COMPETE PROJECT KICK OFF MEETING

1st and 2nd March 2007

"Status of Zambia's Biofuel Programme and Elements of Biofuels Strategy "

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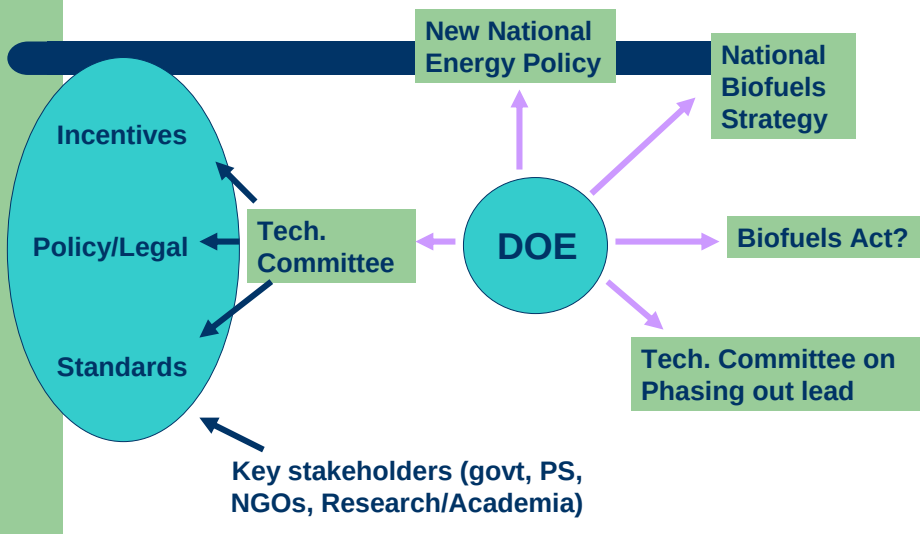
Zambia

Outline of Presentation

- Status of biofuels development
- Policy Issues/Biofuels Strategy
  - Blending Ratios
  - Technical Specification Standards
  - Production/ Distribution Networks
  - Technical, Social and Environmental Considerations
  - Incentives
- Institutional and Regulatory Arrangements
- Conclusions

STATUS OF THE BIOFUELS PROGRAMME



Policy Issues

- The Government of the Republic of Zambia through the Ministry of Energy and Water Development is in the process of finalizing an Energy Policy including sub policies on biofuels development.
- Currently the following are the policy measures for biofuels:
- Ensure security of supply and stabilization of prices of fuels by promoting the utilization of bio-fuels for transport as an alternative to petroleum by:
  - Encouraging the growing of energy crops
  - encouraging investment in biofuels through appropriate incentives.
  - promote the participation of at least 25% Zambians in the Biofuel industry are shareholders
  - ensuring that at least 60% of biofuels produced is used in Zambia

Policy Issues

- To ensure availability of data and information on market demand, resource assessment and applicability of biofuels by:
- undertaking studies on the economic feasibility of using biofuels for transport (e.g., ethanol and bio-diesel)
- undertaking studies on needs/demand, resource and technology assessments of biofuels
- building capacity to monitor and regulate biofuels exploitation and development;

Blending Ratios

- Selection of blending ratios will be influenced by various factors:
  - technical considerations
  - feed stock availability at reasonable cost, and
  - market considerations.

Blending Ratios

Ethanol

A blending ratio of E10 is being recommended based on the following reasons

- Availability of reasonable quantities of molasses feedstocks both from Nakambala and Kafue Sugar estimated at 70,000 tonnes per annum. Such a volume once fermented and distilled will produce 16 million litres of ethanol per annum
- However, to meet current and projected E10 demand, requires 18 million litres of E10. To off set this deficit requires complementary feedstocks from growing of sweet sorghum. All together 30,000 tonnes of sweet sorghum feedstock are required to be grown on a land requirement of 1000 hectare.
- An E10 ratio if blended at INDENI can serve as an octane enhancer to replace lead, and manganese based additives.

Blending Ratios

Biodiesel

The factors influencing blending ratios are; Application of biodiesel either in furnaces and boilers, on one hand, or diesel engines and manufacturing warrants considerations on the other.

Based on these considerations the following blending ratios are recommended:

- B5 for those vehicles with diesel engines under manufacturer's warranty considerations
- B20 for those vehicles without warranty considerations
- B100 for use in boiler and furnaces, and other robust engines such as tractors and stationary engines to include hammer mills diesel electric plants etc.

Technical Specs/ Standards

Several countries have developed standards and technical specifications for ethanol and these include Brazil, Colombia, India and USA. Zambia can select from these standards for their standards.

Technical Specs/ Standards

Fuel ethanol Standards for Brazil

	Characteristics	AEAC(Anhydrous)	AEHC(Hydrous)
1	Appearance	Clear and free of suspension matter	
2	Total acids, as acetic acid (30p.p.m) (30p.p.m)	30 max 30 max	
3	Electricity conductivity	500 max	500 max
4	Chlorides, as Cl. (1 p.p.m)	-	1 max
5	Sulphate, as SO4 (4 p.p.m)	-	4 max
6	Specific gravity at 20° C, (at point of production)	791.5 max	809.3±1.7
7	Specific gravity at 20 ºC, denatured with 3% v/v gasoline	(a point of sale)	808.0±3.0
8	Material non-volatile at 105ºC, (at point of production)	30 max (30 p.p.m)	30 max (30 p.p.m)

Technical Specs/ Standards

9	Copper, as Cu, (0.07 p.p.m)	0.07 max	
10	Iron, as Fe. (5 p.p.m)	-	5max
11	Sodium, as Na. (2 p.p.m)	-	2max
12	Acidity/Alkalinity	-	7.0±1.0
13	Residue on evaporation, (at point of sale)	-	50 max (50 p.p.m)
14	Ethanol content, (at point of production)	99.3 min	93.2 ±0.6
15	Ethanol content, when denatured with 3% v/v gasoline(at point of sale)	-	92.6 to 94.7
16	Gasoline content, (at point of sale) (3.0% v/v)	-	30 max

Technical Specs/ Standards

Table 3: Fuel ethanol Standards for Colombia

Sr. No	Characteristics	Units	Specifications
1	Color	-	Colorless
2.	Appearance		See Note 1
3	Total acids as acetic acids	Mg/100mL	3.0
4	Electricity conductivity	S/m	500
5	Density at 20 ^{o}C	Kg/m^{3}	791.5
6	Ethanol concentration, min	%v/v	99.5
7	Ethanol concentration, min	^{o}INPM	99.5
8	Chloride content, max	mg/kg	0.03
9	Non volatile material, max	mg/kg	0.010
10	Copper content, max	mg/kg	0.070
11	Alkalinity	-	Negative
12	Water content, max	%w/w	Negative
13	Residual solids, max	mg/100mL	5.0

Technical Specs/ Standards

Table 4: Fuel ethanol Standards for India

SPECIFICATION	IS 321-1964 (GRADE-2)
Ethanol% v/v	99.5
Appearance	Free from suspended or precipitated contaminants (clear and bright)
Water content, % v/v	Less than 0.2%
Boiling point deg C	78 ± 0.7
Existing gum max. mg/100ml	5
Chloride ion content max	40 ppm
Copper content max. mg/kg	0.1
Acetic (as acetic acid) max. mg/litre	0.007

Technical Specs/ Standards

Table 5: Fuel ethanol Standards for USA

No	Characteristics	
1	Ethanol volume %, min	92.1
2	Methanol, volume%, max	0.5
3	Solvent washed gum, mg/100mL, max	5.0
4	Water content, volume %, max	1(note1)
5	Denaturant content, volume %, min	1.96
6	Volume %, max	4.76
7	Inorganic chloride content, mass ppm (mg/L), max	40 (32)
8	Copper content, mg/kg, max	0.1
9	Acidity (as acetic acid CH3COOH), mass % (mg/L), max	0.007(56) (note 3)
10	pH	6.5 to 9.0
11	Appearance: Visibly free of suspended or precipitated contaminants	Clear and bright

Technical Specs/ Standards

INDENI Petroleum Refinery Company

INDENI REFINERY STANDARDS				LOCAL FACILITY
ANALYSIS	TEST METHOD(S)	LIMITS		TEST RESULTS
		MIN	MAX	
Specific gravity @15/4°C	ASTM D 1298	0.82	0.87	0.8808
Appearance	Visual	Clear	Clear	Clear
Flashpoint PM, close cup °C	ASTM D 93	60.00		>150
ASTM color	ASTM D 1500		3.5	0.8
Cloud point °C	ASTM D 2500		4.5	…
Cetane index calculated	ASTM D 976	50.00		46.97
Kinematic Viscosity @ 40 °C	ASTM D 445	2.00	5.50	5.47
Total sulphur %m/m	ASTM D 2622/D129		0.75	0.029
Copper corrosive number, 3hrs @ 100 °C	ASTM D 130		1	….
Conradson Carbon Res 10% bottom, %m/m	ASTM D 524		0.15	….
Ash, %m/m	ASTM D 482		0.01	….
Water, %Vol	ASTM D 95		0.05	….
Sediments, %Vol	ASTM D 1796		0.01	….

Technical Specs/ Standards

Total Acidity, %Vol	ASTM D 664		1.00	…
ASTM DISTILLATION	ASTM D 86			
I.B.P °C	"			92
5 % Vol Evaporated @ °C	"			182
10 % Vol Evaporated @ °C	"			305
20 % Vol "	"			319
30% Vol "	"			323
40 % Vol "	"			323
50 % Vol "	"			324
60 % Vol "	"			324
70 % Vol "	"			324
80 % Vol "	"			340
90 % Vol "	"			340
95 % Vol "	"			340
E. B.P °C	"			…
% Vol Evaporated @ 240°C ml	"			…
% Vol Evaporated @ 310°C ml	"			…
% Vol Evaporated @ 310°C ml	"			…

Technical Specs/ Standards

- **Table 7: Biodiesel, B100, Specification**

Biodiesel, B100, Specification

Property	ASTM Method	Limits	Units
Flash Point	D93	130 min.	Degrees C
Water & Sediment	D2709	0.050 max.	% vol.
Kinematic Viscosity, 40 C	D445	1.9 - 6.0	$mm^2/sec.$
Sulfated Ash	D874	0.020 max.	% mass
Sulfur	D5453	0.05 max.	% mass
Copper Strip Corrosion	D130	No. 3 max.	
Cetane	D613	47 min.	
Cloud Point	D2500	Report	Degrees C
Carbon Residue 100% sample	D4530**	0.050 max.	% mass
Acid Number	D664	0.80 max.	mg KOH/gm
Free Glycerin	D6584	0.020 max.	% mass
Total Glycerin	D6584	0.240 max.	% mass
Phosphorus Content	D 4951	0.001 max.	% mass
Distillation Temp, Atmospheric Equivalent Temperature, 90% Recovered	D 1160	360 max.	Degrees C

* To meet special operating conditions, modifications of individual limiting requirements may be agreed upon between purchaser, seller and manufacturer.
** The carbon residue shall be run on the 100% sample.
# A considerable amount of experience exists in the US with a 20% blend of biodiesel with 80% diesel fuel (B20). Although biodiesel (B100) can be used, blends of over 20% biodiesel with diesel fuel should be evaluated on a case-by-case basis until further experience is available.

Technical Specs/ Standards

European and Australian Standards for Biodiesel

Standard/Specification		Unit	EU	Australia
Date			EN 14214	
Application			July 2003	September 03
			FAME	FAME
			automotive	
Density	15°C	kg/m³	860-900	860-890
Kinematic	20°C	mm²/s	-	-
Viscosity	40°C	mm²/s	3.50-5.00 [16]	3.5-5.0
	L.B.P.	°C	-	-
Distillation	5%	°C	-	-
	95%	°C	-	≤ 360 / 90%
	250°C	%	-	-
Distillation	350°C	%	-	-
	≥70°C	%	-	-
Flashpoint		°C	≥ 120	≥ 120
CFPP		°C	+22	TBA [16]
Pourpoint	sum/winter	°C	-	-
Cloud point		°C	-	-
Total Sulfur		% mass	≤ 0.0010	≤ 0.0050.001 [23]
CCR	100%	% mass	-	≤ 0.050
	10%	% mass	≤ 0.30 [17]	or ≤ 0.30
Sulfated ash		% mass	≤ 0.02	≤ 0.020
(Oxid) Ash		% mass	-	-
Water cont.		mg/kg	≤ 500	-
Total contamination		mg/kg	≤ 24 [18]	≤ 24
Water & Sediments		% vol.	-	≤ 0.050
Cu-Corrosion	3h/50°C		class 1	≤ No. 3
Cetane No.		-	≥ 51	≥ 51
Acid value		mgKOH/g	≤ 0.50	≤ 0.80
Oxidation	IP 306	g/cm²	-	-
Stability	ISO 12205	g/cm²	-	-
	EN 14112	h	≥ 6.0	≥ 6
Thermal stability			-	-
Storage stability			-	-
Methanol content		% mass	≤ 0.20	≤ 0.20
Saponification		mgKOH/g	-	-
Ester content		% mass	≥ 96.5	≥ 96.5
Monoglycides		% mass	≤ 0.80	-
Diglyceride		% mass	≤ 0.20	-
Triglyceride		% mass	≤ 0.20	-
Free glycerol		% mass	≤ 0.020	≤ 0.020
Total glycerol		% mass	≤ 0.25	≤ 0.250
Iodine No.			≤ 120	-
Linolenic methyl ester		% m/m	≤ 12.0	-
Polyunsaturated	≤4 doub.b.	% m/m	1 [19]	-
Phosphorus content		mg/kg	≤ 10.0	≤ 10.0
Alcaline metals	Na + K	mg/kg	≤ 5.0	≤ 5.0
Alcaline metals	Ca + F	mg/kg	≤ 5.0	≤ 5.0
Net calorific value		MJ/kg	-	-

[15] If CFPP is -20°C or lower, the viscosity measured at -20°C shall not exceed 48 mm²/s
[17] ASTM D 1160 shall be used to obtain the 10% distillation residue
[18] Pending development of a suitable method, EN 12662 shall be used
[19] Rapeseed methyl ester or ethyl to be developed
[23] For diesel fuel
[24] Beginning with 1 Feb 2006
[25] Alcohol
[26] Only for FAME as heating fuel solely, same limit as for mineral oil according to national regulations
[28] Free for additives for cold flow improvement or cloud point depressing, only for blending purposes

- From a fuel technical point of view, biodiesel is a good replacement for fossil diesel- for example; it has less sulfur content, higher viscosity and better lubricating properties. Biodiesel is environmentally friendly and has no adverse effects on engines as long as it is manufactured and utilized according to internationally accepted standards to enable vehicle warranties to be honored.
- However, since the gross calorific value of biodiesel is relatively lower than that of fossil diesel, there is a power loss of 3% due to combustion derailment, leading to an increase in specific fuel consumption of 6% on maximum power and 3% on maximum torque. In practice, diesel engines very rarely run at maximum power resulting in minimum specific fuel consumption losses.

Distribution Networks

General Characteristics

- It is advisable that biofuels processing plants have to be situated around main feedstock producing areas, and be supported by a satisfactory road and transport infrastructure. Similarly, a good road and transport (both road & rail) infrastructure is required to transport biofuels from processing plants to distribution points. Location of distribution points will largely be influenced by blending philosophy adopted.

Distribution Networks

Specific Characteristics

Ethanol

- In order to meet the criteria of proximity of feedstocks to the plant, it is suggested that the fuel ethanol plant, be situated around the two major sugar producing companies, Nakambala Sugar and Kafue Sugar, which will provide the bulk of the feedstock (molasses) required for fuel ethanol production. By coincidence, there is a well developed farming infrastructure of both commercial and small/ medium scale farms, around Lusaka, Kafue and Mazabuka, who can engaged to grow sweet sorghum to provide complementary feedstock to the processing plant to offset the shortfall anticipated for molasses feedstock.

Distribution Networks

- Blending points and distribution networks will depend on the policy of using ethanol to substitute lead based additives, as an octane enhancer for gasoline at INDENI. Assuming this policy is accepted, it is recommended that the fuel ethanol to be produced from the processing plant in Mazabuka/ Kafue will be transported to INDENI in Ndola. Adjacent to INDENI, the processing plant will require construction of a storage depot for supplying fuel ethanol to INDENI for blending purposes.
- It is further recommended that fuel ethanol produced from this proposed facility and any other plants to be established in Zambia be blended at site, at any Oil Marketing Company's (OMC's) depots or filling stations- straight from the plant. The fuel blended will then be transported to their respective dealers. In this case OMCs will be encouraged to install special filling pumps for the blend.

Distribution Networks

Biodiesel

- Since biodiesel feedstocks can be grown in most parts of the country, it is recommended that processing plants be situated in any location depending on the availability of feedstocks at reasonable cost. Processing plants to be constructed should ensure they meet the standards/ specifications to be stipulated. In addition, the processing plants should conform to the Environmental Protection and Pollution control Act of 1990.
- Biodiesel produced from these plants will be blended on sites or suitable mixing depots either in conjunction with OMCs or any other suitable institution allowed by Energy Regulation Board (ERB). Pure biodiesel from the plants will be sold to any interested institutions.

Technical, Social and Environmental Considerations
Ethanol

Environmental concerns likely to be associated with ethanol production and use arising during feedstocks production, processing, transportation and marketing will be addressed under the Environmental Protection and Pollution control Act of 1990.

- **Required feedstock surplus does not pose a challenge for land required for both food production and energy crops, as it exists.**
- **In addition, Zambia has reasonable adequate rainfall for supporting expanded sugar cane production. Sweet sorghum as a complementary feedstock has even a better advantage, since it can be grown in drier parts of the country.**

Technical, Social and Environmental Considerations
Ethanol

- Besides Ethanol is an excellent oxygenate and octane enhancer and is a good additive for phasing out lead and other toxic octane boosters like benzene, aromatics, MTBE etc.
- In addition, it has high octane number that improves engine performance, and has low sulfur content.

Technical, Social and Environmental Considerations Ethanol

- However, during processing, an area of concern is production of stillage.
- Stillage however, can be processed during bio-methane process to biogas which can be used in boilers for producing either process steam or electricity.
- The by-product in slurry form can be used as a fertilizer in the fields.
- During transportation, it is important that the alcohol is denatured to remove the alcoholic flavour
- Although ethanol is more biodegradable than gasoline, it is important all stringent precautions and safety standards applied to gasoline during handling and storage are also applied to ethanol

Technical, Social and Environmental Considerations Biodeisel

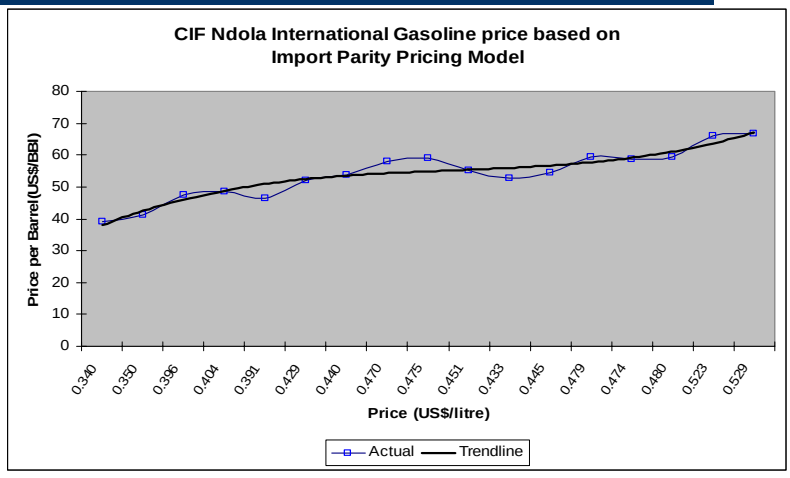
- **Biodiesel has a reasonable cetane number that enhances engine performance and good lubrication that reduces wear and low content of sulfur. It has similar advantages like ethanol with regards to GHG reduction.**
- **During the esterification process, the major by-products are crude glycerol and fertilizer. Glycerol can be sold to manufacturers where it is distilled to make various grades of glycerine.**
- **Care should be taken during recovery of methanol to avoid spillage. Since methanol is highly flammable, special procedures have to be taken during handling, transportation and storage.**
- **Although flash point of biodiesel is higher than fossil diesel, it should be treated in the same way as petroleum products, by following fire hazards and other safety measures like is in the case of diesel.**

INCENTIVES

General criteria

- Incentives on biofuels will be granted based on the following general criteria.
  1. The production price as far as possible has to be within a reasonable margin of CIF Ndola international prices for ethanol sold to INDENI.
  2. Pump prices for biodiesel and ethanol sold to OMCs and dealers should be between 5% and 10% below prevailing prices for fossil diesel and gasoline.
  3. The feedstock to be used for producing biofuels has to be grown locally at reasonable cost.

INCENTIVES



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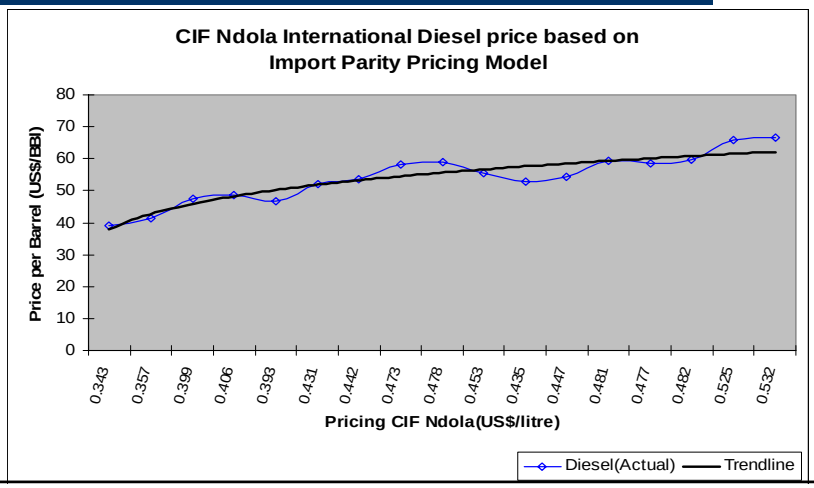


INCENTIVES

Specific Incentives

- Specific incentives on biofuels will be provided based on their economics of production viz a viz gasoline/ diesel pump prices taking into account taxes such as; road levy, excise duty, ERB fees, Strategic Reserve fund and VAT, and related costs such as transport margin, OMC margin, and dealer margin.
- Ethanol produced for use at INDENI for the purpose of blending with gasoline will have zero tax since it will be regarded as a raw material to INDENI. INDENI in the process will include the usual taxes it has for other fossil fuels.
- Tax free and duty free status for all capital equipment and plant for the production and use of biofuels.

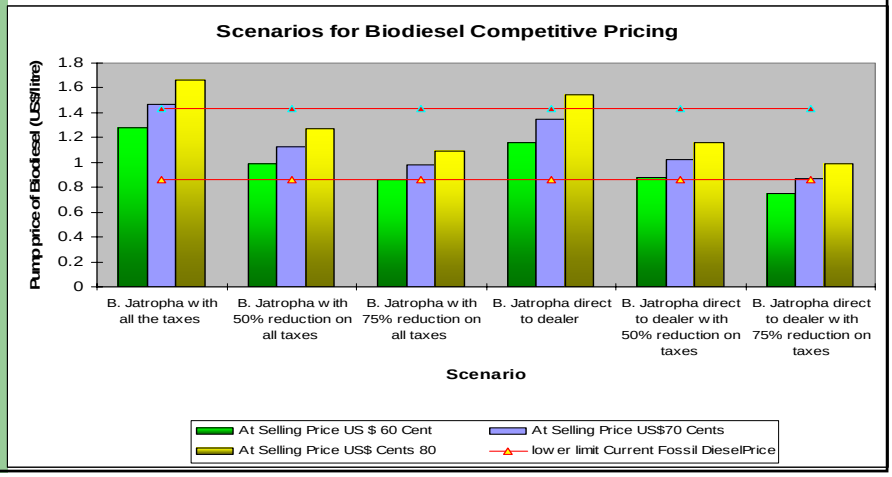
INCENTIVES

Possible Incentives Scenarios

- Given below are possible incentive scenarios based on results of MS-algorithms for determining prices for petrol, diesel and biodiesel influenced by various factors such as international fossil fuels, taxes and related costs for the following
  - i) Biodiesel Jatropha
  - ii) Biodiesel vegetable oil (imported) with duty
  - iii) Biodiesel vegetable oil (imported) without duty
  - iv) Biodiesel soybean with seed cake
  - v) Ethanol to dealer through OMCs
  - vi) Ethanol straight to dealer
  - vii) Ethanol to INDENI

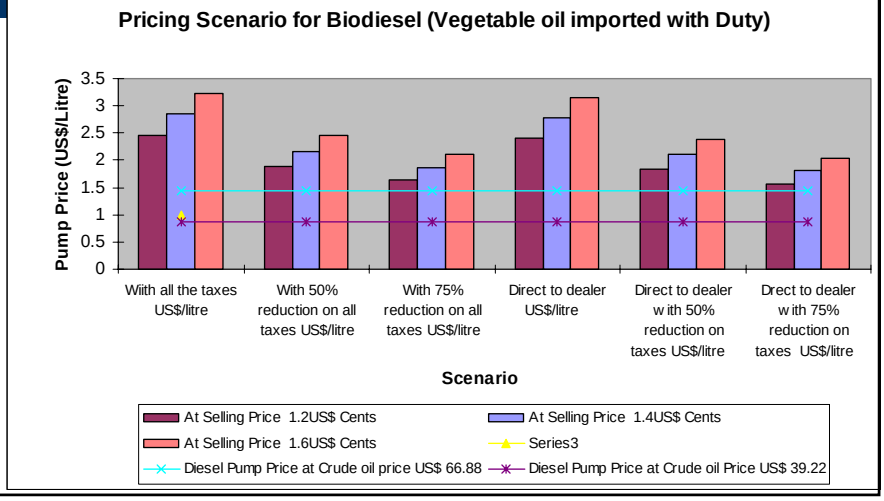
INCENTIVES

Figure 3: Biodiesel from Jatropha



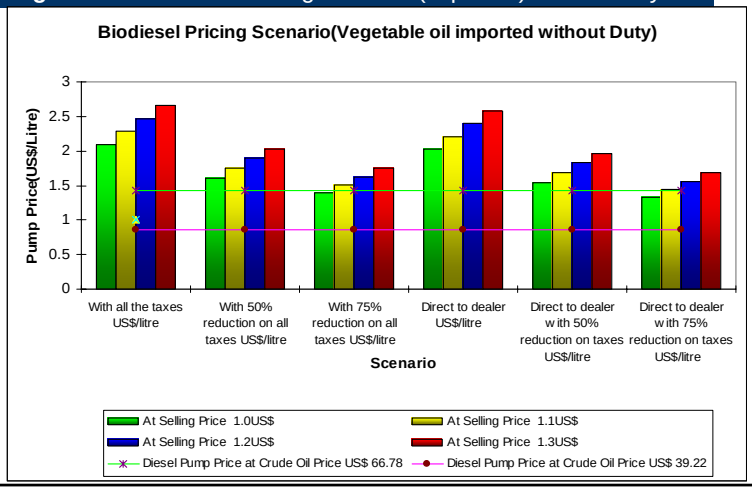
INCENTIVES

Figure 4: Biodiesel from vegetable oil (imported) with duty

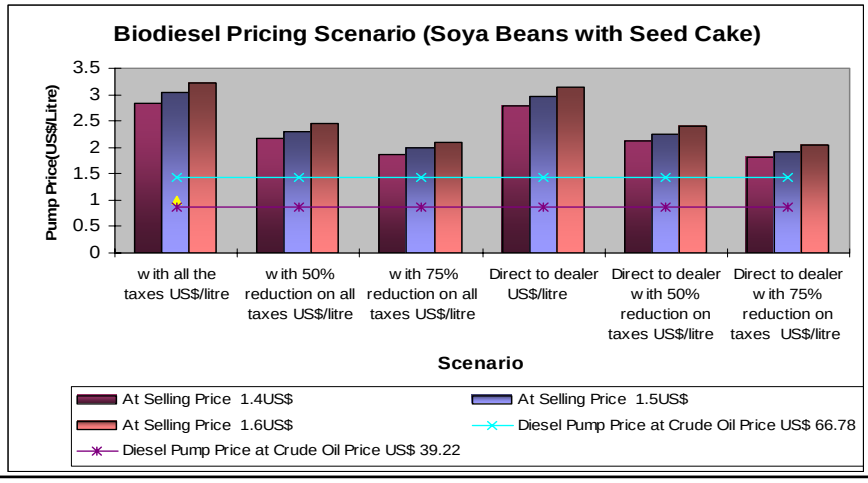


INCENTIVES

Figure 5: Biodiesel from vegetable oil (imported) without duty

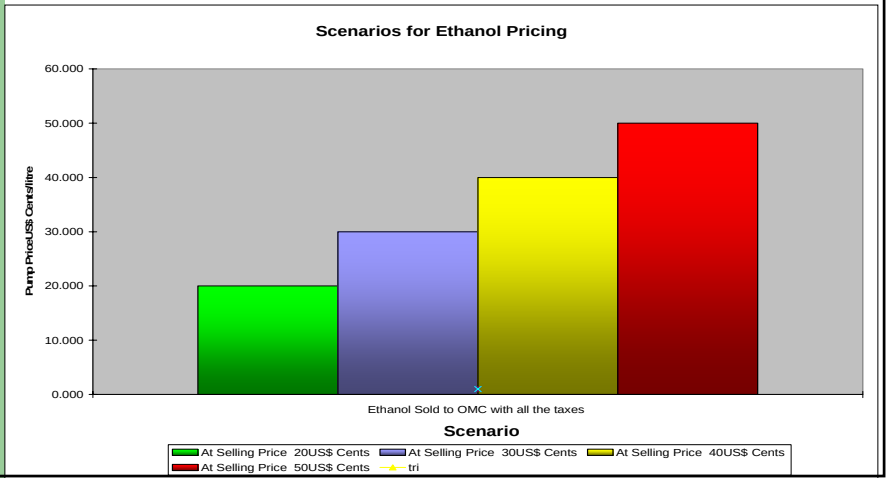


INCENTIVES



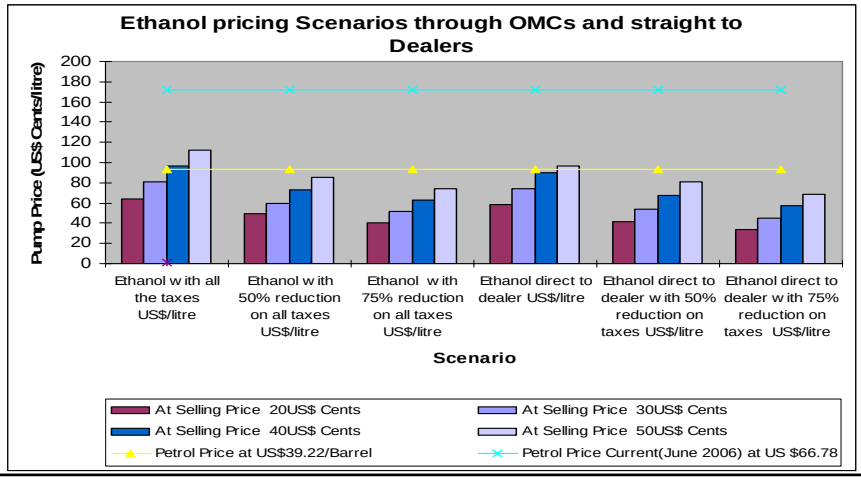
INCENTIVES

Figure 7: Ethanol sold to dealer through OMCs

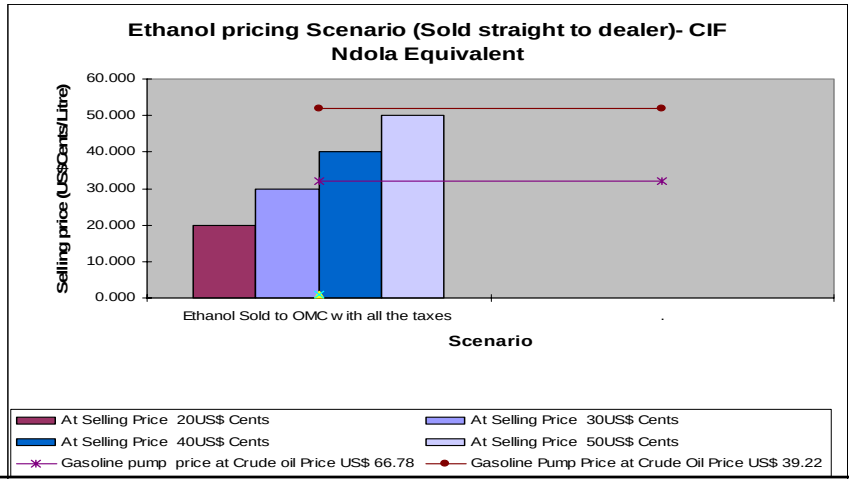


INCENTIVES

Figure 8: Ethanol sold direct to dealers



INCENTIVES



INCENTIVES

For scenarios from Figures 3 to 9 the following incentive options were considered

i) All taxes included without reduction

ii) 50% reduction on all taxes (road tax, excise duty, and VAT)

iii) 75% reduction on all taxes.

iv) Ethanol direct to dealer with 50% reduction on all taxes

v) Ethanol direct to dealer with 75% reduction on all taxes.

INCENTIVES

Observations

- Pump prices for biodiesel and gasoline are being influenced by various factors including prevailing international crude oil prices, taxes, exchange rates, related costs such as transport costs, OMCs margin and dealer's margin on one hand, and feedstock price on the other.
- In view of the volatility of international crude oil prices the incentives will be provided on a dynamic basis depending on the exchange rate and international crude oil prices. Results so far include the following:

INCENTIVES

Biodiesel

At prevailing crude oil price of US$ 70 per barrel

i) Biodiesel production price of US$0.60 per litre with all taxes is viable and therefore no incentives needed.

ii) Biodiesel production price at US$ 0.70 per litre is viable at 50% and 75% tax reduction

iii) Biodiesel at selling price of US$ 0.80 per litre is viable at 50% and 75% tax reduction

iv) Biodiesel vegetable oil (imported) with duty selling price is not viable at all.

v) Biodiesel vegetable oil (imported) without duty is viable at selling price of US$1.00 with 75% reduction on taxes.

vi) Biodiesel soybean without cake is not viable at all.

vii) Biodiesel soybean with cake is not viable at all.

ix) Biodiesel from groundnuts and cotton seeds are not viable in view of their higher O&M costs than soybean.

INCENTIVES

At prevailing crude oil price of US$ 40 per barrel and below

i) Biodiesel jatropha is only viable at selling price US$0.60 at 75% reduction on all taxes.

ii) The rest of the biodiesel scenarios related to imported vegetable, soybean, cotton, and groundnuts are not viable at all.

INCENTIVES

Ethanol

At prevailing crude oil price of US$ 70 per barrel

i) Ethanol at selling prices of US$ 0.20, 0.30, 0.40 and 0.50 per litre to INDENI is viable.

ii) Ethanol sold to the dealer at prices of US$ 0.20, 0.30, 0.40 and 0.50 per litre is viable

At prevailing crude oil price of US$ 40 per barrel and below

i) Ethanol is only viable at selling prices of US$0.20 and US$ 0.30 per litre when sold to INDENI

ii) Ethanol sold straight to the dealer through OMCs is viable at selling prices of US$ 0.20 and US$0.30 per litre, and hence do not need incentive, whilst US$0.40 and US$0.50 are viable at 50% reduction on all taxes

iii) Ethanol sold straight to dealer is viable at US$0.20, US$0.30, US$0.40 whilst US$0.50 is only viable at 50% tax reduction

Institutional and Regulatory Arrangements

Biofuels development implementation framework

- The framework will provide background information related to opportunities and challenges related to biofuels development.
- The framework will also specify the blending ratios for both gasoline and diesel, their technical standards/ specifications, production / distribution network, environmental requirements and broad incentives.
- The decision to be made is whether the framework has to be made into an Act or not. This is so because most of the issues contained in the framework can be addressed within existing regulation.
- The disadvantage of mandating biofuels development through an Act of Parliament will prohibit biofuels projects to be developed under the Kyoto Protocol within the Clean Development Mechanism

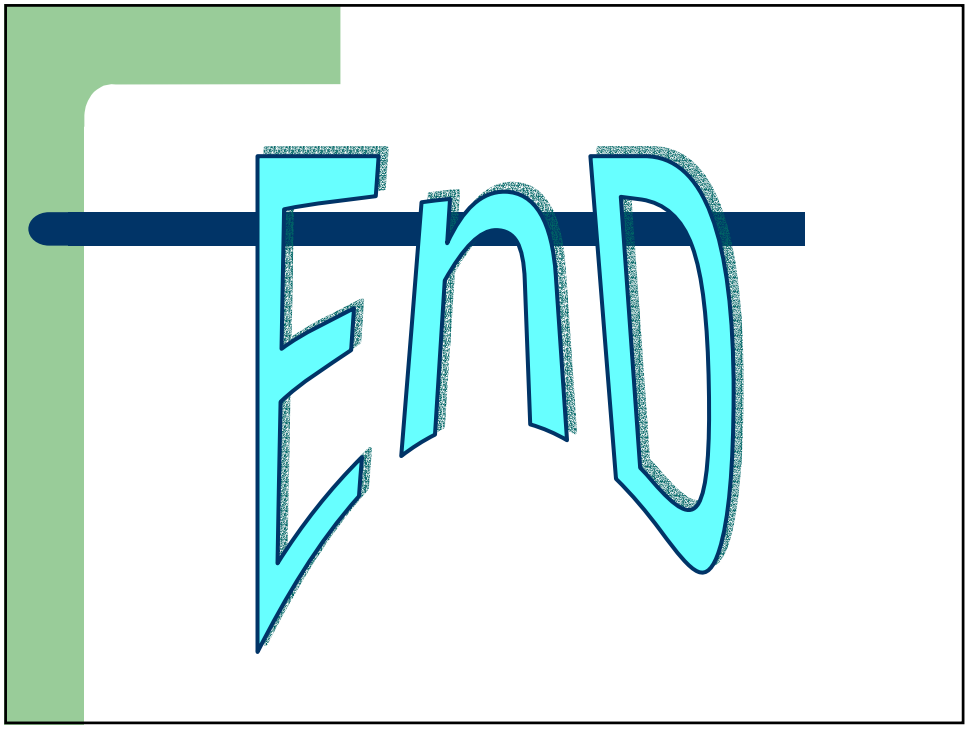
Institutional and Regulatory Arrangements

Institutional and Regulatory arrangements

- It is being proposed that technical issues contained in the biofuels development framework be handled by existing institutions and regulatory authorities.
- It is being proposed that the blending issues and technical specifications/ standards be issued under the ERB Act. Environmental issues are to be handled under the Environmental Protection and Pollution control Act of 1990.
- Incentives on biofuels could be handled under the incentive provision of the Ministry of Finance and National Planning.

CONCLUSIONS

- **The framework once formulated and implemented will go a long way to promote biofuels production and use, and contribute to economic enhancement through saving of foreign exchange, and provision of employment opportunities and consequently contribute to poverty reduction.**
- **Besides biofuels use will enhance environment integrity through reduced air pollution and green house gases GHG abatement.**
- **The framework will further create an environment to enhance sustainable business development from agriculture, production/ processing, distribution and marketing.**
- **Whilst developing business in this sector, it is advisable that all stakeholders should strive to make their business activities as sustainable as possible through innovative planning and synergies. This is so because the fuel business operates in a competitive global environment.**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