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# **"Biofuels and Sustainable Rural Development"**

## **"International Seminar on Biomass Energy and Sustainable Rural Development"**

**UNAM**  
**Morelia, Mexico**  
**June 26-28, 2003**

**Boris E. Utria**  
RPTES Program Manager  
Africa Energy Unit  
The World Bank



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## **Presentation Outline**

**1. Sustainable Biomass Energy Carriers**

**2. Brasil's PROALCOOL Example**

**3. Millennium Gelfuel Example**

**4. Biofuels and Rural Development**

**5. PRSP Bioenergy Assessments**

**5. Moving Biomass Energy Forward**



## Presentation Outline

### 1. Sustainable Biomass Energy Carriers

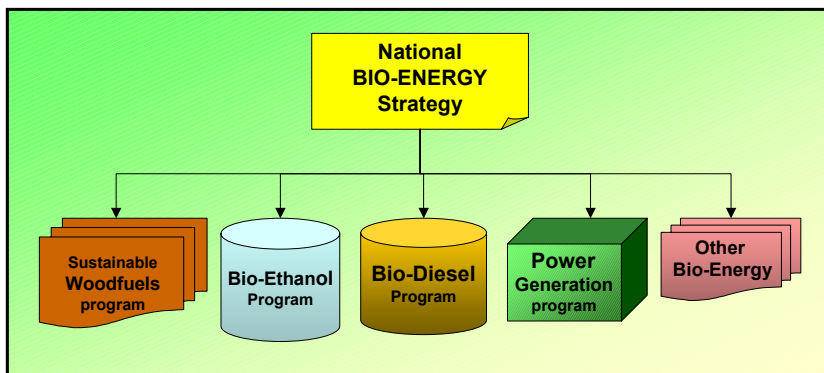
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**Vision:** Contribute to Poverty Alleviation and Climate Change Mitigation in client countries through the development of comprehensive and sustainable biomass energy sector policies, strategies and investments.



Moving LDC's towards a "Renewable Energy Platform" for a sustainable future .....

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## Presentation Outline

1. Sustainable Biomass Energy Carriers

2. Brasil's PROALCOOL Example

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## BRASIL: PROALCOOL Main achievements & impacts

- **12 million m<sup>3</sup> ethanol** (20X 1975);  
Oil displacement: 200,000 barrels/day;
- **2.5 million neat ethanol cars** in operation  
**15.5 million cars** using 22% anhydrous ethanol-gasoline blend; **> 1/3 of gasoline displaced;**
- **\$48 billion FOREX** expenditures avoided in 1975-02, with an investment of **\$5 billion** (2001 \$) in local currency.

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## BRASIL: PROALCOOL Main achievements & impacts

- 320 million metric tons of sugarcane produced in 2002 (4 times more than in 1975); 20 million ton sugar (3X 1975);
- > 300 ethanol distilleries (200 annexed); 25,000 gas stations selling hydrous ethanol today;
- **700,000 jobs**  
created in production chain @ US\$10-20K/job  
(4x lower than avg.)

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## BRASIL: PROALCOOL Main achievements & impacts

(Cont.)

- Demonstration that massive biomass program can be established in a short term;
- Sugarcane/sugar/ethanol technology development demonstrated by productivity increases and cost reduction;
- Development of market based Ethanol price system;
- "Lessons Learned" for replication.

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## BRASIL: PROALCOOL Environmental Impacts

- **Lead displacement** due to octane enhancement properties of ethanol: lead concentrations in São Paulo dropped **93%** from 1978 to 1991
- **NO<sub>x</sub>, CO and Sulfur** emissions from ethanol fuels are reduced while HC (hydrocarbons) and aldehyde emissions are increased. However ethanol HCs and aldehydes are less toxic than gasoline's.
- The environmental impacts from ethanol production, particularly the **stillage** disposal, have been resolved
- **CO<sub>2</sub>** emissions from ethanol vehicles are absorbed back by sugarcane growing in a closed cycle, making ethanol fuel eligible for CDM / Kyoto Protocol

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## BRASIL: Trends and Future Prospects

- **Cogeneration** using sugarcane bagasse (from current 20 kWh/ton to 100-600 kWh/ton sugarcane)
- **Other energy uses for ethanol:**
  - ⇒ Vegetable oil transesterification (**Bio-Diesel**)
  - ⇒ Fuel cell
  - ⇒ Household cooking (ethanol / Gelfuel)
- **International market development:** potential demand for ethanol as **energy** and **environmental commodity** in USA, EU, India, China, Canada, Japan, etc). Opportunities open by the MTBE phase out in California for reformulated gasoline. Removal of present tariff and non-tariff barriers to imports is required for the development of sustainable international fuel ethanol market.
- **Flexible-fuel vehicle:** one vehicle/multiple fuels
- **Greenhouse gases abatement - carbon credits/CDM**

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## MILLENNIUM GELFUEL

*A Renewable and Low-Cost Cooking Fuel for Africa*



**A World Bank Energy & Poverty Alleviation Initiative: Redirecting an existing commercial energy product with RPTES (AFTEG) "knowledge" support.**

***Winner of a Technological Development Award from the "Development Marketplace 2000"***

# MILLENNIUM GELFUEL

*A Renewable and Low-Cost Cooking Fuel for Africa*

Millennium Gelfuel = Ethanol-Based Fuel Produced From Agricultural Crops



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# MILLENNIUM GELFUEL

*A Renewable and Low-Cost Cooking Fuel for Africa*

Production Process/Costs



End-use Technology



Distribution Systems

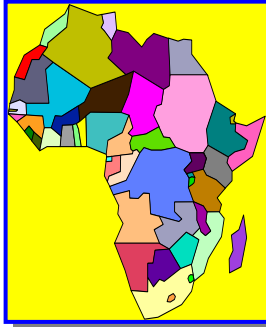


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**Consumer Acceptability**



**Gelfuel Production  
 Geo-Economics**

**ID. of Pilot Projects**



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**Comparison of CO<sub>2</sub> Emissions at Preparation of Standard Meal**

Fuel	Stove Type	Fuel usec (kg)	CO <sub>2</sub> production (gm/kg)	CO <sub>2</sub> Emission (gm/meal)	Comparative Emmissions Ratios
LPG	Gas burner	0.188	3028	569	119.8
Kerosene	Wick	0.205	3137	643	135.4
	Pressurized	0.203	3137	637	134.1
Charcoal	Traditional	0.413	3298	1362	286.7
	Improved	0.282	3298	930	195.8
Fuelwood	Traditional	0.874	1832	1601	337.0
	Improved	0.605	1832	1108	233.3
M.Gelfuel	Cover + regulator	0.310	1533	475	100.0
	RPTES Stove	0.331	1533	507	106.7



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**MILLENNIUM GELFUEL**  
*A Renewable and Low-Cost Cooking Fuel for Africa*

**"RP TES" MG Stove & Burner**



@RP TES 2001



@RP TES 2001

**Cost: US \$2-8 depending on materials utilized**



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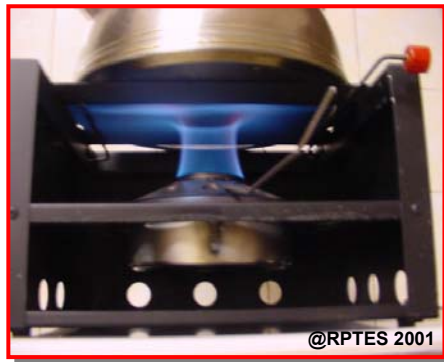


**MILLENNIUM GELFUEL**  
*A Renewable and Low-Cost Cooking Fuel for Africa*

**Millennium Gelfuel**  
**Efficient Combustion + Clean + Safe**



@RP TES 2001



@RP TES 2001

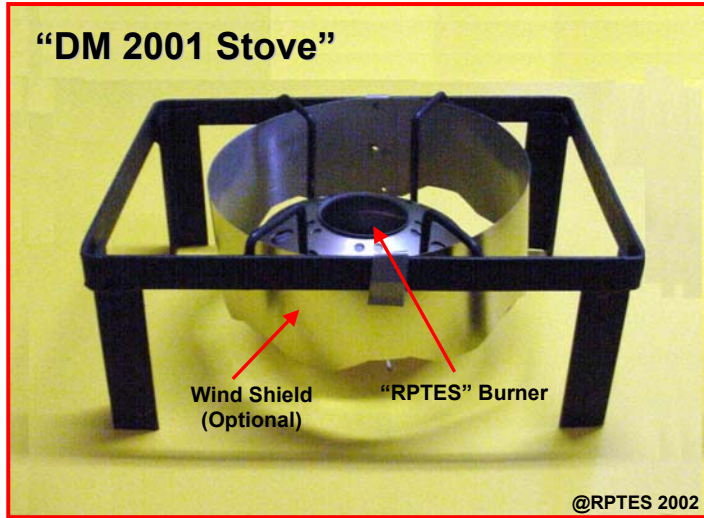


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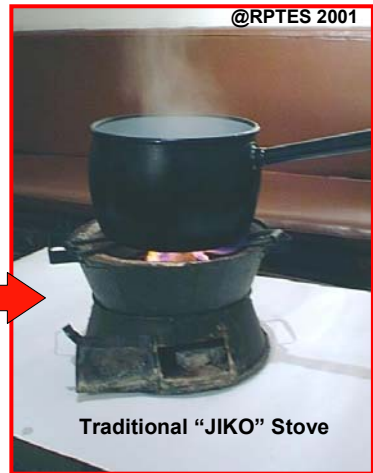


### “DM 2001 Stove”



@RP TES 2002

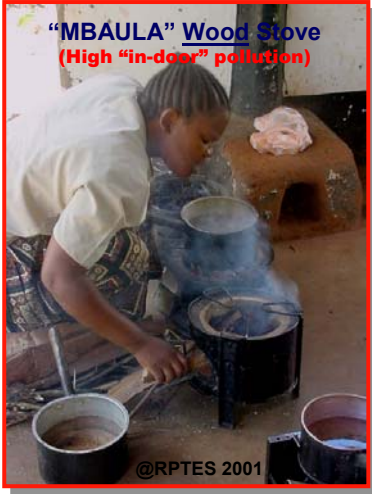
### Adaptation to Existing Traditional/Improved Stoves in Africa



Traditional “JIKO” Stove



**MILLENNIUM GELFUEL**  
A Renewable and Low-Cost Cooking Fuel for Africa



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**MILLENNIUM GELFUEL**  
A Renewable and Low-Cost Cooking Fuel for Africa

**Wholesale/Retail Shipping & Dispensing Units**



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# MILLENNIUM GELFUEL

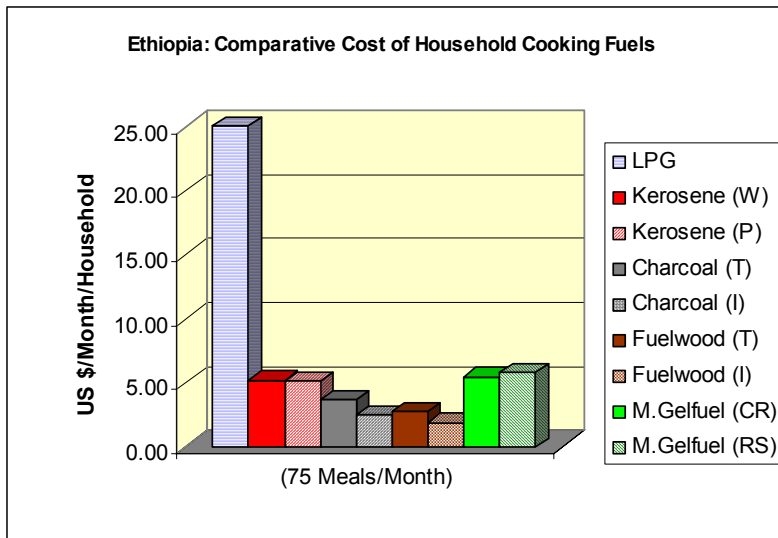
A Renewable and Low-Cost Cooking Fuel for Africa



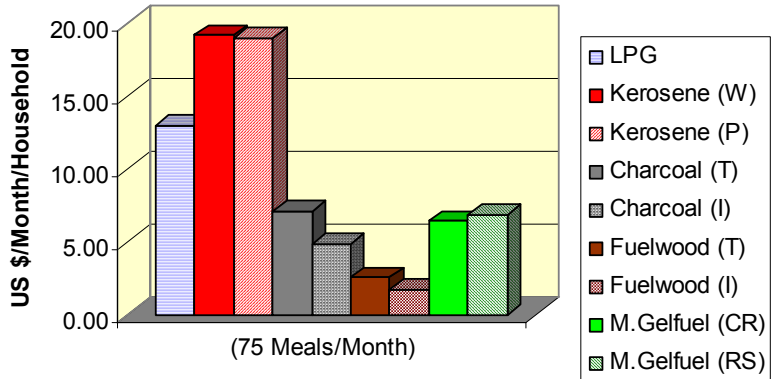
A low-cost package to allow low-income households access to the Millennium Gelfuel

# MILLENNIUM GELFUEL

A Renewable and Low-Cost Cooking Fuel for Africa

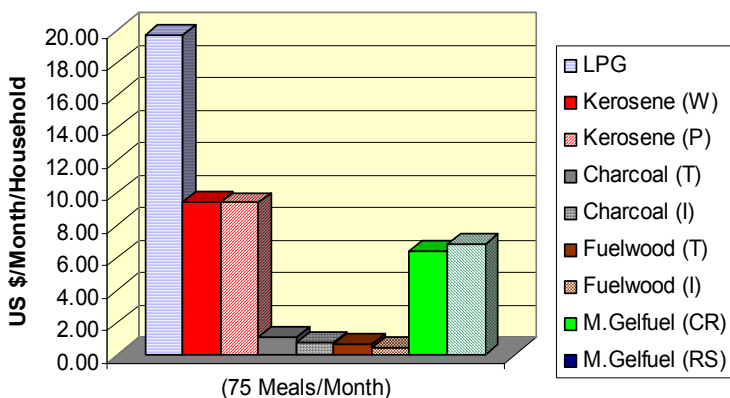


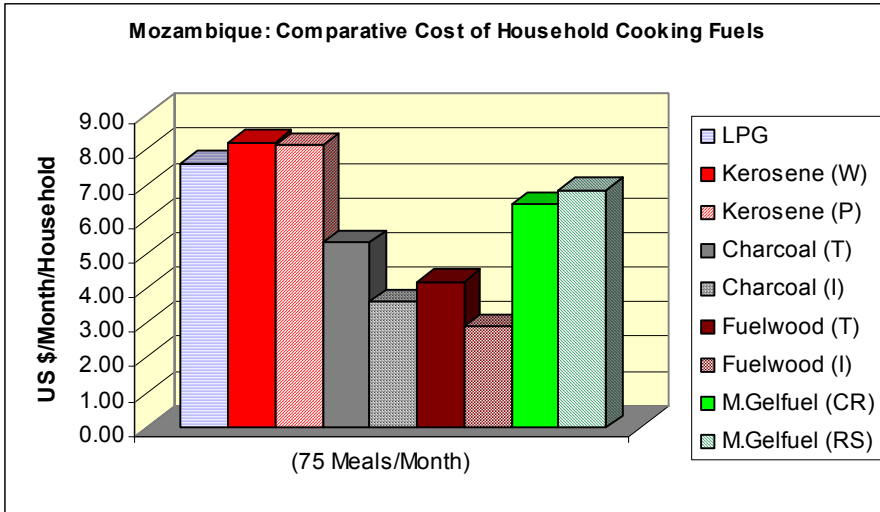
### Zimbabwe: Comparative Cost of Household Cooking Fuels



### MILLENNIUM GELFUEL A Renewable and Low-Cost Cooking Fuel for Africa

### Malawi: Comparative Cost of Household Cooking Fuels





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**Current Gelfuel Production:**

**Zimbabwe: 30,000 lt/m**

**South Africa: 60,000 lt/m**

**Malawi: 10,000 lt/m**

**Project Proposals (GEF MSP):**

**Ethiopia: 600,000 lt/m**

**Mozambique: 250,000 lt/m**

**Malawi, Madascar, Senegal, China, Zimbabwe ....**



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4. **Biofuels and Rural Development**

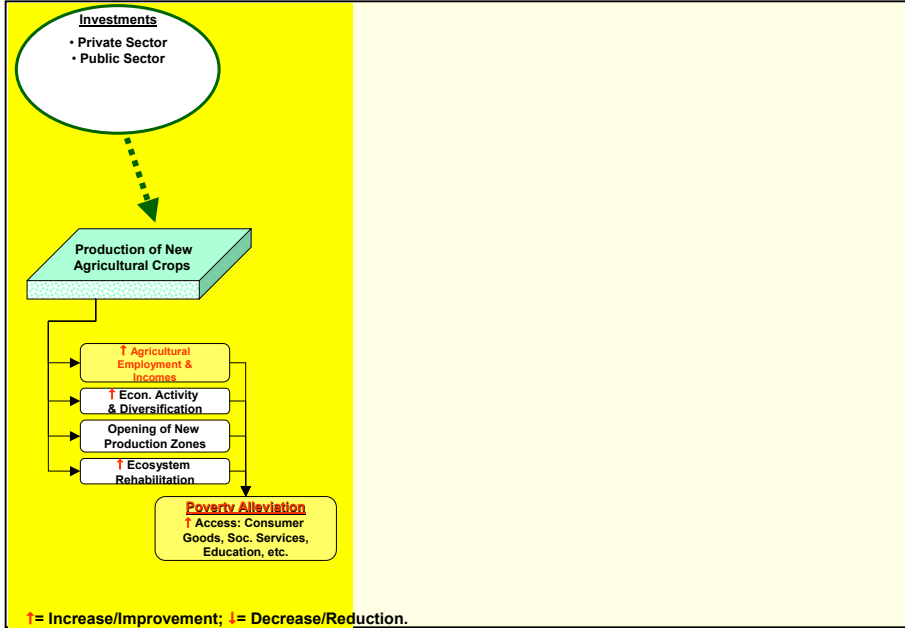
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### Ethanol/Millennium Gelfuel: A Sustainable Engine for Rural Transformation

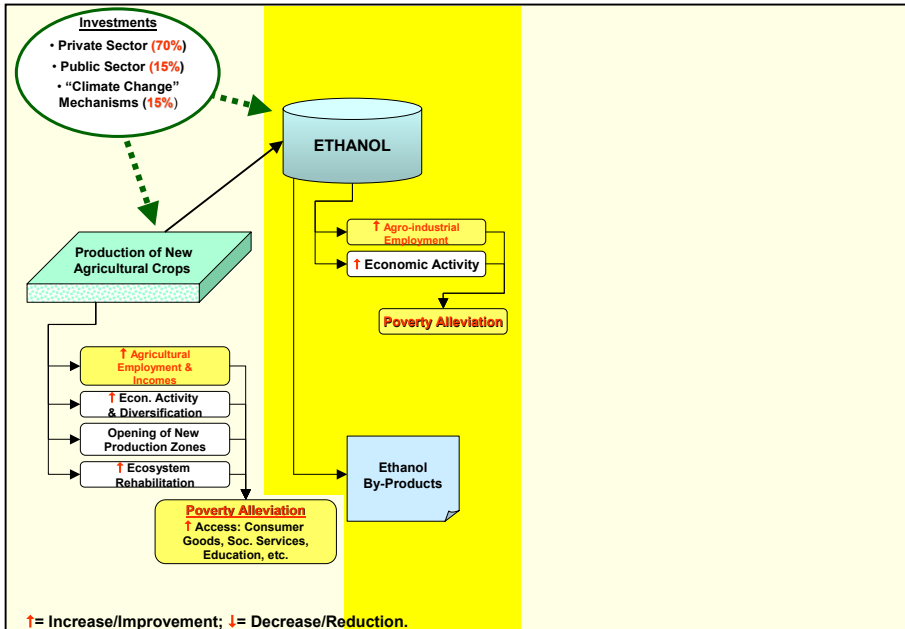


POVERTY → → → → ALLEVIATION

## Ethanol/Millennium Gelfuel: A Sustainable Engine for Rural Transformation

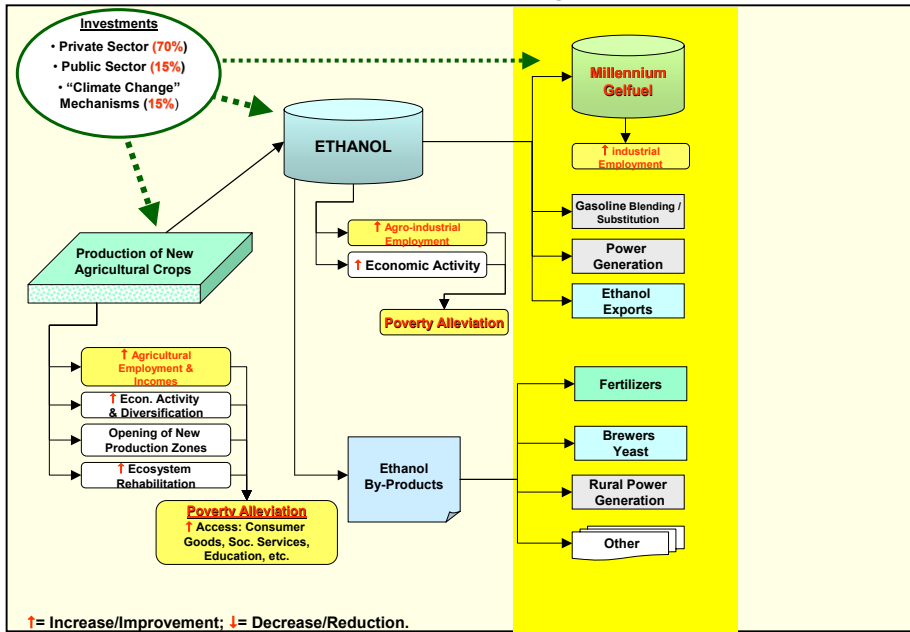


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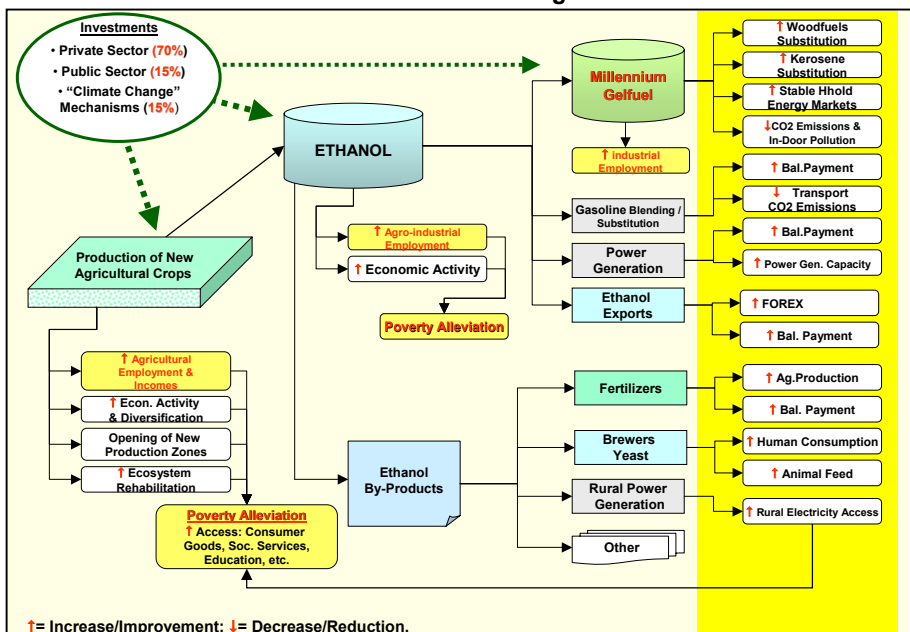




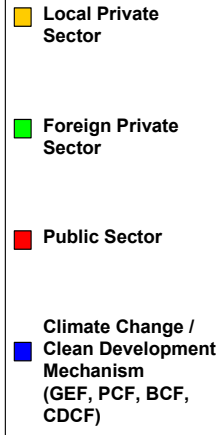
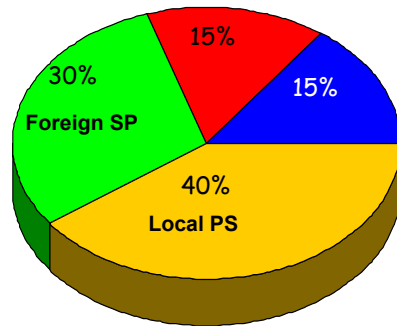
## Ethanol/Millennium Gelfuel: A Sustainable Engine for Rural Transformation



## Ethanol/Millennium Gelfuel: A Sustainable Engine for Rural Transformation



# BIOFUELS: FUNDING STRATEGY



**Private Sector 70%**  
**Public Sector 15%**  
**"Climate Change/CDM" 15%**

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## MILLENNIUM GELFUEL A Renewable and Low-Cost Cooking Fuel for Africa

TABLE 2: Land Requirements, Rural Employment and Millennium Gelfuel Production From 25% and 50% Increase in Agricultural Crops in Africa <sup>(1)</sup>

25% Production Increase over Year '2000 Crop Levels	SUGAR CROPS						STARCH CROPS						ALL CROPS					
	SUGAR CANE			SWEET SORGHUM			CASSAVA			MAIZE			SWEET POTATOES			TOTALS		
	(2) Ha (10 <sup>3</sup> )	(3) Jobs (10 <sup>3</sup> )	(4) Gelfuel (10 <sup>6</sup> Lt)	(2) Ha (10 <sup>3</sup> )	(3) Jobs (10 <sup>3</sup> )	(4) Gelfuel (10 <sup>6</sup> Lt)	(2) Ha (10 <sup>3</sup> )	(3) Jobs (10 <sup>3</sup> )	(4) Gelfuel (10 <sup>6</sup> Lt)	(2) Ha (10 <sup>3</sup> )	(3) Jobs (10 <sup>3</sup> )	(4) Gelfuel (10 <sup>6</sup> Lt)	(2) Ha (10 <sup>3</sup> )	(3) Jobs (10 <sup>3</sup> )	(4) Gelfuel (10 <sup>6</sup> Lt)	(2) Ha (10 <sup>3</sup> )	(3) Jobs (10 <sup>3</sup> )	(4) Gelfuel (10 <sup>6</sup> Lt)
Central Africa	0.1	0.0	93.3	0.4	0.2	122.3	0.6	0.2	1,257.7	0.7	0.2	385.6	0.0	0.0	39.8	1.7	0.7	1,898.5
Eastern Africa	0.1	0.1	437.1	0.8	0.4	301.7	0.8	0.4	1,250.7	2.7	0.9	1,989.6	0.3	0.1	275.5	4.8	1.8	4,254.6
Southern Africa	0.1	0.0	583.4	0.1	0.0	54.1	0.0	0.0	0.0	0.9	0.3	1,611.1	0.0	0.0	2.5	1.1	0.4	2,251.1
Western Africa	0.0	0.0	89.3	3.0	1.3	1,116.0	1.2	0.5	2,610.9	1.8	0.6	1,331.0	0.1	0.1	134.4	6.2	2.5	5,281.6
<b>Total -&gt;</b>	<b>0.3</b>	<b>0.1</b>	<b>1,203.1</b>	<b>4.3</b>	<b>1.8</b>	<b>1,594.1</b>	<b>2.6</b>	<b>1.1</b>	<b>5,119.3</b>	<b>6.1</b>	<b>2.1</b>	<b>5,317.2</b>	<b>0.5</b>	<b>0.2</b>	<b>452.2</b>	<b>13.8</b>	<b>5.4</b>	<b>13,685.9</b>
<b>50% Increase</b>																		
Central Africa	0.1	0.1	186.5	0.8	0.3	244.5	1.1	0.5	2,515.4	1.4	0.5	771.2	0.1	0.0	62.6	3.4	1.4	3,780.1
Eastern Africa	0.2	0.1	874.2	1.7	0.7	603.3	1.6	0.7	2,501.4	5.4	1.9	3,979.2	0.7	0.3	551.0	9.6	3.7	8,509.2
Southern Africa	0.2	0.1	1,166.8	0.1	0.1	108.3	0.0	0.0	0.0	1.9	0.7	3,222.2	0.0	0.0	5.1	2.2	0.8	4,502.3
Western Africa	0.0	0.0	178.7	6.1	2.5	2,232.0	2.4	1.0	5,221.8	3.6	1.3	2,662.0	0.3	0.1	268.7	12.3	5.0	10,563.2
<b>Total -&gt;</b>	<b>0.5</b>	<b>0.3</b>	<b>2,406.1</b>	<b>8.7</b>	<b>3.6</b>	<b>3,188.1</b>	<b>5.1</b>	<b>2.3</b>	<b>10,238.6</b>	<b>12.2</b>	<b>4.3</b>	<b>10,634.5</b>	<b>1.0</b>	<b>0.4</b>	<b>887.4</b>	<b>27.5</b>	<b>10.8</b>	<b>27,354.8</b>

Source: Phillips, T., "Agro-Economic Assessment of the Potential to Produce Fermentation Ethanol Alcohol In Africa", RPTES Program, 2002.

- Notes: (1) Projections based on 25 and 50 percent of 2001 and production of the specific crop. It is assumed that yields remain constant and that labour inputs will increase in proportion to production increases. Required land expansion was constrained by availability of suitable land. Sources: (a) for Production data: FAO, Agricultural Production, FAOSTAT (<http://apps.fao.org>); (b) for Suitability data: IIASA and FAO, (2000); and (c) for Global Agro-Ecological Zones <http://www.fao.org/ag/AGL/agll/gaez/index.htm>.  
(2) Land requirements of projection scenarios presented in million Hectares (Ha).  
(3) Employment Generation presented in millions and only reflect new jobs in the agricultural production phase. Actual number calculated on the basis of total number of day/person labour input divided by 250 workdays/year. Agro-industrial employment in ethanol distillation and gelfuel production is estimated to be of the order of 100,000 new permanent jobs not included.  
(4) Millennium Gelfuel production calculated on the basis of 1.2:1 volume ratio with respect to ethanol alcohol production.



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	(2)	(3)	(4)	(2)	(3)	(4)	(2)	(3)	(4)	(2)	(3)	(4)	(2)	(3)	(4)	(2)	(3)	(4)			
	Ha (10 <sup>5</sup> )	Jobs (10 <sup>5</sup> )	Gelfuel (10 <sup>6</sup> Lt)	Ha (10 <sup>5</sup> )	Jobs (10 <sup>5</sup> )	Gelfuel (10 <sup>6</sup> Lt)	Ha (10 <sup>5</sup> )	Jobs (10 <sup>5</sup> )	Gelfuel (10 <sup>6</sup> Lt)	Ha (10 <sup>5</sup> )	Jobs (10 <sup>5</sup> )	Gelfuel (10 <sup>6</sup> Lt)	Ha (10 <sup>5</sup> )	Jobs (10 <sup>5</sup> )	Gelfuel (10 <sup>6</sup> Lt)	Ha (10 <sup>5</sup> )	Jobs (10 <sup>5</sup> )	Gelfuel (10 <sup>6</sup> Lt)			
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## COLOMBIA:

**Scenario: 180,000 Empleos/500,000 Ha. \***

### Land Requirements, Ethanol Production, Employment and Investment Envelope

CULTIVOS	Hectareas	Biomasa Ton/Yr (Millones)	Alcohol Etanol Lt/Yr (Millones)	GENERACION DE EMPLEOS DIRECTOS					INVERSION REQUERIDA	
				Nivel Capacitacion			Total		Baja	Alta
				Bajo	Medio	Alto	100%	# Empleos		
				60%	10%	30%	100%	Permanentes	(Millones US \$)	
Cana de Azucar	100,000	5	350	6	1	3	10	37,037	91	156
Sorgo Sacarino	150,000	14	745	11	2	5	18	66,667	1,236	2,120
Maiz	150,000	1	333	7	1	3	11	40,833	86	148
Yuca	100,000	1	216	6	1	3	9	34,815	56	96
<b>Total</b>	<b>500,000</b>	<b>21</b>	<b>1,644</b>	<b>29</b>	<b>5</b>	<b>15</b>	<b>48</b>	<b>179,352</b>	<b>1,470</b>	<b>2,519</b>

(\*) Target proposed by national government within the "Plan Colombia" Context is of 380,000 ha. for the 2002-2006 period.

## COLOMBIA:

**Scenario: 180,000 Empleos/500,000 Ha. \***

### Land Requirements, Ethanol Production, Employment and Investment Envelope

CULTIVOS	Hectareas	Biomasa Ton/Yr (Millones)	Alcohol Etanol Lt/Yr (Millones)	GENERACION DE EMPLEOS DIRECTOS					INVERSION REQUERIDA	
				Nivel Capacitacion			Total		Baja	Alta
				Bajo	Medio	Alto	100%	# Empleos Permanentes		
				60%	10%	30%	(Millones Persona/Dia/ha.)	(Millones US \$)		
Cana de Azucar	100,000	5	350	6	1	3	10	37,037	91	156
Sorgo Sacarino	150,000	14	745	11	2	5	18	66,667	1,233	2,120
Maiz	150,000	1	333	7	1	3	11	40,833	86	148
Yuca	100,000	1	216	6	1	3	9	34,815	56	96
<b>Total</b>	<b>500,000</b>	<b>21</b>	<b>1,644</b>	<b>29</b>	<b>5</b>	<b>15</b>	<b>48</b>	<b>179,352</b>	<b>1,470</b>	<b>2,519</b>

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## Presentation Outline

1. Sustainable Biomass Energy Carriers

2. Brasil's PROALCOOL Example

3. Millennium Gelfuel Example

4. Biofuels and Rural Development

**5. PRSP Bioenergy Assessments**

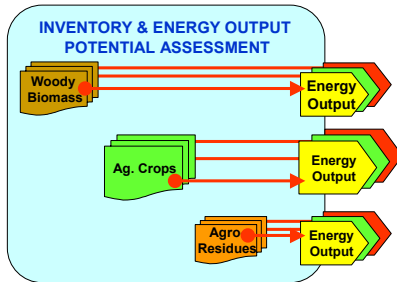
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## AFTEG/BEWP (FY04-06):

# Biomass Energy Inventory & PRSP Assessment



- **Biomass Energy Inventory:** establish potential bio-energy scenarios (carriers and output levels).

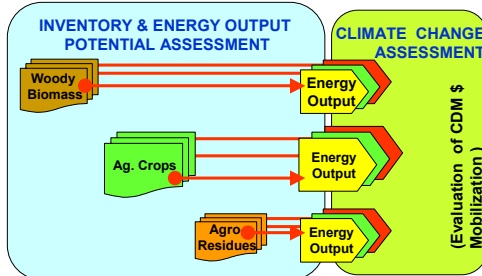
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## AFTEG/BEWP (FY04-06):

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- **Biomass Energy Inventory:** establish potential bio-energy scenarios (carriers and output levels).

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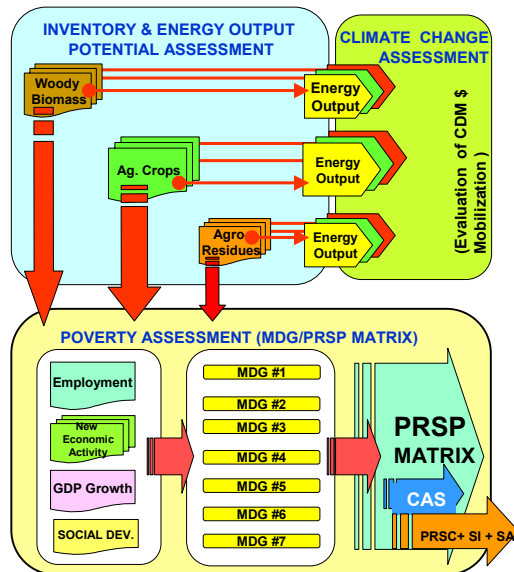
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## AFTEG/BEWP (FY04-06):

# Biomass Energy Inventory & PRSP Assessment



- Biomass Energy Inventory:** establish potential bio-energy scenarios (carriers and output levels).
- Climate Change Assessment:** establish compliance of potential bio-energy scenarios with Agenda 21 and UNCCC and estimate possible mobilization of CC funding.
- Poverty Assessment:** estimate impacts of potential bio-energy scenarios with respect to MDGs and WB poverty alleviation objectives, and elaborate PRSP energy sector coefficients to assist in definition of CASes and operational instruments.



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## Presentation Outline

1. Sustainable Biomass Energy Carriers

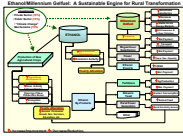
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**5. Moving Biomass Energy Forward**



## Moving BioEnergy Forward

- Upgrade of Analytical and Economic Evaluation Tools
- Medium-to-Long Term Evaluation Frameworks
- Multi-Sectorial & Multi-Disciplinary Work
- Lead Role for Agriculture and NRM Expertise
- Conducive "Policy Frameworks" (Governments)
- Supportive Role for Development Agencies
- Lead Implementation Role for Private Sector
- Mobilization of Clean Development Mechanisms



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# To be continued ...

Thank you.

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