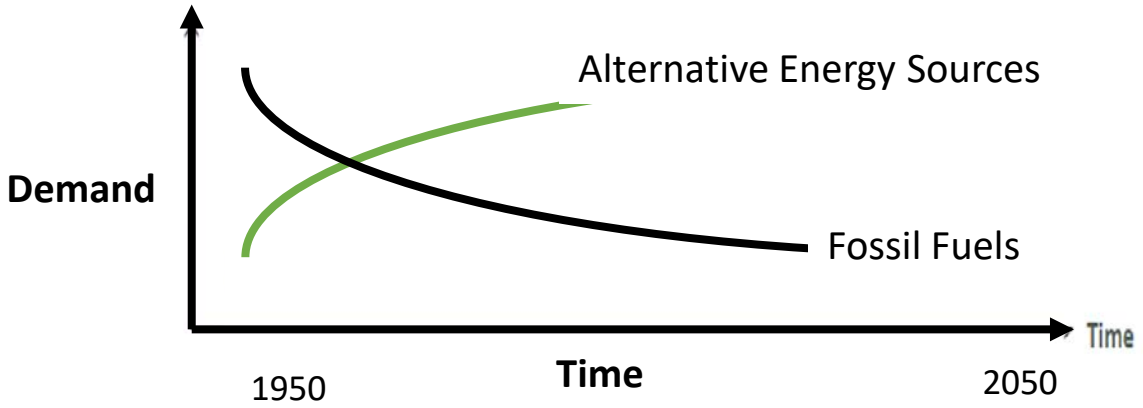
India Renewable energy Scenario

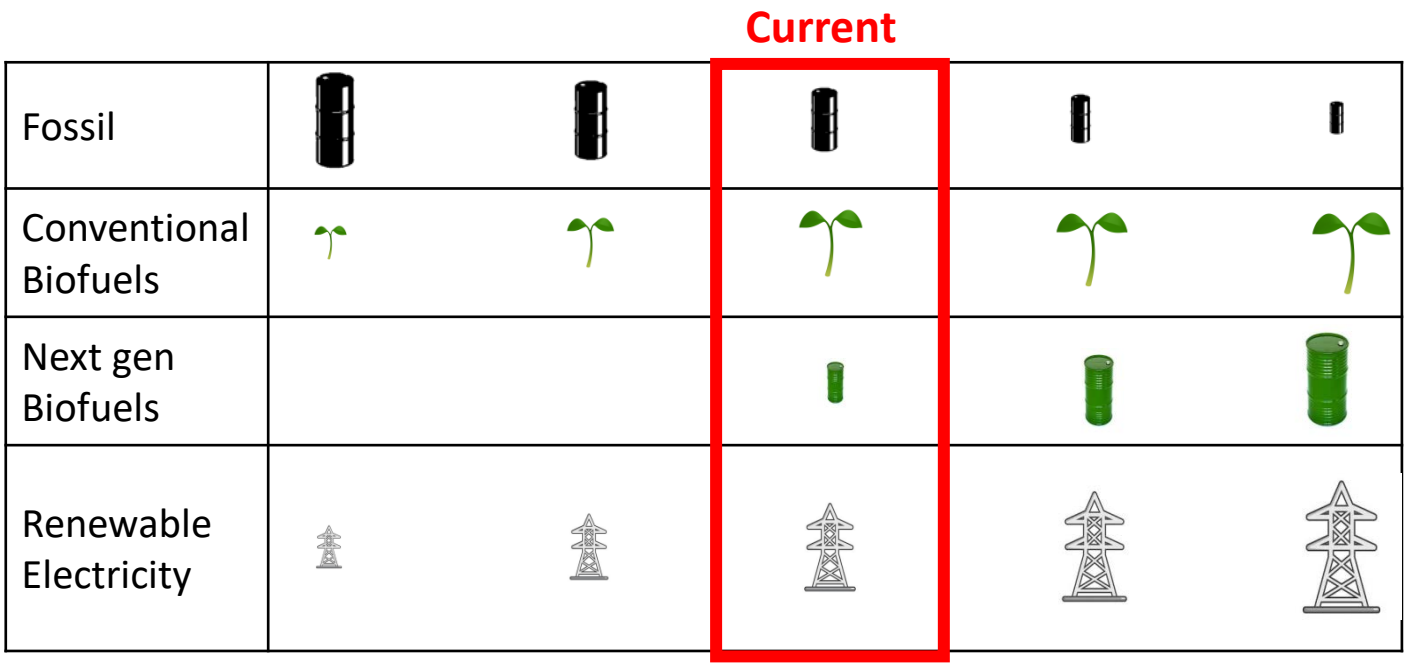
"**By 2030**, **we project that the cost of wind** and **solar will be between Rs 2.3-2.6** per Kilowatt hour (kWh) and **Rs** 1.9-2.3 per kWh, respectively, while the **cost** of storage **will** have fallen by about 70 per cent,"

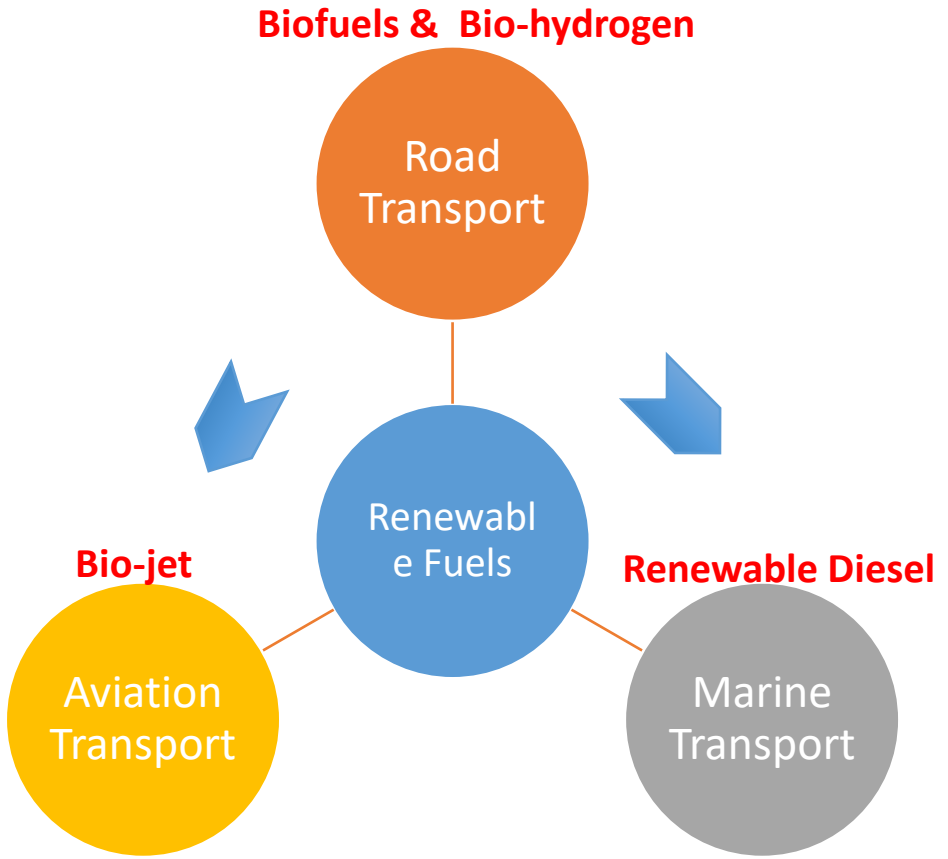
https://energy.economictimes.indiatimes.com.

https://www.investindia.gov.in/sector/renewable-energy

Bio-Mobility™ : Carbon Neutral Technologies





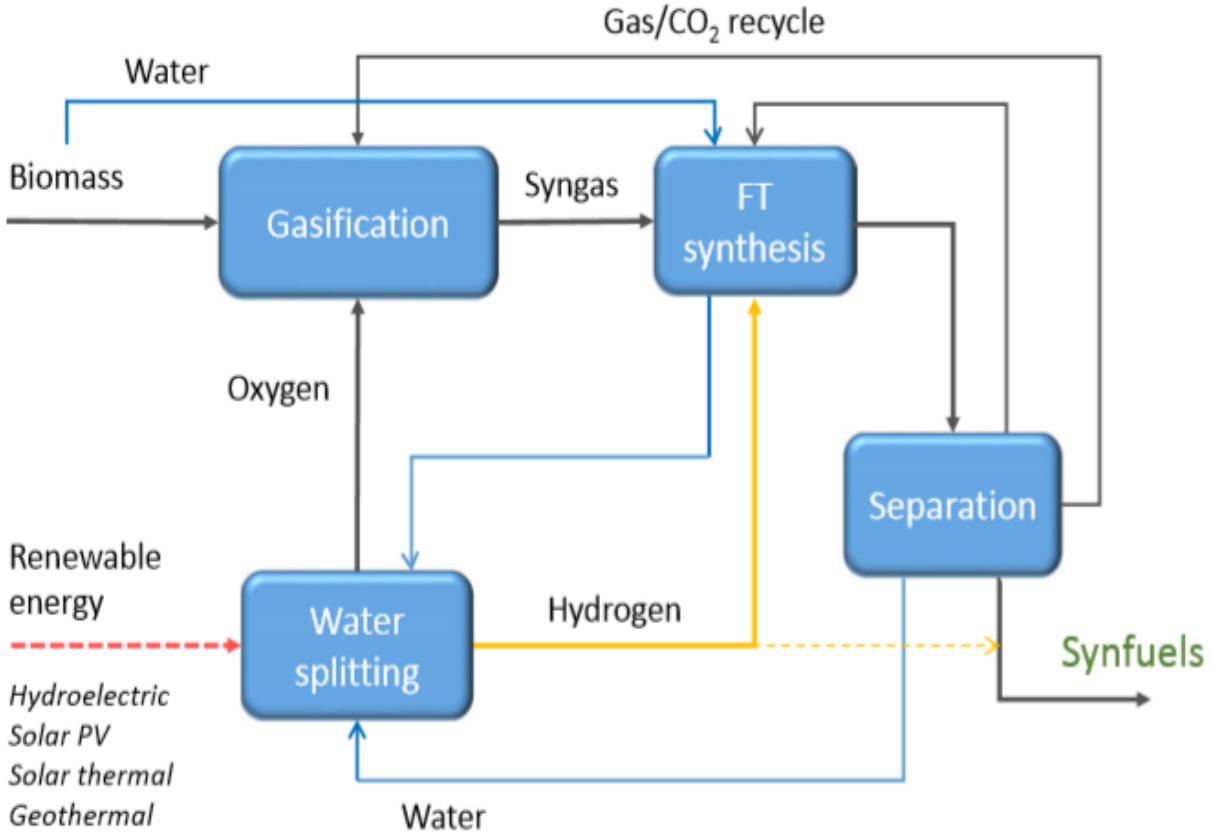


Bio-Mobility & E-Mobility will co-exist

Future : Carbon Neutral Biomass to Liquid (BTL) Technologies

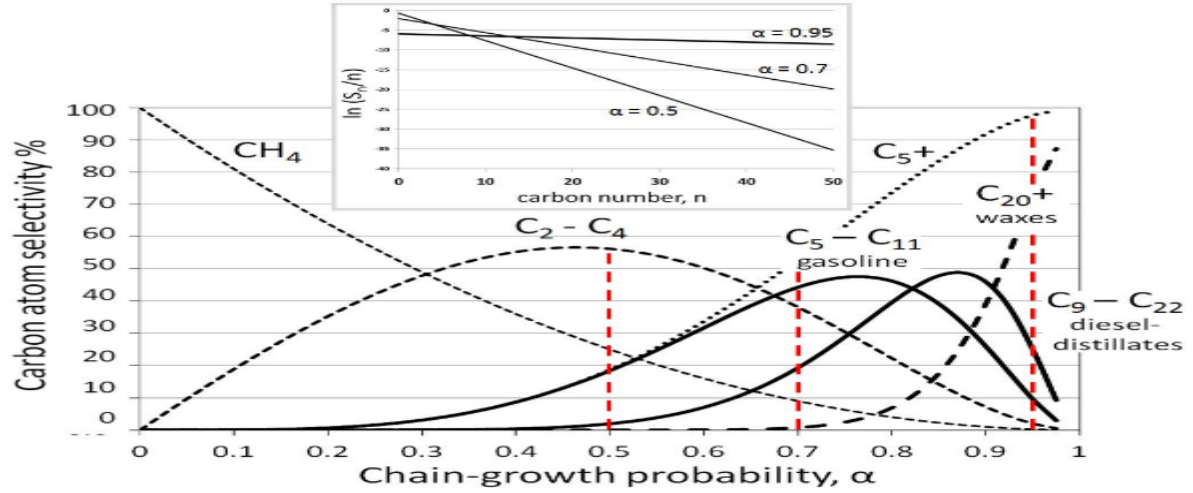
Enhanced energy efficiency in fuel synthesis from biomass

Conceptual water management



Challenges

- ➢Large-scale installation needed or co-location with refinery- Capex challenge
- ➢Detailed gas cleanup necessary to protect catalyst
- ➢Wide product distribution

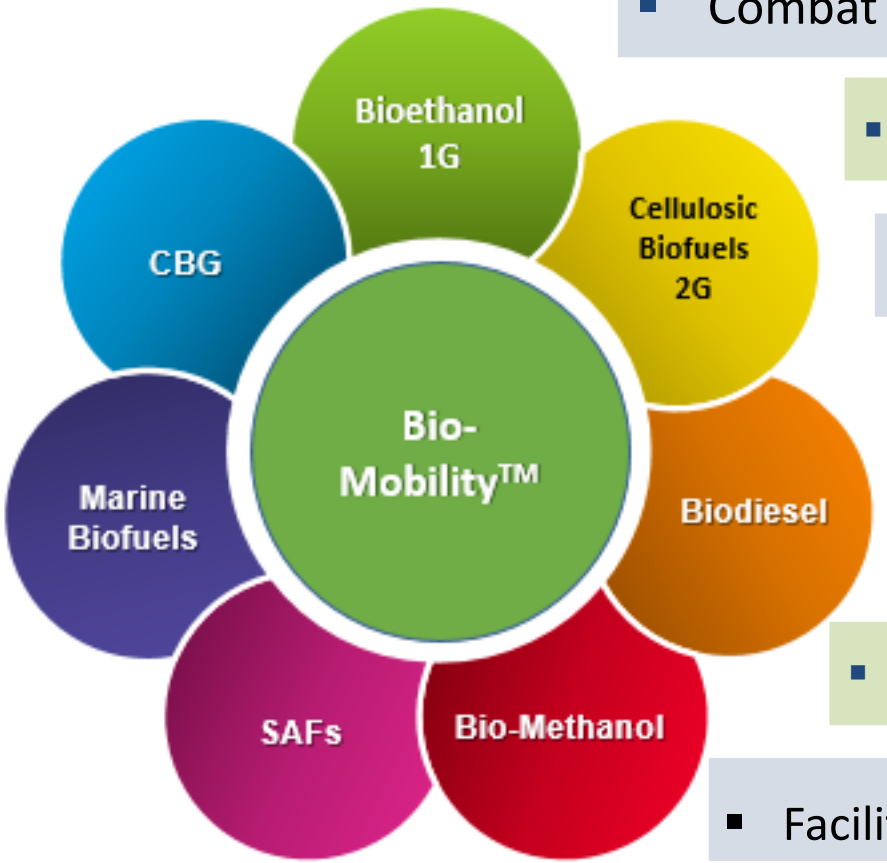


Fischer-Tropsch product distributions in terms of interesting hydrocarbon fractions as a function of the chain-growth , alpha. The insert shows a few Anderson-Schulz-Flory plots according to the logarithmic form.

Summary

Bio-Mobility™ denotes carbon neutral renewable transportation fuel produced from Biological resources like Fuel Ethanol.

Bio-Mobility™ helps to -



- Combat Climate change; Help meet Cop 21 Obligations
- Fight pollution & Minimize GHG emissions
- Uses existing fuel infrastructure
- Leverage existing SCM of the Automobile industry
- Inclusive growth- Boost rural economy by job creation
- Carbon neutral no environmental issue of waste disposal
- Facilitate energy security & save valuable foreign exchange

Praj presence across the globe with 750+ references in more than 75 countries.

THANK YOU