Offsetting Pollution Abatement Costs through Benefits of Circular Economy

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The Energy and Resources Institute





Creating Innovative Solutions for a Sustainable Future

Content

- Agriculture Waste
- Syngas / Waste gas
- Plastic waste
- Waste Glycerol

More than the “3R”

Source: Missouri state university

Waste valorization for circular economy

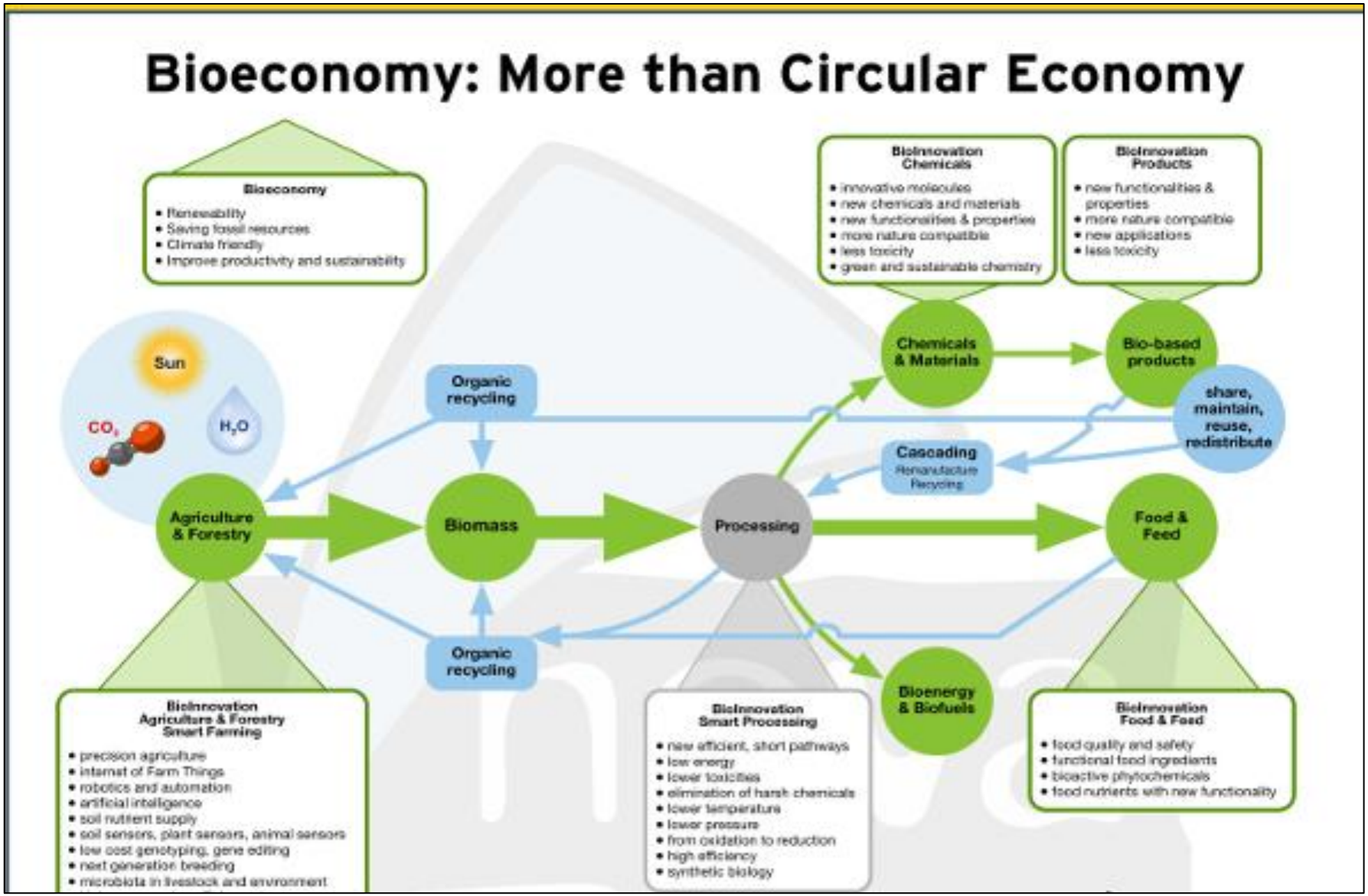
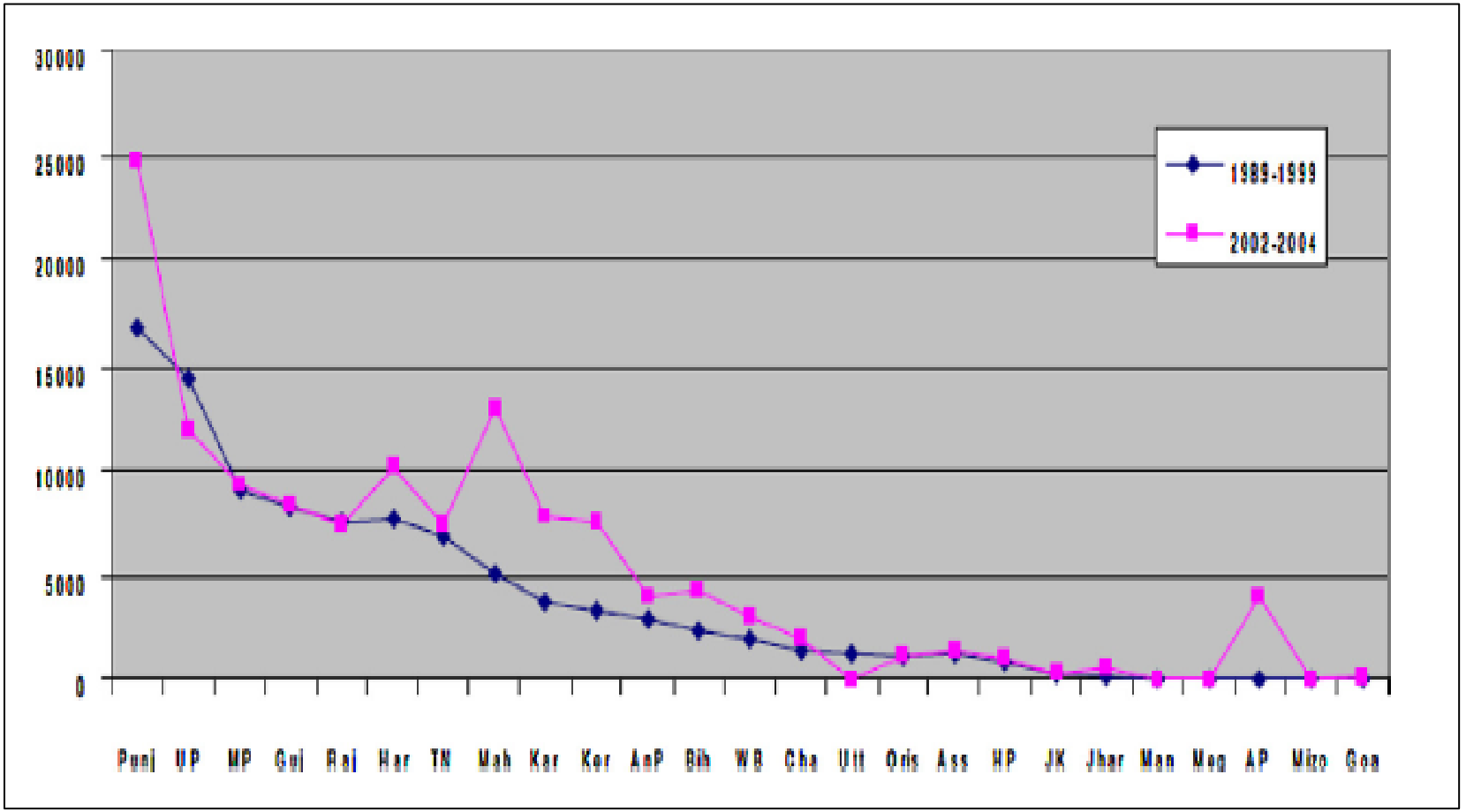


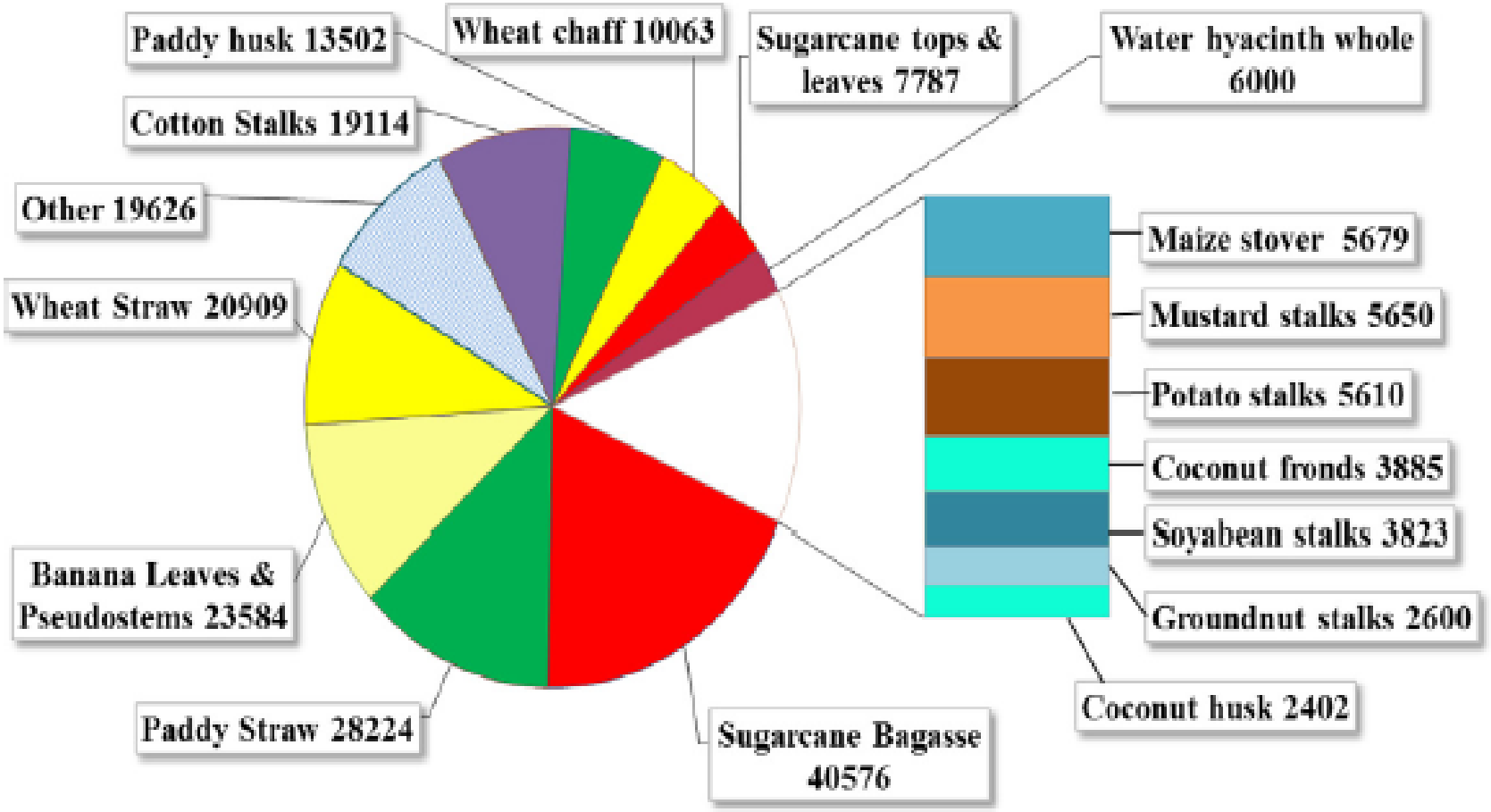
Image source: Nova Institute of Germany

Agriredisues in India



State wise comparison between biomass surplus availability between the years 1989–1999 and 2002–2004 (TERI, 2008).

Agriresidues in India



Residue wise contribution (Kton) to total biomass surplus.

Ref: Cardoen D, Joshi P, Diels L, Sarma PM, Pant D. Agriculture biomass in India: Part 2. Post-harvest losses, cost and environmental impacts. Resources, Conservation and Recycling. 2015 Aug 1;101:143-53.

Utilization of Agriresidues in India

Aggregated Residue utilization in Haryana, Punjab and West Bengal.

State	Animal feed (%)	Thatching (%)	Fertilizer (%)	Domestic fuel (%)	Industrial use (%)	Total utilization (%)	Surplus (kton/year)
Haryana	56	0.3	2	8	6	72	8044
Punjab	68	0.2	2	1	NA	71[1]	11979
W. Bengal	43		18		6	67	9429

Ref: Cardoen D, Joshi P, Diels L, Sarma PM, Pant D. Agriculture biomass in India: Part 2. Post-harvest losses, cost and environmental impacts. Resources, Conservation and Recycling. 2015 Aug 1;101:143-53.

Rice production in India

Total rice straw produced in India	97,192 kt
Surplus produced	22,289 kt
Rice straw used for domestic purposes	27,320 kt (28% of total surplus)
Other activities	47,584 kt
Lower heating value of rice straw	14 MJ/kg
% contribution from open burning	0.05
GHG emissions from open field burning	566,165 tCO_2ea^{-1}
Total surplus subjected to open burning in Punjab and Haryana	48%
Total rice straw burnt in India	13,915 kt (62% of total surplus)

Ref: Singh R, Srivastava M, Shukla A. Environmental sustainability of bioethanol production from rice straw in India: a review. Renewable and Sustainable Energy Reviews. 2016 Feb 1;54:202-16.

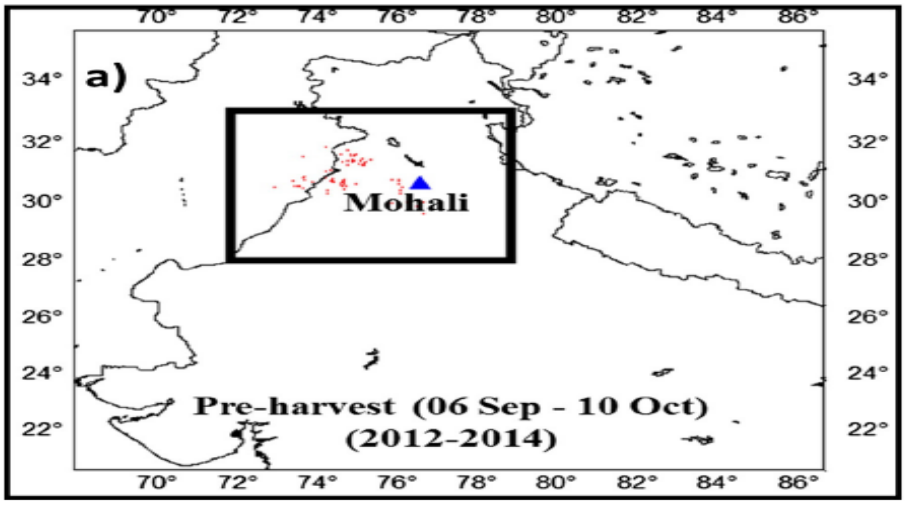
Burning of Paddy

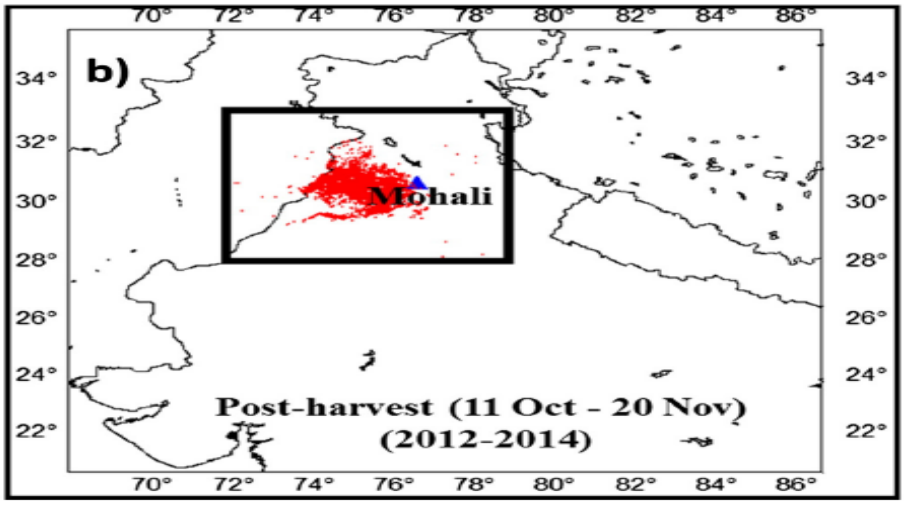
S.no.	Name of pollutant	EF (g/kg_{dm})	India (Gg)
1	CO_2	1460	16253
2	CH_4	1.20	13
3	N_2O	0.07	1
4	CO	34.70	386
5	NMHC	4	45
6	NOx	3.10	35
7	SO_2	2	22
8	Total particulate matter (TPM)	13	145
9	Fine particulate matter ($PM_{2.5}$)	12.95	144

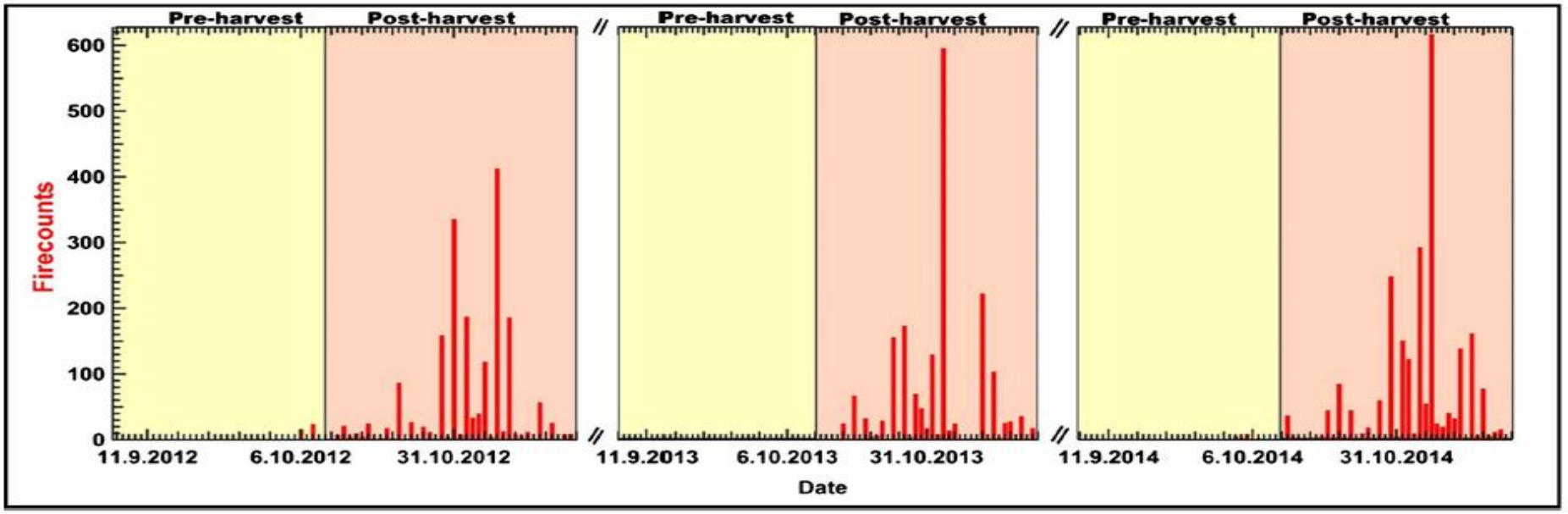
Gg- Giga gram, g/kg_{dm} = gram per kg of dry matters

Ref: Singh R, Srivastava M, Shukla A. Environmental sustainability of bioethanol production from rice straw in India: a review. Renewable and Sustainable Energy Reviews. 2016 Feb 1;54:202-16.

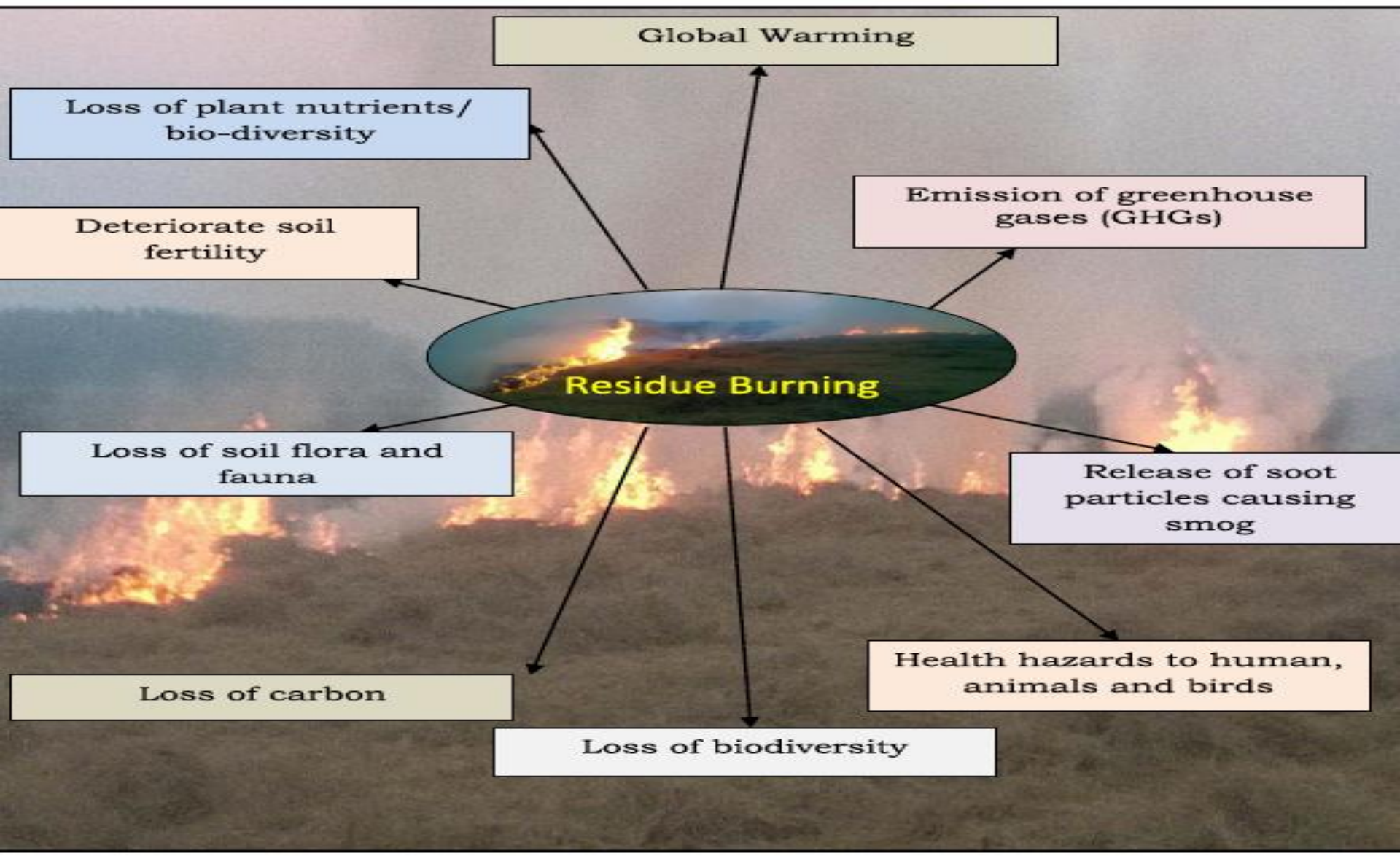
Fire counts pre/post harvesting of paddy







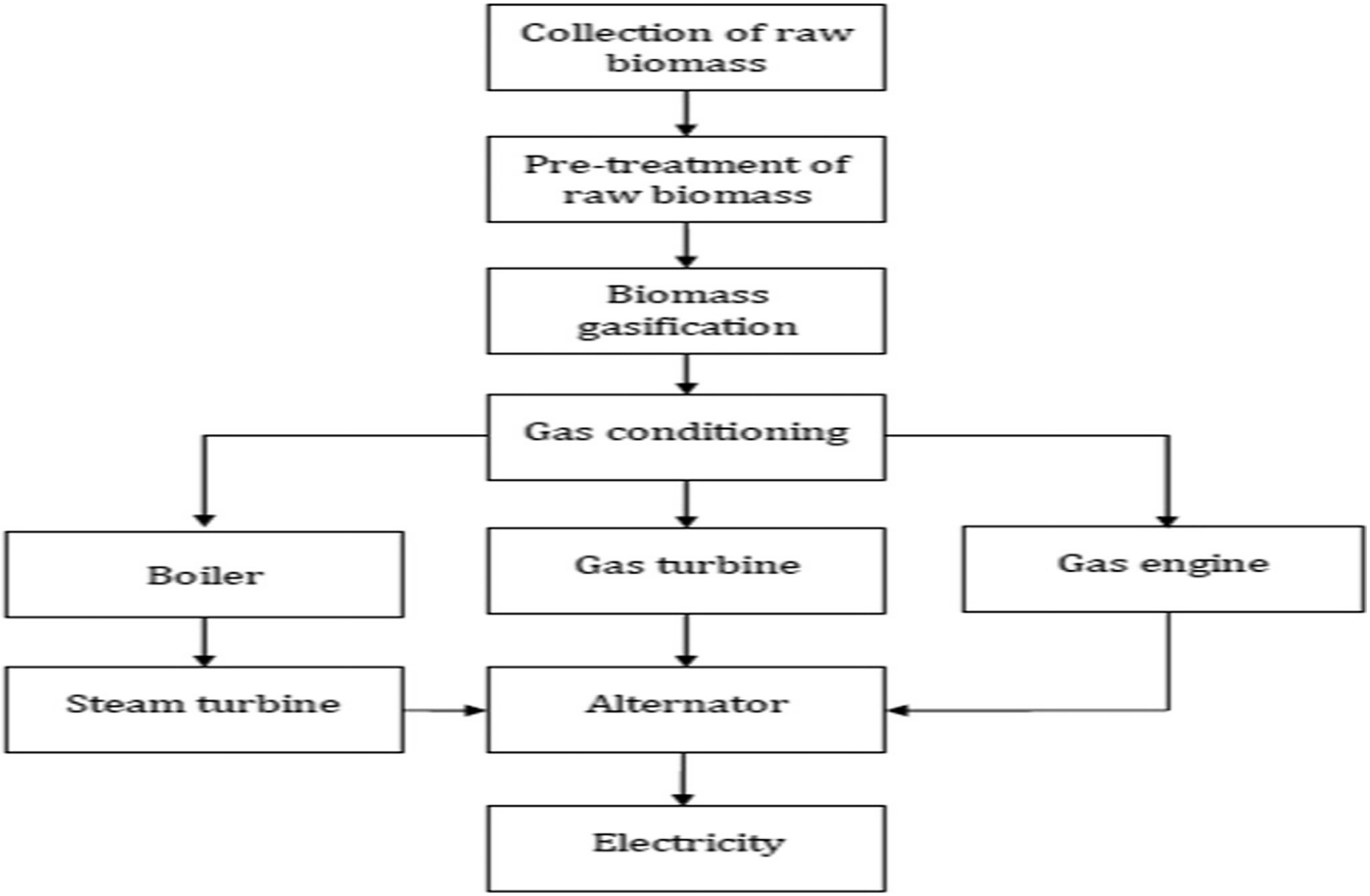
Ref: Chandra BP, Sinha V. Contribution of post-harvest agricultural paddy residue fires in the NW Indo-Gangetic Plain to ambient carcinogenic benzenoids, toxic isocyanic acid and carbon monoxide. Environment international. 2016 Mar 1;88:187-97.



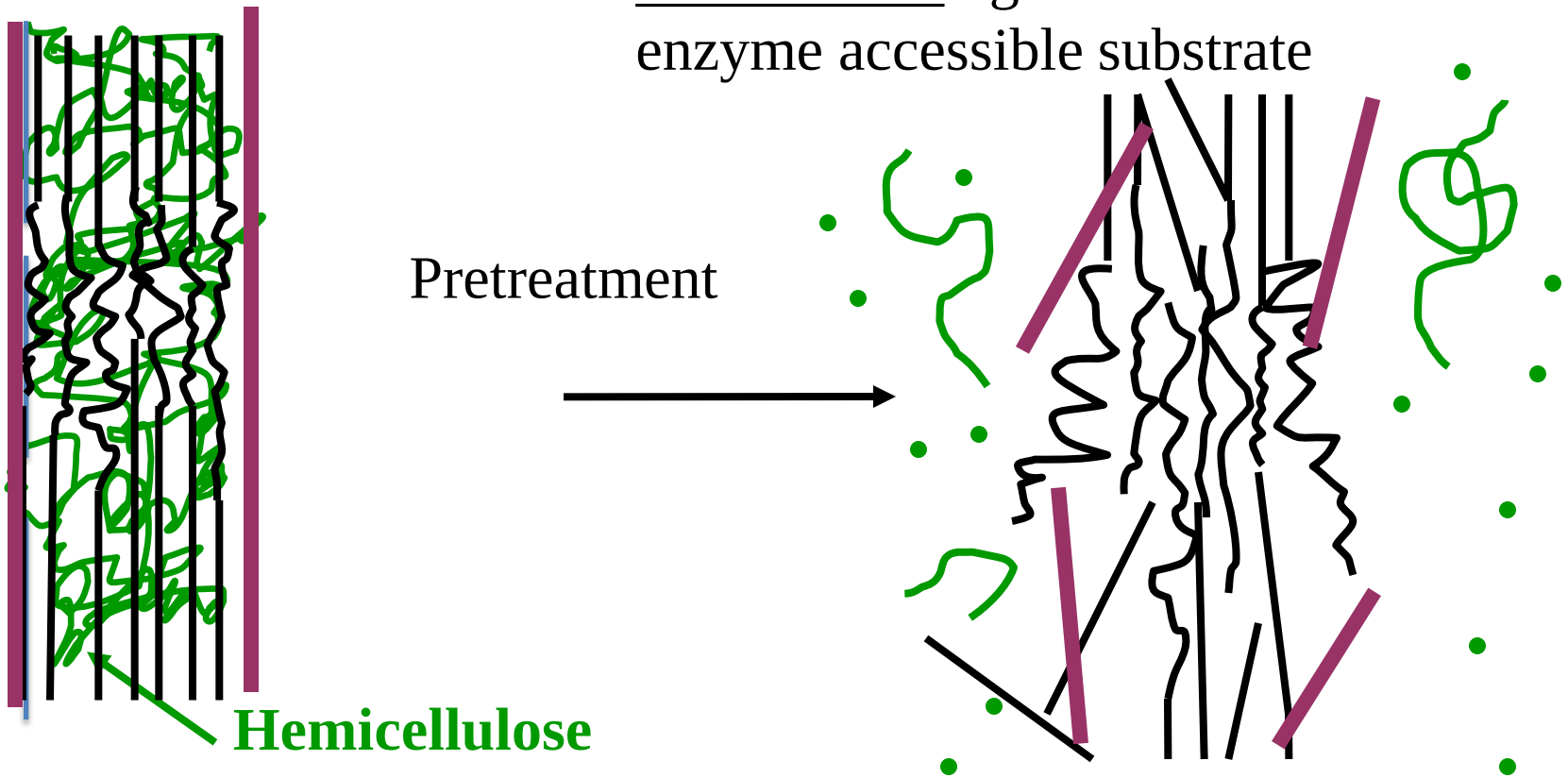
Immense amount of emissions generated due to the burning of the paddy straws causes smog and increase in pollution levels in the adjoining areas especially Delhi

Ref: Lohan SK, Jat HS, Yadav AK, Sidhu HS, Jat ML, Choudhary M, Peter JK, Sharma PC. Burning issues of paddy residue management in north-west states of India. Renewable and Sustainable Energy Reviews. 2018 Jan 1;81:693-706.

Biomass to Electricity

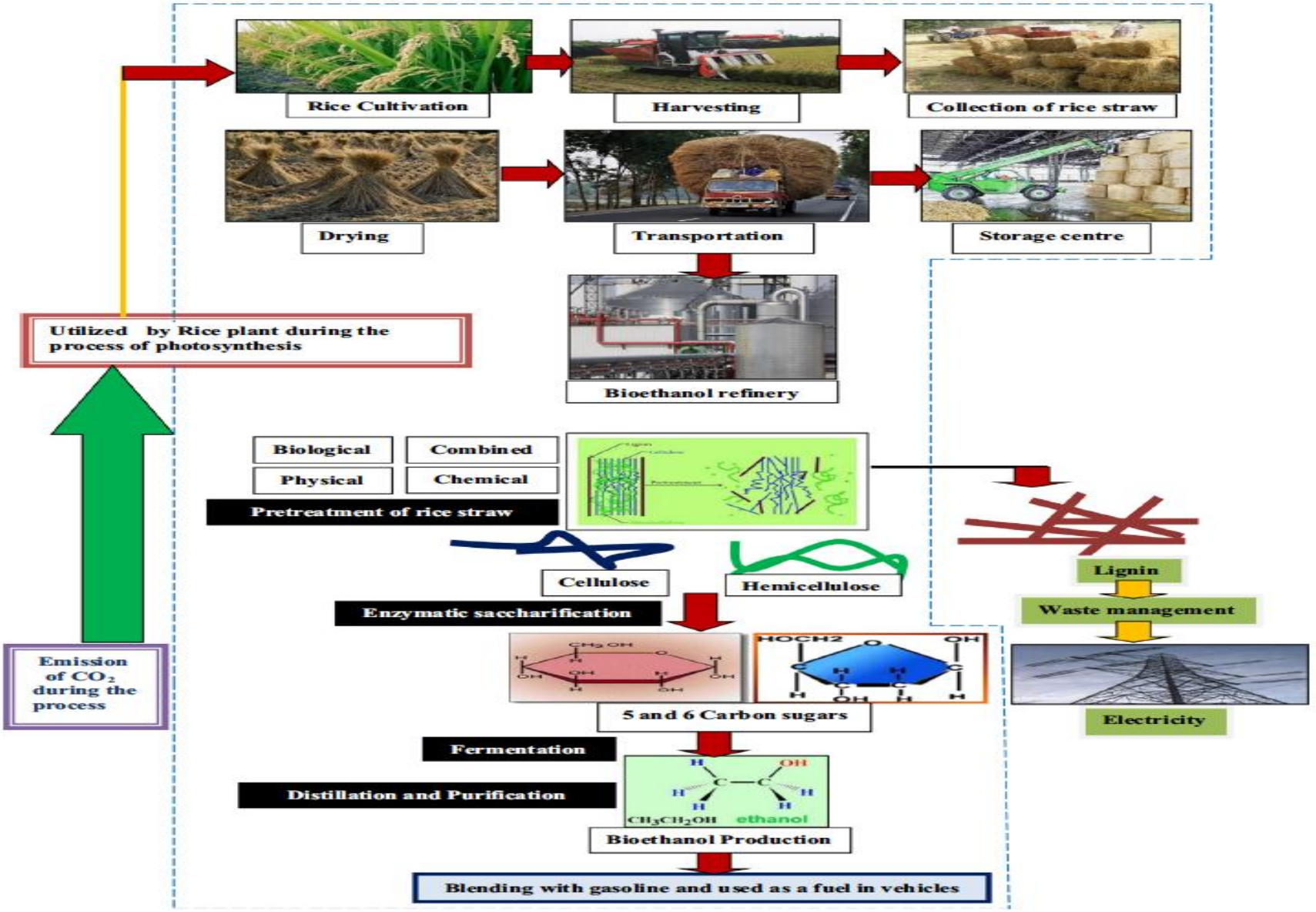


Biotechnological Route to utilize waste



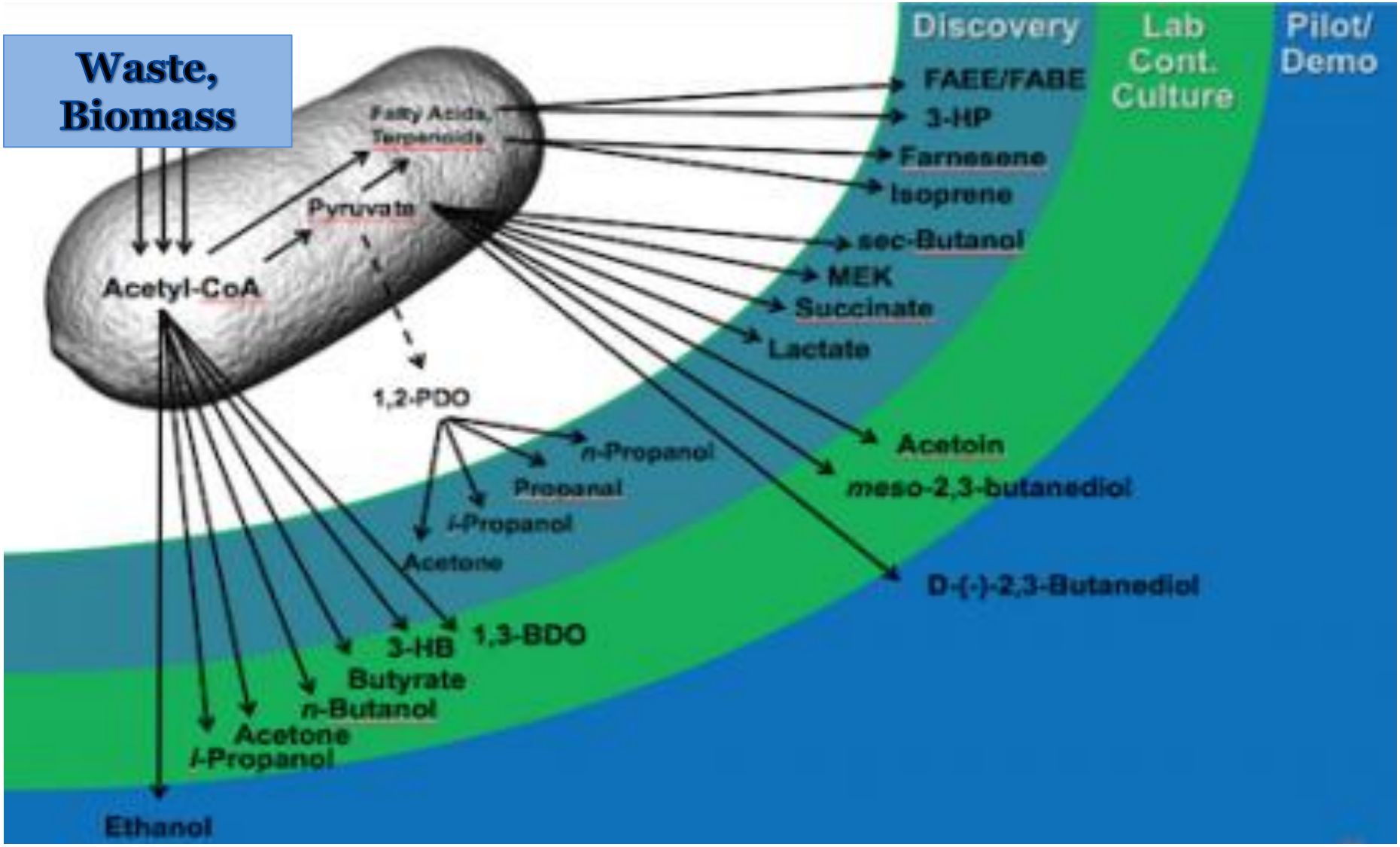
The chemical composition of rice straw depends on varieties and growing season
The general composition of rice straw is cellulose (33–47%),hemicellulose (19– 27%), lignin(5–24%) and silica(18.3%)

Bioethanol production from waste



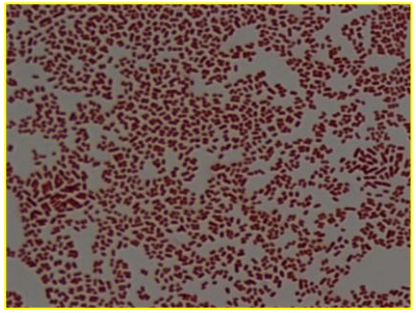
Ref: Singh R, Srivastava M, Shukla A. Environmental sustainability of bioethanol production from rice straw in India: a review. Renewable and Sustainable Energy Reviews. 2016 Feb 1;54:202-16.

Biochemicals from waste valorization



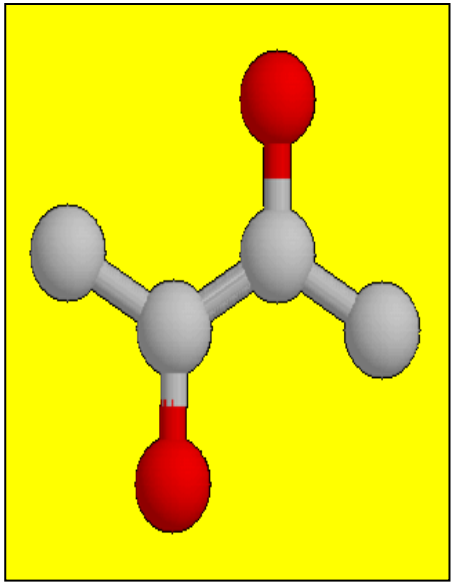
Reference: Lanzatech.com

Biomass to 2,3-Butanediol (Green chemical)



Microbes

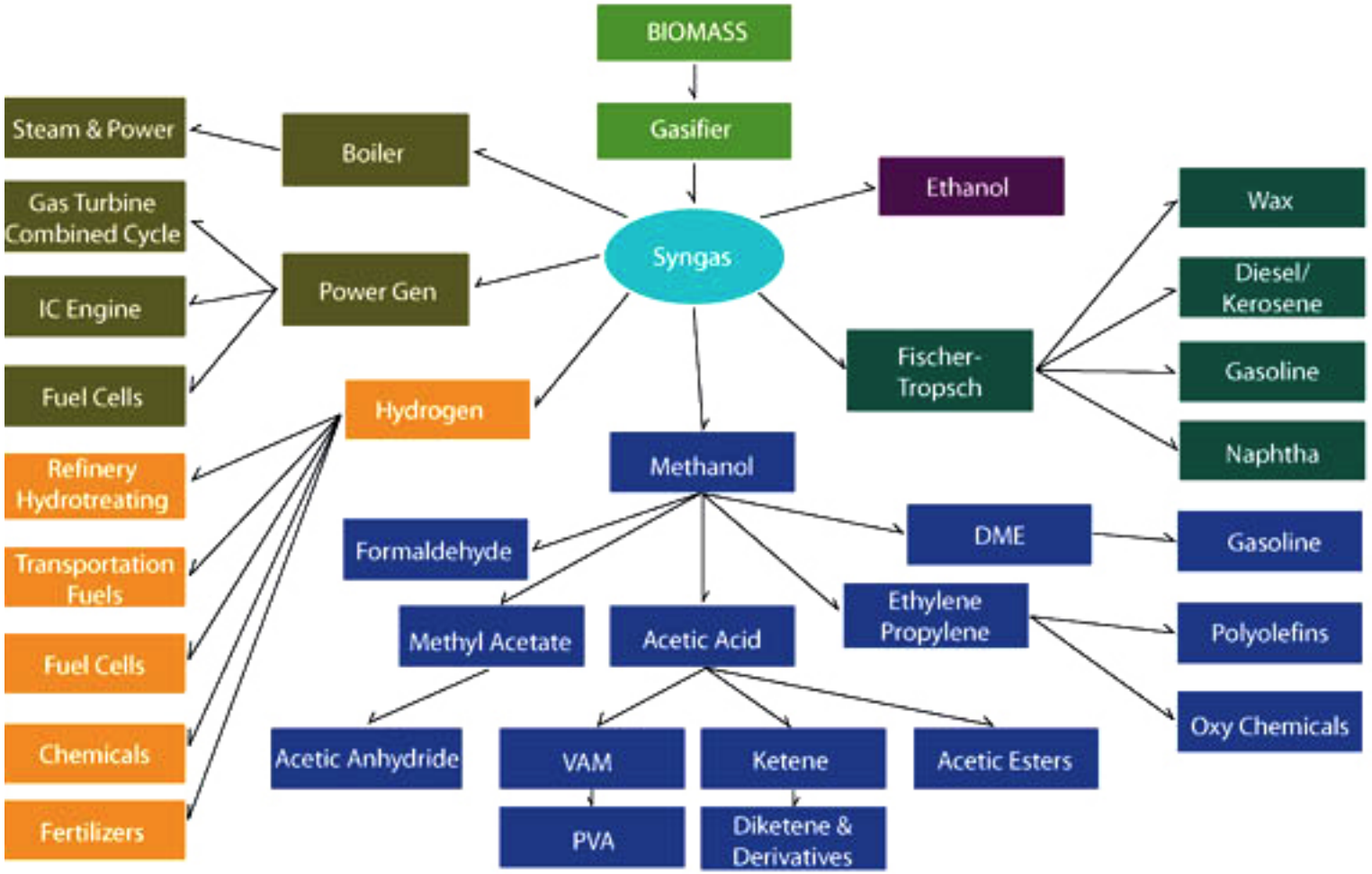
Fermentation



2,3-Butanediol

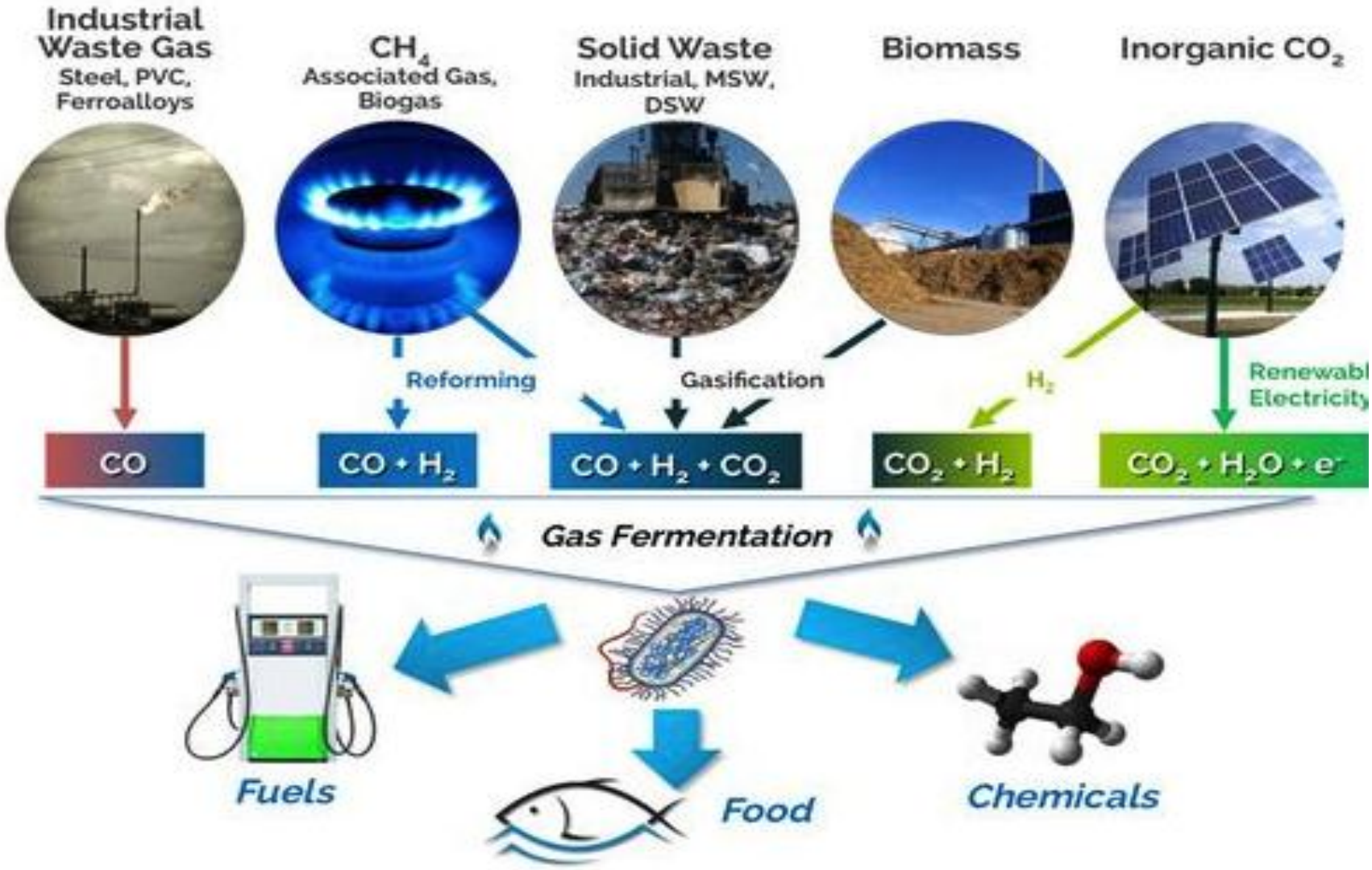
The global demand for 2,3 Butanediol was 58,000 tons in 2010, which is expected to reach 74400 tons by 2018, growing at a rate of 3.2% from 2013 to 2018.

Syngas to Product synthesis



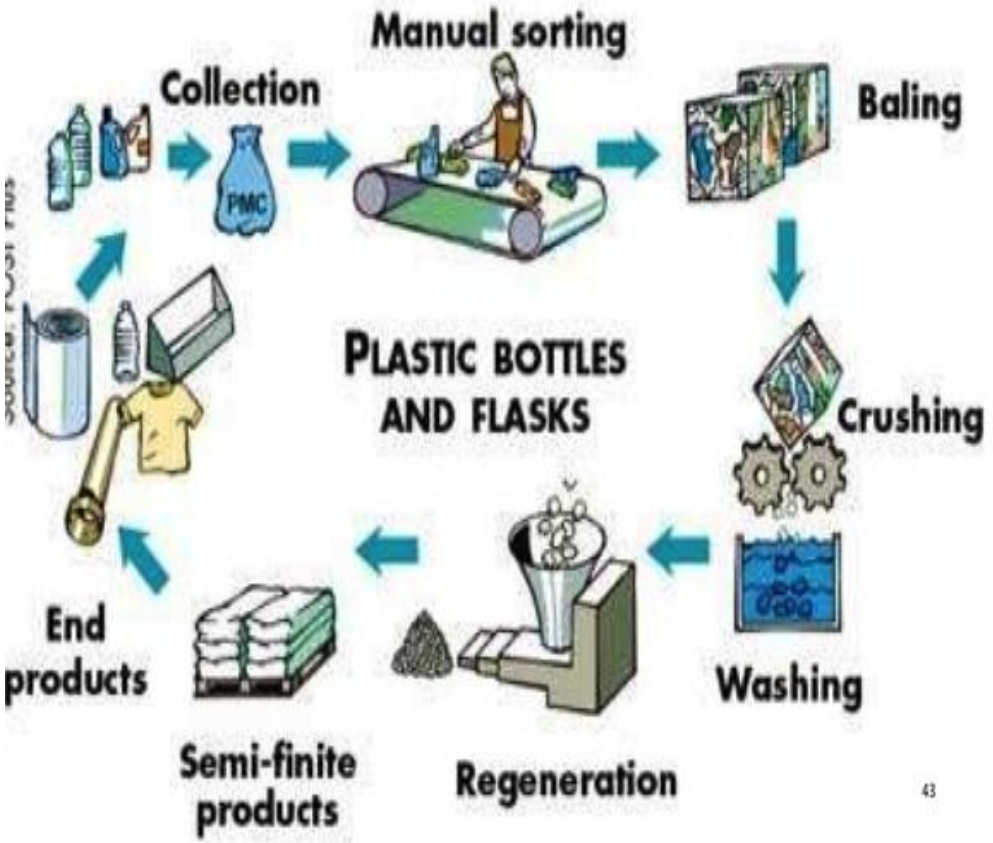
Ref: syngastech.org

Reuse of waste gas from different sources



Ref: make a smart city.com

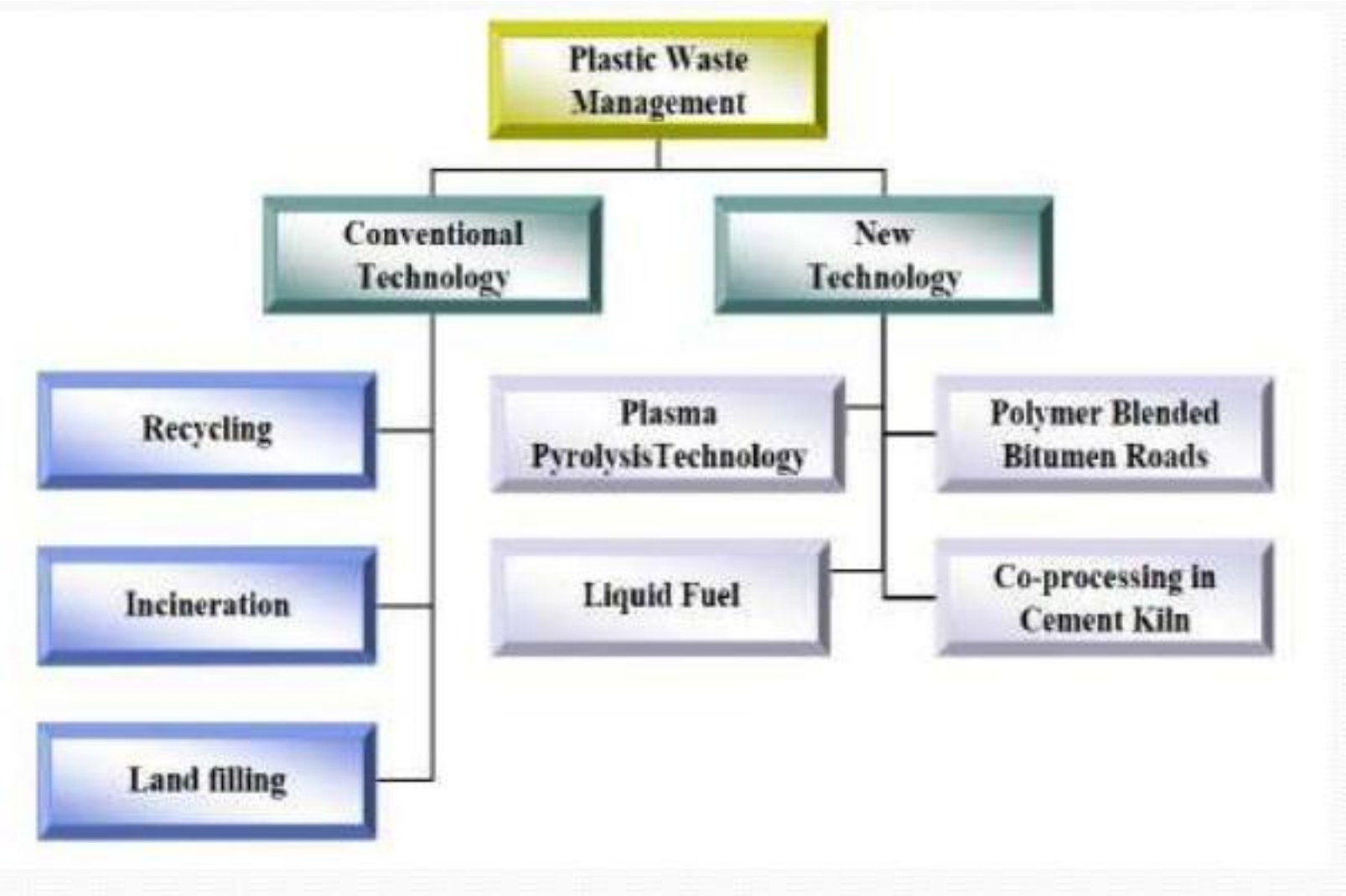
Reuse of plastic waste



Per Capita Plastic Consumption (in kg)

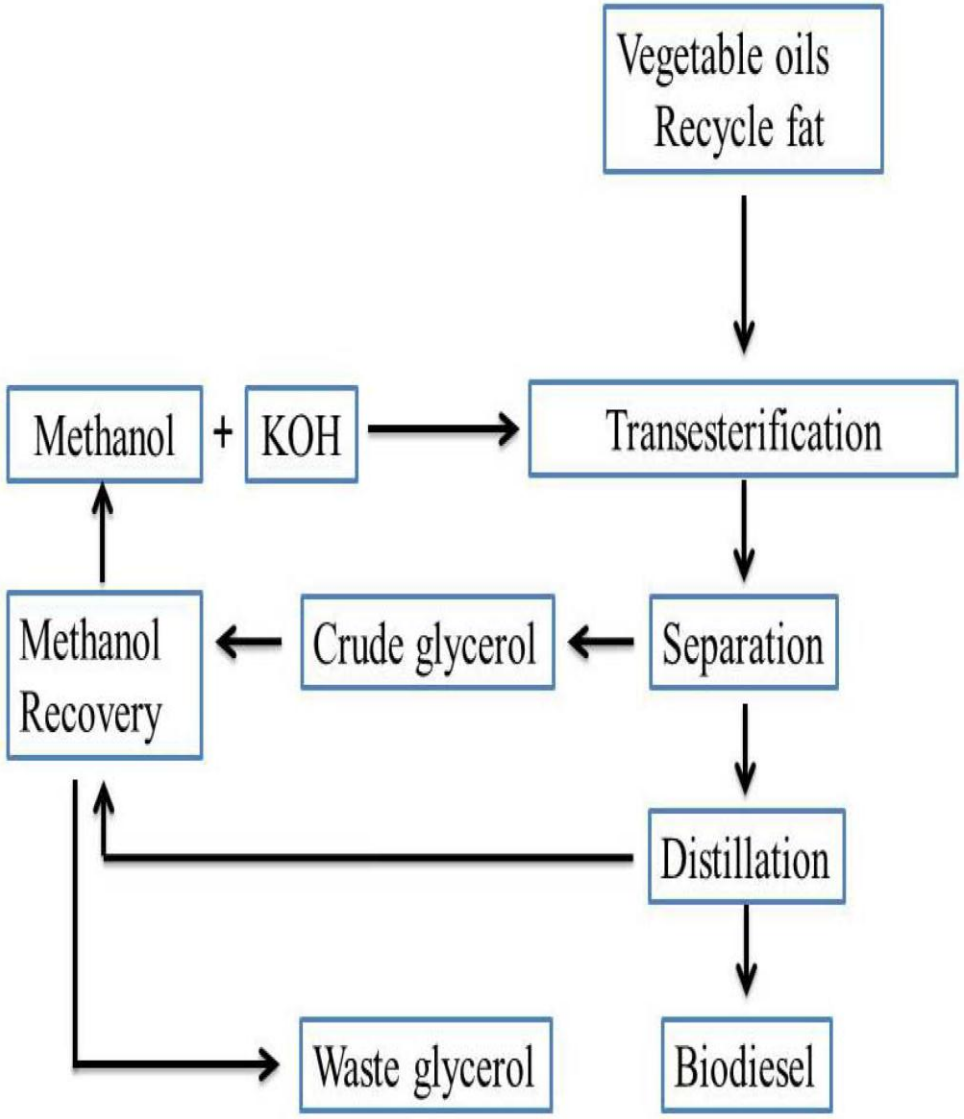
Ref: The Economic times

Plastic waste management



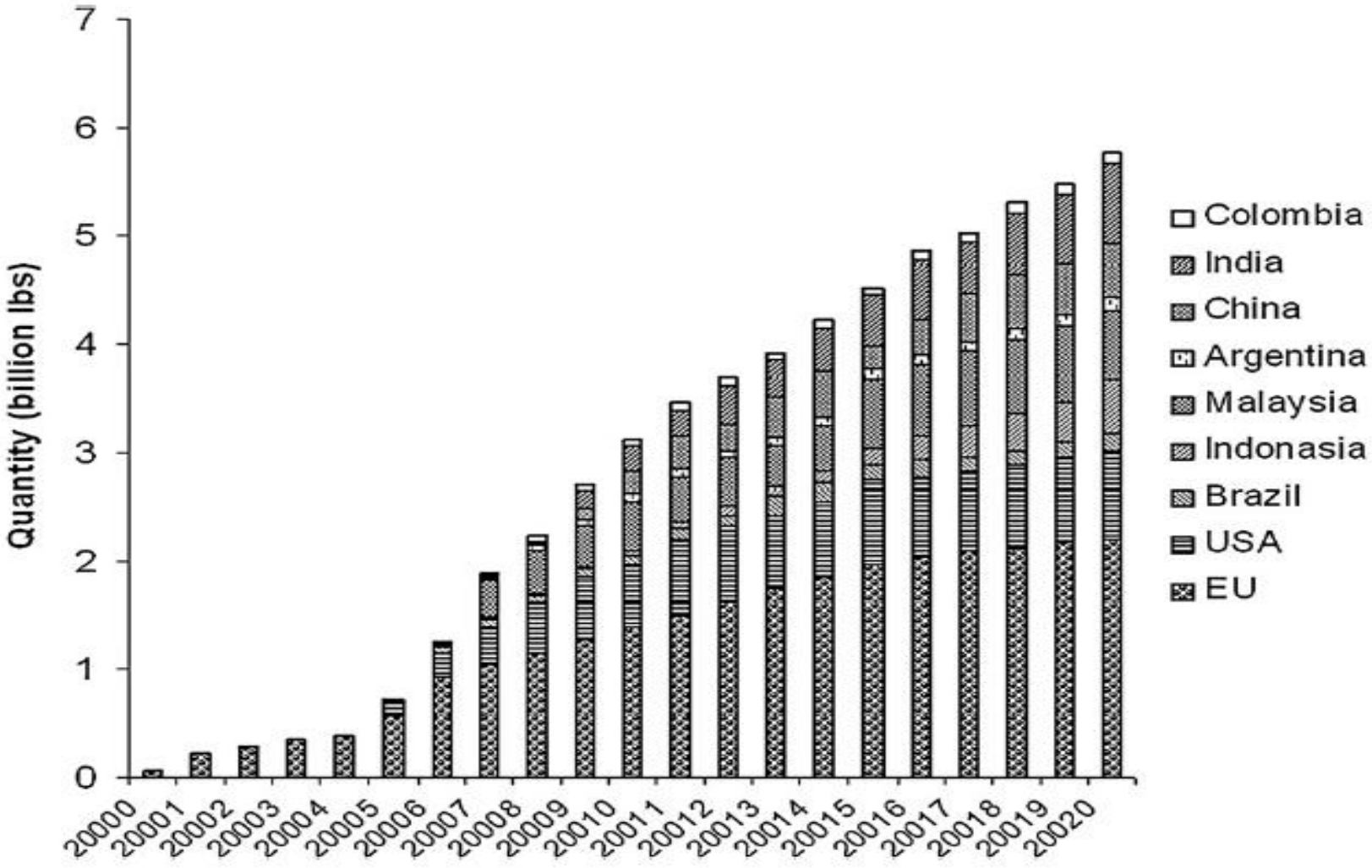
Source: Slideshare.net

Biodiesel derived Crude/Waste Glycerol



Ref: San Kong P, Aroua MK, Daud WM. Conversion of crude and pure glycerol into derivatives :a feasibility evaluation. Renewable and Sustainable Energy Reviews. 2016 Sep 1;63:533-55.

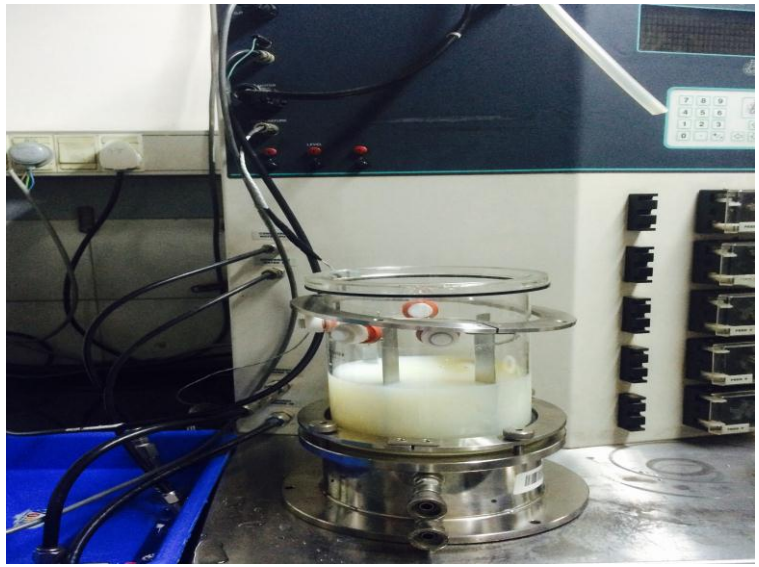
Biodiesel derived Crude/waste Glycerol



Estimated production of crude glycerol from different countries

Ref: Ayoub M, Abdullah AZ. Critical review on the current scenario and significance of crude glycerol resulting from biodiesel industry towards more sustainable renewable energy industry. Renewable and Sustainable Energy Reviews. 2012 Jun 1;16(5):2671-86.

Waste Glycerol (Cost 0$)

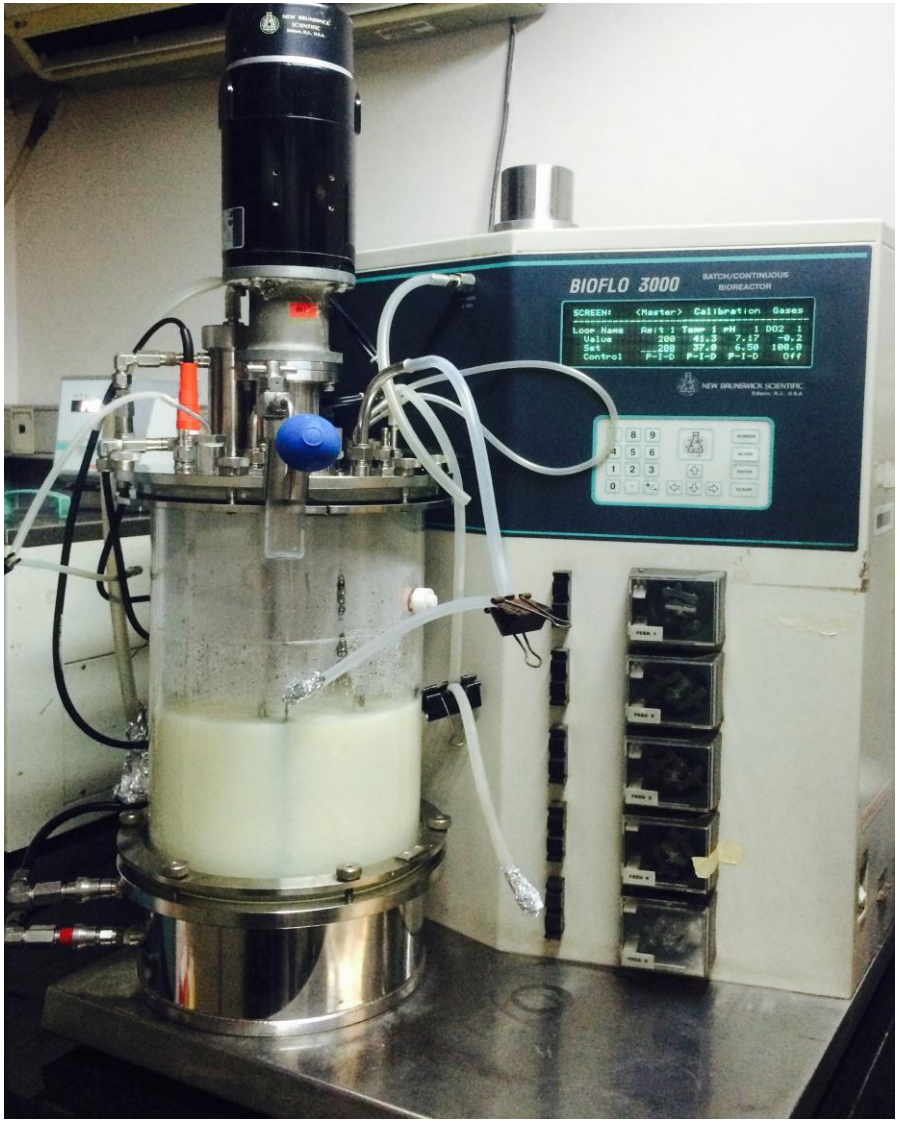


Waste glycerol components

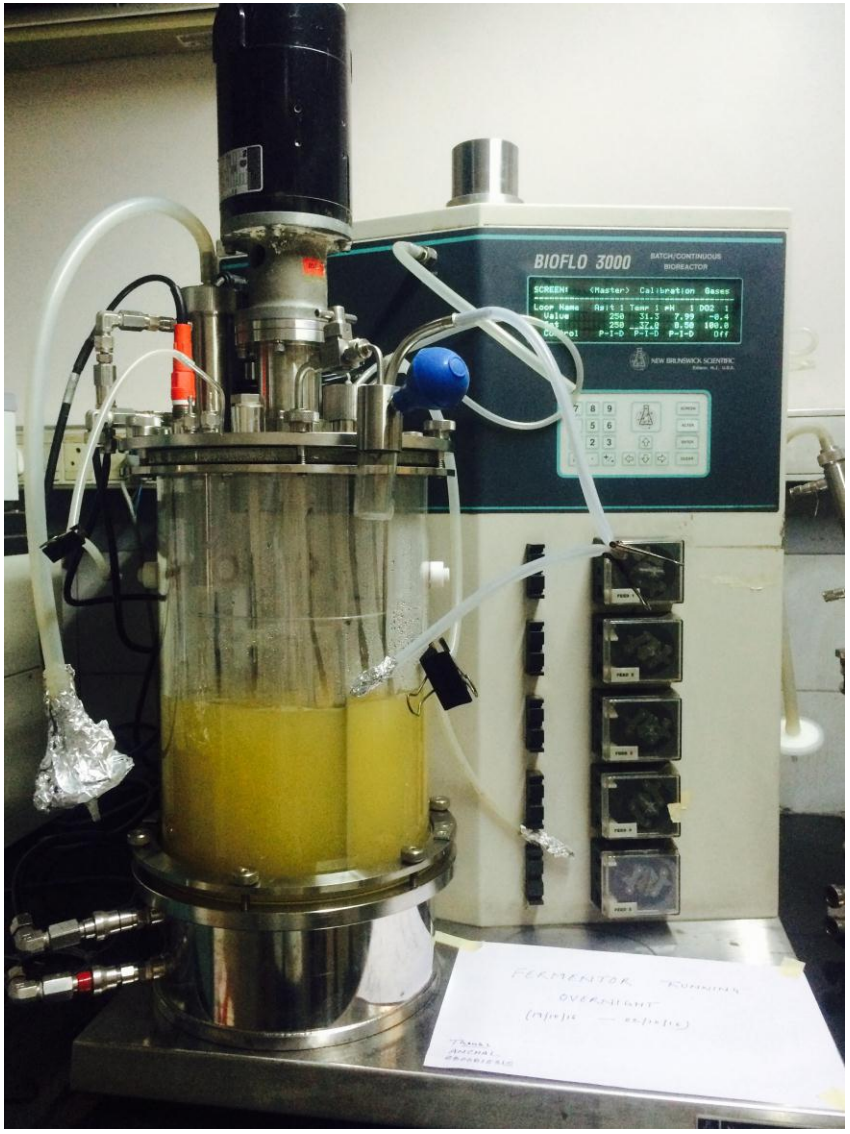
(on type of crop used for biodiesel)

- **Glycerol 20-65%**
- **Soap**
- **Methanol**
- **Sodium/potassium Salts**

Waste glycerol to 2,3-Butanediol



Before



After 24hrs

Challenges

- Pretreatment methods needs to be cost effective.
- Transportation of raw material to balance demand and supply.
- Upscale is a challenge.
- Technical challenges for environment friendly downstream purification and waste treatment
- Analysis of the processes, technologies, and markets, incorporating uncertainty in key technological and market parameters.

Way forward

- **Advanced pretreatments integrated with plant science-** To enhance the digestibility/reactivity of the fiber component (cellulose and hemicellulose)
- **Enzymatic hydrolysis of pretreated celluloses** -To produce fermentable sugars, remove part or all of the cellulose and hemicellulose, increase feed value of residual solids.
- **Use of genetically engineered strain -** Strains capable of assimilating pentoses and hexoses with reduced byproducts.
- **Separations technology (Downstream)** – Use of energy efficient recovery of different bio-products from fermentation broth.
- **Comprehensive economic analysis** – Analysis of the processes, technologies, and markets in India for circular economy

Thank you