



"Sustainable Bio Resources in India"

WBA - Roundtable Seminar - 26th Nov 2014

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INDIA – BIO RESOURCES AVAILABILITY

BIOMASS HAS VERY SIGNIFICANT CURRENT/FUTURE SHARE IN INDIAN HOUSEHOLDS ENERGY CONSUMPTION (mill TOE)

NEED TO ENHANCE EFFICENCY & OPTIMISE ENERGY YIELD

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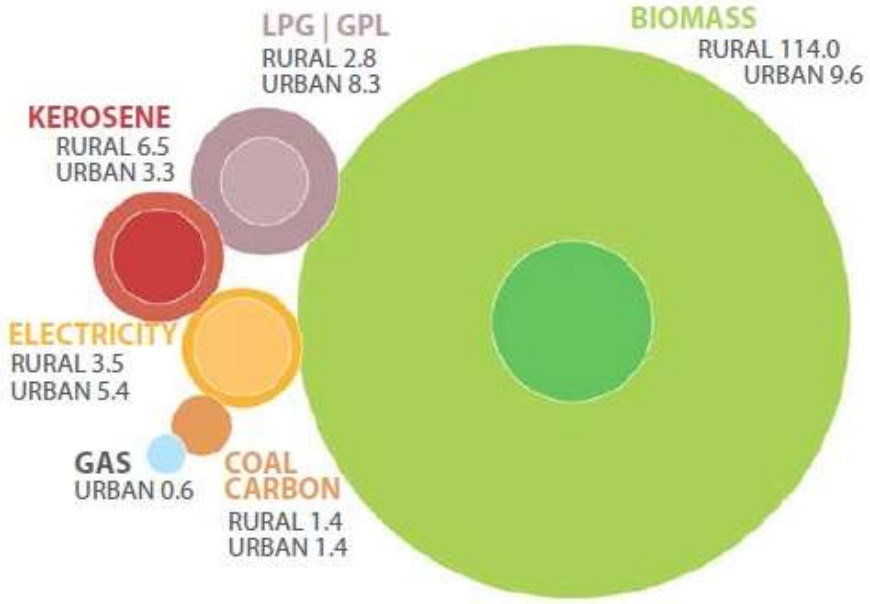

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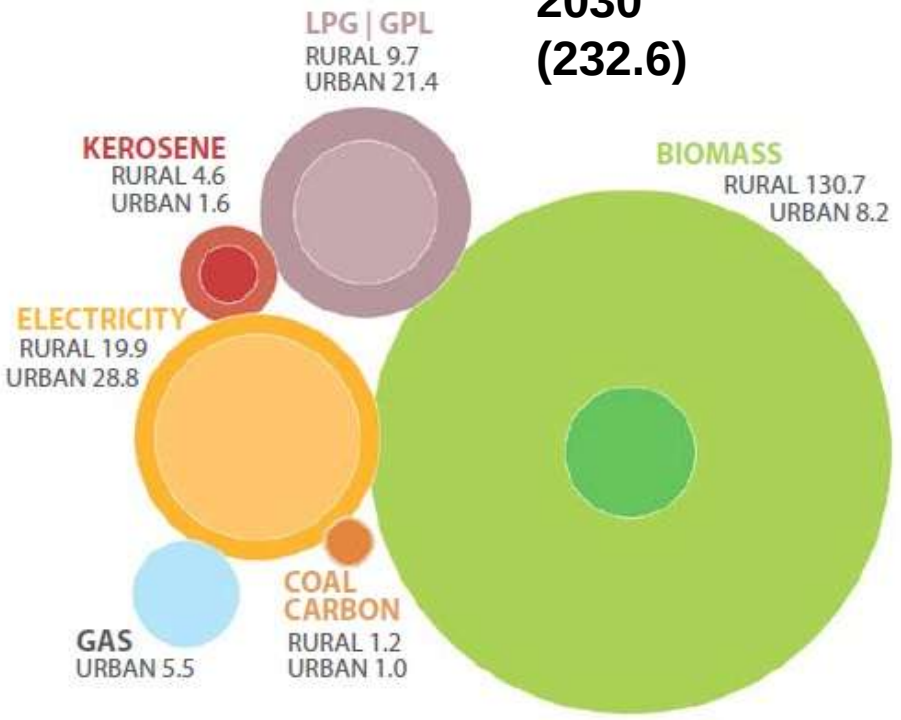


All H/H : Electricity : 8.9 -> 48.7; LPG/N.Gas : 11.7 to 36.6; Biomass : 123.6 -> 138.9

Rural H/H : Electricity : 3.5 -> 19.9; LPG/N.Gas : 2.8 to 9.7; Biomass : 114.0 -> 130.7

Bio energy, currently, contributes 23.5% of India's primary energy (750 mill TOE) .

Source: International Development Policy: Energy and Development, 2011
Data: IEA, World Energy Outlook 2007

BIO RESOURCES AVAILABILITY

- Sustainable Bio Resources, **linked to land & coastline** are summarized in chart below

SOURCE	AVAILABILITY (million hectares)	BIO RESOURCE	APPLICATIONS
Forests Land	70.0 overall 28.8 open forest	(a) Fast growing bamboo/tree species (under National Mission for Greener India) (b) Forest residues, lantana, etc., that can be sustainably harvested/collected	(i) Cooking/Heating fuel (ii) Feedstock for Boilers/Gasifiers (iii) Pyrolysis for Liquid BioFuels
Agriculture Land	141.0 nett cropped ≅ 200.0 gross cropped ≅ 55.0 lying fallow for 6 months.	(i) 120 million tons of Agro Processing units residues (bagasse, husk) …… (ii) 600 million tons of agricultural residues (iii) Short cycle leguminous/silage crops cultivated when land is fallow.	(i) Feedstock for Boilers/Gasifiers …….. (ii) Pyrolysis for Liquid BioFuels …… (iii) Feedstock for Bioethanol/Biogas Plants.
Grazing/Fallow Land	≅ 50.0 overall	(a) Non edible oil seeds (b) Algae with high lipid content …… (c) Appropriate species of bamboo/trees …… (d) Short cycle leguminous/silage crop (e) Algae which gives high Biomass yield	(i) Production of SVO/Bio diesel …….. (ii) Cooking fuel (iii) Feedstock for Gasifier/Boilers …….. (iv) Feedstock for Bioethanol/Biogas Plants. …… (v) Pyrolysis for Liquid BioFuels
Coastline	7517 km (including Islands)	(i)Algae with high lipid content or with high biomass yield. (ii) Sea Weeds	(i) Production of Biofuels through Bio Ethanol Refineries or Hydro treatment. ..... ii) Pyrolysis for Liquid BioFuels

INDIA – POTENTIAL for PLANTATIONS

- ***State of Forest Report 2009***
  - About 28.83 million (out of total 71 million) hectares is of open forest lands (tree cover of canopy density between 10-40%) &
  - 0.28 million hectare of scrub land (tree cover of canopy density less than 10%).
- **National Mission for Greening India**
  - Aims at increasing forest / tree cover on 5 million hectare forest / non forest lands and
  - improves quality of forest cover on another 5 million hectare which will be taken up on degraded forest land.
- Therefore, identifying **2.0 million hectare**s for energy plantations may not be a major constraint, subject to enabling policy guidelines framed by the Ministry of Environment & Forest and Ministry of Rural Development.

Agriculture waste (incl. inferior quality "dry" fodder)

(Indian Agriculture*characterised by low farm yields – through sub-optimal farming of grains)*

Agricultural Crop	Gross Area (mill hectares)		Production (mill MT)
	Cultivated	Irrigated	
Rice	43.5	22.4	
Wheat	26.6	23.5	
Other grains	29.4		
Pulses	22.4		
SUB TOTAL- FOOD GRAINS	***121.9***		***230-250***
Oilseeds	27.7	6.5	
Cotton	8.9	2.6	
Sugarcane	4.2	4.0	
Tea/Coffe	0.8		
SUB TOTAL- CASH CROPS	41.6		350-400

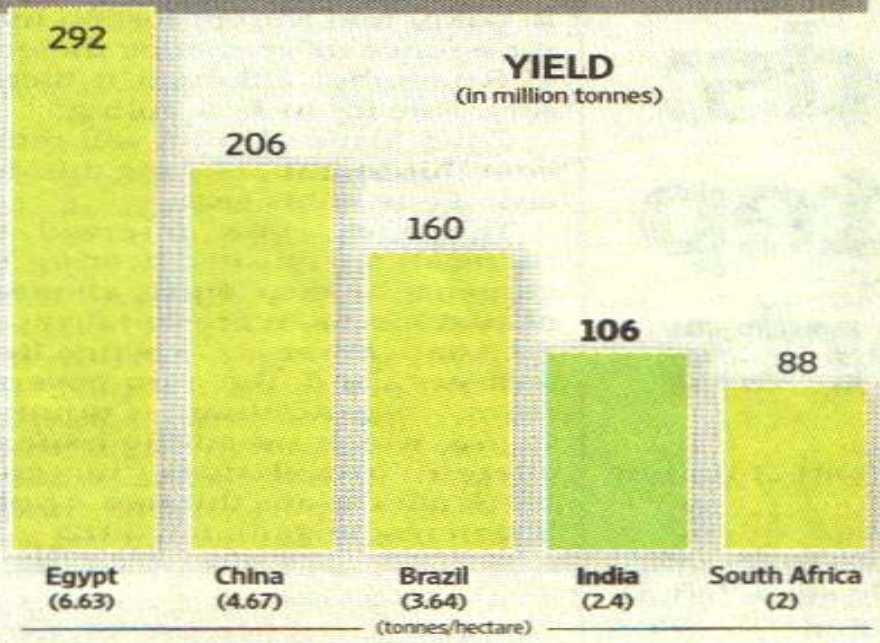
- ***40% of land is under "1 season" mono cropping*** *: potential for sustainable cultivation of "short cycle" cellulosic biomass, as animal feed + make agri residues surplus (to be feedstock for bio energy projects). Yields improvement through adding compost (produced from processing manure/bio waste)*

INDIA'S AGRICULTURE YIELD RATES LAG THOSE OF BRICS COUNTERPARTS

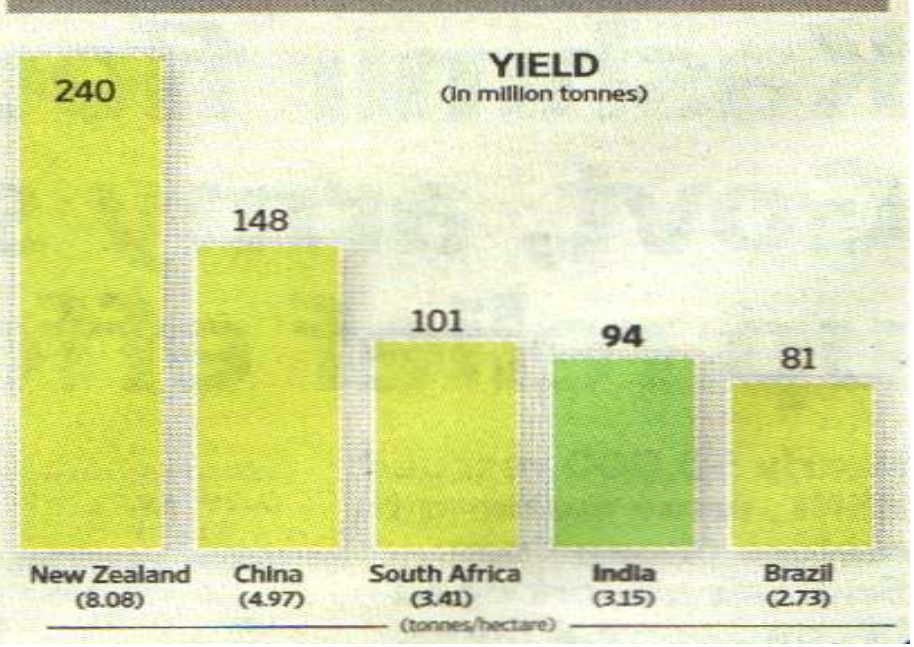
India's yield rates for rice and wheat—tonnes produced per hectare—is drastically lower than even BRICS counterparts. Currently, India produces 106.19 million tonnes of rice a year from 44 million hectares of land. That's a yield rate of 2.4 tonnes per hectare, placing India at 27th place out of 47 countries. And with 93.51 million tonnes of wheat from 29.65 million hectares, India's yield rate of 3.15 tonnes per hectare places it 19th out of 41 countries.

Compiled by **TCA Sharad Raghavan/Mint**

RICE



WHEAT



Napier Grass – CO3 & CO4 – as Cattle feed

CO-3 is an inter-specific hybrid between Bajra (Pennisetum americanum L.) and a selection of a common Napier (Pennisetum Purpureum Schum) It is one of the highest yielding perennial tropical fodder grasses, up to 150 tons/acre/year (16.2% dry matter, 58% digestability, 9.38% crude protein)

CO-4 : *Pennisetum purpureum* is a monocot C4 perennial grass in the Poaceae family. It is tall and forms in robust bamboo-like clumps. It is a heterozygous plant, but seeds rarely fully form; more often it reproduces vegetatively through stolons which are horizontal shoots above the soil that extend from the parent plant to offspring. This species has high biomass production, with cultivation throughout the year. Additionally, it requires low water and nutrient inputs. Planting & Harvesting norms as below

i. **PLANTING**

Irrigate through the furrows and plant one rooted slip/stem cutting per hill. Spacing 50 x 50 cm and 40,000 planting material in one hectare. As a mixed crop, 3 rows of Cumbu Napier Hybrid and one row of Desmanthus can be raised to increase the nutritive value.

ii. **HARVESTING**

First harvest is to be done on 75 to 80 days after planting and subsequent harvests at intervals of 45 days to give yield of around 400 t/ha (or 64 tons dry matter) per year.

Silage/ Rotation Crops – Seasonal

Tropical Sugar Beet (TSB) : Moderate water & fertlliser requirement , 30 – 40% of cane.

Excellent rotational crop for enhancing yield of the next crop. Can be grown in saline & alkaline soils & rejuvenates soil

Total yields of 120 to 140 tons/hectare (TSB + Maize Silage)

Sorghum (*Sorgum bicolor*) is known as a grain crop and has a variety that is used as livestock fodder. Its high rate of photosynthesis produces leafy stalks up to 5 metres tall that make excellent silage. Sweet sorghum has a wide adaptability, a marked resistance to drought and saline-alkaline soils, and fodder sorghum has tolerance to water logging.

Sorghum *yields are of the order of 100 -120 MT/hectare* with irrigation

SORGHUM

Silage Preparation & Storage

Silage Pile

Horizontal Silo's (Bunkers)

India's current fodder consumption (green + dry) is around 1 billion MT. Cultivating short cycle cellulosic biomass ,as 2nd crop in rain fed areas, can enhance availability to 2 billion MT … meeting needs of Animal feed as well as generating surplus for Bio-energy .

Poor quality fodder is a key cause of low milk yields in India … 70 million producers average only 6 to 8 liters/day of milk.

Milk production (annually 120 mill tons, targeted as 200 mill tons by 2021) is a key element of farm households nutrition & income (from milk sales)

Rice Straw – Punjab, Haryana, UP, Bihar

Satellite picture of Punjab (end Sept – early Nov))

- **> 40 million MT rice straw is annually generated in North India (Punjab, Haryana, Uttar Pradesh & Bihar) where wheat is the winter crop & rice is summer crop. > 90% of this rice straw is burnt in fields. Hence, significant resource for Cellulosic Ethanol production.**

Black Carbon – from burning of Paddy straw – reduces wheat output

PRIYANKA PARASHAR/MINT

Under threat: *A study has said air pollution seems to have hit wheat production in India.*

'Pollution hits grain output'

Rome: Air pollution seems to have a direct, negative impact on grain production in India, a study warned on Monday, with recent increases in smog decreasing projected yields by half.

Analysing 30 years of data, scientists developed a statistical model suggesting that air pollution caused wheat yields in densely populated states to be 50% lower than what they could have been in 2010.

Up to 90% of the decrease in potential food production seems linked to smog, made up of black carbon and other pollutants, the study said. Changes linked to global warming and precipitation levels accounted for the other 10%.

"The numbers are staggering," Jennifer Burney, an author of the study and scientist at the University of California said.

REUTERS

Source : Mint, 5th November, 2014

SUGARCANE RESIDUES (Bagasse) + CaneTrash

Cultivation area : 4.2 million ha
Cane produced : 350 million tons/year

Bagasse available (dry matter) :55 million tons/year
Cane trash available (dry matter) : 20 million tons/year

Total cellulosic-ethanol potential : > 16 million tons/year
(annual , 2017 , petrol demand : 22 million ton)



Manure Treatment (anaerobic digestion) Systems

India has 283 million bovine animals, India, annually, produces 120 mill tons Milk → 200 mill tons (by 2020)

India has 500 million poultry birds, with high CAGR (eg Namakkal district)

(in lakhs)

Average strength of layer birds in Namakkal zone in the last 10 financial years

2000 - 01	171.18
2001 - 02	212.71
2002 - 03	225.42
2003 - 04	219.19
2004 - 05	234.49
2005 - 06	307.34
2006 - 07	339.79
2007 - 08	367.35
2008 - 09	398.62
2009 - 10	407.34
2010 - 11	447.19
2011 - 12	500*

*average strength after expansion

1250 million tons/year manure (18% DS)

10 million tons/year dry manure (75% DS)

To produce <u>Biogas</u> + assured quality compost (major/micro nutrients + humus)

Horticulture linked Bio waste processing

India's Horticulture output is 210 mill MT against NHM target of 350 mill MT → waste (30 to 40% of output, which can be processed to produce biogas + organic fertiliser)

China's vegetable output is 330 kg per capita (> 3 times Indian output & twice world average)

Cold Storage

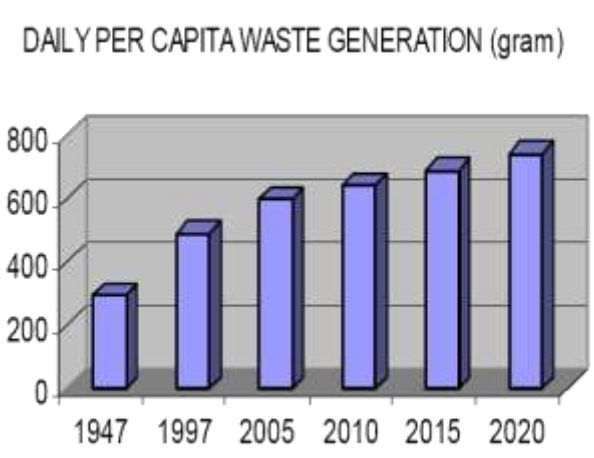
- **Indian farmers tend to cultivate grains (even with sub optimal returns, rather than vegetables) as they are not perishable.**
- **Green Houses & Cold Chain infrastructure would (a) stimulate non grain farming (b) enhance farmers income (c) meet nutrition needs of the community (d) open up significant opportunities for exports**
- ***Liquid CO2 controlled injection into Green Houses would double the yield***
- ***Dry Ice (produced from liquid CO2) could meet cooling needs of "Pack Houses" & refrigerated transport.***
- ***Compost will increase yields***

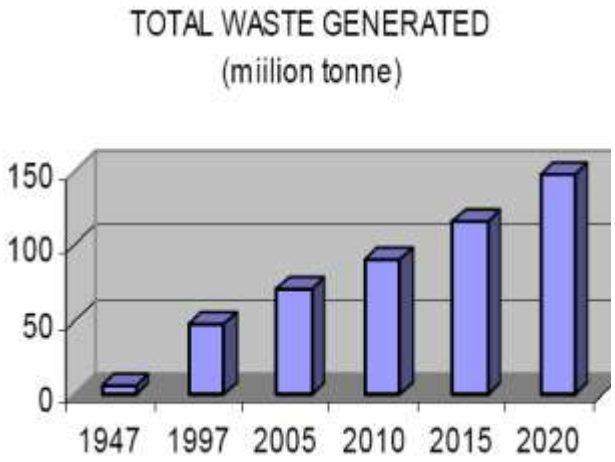
Cut Vegetables

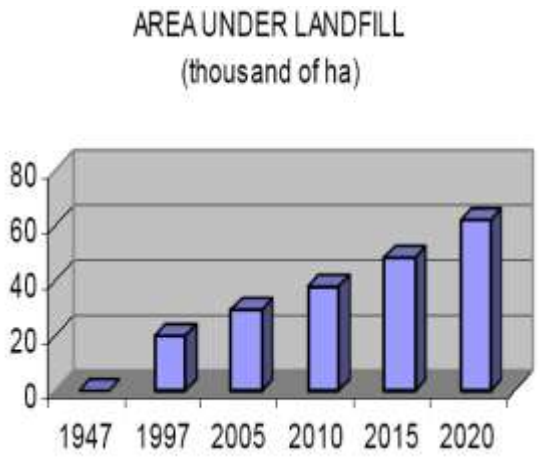
Tomato Puree

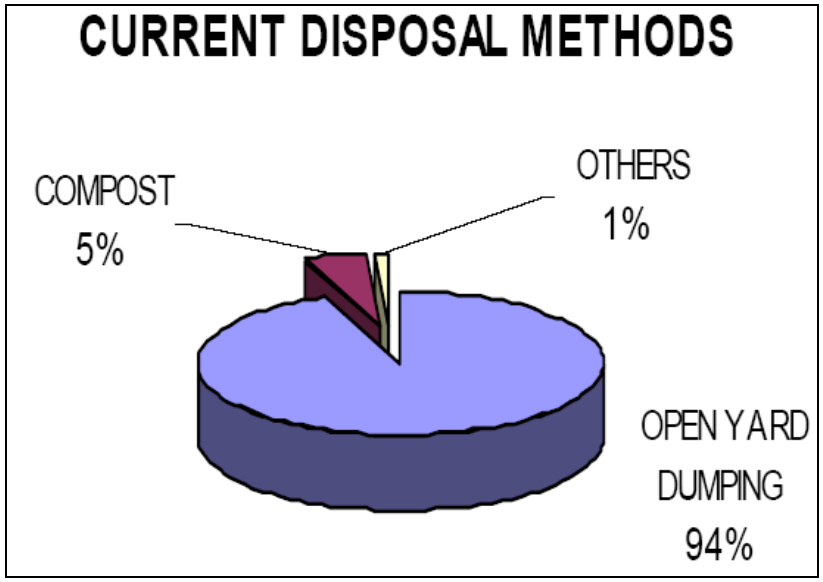
Mango Pulp

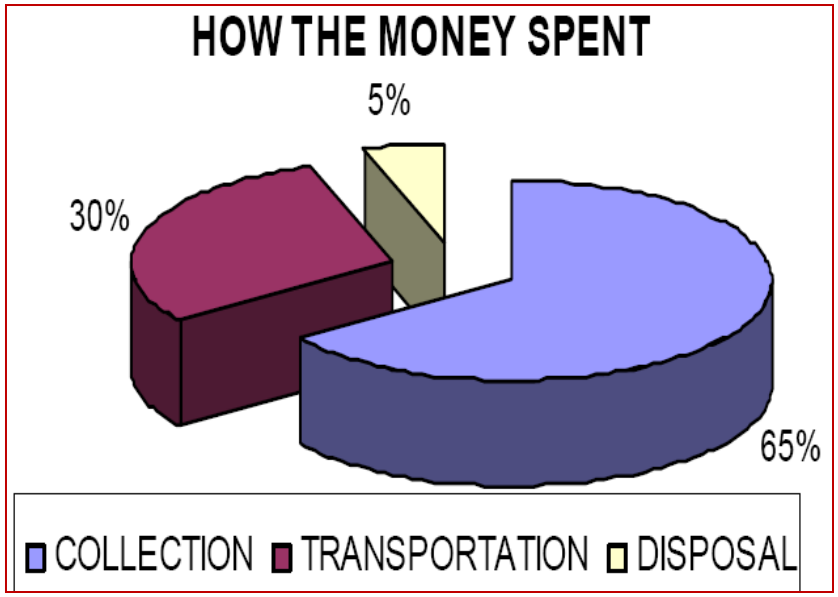
MUNICIPAL SOLID WASTE … Indian Scenario











- **Energy content in waste is not being used**
- **No creation of new jobs**

→ negative added value!!!

Sewage Treatment

- **Sewage in Urban areas, estimated to be 37,700 MLD and anticipated to grow to 50,000 MLD by 2020.. Higher if Industrial effluents is added. CAGR of 1.60%**

- **Presently, only 34% being treated**
- **Contamination of ground water/ water bodies,**
- **Results in health and hygiene issues.**

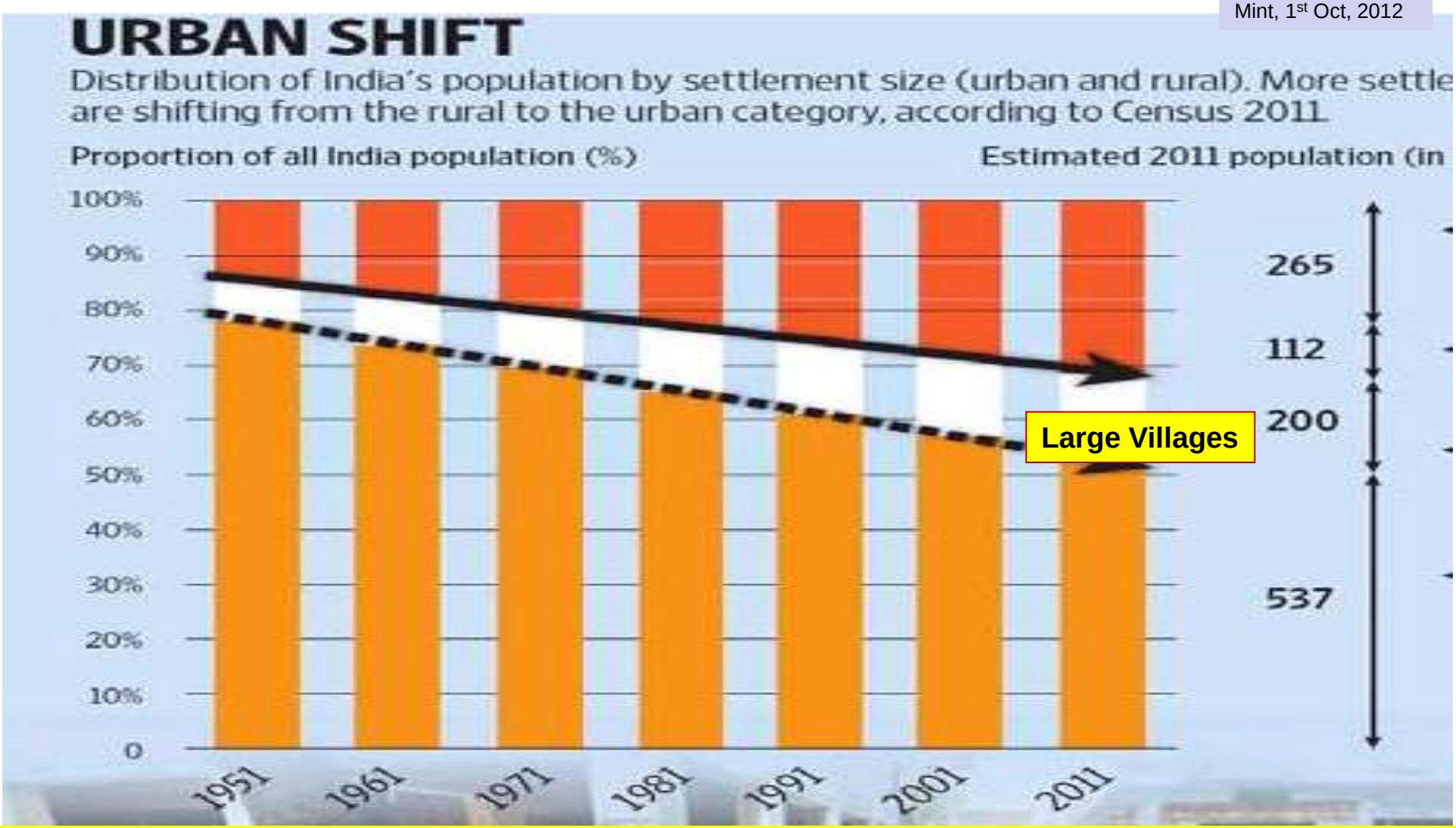
- **Among multiple treatment technologies,**

  anaerobic treatment is preferred choice
  - **Since it uses minimal energy**
  - **Produce energy rich biogas**
  - **Produces sludge to compost**

SOCIO – ECONOMIC IMPERATIVES – OPTIMAL UTILISATION OF BIO RESOURCES FOR ENERGY ACCESS & ENERGY SECURITY

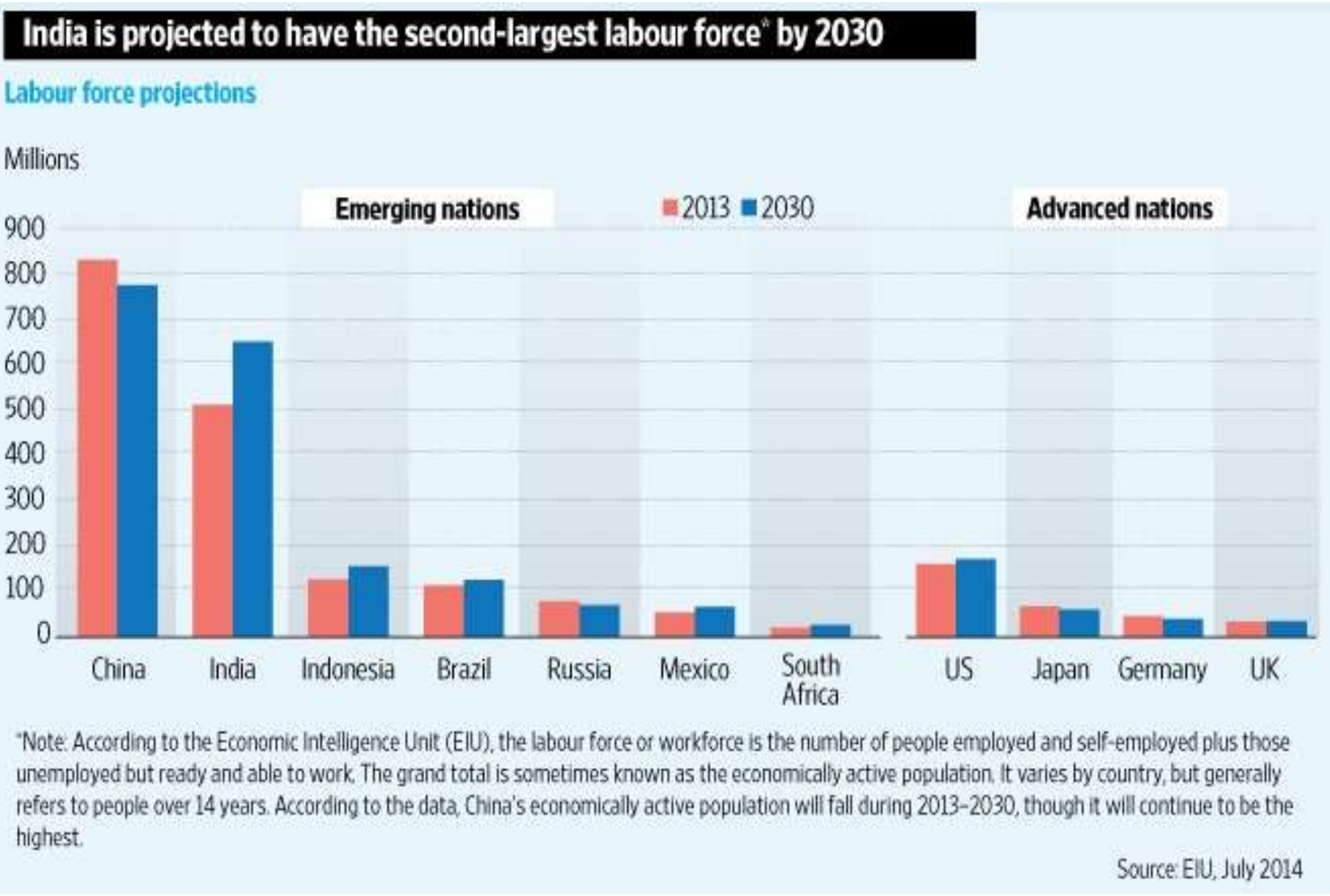
Need to stimulate non farm economic activity

Mint, 1st Oct, 2012



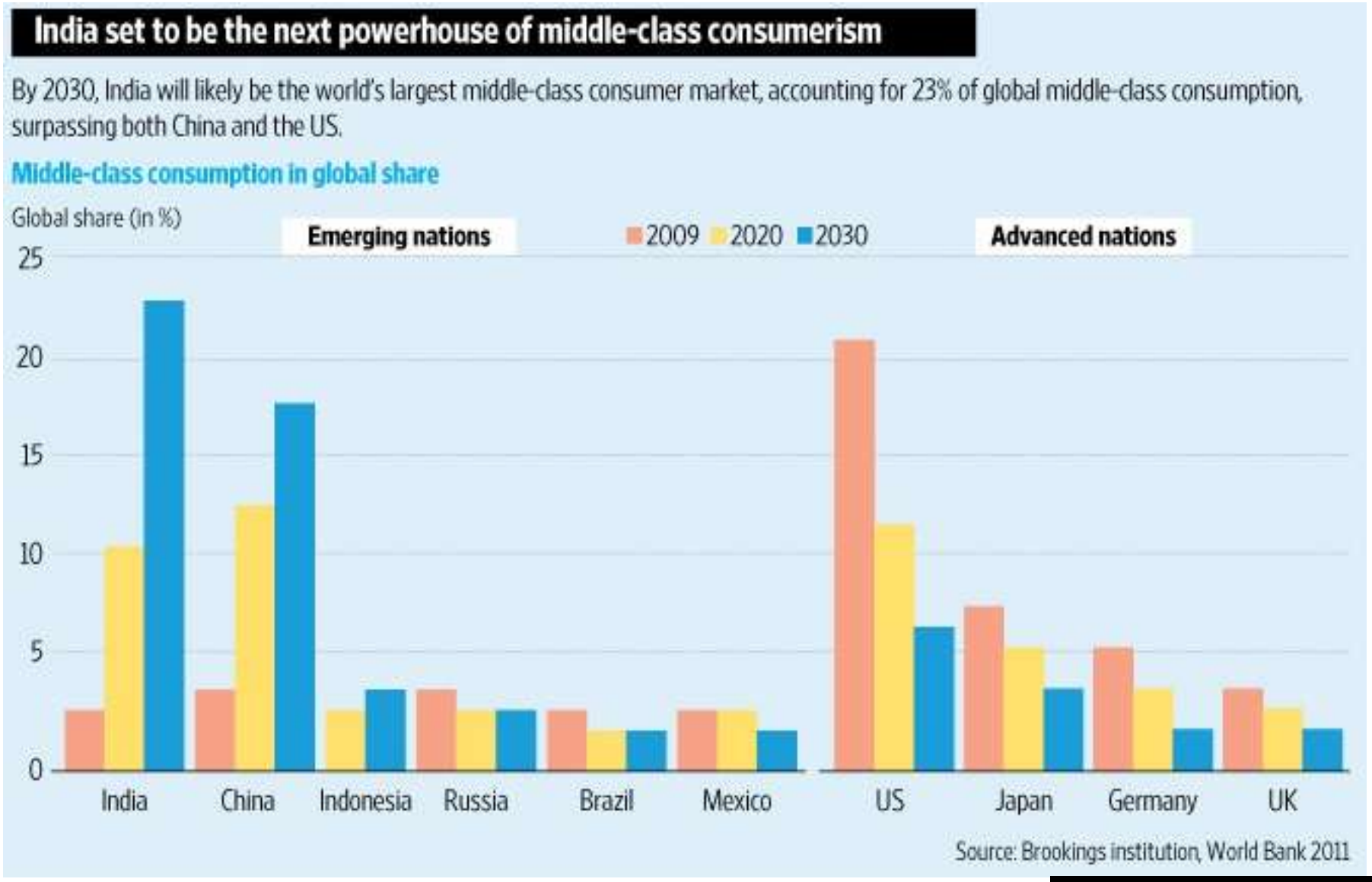
Around 8,000 "Urban Centres" (including about 4,000 "Census towns").
These should be economic growth centres but <u>suffer from poor energy access</u>.
This could, potentially, lead to major socio-economic unrest.

Labor Force – needs productive employment



Source : Mint, 4th November,

Need to ensure Energy Access – to avoid social disparities & migration



Source : Mint, 4th November,

Electricity Scenario

About 400 million households in India lack electricity access.

Furthermore, even where there is electricity access the quality as well as availability of supply is very poor.

Equally significantly, the actual cost of electricity supply to rural households is very high as the demand is typically from 6 PM to 11 PM, (coinciding with the Indian grids peak load) is very high due to (a) power purchase at peak rates (b) high distribution losses (c) high O&M costs due to low grid utilization factor.

DDG based on diesel generator sets has been a solution for many decades and regrettably often the only source of access to economically disadvantaged communities, forming part of the 400 million households without electricity access.

DDG hybrid solution (Solar + Biomass), has emerged as optimal techno-economic solution for enhancing electricity access. Solar PV, Biomass Gasification and Biogas Plants have proven business models, with potential for wide scale replication.

India "Integrated Energy Policy" Projected Primary Commercial Energy (PCE) Requirements (9% GDP Growth Scenario)

Year	Coal		Oil		Natural Gas		Hydro	Nuclear	Total PCE
	Total (Mill TOe)	Non Power (Mill Ton)	Total (Mill TOe)	Non Power (Mill Ton)	Total (Mill TOe)	Non Power (Bill cum)	Mill (TOe)	(Mill TOe)	(Mill TOe)
2011-12	283	170	186	178	48	32	12	17	546
2016-17	375	237	241	231	74	45	18	31	739
2021-22	521	334	311	299	111	65	23	45	1011
2026-27	706	475	410	395	162	93	29	71	1378
2031-32	937	684	548	528	240	133	35	98	1858

Demand for (non electric) applications of Oil & Gas + Coal -> for Heating & Transport

Bioenergy can replace fossil fuels for Heating & Transport application

Demand Scenario of Various Energy Items for Household Consumption in India

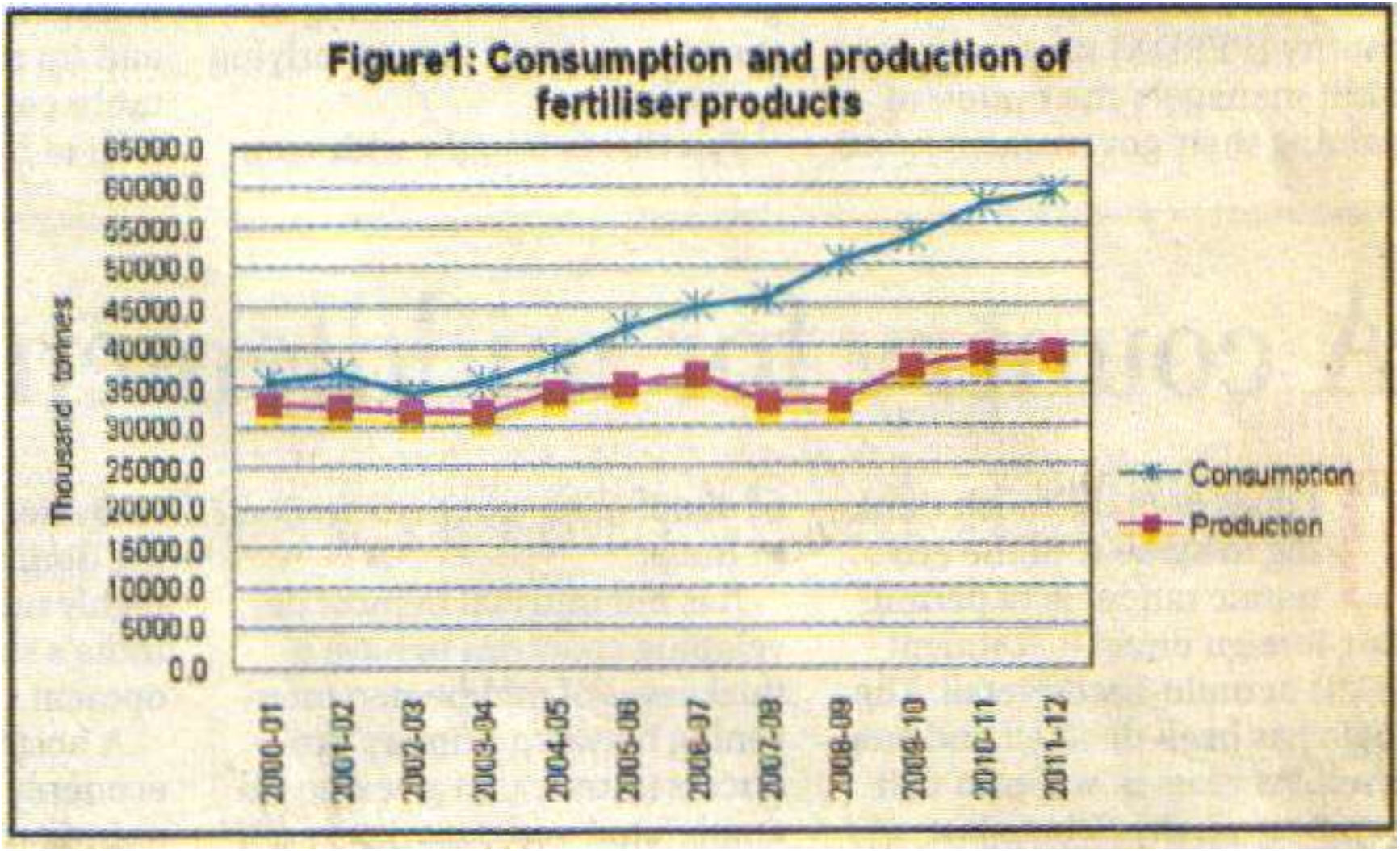
(Mtoe)

Year	Fire Wood & Chips		Electricity		Dung Cake		Kerosene		L.P.G.	
	8%	9%	8%	9%	8%	9%	8%	9%	8%	9%
2000	79.62	79.62	8.43	8.43	29.61	29.61	10.07	10.07	6.42	6.42
2006	88.64	88.78	18.17	19.26	36.97	37.33	12.68	12.77	15.85	16.87
2011	94.11	94.05	27.17	29.68	40.42	40.48	14.01	14.02	23.94	26.07
2016	98.44	98.50	38.38	42.28	41.93	41.35	14.84	14.70	33.11	35.93
2021	102.06	102.46	50.39	54.78	41.79	40.87	15.16	14.93	41.63	44.16
2026	104.64	105.07	61.37	64.95	40.95	40.28	15.17	14.93	48.11	49.63
2031	106.39	106.59	69.72	71.80	40.47	40.21	15.12	14.96	52.27	52.89

Demand for Fire wood & chips + Dung cake forecast as > 130 mill Toe in 2031 !

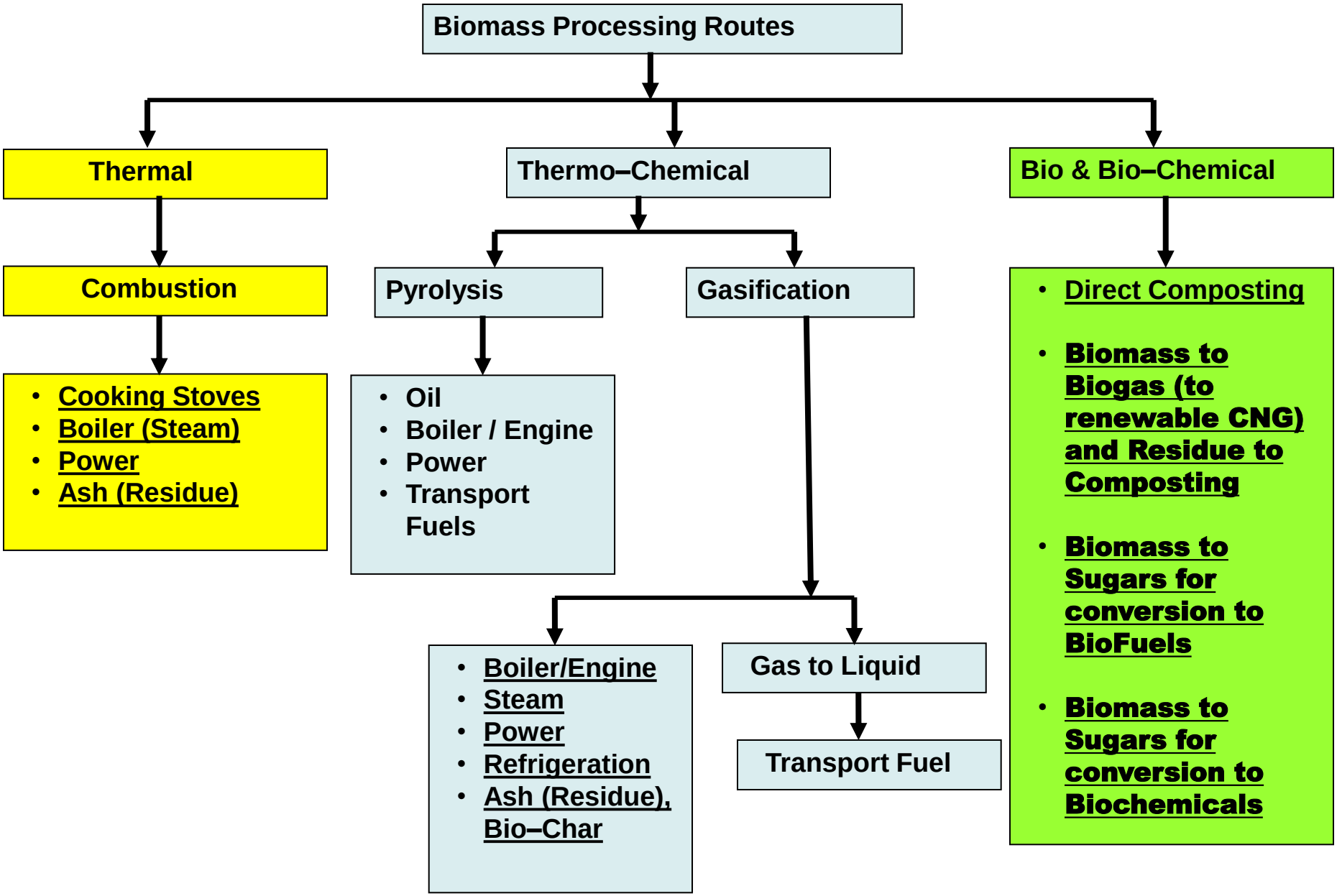
Need for technology interventions to enhance efficiency of use

Increasing Imports of Chemaical Fertilisers



Need to displace chemical fertilisers with assured quality <u>compost</u>

INDIA – BIO ENERGY OVERVIEW


Biomass Processing Routes
Thermal
Thermo–Chemical
Bio & Bio–Chemical
Combustion
Pyrolysis
Gasification
• Cooking Stoves
• Boiler (Steam)
• Power
• Ash (Residue)
• Oil
• Boiler / Engine
• Power
• Transport Fuels
• Direct Composting
• Biomass to Biogas (to renewable CNG) and Residue to Composting
• Biomass to Sugars for conversion to BioFuels
• Biomass to Sugars for conversion to Biochemicals
• Boiler/Engine
• Steam
• Power
• Refrigeration
• Ash (Residue), Bio–Char
Gas to Liquid
Transport Fuel

ECONOMICS OF BIOMASS TO BIOENERGY

- **Biomass cost needs to evaluated, not as Rs./MT (with variations in moisture & ash content) but as Rs./kg of "Dry organic matter", which will have a uniform Calorific Value of 4500 Kcal/Kg. Rs.4/Kg of dry organic matter would be realistic cost for biomass, benchmarked with landed cost of coal. Hence giving attractive returns to farmers**

- **Value realization from processing biomass to bioenergy would typically be**

Technology Option	Bioenergy/Kg Dry organic matter	Value realization
❖ Combustion (Steam Generation)		
a) Stand alone Power Plant	1.1 KWe	≅ Rs.6
b) Cogeneration Plant (with thermal energy ≅ 45% of total energy)	0.88 Kwe + 2.7 KWth	≅ Rs.7-8
❖ DDG (Biomass Gasifier)	1.1 Kwe	≅ Rs.7-8
❖ Combustion (Ind. Heating, replacing furnace oil)	4 KWth	≅ Rs.12
❖ 2nd Gen Bio Refinery	0.3 L Bio Ethanol + 0.7 Kg "pith"	≅ Rs.14-15
❖ Biomethanation (digestable organic matter ≅ 80% of dry organic matter)	0.25 Kg CBG +0.25 Kg Compost + 0.5 Kg CO2	≅ Rs.14-15

Comparison of Paddy Straw use for Bio-Ethanol vs. Power generation

Maximum power exported : 1 KWH/kg paddy straw (dry matter)

Bio-Ethanol generation : > 0.3 liter/kg paddy straw (dry matter)

Return as biofuel from 1 kg paddy straw = Rs 13

Return as power from 1 kg paddy straw = Rs 6.5

Note (1) : Even at high biomass tariff paid in Punjab, developers are finding it difficult to fire large amounts of paddy straw. Either biomass power plants operate at low PLF *or* Plants with high PLF, fire only 25% paddy straw. Paddy straw burning in Boilers causes slagging & corrosion

Note (2) : Paddy straw use in 2nd Generation Bio-Refineries, produces Cellulosic Ethanol, Bio CNG & Pellets + Compost (thus productively using all dry matter in biomass). Compost + treated effluent (liquid fertiliser) increases farm yields & reduces chemical fertiliser use, hence makes farmers stake holders to the project.

Comparison of Bagasse use for Bio-Ethanol vs. Power Generation

Maximum power exported : 0.67 KWH/kg bagasse

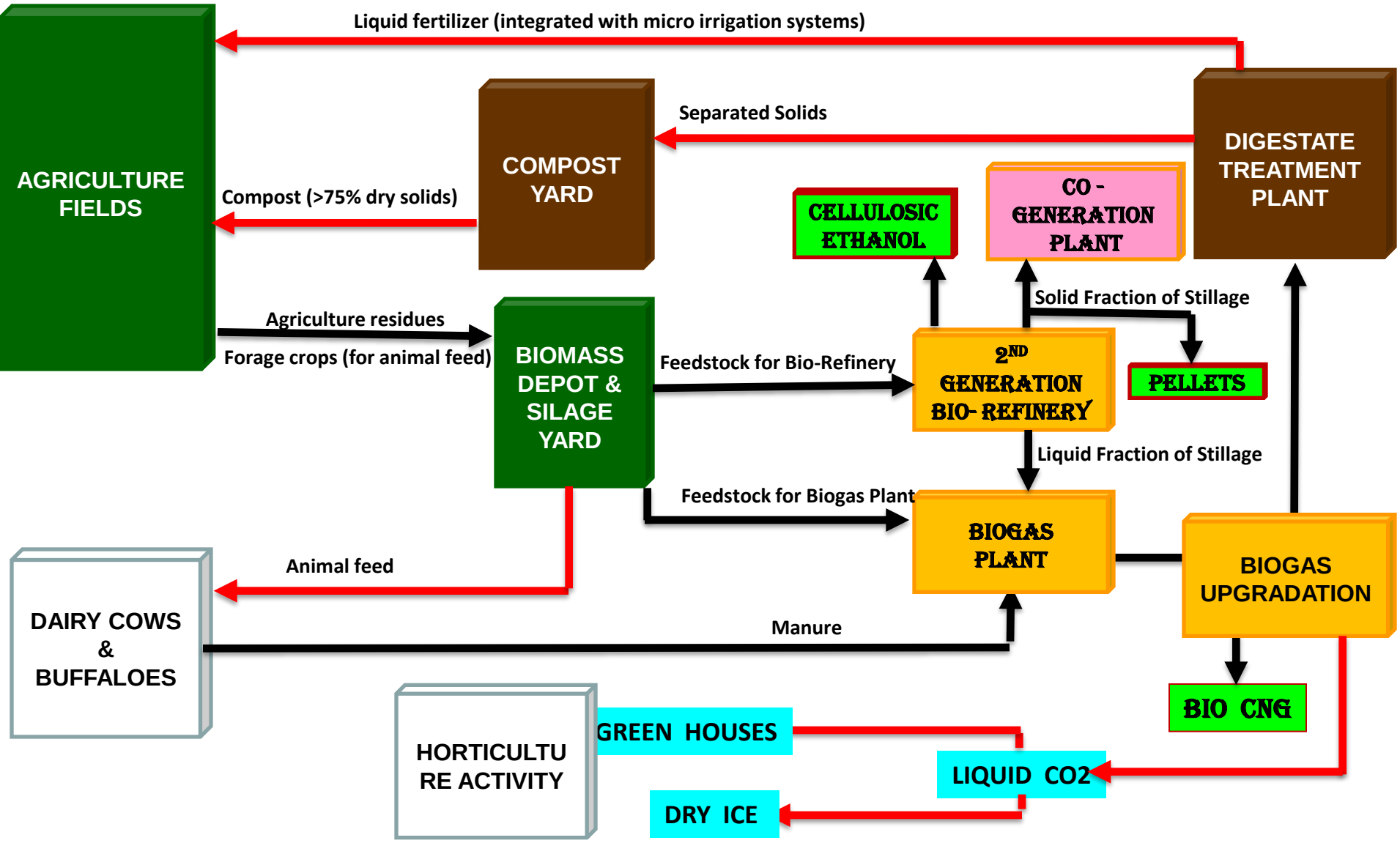
Bio-Ethanol generation : > 0.3 liter/kg bagasse

Return as biofuel from 1 kg bagasse = 0.21 USD

Return as power from 1 kg bagasse = 0.06 USD

Power & Steam requirement of Sugar Mill will be supplied by Cogeneration Plant firing the "lignin" residue of Bio-Refinery → no adverse impact on Sugar Mill operations.

2nd GEN BIO REFINERY - LINKAGE WITH SUSTAINABLE AGRICULTURE



BIOENERGY – KEY SECTORS & POLICY INTERVENTIONS REQUIRED

 # PLANTATIONS & DEPOTS : National Mission for Greening India goals to be converted to specific PPP programmes, MoF & MoEF to facilitate funding mechanisms from NCEF & NABARD

 # COOKSTOVES : Registered PoA to made effective through Carbon price stabilisation mechanisms (NCEF, GCF, etc). Focus on mitigating health hazard

 # BIOWASTE PROCESSING : State Pollution Control Boards to mandate Bio waste processing to Compost & Energy. Capital subsidies for mitigating health/ environment hazard & displacing chemical fertilisers.

 # BIOFUELS & RENEWABLE CNG : MoP&NG to compute delivered cost of Petrol/ Regasified LNG/ LPG … this will justify 2nd Gen Biofuel price of > $ 0.7/litre & Biomethane price of > $ 0.9/Kg.

 # DDG : CERC/ SERC's to compute delivered cost of electricity, 6 to 11 pm, to "rural" households with "peak power" purchase cost … this will justify tariff of Rs 8-9/KWh