Biomass energy – Troubling questions and beyond-naïve thoughts

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What is discussed?

- Important national energy demands and issues
- Biomass based steam power
- Cooking solutions - biomass fuels based
- Small electricity (1, 10 kWe to 1 MWe)
- Liquid fuels from biomass
- Important conclusions

Important national energy demands and issues

- Issues of steam power generation from solid bio-fuels – moisture, Na, K linked problems, size and emissions
- Affordable quality solid fuels (sundry and suitably shaped and sized) to meet cooking needs – despite significant need, matter has not been addressed adequately.
- Refined plant oils to replace diesel – the most economic imperative. Can be integrated with other energy demands
- Producing quality fuels from urban solid waste – reducing waste magnitude in cities and simultaneously

Biomass based steam power - 1

- There are a large number of biomass based steam power plants in the country at power levels of 4 to 12 MWe (some may be of even larger capacity).
- Those based on captive fuel – largely like rice husk have been working well largely due to fuel homogeneity and continuous – or near continuous availability.
- Those that depend on large range of agro residues and bio-industrial wastes have serious problems.
- These arise from (a) availability that reduces or procurement cost keeps rising with time, (b) moisture related issues and (c) sodium/potassium related deposits in the super heater sections of high pressure boilers (60 ata).
- A visit to one of these typical plants in Tamilnadu has revealed lack of understanding of some basic issues – this permeates the boiler consultant group as well

Design:10 MWe, 14 t/h sun-dry biomass, largely,
65 ata boiler. Triveni steam turbine

On an annual basis, they roughly use

1. Coconut frond (20,000 t at 65 % moisture)
2. Topioca (10,000 t at 20 % moisture)
3. Mango stones (10,000 tonnes at 40 % moisture)
4. Plywood waste, cashew wood (40,000 t at 50 % m)
5. Bagasse (10,000 t at 45 % moisture)
6. Juliflora prosopis (10,000 t at 30 % moisture)
7. Other biomass ~ 11,000 t at 30 % moisture)
8. Usage~100,000 t/y of 60 % moisture over 3 years
9. 70000 t (> 500 kg/m^3) and 12000 t (< 400 kg/m^3)
9. Procurement radius ~ 10 to 250 km,
10. Cost ~ 1000 – 2500 Rs/t

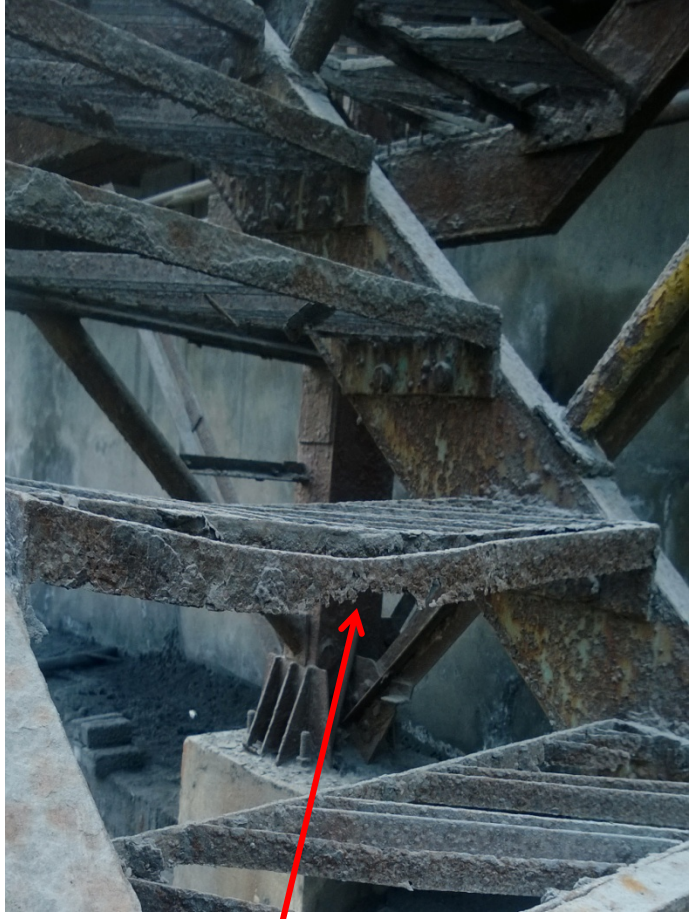
All solid waste use drum chipper and wood chippers using 10 % generated power (~ 1 MWe)

PLANT PERFORMANCE DATA			
Description	2010-11	2011-12	2012-13
Power generation in MU	41.48	44.58	59.50
Plant Load Factor	47.35	50.89	67.93
Steam generation in Tons	185547	204956	273372
Fuel Consumption in Tons	77230	97161	119781
Average fuel GCV Kcal/kg	2300	2170	2317
Enthalpy of steam in K.Cal - h1	810	810	810
Enthalpy of feed water in K Cal - h2	155	155	155
Boiler Efficiency in %	62.42	63.67	69.11
Sp. Steam Consumption - Kgs / Kwh	4.47	4.60	4.59
Specific fuel consumption Kgs/Kwh	2.15	2.18	2.01
Steam generation/Ton of fuel	2.09	2.11	2.40
Auxiliary Consumption %	12.45	11.72	10.77
Turbine heat rate Kcal/Kwh	2930	3011	3009
Station heat rate Kcal/Kwh	4282	4729	4060

Best specific biomass consumption - 1.4 kg/kWh; Now – 2 kg/kWh at 50 % mean moisture and chipper power consumption of 1 Mwe; Generated power ~ 6 - 7 MWe instead of 10 MWe.

There is no dryer. It is unclear to the management if drying outside is better than drying inside the boiler.

It is assumed that chipping is the most appropriate way to homogenize the biomass shape and size.



Significant chemical corrosion due to Na, K and Cl. Use of coconut fronds that collects a fair amount of NaCl that Is usually administered as a nutrient is considered responsible

What is the solution?

- Change the philosophy from reducing the fuels to small size to retaining the larger size of fuels as it were and increasing the size of fine fuels through baling/briquetting. This is because most fuels obtained (80 %) belong to large size category.
- This implies that the net energy used in the conversion process is smaller. Reduction of internal use of energy implies adding more to the grid.
- With regard to coconut fronds and others with Na & K problems, the chipped material is to be soaked in water so that leaching of the potassium and sodium salts occurs and then squeezed and dried. That coconut fronds occupy only 20 % mix on the average implies energy use in this can be lived with.
- Drying the fuels outside the combustion system is to be understood as more efficient. Heat for drying is to be derived from exhaust gases.
- This material mix should used in a conceptually new combustion system to enable conversion with little emissions.

Drying outside vs. Drying inside

Hot gases at 1500 K

Biomass with 10 % moisture

0.9 kg dry biomass + 0.1 kg moisture

Heat from 0.9 kg biomass (16.2 MJ) releases 0.1 kg water into steam (0.22 MJ) and then raises it to flame temperature that requires a heat of 0.2 MJ of heat. The net heat derived is about 15.7 MJ - 1.1 MJ required anyway leading to 14.6 MJ

Hot gases at 1000 K

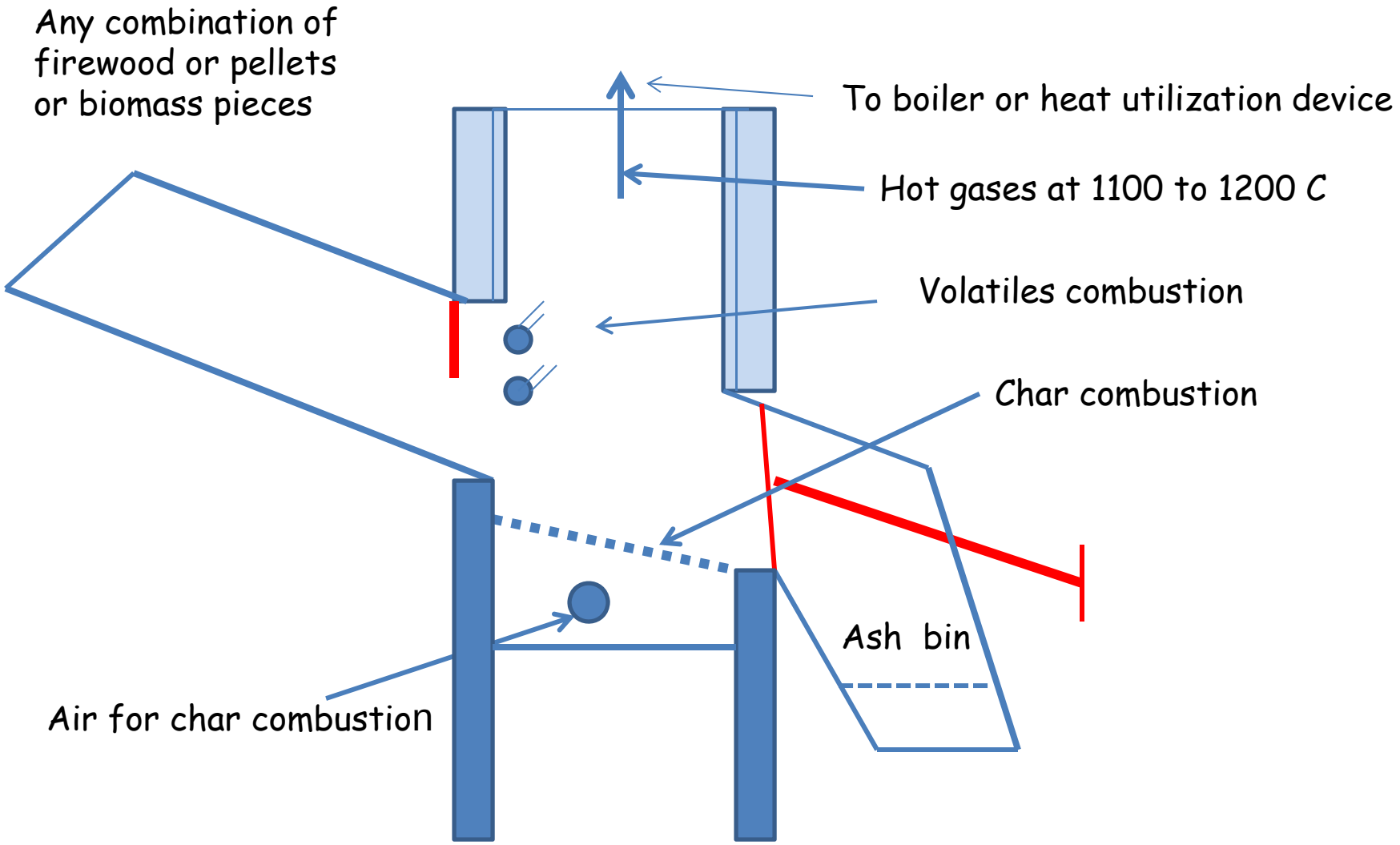
Biomass with 50 % moisture

0.5 kg dry biomass +0.5 kg moisture

Heat from 0.5 kg biomass (9 MJ) releases 0.5 kg water into steam (1.1 MJ) and then raises it to flame temperature that requires a heat of 1.1 MJ of heat. The net heat derived is about 6.8 MJ

Benefits are very obvious!

The new combustion device – 1 to 10,000 kg/h tested between 1 – 100 kg/h presently

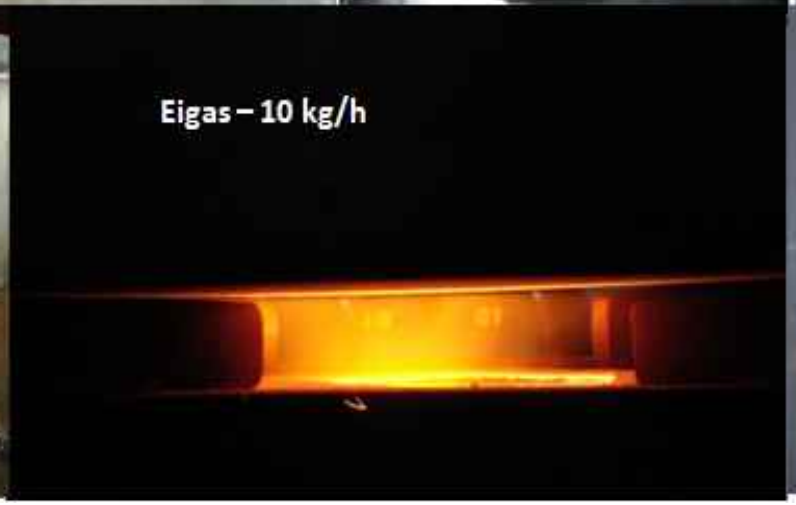


Ideas need to be implemented yet since overcoming tradition controlled by consultants happens to be very tough

……..Let us move on

The issues – cooking fuels

- India has about 120 to 140 million households amongst 240 households depending on biomass for cooking. This is inefficient and beset with emission problems.
- Interesting aspect is that efficiency and emissions from biomass stoves are inversely linked. Both nationally and internally there is growing awareness of the need to enhance the efficiency and reduce the emissions (CO, particulates and PAH).
- Modern fan based stove designs that overcome these problems have entered the market. Finding well prepared solid fuels is the core issue.
- Scaling strategies for these solutions to national level is the other issue.



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 – one for gasification and one for controlled combustion.

The combustion process in a 0.6 and 6 kg/h systems is the same

Biomass for distributed electricity generation

- India (MNRE) has invested substantive finances into research, technology development; also for promotion largely by capital subsidy over the last two and a half decades.
- Consequently, tested technologies have been commercially marketed over the last decade both within India and overseas.
- Power generation systems of 25, 100, 250, 1000 kWe (using multiple 250 kWe engines) have functioned for long durations on 24 x 7 basis. One system of 100 kWe in a project of the Karnataka Government operated for 1000 continuous hours.
- This technology accepts multiple fuels from chipped wood to solid agro-residues like coconut shells and corncobs, What is fed into the reactor is sun-dry (drier is a part of the technology).
- GE, India has a technology transfer from IISc apart from other smaller players.

1KgPH DINJAM PLANT

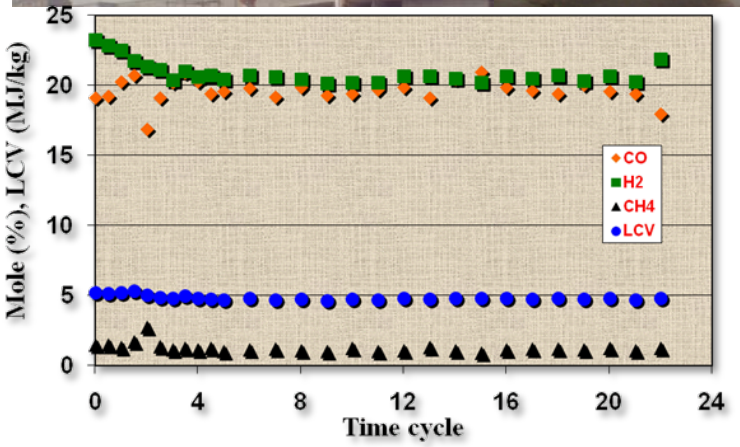
System cost~
150000 Rs/kWe

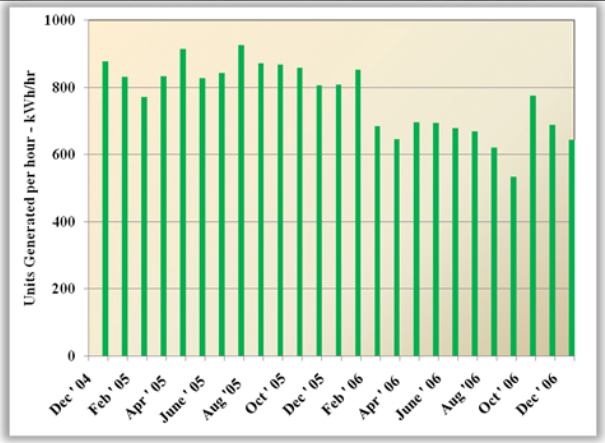
Investment ~ 65 million Rs/MWe

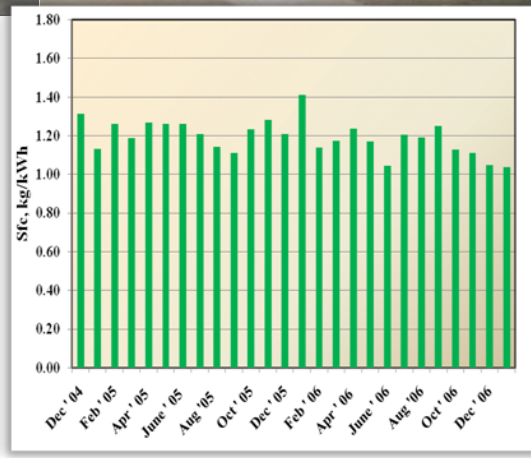
Fuel cost : 3.5 to 4.0 Rs/kWh,
O & M ~ 1.5 Rs/kWh
Financial cost ~ 0.5 Rs/kWh

Cost of energy ~ 5.50 to 6.00 Rs/kWh

BMC GASIFIER PLANT(1700Kgph)







H_2 & CO : 19 ± 1%; CH_4 : 1.5%; LCV 4.8 MJ/kg.
Cold gas efficiency : 83 - 85%

Monthly average power output over 2 yrs.

Monthly average sfc

Large amount of experimental data on actual performance of gasifier based thermal and electricity generation systems at the laboratory and field systems are posted at the website http://cgpl.iisc.ernet.in

These include small and large systems operating on coconut shells (nearly impossible for technologies other than IISc technology to work), Prosopis Juliflora, waste wood from forests, etc

Liquid biofuels - some irksome questions (1).

- GoI recently made an announcement "***India's oil import bill*** *leaped 40 per cent to a record $140 billion in 2011-12 as high oil prices shaved off much of the nation's GDP growth rate*". **That it was just 20 billion USD ten years ago 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
- 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?
- Surely, it is 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.

Liquid biofuels - some irksome questions (2).

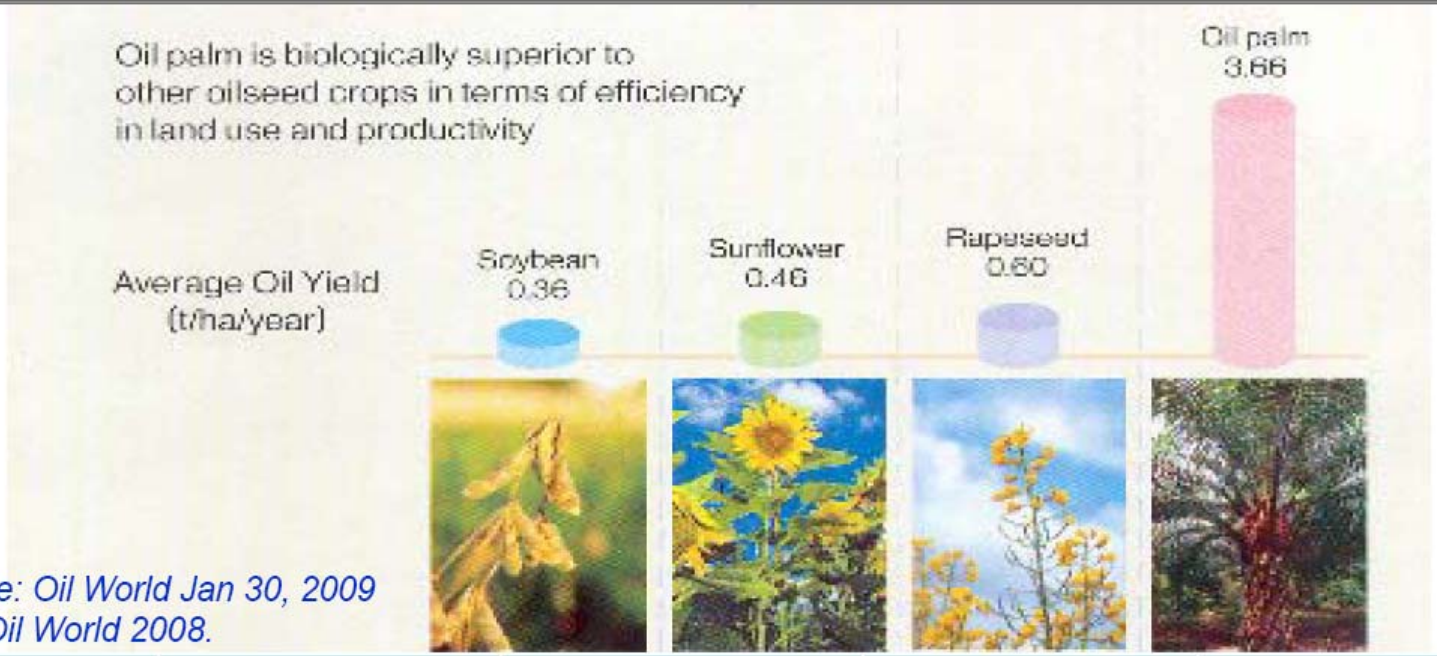
- Unless we must move into large scale production no difference to the economy can be made. This to my mind, is the single largest economic issue (compared to any discussed in the last 5 years).
- Has nobody else done things like greening barren lands? The answer is Israel has done fabulous things – 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)? 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? Why should only Government get involved in these. Can it not energize private partnership?

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

Oil Palm – the most productive oil crop



Source: Oil World Jan 30, 2009 and Oil World 2008.

Oil Crop	Production (million t)	% of total production	Total area (million ha)	% of total Area
Oil palm	**42.99**	**33.58**	**10.50**	**4.74**
Soya bean	**36.87**	**28.80**	**94.25**	**42.50**
Rapeseed	**19.82**	**15.48**	**27.15**	**12.25**
Sunflower	**10.80**	**8.52**	**24.09**	**10.87**

Major Vegetable oil production: 128 Mn T

Feedstock for biodiesel in Malaysia

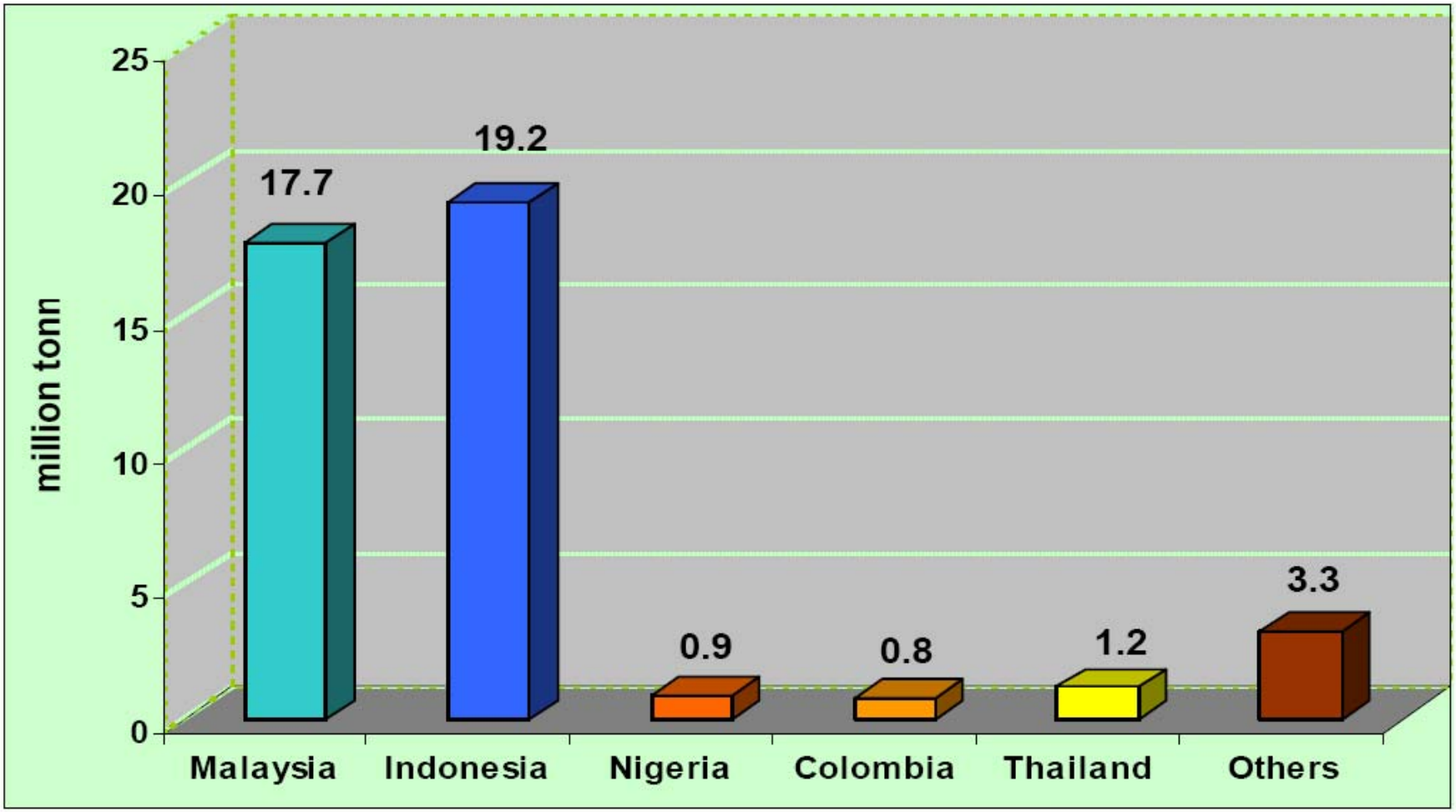
Fresh Fruit Bunch

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



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.**

Liquid bio-fuels – some answers (1)

- The GoI should entrust IOCL and HPCL with the responsibility of increasing the fraction of bio-fuels to some meaningful value – say 40 % in five years. It is up to them to use the Govnmental machinery, R & D institutions and private industry to create wealth. As far as I know, only Brazil has thought wisely and entrusted Petrobraz to factor bio-oil production in the country. We 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.
- 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.

Liquid bio-fuels – some answers (2)

- 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 not difficult to solve either since everybody benefits – the people, the Government and the environment.
- Brazil, Malaysia and Indonesia have benefited enormously from growing and producing bio-oils (Oil palms) and we should also benefit from it.

Liquid bio-fuels – some answers (2)

The multiple benefits are:

(1) What goes out of the country will get integrated into Indian economy – the sector that has been not given as much primacy,
(2) Liquid fuel availability will be less affected by changes in OPEC
(3) Prepared solid fuels (nearly 80%) will be available for other energy uses – cooking and small scale electricity,
(4) Land becomes green
(5) Rural people will become fuel producers apart from food
(6) Treated as an industry, farmers may become agricultural employees with regular income. Farmer suicides will be alleviated.
(7) Environmental issues will have been tackled. India need be less concerned about Climate change issues on an international front.

And finally (1),

- Recognize that any oil produced constitutes 20 to 25 % of the biomass that the plant produces. Rest of the biomass is solid.
- Create a strategy to produce solid wastes into shaped, sized dry mass in the form of pellets, briquettes or sized firewood with identification of meaningful combustion properties – density and ash content and make them available in the market.
- This should be kick-started by Government. Private industry will then take over. Competition will bring down the cost of solid fuels.
- Making "good" solid fuel available allows private stove manufacturers to make a difference to the cooking solutions that are kitchen and environment friendly.
- Recognize that biomass is responsible for food, fuel, fiber and chemicals unlike other renewables and do not ignore it. Face debates squarely depending on rational data and not simply fears.

And finally (2),

- Change fiscal incentives from upfront to performance based. Involve banks or other financial institutions as needed.
- Reduce the finance outgo from 120 to 140 billion USD to 20 billion USD in ten years… a good enough publically acceptable mandate!!.
- We must remember the poor also benefit. The advanced stoves and good solid fuel will make their cooking environment very friendly.
- Small bio-power can also give them electricity that they can turn on and off as they want.

…..Thank you