Can India reduce the FE outgo on oil to about a third of the current value?

Can one derive simultaneous societal benefits?

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The plan of presentation

- Current Crude oil utilization in the country
- What bio-fuel replaces what fossil fuel
- Waste potential – the range and a summary
- Strategy for the wasteland
- Techno-economic issues
- Are these ideas new at all – if not, why have they not worked?
- The gasification technology for industrial heat, electricity and domestic cooking
- The win^6 situation
- The summary

Current Crude oil utilization in the country

- The country uses about 104 million tonnes of crude oil (fossil fuel). It imports 70 % of this amount at 27 to 30 billion USD (Rs. 120,000 to 140,000 crores)

- The most critical of the uses is in reciprocating engines for heavy transport (road and rail) that has significant impact on inflation index

- Many industries depend for electricity generation on large reciprocating engines and these use furnace oil. Even larger number of industries depends on furnace oil for high grade heat.

- The crude oil prices moving from the 27 to 30 USD/barrel bracket to about 50 USD/barrel bracket in six months and has touched 70 USD/barrel. There are no reasonable expectations of the costs coming down..

Derivative from crude oil	Amount MT/yr	Nature of use
High speed diesel	40	Heavy vehicle transport
FO/LSHS (Furnace oil/Low sulfur heavy stock)	14	Stationary power generation Combustion in furnaces
Naphtha/NGL LDO (Light diesel oil)	12 02	Stationary power generation
Total	68	Transport and stationary power
LPG	10	Domestic cooking and Vehicle transport
Gasoline (petrol) Kerosene	09 12	Vehicle transport Domestic cooking/power
Total	31	Domestic / transport /stationary power

MT/yr = Million tonnes per year

What replaces what?

HSD, LDO, LSHS, FO (about 68 million tonnes out of which 65 % is the prime fuel for transport, HSD)

Can be replaced by vegetable oils (non-edible) in part or wholly, some directly and some with refinement – esterification.

Gasoline as transport fuel can be replaced by ethanol from sugar industry, again in part or wholly.

Kerosene as an engine fuel by ethanol

Kerosene as a fuel for lamps by esterified vegetable oil

Kerosene as a cooking fuel by modern electricity supported solid fuel combustion systems

Q: Can we reduce the foreign exchange outgo by indigenous oil production?

Can we benefit by associated activities?

A: Use the assets, namely unused land and water with nutrients to create oil seeds, and use waste biomass from these operations and also use the urban, peri-urban solid wastes to create energy supplies – oil for transportation and solid fuels for rural energy security

Waste potential

- Agricultural wastes
  - Magnitude and distribution over the country deduced from Ministry of Agriculture data, field surveys under MNES, ISRO (RRSSC) all GIS based information
  - 100 – 120 million tonnes, amounting to installed capacity of 150,000 MWe
- Devoted existing plantation output and wastes – crude estimates – 20 million tonnes

Waste Land Estimation

- ✓ National Remote Sensing Agency (NRSA) of ISRO spearheaded a 2 year project under MRD
- ✓ The satellite images from IRS – LISS III camera of 2003 were used in the interpretation
- ✓ This major effort involved 200 scientists and 100 GIS specialists.
- ✓ It is published in 2005 by Government of India
- ✓ Of the 55 million Hectares of wasteland, 33 million hectares are classified as “Culturable” wasteland

Watse land Biomass NRSA: 1986-2000				
State	**Area MHa**	**Residue Generation MT/Yr**	**Excess Biomass MT/Yr**	**Power Projected MW**
Andhra Pradesh	4.1	35.3	30.0	4197.9
Arunachal Pradesh	0.6	6.1	5.2	722.3
Assam	1.2	12.0	10.2	1432.2
Bihar	0.4	4.5	3.8	533.4
Chhattisgarh	0.1	0.8	0.7	93.2
Gujarat	1.9	16.7	14.2	1985.8
Haryana	0.3	2.3	2.0	279.4
Himachal Pradesh	0.0	0.4	0.3	47.0
Jammu & Kashmir	0.8	7.9	6.7	943.6
Jharkhand	1.0	10.1	8.6	1200.3
Karnataka	1.1	10.6	9.0	1261.7
Kerala	0.1	1.1	0.9	127.5
Madhya Pradesh	5.1	50.8	43.2	6050.2
Maharashtra	4.5	35.1	29.9	4182.2
Manipur	1.2	11.7	9.9	1391.3
Meghalaya	0.3	2.8	2.4	330.3
Mizoram	0.3	3.3	2.8	395.0
Nagaland	0.3	2.7	2.3	319.2
Orissa	1.6	9.9	8.4	1181.7
Punjab	0.0	0.2	0.2	24.5
Rajasthan	5.5	26.1	22.2	3108.8
Sikkim	0.1	0.8	0.7	95.1
Tamil Nadu	1.4	11.1	9.4	1319.5
Tripura	0.1	1.0	0.9	122.4
Uttar Pradesh	0.7	6.0	5.1	718.6
Uttaranchal	0.5	3.2	2.7	375.2
West Bengal	0.4	2.1	1.8	253.4
Total	**33.69**	**274.73**	**233.52**	**32691.7**

District wise for West Bengal

Waste land Biomass NRSA: 1986-2000

District	Area kHa	Residue Generation kT/Yr	Excess Biomass kT/Yr	Power Projected MW
Bankura	41.1	248.9	211.5	29.6
Bardhaman	30.2	182.9	155.5	21.8
Birbhum	25.8	156.2	132.8	18.6
Cooch Behar	2.1	12.5	10.6	1.5
Darjiling	7.4	45.0	38.3	5.4
Hooghly	0.9	5.3	4.5	0.6
Howrah	1.9	11.4	9.7	1.4
Jalpaiguri	10.1	61.2	52.0	7.3
Malda	42.5	257.2	218.6	30.6
Midnapore	56.1	339.9	288.9	40.4
Murshidabad	36.0	218.3	185.5	26.0
Nadia	10.7	64.8	55.0	7.7
North Dinajpur	7.1	43.2	36.8	5.1
North24Parganas	1.5	8.8	7.5	1.0
Puruliya	76.9	465.5	395.7	55.4
South Dinajpur	1.2	7.1	6.0	0.8
South24Parganas	0.2	1.5	1.3	0.2
Total	351.6	2129.6	1810.2	253.4

What to grow in the wasteland?

- *Hardy plantations/Trees to nurture the land to a reasonable stage to begin with*
- *Beyond a point a whole range of oil bearing trees*

Table 4 Oil production from land in kg/Ha for various oils

Crop species	Output oil* tonnes /Ha
Palm oil	5.0
Coconut	2.2
Brazil nuts	2.0
Jatropha	1.6
Jojoba	1.5
Rapeseed	1.0
Groundnut	0.9
Sunflower	0.8
Pongemia	0.8
Soybean	0.4

*The maximum that can be obtained with appropriate addition of water and nutrients.

Thus…..

- With care and attention, the land could be used to yield in about five years a productivity of significant nature.

- A simple assessment of yields is as follows: 1 tonne per Ha of oil + 4 tonnes of dry solid output or 10 tonnes of dry solid output or a mix – leading to [33+ million tonnes of oil + 130 million tonnes of solid biomass] or 330 million tonnes of solid biomass. The precise choice depends on locally perceived benefits and can be tuned by financial interventions

- These data have been refined with more careful calculations; but the broad numbers are about same

Urban waste potential…

- Urbanization and modern living have resulted in solid wastes that litter the roads and management of these has been a nightmare for the communities and municipalities.

- There are 300+ class I cities with a total population of 200+ million people with waste generation of 40000 to 50000 tonnes per day of wastes with 1500 to 2500 tonnes of non-biodegradable organic waste with an electricity potential of 1500 to 3000 MWe.

Urban waste potential….

- ✓ On a more relevant waste dump-site basis, the capacity is 50 to 100 tonnes per day of wastes with dry organic matter of 10 to 25 tonnes per day – power generation capacity of 0.5 to 1 MWe.
- ✓ A key feature is that middle level towns have very poor infrastructure for waste management. There are technical issues of handling them by *methods that bring in revenue*. Unless, the waste handling is considered as a possible profit center, solutions for clean up become impractical.

Waste Potential…

- Modern gasification technologies are the most scale relevant. For 25 dry tonnes of organic waste including about 2 to 3 tonnes of non-biodegradable organic mass, a 1 MWe plant gasification plant with upstream waste handling facility is considered the most relevant and useful system.

- Currently there is no support for development on this effort by the states.

Waste Potential…

- The effort required by MNRE needs to be augmented particularly in view of continued adverse observations by the Supreme court on the street cleanliness of cities and townships.

- Urban development ministry and Ministry of Tourism also should be seriously interested. However, passing the buck seems to be the fate of waste management.

- The one ministry that should take leadership role even though it is involved in the final stages of waste handling is perhaps MNRE.

Waste Assets – a summary

- ✓ 100+ million tonnes of agricultural wastes
- ✓ 20+ million tonnes of plantation waste
- ✓ 33+ million Hectares of waste land that could lead to 33 + million tonnes of non-edible oil (equivalent of 25 to 27 million tonnes of HSD) and 130 million tonnes of solid biomass
- ✓ 40000+ tonnes per day of Urban solid waste

Strategy for waste land - 1

- This is the key issue of great concern and should be handled with great care.
- Land is a property of the States. Encouraging their productive use should be centrally planned with a well structured arrangement.
- One of the principal planned outputs should be non-edible oil seeds.
- To encourage this, it is vital that procurement of the oil should be well defined.
- The principal owner of the output could be Indian Oil Corporation or a similar agency.

Strategy for waste land - 2

Success of this initiative is strongly related to wide partnership base –

- Involve industrialists and others who can invest, panchayats in whose domain, the land is located to enable help various actions, and large labor population.
- Industrialists who can be leased the waste land for its development using incentives, perhaps on tax basis.
- Involvement of local panchayats for support and helping settle labor and payment terms for the development of the land under the leadership of the local government.
- The package design should be such that everybody in the chain should financially benefit in a rational way.

Strategy for waste land - 3

Assuming two/three labor per Hectare, the job opportunity on 33 million Hectares of waste land would be about 66 to 100 million rural jobs – perhaps no other initiative can think of providing for so many jobs, a fair number being unskilled.

- The procured seeds are sent to oils mills for processing and the oil to refineries located in a distributed way before the oil finds its way to IOC.
- There are issues of problems like in ethanol. The difference between ethanol program and bio-oil program is that in the first case we are tied down to sugar industrialists; in the latter, to a very large number of panchayats.
- Management issues are likely to be lower.

Techno-economic issues - 1

- Extraction process is by screw/solvent processes, choices decided by economics
- For use in thermal applications (perhaps not the most appropriate), they can be used on as-processed basis.
- For reliable use in transport vehicles, trans-esterification is desirable. Both extraction and further processing are standard processes assimilated by the industry.
- Tests have been made at RDSO with large power engines used for rail traction. Technical issues have been addressed in several laboratories – power performance and emissions. There is a large body of international work that is accessible.

Techno-economic issues - 2

- ✓ What is required is sensitizing the production process. This can be sensitized provided the plan to sell these oils is in place – one could make do with 5 % addition to Diesel to begin with, keep increasing it even to 100 % when the production is adequate.
- ✓ Typical costs of production would vary between Rs. 12 – 16 per liter according to detailed calculations with several stakeholders getting their due.
- ✓ These can be done only by a market driven central agency. It is suggested that IOC/Other agency could take responsibility.
- ✓ The fact that they can make profits in this venture is vital for their interest in this subject.
- ✓ The users on the other hand have to face much less of enhancements of costs of these fuels for transport.

Are these ideas so new at all? And if not, why have they not worked – 1

- Ideas on liquid biofuel are not new.
- Even now there are a number of interested states – Tamilnadu, in particular, but other states like Karnataka and Madhya Pradesh are also taking interest.
- However, without an overall central arrangement for purchase and distribution in a commercial manner there is a danger of people being disillusioned and hence, such initiatives backfiring
- The key to the success of liquid bio-fuel production and use is to find an interested “owner” – the suggestion here is IOC. Petroleum ministry should be at the front end on this subject.

Are these ideas so new at all? And if not, why have they not worked – 2

- Once trees are grown, there will always be solid residues.
- In any case, options should be provided to the grower to choose a mix of solid fuel trees and oil seed bearing trees to optimize his revenue stream
- These will call for solid bio-fuel technologies to service the nation. These are indeed of recent development
- Also, urban solid wastes need to be dealt with. These also call for gasification based technologies to penetrate the market. Technology availability is not a constraint.
- The growth may be slow. But it will pick up on its own with the required demonstration to entrepreneurs.
- The key therefore, is to address the use of waste land with deep commitment.

Maximizing the output-to-input finance

- By involving several partners, this program can be dealt with a minimum Government financial input
  - Administration redeployed
  - Industrialists, investors with a tax based incentive to invest in land development
  - Involving local panchayats to deal with local issues

Status of dealing with wastes - 1

- Agricultural and plantation wastes – gasification, combustion technologies are being supported for R & D, demonstration and subsidy for commercial use by MNRE.

- Combustion technologies (steam route) are well known and are economical at >3 MWe costing about Rs. 4 – 5 crores per MWe

Status of dealing with wastes - 2

Gasification technologies are more modern in terms of greater efficiency at smaller scales (10 kWe to 3 MWe) – 25 to 28 % (bioresidue to electricity) and cost about the same as 200 MWe class steam plants on per MWe basis

A 1 MWe system costs Rs. 4.5 crores and 10 kWe system will cost about Rs. 6.0 lakhs.

A not-too-well known feature of gasification systems is that they need about 1/4th of the water required for operating a steam power generation system.

On gasification technology - 1

- Gasification process converts solid fuel into a gaseous fuel.

- Such a gaseous fuel, if clean and is at near ambient temperature can be used to generate heat, electricity or chemicals.

- When air gasification is used with biomass, one gets a gas that has about 20 % each of CO and H_2 and 1.5 % CH_4, rest being inerts (CO_2 and N_2)

- The critical aspects of the process are:
  - how small is the tar fraction in the hot gas
  - how small is the particulate content in the cold dry gas?

On gasification technology - 2

For meaningful practical use, another key demand is:

can the same system use a number of bio-fuels, since bio-fuel availability is seasonal. The demand can be made more stringent by asking if urban solid wastes can also be used in the same system.

On gasification technology - 3

For large power levels ~ 5 MWe, fluid bed, bubbling fluid bed, circulating fluid bed gasifiers are developed.

These have very large hot tar that is broken in high temperature catalytic beds.

For < 3 MWe, fixed bed downdraft reactor based gasifiers are developed.

Two classes of such designs are closed top and Open top reactors.

While most countries have pursued closed top designs, and a few others, some very new concepts that are still in testing stage, IISc pursued a open top staged air supply based reactor design for over twenty years now.

On gasification technology - 4

- ✓ Biomass needed for a typical 1 MWe system is about 7000 to 9000 tonnes of dry biomass (~ 10 % moisture) for 7000 hours per year operation.

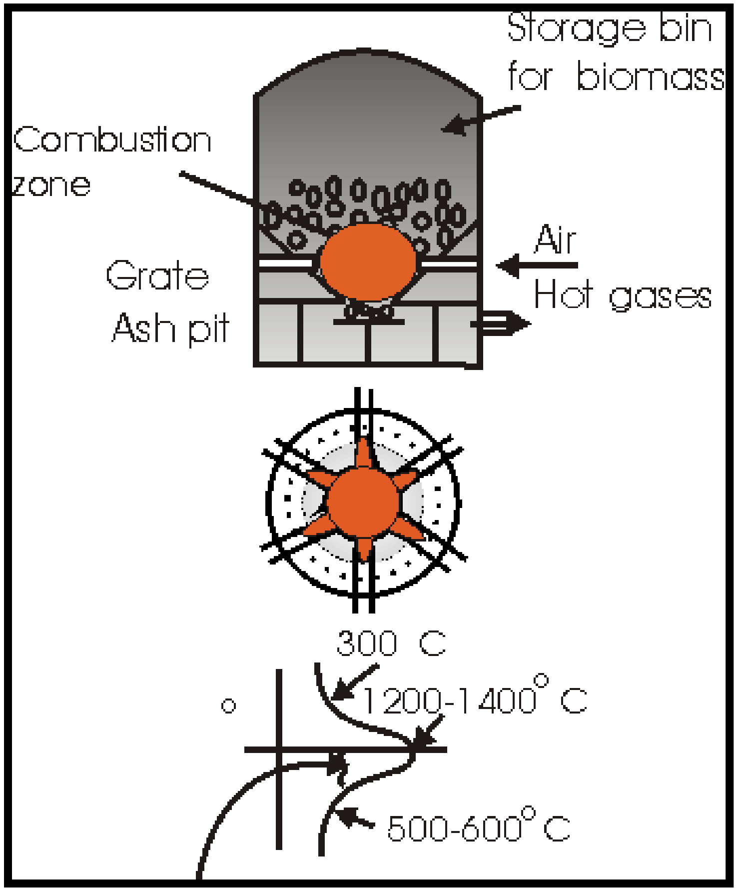
- ✓ Biomass sourcing for very large power systems would pose serious problems and hence it is more appropriate to concentrate on < 3 MWe applications unless one has captive fuel.

- ✓ This implies a fixed bed gasification strategy as the more sustainable option for India

- ✓ If one were to demand fuel-flex gasifier including agro-wastes, solid biomass and USW, the only option would be the IISc gasification technology. … Why?

Closed Top Reactor design

Concept evolved during II WW period



Findings

Combustion zone confined to a small region

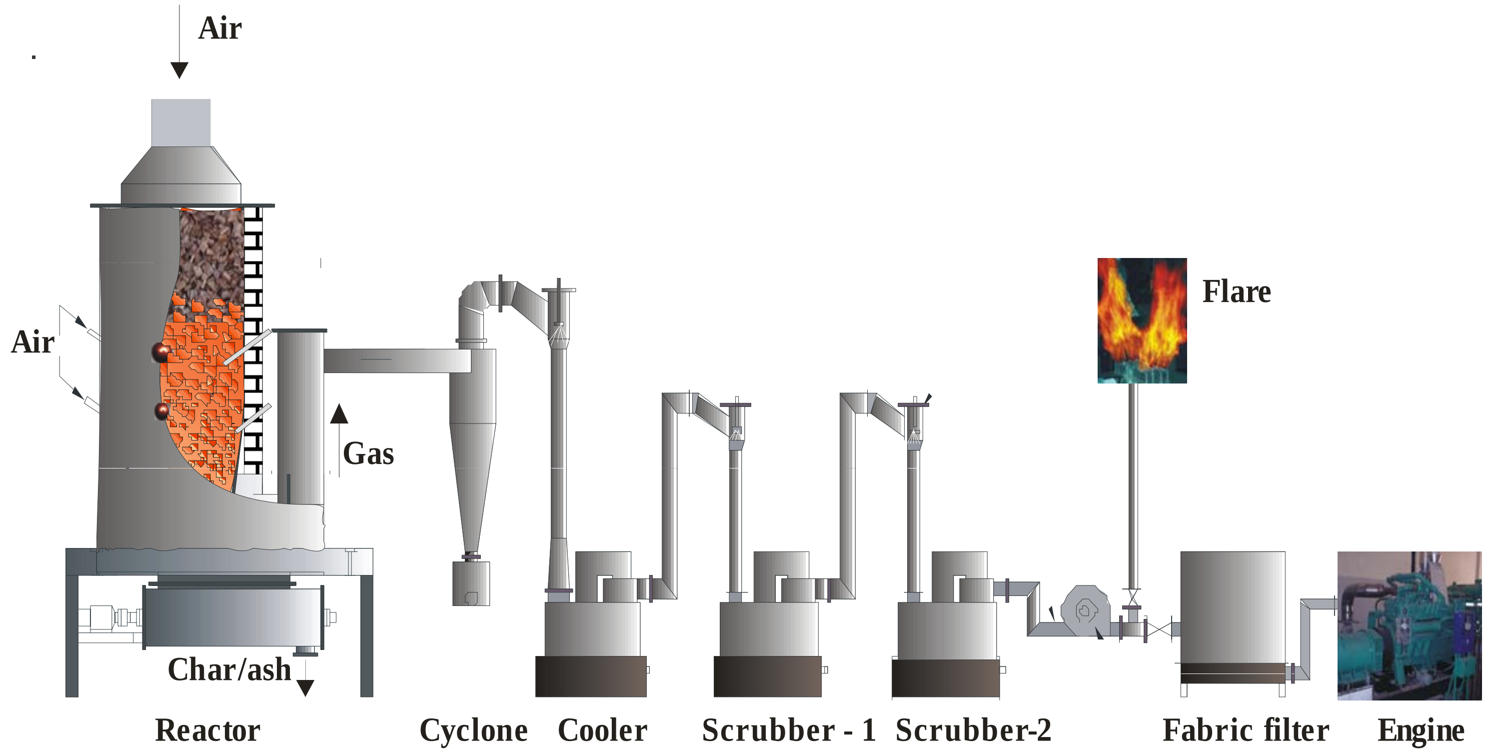
Regions of low temperature

Can handle only woody biomass

Turn down ratio limited

Problem of consistent gas quality

Open Top downdraft re-burn Gasifier



Ceramic reactor to withstand high temp oxidizing and reducing environment; bottom screw system meant for ash extraction (hi ash biomass)

Generation of activated carbon with surface area of 450 to 550 m2/g in the bottom section (600 to 800 C)

Cooling and cleaning train to get dry gas at (P + T) < 10 ppm

The crucial difference between the closed top and IISc design

All the air enters only through one set of radial holes in the closed top design. At high throughput, peak temperatures may cause ash fusion or at low throughputs tar may leak through some azimuthal sectors

In IISc design, air entry occurs in stages and the flow from the top makes the access to oxidizer more uniform over the cross section.

It is possible to control the peak temperature and make it broad enough to ensure "No ash fusion" + "Low tar" over a range of throughputs.

Biomass that have been used in gasification systems

Coconut Shells

Coffee Husk

Dry Grass

Marigold Pellets

Biomass that have been used in gasification systems

Paper Trash

Pine Needles

Rice Husk

Sawdust

The building housing
the system

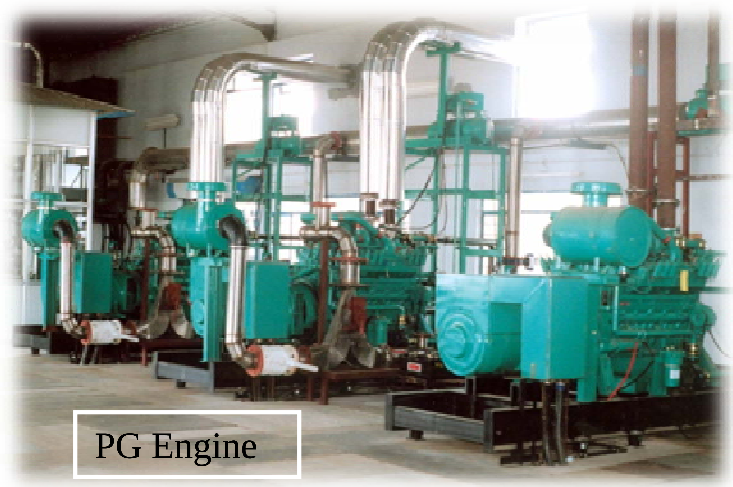
The gasification system

Snapshots of grid-linked1 MWe biomass based power plant (Coimbatore, 2003+)

The Power Plant

Gas Cleaning Unit

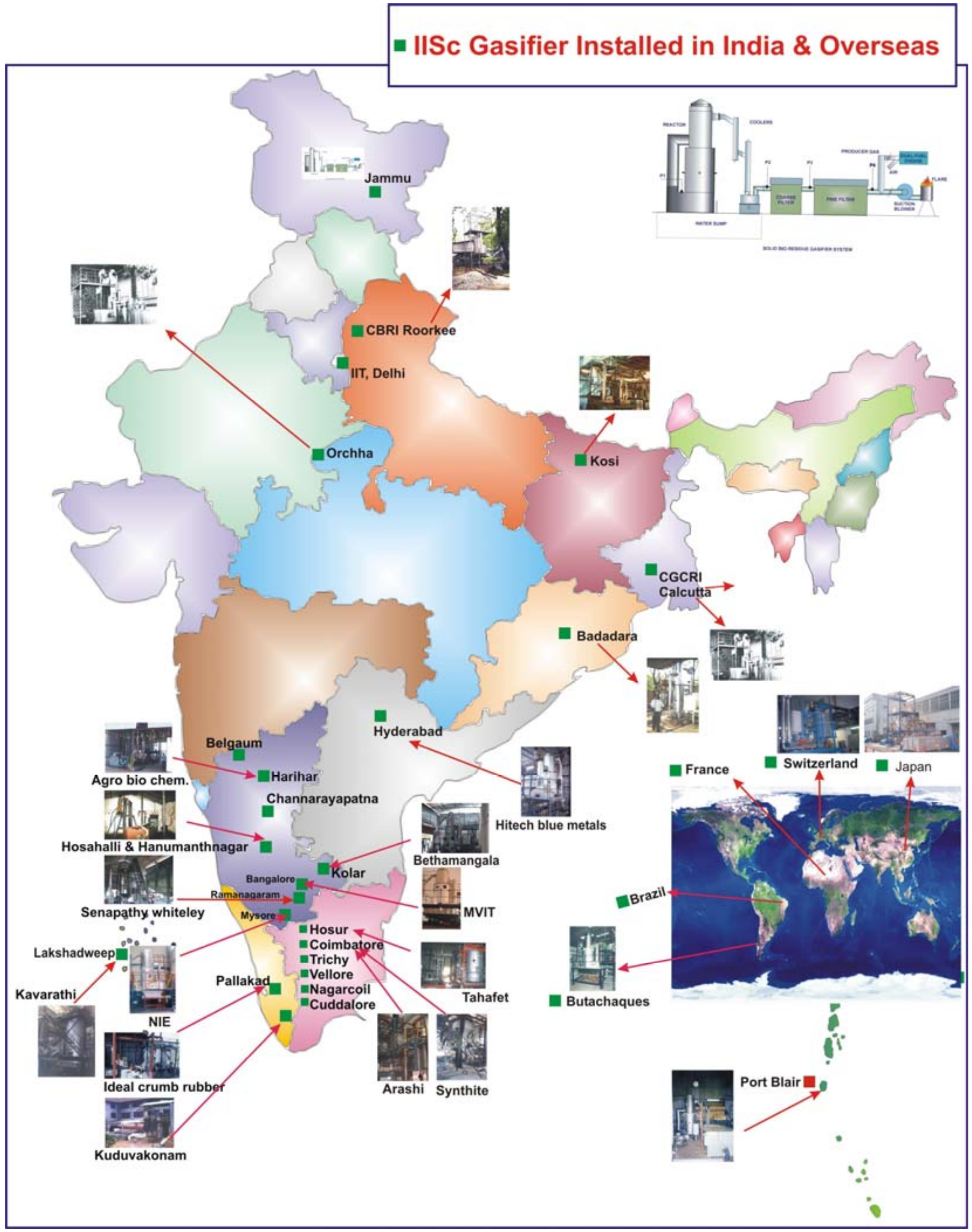
Fuels used: Coconut shell for 1 year → then Prosopis Juliflora for an year → and then again Coconut shell



PG Engine

Operating performance

SYSTEM	ESTBLD	CAPACITY	FUEL	HRS PER YEAR (OPERATD)	PLANT AVAI-LABILE?
ARASHI HI-TECH BIOPOWER	2002 (D-F) 2004 (GAS)	1 MWe	Julifora Prosopis, Coconut shell	6500	>85 %
HINDUSTAN PENCILS	2003 (D-F) 2005 (GAS)	200 kWe	Sawdust briquette	5500	> 95%
TANFAC	2003	1100 kg/hr	Juliflora Prosopis, Forest waste	7500	>95%
TAHAFET	2001	300 kg/hr	Juliflora Prosopis	7000	>95%
CRUMB RUBBER (1)	2002	80 kg/hr	Wood, Coconut shell	7000	>97%



IISc Gasifier Installed in India & Overseas
Jammu
CBRI Roorkee
IIT, Delhi
Orchha
Kosi
CGCRI
Calcutta
Badadara
Hyderabad
Hitech blue metals
Belgaum
Agro bio chem.
Harihar
Channarayapatna
Hosahalli & Hanumanthnagar
Bethamangala
Kolar
Bangalore
Ramanagaram
Mysore
MVIT
Senapathy whiteley
Hosur
Coimbatore
Trichy
Vellore
Nagarcoil
Cuddalore
Tahafet
Lakshadweep
Kavarathi
Pallakad
NIE
Ideal crumb rubber
Kuduvakonam
Arashi
Synthite
France
Switzerland
Japan
Brazil
Butachaques
Port Blair

Technology Status Summary

- Technology Package : 1 to 1200 kg/hr modules
- Technology transferred – 8 (India) + 2 (Overseas)
- Partnering with Cummins Ltd for power projects
- Over 50 Plants in Operation in India & Overseas
- Biomass used: Prosopis Juliflora, Ipomia, Coconut shell, Sawdust briquettes, Mulberry stalk, Forest residues (*in a few cases shifting from one to the other biomass due to rising costs of one*)
- Operating experience ~ 30000 hours (single system) and over 250,000 hours totally

What about domestic heat?

- **Close coupled gasifier based combustion systems using pelletized fuel based on agro-residues have been developed and technology transferred to BP, India.**

- **Other designs for firewood class fuels using advanced ejector based concepts have been developed.**

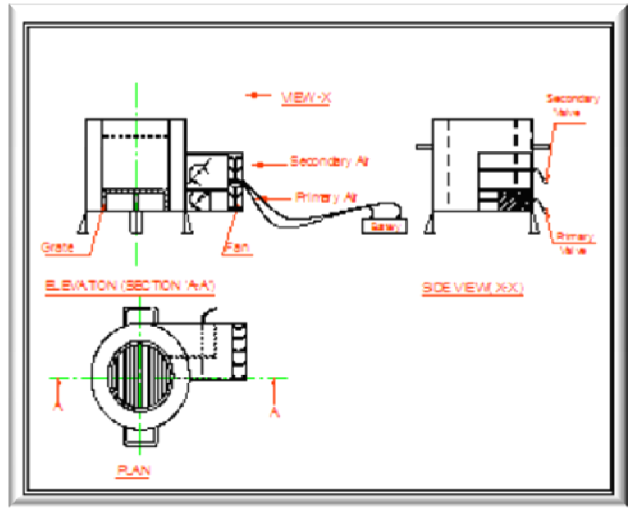
- **Both these are designed for “affordable” cost and reasonable life (> 2 years)**

Solid Biomass Stove

Forced Draft Gasification Stove

Good for solid bio-residues

Power level ~ 2 – 4 kWth



Air is provided by a small fan, distributed below grate and at the top. The bottom air is primary air for gasification and the top air is secondary air is for the combustion of gaseous fuel. The ***power of the stove*** is directly proportional to the ***air flow rate*** through the bed since the gasification process maintains the air-to-fuel ratio appropriately. This is valid over a range termed "turn down ratio, typically about 3

Results on water boiling efficiency

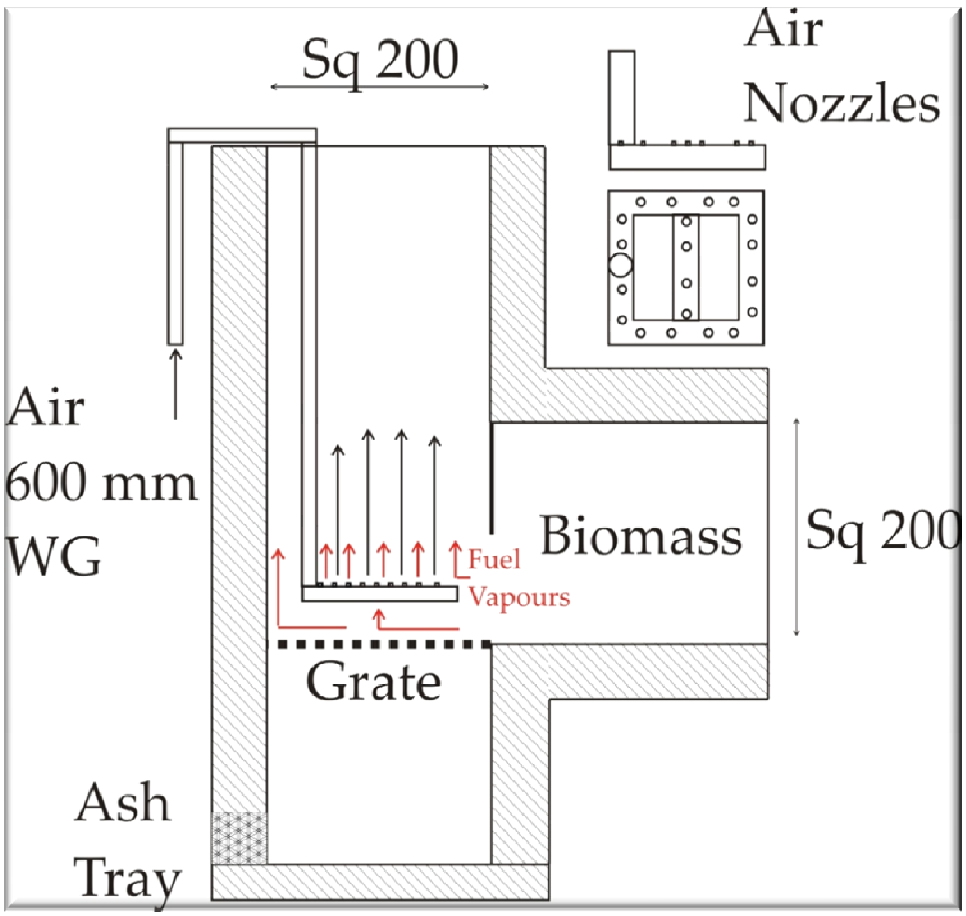
100 mm dia stove, 6 liter vessel

Biomass	Amount, g	Ash %	Power kW	Time min	ΔT_w °C	Efficiency %
Wo	130	0.8	2.1	21	36	47.7
Wo + M	30 + 225	10.4	2.5	24	62	47.3
Wo + CS	30 + 242	1.0	1.6	48	71	47.1
Wo + CHB	25 + 360	4.0	2.2	51	67 + 57	51.2

100 mm dia stove,10 liter vessel

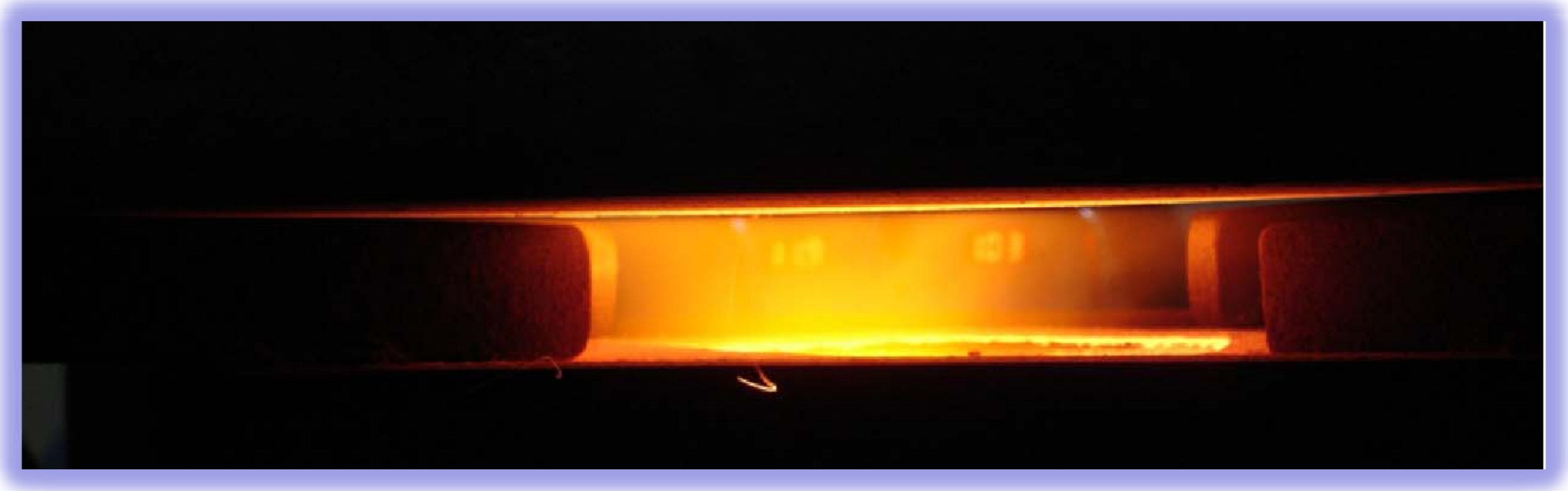
Biomass	Amount, g	Ash %	Power kW	Time min	ΔT_w °C	Efficiency %
Wo	130	1.1	2.5	16	23	52.5
Wo + M	85 + 120	7.8	2.0	26	38	58.2
Wo + CS	30 + 230	0.6	2.1	40	46	53.5
Wo + CHB	25 + 360	4.0	2.0	60	67	54.2

Ejector Stove

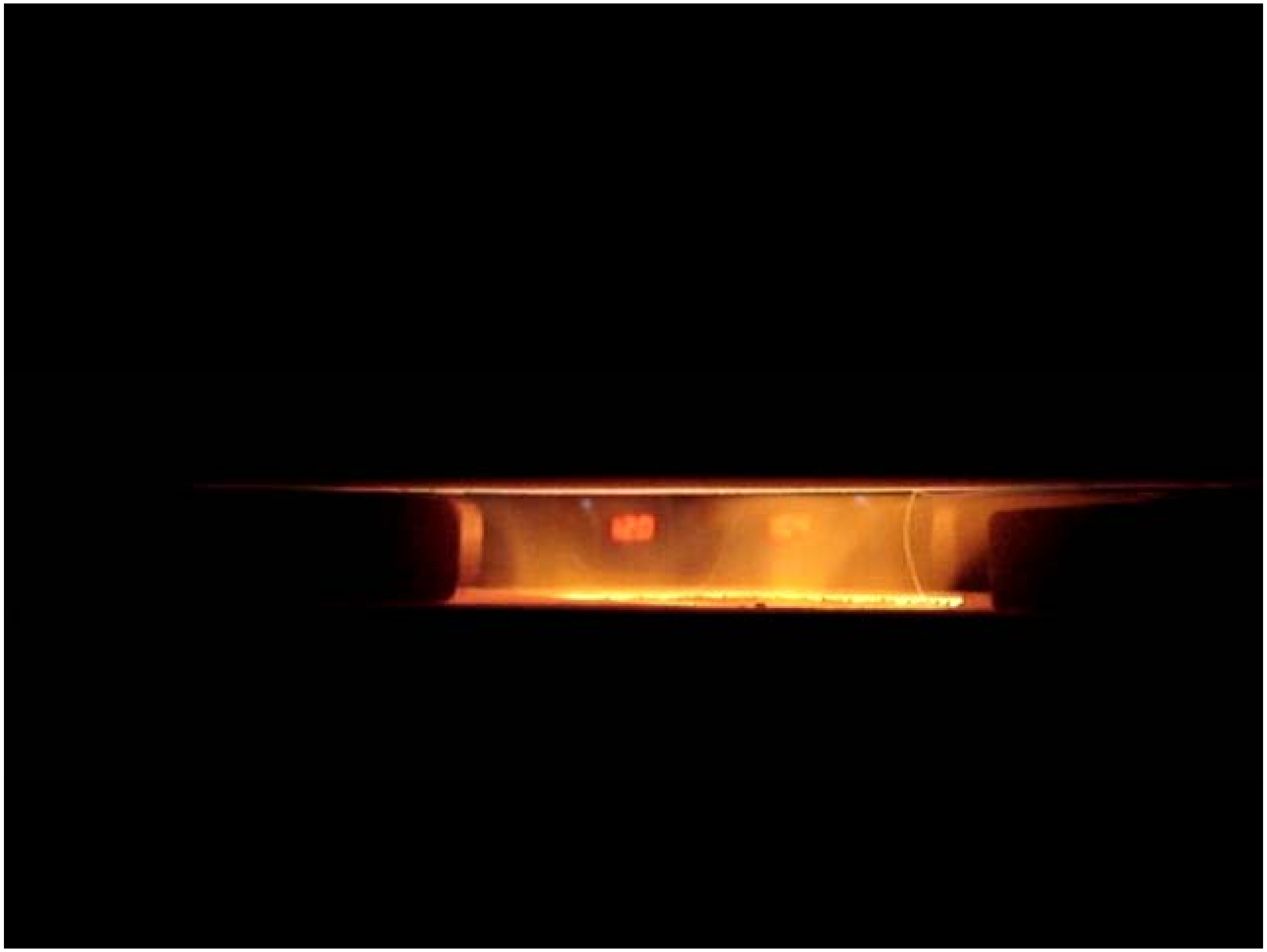


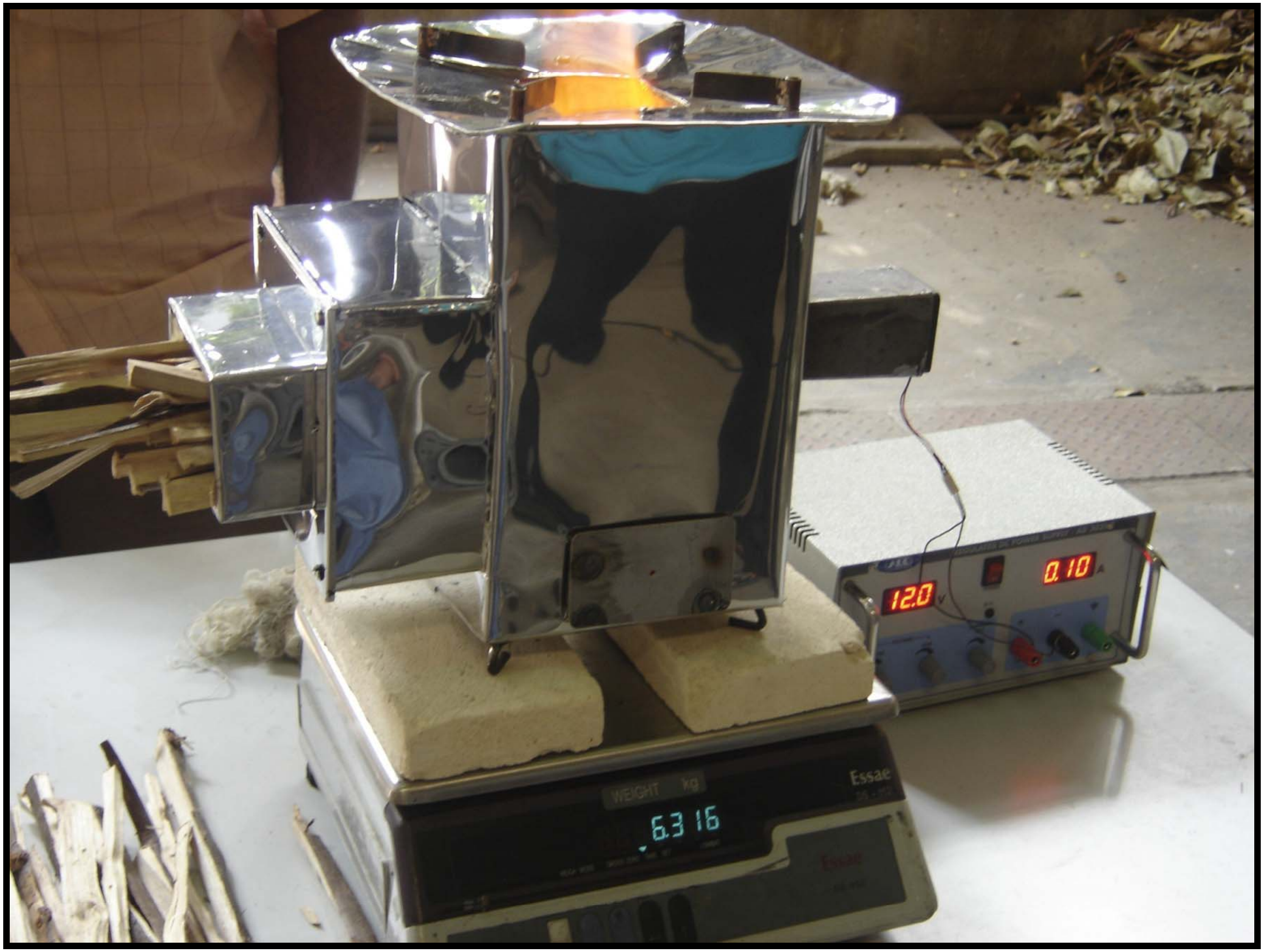
The stove on a balance…

EIGAS – 10 (10 kg/hr)



Movie

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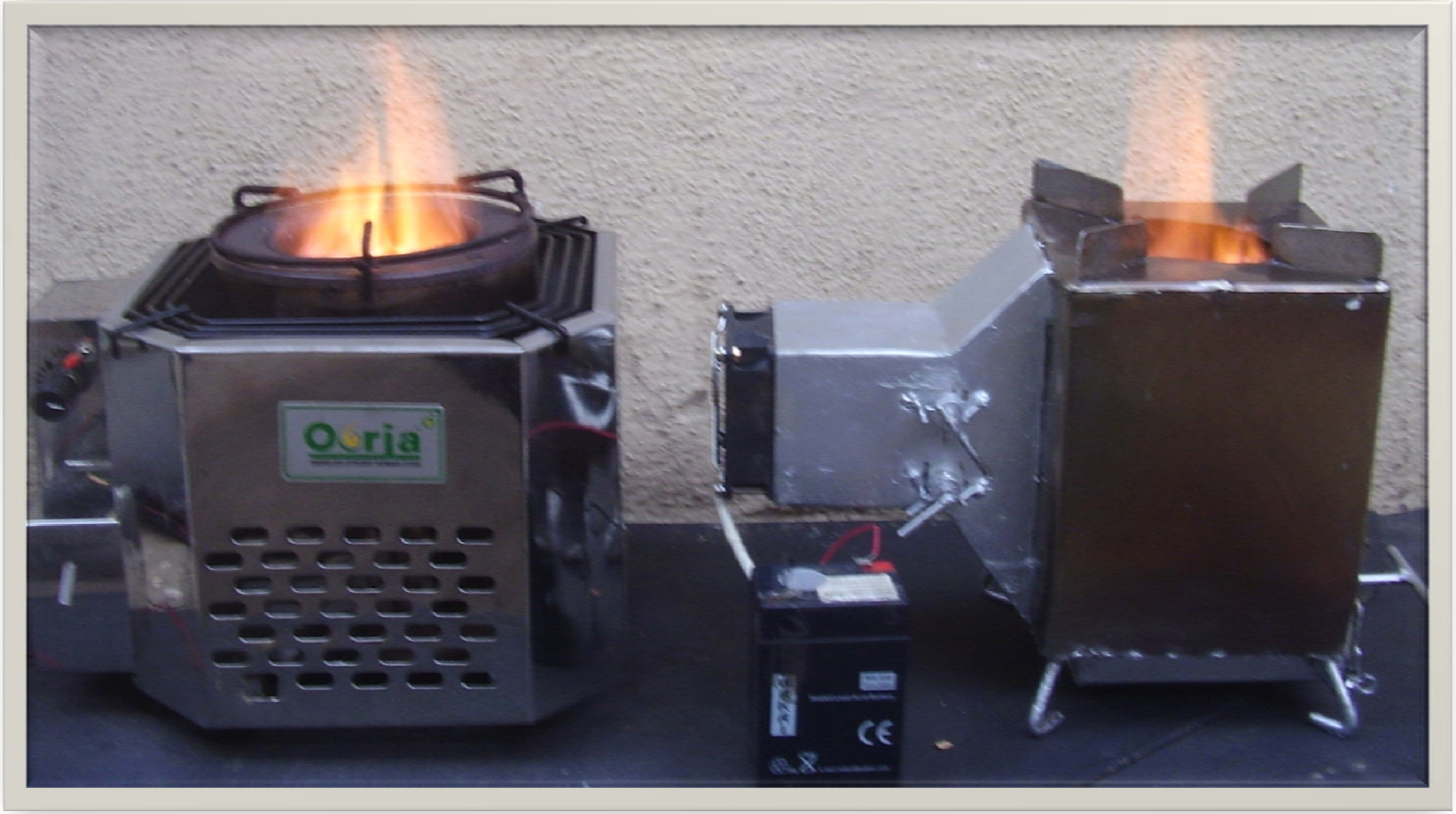
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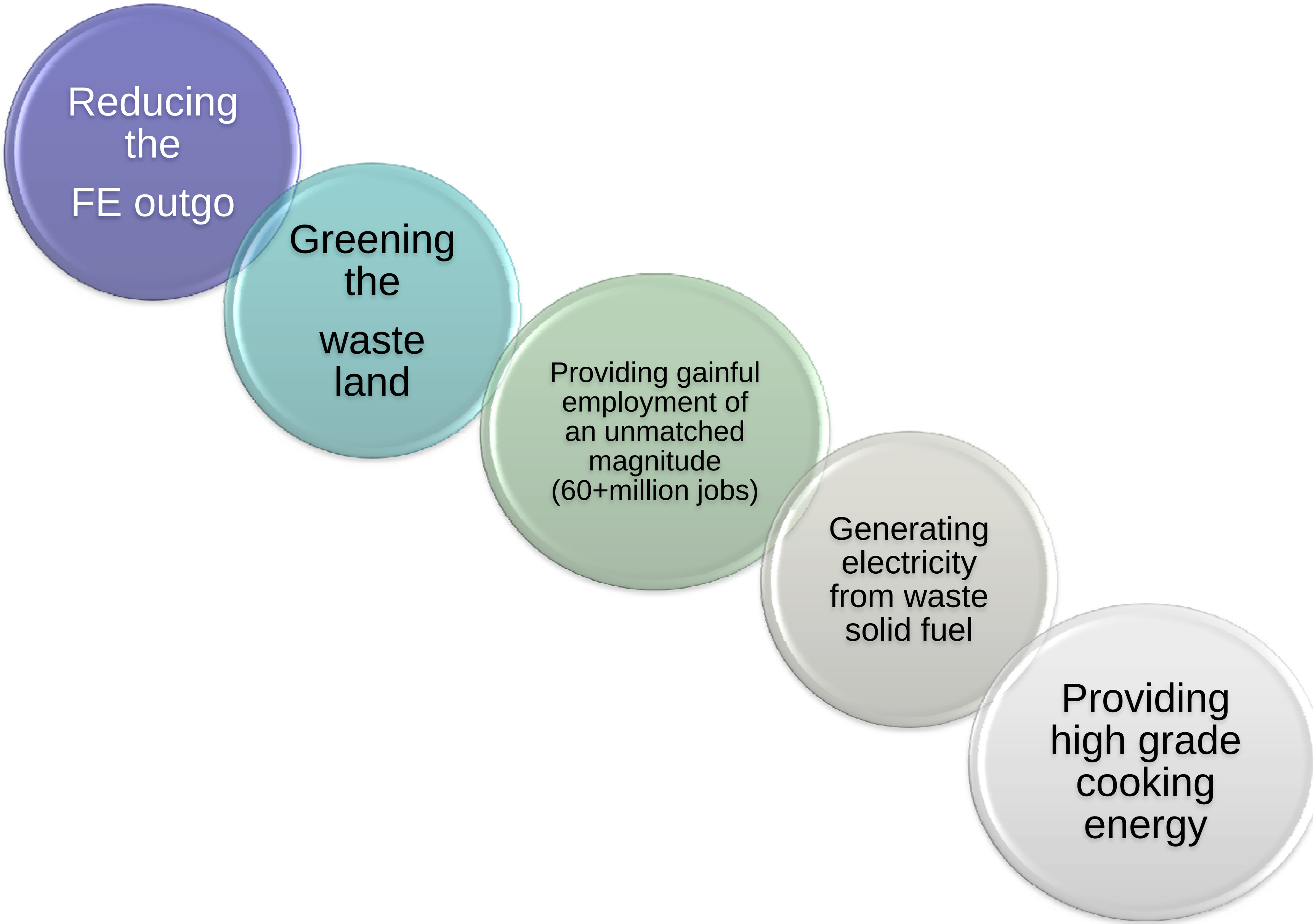
Summary on new technologies

There is enough technological capability in India on modern gasification technology for handling solid fuel based cooking energy, high grade heat and electricity.

These must be integrated into a larger framework of bio-fuel based economy for wealth and health (waste reduction).

The win^6 situation



Summary

Create demonstration projects for USW in Tier-2 cities for clean-up of temple towns, tourist destinations

Provide in this process an additional 60+ million jobs across the country.

By designing a package with suitable owners of the products – IOC – Oil, village institutions – electricity from bio-residues, Investors – Output from lands leased from Government, one can generate internal revenue to substantially reduce the FE outgo.

THANK YOU..........

Advanced Bio-residue Energy Technologies Society
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