Urban solid waste – non-ignorable science based native solutions

- Brief history - Lessons from the past
- Further Analysis
- A solution from integrated thinking
- Advanced solid fuel combustion systems
- Financial and general aspects

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Brief history - Lessons from the past

- The actual composition of the urban solid wastes has been changing over decades and with better economic urban setting.
- More packaged goods have come in, inevitably leading to greater waste generation.
- What was 0.2 kg/person/day in a metropolitan city the 1985 has become 0.8 kg/person/day in 2010.
- Interestingly recyclables like glassware, plastic-ware, metal parts are quite often taken away from homes to private paper and waste receiving shops even before the waste reaches the dump yard.
- Market wastes in several cities are taken care even though not efficiently or regularly.
- It is only sand and grit filled bio-wastes as well as other cellulosic house-hold wastes that end up in local garbage bins and if not removed every day might cause disagreeable foul smell.

Lessons from the past

- Three possible solutions were being conceived in the eighties.
- These are
  - (a) composting including vermi-composting
  - (b) biomethanation and
  - (c) incineration.
- Composting, a simple solution aimed at producing a useful fertilizer, has no possibility of coupling energy extraction. Vermi-composting works very well at small scale.
- Both these are less useful compared to incineration when the aim is to manage very large amounts of generation on a daily basis.
- All the three approaches have been tried out in the country and have had inadequate success *for the scale demanded.*
- Composting tried out in Mumbai and Trivandrum led to large production of compost that was not well received by the market significantly due to its lower fertilizer quality and had to be shutdown.
- Biomethanation, needing for greater first investment cost was tried out without recognizing the possible mismatch between waste delivered and size of the plant for economic operations and had to shut down the operations.

Lessons from the past

- Electricity being the final salable commodity was controlled by the electricity utility that would agree to purchase at certain tariffs would sometimes delay payments making the already difficult-to-sustain operation even more difficult.

- Incineration with investment cost about 70 % of that of biomethanation process (which is 10 to 12 crores/MWe) was a worthwhile process that has had two problems.

  Large initial capital subsidies from MNRE encouraged less-than-serious industrialists to build the plants and not run them at all or find reasons for not running them.

  Plant designs have not adequately recognized the variability in throughput and quality over seasons.

Lessons from the past

- Corporations and municipalities have been given an impression substantially by the Government that these technologies are worthy of industrial investments as long as they agree to provide the wastes to dump sites nearly-free of cost.

- The projects were undertaken by some (for instance at Lucknow) without an understanding of the commercial risks involved in the aspects related to chain of waste to energy – availability of adequate amount of delivered waste with minimal civil construction debris and stability of getting tariffs on electricity supplied to grid because of inadequate commitment of the all concerned to contracts.

- Courts were no answer to resolution of conflicts because of inordinate delay in the resolution process. Mired up in this complex societal environment, waste-to-energy projects have remained non-capitalized.

Lessons from the past

- In recent times, politicians – Corporators, MLAs and MPs have taken extraordinary interest – visiting many countries, bringing in political leaders of those countries hoping to resolve the problem locally.
- There is little realization about the substantial differences in the nature of wastes and cultural attitudes between the east and the west.
- The issues of wastes in developed nations arise much more from plastics and those from the developing nations more of biogenic origin.

Lessons from the past

- Culturally, developed nations conduct affairs in which cleanliness is practiced both inside a dwelling as well as outside, with the expectation and fulfillment of cleanliness outside dwellings being much more.

- In developing nations, India in particular, the attitude is that cleanliness inside the house is the dweller's responsibility, but waste thrown out is nobody's responsibility (or shall we say, State's).

If this were not so, how is it that most important temple towns are so unclean!

- Unless respect for cleanliness in the environment is much stronger than what it is today, it is difficult to expect societal response that can become a peer pressure.

Lessons from the past

- Large amounts of international collaboration and investment through equipment appeared as possibility in the nineties but resulted in nothing meaningful on ground.
- Part complaint is the dishonoring of PPA's agreed to between parties – to supply the appropriate quality waste, to set an appropriate tariff etc.
- In general, the field has not had adequate technical and financial investments needed to achieve the objectives of reducing the waste in useful ways.

The picture of world waste magnitude

Nation	Million metric tonnes to WTE
EU 25	48.8
Japan	40.0
USA	26.3
Taiwan	7.0
Singapore	4.0
China	3.0
Switzerland and Norway	3.8
South Korea	1.0
All other	9
Total	143

In India it constitutes about ~ 1 – 1.5 million metric tonnes per day
The issue is not very large and yet we have not dealt with well

Example from recent actions - 1

Pune Municipal Corporation's waste-to-green energy project in Hadapsar is limping; Umesh Isalkar, TNN Aug 29, 2013, 06.57AM IST

- The Pune Municipal Corporation's (PMC) waste-to-green energy project of processing garbage in Hadapsar has run into trouble.

- Mumbai-based Rochem Separations Systems (India) Pvt Ltd, which was operating the plant on a build-operate-transfer basis to process 700-tonne dry waste every day and generate 10 MW electricity has failed to run to its full capacity.

- Representatives of Hill Side residential complex said, "…..During last year's monsoon, the leachate (liquid toxic waste that seeps through wet garbage) from the garbage was all over the area after the compound wall of the plant collapsed.“

- **Vikas Jagtap, vice-chairm**an of Ramtekdi Industrial Association, which has 105 companies as members said, "We have lost one multi-national project due to the garbage processing plant as foreign investors withdrew after visiting the site. We have filed a case in Bombay high court as the garbage processing plants located …very little garbage is processed."

Example from recent actions - 2

Pollution level near Okhla waste-to-energy plant 25 times above limit

Kamala Kelkar : New Delhi, Mon Jun 03 2013, 02:36 hrs

- The process of burning solid waste to convert it to energy at a recycling plant in South Delhi has made the air near the unit 25 times more polluted than the permissible limit, a surprise check of the Okhla waste-to-energy plant has revealed.

- The National Green Tribunal (NGT) asked Central Pollution Control Board (CPCB) to conduct a check. The board submitted the findings of the expert committee to the tribunal last week.

- The level of dioxin and furan emitted from Boiler Stack I was measured at 12.4 ng TEQ/Nm3 and from Stack II at 2.8 ng TEQ/Nm3. The Delhi Pollution Control Committee allows 0.1 ng TEQ/Nm^3.

- Stack II emission for particulate matter was measured at 1,414 mg/Nm^3 while the DPCC only allows for 150 mg/Nm^3.

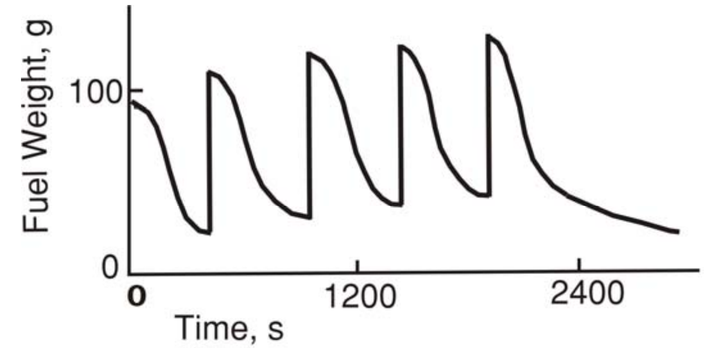
Solution strategy

- How can one find a solution in this complex situation?
- Replace the end point of conversion from electricity to good solid fuel. This has to be done by
  A. Using an environmentally clean transparent approach
  B. Ensuring that every process in the chain becomes an independent profit center (however small)
  C. Ensuring the involvement of the State for only policy
- Electricity must be replaced by generating quality solid fuels arises from recognition that it is a publicly salable commodity and that there is enormous shortage of cooking fuels for the less privileged classes in the country.
- The extent of bio-waste usage (firewood, agricultural wastes and cow-dung) for cooking in the country is about 450 million metric tonnes at an average efficiency of conversion to cooking pot of 10 to 15 %.

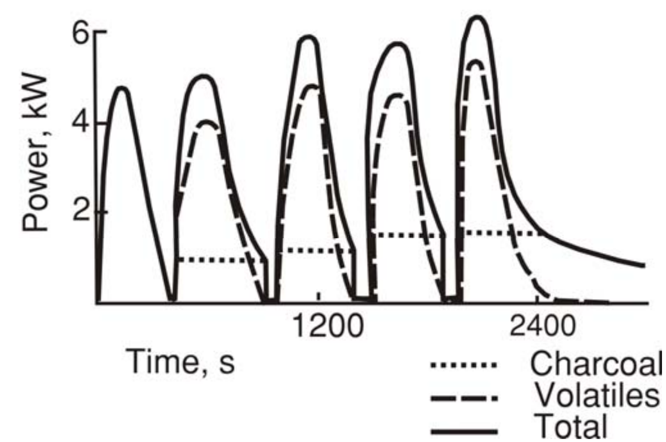
Solution strategy

- Combining the need for fuel for a large population (~ 100 million house holds) with good quality fuel production from USW we have taken care of two issues from a single point approach
  -- Why is the biomass stove efficiency is so poor, why it has remained poor for such a long time and what should be done?

Conventional wood stoves requiring periodic supply of fuel are characterized by volatile generation with large peaks: leading to large fluctuations in air-to-fuel ratio in the combustion process.



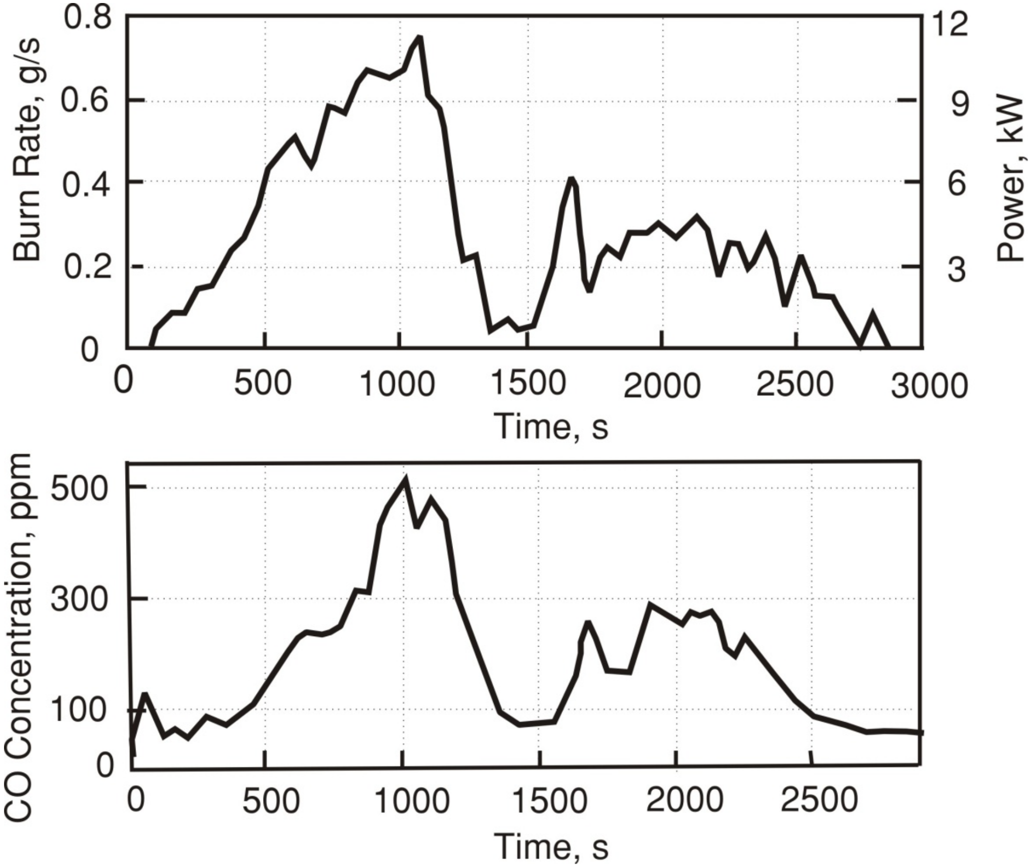
This leads to much lower flame temperatures and hence, lower efficiency as well as - smoking & sooting



CO & other products of incomplete combustion (PIC) also get emitted.

Emission patterns

There is a clear link between higher CO emissions with intermittent fuel feeding



Operation of a typical one pot metal stove with periodic fuel supply

Why have things remained poor for a long time?

- There are two technical reasons.

a. Nature of fuel

- Solid bio-fuels for stoves are non-standard. This is often extolled as a virtue – they are considered affordable as they are picked by the poor by travelling distances – the general principle being "finders – keepers" – you do not pay for the fuel – really?

- All other fuels are processed to specs, sold commercially and they perform to specs.

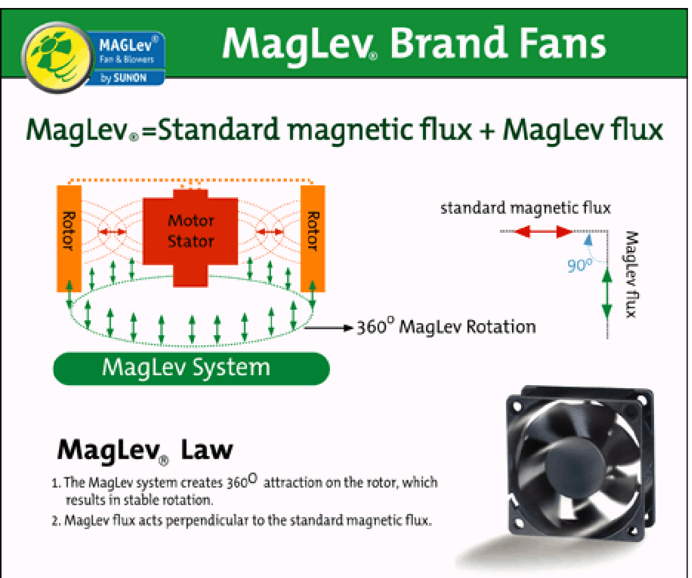
- Would it be scientifically appropriate to expect a wood stove to accept wood fuel what ever size, shape and moisture fraction and perform with high eff. and low emissions?

- The answer is a clear NO. Unfortunately, All the stove programs of the world disregard the issues.

Why have things remained poor for a long time?

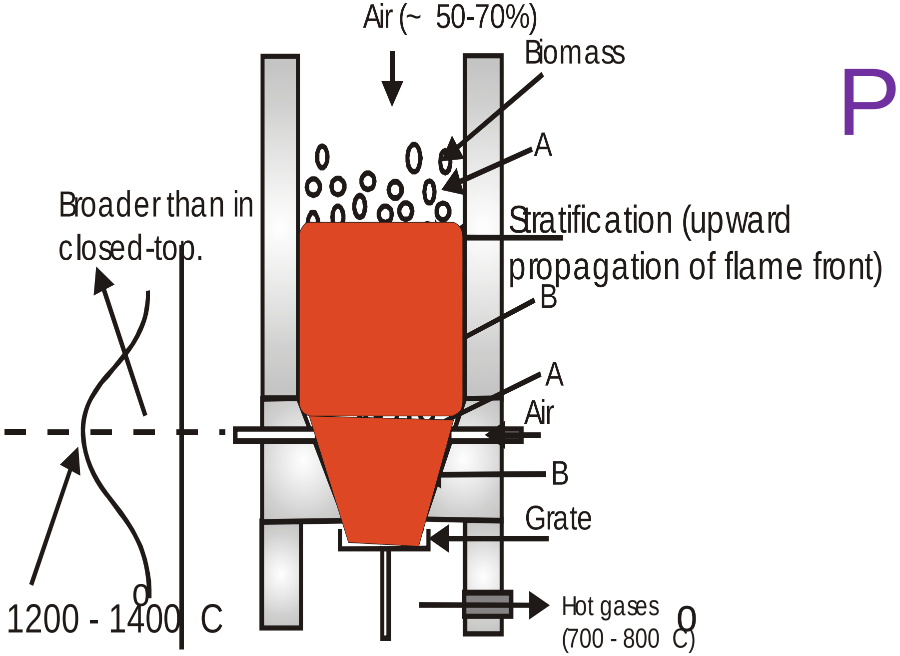
b. Air-to-fuel ratio control

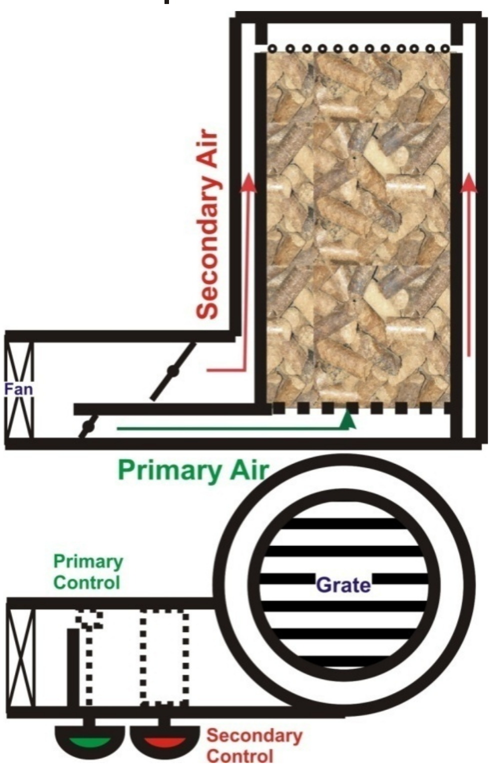
- Inability to control the air flow rate to match the fuel consumption rate with "free-convection" and the non-availability of affordable air supply devices.
- The development of compact air cooling devices for computers generated small, low power consuming fans and blowers.
- Hence technological improvement has been possible in the last ten years.



......What does a fan based stove look like?...

Principles of operation





Reverse the classical downdraft gasifier. Push air from the bottom and you get the reverse downdraft gasifier.

Fan provides the air. This fan is about the same as a computer fan
Air from the bottom is called the primary air and
it controls the power (how? The air for gasification is about 1.8 times the mass consumption rate, the number 1.8 related to the biomass composition. The hot char on the top participates in the conversion process).

The air at the top is proportioned such that it burns up all the fuel gas. This ensures the air-to-fuel ratio for combustion to be such as the peak temperature close to a maximum.

One of these called Oorja stove manufactured by a company called First Energy Private Limited, Pune has produced variants at 3 and 4 kg/h (domestic stove is a 0.75 kg/h pellet burning system) suitable for the hospitality industry (hotels, food supply outfits, and community kitchens) and is being sold along with pellets in various metros. It uses high density pellets of agro-residues.	The flames from pellet combustion. The flame temperatures reach 1000 to 1100 °C. This temperature can be boosted to 1500 °C, the same as will be provided by fossil fuels by other means.

Fuel production and supply

- Fuel is produced from Bagasse, Ground-nut shell, wasted rice bran, and a small amount (~ 5 %) of Sal or other biogenic oils that are wasted.
- These are produced in pellet production plants in Maharashtra (Islampur and Nagpur) and Karnataka (Dharwad) and supplied through a chain of warehouses to users.
- About 1000 tonnes per month of pellets are being supplied to users in Bangalore, Hyderabad, Chennai, Coimbatore, Pune and other places.
- About ten thousand of these stoves are in the market.
- Adaptation of the stove design for other products facilitating dosa making, idli preparation and other frying activities in kitchen have been produced and supplied by the industry.

Supply of solid fuels - 1

- The key issue is the supply of quality fuels.
- Solid bio-fuels have inherent features of moisture, varying shapes and sizes.
- To expect that such biomass of varying quality should burn and provide clean and efficient combustion is fundamentally impossible.
- Science and technology can be used to help matters so that the solid biofuels can be produced with controlled moisture fraction (~ 8 to 10 %, sundry) and with appropriate shapes and sizes – either in the form of pellets, briquettes or sized pieces.
- It is important that these are produced from low cost ingredients.
- Urban solid waste happens to be a desirable choice since it is intended to be disposed off anyway.
- The strategy is to convert the wastes into useful high energy solids of right shapes and sizes by a process that socially acceptable and is not as expensive as producing electricity and hence enables production of affordable solid fuels.
- Electricity will still need to be produced to operate the pellet/briquette production plant. This can use the more difficult of the wastes (dioxin producing – see later)

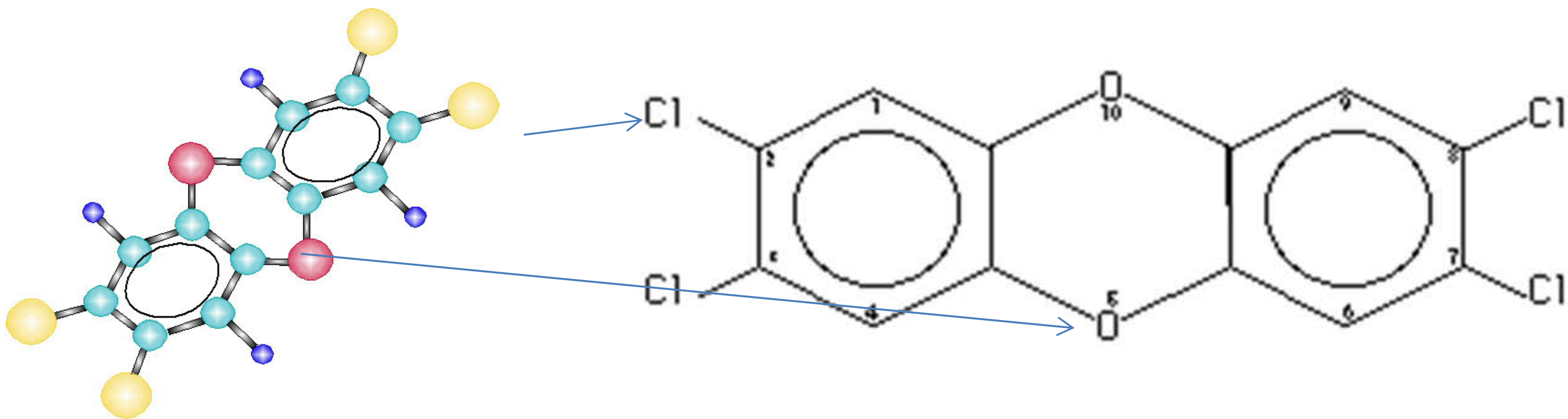
Supply of solid fuels - 2

- One question that has been raised is the presence of plastics in the urban solid waste.
- The magnitude of the plastics that reach the dump yard is around 5 to 7 % of the wastes and the actual material is largely the thin carry-on polythene bags.
- The usual question that has been raised is the presence of dioxins in the burnt gases when plastics are also used.

- Dioxin problem is related to PVC class of plastics that contain significant chlorine. Separation of PVC material ensures that the problem of dioxins does not occur in the pellet production.

- PVC material per–se along with other solid waste can be used in a gasification plant aimed at electricity generation for operating the plant (typically 10 – 20 % of the power capable of being generated by the solid waste).

On Dioxin - $C_{12}H_4Cl_4O_2$

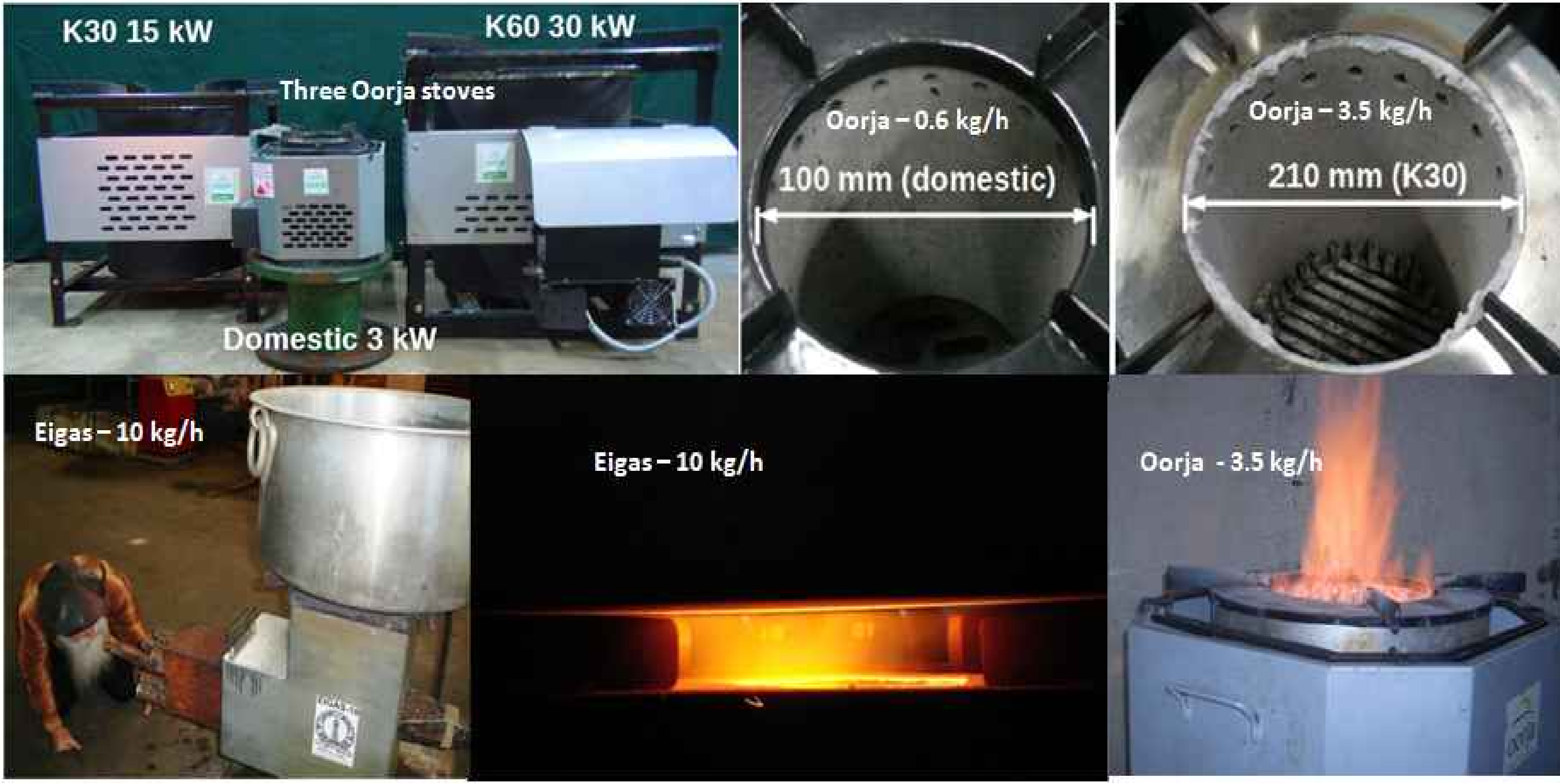


- Pure 2,3,7,8-TCDD was synthesized in 1968. It is a white, micro-crystalline solid (looks like table salt) which is insoluble in water and sparingly soluble in some organic solvents. 2,3,7,8-tetrachlorodibenzo-p-dioxin, Dioxin, also called Tetradioxin; its melting point is 305 ^0C.
- It is also present in the ambient conditions in the soil. At larger amounts than a minimum, it is considered harmful.
- Its production requires oxidative environment as in combustion
- In gasification one has a reducing environment (products are CO, H_2, CO_2, CH_4, H_2O). Hence production of Dioxins in gasification based plants is very small as shown by large scale experiments (in overseas plants).

The EiGAS design that uses about 1.2 W of electrical power to produce hot burnt gases at 3 kWth with firewood.	**Stove with a circular geometry producing visibly more intense combustion from firewood.**

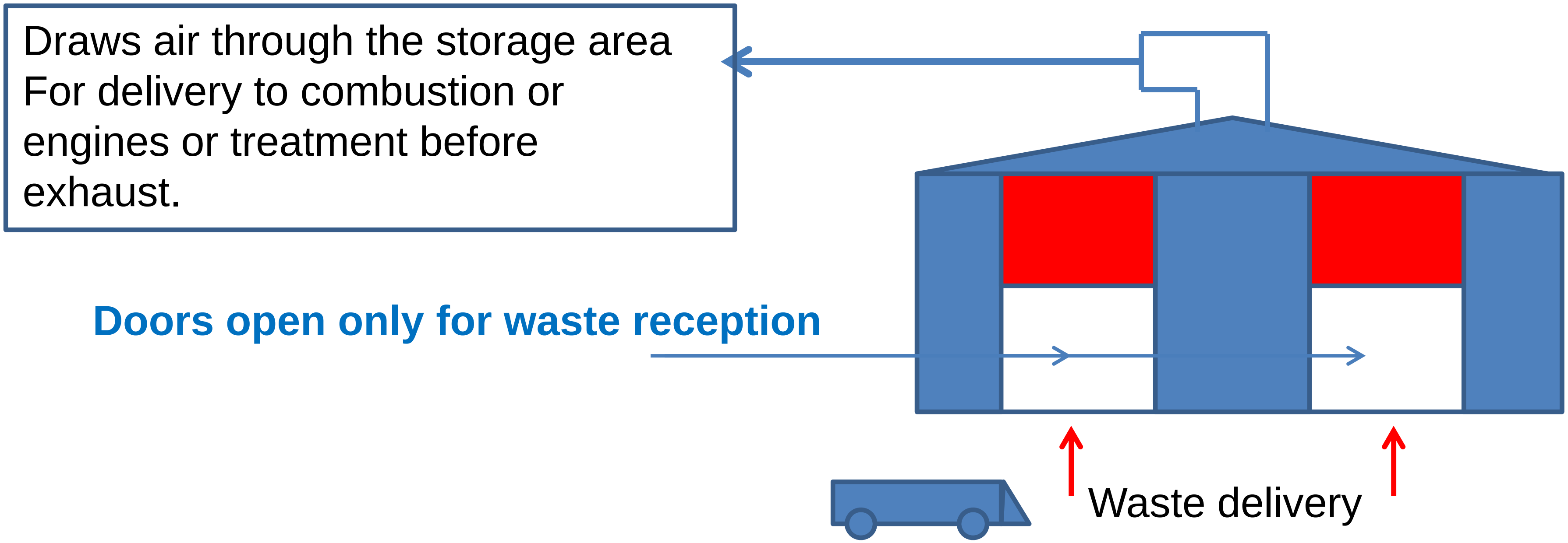
Ejector induced gasifier stove design for a mix of fuels including firewood corn-cobs, cotton stock and pellet fuels; firewood needs to be sized and dried

EIGAS stove being used for raising steam for cooking at Ulavi temple (near Karwar)



- Power supply: The fan depends on a 2 W rechargeable battery source.
- A single charge allows three to four cooking operations. Larger systems for semi-industrial applications have power supply similarly designed.
- But charging in larger systems is not a matter of concern.
- Domestic stove has a single fan with controlled divided air supply.
- Larger systems have two fans –for gasification and controlled combustion.

The waste facility and arrangements



Suggested arrangements have not been implemented in any facility in India today.

This avoids foul smell all around and makes the facility function without objections from anywhere..

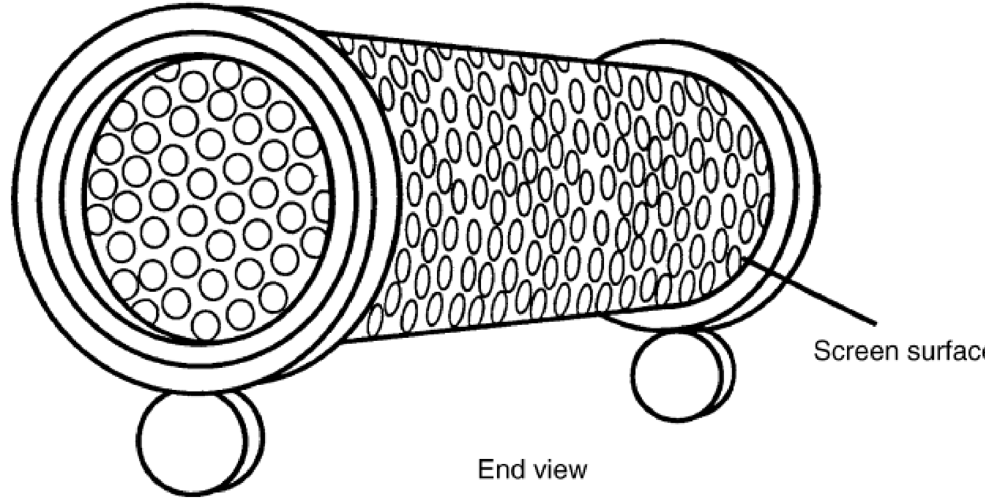
Grab

Conveyor - with checking and picking undesirable stuff

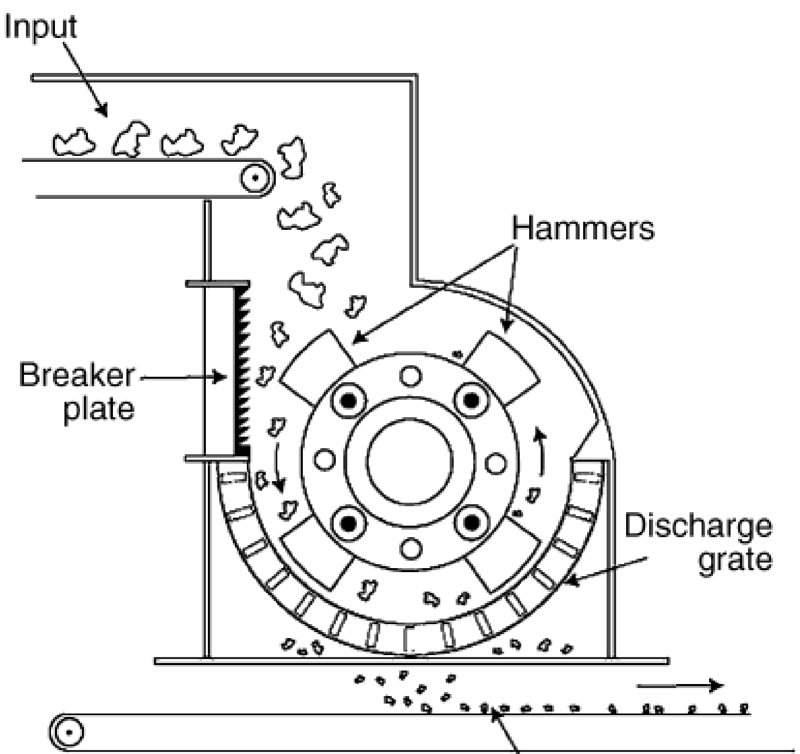
Magnetic separator (steel items) and eddy current (aluminum class) separator →

In addition, one needs a rotating perforated sheet tumbling separator for small stone pieces and grit.

A dryer to take the temperature to close to 100ºC and then again a rotating perforated sheet separator to remove more grit and dried mud.

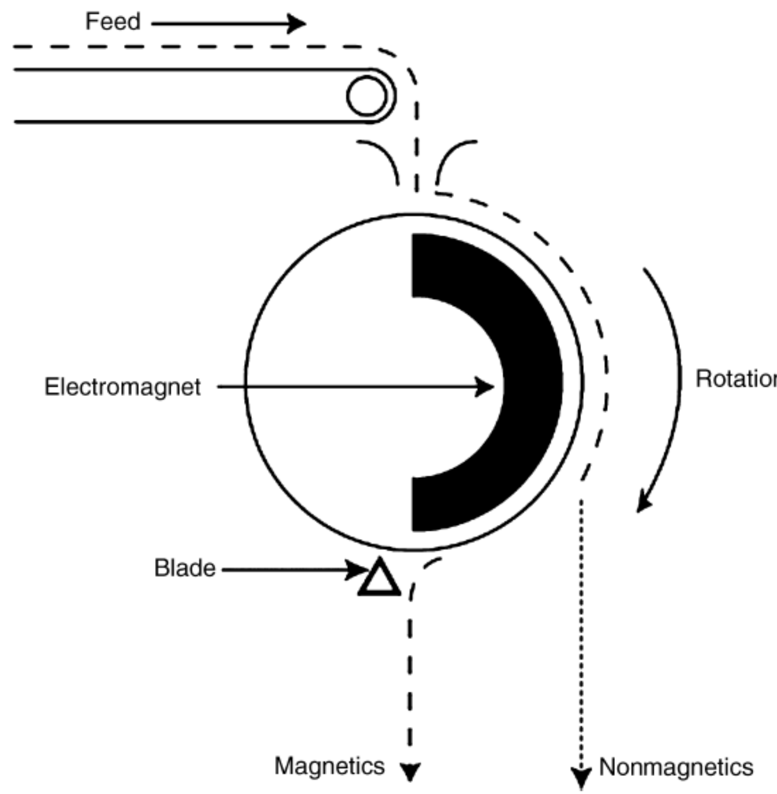


Screen surface
End view



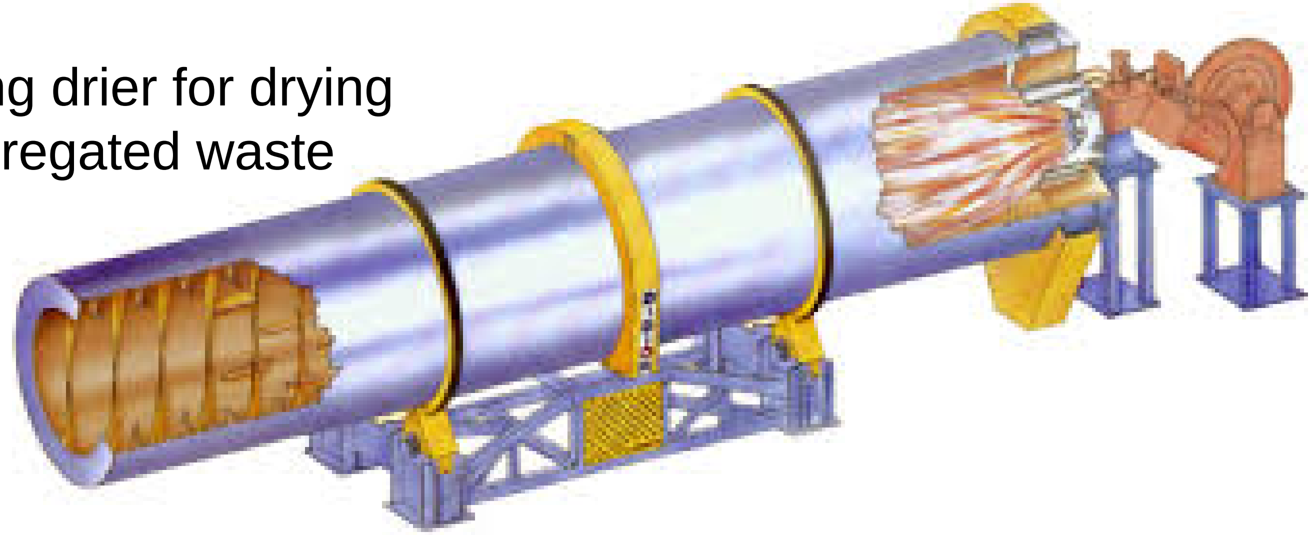
Input
Hammers
Breaker plate
Discharge grate
Discharge

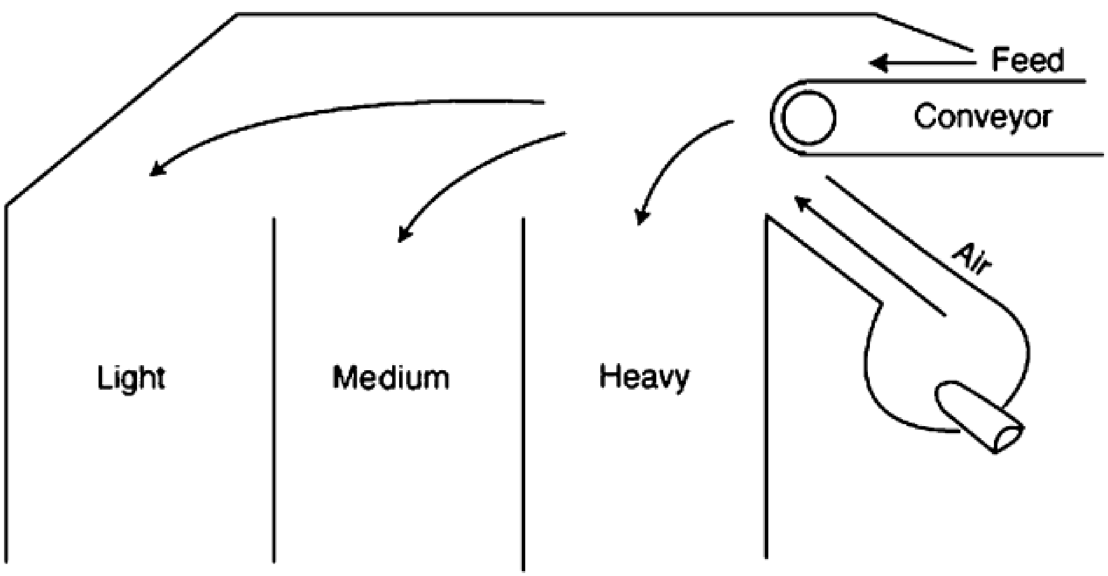
(a)



Feed
Electromagnet
Rotation
Blade
Magnetics
Nonmagnetics

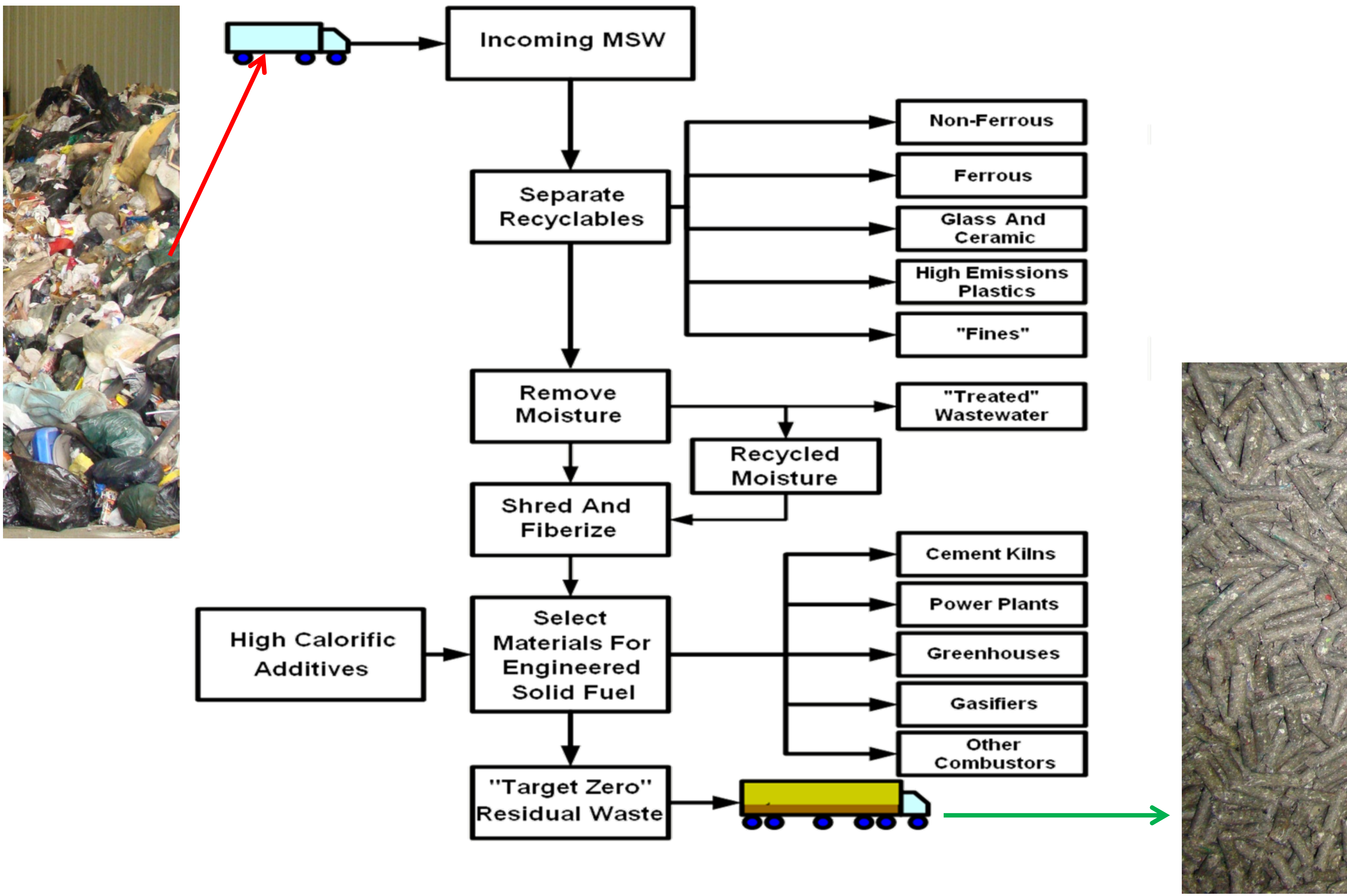
Rotary tumbling drier for drying shredded segregated waste





Aerodynamic Separator

The Technology - Engineered Solid Fuel (ESF)



Financial and general aspects

- The single most important aspect is the return-on-investment assurance if electricity is to be generated.
- The project support must move away from capital subsidy to generation based incentive.
- The tariffs set must be rightly assessed including waste as a health hazard as well as a tourist eye-sore. Such an assessment for encouraging this area leads to electricity tariffs of Rs 12 to 15 per kWh delivered.

- An alternate route of producing valuable fuel for stoves (pellets) by treating the waste in a scientific way (heating to 75°C and maintaining for a minimum time) will reduce the cost of the project up to 60 % and generate salable product with assured revenue beyond state's control on electricity tariffs.
- One/two such projects of significance can change the waste reduction strategy throughout India while also helping other aspects.

Thank you for your attention