# Ethanol and gelfuel: clean renewable cooking fuels for poverty alleviation in Africa

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***This paper presents a discussion on the potential of ethanol and gelfuel as clean renewable and low-cost household cooking fuels for African countries. The discussion is based on the experience of the "Millennium Gelfuel Initiative (MGI)", a public-private sector partnership shepherded by the RPTES Program of the World Bank in Africa. The paper starts by providing a brief background of the household energy sector in Africa. It then summarizes the objectives, scope and outcomes of the MGI. The possibility to promote rural, agricultural and agro-industrial development and poverty alleviation through the establishment of ethanol production programs in African countries is presented next, and a conceptual developmental model is outlined. The paper then touches on three key implementation concerns: context-specific nature of bioenergy production systems; "fuel vs. food dilemma"; and scale-up challenge. The paper concludes with a summary of a possible implementation framework, including the roles of the private sector, governments and the international development community.***

## 1. Background

Roughly two-thirds of African households, more than 580 million people, depend on woodfuels for their daily cooking and heating needs. International Energy Agency (IEA) projections indicate that by 2030 that number will grow to more than 820 million, equivalent to a 27 % increase. According to FAO, current estimates place total consumption at 452 Mt of wood per annum, or 148 Mt of oil equivalent. It is estimated that close to 50 % of these woodfuels are currently traded in the urban and peri-urban markets, and that woodfuels are being increasingly traded in the rural areas, especially in the Sahelian countries [RPTES, 1997]. It is also estimated that all activities related to woodfuel use amount to an economic value of approximately US$ 6 billion, with charcoal accounting for more that US$ 1 billion of that [FAO, 1999]. The prevailing patterns of forestry resource exploitation in most African countries are destructive and unsustainable, and the use of woodfuels in poorly ventilated spaces poses a disproportionate health hazard for women and children. As population continues to grow across the continent, pressure on existing forest resources will also increase through the clearing of land for agriculture and the higher demand for wood and non-wood forest products.

Over the last decade a series of national and regional reviews of the traditional energy sector were conducted by African governments and independent African energy experts. That work, which was undertaken within the framework of the World Bank's Regional Program for the Traditional Energy Sector (RPTES)[2], resulted in a new agenda for action in the sector with regional political endorsement [GAA/RPTES, 2002]. That Agenda is anchored in the realization that: Africa will remain largely dependent on woodfuels for the foreseeable future; it is the large-scale urban woodfuel commercial supply chains – not rural consumption – that pose the main threat to forest stocks and environmental sustainability; and, petroleum prices are expected to increase over time. The new agenda calls for: (1) rapidly increasing socially and environmentally sustainable woodfuel supply management across the region, through community-driven development (CDD) approaches; (2) continuing to promote woodfuel end-use energy efficiency, but through market-based delivery mechanisms, and with an increased emphasis on reducing "indoor pollution"; and (3) continuing to promote inter-fuel substitution in the household and small and medium enterprise (SME) sectors, with an emphasis on the mainstreaming of clean, renewable and endogenous fuel options.

## 2. The "Millennium Gelfuel Initiative – MGI"

Between 2000 and 2003 the RPTES Program, with funding support from the World Bank's Development Marketplace Program[3], shepherded the Millennium Gelfuel Initiative (MGI), a public-private partnership aimed at adapting and disseminating an existing ethanol-based cooking fuel – gelfuel – for the African household sector [World Bank, 2004]. Gelfuel is based on ethanol produced through the fermentation and distillation of sugars (derived from molasses, sugar cane, sweet sorghum, etc.) or starch crops (cassava, maize, etc.). To produce gelfuel, denatured ethanol is mixed with a thickening agent (cellulose) and water through a very simple technical process, resulting in a combustible gel. The gelfuel is thus renewable and can be locally produced in most countries in Africa. Jellified and/or solidified liquid fuels (kerosene and ethanol) have been in use since World War II, when they were used by soldiers for cooking. More recently, and until the MGI, several variations of jellified ethanol have been produced in small volumes in various countries for up-market recreational (camping, barbecue fire-lighting, etc.) and catering applications. Within the MGI the private sector, represented by the Millennium Gelfuel Company (MGC, Zimbabwe), provided the fuel and stove design R&D capacity and marketing knowledge to package a commercially viable product. RPTES contributed with its knowledge of the household energy sector and the mobilization of its network of national RPTES teams to conduct a series of in-country consumer acceptability tests, stove adaptation work and production and/or market feasibility studies.

*2.1. MGI objectives*

The overall objective of the MGI was to promote the development of a locally-based renewable energy production model for African countries capable of delivering "low cost, safe and clean modern energy services" to the household sector while: generating sustainable rural employment and incomes; promoting rural and agricultural development; reducing the dependence on traditional woodfuels; and, providing for viable alternatives to imported modern fuels. Within that context the MGI set out to: (1) improve the MGC's existing gelfuel concept; (2) reduce its production, packaging and marketing costs; (3) develop efficient low-cost stoves for the gelfuel and attempt to adapt existing woodfuel stoves for its use; (4) assess the commercial viability of the gelfuel in several representative African household energy markets through market potential assessments and consumer acceptability surveys; (5) assess the potential for the local production and marketing of gelfuel in the Sub-Saharan Africa region, through a geo-economic assessment of the potential to increase the production of ethanol (principal gelfuel ingredient) in the region; and, (6) identify potential follow-up investment projects for implementation. While the MGI was focused on the application of gelfuel for cooking, the development of safe "direct ethanol" cook stoves – to further minimize fuel costs – and other ethanol and/or gelfuel appliances for lighting, refrigeration and space-heating was envisaged as essential follow-up work.

*2.2. Summary of achievements and outcomes*

The MGI and its subsequent follow-up work on direct ethanol cooking use has achieved the following main concrete results to date (June 2004) [RPTES, 2004].

1. Reduction by more than 50 % of the original cost of the gelfuel as a result of improvements in its combustion characteristics and end-use energy efficiency, and improvements in its production process and packaging systems. Current cost of ethanol in countries studied ranged between US$ 0.15 and US$ 0.35 per liter (l). Actual or estimated retail price of the gelfuel (subject to country-specific production conditions) lies within the range of US$ 0.30-0.70/l, with an end-use energy equivalence of 1:1 to 1:1.2 based on volume, with respect to kerosene.
2. Development and marketing of 5 low-cost/high-efficiency gelfuel stove models (US$ 2-20) and of a gelfuel burner (US$ 0.50-4.0) which can be retrofitted into a wide range of existing African wood and charcoal cooking stoves (Figure 1).
3. Establishment and monitoring of the competitiveness of gelfuel and ethanol vis-à-vis other household fuels in various countries in Africa (Table 1).
4. Establishment of the environmental comparative advantages of the gelfuel vis-à-vis other household fuels through $CO_2$ emission testing (Table 2).
5. Confirmation of the consumer acceptability of the gelfuel and/or ethanol in the household energy market through consumer tests and marketing assessments conducted in Ethiopia, Madagascar, Malawi, Mali, Senegal, Mozambique, Senegal, South Africa and Zimbabwe [Tilimo and Kassa, 2004].
6. Private-sector gelfuel plants were established and are in operation in Durban, South Africa (200,000 l/month production capacity), Lilongwe, Malawi (25,000 l/month production capacity), and Harare, Zimbabwe (20,000 l/month production capacity)[4].
7. Governments of more than 15 African and 5 Latin American countries have already expressed interest in the local production and marketing of gelfuel or direct ethanol for household applications.
8. Private-sector gelfuel or ethanol projects have been identified and are under different stages of preparation in Benin, Ethiopia, Madagascar, Malawi, Mozambique, Senegal and South Africa. Additionally, the European group "Energia-Transporti-Agricultura (ETA)"[5] is preparing a pilot rural energy project which includes a gelfuel component, for Guangdong Province, China.
9. Development and marketing of a low-cost (US$ 15) high-efficiency, non-spill, direct ethanol stove (based on the adaptation of the standardized gelfuel burner)[6]. Producer performance tests and consumer feedback indicate that the cost of cooking with the new Greenheat direct ethanol stove is 50 % lower than with the gelfuel option, as the effect of the better stove efficiency gets further compounded by the lower cost of the direct ethanol (approximately 70 % of the cost of gelfuel). Under this scenario, direct ethanol cooking is competitive even with fuelwood and charcoal in all countries studied (see Table 1). While the direct ethanol does not appear to offer the same level of safety provided by the gelfuel option, its dramatic reduction in costs should have a significant impact on the penetration of direct ethanol in the market in the near future.

In addition to the above specific achievements, the MGI has also stimulated a broad discussion among international energy experts, national policy-makers, the private sector, the donor community, academia, and NGOs on the opportunities for and issues concerning ethanol and ethanol-based fuels for the delivery of modern household energy services (cooking, lighting, heating and refrigeration) in Africa – and other developing areas of the world. The awareness, knowledge and interest created by that discussion has contributed to the inclusion of ethanol, gelfuel

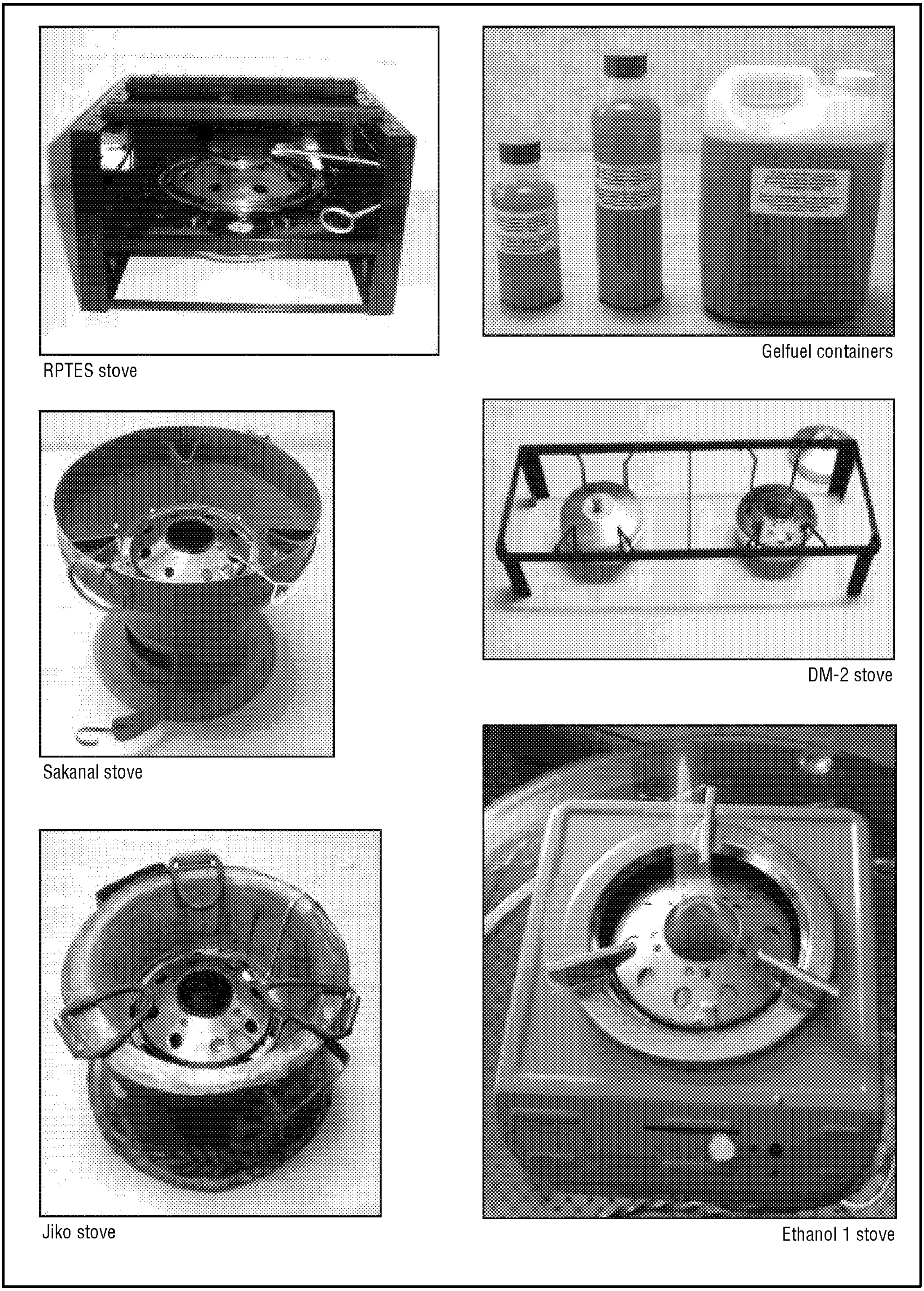


Figure 1. Millennium Gelfuel Initiative: gelfuel and ethanol stoves

**Table 1. Comparative cost of household cooking fuels in selected countries (2004)[1]**

| Fuel/stove type | US $ household cooking costs per month[2] | | | | | |
|---|---|---|---|---|---|---|
| | Ethiopia | Malawi | Mozambique | Senegal | South Africa | Zimbabwe |
| LPG burner | 30.21 | 18.16 | 7.62 | 6.11 | 12.56 | 13.02 |
| Kerosene (W) | 10.42 | 12.31 | 8.21 | 7.52 | 11.54 | 19.23 |
| Kerosene (P) | 10.32 | 12.20 | 8.13 | 7.46 | 11.44 | 19.06 |
| Charcoal (T) | 7.74 | 11.26 | 5.33 | 6.02 | 15.88 | 7.15 |
| Charcoal (I) | 5.29 | 7.69 | 3.64 | 4.11 | 10.85 | 4.88 |
| Fuelwood (T) | 7.02 | 8.94 | 4.20 | 4.10 | 16.81 | 2.52 |
| Fuelwood (I) | 4.86 | 6.19 | 2.91 | 2.84 | 11.63 | 1.75 |
| Millennium Gelfuel (CR) | 8.81 | 15.52 | 6.41 | 6.41 | 6.41 | 6.41 |
| Direct ethanol (CR)[3] | 3.30 | 5.51 | 2.40 | 2.40 | 2.40 | 2.40 |

**Notes**

1. Does not include purchase cost of stoves.
2. 75 meals/month = 2.5 meals/day × 30 days/month.
3. The significantly higher performance efficiency (50 %) of the direct ethanol has not yet been independently verified. Hence, figures in the table incorporate only an efficiency gain of 20% and a cost differential per l of 30 % in favor of the ethanol.

**Table 2. Comparison of $CO_2$ emissions from the preparation of a "standard meal"**

| Fuel | Stove type | Amount of fuel used (kg) | $CO_2$ production (g/kg)[1] | $CO_2$ emission (g/meal) | Comparative emission 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 |
| Millennium Gelfuel | Cover + regulator | 0.310 | 1533 | 475 | 100.0 |

Source: [BTG, 2001]

**Note**

1. Values for cooking test only, not entire life-cycle emissions.

and other biofuels in African energy policy agendas at the national (Benin, Burkina Faso, Gambia, Guinea-Bissau, Senegal, Madagascar, Mali, Malawi, Mozambique, South Africa, Zambia, etc.) and regional levels (NEPAD, EUMOA, CILSS, SADC, RPTES-GAA), and to the emergence or crystallization of a number of parallel and – in some cases – competing private sector gelfuel and ethanol R&D efforts and projects (TH Company, South Africa; ENDA-TM, Senegal; FINCHAA "K-50", Ethiopia; M&S Gelfuel, Malawi; Iacona-FINCHAA, Ethiopia; and Blue Wave Stove and "80nol Fuel", Malawi).

## 3. Bioenergy and the MDGs: a potential "poverty alleviation engine" for Africa

While bio-energy has captured renewed attention among donors and policy-makers, its potential to contribute towards the Millennium Development Goals (MDGs) has yet to be tapped[7]. Ethanol offers an excellent platform to simultaneously advance various MDG objectives. The scale-up of ethanol production in Africa would require the establishment of new crop plantations, distilleries and other agro-industrial facilities. That would result in new agriculture and agro-industrial jobs (crops, distillation, processing of ethanol by-products and gelfuel production) and in new products (energy, fertilizers, animal feed, etc.) with guaranteed market absorption. The employment would drive up rural incomes, improving access to health and education, and to other commercial modern energy services. Under adequate and socially responsible policy frameworks, a sustainable process of local rural economic growth and diversification would gradually develop with broad poverty alleviation impacts. The scale of this potential "sustainable model for local rural development" would be proportional to the level of biofuel production.

The "economic mechanisms" in operation here are: (1) linking the commercial demand for traditional and modern fuels for household – and other sector – applications with the existing local potential capacity (land, labor, water, knowledge, etc.) to produce alternative modern fuels; and (2) re-orienting the financial resource flows away from "commodity purchase" (energy imports) towards "capital investments" (biofuel production facilities) and "welfare" build-up (employment and income generation, and a suite of other quantifiable positive macro- and micro-economic, social and environmental externalities) (Figure 2). While the depth and persistence of foreign exchange problems in most African countries have been linked to petroleum importation dependency[8], the Brazilian PROALCOOL program is estimated to have leveraged $ 48 billion in avoided hard currency expenditures on the basis of a $ 5 billion investment [Vieira de Carvalho, 2003].

To place this "development vision" in context it is necessary to consider that the current total production of fermentation ethanol in Africa is less than 500 million (M) l/year. In order to meet just 30 % of the current African household energy consumption for cooking with gelfuel, the production of ethanol would have to be scaled up to some 10 billion (G) l/year, resulting in close to 12 Gl/year of gelfuel. That would require the establishment of some 14 Mha under new crops and more than 300 large-size new distilleries (e.g., 30 Ml/year capacity), and would generate between 3.2 and 5.4 million new full-time rural jobs and about 100,000 agro-industrial jobs [Phillips, 2002]. Additionally, such a program could result in the commercially viable production of a number of by-products such as: (1) about 1.25, 0.25 and 1.87 Mt equivalent of nitrogen, phosphorus and potassium fertilizers, respectively; (2) 810,000 t of dried brewer's yeast, suitable for human consumption and animal feed; (3) between 4,500 and 7,500 MW of cogeneration capacity; and (4) between 7 and 28 Mt/year of carbon abatement, depending on the power generation technology used [Williams, 2002]. While these indicative figures suggest that it would be necessary to set up large agro-industrial enterprises, today's ethanol distillation and gelfuel production technologies are flexible in terms of scale, allowing even for the implementation of systems as small as 100,000 l ethanol/year suitable for community-based projects.

## 4. Important considerations for implementation

- *Context-specific nature.* The viability of producing any forms of bioenergy is highly subject to site- and project-specific conditions: agro-climatic variables (solar radiation, soil quality and productivity, rainfall, temperature, etc.), the availability of land and critical production inputs (labor, water, etc.), existence of adequate infrastructure (transportation of inputs and then production from plant to markets), and technical-economic conditions (local cost of inputs, cost of technological transfer and adaptation, cost of maintenance, etc.) [Trindade, 2003]. Hence, bioenergy is neither a global panacea nor a blanket energy solution.
- *The "fuel versus food" dilemma.* The scale-up of agricultural crops for bioenergy can and *should only be done without competing with food production* and without resulting in incremental forest land clearing. Table 3 presents summarized estimates of the land area in hectares (ha) that would be required in Africa to set up *new plantations* (sugar cane, sweet sorghum, cassava, maize and sweet potatoes) equivalent to scaling up crop production by 25 % and 50 % over actual 2000-01 harvest levels [Utria, 2002]. These scenarios are based on a "constrained projection" food security assessment methodology where up-scaling potential is strictly subject to the availability of "suitable" and "very suitable" idle land and other necessary production inputs. As shown in Table 3, even a 50 % scale-up would be possible without necessarily creating food/energy trade-off problems. Adequate policy and regulatory frameworks would nevertheless be required to ensure that no such conflicts arise. This is an area where international agency policy support and implementation monitoring and evaluation would be extremely valuable. Table 3 also shows how much new full-time agricultural employment (millions of jobs) would be created and the volume of gelfuel production that could be achieved (millions of liters) from only the incremental crop production, for those two scenarios[9]. Other benefits would include providing for ecosystem rehabilitation over large tracts of land, reducing biomass fuel-related deforestation and/or reducing oil import expenditures as direct ethanol and/or gelfuel substitutes for woodfuels and/or imported kerosene.
- *The scale-up challenge.* There is no question that expanding the production of ethanol in Africa even to meet just one-third of the current household energy demand would be a challenge. Then, looking down the line, ethanol could be utilized for motor vehicle gasoline and diesel blending and/or substitution[10], for independent/remote power generation and as an input for numerous other industrial products (plastics, paints, cosmetics, beverages, etc.). While doing so would dramatically increase the size of the challenge, it would also multiply its associated economic and social development opportunities and impacts. Harnessing Africa's enormous bioenergy potential should be viewed as a leading item on the region's broader sustainable development agenda and a cross-sectoral theme, rather than a narrow energy sector issue. To this effect it is always useful to remember that Brazil – a single country – was able to scale up its ethanol production from about 1 Gl/year in 1974 to 10 Gl/year in 1979 and to 14 Gl/year by 1989 [Moreira and Goldemberg, 1999].

## 5. An implementation framework: a private/public sector partnership

RPTES has estimated that the total required investments (agricultural and agro-industrial) for a 12 Gl/year ethanol and Millennium Gelfuel program in Africa (10 Gl/year ethanol) would be of the order of US$ 0.60 to US$ 0.70 per l/year of installed ethanol production capacity, thus totaling somewhere between US$ 7.2 and US$

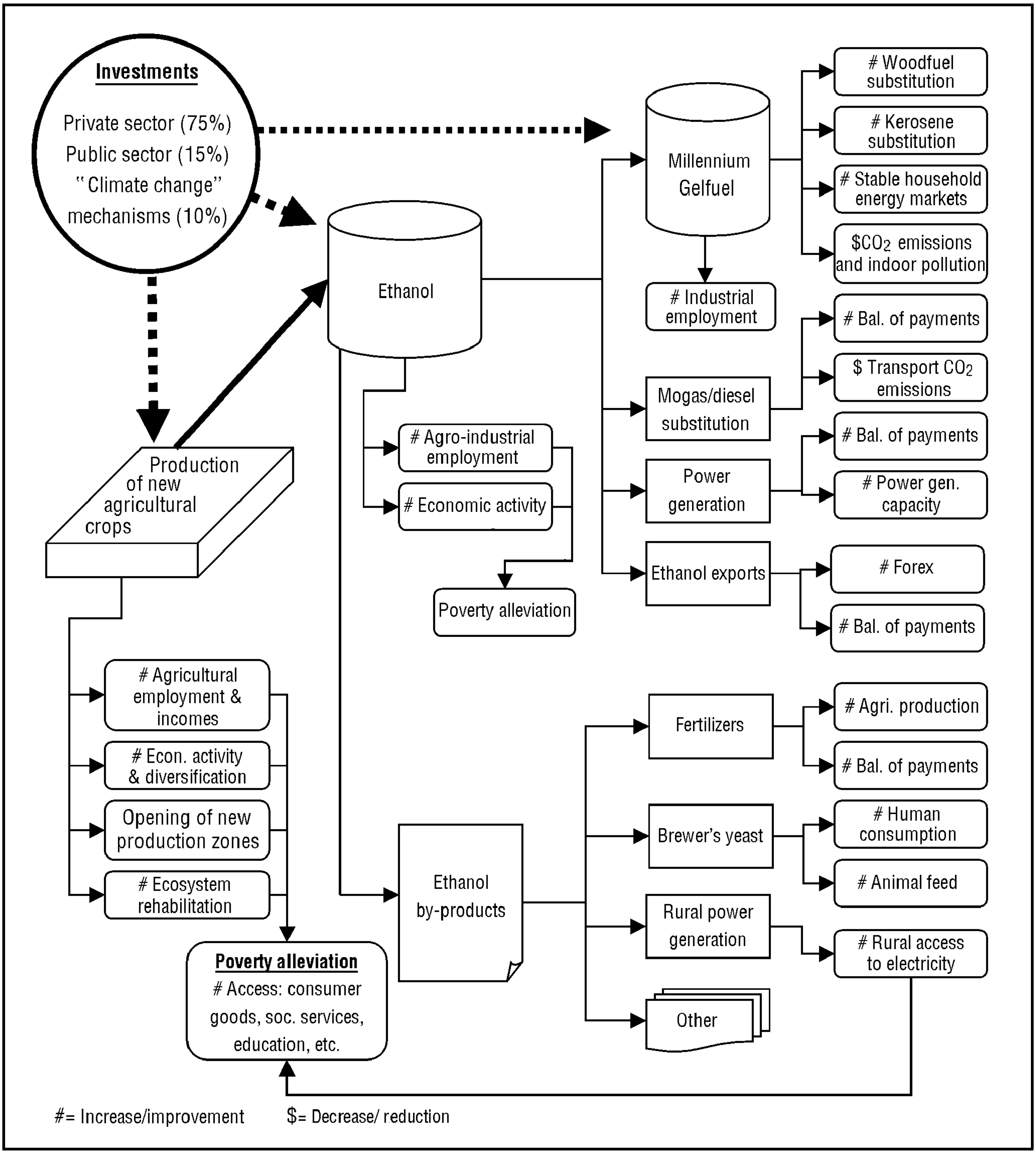


Figure 2. Ethanol/Millennium Gelfuel: a sustainable engine for poverty alleviation

Source: Modified from Utria, 1980

8.4 billion spread over 10 to 15 years [Utria and Williams, 2002]. Given that ethanol and Millennium Gelfuel production would be done on a commercially viable basis, the implementation of investment projects and/or programs should be based on strategic partnership between the private and public sectors, with some donor community support (infrastructure development, technical assistance, capacity development and carbon financing).

The *private sector* would be responsible for mobilizing up to 75 % of the financing for the investment components (agriculture, distillation capacity and agro-industrial systems) and should provide the necessary management capacity.

Governments would: (1) establish "private sector enabling environments" – conducive fiscal and legal regulation, basic rural infrastructure, etc.; (2) lay down the necessary policy frameworks to ensure a social and environmentally responsible implementation process; and (3) underwrite new rural infrastructure investments (assets and services) and the rural capacity development that will

**Table 3. Land requirements, rural employment and gelfuel production from 25 % and 50 % increase in agricultural crops in Africa[1]**

| 25% production increase over 2000 crop levels | Sugar crops | | | | | | Starch crops | | | | | | | | | All crops | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sugar cane | | | Sweet sorghum | | | Cassava | | | Maize | | | Sweet potatoes | | | Totals | | |
| | (2) | (3) | (4) | (2) | (3) | (4) | (2) | (3) | (4) | (2) | (3) | (4) | (2) | (3) | (4) | (2) | (3) | (4) |
| **Region** | Land ($10^6$ ha) | Jobs ($10^6$) | Gelfuel ($10^6$ l) | Land ($10^6$ ha) | Jobs ($10^6$) | Gelfuel ($10^6$ l) | Land ($10^6$ ha) | Jobs ($10^6$) | Gelfuel ($10^6$ l) | Land ($10^6$) | Jobs ($10^6$) | Gelfuel ($10^6$ l) | Land ($10^6$ ha) | Jobs ($10^6$) | Gelfuel ($10^6$ l) | Land ($10^6$ ha) | Jobs ($10^6$) | Gelfuel ($10^6$ l) |
| Central Africa | 0.1 | 0.0 | 77.7 | 0.4 | 0.2 | 101.9 | 0.6 | 0.2 | 1,048.1 | 0.7 | 0.2 | 321.3 | 0.05 | 0.02 | 33.1 | 1.7 | 0.7 | 1,582.1 |
| Eastern Africa | 0.1 | 0.1 | 364.3 | 0.8 | 0.4 | 251.4 | 0.8 | 0.4 | 1,042.3 | 2.7 | 0.9 | 1,658.0 | 0.3 | 0.1 | 229.6 | 4.8 | 1.8 | 3,545.5 |
| Southern Africa | 0.1 | 0.0 | 486.2 | 0.1 | 0.0 | 45.1 | 0.0 | 0.0 | 0.0 | 0.9 | 0.3 | 1,342.6 | 0.004 | 0.002 | 2.1 | 1.1 | 0.4 | 1,876.0 |
| Western Africa | 0.0 | 0.0 | 74.5 | 3.0 | 1.3 | 930.0 | 1.2 | 0.5 | 2,175.8 | 1.8 | 0.6 | 1,109.1 | 0.1 | 0.1 | 112.0 | 6.2 | 2.5 | 4,401.4 |
| Total | 0.3 | 0.1 | 1,002.6 | 4.3 | 1.8 | 1,328.4 | 2.6 | 1.1 | 4,266.1 | 6.1 | 2.1 | 4,431.0 | 0.5 | 0.2 | 376.8 | 13.8 | 5.4 | 11,404.9 |
| **50% increase** | | | | | | | | | | | | | | | | | | |
| Central Africa | 0.1 | 0.1 | 155.4 | 0.8 | 0.3 | 203.7 | 1.1 | 0.5 | 2,096.1 | 1.4 | 0.5 | 642.6 | 0.1 | 0.0 | 52.2 | 3.4 | 1.4 | 3,150.1 |
| Eastern Africa | 0.2 | 0.1 | 728.5 | 1.7 | 0.7 | 502.8 | 1.6 | 0.7 | 2,084.5 | 5.4 | 1.9 | 3,316.0 | 0.7 | 0.3 | 459.2 | 9.6 | 3.7 | 7,091.0 |
| Southern Africa | 0.2 | 0.1 | 972.3 | 0.1 | 0.1 | 90.2 | 0.0 | 0.0 | 0.0 | 1.9 | 0.7 | 2,685.2 | 0.01 | 0.00 | 4.2 | 2.2 | 0.8 | 3,751.9 |
| Western Africa | 0.05 | 0.02 | 148.9 | 6.1 | 2.5 | 1,860.0 | 2.4 | 1.0 | 4,351.5 | 3.6 | 1.3 | 2,218.3 | 0.3 | 0.1 | 223.9 | 12.3 | 5.0 | 8,802.7 |
| Total | 0.5 | 0.3 | 2,005.1 | 8.7 | 3.6 | 2,656.8 | 5.1 | 2.3 | 8,532.2 | 12.2 | 4.3 | 8,862.1 | 1.0 | 0.4 | 739.5 | 27.5 | 10.8 | 22,795.7 |

Source: Phillips, 2002.

**Notes**

1. Projections based on 25 and 50 % 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 reflects 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, 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 production.

be required to underpin large scale-ups in agricultural production systems.

The successful implementation of such a program would also require active participation by the *donor community* (multilateral and bilateral). In the short-term phase, it would be essential to: (1) support "pilot/demonstration" projects in representative countries in Africa, through which key implementation issues could be tested and fine-tuned; and, (2) assist governments in the elaboration of the necessary multi-sectoral policy frameworks (energy, agriculture, rural development, trade, etc.). Subsequently, in the scale-up phases, the donor community could play a key role in the mobilization of: (1) flexible "climate change" funding instruments (GEF, carbon funds, bilateral environmental programs, etc.) in support of the expected private sector investments; (2) conventional concessional financing instruments to underwrite public investments on the new rural infrastructure and capacity development; and, (3) financing support to the private sector (IFC, investment corporations, etc.). ■

#### Notes

1. The content of the paper is the responsibility of the author and does not necessarily constitute an official position of the World Bank Group
2. RPTES was established in 1993 by the World Bank, with support from the Directorate General for International Cooperation (DGIS) of the Netherlands. The work of the RPTES was completed in 2004 with the mainstreaming of the traditional energy agenda within the World Bank and the transfer of its regional capacity-building and knowledge management work program to the "Biomass Energy Program -- BEP" of the West African Economic and Monetary Union (UEMOA).
3. For information on the Development Marketplace Program: www.developmentmarketplace.org
4. The gelfuel plant in Zimbabwe was temporarily closed in May 2004 owing to the unavailability of ethanol supplies from the Triangle distillery and to political disturbances and civil unrest where the plant is located. The gelfuel plant will resume operations as soon as the situation stabilizes.
5. Energia-Transporti-Agricultura -- ETA-Florence, Italy (www.eta-florence.org).
6. This development was completed in 2003 by "Greenheat-South Africa", ex-MGC Zimbabwe.
7. For a more detailed discussion on energy and the MDGs, see [DfID, 2000, Annex II].
8. See [AFREPREN, 2000].
9. 1 l of ethanol results in the production of 1.2 l of gelfuel. Thus, 11.4 Gl and 22.7 Gl of ethanol are equivalent to 13.6 Gl and 27.3 Gl of gelfuel, respectively.
10. For more information, see [Fulton, 2004].

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