Solid and liquid biofuels –

What can we expect on big and small benefits?

- Background and details
- The energy scenario today and the classical fourth source syndrome
- Principal issues and way forward on liquid biofuels, cooking energy, and distributed electricity generation
- The non-elitist solution – biomass-hydro-wind-SPV combination

This is not a bathtub.

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October 10, 2013, NIE

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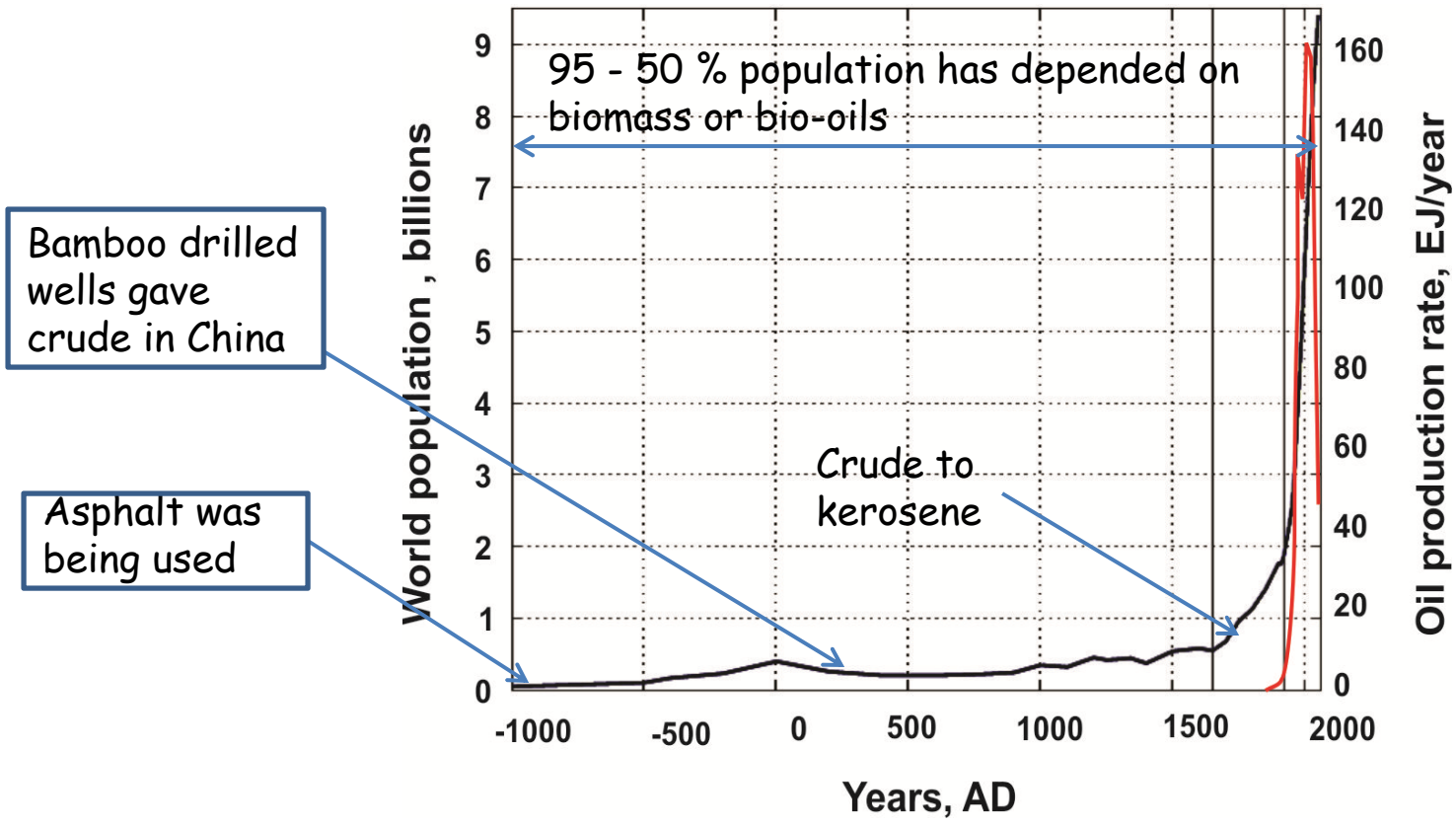
Before that…….

My worry and concern

- Am I am going to speak somewhat "same things" again and again to the audience who is already empathetic to what I wish to say….
- Somewhat like Harikathakar (giving musical discourse of the stories of the Lord) equivalently Lenore ballads in Germany….
- I will try to be inventive under these difficult circumstances and I seek your pardon if it is not adequately so.
- Most distinguished articles/governments including the Indian govt.) treat alternate energy sources in the following order: Solar/Wind/Hydro/Biomass – the fourth source syndrome.
- The first two are recognized as intermittent; the last one is the only one that has the promise of being a 24 x 7 availability and yet it is always treated as the last alternative.
- It is not to be forgotten that biomass contributes to food, fiber, energy and chemicals transforming the classical statement "money does not grow on trees" to "money grows on trees" in fact contributing to human survival.

From the last 3000 years…



World population and World oil production over 3000 years that must have constituted about 60 to 70 human cycles;
Human civilization has largely been functioning without oil for over 2800 years;
Having discovered oil, it has produced and consumed so much that arguments about anything being left for use for the next generation loom large (drawn from Patzek, 2008)

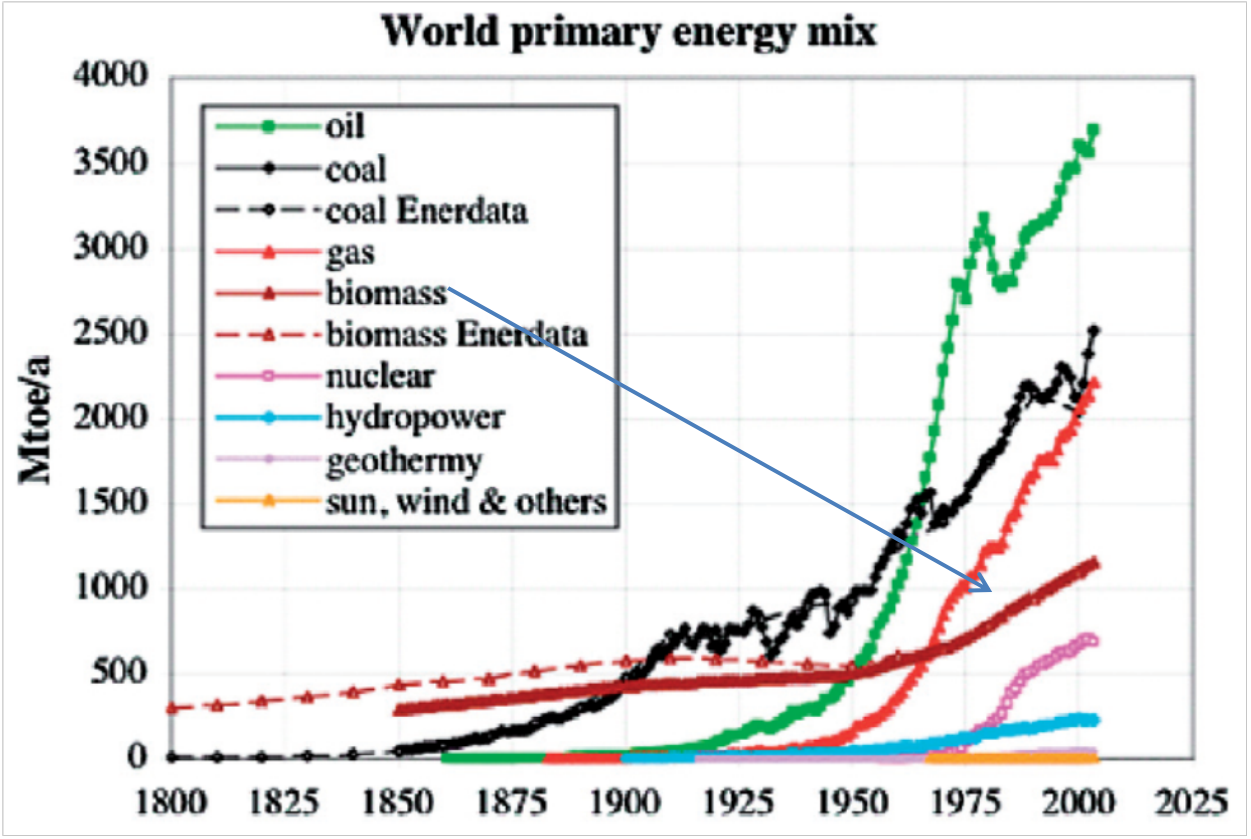
On richness/poverty of countries and so….

- One strong measure (not the only one, though) of a country's richness and economy is based on how much oil it has or its poverty measured by how much oil it has to import.
- Buying oil from international sources was considered a profession worthy of pursuit for the oil companies till about 2005. Oil ruled at less than 30 USD per barrel and this could be afforded by the economies even if the population grumbled once in a while.
- But the roller-coaster variation in the last seven years to levels of 140 USD per barrel and settling down to not less than 60 USD per barrel has not woken up India yet to think of ways of mitigating the economic hardship.

On richness/poverty of countries and so….

- A further factor that has made international headlines is the aspect of climate change due to excessive emission of green house gases like carbon dioxide and methane.
- The implication of this development is that in future renewable energy sources must be brought to centre-stage. Most rich nations (Germany is an exception) may not want to agree to this since the reduction in quality of life would be substantial as this directly impinges on their existence.
- In view of all these, it is better to deal with economy based decision making.
- And those who have to import to procure oil need to think indigenously and preferably, ingeniously. This unfortunately is not happening despite good examples from some countries.

The World energy mix



The range of primary energy sources and the magnitude of use over the 200 years over which most energy sources have been produced and utilized in the world (drawn from Hall et al, 2008)

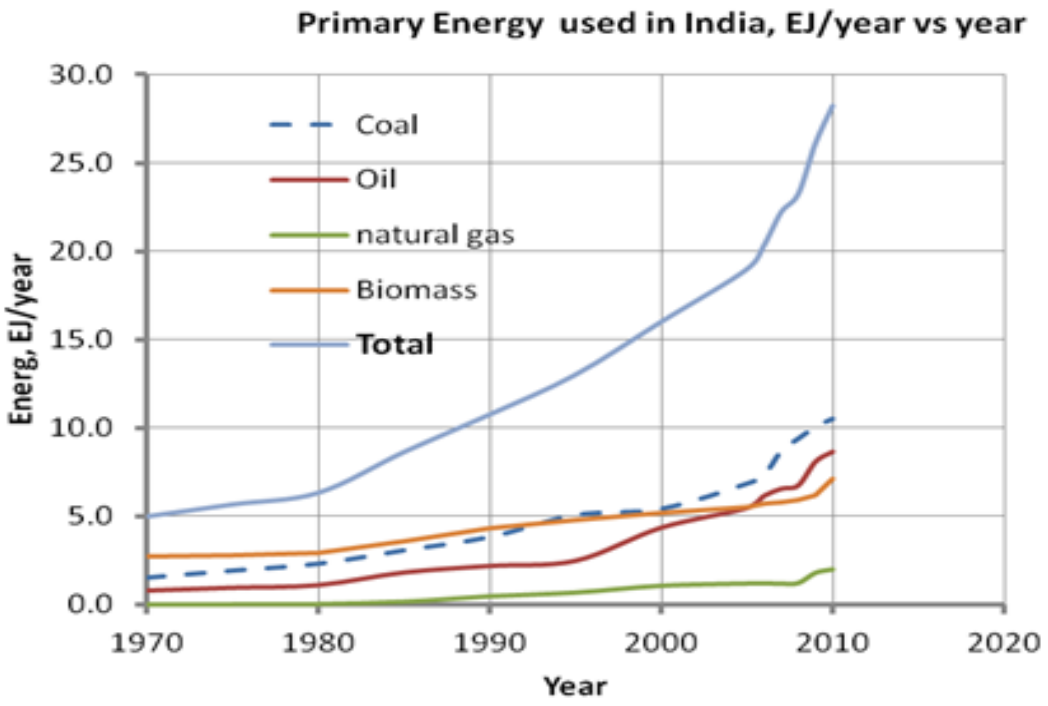
World primary energy mix in million tonnes oil equivalent (mtoe)

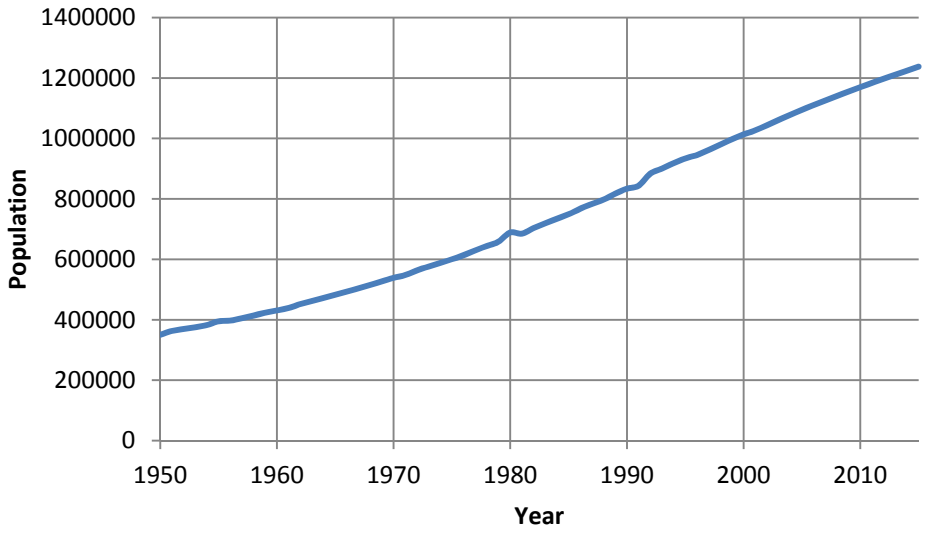
Year / Fuel	2004 mtoe	2010 mtoe	2015 mtoe	2050 mtoe	2050 EJ
Coal	2773	3354	3666	4000	160
Oil	3940	4366	4750	5000	200
Gas	2302	2686	3017	3500	140
Nuclear	714	775	810	1000	40
Hydro	242	280	317	500	20
Biomass and waste	1176	1283	1375	3500	140
Other renewables	57	99	136	1500	60
Total	**11204**	**12842**	**14071**	**22050**	**760**

The amount of energy used over the World in 2010 is 13000 mtoe = 520 EJ = 520 x 10^{18} J. Coal is largely used in power generation, nearly 95 % of it in standard steam cycle. The break-up oil in terms of gasoline, diesel and fuel oil is important. About 900 mta (million tonnes per annum) of gasoline, 1800 mta of diesel and 600 mta of fuel oil are consumed by the World.

Natural gas is used for stationary power generation, as domestic fuel for cooking and in some countries as fuel in city transportation due to its cleaner combustion features.

A remarkable feature is that biomass occupies a visibly important feature. Biomass use is significant across the World





Total Indian consumption is about 4 % of the World consumption

Coal – 600 mmt; Biomass – 450 mmt

High speed diesel (HSD)	– 78.0 mmt
Gasoline	- 26.0 mmt
Fuel oil (furnace oil)	- 20.5 mmt
Naphtha	- 17.5 mmt
Aviation turbine fuel	- 9.6 mmt
Kerosene	- 7.7 mmt
LPG	- 7.5 mmt
Other distillates	- 15.0 mmt

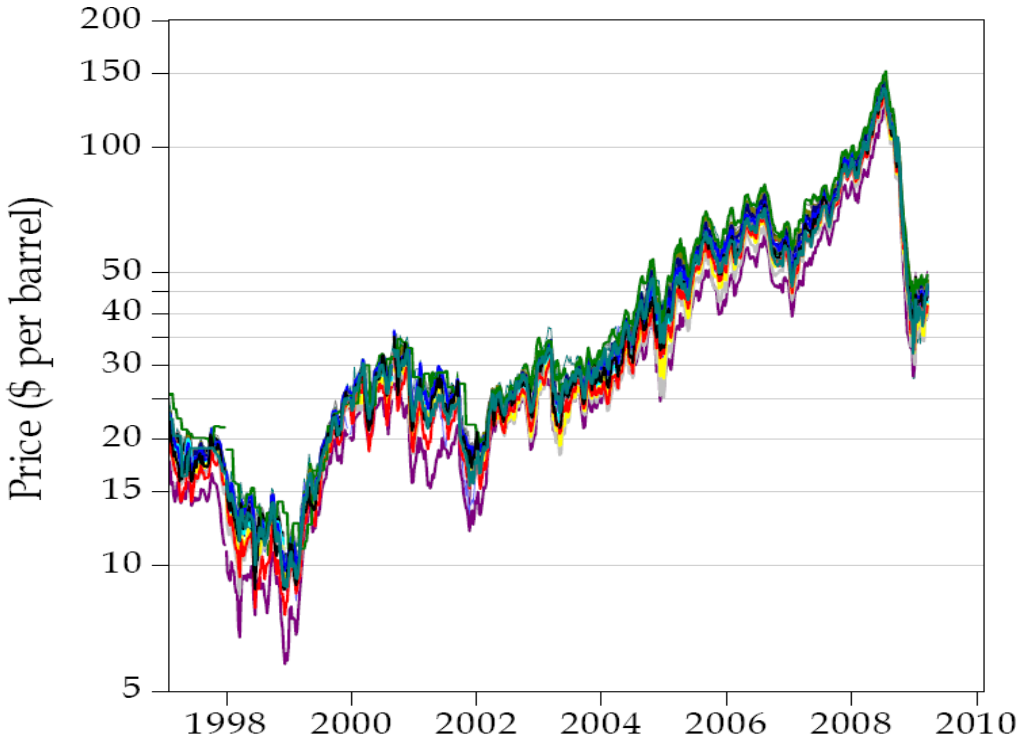
Note that biomass comparable to coal but used most inefficiently. Needs scientific, industrial and policy inputs to make its use efficient and reduce emissions from its use.

The issues

The oil problem

Rural cooking energy problem

Rural electricity availability problem



Oil problem in India and some others as well

- In 2010-2011, India produced about 38 mmt crude internally and imported 164 mmt. As higher economic growth rate is demanded, the demand for oil increases. The internal production increases marginally. **Hence imports keep increasing.**
- A statement on oil imports of India by the previous oil minister Sri. S. Jaipal Reddy who indicated "India's oil import bill leaped 40 per cent to a record **$140 billion (Rs. 720,000 crore)** in 2011-12 as high oil prices shaved off much of the nation's GDP growth rate". That 10 years ago, it was just **$20 billion (Rs. 100,000 crores)** shows the enormity of the problem.
- Very few who matter are concerned (PM, PM and FM) about resolution of the problem. Those who are concerned (like me, for instance and not too many, though) do not matter! …….and business as usual scenario
- The situation is similar in a number of countries importing oil in Africa and Latin America.

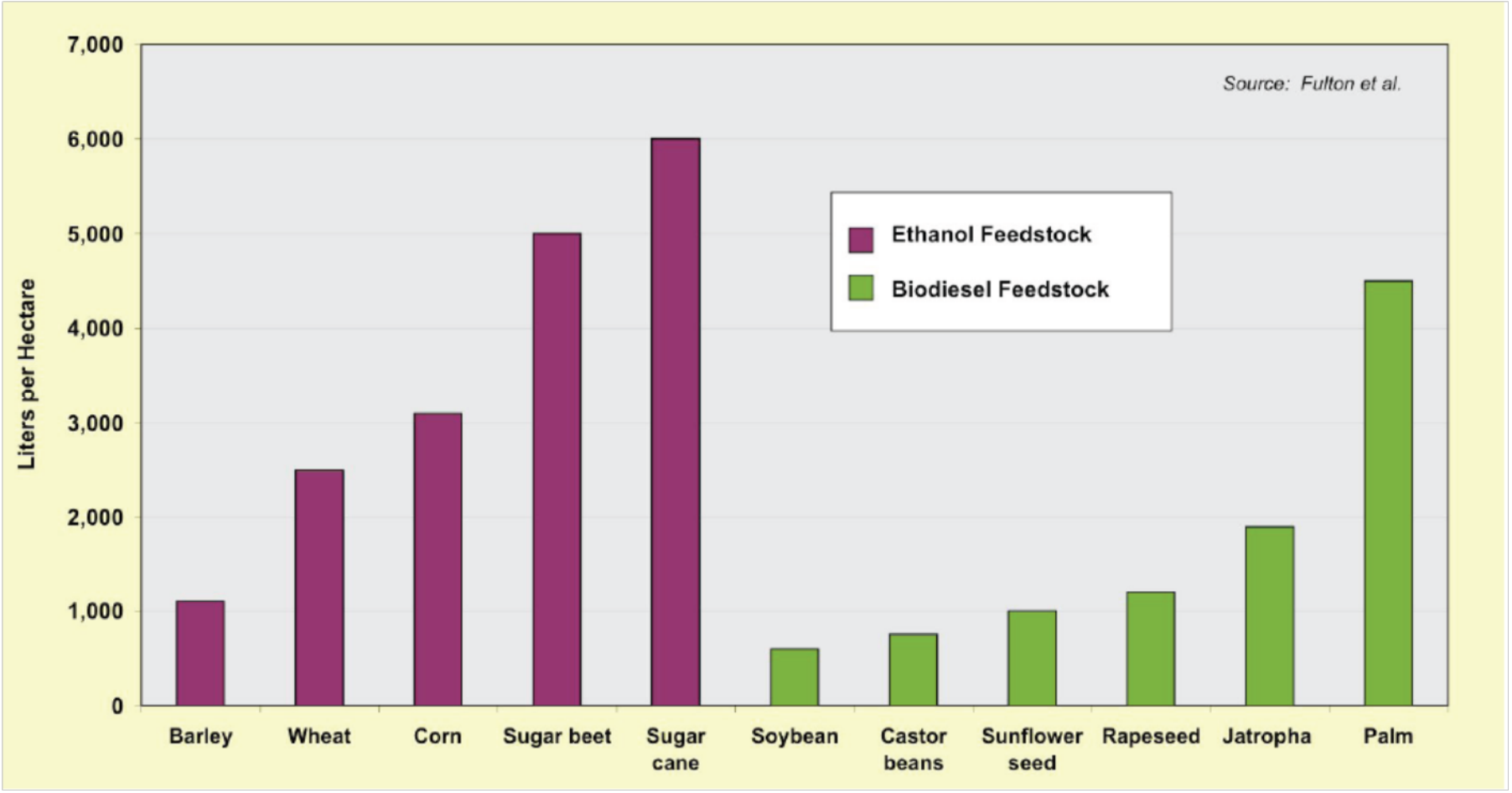
Liquid biofuels - some irksome questions - 1

- Our current wealth – 30 mHa of culturable waste land (MRD-NRSA 2010 report - http://www.indiawaterportal.org/taxonomy/3/Wasteland-Mapping)
- With tropical climate and varied water resources, can't we grow high yield returning plantations of oil producing trees on these lands?
- Is it not possible to produce as much as needed for food and the excess for fuel?
- Surely, these are not easy. Land is not fertile, there may not be enough ground water, etc, etc. And, it costs money. But…..is buying oil from overseas less expensive? – 140 billion USD/year at that. As of now most oil management in the country is a matter of largely trade, is it not?
- And, let us remember that any money that goes out of the country helps labor and economy elsewhere. If a significant part of the money gets circulated within the country, is it not correct to state that it helps locals more than the rich oil possessing country?
- Can we not tread carefully avoiding the currently used agricultural land and deploy only wasted lands?

Liquid biofuels - some irksome questions - 2

- Unless we move into large scale production no difference to the economy can be made. This to my mind, is the single largest economic issue (compared to any discussed in the last 5 years).
- Has nobody else done things like greening barren lands? The answer is Israel has done fabulous things – advanced agriculture in desert regions.
- Has anybody else benefited from bio-related liquid fuels (since usually following is easier than treading new paths – as they say!)?
- The answer is Yes. Brazil, Malaysia and Indonesia have done remarkable things.
- Should we be always concerned with poor yielding Jatropha circus (~ 1 t/ha/y) when it concerns bio-diesel?
- Should we not consider Oil palms of very high yield (4 to 6 t/ha/y)?
- Should we be afraid of food vs. oil debate since it is there anyway with ethanol vs. sugar and true of all biogenic output?

Liquid fuel output per ha for different species



Sugarcane as a replacement for ethanol
Palm oil as replacement for diesel
are the high productivity possibilities.

What has palm oil production done to Malaysia?

Selected slides from the presentation made by Malaysia to

USITC, 2010, www.americanpalmoil.com/pdf/USITCpre-PublicHearing-V2.pdf

Feedstock for biodiesel in Malaysia

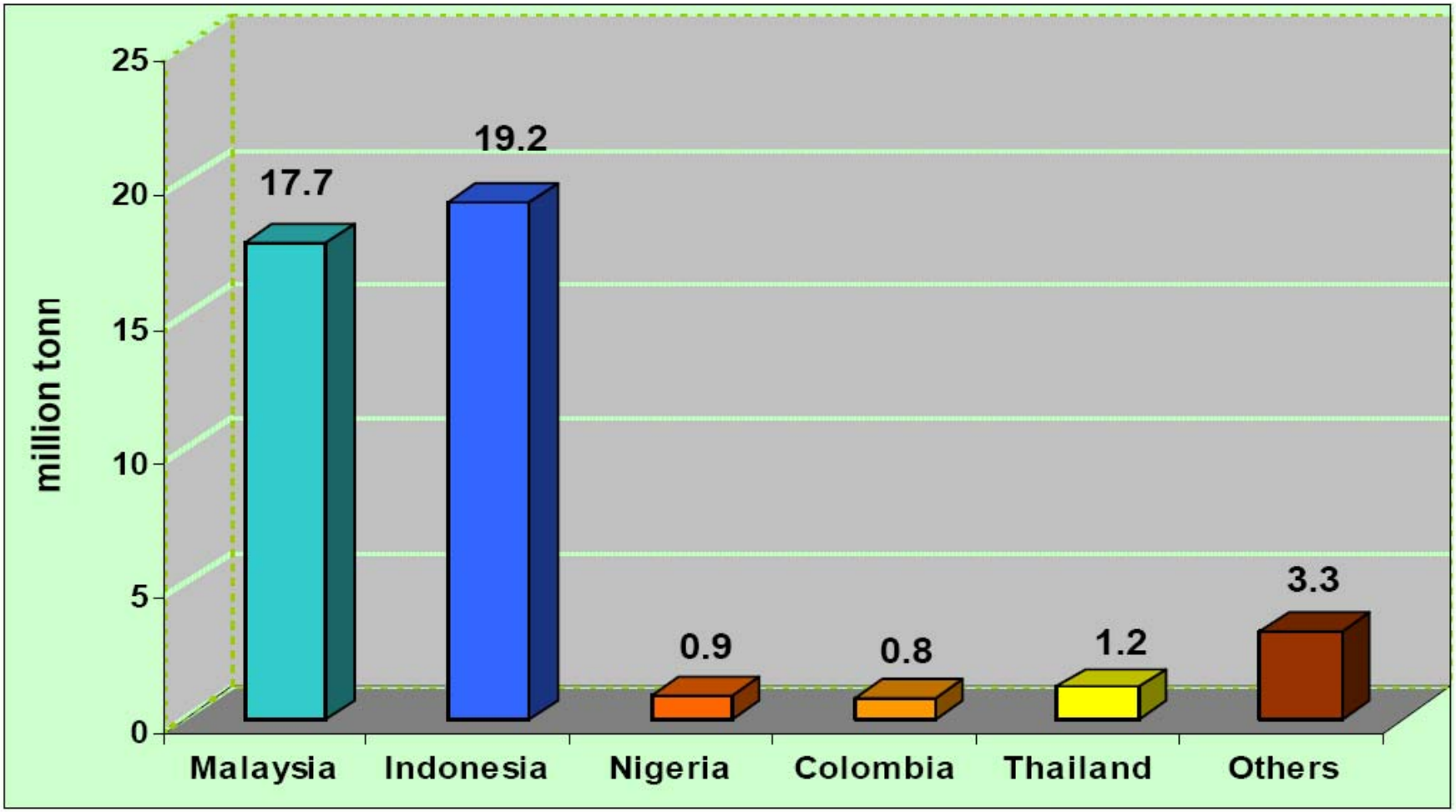
Fresh Fruit Bunch

Crude palm oil, RBD Palm oil, palm olein and palm stearin

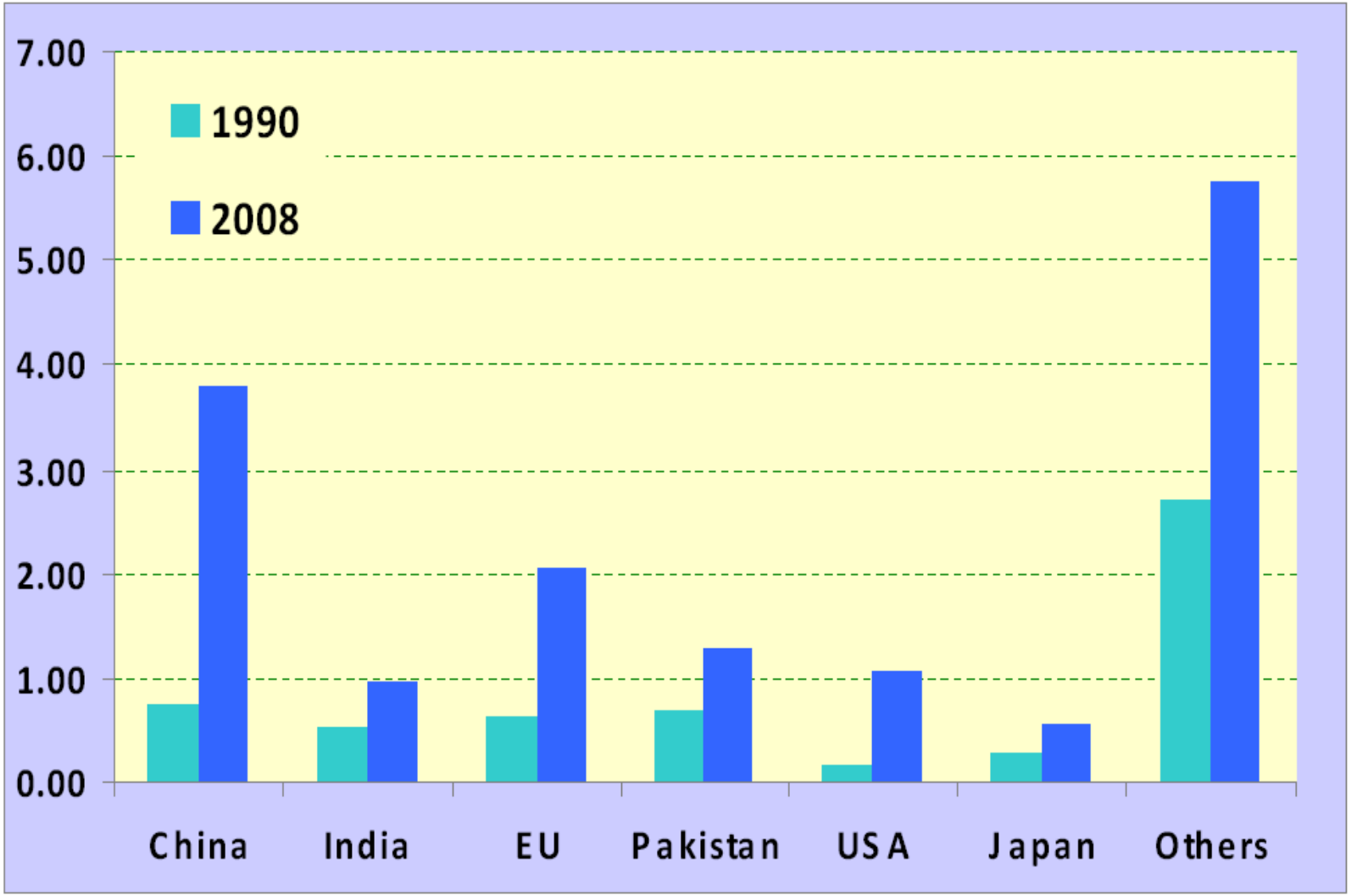
Used Frying Oil

Spent Bleaching Earth (SBE)

Comparison between Malaysia & Other Palm Oil Producers in 2008



Major Importers of Malaysian Palm Oil
(million tones)



Importance of oil palm to Malaysia

Year	Palm oil export value (RM/USD billion)	Export value of all commodities (RM/USD billion)	% of palm contribution in the overall export
1980	2.89 (0.80)	48.80 (13.56)	6.0 %
1990	5.50 (1.53)	20.70 (5.75)	26.6 %
2000	14.94 (4.20)	42.72 (11.87)	35.0 %
2007	45.61 (12.7)	89.60 (24.89)	50.9 %
2008	65.20 (18.1)	112.43 (31.23)	★ 57.6 %

1 USD ~ 3.6 RM

The oil palm industry : a major source of employment

Eradicated poverty and narrowed income gap between town and rural folk

Created rural townships where workers reside and enjoy good quality of life

Contributed to social security and peace

Reduced migration of labor force from rural areas to urban areas

Year	Area (ha)	People Employed (person)
1980	1,203,306	92,352
1990	2,029,464	115,285
2000	3,376,664	251,039
2007	4,304,913	420,000
2008	4,480,000	570,000

A total of 1.5 million in the sector; In Malaysia, the labor per hectare is 0.3; In India it is 2.5
Equivalent Indian job creation over 30 mha is 75 million

http://www.nationmaster.com/graph/agr_wor_per_hec-agriculture-workers-per-hectare

Strengths of Plantation

- At a time when the flow of people from the countryside into the cities is creating major problems in Third World, the Plantation Industry provides contra-cyclical jobs in the heart of the countryside;
  - ✓ not only jobs for agricultural workers but also for skilled mechanics, fitters, laboratory workers, factory operators, drivers, office staff, secretaries and Managers.

- **The oil palm plantation industry is one of the few examples of an agricultural development in the Third World which, without any Government subsidies, can successfully compete with the highly protected farmers in the G7 countries.**

Using new variety of palm oil - High Yielding Materials

	CPO Yield tonnes/hectare/year)
Biological Potential of Oil Palm	18
National Average for Malaysia	4
Best Managed Oil Palm Plantation	8
New Varieties of Oil Palm	10

Is it not sufficient indication for India to move from 0.8 tonnes/ha/yr of Jatropha Grown in small area (10,000 ha class) to high productivity oil palm in large areas Following the experience of Malaysia/Indonesia so that the most important element namely, land area is minimized to grow what is required?

To produce 100 mmt of diesel varieties we would need as of now, 25 mha and when R & D improves in India as well, it could reduce to 17 mha.

The Brazilian approach towards ethanol to replace gasoline and palm oil + soybean oil to replace diesel

Renewable oil Policy – The Brazilian Program

- Petrobraz, the government company was mandated to spearhead research, development and commercialize the production and distribution of renewable liquid fuels, ethyl alcohol and biodiesel.

- Alcohol program – ambitious program lauched by the Brazilan government in the seventies; Gained momentum in the eighties; Faced some problems in the nineties
- The new technology Flex Fuel and the oil prices opened a new perspective for Brazilian domestic market; 7 million cars in 2012

- Biodiesel Program lauched December 2004 aiming to add 2% of biodiesel to diesel oil
- Procedures to incentivise the production: Tax incentives and social labeling – Just companies that have this seal can participate in the supply, etc

Liquid bio-fuels – some answers

- The GoI should entrust IOCL and HPCL with the responsibility of increasing the fraction of bio-fuels to some meaningful value – say 20 % in five years. It is up to them to use the private industry, governmental machinery and R & D institutions to create wealth.

- As far as I know, only Brazil has thought wisely and entrusted Petrobraz to factor bio-oil production in the country. In India, these have not even debated these matters adequately.

- Leasing lands to a very large number of profit making private industries to grow multi-purpose plantations, of course largely oil producing, using all available knowledge in the space within or outside the country.

Liquid bio-fuels – some answers

- Employing local labor including farmers will enhance the local employment –with each hectare accounting for at least six unskilled and skilled jobs. They get paid on a monthly basis because they are employed.

- Due to this reason, farmer suicides cannot occur since they get monthly salaries! Industries (with this land) have invested from their profits in returns that may take time – six to seven years. Facilitating long return time industrial investment in should be facilitated with Governmental fiscal support on taxes, etc.

- No other Governmental money need to flow into this sector. A number of subsidiary issues like involvement of local Panchayats and the work force will throw up human related problems. But then every new issue throws up human problems. These are to be solved since everybody benefits – the people, the Government and the environment.

From oil for transport to rural cooking problems
(device and processed fuel availability)

Societies wish to survive need

- Water, food grains and cooking energy as the fundamental needs

Then, they need electricity next for enhancing productivity

Then they wish to have quality of life electricity.

Size of the problem

- Roughly a third of the World population today uses biomass for cooking that turns to be the more essential need than the quality-of-life enhancing electricity. This amounts to 550 million households across the World!

- In India alone, about hundred and twenty million households (120 mhh) depend on biomass or the variants (like cowdung) for cooking

- Many countries produce charcoal as a cottage industry to produce fuel for cooking. A large part of Indo-china culture believes in charcoal as the fuel for cooking and whole forests are brought down for this purpose -- Cambodia is a leading example that uses effectively 12 kg biomass to for cooking a meal with 2 kg charcoal when even 2 kg biomass will do!

- Yet, the energy plan of Google does not include biomass. A paper by Mark Jacobson (Stanford Uni.) and Mark Delucchi in Scientific American, India (Nov., 2009, p. 38) is suggestive of Hydro/Wind/Solar PV as the only alternatives for the future energy needs of the World. The only serious problems they see are material related!

Bioresidue for cooking

- There are a large number of stove designs in practice.
- Large international donor agencies are involved in funding these efforts.
- They assume (incorrectly) any improved stove must function with a variety of solid bio-fuels despite variation in (a) size, (b) shape and (c) density all of which have significant influence on the efficiency and emissions.
- In recent times, only moisture has been recognized as the enemy of good combustion.
- Good Science that has been applied to most other fields is largely missing here. It is enthusiasts' field!

Bioresidue for cooking

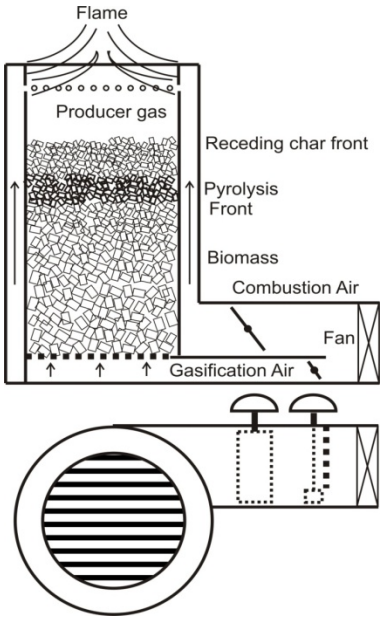
Three aspects that are to be considered are:

- Biomass stoves that show in the laboratory high efficiency (water boiling) and low emissions (called HELE designs) have been developed. It is shown and now better recognized that unless fan based designs are deployed, one cannot get HELE benefits. These devices can bring down the biomass for cooking to about 150 mmt from 450 mmt in India. This is substantive.

- Integrate with oil seed plantations, process the waste biomass not used for fodder and any other biomass, process them to sizes and shapes and create a supply chain for quality fuels.
- It is important to recognize solid bio-fuel also needs to be supplied as mainstream fuel like LPG and kerosene.

- Allow market forces to create competition for the supply of these stoves with governmental intervention limited to quality standards, monitoring by involving private partners, policy directives limited to helping below poverty line people with procedures that are subverted little.

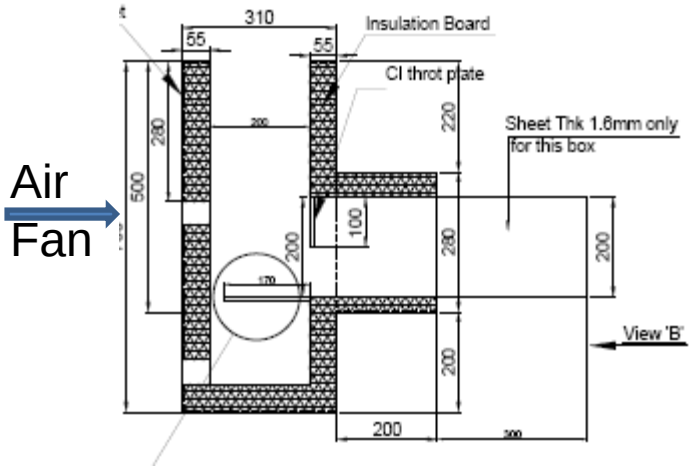
New methods for Domestic cooking/heating needs



Principles - first technique – fire and forget/control

1. Burn from top to bottom of a pile instead of bottom to top (practiced for several thousand years)
2. Recognize that this is a two stage combustion process in which sub-stoichiometric combustion occurs first and then combustion of the gases is completed at near-stoichiometric conditions. The first phase is also termed gasification. Such devices are called "Gasifier Stoves"
3. The power output is proportional to the air flow rate. Hence, controlling it helps vary the power.

Another approach - EIGAS



Principle – Ejector induced gasification based stoves – continuous fuel feed – **can deal with firewood**

An ejector induces an air that draws air through a fuel bed horizontally located.

The use of partial blockage helps the gasification process.

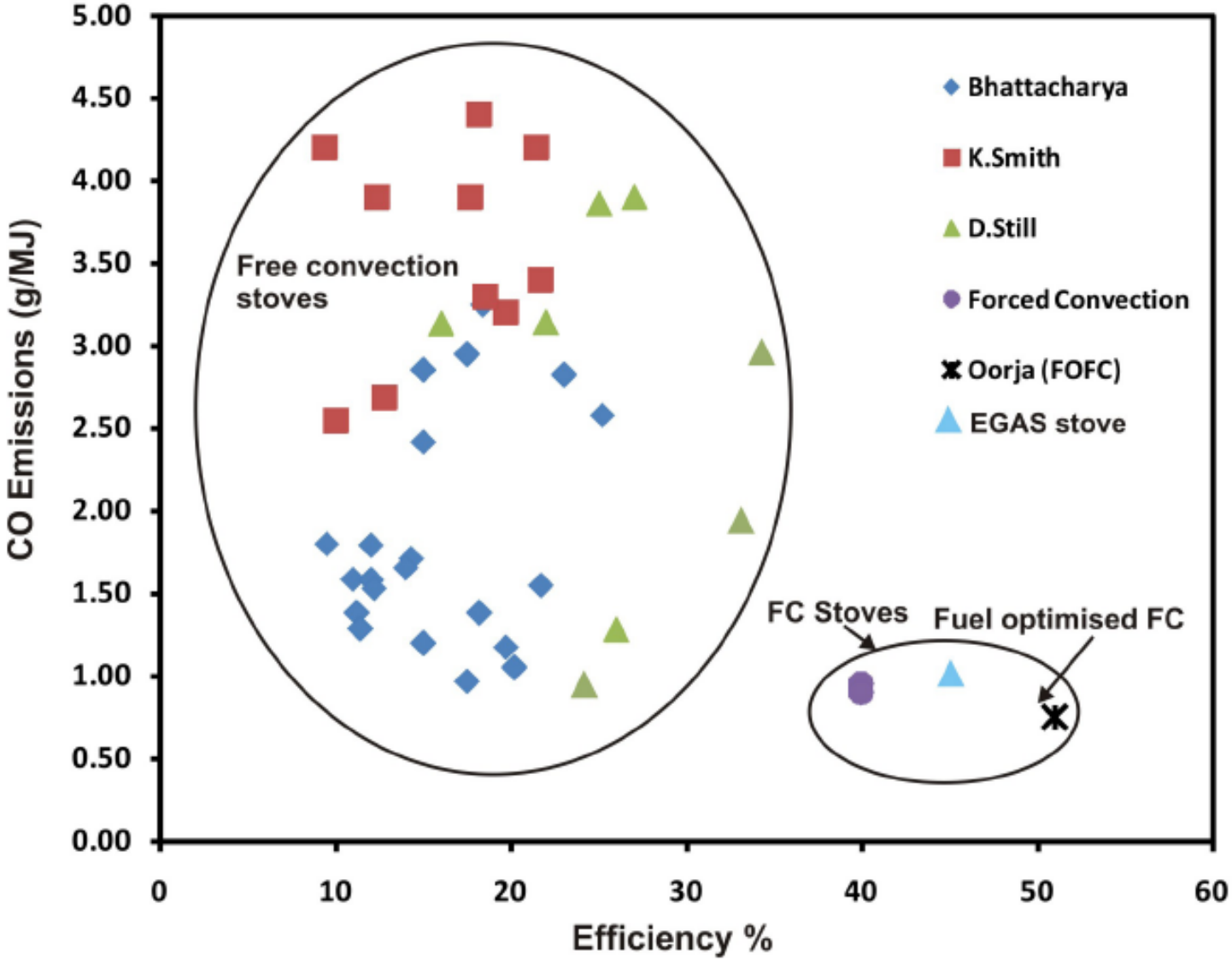
The char bed on the grate allows gasification process to be completed.

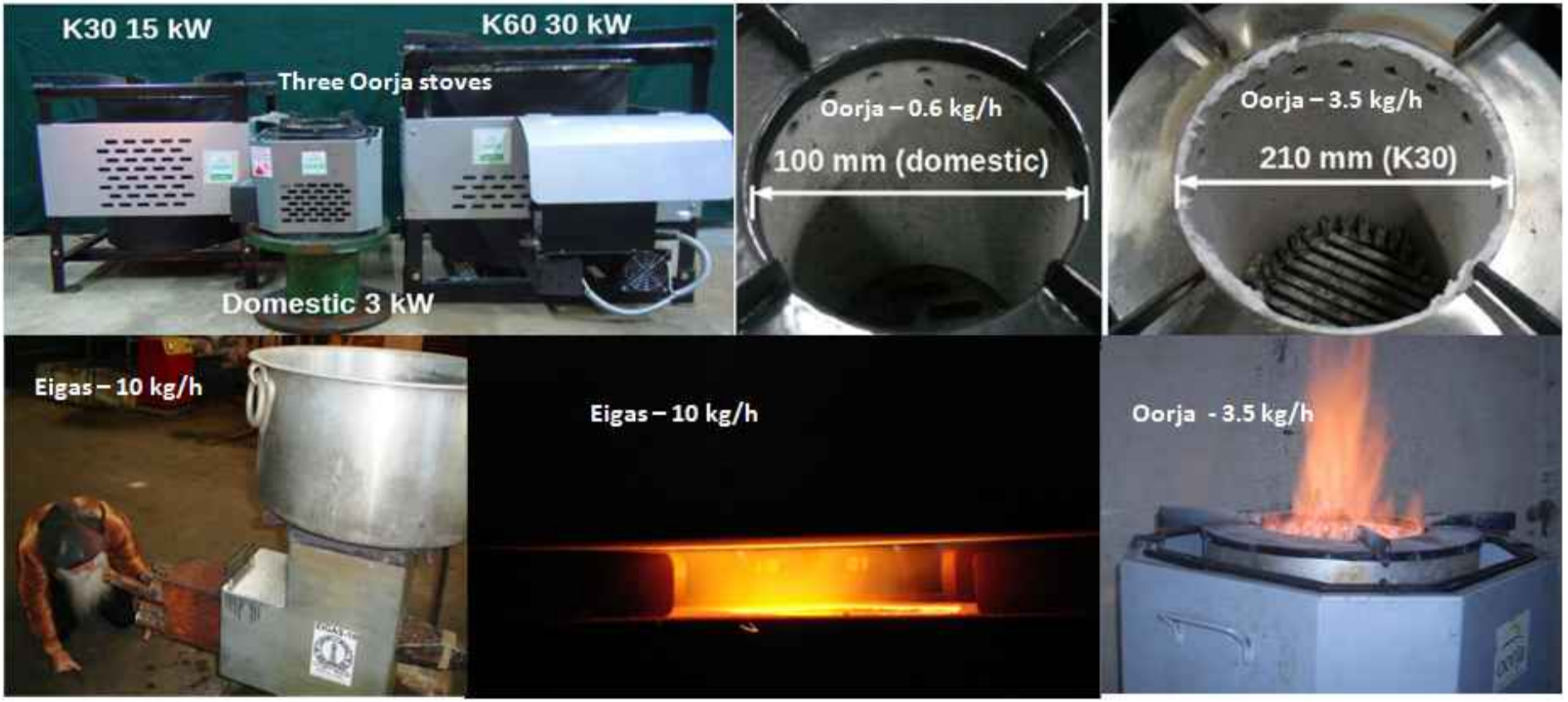
This has been industrialized at various capacities and will enter the market.

Currently, additional research on this class of configurations is underway at CDM, JU

Efficiency and emissions

Bhattacharya et al (2002) have tested efficiencies and emissions from 24 different wood and charcoal stoves of east Asian origin – all of them free convection based. Other data have been compared with new technology stoves based on controlled forced convecton.





Various industrialized modern fan based HELE biomass stove designs realized by industries and used in practice

Achieved: 2 x 0.6 kg = 1.2 kg pellet fuel using agro-residues or fuel wood for cooking

Efficiency = 55 % (water boiling efficiency) = 80 % more than three-stone fire stove

Emissions – see next…

Comparison of stoves for bringing to boil 5 liters of water

Stove	Fuel g	CO g	PM g	CO g/MJ	PM g/MJ
Three stone Fire	**1118**	56	2363	3.13	42.27
Ghana Wood	**996**	50	4287	3.14	68.32
20L Can Rocket	**733**	15	1289	1.28	15.12
Wood Flame Fan	**626**	**9**	48	**0.90**	**0.48**
Wood Gas Fan	**459**	**7**	**27**	**0.95**	**0.20**
Mali Charcoal	**674**	113	260	10.48	2.80
Gyapa Charcoal	**694**	135	587	12.16	6.52
Indian VITA Test 1	**1135**	38	1490	2.09	27.06
T-LUD	**933**	25	694	1.67	10.36
Institutional 310 Rocket	**483**	6	414	0.78	3.20
Lutfiyah's Improved Stove	**823**	16	1231	1.22	16.21
T-LUD	**1296**	18	437	0.87	9.06
BP Stove (IISc)	**380**	**4.5**	**6**	**0.75**	**0.06**
EIGAS – 1 (IISc)	**400**	**7.2**	**9.6**	**1.12**	**0.1**

What about solid fuel availability?

- When oil seeds/fruits including oil palm are processed, it is only about 30 % that leads to oil. The rest will be solid waste. Part of this may go as fodder and the rest for energy purposes. Every such plantation also produces other solid wastes to the extent of up to 4 sun-dry t/h/y.
- The net effect is that about 2000 mta of solid waste (including classified USW) is available for energy conversion purposes in India.
- These wastes (and classified urban wastes) can be and should be converted into solid fuels – in the form sized material and pellets and briquettes with controlled quality - size, shape, density and ash content declared - for use in domestic stoves and industrial operations for heat and electricity generation.
- Unless fuel is costed, it will be wasted most usually – or used rather inefficiently without real concern for wastage.
- This may pose problem for finders-keepers idea of a rural situation. But then quality cannot be expected unless society pays for it.

Renewable electricity - The options and features

- Wind - much enthusiasm all over the World, including India – an intermittent source - valid at reasonable and large power levels - useful for grid linking – PLF ~ 25 % (15000 MWe in India, 2011)
- Solar – again, far more enthusiasm all over the World, including India – an intermittent source – can be generated PLF ~ 25 % (40 MWe in India)
- If these become smaller fraction of conventional power, grid linking helps usage very well. If stand-alone wind and or solar has to be the main supply, one needs to find ways of storage – usually battery or fuel cell. This is expensive and other methods are far more inefficient.
- Hydro power – large and small have a plant load factor of 70 to 75 %. It is also possible that major failure of rains causes serious loss of hydro power – Several countries have experienced it – Brazil, some states in India. (small hydro ~ 3300 MWe in India)
- Biomass and waste to energy are base load power sources as long as the use is limited to or less than production. These can form 24 x 7 option much like coal. Realization of this feature is still to sink into the total systems' thinking (3000 MWe in India).

Biomass electricity

- If domestic applications are to be serviced for quality-of-life electricity at 50 to 200 W capacity, SPV is the only option at this time.
- If a village has to be serviced with electricity for Q-o-L demand as well small industry requirement, biomass option at 10 to 100 kWe is the most appropriate economic option.
- Biomass has a lower density and its growth is widely distributed.
- For economic transportation, It is better to use the biomass in power plants of a maximum of 2 MWe class (that requires 15000 tonnes per year) rather than 20 MWe (0.15 million tonnes per year). The latter is economically and environmentally unsustainable in India and countries with small land holdings.
- Economically operating power plants at power levels of 25 kWe are possible.
- More on these will be covered by Prof. S. Dasappa.

Finally, the non-elitist solution

- Current thinking in India nearly ignores the possibility of obtaining replacement for liquid fuels from biomass even when there is no other alternative.
- When there is alternative for cooking energy, all support and development takes no serious note of holistic designs virtually ignoring science of the subject.
- When there is alternative for electricity, subsidy system is introduced that strongly favors Solar photovoltaics making biomass waste resource compete with it.
- It is desirable to take note of international thinking but not at the expense of native situation created over the last several hundred years as these cannot be changed very fast.
- Hence the recommendation is to change the thinking of hierarchical importance to biomass for liquid fuels, biomass-hydro for base load management and wind-SPV as intermittent power generators feeding into grid appears to be a conceptually meaningful solution for meeting energy needs of the future.
- **In this thinking biofuels becomes the central focus.**

.....Thank you