International Seminar on Bioenergy & Sustainable Rural Development

Casa de Gobierno
Paseo de la República 1500 Col. Oviedo Mota

Morelia, México
26-28 June 2003

SEMINAR PROCEEDINGS

ANES

Bioenergy
LAMNET

The International Seminar of Bioenergy and Sustainable Rural Development was held in Morelia, Mexico, from June 26 to 28 2003. It was organized jointly by the Latin American Thematic Network on Bioenergy (LAMNET), the Center for Ecosystem Research (CIECO) from the National Autonomous University of Mexico, the Food and Agriculture Organization of the United Nations (FAO), the National Association for Solar Energy (ANES) and the State Government of Michoacan, Mexico.

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Coordination: WIP, Germany
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Updated information on this workshop is available at http://www.bioenergy-lamnet.org, http://bioenergia.oikos.unam.mx and http://www.anes.org.

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INTERNATIONAL SEMINAR ON BIOENERGY AND SUSTAINABLE RURAL DEVELOPMENT

OBJECTIVES

To promote and improve the knowledge of the Bioenergy potential in Mexico and in the world as motor for sustainable rural development, agricultural and forestry diversification and the improvement of national and international environmental quality.

SUMMARY

Biomass is a source of clean and renewable energy with great potential for development in Mexico and in the world. Efficiently used, Biomass can significantly contribute to sustainable rural development and employment generation as well as to local and global environment conservation due to its large variety of potential applications and its abundant local availability. From the agricultural and forestry perspectives, bioenergy opens new development opportunities and promotes the creation of rural infrastructure.

The international seminar on bioenergy and sustainable rural development will gather for the first time 160 specialists in Mexico, coming from the academic, private, government and industrial sectors. An overview of the current conditions of biomass energy use in Mexico and in the world will be presented, focusing on the availability of resources, bioenergy conversion technologies and the development of policies for the promotion and financing of bioenergy. The Seminar will also act as an interdisciplinary forum to establish contacts and co-operation projects in the various fields of biomass and bioenergy applications.

ORGANIZING COMMITTEE

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SEMINAR PROGRAMME

THURSDAY, June 26 2003

08:30 Registration

09:00 Opening Session

Antrop. Lázaro Cárdenas Batel, Governor of the State of Michoacán

Sr. Norman Bellino, FAO Representative in México

Dr. Alberto Ken Oyama Nakagawa, Director del Centro de Investigaciones en Ecosistemas (CIECO) – UNAM

Dr. Peter Helm, Co-ordinator Latin America Network on Bioenergy (LAMNET) (Spanish) **10**

Dr. Eduardo Rincón, Presidente de la Asociación Nacional de EnergÍa Solar (ANES)

M. en C. Guillermo Vargas Uribe, Secretario de Urbanismo y Medio Ambiente del Estrado de Michoacán

Dr. Exequiel Ezcurra, Presidente del Instituto Nacional de Ecología

Dr. Omar Masera Cerutti, Coordinator Científico de la Reunión Internacional sobre Bioenergía (Spanish) **13**

Lic. Enrique Bautista Villegas, Secretario de Planeación y Desarollo Estatal

09:30 Coffee Break

09:40 **Plenary Presentation** **15**
A Global Perspective on Bioenergy
Roberto Moreira, CENBIO, Brazil

10:10 Plenary Presentation
Bioenergy Technologies
Giuliano Grassi/Francesco Cariello, EUBIA

10:40 Plenary Presentation
Bioenergy and Sustainable Rural Development
Gustavo Best, FAO

11:10 Discussion
Chair: Rainer Janssen, WIP - Renewable Energies, Germany

11:30 Coffee Break

12:00 Coffee Break

12:30 Plenary Presentation
Ethanol/Gelfuel: Bioenergy and Rural Development
Boris Utria, World Bank

13:00 Plenary Presentation
The Brazilian Experience on Bioenergy
Luiz Horta Nogueira, ANP, Brazil

13:30 Plenary Presentation
Financing Bioenergy Projects
Catherine Vallee, UNDP

14:00 Discussion
Chair: Gustavo Best, FAO

14:30 Lunch

16:00 Poster Session

16:30 Conference Closing and Conclusion

Seminar Organisers Profile

OPENING SESSION

International Seminar on Bioenergy and Sustainable Rural Development
- 5th LAMNET Project Workshop – Mexico 2003

LAMNET – La Red Global en Bioenergia
Cooperación Internacional en Bioenergía

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Estimado Excelentísimo Gobernador del Estado de Michoacán,
Estimados honorables participantes de esta reunión.

Es para mí una gran satisfacción tener la oportunidad de dirigirme a ustedes, para introducirles en el tema: LAMNET

En primer lugar, me gustaría empezar por aclarar ¿Qué entendemos por LAMNET?

LAMNET es una red temática global creada entorno al campo de la bioenergía que se extiende inicialmente por América Latina, pero que se proyecta mundialmente a través de sus programas de cooperación internacional.

LAMNET es una red global formada por 48 instituciones procedentes de 24 países.

Es un foro trasnacional para la promoción del uso sostenible de las bioenergías. (Políticas y Tecnologías bioenergéticas).

LAMNET fue fundada por la Comisión Europea dentro del programa “Confirmación del Papel Internacional de la Investigación Comunitaria” (Enero 2002- Diciembre 2004).

Se encuentra coordinado por WIP, Alemania, asociado con ETA-Energia Trasporti Agricoltura, Italia y la Asociación Europea de la Industria de la Biomasa, EUBIA. Las organizaciones de América Latina CENBIO; Brasil y UNAM, Méjico actúan como puntos de apoyo en aras de una buena coordinación.

Asiste en la elaboración de recomendaciones para el desarrollo y puesta en práctica de políticas de promoción de la biomasa y de la bioenergía, así como, en la identificación de los usos comerciales y las tecnologías fiables aplicadas mundialmente en el ámbito de la biomasa.

LAMNET asume como asuntos prioritarios:

-El análisis del marco de las políticas energéticas,

-La valoración de las demandas de energía y de recursos de la biomasa.

-La evaluación de los sistemas y tecnologías disponibles, así cómo, el desarrollo y la aplicación de políticas y tecnologías en orden a promocionar la bioenergía.

LAMNET, a través de su programa de cooperación internacional, es el medio ideal para la creación y realización de proyectos basados en la energía renovable en la esfera de la biomasa. Entre sus proyectos de cooperación en tecnologías bioenergéticas cabe mencionar entre otros:

- La cogeneración de Calor y Electricidad a partir del "sugar cane bagasse", así como de otros recursos de la biomasa.
- Aplicación a gran escala de la producción de bioetanol a partir de la caña de azúcar, el sorghum dulce y los residuos agroforestales;
- La creación de un mercado global de bioetanol.
- La promoción de sistemas de bioenergía descentralizados a mediana y pequeña escala, entre otros:
- Tecnologías avanzadas en peletizado.
- Directrices en las políticas de promoción de la Bioenergía:

Mayor participación en los eventos internacionales relacionados con las Energías Renovables y el Desarrollo Sostenible, como por ejemplo:

- Taller de trabajo OECD en Biomasa y Agricultura, Viena, Junio 2003

Establecimiento de contactos con organizaciones, instituciones e iniciativas multilaterales

- Iniciativa europea de Energía para la Erradicación de la Pobreza y el Desarrollo Sostenible.

Supervisión y apoyo a las iniciativas de políticas nacionales y regionales

- BRASIL: PROINFA – Programa para el fomento de Fuentes Alternativas a la Electricidad.

Eventos llevados a cabo por LAMNET en el Proyecto de 2002, entre otros:

- Seminario Internacional sobre Bioenergía y Desarrollo Rural Sostenible
- Segundo Seminario Internacional sobre Energía en la agroindustria de la caña de azúcar
- Taller de Trabajo con motivo de la Segunda Conferencia Mundial y Exhibición Tecnológica sobre la Biomasa para la Protección de la Energía, la Industria y el Clima

LAMNET ACTIVIDADES DE DIFUSIÓN:

- Proyecto LAMNET-Página Web: www.bioenergy-lamnet.org
- Proyecto LAMNET-Boletín Informativo (2 temas por año). Por ejemplo:
- Folleto con motivo de la Cumbre Mundial del Desarrollo Sostenible, Johannesburgo, Sudáfrica.
- Folletos temáticos sobre Bioenergía
    - Modernos complejos de bioenergía para pueblos
    - Biocombustible refinado – Pelets y Briquettes
    - Microdestilerías para la producción descentralizada de bioetanol.

MIEMBROS DE LAMNET - 48 miembros (situación en Junio 2003): América Latina, África, China, Europa.

MIEMBROS ASOCIADOS DE LAMNET

Los miembros asociados:

- Serán informados con regularidad de los eventos y actividades del proyecto LAMNET.
- Están invitados a utilizar las plataformas de difusión establecidas en el marco del proyecto LAMNET

En resumen el objetivo principal de LAMNET: es identificar las tecnologías actualmente disponibles, eficientes, de precios competitivos, que proporcionen la oportunidad de convertir la biomasa en servicios energéticos en América Latina, Europa, África y China.

Además la red LAMNET identifica y promueve grandes oportunidades de cooperación internacional, transferencia de tecnología y joint ventures en el campo de las tecnologías bioenergéticas.

Es el punto de referencia para la promoción de la bioenergía y el lugar al que hay que acudir para llevar a cabo actividades relativas al desarrollo sostenible de las energías renovables, dada su estrecha colaboración con organizaciones, instituciones e iniciativas multilaterales existentes en este campo.

Espero que esta pequeña introducción les sirva para tener una idea general de lo que es LAMNET y de cuál es el servicio que presta al desarrollo constante de las energías renovables.

Les agradezco sumamente la atención. Continuaremos en estrecho contacto y seguiremos buscando la realización de proyectos conjuntos con Méjico, en general y especialmente con el Estado de Michoacán.

OPENING SESSION

International Seminar on Bioenergy and Sustainable Rural Development
- 5th LAMNET Project Workshop – Mexico 2003

DISCURSO INAUGURACIÓN SEMINARIO INTERNACIONAL SOBRE BIOENERGÍA Y DESARROLLO RURAL SUSTENTABLE

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Sr. Gobernador de Michoacán Antrop. Lázaro Cárdenas Batel
Distinguidos miembros del Presidium
Distinguidos invitados especiales a este evento
Estimados participantes de esta reunión, muy particularmente todos Uds que se han desplazado desde numerosos puntos del planeta para asistir a este evento
Señores y Señoras

Nos encontramos actualmente ante una crisis profunda del modelo de desarrollo dominante, que se manifiesta en crecientes desigualdades socioeconómicas y altos impactos de tipo ambiental. El cambio climático global que está teniendo efecto por la acción humana sobre el planeta es tal vez una de las manifestaciones más evidentes del agotamiento de este modelo de desarrollo.

Esta crisis del modelo de desarrollo es más acentuada en el sector rural, que se encuentra crecientemente marginado y empobrecido. En este sector es urgente fortalecer las economías locales y encontrar fórmulas innovadoras para frenar la migración, crear empleo y actividades económicas mediante el uso sustentable de los recursos naturales.

Dentro del ámbito energético es impostergable un cambio de paradigmas. La energía debe dejar de ser un pesado lastre ambiental debido a la dependencia excesiva de los combustibles fósiles, para convertirse en uno de los pivotes centrales, “un medio para” el desarrollo sustentable.

Un aporte fundamental en este cambio de paradigmas, es la transición a las fuentes renovables de energía, y dentro de ellas al uso más extendido de la bioenergía, es decir el aprovechamiento de la biomasa como fuente de energía.

La bioenergía es una fuente de energía renovable y limpia que cuenta con un gran potencial de desarrollo en México y a nivel internacional. Se considera actualmente uno de los combustibles claves para hacer la transición de los combustibles fósiles hacia las fuentes de energía renovable.

La bioenergía tiene un sin fin de aplicaciones: Se puede quemar de forma directa –como leña o carbón o bagazo para producir calor y electricidad-, convertir a combustibles líquidos –como el etanol, que reemplaza a la gasolina o el biodiesel-, o convertir en combustibles gaseosos, como el biogas o gas de síntesis para mover turbinas y motores-. Puede ser fuente de hidrógeno para las celdas de combustible que se usan ya en los medios de transporte.

Por su versatilidad de aplicaciones, y su disponibilidad local, utilizada eficientemente la bioenergía presenta un gran potencial para contribuir al desarrollo rural sustentable, para la generación de empleos y para mejorar las condiciones ambientales a nivel local y global. Desde el punto de vista del sector agrícola y forestal, la bioenergía abre nuevas oportunidades de desarrollo y de creación de infraestructura rural.

La Reunión Internacional sobre Bioenergía y Desarrollo Rural Sustentable tiene su génesis en estas premisas fundamentales. Conjunta por primera vez en México más de 80 especialistas en el tema a nivel mundial.

Este esfuerzo ha sido posible gracias a la colaboración y esfuerzo de cinco instituciones: el Gobierno del Estado de Michoacán, quién nos ha recibido en esta, su casa. La Red Temática Latinoamericana sobre Bioenergía (LAMNET), la Organización para la Agricultura y la Alimentación (FAO), la Universidad Nacional Autónoma de México, a través del Centro de Investigaciones en Ecosistemas y la Asociación Nacional de Energía Solar.

Durante dos días, examinaremos la situación actual y el potencial futuro de la bioenergía tanto a nivel internacional como en México, incluyendo aspectos de acceso a recursos, tecnologías de conversión y políticas de promoción y financiamiento a esta fuente de energía, como motor para un desarrollo rural sustentable y una diversificación agrícola y forestal.

La Reunión servirá también como un foro interdisciplinario para iniciar contactos y proyectos de colaboración en las diversas áreas de aplicación de la biomasa como fuente de energía.

Particularmente, se espera identificar y promover proyectos concretos de uso eficiente y sustentable de la bioenergía para el Estado de Michoacán, uno de los estados de la República Mexicana con más posibilidades en este sentido.

Es crucial trabajar por un futuro distinto para este planeta y particularmente para este Estado, un futuro que conjunte oportunidades económicas, equidad social y un uso sustentable de nuestros recursos naturales, particularmente de nuestros los recursos energéticos. Los invito a todos para que encontremos en esta Reunión una fuente de reflexiones, ideas, experiencias concretas, y por qué no, sueños para lograrlo.

Muchas gracias!

PLENARY SESSION

International Seminar on Bioenergy and Sustainable Rural Development
- 5th LAMNET Project Workshop – Mexico 2003

POLICIES FOR PROMOTION OF NEW AND RENEWABLE SOURCES OF ENERGY

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ABSTRACT

New and renewable sources of energy have been considered as an alternative to conventional sources for thirty years. In the last ten years concern with global pollution has been considered as one more positive factor in favor of their use. Even so, their participation in the world primary energy matrix is still quite modest (less than 2.5%). Such small participation is quite often justified by lack of commercial competitiveness requiring further technological improvement to overcome such barrier. However, several studies have shown that, presently, there are technologies for the use of new and renewable sources that make them economically competitive with conventional sources. Even in this circumstance, new and renewables occupy a market share much below their economic potential. Barriers created by socio and behavioral attitudes exist and they add to the technological and economic ones. Also, when economic barriers are present it is necessary to provide incentives since through large-scale use, frequently, it is possible to reduce costs. With so many barriers to overcome it is imperative to create a portfolio of policies to foster the use of new and renewable energy sources. This paper discusses several categories of policies providing examples of policy tools (actions) already implemented or being proposed in some countries to promote alternative sources of energy. Some of the policy tools are designed to improve technology, others to face lack of economic competitiveness with conventional sources, but several are designed to change human habits and promote market transformation. These changes are difficult to perform and can be even harder to implement when there are market forces induced by the present economic power of fossil fuels users and producers. A large portfolio of policy tools is presented and it is expected that decision-makers interested in a larger market share for new and renewable sources will be able to select the most appropriate ones for their countries.

I. INTRODUCTION

Almost all commercial energy used in the world is derived from fossil fuels. Coal, oil and natural gas represent around 90% of the energy supply, while hydro and nuclear electricity represent 5% of the commercial energy supply. The new and renewable sources (modern biomass, solar, wind, geothermal, and small hydro) represent a little over 2%, and from this total 1.7% are due to modern and sustainable uses of biomass (see Figure 1).

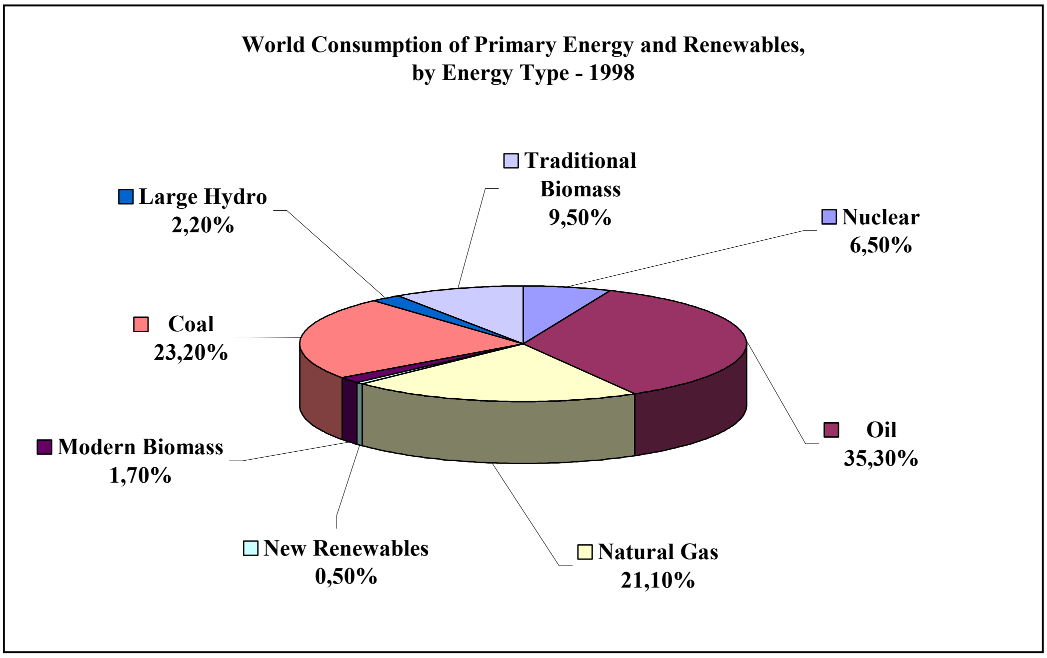

Figure 1: World Consumption of Primary Energy and Renewables

It is worthwhile to remember that new and renewable sources became to be considered as potential contributors to the energy matrix at almost 30 years ago with the oil crisis of 1973 and 1979. During these 30 years their contribution, in absolute value, looks impressive (see Table 1 and Table 2), but on relative basis, increased modestly from zero to 2%. Several barriers prevent their expansion.

Table 1 – Renewable Electricity Grid-Based Generation Capacity Installed as of 2000 (Megawatts)

Technology	All countries	Developing countries
Wind power	18,000	1,700
Small hydropower	36,000	19,000
Biomass power	38,000	30,000
Geothermal power	8,500	3,900
Solar thermal power	350	0
Total renewable power capacity	100,000	55,000
Large hydropower	680,000	260,000
Total world electric power capacity	3,400,000	1,500,000

SOURCE: Martinot et al, 2002

Table 2
Renewable Energy Markets in Developing Countries

Application	**Indicators of Existing Major Markets**
1. Rural residential and community lighting, TV, radio, and telecomm	11 million households receive lighting from biogas 950,000 households with solar home systems (out of 300-500 million households not connected to electric grid) 170,000 household-scale wind-power generators 25,000 PV-powered cellular and satellite phones (serving a rural community)
2. Rural small industry, agriculture, and other productive uses	10,000 PV or wind-powered water pumps (out of 10 million off-grid water pumps total, mostly diesel powered) 100 PV-powered drinking water purifiers/pumps 40 MWp PV for off-grid industrial and telecommunications needs
3. Village-scale mini-grids	5,000 small hydro mini-grids (relative to 100,000 diesel-powered mini-grids) 200 solar or wind hybrid village mini-grids (with diesel)
4. Rural residential and commercial cooking	250 million more-efficient biomass stoves (out of [#] households that use biomass for cooking) 7000 solar cookers 20000 households cook with biogas fuel
5. Residential/ commercial heating	110,000 homes with solar hot water systems 8700 MWth geothermal direct heat production
6. Grid-based bulk power markets	55,000 MW installed capacity producing 200,000 GWh/year (mostly biomass and small hydro)[1]
7. Transport fuels	15 billion liters/year ethanol vehicle fuel produced from biomass 180 million people live in countries mandating mixing of ethanol with gasoline

[1] Some of this capacity serves small village mini-grids rather than central power grids

- **Economic/financial barrier**. A major constraint for many biomass schemes is the relatively high cost per unit of output, because of the small-scale nature of most biomass energy-based projects, high capital and initial investment, high costs of raw material, low cost of competitive fuel, etc. Biomass schemes have to compete with scarce resources and it is a major difficulty to find adequate funding, but even more, that the financial community understands what is being proposed. It is well documented that many biomass schemes, although technically well prepared and costed, often overlook the financial implications. All these factors have combined in discouraging potential financial bankers and investors in biomass energy projects.

- **Institutional and legislative:** Bureaucratic obstacles can be a major problem, because the generally poor understanding such bureaucrats have about biomass, in particular those in the conventional energy institutions, owing to the different nature in which they operate. Integrating new energy sources into the existing energy systems has always required a long time span. Until quite recently almost all major energy suppliers were state monopolies or large private corporations which have made it very difficult for small independent energy producers to enter the market. This situation is changing rapidly where the energy sector is open to competition. The regulatory and legal framework, whether at national, regional or local levels, can often be a barrier, as in most cases legislation deals with conventional (fossil or nuclear based) energy sources and is often behind with regard to other sources. This vacuum creates confusion, delays, etc., when it comes to planning permission. Thus, it is important that there is legislative support to ensure that small independent producers have access to the national grid, or integration with other provincial or local lines, etc.

- **Environmental:** All biomass energy schemes have environmental costs and benefits that need to be quantified and compared with non-biomass ones. Public perception of biomass schemes is important and their views on possible disruption to habitats, ecosystems, conservation areas, visual effects, etc., must be taken into consideration. This has been notoriously lacking in many cases.

- **Socio-political:** Social acceptability and participation are important elements for the success of any modern biomass energy scheme. It is also important that biomass energy schemes do receive political support, to understand the policy implications and to have access to decision-makers, so that they understand the problems, what is being proposed and that issues of competence are well understood. The experience from Austria, Brazil, Sweden, and Denmark, for example, shows that these elements must combine for successful implementation. However, similar policies are still lacking in many countries (World Energy Commission 2000 Report).

Considering such large number of barriers it is clear that expansion of new and renewable sources of energy requires appropriated policies to succeed. The high cost for their production is a serious issue that can be mitigated through significant investments in R&D and “learning by doing”. But even when technology and cost are not any more barriers, renewable sources of energy still face other kind of barriers. In a recent study 68 countries (G-8, 2001) identified some of the market forces stimulating and restraining the growth of New and Renewable (see Column 1 and 3, Table 3). It is worthwhile to observe the large number of policies suggested by the 68 countries study to influence such forces (Column 2, Table 3). In this paper we will provide several examples of policies tools that are being applied or are suggested in the literature to overcome these barriers, while also helping to overcome economic and socio-political barriers.

<table>
<tr><th colspan="4">Table 3: Market Forces</th></tr>
<tr><th>Forces stimulating RE</th><th colspan="2">G8 vehicles to influence forces</th><th>Forces restraining RE</th></tr>
<tr><td>→</td><td colspan="2"></td><td>←</td></tr>
<tr><td>Aspirations to eradicate poverty</td><td rowspan="4">National RE plans</td><td>Co-operation with DC's through ODA**/IFIs***</td><td>Lack of awareness of RE options/ benefits in DC's, IFI's & lack of co-ordination</td></tr>
<tr><td>Aspirations to improve local/global environment</td><td>Climate change & other environment policies: taxation, incentives and fiscal measures, carbon trading CDM,</td><td>Vested interests and subsidies for conventional energy, ignorance</td></tr>
<tr><td>Aspirations to diversify for energy security</td><td>RE portfolio</td><td>Vested interests in conventional energy, ignorance</td></tr>
<tr><td>Energy market liberalization</td><td>Green certificates; Distributed generation policy; Renewable portfolio standards</td><td>Decrease ODA/IFI support for energy projects</td></tr>
<tr><td>Cost reductions for RE technology</td><td colspan="2">R&D policies, public-private-partnership</td><td>Lack of awareness / trust / familiarity with RE technology, other barriers to RE project development; apparent cost competition</td></tr>
<tr><td>Increased FDI* / trade promotion
Increased role of private sector</td><td colspan="2">ECA****, public-private-partnership, tax and other incentives, risk mitigation, global corporate initiative</td><td>Vested interests in conventional energy and export credit support
Decreased role of government</td></tr>
<tr><td>Global integration of markets</td><td colspan="2">Coherent action, policy co-ordination, information exchange, ECA reform</td><td>Market immaturity</td></tr>
</table>

*	FDI	= Foreign Direct Investment
**	ODA	= Overseas Development Assistance
***	IFI	= International Financing Institution
****	ECA	= Enhancing Commercial Agency

There is no "silver bullet" for overcoming the barriers to a more sustainable energy future. Many policy initiatives are needed to increase the availability and deployment of energy efficiency and renewable energy technologies. These policies can be grouped into the following 12 categories (Geller, 2002):

- research, development, and demonstration
- financing
- financial incentives
- pricing
- voluntary agreements
- regulations
- information dissemination and training
- procurement
- market reforms
- market obligations
- capacity building
- planning techniques

II. POLICIES and POLICY TOOLS

1. Research, development, and demonstration

Expand government-funded research, development and demonstration (RD&D) on clean energy technologies in order to reduce their cost and improve their performance. Also, expand RD&D on behavioral and implementation-related issues. Foster collaboration between research institutes and the private sector, and combine RD&D with market development efforts.

Examples of policy tools

1.1 Biomass Research and Development Initiative is a multi-agency effort to coordinate and accelerate all USA Federal bio-based products and bioenergy research and development, as outlined in the Biomass Research and Development Act of 2000 and Executive Order 13134.

Recommendations:

- Fully fund the Biomass Research and Development initiative at its authorized level of $49 million a year, as authorized in the Biomass Research and Development Act.

- Extend the initiative from 2005 to 2010, conducting a review in 2005 to determine which areas of research have proved the most promising.

- Give priority funding in awarding competitive research grants to projects for the commercialization of cellulosic ethanol and the development of energy crops (Ames and Wermer, 2001).

1.2 Utilities Compulsory Investment in Energy Efficiency and R&D - Starting in 1998, the federal regulatory agency for the electric sector in Brazil (ANEEL) began requiring utilities in Brazil to invest at least one percent of their revenues in energy efficiency programs. But only one quarter of the one percent must be spent on efforts that help consumers to use electricity more efficiently. In 2000, the requirement was changed with half of the one percent devoted to an R&D fund, but the minimum amount for consumer-oriented efficiency programs was maintained (Jannuzzi 2001).

1.3 Japan – Importance of R&D to stimulate the learning effect

In June 1998, with PV generation costs three times as high as conventional electricity, Japan set a target of 5000 MWp of newly installed PV capacity by 2010, and established an R&D Programme, - Development of Technology for Practical Application of PV Power Generation Systems- to drive down PV costs thereby helping to insure that the target will be met.

To date the R&D programme has been very successful, with approximately 200 MW of PV installed in the first 18 months. Over ten thousand residential systems have been installed annually as a result of the subsidies. The programme has achieved economies of scale and as a result, significant price reductions: it reduced costs of installed residential PV systems from US$30 in 1993 to US$8 per peak watt in 1998 (G-8, 2001).

2. Financing

Provide financial services to increase the adoption of renewable energy measures. Financing at low interest should reward superior performance; e.g., pay for renewable energy production. Also, financing at low interest should diminish or phase out as markets for renewable energy measures expand.

Examples of policy tools:

2.1 Rural Business-Cooperative Service – RBS in United States provides financial and technical assistance to establish and sustain agricultural cooperatives.

Recommendations:

- The mission of RBS should explicitly state that farmer-owned cooperatives are a crucial component of renewable energy development.

- Provide grants and loan guarantees to establish cooperatives or expand existing cooperatives to undertake wind, biopower, biofuel, and bioproduct development projects. Give priority funding to proposals that aim to produce several marketable products in the same integrated facility, such as a biorefinery (Ames and Wermer, 2001).

2.2 Commodity Credit Corporation Bioenergy Program – CCC is the financing organization for USDA's commodity programs and several conservation programs. The Bioenergy Program provides partial compensation to producers of ethanol and biodiesel for the purchase of commodities to expand existing production (cellulosic energy crops are considered eligible commodities)(Ames and Wermer, 2001).

2.3 Transmission – Facilitate financing for Rural Electrification Cooperatives (RECs) to improve the carrying capacity, reduce line loss and increase the overall efficiency of their existing transmission/distribution networks. In many places, a major barrier to the large-scale development of rural renewable energy resources (especially wind and biomass) is the lack of transmission capacity. Development of rural renewable energy resources is critical to U.S. energy supply, greenhouse gas mitigation, air and water protection and increased farm income and rural economic development. Therefore, it is critical that lack of transmission capacity in the grids owned by RECs not be the downfall of renewable energy development.

Recommendation:

- Provide loan guarantees or other appropriate financing assistance for on-farm renewable energy systems, including wind turbines, solar panels and anaerobic digestion systems (Ames and Wermer, 2001).

2.4 Bangladesh- seeds funding for solar home systems

In 1998 the Global Environment Facility (GEF) provided funding to an organization in Bangladesh, Grameen Shakti, which enabled them to offer improved credit terms, increasing the payment period for solar home systems from one to three years. This had a significant effect on demand. Between 1997 and 1999, Grameen Shakti sold 1500 systems Solar Home Systems and installed 2000 to 2500 systems in the year 2000. Grameen Shakti found that after a “critical mass” of installations, for example 100 systems, the process of building customer confidence and demand became less time consuming, as people bought systems on the recommendations of other customers. Grameen Shakti believes that after three to four years of this profitable growth they will be able to obtain financing from commercial banks. This project has shown that the use of GEF financing to support a “high risk” project, unable to obtain commercial financing on its own, can result in significant growth and provide the means by which an organization can obtain commercial financing (G-8, 2001).

3. Financial Incentives

Provide financial incentives to increase the adoption of renewable energy measures. Financial incentives should reward superior performance; e.g., pay for renewable energy production. Also, incentives should diminish or phase out as markets for energy efficiency and renewable energy measures expand and their costs drop.

Examples of policy tools:

3.1 In USA the idea is to provide “private use” relief for tax-exempt bonds of state and locally owned electric utilities and eliminates tax impediments faced by rural electric cooperatives that inhibit full participation in emerging competitive markets.

- Allow enhanced accelerated depreciation for property used in the transmission or generation of electricity.

- Encourage Federal Electricity Regulatory Commission of USA (FERC) to ensure adequate investment returns that will attract the necessary capital investment in the electric transmission system (Ames and Wermer, 2001).

3.2 Conservation Reserve Program - CRP is the largest of the Farm Bill conservation programs for United States, with a current enrollment cap of 36.4 million acres (equivalent in size to the state of Iowa). Its mission is to preserve land vital for soil conservation, water quality protection, and wildlife habitat. It is recommendable to add renewable energy production to those goals.

Recommendations:

- Permit the growing of biomass crops, and the harvesting of biomass, for the production of biopower, biofuels, and biobased products, on CRP lands with an appropriate reduction in rental payments. The rental reduction should not be so high as to cancel any incentive for a farmer to undertake a biomass project.

- Allow wind turbines to be sited on CRP lands, where ecologically and economically appropriate.

- Give a higher priority in awarding Environmental Quality Incentives Program (EQIP) contracts to producers who propose to convert animal waste operations over to anaerobic digestion systems for the capture and burning of biogas to produce heat and electricity (Ames and Wermer, 2001).

3.3 Greening the Energy Sector Portfolio of Multilateral Banks: the case of ASTAE

The Asia Alternative Energy Programme (ASTAE) was established by the World Bank in 1992. The goal of ASTAE was to mainstream sustainable energy in Asia by ‘greening’ World Bank lending to the power sector in this region. The programme has been so successful that the target of increasing the share of alternative energy in its Asian power sector loan portfolio to 10 percent has now been met and exceeded. In the financial year of 1999 the share was as high as 46.3%. As of June 2000, 38 projects were either in the pipeline, approved or completed and it is projected that the implementation of these projects will avoid around 1GW of conventional capacity (G-8, 2001).

4. Pricing

Reform energy prices. Eliminate subsidies for fossil fuels and enact taxes based on their environmental and social costs. Use some of the tax revenue to support energy efficiency and renewable energy initiatives in order to maximize the energy, environmental, and economic benefits.

Examples of policy tools:

4.1 Ethanol Small Producer Tax Credit – In the United States it is recommendable to expand this credit to include farmer-owned cooperatives. We also recommend allowing all producers with annual production capacity up to 60 million gallons to qualify (currently the limit is 30 million gallons) (Ames and Wermer, 2001).

4.2 "Green technologies are on the verge of becoming one of the next waves in the knowledge economy revolution. I believe the role of Government is to accelerate the development and take up of these new technologies until self-sustaining markets take over. The Government's programme for incentivate renewables will create a new market worth over £500 million through the Renewables Obligation, Climate Change Levy exemptions and the Non Fossil Fuel Obligation. We have already announced £100 million to support offshore wind and energy crops. Today I can announce a further £100 million .... This new money will help us to promote solar PV, give a boost to offshore wind, kick start energy crops, and bring on stream other new generation technologies. This investment in renewable energy technology is a major down-payment in our future, and will help open up huge commercial opportunities for Britain." (Blair, 2001).

5. Voluntary Agreement

Adopt voluntary agreements between governments and the private sector in situations where regulations or market obligations cannot be enacted or enforced. Complement voluntary agreements with financial incentives, technical assistance where needed, and the threat of taxes or regulations should the private sector not meet their commitments

Example of policy tool:

5.1 The Netherlands tax incentives for green investments

The Green Fund System (GFS) was introduced in the Netherlands in 1992, as a co-operative activity between the government and the financial sector. It combines a tax incentive, a framework for designation of green projects and the active involvement of the financial sector. The basic principle behind the system is that the general public receives tax advantages for investments in 'Green Funds'. The Green Funds provide soft loans with low interest rates to green projects. Initially, only projects in the Netherlands were eligible for funding, but in 1995 the scope was extended to projects in developing countries and economies in transition.

The enthusiasm of the public has contributed to the success of the Green Funds system. The Green Fund System has successfully set up a self supporting market development programme for green projects, which is based on existing financing infrastructures and encourages the active support of the financial sector and general public (G-8, 2001).

6. Regulation

Enact regulations or market obligations to stimulate widespread adoption of energy efficiency improvements or renewable energy sources. Make sure these regulations or obligations are technically and economically feasible, enforce them, and update them periodically. Also, structure emissions cap and trading schemes so that they encourage and provide credit for emissions reductions from end-use efficiency improvements and renewable energy technologies.

Example of policy tool

6.1 Harnessing the bagasse resource would require a fully operational legislative environment for Independent Power Production (IPP) in USA. Legislation allowing for IPP exists; thus concrete steps toward implementing the long-term expectation amongst policymakers of private ownership of everything but the grid have been taken. However, the policy framework for operationalizing independent power production is not entirely in place.

Rural Utilities Service – RUS provides grants, loans, and technical assistance to rural electric and water utilities in USA. The following recommendations will likely entail amending the Rural Electrification Act of 1936.

Recommendations:

- **Net Metering:** Rural Electric Cooperatives (RECs) should provide net metering services to their customers (potential small residential generators) to encourage the production and use of renewable energy sources for on-farm use by their members. In essence, net metering allows the electric meter to run backwards as electricity produced by the customer is fed back into the system. In this way, customers already connected to the coops distribution lines can feed into the coops system any excess power they may generate. Thereby customers pay for the net amount of power they consume. Customers should receive a fair price on power they contribute to the system. Over 40 states have already passed various versions of net metering legislation, and bills have been introduced in the House and Senate regarding net metering. Because RECs serve so much of rural America, this is an important way in which RECs can benefit their members and improve the reliability and capacity of their systems.

- **Standardized Interconnection:** Rural Electric Co-ops should provide interconnection to their distribution systems at a fair and non-discriminatory price for their member/customers who want to generate power from renewable energy sources for their own farm. Use but also be able to sell excess power back to the coop. Such renewable resources would include solar, wind, and anaerobic digestion systems. Some states have enacted their own legislation, and bills have been introduced in the Senate (e.g., S. 933), but if farmers are going to be allowed/encouraged to develop their on farm renewable energy resources, then it is important that RECs provide this service to their members. Too many times utilities (of all kinds) have thwarted development of on site renewable energy by not allowing interconnection or by charging exorbitant fees (Ames and Wermer, 2001)..

6.2 Tax treatment and duties for imported biofuels

This issue is being discussed in many fora (Faaij et al, 2002). Very few of the new and renewable energy sources have the potential to be traded in significant amount. Wind, solar, small hydro sources are potential sources of electricity and such form of energy is essentially consumed in the producing site or nearby. Biomass, which can be used as a source of biofuel, heat, electricity or a combination of them, has some potential to be consumed in different regions than the one it is produced. In particular, biofuels are, probably, the most feasible form of biomass that can be transported over large distances and still be economically competitive with conventional liquid fuels. Tropical countries with abundance of rainfall have a significant advantage as producers of biofuels (Moreira, 2002) and are potential exporters.

Unfortunately, many developed countries with much less opportunities to produce them due their temperate climate impose trade barriers to protect their farmers. In a global economy such attitude is becoming susceptible to criticism. One possible way for the removal of trade barriers is to require fair use of commercial practices promoted by the World Trade Organisation. Through enforcement of policies designed by WTO it should be possible to open developed country's market to biofuel produced in tropical countries.

6.3 Adopt Minimum Efficiency Standards for New Thermal Power Plants

Brazil has sought for some time to increase electricity supplies from thermal power plants, but Brazil lacks high-quality coal reserves and development of natural gas was quite limited until recently. The increased supply of natural gas has sparked great interest in the construction of natural gas-fired power plants. Utilities or private developers proposed many projects in recent years.

The great majority of the gas-fired power plants proposed or under construction is simple-cycle plants, meaning efficiencies of 30-35 percent rather than 50-60 percent achieved by state-of-the-art combined-cycle plants. Private investors prefer simple-cycle plants because of the lower investment costs, shorter construction time, and greater flexibility to respond to varying load conditions. In the future, some of these plants may be converted to combined-cycle operation.

Minimum efficiency standards could be adopted for all new gas-fired power plants that enter into operation in Brazil. Also, plants built as simple cycle gas turbines could be required to add steam turbines and operate as combined cycle plants if they are used more than a nominal amount. This policy would require all gas-fired power plants used over 500 hours per year to meet or exceed an efficiency level of 55 percent. This requirement also would narrow the difference in capital cost between electricity only and CHP plants, thereby helping to stimulate investment in CHP systems (Szklo and Geller, 2003).

6.4 Adopt Minimum Fuel Economy or CO_2 Emissions Standards for New Passenger Vehicles

There are no fuel efficiency standards for new cars or light trucks in Brazil. Vehicle manufacturers receive some tax incentives for producing vehicles with engines one liter or smaller in volumetric capacity. But the fuel efficiency of Brazilian cars and light trucks is still relatively low. In 1998, the average fuel economy of all passenger cars in circulation in Brazil was about 23.5 mpg or 10 kilometers per liter (km/l), while the average fuel economy of all new passenger cars sold that year in the country was about 26 mpg (11 km/l) (Azuaga 2000).

Passenger vehicles sold in Brazil are relatively inefficient because of the outdated technology employed in one-liter Brazilian engines. Most of these engines are derived from 1.6 liter-engines used to equip older models. But vehicle production by the multinational auto manufacturers is rapidly growing in Brazil. As production expands, it would be reasonable to insist that new vehicles include a variety of fuel-efficient technologies.

This policy calls for adopting passenger vehicle fuel efficiency standards in Brazil. These standards could be expressed in terms of either an increase in fuel economy (the approach followed in the United States) or a reduction in CO_2 emissions per kilometer traveled (as is the case in Europe). The advantage of a CO_2 emission standard in Brazil is that auto manufacturers could opt either to raise fuel efficiency or produce and sell more ethanol (and other cleaner fuelled) vehicles. If a CO_2 emission standard were adopted, manufacturers most likely would comply through some combination of efficiency improvement and fuel shifting (Szklo and Geller, 2003).

7. Information dissemination, and training

Disseminate information and provide training to increase awareness and improve know-how with respect to renewable energy options. Combine these efforts where possible with incentives, voluntary agreements, or regulations in order to increase their impact.

Example of policy tool:

7.1 RETScreen: a tool for market coherence

RETScreen is a global decision support and capacity building tool for assessing potential renewable energy projects developed by the Energy Diversification Research Laboratory of Canada. The tool evaluates the energy production, life cycle costs and greenhouse gas emission reductions for renewable energy projects at any geographic location around the world.

The tool enables planners and decision-makers to routinely consider renewable energy technology projects at the critically important initial planning stage. The tool has been used widely to date for example for: preliminary feasibility studies, project lender due-diligence, market studies, policy analysis, information dissemination, training, sales of products and/or services, project development and management, product development and research and development (G-8, 2001).

8. Procurement

Use bulk procurement to help commercialize and establish initial markets for innovative clean energy technologies. Governments should purchase energy-efficient products, renewable energy devices, or "green power" for their own use, as well as sponsor and help organize bulk purchases by a wide range of public and private entities.

Examples of policy tools:

8.1 Establish Federal Purchasing Programs - Executive Order 13134 and the Agricultural Risk Protection Act of 2000 set the goal of tripling the use of biofuels and biobased products in the United States by 2010. We recommend establishing a purchasing requirement for all federal government agencies and contractors that sets increasing percentages for purchase of biofuels and biobased products consistent with the above goals. We also recommend a Federal Renewable Portfolio Standard requiring agencies to purchase no less than 10 percent non-hydro renewable power by 2010, and 15 percent by 2015 (Ames and Wermer, 2001).

8.2 PROINFA – a Brazilian Federal Program foresee raising the share of renewable energy power generation by adding 3,300 MW installed capacity of wind, small hydro, and biomass based electricity generation, offering long-term contracts with special conditions through ELETROBRAS the holding of the public electricity utilities, lower transmission costs, and lower interest rates from the local development banks. While the program is very indicative of a positive approach of the federal government, the "special conditions" were only precisely defined by the end of December 2002, although there are already some concerns with the process designed for collection of funds that will support the programs. Several possible projects are in the pipeline; many of them have received approval of ANEEL, while others have construction licenses issued by state authorities. Nevertheless, the initial call for project qualification to the program will occur by the middle of 2003, if time schedule set by the law will not be postponed.

8.3 PV Market Transformation Initiative in India

The PV market in India was approximately 10 MWp/year in 1997. Government PV purchasing and subsidy programmes have played a significant role in supporting the development of an Indian PV industry. However the market is characterized by:

- an unacceptably high incidence of system failure in the field
- inadequate marketing, distribution, customer support and after-sales service attributable to private sector markets being suppressed by subsidy programmes.
- general lack of consumer awareness of PV technology and its benefits.
- dependence on end-user subsidy.
- underdeveloped availability of consumer finance which is crucial to make solar home systems affordable.

The PVMTI programme aims to build up financing, distribution and service capability. This will be achieved through the provision of finance for sustainable and replicable commercial PV business models, the financing of business plans with commercial loans at below-market terms or with partial guarantees or equity instruments, and the provision of technical assistance to PV businesses on planning, financing operations and technology (G-8, 2001).

9. Market Reforms

Aim to transform markets. Integrate policies into market transformation strategies, addressing the range of barriers that are present in a particular locale. Make the policies strong enough to remove or overcome these barriers. And allow them to evolve over time as some barriers are removed and others come to the forefront.

Examples of policy tools:

9.1 PROALCOOL Program in Brazil – This program was introduced in 1975 with the purpose to diversify the sources of liquid fuels. To guarantee commercial space for ethanol, which at that time had a price above US$0.60/liter, the government created a fund with resources collected from tax on conventional gasoline (Moreira and Goldemberg, 1999).

9.2 Fuel Diversity and Supply - No individual fuel is capable of providing the energy to meet all of our nation’s electricity demands. Rather, a diversity of supply options is key to affordable and reliable electricity. Policymakers and regulators need to work together to reconcile conflicting energy, environmental, and other public policy goals in order to capitalize on our nation’s abundant natural resources and address challenges that now limit the development and viability of numerous fuel sources (Ames and Wermer, 2001).

9.3 Equipment Testing for Biofuels - Many gasoline and diesel engine manufacturers will not certify their engines to run on higher blends of ethanol and biodiesel. USDA and the Environmental Protection Agency should provide research grants to test biofuels in higher concentrations in farm equipment, construction equipment, diesel generators, and other applications. USDA should work in collaboration with equipment manufacturers to certify their engines to run on biofuels, and promote their use to consumers (Ames and Wermer, 2001).

9.4 Establishment of Independent Power Suppliers in Brazil – The reform of the Electric Sector in Brazil unbundled the sector into generation, transmission, and distribution assets. This model introduces competition among generators, maintains a neutral common carrier managed by the ONS and allows free consumers and producers, including IPPs, ready access to the grid. Privatizing distribution companies first was viewed as a crucial step not only in selling off the gencos but also in making IPP projects viable. Since the distribution companies would be the buyers of the energy sold by the gencos and new IPP producers, the credit risk to new investors would be reduced if the distribution companies were already financially sound and under private ownership. This policy was very relevant for the significant increase in the number of sugarcane mills interested in sales of co-produced surplus electricity to the grid, as shown in Figure 2.

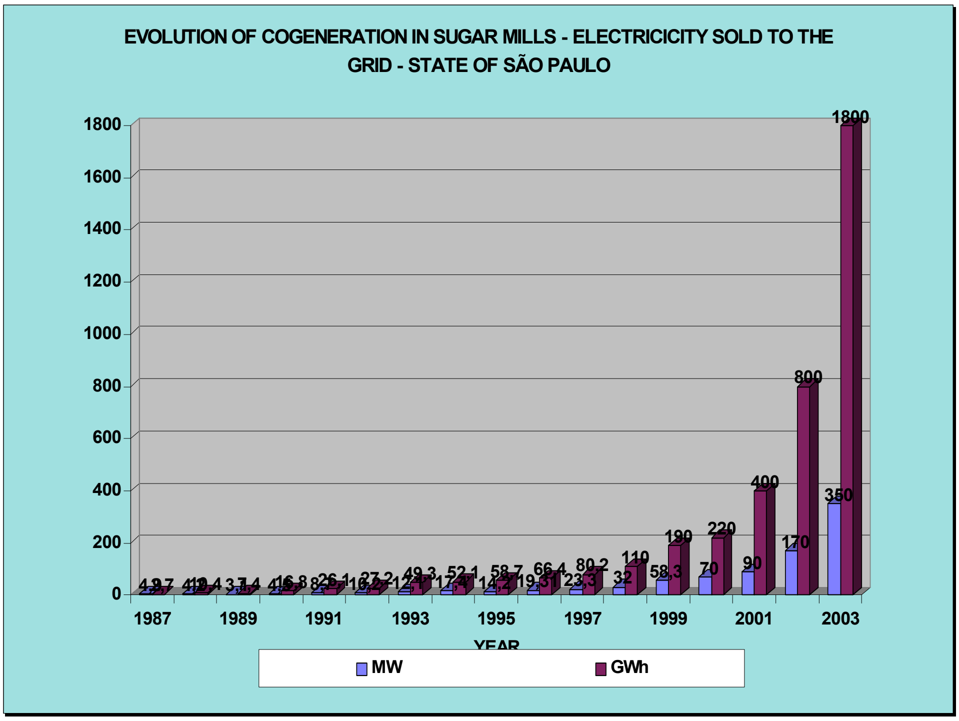

Figure 2: Evolution of Electricity generation in Sugar Mills

9.5 Sri Lanka: the importance of IPP regulation

In Sri Lanka, the World Bank/GEF Energy Services Delivery project was started in 1997 with the aim of promoting the provision of grid electricity by private-sector power developers. The project had the effect of opening up the market to third party mini-hydro developers. More than 21 MW of small hydro has been financed by independent-power-producers (IPPs) as a result of the project. Also regulatory frameworks for IPPs were developed, including standardized “non-negotiable” power-purchase tariffs and contracts (Power Purchase Agreements -PPAs). This project provided sufficient incentive for the national utility to adopt IPP frameworks and agree to PPAs, which together with demonstration of the technology through previous mini-hydro installations and new incentives for developers (such as import duty waivers and income tax concessions) succeeded in stimulating the market (G-8, 2001).

10. Market Obligation

Enact regulations or market obligations to stimulate widespread adoption of renewable energy sources. Make sure these regulations or obligations are technically and economically feasible, enforce them, and update them periodically. Also, structure emissions cap and trading schemes so that they encourage and provide credit for emissions reductions from end-use efficiency improvements and renewable energy technologies.

Examples of policy tools:

10.1 In September 2001, the European Union (EU) adopted the Directive on the promotion of electricity produced from renewable energy sources in the internal electricity market. According to this Directive, "EU member states shall have their own national indicative targets (of renewables) at 12% share of gross national energy consumption by 2010 and 22.1% share of electricity generation by 2020" (Goldemberg, 2002).

10.2 The Brazilian Energy Initiative - A meeting of the Ministers of Environment, from Latin American and Caribbean Countries, which met in São Paulo in May 2002 prior to PrepCom IV, adopted as a resolution the Brazilian proposal drafted as:

- "Increase in the region the use of renewable energy to 10% as a share of total by 2010" (Draft of the Final Report of the 7th Meeting of the Intersessional Committee of the Forum of Ministers of Environment of Latin America and the Caribbean)

The Brazilian proposal allows trading of "new renewable energy" certificates among countries.

Other proposals were presented in Bali:

- "Diversify energy supply by developing cleaner, more efficient and innovative fossil fuel technologies, and promote the increase of the share of non- hydro renewable energy sources to at least 5% of total primary energy supply by 2010"(Switzerland).

- "Diversify energy supply by developing cleaner, more efficient and innovative fossil fuel technologies, and promote the increase of the share of new renewable energy sources by at least 2% with the objective of increasing the global share to at least 15% of total primary energy supply by 2010. To achieve this all countries should adopt and implement ambitious national goals. For industrialized countries, these goals should aim at an increase of the share of renewable energy sources on total primary energy supply by, at as least, 2 percentage points by 2010 relative to 2000". (European Union)

They were all consolidated in a bracketed text PrepCom IV in Bali and included in the Chairman's Report (June 2002), which means it will be the object of further negotiations before or/at WSSD in Johannesburg.

[[Diversify energy supply by developing cleaner, more efficient and innovative fossil fuel technologies, and promote the] increase of the share of [non-hydro]/[new] renewable energy sources [by at least 2%]/[with the objective of increasing the global share to at least 15% of total primary energy supply by 2010.] [To achieve this all countries should adopt and implement ambitious national goals.][For industrialized countries, these goals should aim at an increase in the share of renewable energy sources of total primary energy supply by at least 2 percentage points of total energy supply by 2010 relative to 2000.]/[to at least 5% of total primary energy supply][by 2010].] at the goal level by 2010. To achieve this, all countries should adopt and implement specific national goals;]]

Recent discussions between Brazil and Sweden led to the following formulation for a target: increase the share of modern renewable energy in the world's energy supply by 10% by 2012 (Goldemberg, 2002).

10.3 Renewable Portfolio Standard - Establish a national Renewable Portfolio Standard that will require 20 percent of power generated in the United States by the year 2020 to be derived from non-hydro renewable energy sources. This ensures a market for renewable power, critical to the development and use of renewable energy across the country and on America's farms (Ames and Wermer, 2001).

10.4 Texas Portfolio Standards

Under the Renewables Portfolio Standard (RPS) in Texas retail electricity suppliers have a requirement to include a specified percentage of renewables in their generation portfolio. The policy is backed up by annual renewable energy generation targets. Texas has set targets increasing to 2,880MW of renewables to be installed by 2009; this includes the addition of 2000MW from new renewable generating projects. Wind energy is currently dominating the new installed capacity of renewables with supply costs of around 3 cents/kWh (which includes a 1.7-cent/kWh federal production tax credit).

Projections show that the first year target of 400MW of new capacity to be installed during 2002 and 2003 will be exceeded significantly. The key factors considered to be contributing to the success of the policy are clear renewable energy targets, clear renewable resource eligibility requirements, stringent non compliance penalties, a Tradable Renewable Energy Certificate system that encourages flexibility and minimizes costs, and a dedicated regulatory commission that fully involved numerous stakeholders during the detailed design of the policy.

A major lesson from Texas is that, while the RPS is new and relatively untested as a policy tool, it has the potential to cost-effectively support the establishment of a robust renewable energy market (G-8, 2001).

10.5 Renewable Fuels Standard - Establish a national Renewable Fuels Standard (RFS) that would require an increasing percentage of transportation fuel sold in the United States to be renewable biofuels, such as ethanol and biodiesel. The RFS should contain a credit trading system to allow refiners, blenders, and retailers to buy and sell credits from each other to meet their content goals. The RFS should also contain an incentive to expand the production of cellulosic ethanol (Ames and Wermer, 2001).

10.6 Proposal to Foster Use of Sugarcane Residues - A combination of policies could facilitate higher efficiency bagasse cogeneration in Brazil as well as encourage use of leaves and tops for energy production, where appropriate. Some of these policies are similar to those needed to stimulate CHP with natural gas:

1) Require utilities to purchase excess power from sugar mills at avoided generation, transmission, and distribution costs via long-term contracts;
2) Require utilities to interconnect CHP systems to the power grid without excessive delay or unreasonable technical requirements;
3) Continue to develop and demonstrate more efficient technologies such as bagasse gasification and combined cycle power generation in sugar mills (Szklo and Geller, 2003).

10.7 Green electricity in Italy - In 1999 Italy introduced a quota system that obliges each power supplier from 2002 on, to feed electricity from renewable energy sources (2% of the non renewable electricity generated or imported in the previous year) into the Electrical National System. Suppliers can meet this obligation by building their own RE-plants or by buying certificates. This “Compulsory Renewable System” (CRS) follows defined rules regarding certificate issuing and trading.

The Italian government considers separate trading of green certificates and electricity to be one of the best options to promote renewable sources inside the European common market. The Italian government strongly advocates a common market, where all participants share similar rules and where green certificates are not merely a proof of origin, but a title per se, which can be sold separately (G-8, 2001).

10.8 German Renewable Energy Law

The German Renewable Energy Law was passed in 2000, in order to establish a framework for doubling the market share of renewable energy sources by 2010. The law sets specific maximum payback prices for each individual renewable energy technology, based on their annually decreasing real cost. The aim of the tariffs is to initiate a self-sustaining market for renewables and create a critical mass through a large-scale market introduction programme, whilst not imposing any additional burden on the taxpayer. A key lesson learned is that a law, which takes into account learning curves for renewable energy technologies through decreasing feed-in tariffs, is appropriate, particularly in a deregulated market. It has led to the largest installed wind energy capacity in the world (G-8, 2001).

10.9 Morocco: Rural Electrification Programme

Morocco has set up a rural electrification programme with the aim of increasing rural electrification from 20% in 1995 to 80% by 2006. The electricity utility ONE has assessed the areas where grid connection is the best option through the use of economic criteria. A cost per household for the grid connection of each village is calculated. The households which exceed the economic limit for grid connection are then identified as potential candidates for off-grid electrification. In these rural locations it is more economic to install solar home systems than to provide a connection to the grid (G-8, 2001).

11. Capacity Building

Build capacity to implement effective energy efficiency and renewable energy policies and programs in all countries. Also, train and support the businesses that will manufacture, market, install, and service clean energy technologies.

Examples of policy tools:

11.1 Agricultural Research Service - ARS is USDA's primary scientific research agency. The **Bioenergy and Energy Alternatives program** does research in the areas of ethanol, biodiesel, energy alternatives for rural practices, and energy crops.

Recommendations:

- Increase funding within the **Bioenergy and Energy Alternatives program** for the development of biofuels and energy crops.
- Expand the mission of the **Cooperative State Research, Education, and Extension Service (CSREES)** to promote the development of renewable energy resources on America's farmland.
- Provide funding to CSREES to provide education and technical assistance to farmers and farmer-owned co-ops for the development and marketing of renewable energy resources, including biomass, wind, solar, and geothermal. The CSREES should also conduct outreach to the general public on the societal benefits of developing these resources.
- Stipulate that the CSREES should work in close collaboration with the Regional Biomass Programs, sponsored by the Department of Energy. Together, the organizations should provide assistance to farmers for growing, handling, and processing energy crops and waste streams for the production of biopower, biofuels, and biobased products. Where possible, the two organizations should share resources, staff, and expertise (Ames and Wermer, 2001).

11.2 Guidelines for national renewable energy plans in developing countries (NREL/TCAPP, 2001).

Developed countries should facilitate preparation and implementation of renewable energy development plans, especially where such plans and planning activities:

- Drive the budgeting and policy decisions in developing countries so that the plan recommendations translate into real commitments for action at national and local levels.
- Integrate renewable energy strategies and initiatives with national and local economic, poverty alleviation, health, environmental, and other development programs
- Engage the business and finance community in structuring and implementing initiatives to ensure that they build sustainable markets and accelerate renewable energy investment
- Provide a vehicle for co-ordinating and focusing bilateral and multilateral donor support for renewable energy programs in developing countries
- Engage and build support from all key stakeholders in the country, including national and local government agencies, community groups, technical institutions, businesses and finance organizations, and other key stakeholders.

12. Planning Techniques

Carry out both integrated energy resource planning and integrated transportation and land use planning in order to guide investments to options that minimize overall societal costs (including environmental costs). Energy and transportation plans should contain concrete goals, actions for achieving the goals, and monitoring and evaluation procedures.

Examples of policy tools:

12.1 Local use in developing countries vs. export. Exporting country has the choice of exporting biofuels or CO2 credits. A sensitivity analysis would be needed to show at which levels of CO2 prices and biofuels prices which option would be best. Fossil reference systems can make a difference (coal vs. oil vs. gas) (Schalamadinger, 2002)

12.2 From the view of industrialized countries technology export opportunities should be considered (e.g., processing and end use of biofuels). Security of fuel supply issues to be considered (Schalamadinger, 2002).

12.3 Biofuels import could alleviate concerns of wood industries regarding biomass energy use (competitive use of their resource). Could be important to get wood industries involved. Effects of biofuels trade on future power plant / refinery siting in Europe should be considered (Schalamadinger, 2002).

12.4 National Plan in China

China Renewable Energy Plan – The Government of China has developed 5 year plans to accelerate renewable energy development through market based policy instruments. In addition the Government will introduce a range of fiscal measures, such as VAT and income tax reduction, interest rate subsidies and government subsidies, to pay for part of the additional financial costs of new renewable energy capacity (G-8, 2001).

Currently the government is considering:

- To create a Mandated Market Share for renewable energy in the form of a legal requirement that a specified share of electricity comes from renewable energy.
- To introduce an instrument, such as trading, to share the incremental cost and benefits among the regions in China

III CONCLUSIONS

As has been pointed out by IPCC (Moomaw et al, 2001) in the short term (2010 – 2020) there is no shortage of technologies to abate Greenhouse Gas Emissions. Some of the technologies are already cost-effective and others can be used if carbon emission has costs up to US$100/tC. Even so, market potential for them is presently small and probably will continue to grow slowly. The market potential is well below the economic market potential, which is lower than the socio-economic market potential. The IPCC document concludes that lack of policies is the major obstacle for pushing up market potential to the level of the economic and socio-economic potential.

In this paper we try to classify policies in different categories and provide examples of practical policy tools (actions) already taken or being suggested to implement such policies. Examples were extracted from the literature and the list is far from complete, since we investigate a limited number of actions proposed in a limited number of countries. Nevertheless, the purpose of this document is to give insight to police makers about several possible policy tools that can be proposed to foster policies to promote the use and production of renewable sources of energy.

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PLENARY SESSION

International Seminar on Bioenergy and Sustainable Rural Development
- 5th LAMNET Project Workshop – Mexico 2003

Las Energías Renovables y la Política Pública en México

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1. Introducción

Las energías renovables (ER), entendidas como formas de energía que tienen una fuente prácticamente inagotable (que es el Sol) y que a través de diversas tecnologías pueden ser transformadas a los servicios energéticos que requieren las actividades humanas (iluminación, calor, frío, fuerza motriz), han sido utilizadas por la Humanidad de muchas maneras a lo largo de su historia. Sin embargo, en la actualidad, cuando el uso de la energía es mucho más intensivo que en cualquier otro momento histórico, las ER son utilizadas marginalmente, y sólo hasta hace un par de décadas se inició un proceso de mayor utilización de estos recursos energéticos a través del desarrollo de nuevas tecnologías.

De esta manera, en los últimos veinte años, en un proceso asociado también a preocupaciones ambientales, apoyado por políticas públicas de fomento en países desarrollados y empujado por iniciativas empresariales de negocio, las ER han retomado un lugar de gran importancia en la agenda energética mundial.

En México, donde tenemos abundancia de recursos energéticos renovables y claras oportunidades para aprovecharlos, los avances han sido lentos, en particular porque las condiciones económicas del país han llevado, en muchos sentidos, a buscar las opciones más baratas en el corto plazo, lo que ha dejado fuera a alternativas como las representadas por las ER.

En este documento se hace un repaso de las bases para que exista política publica de fomento de las ER en México, de las mejores practicas internacionales, de propuestas que se han hecho en México dentro del Gobierno Federal y una reflexión sobre el posible papel que pueden tener los gobiernos estatales y municipales en el futuro de las ER en México.

2. La política pública y sus bases.

Existen bienes que se consideran públicos porque su existencia y/o aprovechamiento tiene un beneficio para el total de una comunidad, ya sea la presente o la futura. En este sentido el orden publico, la salud, el medio ambiente, los recursos naturales y una economía sana son bienes comunes que se tienen que cuidar. La política pública, entendida como acciones llevadas a cabo por la autoridad y que favorecen o impiden procesos económicos y sociales se justifica, por lo tanto, porque cuida esos bienes a nombre de la comunidad.

a. Las ventajas y beneficios.

El establecer mecanismos de política publica para un mayor aprovechamiento de las energías renovables tiene como objetivo primario cuidar dos bienes públicos directamente afectados por la energía y su uso: el medio ambiente (el aire, el agua, el suelo) y los recursos naturales no renovables (los hidrocarburos). Además, la necesidad y oportunidad para establecer política publica que promueva el aprovechamiento de las energías renovables en México se fundamenta en un conjunto de beneficios y ventajas que, integrados, ubican claramente la necesidad de establecer estrategias de política pública para aprovecharlas. A continuación se enumeran y explican estos posibles beneficios y ventajas.

- *Gran potencial aprovechable*. México posee un potencial considerable de generación de energía a partir de energías renovables, tanto por su extensión territorial (2 millones de kilómetros cuadrados), como por su ubicación geográfica, comprendida entre las latitudes 14 y 33 del hemisferio norte, de gran disponibilidad solar. Al Oeste y al Este, el país está limitado por grandes litorales del Océano Pacífico y el Golfo de México que producen lluvias prácticamente durante todo el año y varias zonas geográficas preferenciales de viento.
- *Necesidad de diversificación energética*. La generación eléctrica actual en México depende en más de un 70% de combustibles fósiles, lo que hace necesario el diversificar las fuentes de energéticos primarios para la generación de electricidad.
- *Altos impactos ambientales de la generación eléctrica actual y creciente sensibilidad ambiental en la población*. El nivel relativamente alto de emisiones de gases contaminantes y los altos requerimientos de agua que implica la generación a partir de combustibles fósiles, aunado a una cada vez mayor sensibilidad social sobre los impactos sobre el ambiente natural que estos representan, han creado expectativas sociales sobre energías cuyo aprovechamiento tiene menores impactos de este tipo.
- *Madurez de la tecnología asociada al aprovechamiento de las ER*. Las tecnologías de conversión a energía eléctrica a partir de energías renovables tienen ya costos que les permiten competir con sistemas convencionales en nichos de mercado cada vez mayores.
- *Necesidad de electrificación rural*. Actualmente, más de 5 millones de mexicanos que viven en zonas alejadas de la red eléctrica no tienen ese servicio, el cual es fundamental para tener acceso no sólo a los servicios energéticos sino también a agua potable y educación. Es precisamente en este tipo de comunidades, lejanas de la red, que, en muchos casos, resulta más barato obtener la electricidad de sistemas que aprovechan a las energías renovables que de una extensión de la red.
- *Necesidad de generación distribuida*. La generación distribuida, entendida como la generación de electricidad en pequeña escala en las instalaciones de los usuarios finales en la red eléctrica, fortalece la regulación de la red eléctrica y, por lo tanto, la calidad del servicio y el nivel de facturación en los mismos. De esta forma, la pequeña producción y el autoabastecimiento con ER pueden apoyar una mejor operación del sistema eléctrico.
- *Capacidad para producir equipos en México*. En México existe capacidad industrial para producir una fracción importante de los elementos (materiales, equipos y sistemas) que son necesarios para generar electricidad a partir de energías renovables. Esto puede resultar en que un aprovechamiento de las oportunidades energéticas también resulte en el desarrollo de una industria nacional especializada y que pueda estar en condiciones de exportar a otros países del Continente Americano.

- *Capacidad nacional de investigación y desarrollo*. En el país están establecidos y en plena operación varios centros de investigación y desarrollo que han existido durante más de veinte años y en ellos se tienen los más altos niveles de conocimiento tecnológico y se desarrollan proyectos de aprovechamiento de energías renovables. Igualmente, aunque relativamente pequeños con relación al gran potencial que se tiene, existen cuadros profesionales que pueden ser la base de un crecimiento de este tipo de capacidades.
- *Posible motor de desarrollos regionales*. Las energías renovables son implícitamente muy locales: los potenciales de viento, de los ríos y de la radiación solar dependen de su localización, y su aprovechamiento puede servir para desarrollar las regiones donde se presentan los recursos. En este sentido, el viento en Oaxaca, la biomasa en Durango o la mini hidráulica en Puebla son binomios que reflejan posibilidades de desarrollo regional.

b. Las barreras.

Sin embargo, el aprovechamiento de las ER tiene obstáculos de diversos tipos:

(1) Técnicos. Las ER son intermitentes (no están disponibles todo el DIA ni con intensidad constante) y porque requieren de grandes espacios para ser aprovechadas.

(2) Económicos. La tecnología de aprovechamiento de las ER todavía no permite, para la mayoría de las aplicaciones, costos de la energía útil menores a los sistemas convencionales, y la mayor parte de los costos se tiene que pagar por adelantado.

(3) Sociales. La mayoría de la población desconoce y, por lo tanto, no tiene confianza plena en la tecnología de aprovechamiento de las ER.

c. Los objetivos de la política publica.

Por lo referido arriba, la política pública para el fomento del aprovechamiento de las ER debe tener objetivos claros, tales como:

(1) Establecer confianza en la tecnología, lo cual se logra con información y con la normalización de equipos y sistemas.

(2) Nivelar el campo de juego con regulación que elimine barreras de entrada como altos costos de transacción o precios de los energéticos que no reflejen sus externalidades negativas.

(3) Identificar nichos de mercado, evaluando los recursos con recursos públicos.

(4) Promover el desarrollo de conocimiento para el abaratamiento en aplicación de la tecnología relacionada.

Para llevar adelante estas acciones, la política pública para las ER tiene instrumentos característicos como leyes que las sustentan, incentivos fiscales, impuestos (que se aplican a través de fondos especiales), especificaciones técnicas obligatorias o la obligación de compra de ER, además de instituciones que sirven para coordinar acciones, catalizar procesos e informar y educar a usuarios específicos o a la población en general y/o emitir certificados con valor de mercado.

3. Las Mejores Practicas Internacionales para el Fomento de las ER.

Definir el camino más adecuado para promover el desarrollo de las ER en México ha sido un tema de discusión por muchos años, sin que exista a la fecha un claro consenso en algún sentido particular. Sin embargo, desde hace ya más de cuatro años, la Comisión Nacional para el Ahorro de Energía, en conjunto con la Asociación Nacional de Energía Solar (ANES) y de otras organizaciones públicas y privadas, y teniendo como referencia a la experiencia internacional, ha fomentado una discusión especializada y pública sobre este importante tema.

En particular, en mayo del año 2001, organizado por la propia Conae, el Instituto de Investigaciones Eléctricas y la Agencia Internacional de la Energía, se llevó a cabo en Cocoyoc, México, el encuentro de alto nivel denominado "Mejores prácticas en energías renovables: compartiendo experiencias para el desarrollo de mercados". El objetivo de este encuentro internacional fue el de facilitar el diálogo entre actores nacionales e internacionales sobre perspectivas y oportunidades futuras para el desarrollo de las energías renovables en México.

De la reunión, que hizo un amplio repaso del estado tecnológico, de los mercados y de las políticas públicas relacionadas a las ER, se concluyó, de manera central, que, para ampliar el aprovechamiento de las ER, el énfasis en este momento debe darse en la búsqueda de mecanismos de mercado para las mismas ya que, cuando menos para los aprovechamientos mini hidráulicos, de biomasa y de viento, la tecnología tiene un alto nivel de desarrollo y disponibilidad, lo que pone al desarrollo de tecnología como una prioridad secundaria si lo que se pretende es el aprovechar a las ER.

Esta conclusión es fundamental, ya que uno de los puntos de discusión centrales en el contexto de los encuentros organizados por la Conae había sido el relacionado a las prioridades de las políticas públicas en México para el desarrollo de las ER y sobre las cuales se han establecido dos posiciones muy claras: la que considera como central el concentrar los esfuerzos en el desarrollo de la tecnología y la que defiende la idea de que este desarrollo vendrá asociado a una mayor demanda de las ER como resultado de las políticas de fomento.

A su vez, se establecieron como elementos fundamentales de política para un desarrollo cabal de las oportunidades de las ER en México, los siguientes:

- *Un marco legal específico*. Un marco legal específico que dé seguridad a inversiones y que haga que los proyectos obtengan financiamiento convencional.

- *Un régimen especial de incentivos*. Es necesario, para que las energías renovables puedan ampliar su participación en el mercado y como lo demuestra la experiencia internacional, que se establezca, bajo una lógica de "inversiones para el aprendizaje", un régimen especial de incentivos.

Finalmente, se estableció que se ha demostrado que, además de lo referido arriba, existen otros elementos que han probado su valor en la experiencia de los países que más han desarrollado su potencial de ER. Estos elementos son:

- Certidumbre en los plazos a los que se dan los financiamientos. Se considera que plazos entre diez y quince años serían los apropiados.
- Incentivos por desempeño y diferenciados. Se recomienda que los incentivos estén basados en desempeño (energía producida) más que en inversión (capacidad instalada) y que éstos no sean homogéneos, sino de acuerdo a tipo de energía renovable y tecnología de transformación.
- Normas técnicas. Se considera necesario que se aseguren la calidad de los equipos y sistemas, específicamente a través de especificaciones técnicas particulares.

4. La propuesta de un Mercado de Energía Verde-

En función de lo establecido previamente y como resultado de un proceso de integración de conceptos, experiencias y propuestas, la Conae, a finales de 2001, puso sobre la mesa de discusión entre autoridades y especialistas en temas energéticos, una propuesta para un mercado de Energía Verde. Esta propuesta incluía:

- *Régimen especial en la Ley del Servicio Público de la Energía Eléctrica*. Este régimen especial es lo que aportaría la certidumbre jurídica a los inversionistas y permitiría la existencia de un conjunto de contratos y tarifas especiales, en particular aquellos que se establezcan entre los generadores y la Comisión Federal de Electricidad (CFE) y entre CFE y los usuarios finales. Asimismo, el régimen especial tendría un alcance limitado en tiempo y capacidad establecida de generación, además de las reglas de entrada para generadores candidatos.

- *Concurso anual de compra de Energía Verde*. En función de las metas establecidas dentro del Régimen Especial, y como una forma de establecer una masa crítica de proyectos y de los precios máximos de compra, anualmente se abriría un concurso para comprometer la compra de Energía Verde a largo plazo por parte de la CFE y en el cual el principal parámetro sería el precio unitario de la electricidad. De manera específica se plantea que el Régimen Especial pudiese operar a partir del 2003, iniciando con un concurso para 100 MW y duplicando la nueva capacidad cada año hasta llegar a un total de 1,500 MW en el 2006.

- *Contratos de compra de largo plazo y precio fijo por energía producida*. Este tipo de contrato se firmaría entre el (los) generador(es) ganadores del concurso anual y la empresa eléctrica y establecería, en lo fundamental, el precio de compra (que sería fijo), el plazo del contrato y el compromiso de compra de toda la electricidad generada.

- *Tarifa verde*. Esta sería una tarifa especial, ofrecida por la CFE a sus usuarios, para la compra, sin subsidios, de la Energía Verde.

- *Sistema de certificación de Energía Verde*. Para garantizar la cualidad “verde” de la electricidad, la Conae planteaba como necesaria la existencia de un sistema, acreditado internacionalmente, que haga transparente el origen y destino de la electricidad generada a partir de ER.

5. El papel de los Gobiernos Estatales

Los estados y municipios pueden aprovechar a las energías renovables como recursos energéticos propios. Aprovechar la energía solar, la mini-hidráulica, la biomasa y los residuos sólidos y líquidos (incluidos los desechos sólidos de la basura que pueden utilizarse para generar gas y electricidad) para generación de electricidad para usos propios está permitido desde 1992, cuando se llevan a cabo modificaciones a la Ley del Servicio Público de la Energía Eléctrica. Esto ha abierto la posibilidad de que localmente se busque el aprovechamiento de estos potenciales.

Por muchas razones, más allá de lo que ya se trabaja en México a nivel federal, es muy importante, precisamente por el impacto económico local, que los estados y municipios se involucren más activamente en los esfuerzos nacionales para el aprovechamiento de las energías renovables. Es significativo que pocos estados tengan un área dedicada a la energía, mas aun cuando ésta es un elemento clave para el desarrollo. De hecho, pocas autoridades a ese nivel desconocen que poseen oportunidades de aprovechamiento de las energías renovables (solar, viento y biomasa) que pueden significar no solo una menor dependencia de la federación sino también el desarrollo de oportunidades de desarrollo locales.

Por lo tanto se hace necesario en México desarrollar capacidades institucionales descentralizadas e integrales en materia de energía en los estados y municipios, como una condición indispensable para poder aprovechar cabalmente todas las oportunidades de energías renovables. Para esto hay que establecer organismos específicos, como Comisiones, Institutos o Secretarías de Energía, con personal especializado (planeadores, promotores y reguladores), y capaces de proporcionar información sobre recursos convencionales y renovables, y los usos finales de la energía.

Estas instituciones locales deberán contar con herramientas para identificar y analizar las mejores alternativas, diseñar sistemas de información geográfica y llevar a cabo una planeación integrada de recursos energéticos en su región de influencia. Igualmente, deberán tener capacidad para tomar decisiones sobre inversiones y regulaciones e incentivos en la materia. Igualmente, deberán apoyar la integración institucional de actores y temas actualmente dispersos—particularmente en cuanto a desarrollo regional, industria, medio ambiente e investigación y desarrollo—y promover la capacitación de personal integrador y de mando.

6. Conclusiones: Hacia el futuro de las ER en México

Es necesario y urgente, por su impacto positivo sobre bienes de carácter público, un mayor reconocimiento al valor estratégico de las energías renovables en México. Para esto, es indispensable que se definan instrumentos de política publica que se establezcan con bases jurídicas sólidas y con instrumentos que permitan aprovechar al máximo recursos públicos escasos.

Asimismo, es fundamental que los gobiernos estatales y municipales se involucren a las tareas de fomento de las ER, ubicando sus oportunidades y aprovechando los mecanismos que ya están en el marco legal.

Finalmente, y concientes que un aprovechamiento cabal de las oportunidades de utilización de energías renovables en nuestro país requerirá de tecnología desarrollada en otros países, el trabajo de desarrollo tecnológico debe concentrarse en apoyar la adaptación de esa tecnología a las condiciones locales.

WORKING GROUP 1: LIQUID FUELS

International Seminar on Bioenergy and Sustainable Rural Development
- 5th LAMNET Project Workshop – Mexico 2003

WORKING GROUP SUMMARY

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The workshop was attended by 35 persons. Six presentations were given on different aspects and technologies related to liquid fuels derived from biomass. The discussion can be summarized in four main points:

Biomass resources

It is important to assure the sustainability of biomass resources, taking into account both its availability and an adequate biodiversity. Extensive areas under monocultures should be avoided.

Crop rotations and intercropping are promising agriculture practices that will help keep adequate nutrient levels and diversification.

The intensification of biodiesel production represents a big challenge from the perspective of biomass resources.

Acid or enzimatic hydrolisis of cellulosic material will open new potentials; there are currently several technical options, but the costs are still too high.

More support is required from Governments regarding technology R&D.

Policy Issues Regarding Fuel Blends

Apart from technology limitations, the importance of decisions regarding sugar and oil prices, both nationally and internationally, together with their implications for the balance of payments and markets were discussed.

It seems that decisions on levels of blending (e.g. ethanol versus gasoline) respond more than anything to macroeconomic considerations.

Agriculture institutions and oil companies should collaborate more in the field of ethanol-gasoline blends. There is a strong need to develop interdisciplinary teams to tackle the specific issues.

In the case of Mexico, it is important to identify organizations that can put forward issues related to biofuels. The Free Trade Agreement (NAFTA) has had a negative impact in the sugar sector, and has thus inhibited the development of liquid fuels.

Climate change issues

Discussions centered in the Clean Development Mechanism and the Kyoto Protocol.

Projects aiming at participating in the CDM should carefully address the issue of additionality, in order to avoid being non-eligible. The opportunities offered by the GEF, and the Carbon Prototype Fund from the World Bank should be carefully examined.

Sustainable Development Issues

Participants stressed the importance of promoting bioenergy in such a way that it clearly responds to the local agendas. For example, in the case of Mexico, municipal and state authorities are gaining decision-making power. Many new investment opportunities, including issues associated to liquid fuels, need to be negotiated at the local level.

A critical point in the development of liquid biofuels is the potential positive impact in the generation of new jobs.

WORKING GROUP 1: LIQUID FUELS

International Seminar on Bioenergy and Sustainable Rural Development
- 5th LAMNET Project Workshop – Mexico 2003

THE PATH IS CLEARING FOR FUEL ALCOHOLS IN COLOMBIA

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Abstract

This is an ambitious program which introduces renewable fuels in the national energy basket, which purpose is to improve air quality, and at the same time, natural renewal resources have a better use, generating a wide stimulation to country development reducing greenhouse effect gas emission. The program includes the expansion of sugar cane growings and some other agricultural products, and the building of nine agroindustrial complexes in different regions of the country to produce anhydrous bioethanol which will be mixed with gasoline producing a new fuel for the country.

La Corporación para el Desarrollo Industrial de la Biotecnología y Producción Limpia – CORPODIB – (The Corporation for Industrial Development of Biotechnology and Clean Production), a mixed entity, a non profit association, have been promoting seven years ago, a national program to introduce renewable fuels, particularly fuel bioethanol and biodiesel. The program is directed to the reduction of movable sources emissions and to the development of energy agriculture in the country.

Law 693 of September 2001 demands the use of biomass ethanol in gasolines used in the main cities of the country. Law regulation indicated that not later than September 27th, 2005, gasolines of Bogota, Cali, Medellín and Barranquilla should contain fuel alcohols in a 10% volume. The same condition is set one year later in the cities of Bucaramanga, Cartagena and Pereira. While agroindustrial projects are developed, its use will be extended in the rest of the national territory.

“We just approve the rules and now we have to install the alcohol distilleries in Colombia, so they are at a prudent distance of the greatest fuel consumption places” said President Uribe[2] in his recent trip to Brazil. With rules of Law 693 of fuel alcohols, Colombia will enter the era of clean fuels, of sustainable production and which respect the environment.

CORPODIB has estimated, in the full application of the program, an annual decrease of six million tons in greenhouse effect gases (GEI) with an important economic potential in the proceeding of Emissions Reduction Certificates (CRE’s) through the Clean Development Mechanism (MDL)of Kyoto Protocol.

[2] Ofiprensa Finagro. 11/03/2003

AGRO FUEL

The sugar cane is an excellent growing to produce energy due to its high efficiency level in the photosynthesis process, condition which is located in the first option to fuel ethanol production. Growings as yuca, potato, corn and others are included for agroecological regions which make that its use is profitable.

A 10% of ethanol in gasolines will demand 700 millions of liters per year, which belong to sugar cane growings of 150 thousand hectares around alcohol complexes identified in the North Coast, Antioquia, Cundinamarca, Hoya del Río Suárez (Santander y Boyacá), Llanos Orientales, Valle del Cauca, Eje Cafetero, Huila, Nariño and Norte de Santander.

ECONOMIC BENEFITS FOR THE COUNTRY

The program will generate 150.000 new employments, direct and indirect employments, mainly in the agricultural sector, related to the new fuel production, substituting 130 MUSD per year, which nowadays are consumed in gasoline. The agro participation in the energy sector is equivalent, in terms of fuel production, to the building of an oil refinery of 40.000 BPD and it represents a growing of the agricultural PIB of 3%.

FUEL ALCOHOLS IN THE WORLD

Brazil introduces the use of fuel alcohol around 30 years ago.
In year 2002, it produces 13.000 MLA and exported 500 MLA[3].

Its production is supported by 307 distilleries with incomes over 4.000 million Dollars in figures of 2002. The sector uses near one million of workers in the country and in industry. It has a cultivated area of 6.5 millions of hectares with a performance of 85 tons of sugar cane per hectare.

In the middle of the 70s, when oil prices were very high due to the Arab-israeli conflict, Brazil, which depended on imported oil, applied a program of alcohol use in gasoline creating Proalcool to promote its growing. The results were very positive and at the ten years, the production was 11 thousand millions of liters and the greater part of the auto fleet was moved with the new fuel. Nowadays, there are 3 millions of autos moved 100% with ethanol and the remaining 17 millions use gasoline mixed with a 25% of alcohol.

In the United States, the fuel ethanol production is growing. In 1996, American producers located in market 3.500 millions of liters of alcohol and in 2002 the figure was increased up to 7.000 millions of liters. It is mainly used in 10% mixtures in gasoline. There is a new law which will treble bioethanol demand, reaching a figure of 17.500 millions of liters at a medium term. This is mainly due to the necessity of substituting MTBE additive (metil-ter-butil-eter), highly pollutant, and prohibited in seventeen states of the United States and in some other countries.

Canadá requests a mixture of 10% in the most polluted regions. México will adopt the same solution in order to deal with grave problems of the capital city.

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[3] The Brazilian Foreign Trade Magazine. Noviembre 2002
MLA: Millones de litros por año

Japan, with a fleet of 72.6 millions of vehicles, is prepared to import increasing volumes of alcohol from Brazil. Thailand, per Law obligues to add 10% of alcohol in gasoline in areas with environment problems. China advances alcohol tests and creates an initial demand of 7.000 millions of tones per year.

The European Union, where environment stuff is urgently dealt, should use in all countries, from 2005, unless 10% of biofuels, according to the Resolution of the European Parliament. In 2010, the ratio should increase to 5.75%.

THE ALCOHOL PROGRAM IN COLOMBIA

In order to meet the requirements of Law 693, and extending the use to the rest of the national territory, alcohol agroindustrial complexes should be installed and distributed in different regions of the country. CORPODIB studies, indicate, industrial facilities locations and sizes as they are shown in Table 1.
Indicative projects of fuel alcohol producers

Location	Capacity Liters/day	Raw material
Hoya del Río Suarez	300.000	Sugar cane
Vegachí (Antioquia)	350.000	Sugar Cane
Valle del Cauca	300.000	Sugar cane
Northern Coast	300.000	Sugar cane - yuca
Cundinamarca	150.000	Sugar cane
Llanos Orientales	100.000	Yuca – Sugar cane
Eje Cafetero	250.000	Sugar cane
Huila	200.000	Sugar cane
Nariño	150.000	Sugar cane

The first projects will be developed in Hoya del Río Suárez, Vegachí and Valle del Cauca, cane regions, where the first steps are in process.

Alcohol production costs from sugar cane are estimated between 27 and 30 dollar cents per liter. Taking into account that fuel alcohol does not pay gasoline taxes, as it was approved in tax reform last year, investments are profitable both for the cane producer and for the agroindustry investor. Dollar return rates are over 20%, which makes that projects are attractive for national and foreign investors. These profitabilities are achieved without increasing fuel cost for the final consumer.

Available technologies in market for anhydrous alcohol production have substantially evolved from its initiation 30 years ago in Brazil. Progress has been remarkable in fermentation performances, process energy efficiency, ethanol drying, electricity cogeneration from bagasse to strong wine processing.

The strong wines, a plant byproduct which was before thrown away and it polluted rivers and water springs, now is transformed in a rich potassium fertilizer which is totally applied in the same plantations contributing to the process economics. Industrial equipment investments are around 400 million dollars in next 5 years, approximately a 70% of equipments will be nationally manufactured. Investments near to 100 million dollars are required in infrastructure (ways, bridges and plantations harvest systems) and growings adaptation in the same period.

HOW FUEL ALCOHOLS PRODUCTIVE CHAIN OPERATES

Fuel ethanol should be mixed with gasoline nearest the consumption point, due to the afinity of anhydrous alcohol with water. Gasoline storage and transport (poly pipelines) have water in minor proportions which causes problems in ethanol-gasoline mixture. For this reason, alcohol production should be done in different regions of the country where exists raw material and consumption centers are near.

Ethanol will be transported through tank truck from distilleries to supply plants located near big cities and there, the wholesale distributor will make mixtures according to specifications set by the Ministry of Environment, before it is dispatched in tank truck to the service stations. The system, as it is seen, maintains the same condition as nowadays, only with the change of some tanks and mixture systems in supply plants. Storage capacity in supply plants is a 10% of gasoline storage capacity.

The refinery, continues its production, as nowadays base fuel and dispatching it by polypipelines to the supply plants. Due to ethanol has a high content of octane, gasoline dispatched from the refinery requires less octane, with an economic benefit in productive chain operation.

The final consumer will be helped with a better quality fuel, which will reduce atmosphere harmful emissions in a 25%.

WORKING GROUP 1: LIQUID FUELS

International Seminar on Bioenergy and Sustainable Rural Development
- 5th LAMNET Project Workshop – Mexico 2003

Automotive Fuels from Flash-pyrolysis of Biomass Bio-oils

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INTRODUCTION

The conversion of biomass into liquid products has a precise objective: to transform a material which is bulky, difficult to handle and with a low energy density into an oil which can be used to produce chemicals or as a fuel suitable for transportation and for use in power plants (boilers, engines and gas turbines).

Pyrolysis is the most direct way of converting biomass into liquid fuels. Bio-oils have a high oxygen content (30-40% dry basis), as can be seen by the presence of phenols, alcohols, carboxylic acids and ketones. The composition depends on the process used as well as the biomass type and the processing conditions. Unfortunately there are some problems mainly with the storage, transport, piping and combustion of pyrolysis oils. They are unstable and tend to polymerise when heated, even at moderate temperatures. The viscosity is generally high and increases with storage time. Their calorific value is low and their water content may be a serious drawback in this respect.

These characteristics make bio-oils incompatible for use with petroleum derived feedstuffs, but their quality can be improved by eliminating the oxygenated fraction. One method is hydrotreating under hydrogen pressure in the presence of a catalyst. The reactions which occur are hydrogenation of double bonds, elimination of oxygen as water and hydrogenation-hydrotreating of large molecules[1].

Between 1993 and1997 the Department of Chemistry of the University of Sassari was involved as a contractor in a project financed by the European Community (Air-CT92-0216), whose aim was to develop a hydrotreating process to upgrade flash-pyrolysis bio-oils[2].
Studies and trials performed by the participants, showed that the bio-oil could be completely hydrogenated. Further study carried out by the Department of Chemistry (INTERREG II) demonstrates that the characteristics of the hydrogenated bio-oil are such that it can be used in the usual refinery processes[3].

HYDROTREATING OF FLASH-PYROLYSIS BIO-OIL

Bio-oil upgrading was performed at DMT-Gesellschaft für Forschung und Prüfung mbH 10 kg/h pilot plant in Essen (D), using their IGOR Technology. The operating conditions are shown in Tab. 1

Tab. 1 Pilot plant operating conditions

Bio-oil feed rate	11 kg/h
Reactor volume	11 dm^3
Specific oil feed rate	1 kg/dm^3 h
Total pressure	30 MPa
Reaction temperature	380 °C

The yield of hydrogenated bio-oil was 52.8% with respect to the dry bio-oil The fraction that can be considered as the main final result of the process was 64% of the total product. Additional information can be found in Contract No. Air-CT92-0216 Final Report, September 1997[4].

CHARACTERISATION OF HYDROGENATED BIO-OIL

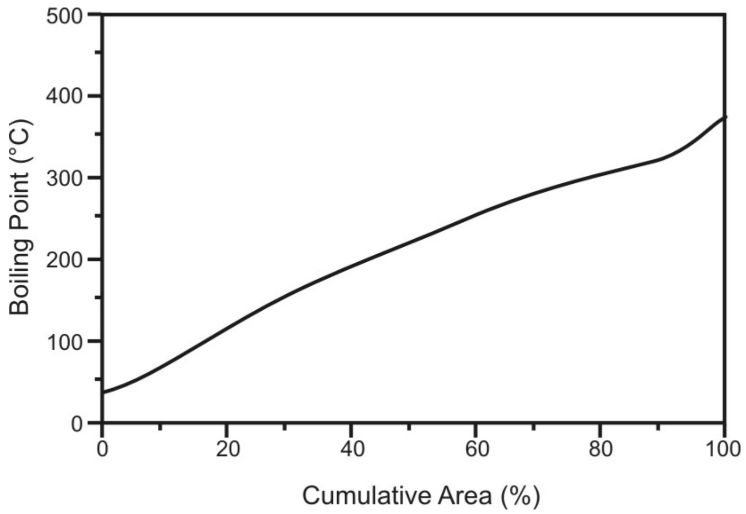
Hydrogenated bio-oil is a clear, low viscosity liquid. Some chemical and physical analyses of this are summarised in Tab. 2, and compared to the starting flash-pyrolysis bio-oil.

Tab. 2 Boiling range distribution of the hydrogenated product

		Hydrogenated Bio-oil	**Flash pyrolysis Bio-oil**
Density @ 20°C	g/cm^3	0.801	1.258
Viscosity @ 20°C	mm^2/s	1.35	857.8
Pour Point	°C	< -35	
Flash Point	°C	< 6	
LHV	MJ/kg	21.4	19.8
Ash	% wt.	0	0.4
Moisture	% wt.	<0.05	20.5
C	% wt. (dry)	87.3	46.0
H	% wt. (dry)	12.7	6.9
O	% wt. (dry)	<< 0.1	47.0
N	ppm (dry)	2	352
S	ppm (dry)	32	57

The boiling point range shows an initial boiling point of 35°C and a final boiling point of 396°C, and thus covers the distillation range of a mixture of gasoline and diesel fuel. The boiling range was performed by the procedure ASTM D 2887 (simulated True Boiling Point distillation) as is shown in Fig. 1.

Fig. 2 Boiling range distribution of the hydrogenated product



Although a GC-MS characterisation was performed, in which 75 compounds were identified, the composition of the product is better represented by PONA analysis.

The mixture is constituted of differently substituted cycloalkenes and of saturated aliphatic compounds. The former are derived from lignin and the latter from cellulose. The small amount of aromatic compounds is derived from cellulose degradation. The distribution of the different classes of compounds is reported in Tab. 3.

Tab. 3 PONA analysis of the hydrogenated bio-oil

CLASS	**CONCENTRATION (% wt)**
Paraffins	22.7
Olefins	2.4
Naphthenes	68.0
Aromatics	6.9

The mixture was rectified and two fractions were obtained. The lighter one (B.P. < 210°C, 51.3% wt.) is like a gasoline and the heavier one ($B.P._{max}$ = 396°C, 46.9% wt.) is like a gas oil.

The distillation curves of the two fractions were determined according to the procedure ASTM D 2887. They are reported in Fig 3 and Fig. 4.

Fig. 3 Distillation curve of light fraction

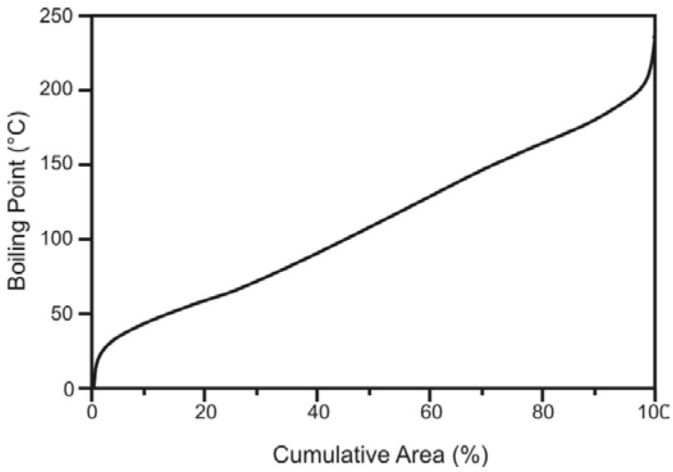
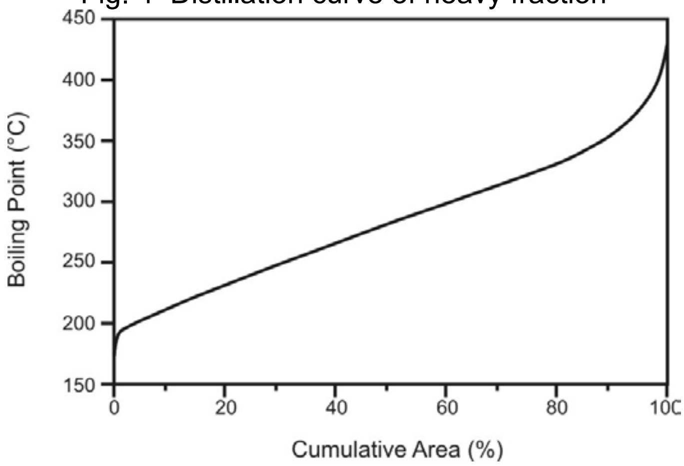


Fig. 4 Distillation curve of heavy fraction



LIGHT FRACTION (B.P. < 210°C)

Characterisation

The distillation range of this fraction may be classified as gasoline like, and thus the main analyses for this commercial product were performed. The results, compared with specifications of commercial gasoline, are reported in Tab.4, 5 and 6 .

Tab. 4 PONA analysys of light fraction

CLASS	**CONCENTRATION (% wt.)**	
	Hydrogenated product Light fraction	**Commercial gasoline ***
n-paraffins	13.45	50 – 62
iso-paraffins	11.88	
naphthenes	57.30	
aromatics	16.25	< 40
olefines	1.12	< 10

Tab. 5 BTEX analysis of light fraction.

COMPOUND	**CONCENTRATION (% wt.)**	
	Hydrogenated product Light fraction	**Commercial gasoline ***
benzene	0.16	< 1
toluene	0.57	
m+p - xylene	0.21	
o - xylene	0.10	

Tab. 6 Industrial characterization of light fraction

			Hydrogenated product Light fraction	**Commercial gasoline ***
Density @ 15°C	ASTM D 1298	g/cm^3	0.8038	0.725-0.77
Distillation	ASTM D 86			
Initial Boiling Point		°C	34.4	> 30
10% evaporated		°C	100.0	< 70
20% evaporated		°C	108.0	
50% evaporated		°C	138.9	
90% evaporated		°C	184.1	< 180
Final Boiling Point		°C	199.6	< 215
Copper corrosion (3h @ 50°C)	ASTM D 130		absent	< 1
Vapour pressure @ 100°F	ASTM D 323	kg/cm^2	0.108	0.4 - 0.7
Gum test	ASTM D 381	$mg/100cm^3$	< 3	< 8
Oxidation stability	ASTM D 525	min	> 420	> 420
Clear octane number (Research)	ASTM D 908		53	> 83 **
Neutralization number	ASTM D 974	mg KOH/g	absent	< 0.04
Bromine number	ASTM D 1159	gBr/100g	7.03	
Flash point	ASTM D 93	°C	10	< 21

(Specification of the CE 98/70 directive)*

The results of the analyses performed on the light fraction of hydrogenated bio-oil and the comparison between these values and those for commercial gasoline show that the two products are completely different.
Even though the distillation range is the same for the two products, in the light fraction there is a lack of low boiling compounds. In agreement with this result the light product has low vapour pressure, considerably lower then the typical value for commercial gasoline. Thus using this product as automotive fuel involves difficulty in ignition and warming up the engine, as well as carburation problems and thus lower acceleration.
Moreover the octane number of the hydrogenated oil is too low. This is due with the low aromatic content, wich is also below the value permitted from the directive 98/70/CE, which sets a 40% vol. limit, as well as to the low iso-paraffins content. The main components are the saturated compounds, particularly napthenes, which have a poor antiknock blending value.
The high content in naphthenes compounds and *n*-paraffins however made this product suitable as feedstock for the catalytic reforming process.

Reforming

Reforming is a catalytic process which causes the aromatization of naphthenes and isomerisation of *n*-paraffins, with the final being the conversion of the feedstock into a high octane gasoline suitable as base for automotive fuel. The reforming of the light fraction was performend using a Pt/Al_2O_3 commercial catalyst (Engelhard E–302). (Tab. 7).

Tab. 7 Reforming catalyst properties

Chemical properties		
Pt	%p	0.6
Al_2O_3	%p	98
Clorides	%p	1
Physic properties		
Surface area	m^2/g	175-220
Average Diameter	mm	1.65
Average length	mm	5
Specific weight	kg/m^3	752 – 832

Tab. 8 shows the operating conditions in comparison with the parameters commonly used in industrial processes.

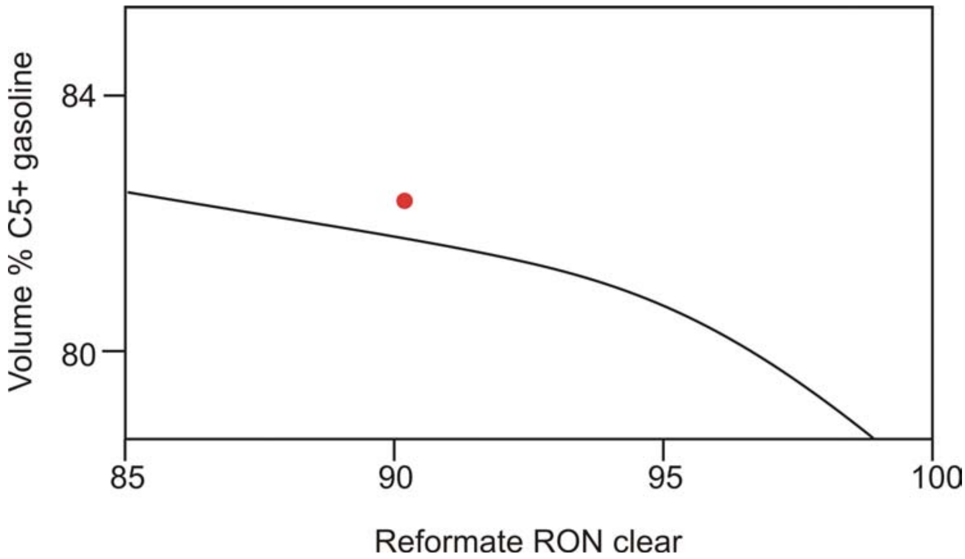
Tab. 8 Operating conditions of the reforming process

		Operating conditions	Typical conditions
WABT*	°C	400	450 - 500
Space velocity	h^{-1}	4	1 - 4
Pressure	MPa	3	2 - 7
H_2/HC feed	mol/mol	5	3 - 10

* Weight Average Bed Temperature [$T_{in}+0.75(T_{out}-T_{in})$]

Yields obtained in the process are shown in Tab. 9. The results are quite comparable with the industrial ones and can be estimated using the Fig. 5 [5]. The point highlighted represents ours yields, the continuous curve the average values of the reforming process.

Fig. 5 Catalytic reforming yield correlation



Tab. 9 Yields of the reforming process

	Liquids	Gases	H_2	Coke
Reforming of bio-oil	82,4	15,1	2,4	$3 \cdot e^{-3.5}$
Typical values	82	14	2	$3 \cdot e^{-5} – 3 \cdot e^{-6}$

The reformate was analysed and the results are reported in Tab. 10.

Tab. 10 Characteristcs of the reforming product

			Reforming product	Commercial reformate
Density @ 15°C	*ASTM D 1298*	g/cm^3	0.825	< 0,81
Distillation	ASTM D 86			
Initial Boiling Point		°C	43,9	> 30
10% evaporated		°C	76,3	
20% evaporated		°C	90,3	
50% evaporated		°C	130,2	
90% evaporated		°C	196,6	
Final Boiling Point		°C	213	< 215
Gum test	ASTM D 381	mg/100ml	1	< 4
Oxidation stability	ASTM D 525	min.	> 480	> 480
Clear octane number (Research)	ASTM D 908		90	> 86,5
Copper corrosion (3h @ 50°C)	ASTM D 130		< 1	< 1

The reformed bio-oil has characteristics very like those typical of a commercial product. The suitability of this product as a blending stock for gasoline production is demonstrated in particular by the distillation range, the small content of gums and low corrosiveness and by the high octane number.

HEAVY FRACTION (B.P.$_{max}$ = 369°C)

The gas oil in mainly used as diesel fuel, as feedstock for steam cracking process in oil industry and as fuel for heating plants. The commercial value of this products decreases in the following order: diesel fuel, industrial gas oil and heating plant fuel.
Tab. 11 shows the results of the analyses performed on the heavy fraction of the hydrogenated bio-oil compared with the specification of a commercial diesel fuel and an industrial gas oil.

Tab. 11 Characteristics of the heavy fraction

			Hydrogenated product Heavy fraction	**Commercia l diesel fuel**	**Industrial gas oil**
Density @ 15°C	ASTM D 1298	g/cm^3	0.9024	< 0.84	
Distillation	ASTM D 158				
Initial Boiling Point		°C	224	> 170	
recovered @ 250°C		% vol.	11.5	< 65	
recovered @ 300°C		% vol.	53.8	> 60 e < 80	> 50
recovered @ 350°C		% vol.	86.5	> 87	
Final Boiling Point		°C	396	< 500	< 500
Colour	ASTM D 1500		2.5	< 2	< 2
Flash point	ASTM D 93	°C	102	> 55	> 55
Sulphur	ASTM D 129	% wt.	0.025	< 0.03	< 0.07
Corrosion number	ASTM D 130		absent	absent	absent
Cloud point	ASTM D 97	°C	non detectable		< +50
Neutralization no.	ASTM D 974	mg KOH/g	0.27	< 2	
Oxidation stability	ASTM D 525	min	> 420		
Cetane index	ASTM D 976		38.5	> 47	> 30

The product is very dense, but above all has a low cetane index value. These characteristics make this fraction unsuitable for use as diesel fuel or for further refining aimed at this purpose. The product is however quite suitable as a feedstock for the steam cracking process. For this use the low sulphur content is particularly useful.

CONCLUSION

The technical feasibility of the hydrogenation of flash-pyrolysis bio-oils on a pilot scale was demonstrated. The product meets the requirement of all international standards for heating oils, industrial oils and motor fuels. In particular a series of operations were experimented from which it is possible to obtain a reformated gasoline with a high octane number and a industrial gas oil to be processed in a petrolchemical factory.

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WORKING GROUP 2: GENERATION OF ELECTRICITY

International Seminar on Bioenergy and Sustainable Rural Development
- 5th LAMNET Project Workshop – Mexico 2003

WORKING GROUP 2: SUMMARY

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Using biomass for electricity generation is widely recognized as a key issue for sustainable development both in industrialised and developing countries.

Nowadays biomass is used as a primary energy source (cooking fuel) especially in the southern hemisphere, but this use is generally considered as non sustainable, as it depletes the resource and the combustion process is often inefficient and heavily polluting; biomass could play, instead, an important role in rural electrification, where modern conversion technologies could be adopted, combining energy production and low polluting gas emissions. Biomass in fact has a huge potential as it represents a distributed feedstock, generally available where the power production is required, and its combustion is potentially CO_2 free.

The passionate discussions during the Electricity Generation working group of the International Seminar on Bioenergy & Sustainable Rural Development were concerned with the investigation of possibilities for an effective exploitation of biomass for power production with particular interest on the Mexican framework.

Mexico is in fact rich in Biomass but it is not clear whether this will ever result in a distributed renewable bio-electricity generation. Several different scenarios on the future portfolio of energy sources in Mexico have been discussed, but even the most promising from the sustainable development point of view, predicting a 59% RES penetration in 2025, confines biomass to a minor role (about 3% of total power generation). Therefore, the challenge to face during the next years is, for Mexico and world-wide, to increase this percentage by pushing further the research of new conversion technologies, providing new cost effective solutions and identifying the best possible policy options.

The 30 international Bioenergy experts gathered for the seminar Working Group suggested different possible scenarios and technologies to be adopted.

One possible solution is represented by energy dedicated crops such as trees and perennial grasses grown specifically to provide feedstock for energy production. In particular bamboo (100 ton/ha) and some species of eucalyptus offer promising opportunities for biomass production in Mexico. Dedicated crops, however, often arise opposition as they are seen as a menace for bio-diversity. Additionally, it is difficult to regard dedicated crops as the only solution for a wider Bioenergy production as they involve high costs for production and processing.

Another possible option identified within the working group has been that of increasing the efficiency of existing power plants using biomass as a feedstock. In particular, old sugar cane bagasse power plants which are operating in Mexico at sugar mills could be turned into efficient CHP plants with low investment costs, thereby maximising the exploitation of what is generally considered as a production waste. The example of countries such as Brazil and South Africa, where bagasse plants are growing in number and efficiency, should be followed. Finally, it is important to highlight once more the importance of providing a policy framework able to maximise the productivity of the plants, allowing them to feed in the electrical grid.

Another feedstock to be taken in consideration is biogas. Biogas can be produced from Municipal Solid Waste degradation or from anaerobic digestion of animal manures.
Two good example of existing projects have been presented: a plant in Costa Rica, burning biogas derived from MSW degradation and a project for a 75 MW power plant burning biogas derived from anaerobic digestion of animal wastes.

An important role in distributed generation future scenarios could be played also by biofuel burning microturbines, being small gas turbines with a capacity of 20-100 kWel. Thereby, it is important to investigate the possibilities of feeding these microturbines with both liquid and gaseous biofuel, as this would allow to achieve a faster and "renewable" rural electrification. However, at present there are several barriers to overcome: first of all the high costs of the technology and high sensitivity of turbine materials to common chemical compounds present in biofuels such as H_2S and SiH_4.

The working group analyzed different possible scenarios for future power distributed generation utilising biomass as feedstock. At present no technology can be classified as the future leader in the power production sector. Therefore, different technological solutions have to be carefully analysed addressing both main advantages and critical aspects.

WORKING GROUP 2: GENERATION OF ELECTRICITY

International Seminar on Bioenergy and Sustainable Rural Development
- 5th LAMNET Project Workshop – Mexico 2003

FUTURE PARTICIPATION OF BIOENERGY IN THE MEXICAN ENERGY MIX FOR POWER GENERATION

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ABSTRACT

Three scenarios relating to the environmental futures of electricity generation in Mexico up to the year 2025 are presented. The first scenario emphasises the use of fueloil fuelled steam turbine plants, and represents the historic path of Mexico's energy policy mid-90's. The second scenario prioritises the use of natural gas fuelled combined cycle plants, reflecting the energy consumption pattern that arose in the mid-90's as a result of reforms in the energy sector. The third scenario takes into account the present and medium term use of natural gas technologies that the energy reform has produced, but after 2007 a high and feasible participation of renewable sources of energy is considered. The participation of bioenergy in the form of firewood and bagasse is emphasized The energy consumption of the three scenarios are calculated up to the year 2025 with its corresponding CO_2 emissions.

INTRODUCTION

In January 2001 the Intergovernmental Panel on Climate Change (IPCC) Working Group I [WGI, 2001] reported: 1. The Earth's average surface temperature has increased by 0.6 ± 0.2 ^{o}C during the last 100 years; 2. Snow cover and ice extent have decreased and global average sea level rose between 10 cm and 20 cm during the 20th century; 3. Concentrations of atmospheric greenhouse gases (GHG) (CO_2, N_2O and CH_4) have continued to increase as a result of human activities; 4. There is a positive radiative forcing produced by increased concentrations of GHGs that tends to warm the Earth's surface; 5. There is a negative radiative forcing due to natural causes (changes in solar radiation output, explosive volcanic activity) and from anthropogenic aerosols (biomass and fossil fuel organic carbon combustion) that tends to cool the surface on a regional scale, and 6. The balance between the atmospheric mixture of long lived GHGs and short lived anthropogenic aerosols results in a net positive radiative forcing that tends to global warming.

Mexico is one of the countries that have signed and ratified the Kyoto Protocol. The Kyoto Protocol calls for reducing the GHG emissions to a lower level than 1990. In that year Mexico emitted 444 million tons of CO_2 or 2% of world emissions [INE, 2003]. These reductions would have to be accomplished between 2008 and 2012.

Mexico has one of the highest levels of CO_2 emissions per unit of GDP in the Americas. Due to its international commitments it is of utmost interest for us to analyse which technological trends for energy generation and use, particularly in the power sector, can reduce these emissions without distressing the rapid economic growth that Mexico needs.

In this paper the possibilities of technological restructuring of the electricity generation sector, particularly with renewable sources are explored, and how these changes affect CO_2 emissions by the year 2025. In 1996, the total generating capacity was 34733 PJ, from which 31% were renewables, mainly hydropower. See Table 1. In our base or BAU scenario the most likely path is to fulfil the electric sector expansion using fossil fuelled plants, decreasing renewables' participation down to 13%.

Table 1. Energy technologies mix including new renewables [Islas, 2001].

POWER PLANTS	BASE YEAR 1996 %	TREND 2025 %	OFFICIAL 2025 %	TRANSITION 2025 %
NON RENEWABLES				
COMBINED CYCLE - NG	5.6%	2.1%	61.3%	16.1%
STEAM TURBINE - OIL	41.1%	74.6%	15.4%	15.4%
INTERNAL COMBUSTION - OIL	4.8%	4.2%	4.2%	2.9%
COAL	7.5%	2.8%	2.8%	2.8%
FUEL OIL AND DIESEL FIRED	6.0%	2.3%	2.3%	2.3%
NUCLEAR	3.8%	1.4%	1.4%	1.4%
RENEWABLES				
HYDROELECTRIC	28.8%	11.5%	11.5%	23.5%
WIND	0.0%	0.1%	0.1%	13.8%
SOLAR PHOTOVOLTAICS	0.03%	0.01%	0.01%	5.9%
GEOTHERMAL	2.2%	1.0%	1.0%	4.7%
MICRO-HYDRO	0.12%	0.05%	0.05%	3.2%
FUEL CELLS	0.0%	0.0%	0.0%	1.7%
BAGASSE	0.0%	0.0%	0.0%	1.7%
MUNICIPAL SOLID WASTE	0.0%	0.0%	0.0%	1.5%
FUELWOOD	0.0%	0.0%	0.0%	1.5%
SOLAR THERMAL-ELECTRIC	0.0%	0.0%	0.0%	1.4%
TOTAL GENERATING CAPACITY %	100.0%	100.0%	100.0%	100.0%
TOTAL GENERATING CAPACITY MW	**34733**	**92499**	**92499**	**92499**
NON RENEWABLES	69%	87%	87%	41%
RENEWABLES	31%	13%	13%	59%
TOTAL BIOMASS (BAGASSE+ FUELWOOD)	0.0%	0.0%	0.0%	3.1%

To understand the role that renewable energies can play in reducing the mentioned electricity sector atmospheric emissions are of utmost importance. The purpose of this study is to determine these environmental impacts for three energy scenarios by the year 2025. These scenarios are: 1) the trend or BAU scenario; 2) the official scenario; and 3) the transition scenario with renewable energy sources. The last scenario is a renewable energy mix scenario, based on a thorough review of the economic and technical potential of renewable energies. From which Bioenergy will be considered here in two forms, bagasse and firewood.

The scenarios were built taken into account the following information: the technological change of power plants and considering the available resources in Mexico. We assume that power sector technology will continue to evolve between 1996 and 2025. This evolution is expressed as decreasing capital costs per power unit. (See Table 2)

Table 2. Capital cost evolution for energy technologies in USD 1997/kW. [Islas, 2001].

PLANTS	1997	2000	2005	2010	2015	2020	2025
Combined Cycle	813[1]	428[2]	428[2]	428[2]	428[2]	428[2]	428[2]
Gas Turbine	455[1]	453[2]	453[2]	453[2]	453[2]	453[2]	453[2]
Internal Combustion	455[1]	453[2]	453[2]	453[2]	453[2]	453[2]	453[2]
Geothermal	2030[1]	1372[3]	1250[3]	1194[3]	1147[9]	1100[3]	1100[3]
Carboelectric	1467[1]	1212[2]	1212[2]	1212[2]	1212[2]	1212[2]	1212[2]
Dual	1756[1]	1438[2]	1438[2]	1438[2]	1438[2]	1438[2]	1438[2]
Wind	1232[7]	750[3]	720[3]	675[3]	665[3]	655[3]	655[3]
Nuclear	2559[1]	2116[4]	2116[4]	2116[4]	2116[4]	2116[4]	2116[4]
Hydro	1912[1]	1750[2]	1750[2]	1750[2]	1750[2]	1750[2]	1750[2]
Steam Turbine	933[1]	776[2]	776[2]	776[2]	776[2]	776[2]	776[2]
MicroHydro	3001[5]	3001[5]	3001[5]	3001[5]	3001[5]	3001[5]	3001[5]
Solar Photovoltaic	9300[3]	5300[3]	2900[3]	1500[3]	1305[9]	1110[3]	1110[3]
Solar Thermal	4051[6]	4051[6]	3234[6]	2418[6]	2380[6]	2342[6]	2342[6]
Municipal Solid Waste	5892[6]	5892[6]	5892[6]	5892[6]	5892[6]	5892[6]	5892[6]
Bagasse	2102[3]	1892[3]	1650[3]	1464[3]	1361[9]	1258[3]	1258[3]
Firewood	1965[3]	1745[3]	1510[3]	1346[3]	1380.5[9]	1115[3]	1115[3]
Fuel Cells	3000[8]	1607[6]	1568[6]	1568[6]	1568[6]	1568[6]	1568[6]

1 COPAR 1996 *4 EPRI 1993* *[7] ANES 2000*
[2] COPAR 2000 *[5] Rand Corporation 1999* *[8] IEA 1997*
[3] DOE & EPRI 1997 *[6] NEA/IEA 1998* *[9] Interpolated values*

BIOENERGY RESOURCE ESTIMATION FOR FOWER PLANTS

A Mexican energy resources database was prepared in spreadsheet format, it shows availability details of bagasse, firewood and the rest of the renewables for the present, medium and long term.
Firewood is the most used form of bioenergy with 256 PJ, that's 75% participation consumed totally for residential use, followed by bagasse consumed mostly in sugar industry for heat (15%) and electricity generation (10%) [SENER, 2001].

We considered bagasse as the only bioenergy form in use for combined heat and power generation in the sugar industry, in fact 84% of the electrical power needed in the sugar industry is self generated, but with very old technologies, mostly steam turbines, as suggested by (Navia, 1987), we considered a recent technology consisting in bagasse gasification as an input fuel for a gas turbine, which give a much more efficient performance than the previous technology. Details of data entered for the installed capacity estimations for bagasse can be found in Table 3. As seen from that table we chose approximately half of the installed capacity potential, in order to prevent us from being too optimistic, and thinking that just about half of the 68 sugar cane mills existing in Mexico could afford to install a 50 MW power plant.

Table 3: Bagasse installed capacity estimation and firewood area calculations.

ENERGY CROP	BAGASSE		FIREWOOD (SALIX)
AREA [hA]	580,000	in 1986	342,945
PRODUCTION [Mton]	35.7	in 1986	3.4
CROP YIELD [ton/hA]	61.6		10
ENERGY YIELD [kWh/ton]	430	in 2025	4,500
TECHNOLOGY	Gasification + Gas turbine	in 2025	IGCC; EFF=47%; PF=60%
GENERATED ELECTRICITY [GWh]	15,351		15,432
MAXIMUM INSTALLED CAPACITY	3,400		DEPENDING ON AREA
INSTALLED CAPACITY [MW]	**1,529**		**1,380**
SOURCE	Navia, J. et al. ANES proc., p 304 (1987)		Gustavsson, L. And Borjesson, P. En. Pol. 26(9), p 699 (1998)

Firewood was not taken as a participant in the Mexican installed electric capacity initially, but we consider that is a must to include it as an important renewable resource in the near future beginning its participation in 2010, when its capital costs are more competitive as seen on table 2. Also the expected efficiency in firewood technologies is 47% by 2030 [IEA, 1998] contrasting with the actual efficiency of 36%. To calculate the area needed for the energy crops, we started proposing an installed capacity as an educated guesses we decided to take an installed capacity almost equal to the bagasse power plants, thinking also that the same power plant could handle both fuels, in that configuration the storage of bagasse is avoided.

Then, the energy yields values of firewood, were taken from [Gustavsson, 1998], and the technology that would be more likely to be in its mature state, between 2010 and 2015, reaching a 40% efficiency is the Integrated Gasification and Combined Cycle plants (IGCC). Finally the obtained area is smaller than the actual sugar cane fields.

METHOD

The Long Range Energy Alternatives Planning (LEAP) program was used. It is a user-friendly software tool for integrated energy-environment analysis and greenhouse gas mitigation analysis developed by the Stockholm Environment Institute – Boston with support from international organisations. It is a bottom-up accounting model which, when applied to the electricity sector, allows evaluation of different energy policies in electricity generation (such as energy efficient use, fuel substitution and technological changes) and their corresponding emissions.

In this study it was necessary to calculate the electricity demand by the different Mexican end-use sectors. The following sectors were considered: residential, commercial, public, agricultural, industrial, transport and energy sector self-consumption.

ASSUMPTIONS

For all the energy scenarios developed for Mexico from 1996 to the year 2025 the following common hypotheses were considered: 1. Constant economic growth with a 4% GDP average annual increase; 2. Constant average annual population growth of 1.21%, resulting in 130 million people by the year 2025; 3. Constant end-use demand structure; 4. Energy and particularly electricity demand grows 4% per year as the GDP; 5. The installed power capacity increases by 5% up to the year 2007 [Secretaría de Energía 1998]; 6. After 2007, the annual growth rate of the installed capacity is considered constant at 3.4% [Alonso 1994], and 7. Finally, 3% of the new electricity supply is devoted to satisfy the peak power demand by means of internal combustion engines burning diesel and natural gas.

The electricity demand in Mexico grew at an AAGR of 7.7% between 1966 and 1989. During the nineties this rate fell to 5.1%. Up to now, the electricity demand growth rate has always been greater than the GDP's growth rate (4.2% and 3.4% respectively). Due to improvements in energy efficiency of end use technologies and to an effective energy savings programs, this difference is decreasing. We assume that this tendency continues, reaching zero by 2012, and that by the year 2025 the electricity demand rate is 0.8% less than the GDP rate. Based on these assumptions, the electricity demand between 1996 and 2025 is 4%, identical to the assumed GDP growth rate.

SCENARIO BUILDING

Three different paths were considered for the evolution of the energy sector in Mexico.
The Trend scenario was selected to provide a baseline comparison and also to establish an upper limit for the GHG emissions of the Mexican power industry. The most used fuels are oil products. In the power generation sector all new capacity supply is accomplished with technologies that use mainly fueloil.

In this scenario, fueloil consumption increases with an AAGR of 5.8%. The installed capacity of the power sector utilities which use fueloil increases from 14,283 MW to 66,849 MW by the year 2025, representing 70% of the total installed capacity. This scenario is economically feasible only if the fueloil prices are much lower than natural gas prices. Under this conditions the vapour turbine plants would be the most competitive, according to Comision Federal de Electricidad (CFE), the Mexican public utility company [CFE, 1997]. This situation would make it very difficult to introduce renewable sources into the energy mix in the long term.

The Official scenario was chosen because it represents the continuation of the present policy of the Mexican Energy Secretary, in which natural gas (NG) is the privileged fuel. The information to construct this scenario was taken from government publications in which the medium term future planning of the power industry is described. It reflects the new path in fuel consumption in the Mexican power sector, which was established as part of the electrical industry reform in 1992 [Secretaría de Energía, 1998].

All new installed capacity is accomplished using NG technologies, giving preference to combined cycles. Natural gas has an AAGR of 9.9%. In absolute terms this expansion permits an increase from 135 PJ to 2110 PJ in 2025, representing 55% of the total electricity consumption. The installed capacity of combined cycle for power generation increases from 1957 MW to 56, 668 MW, representing 62.3% of the total installed capacity.

In the Transition scenario, natural gas is privileged until 2007 and then renewable energies are preferred between 2007 and 2025. Table 4 shows the specific hypothesis employed in this scenario. It is considered viable from an economic and technological point of view and is fully referenced to the technical and economic feasibility study of a high renewable scenario share made by the [EIA 1998].

The combined cycle plants fuelled with natural gas are considered the most competitive technology for power generation up to the year 2010 [INE 1990, CFE 1997]. After 2010, it is assumed that renewable technologies are technically and economically feasible By 2025, the renewable energies grow at an average annual rate of 5.61% and account for 54% of the installed power capacity.

In this scenario we assume a gradual internalisation of externalities of power generation of current power sources, high fueloil and natural gas prices, and an intensified industrial learning within the electrical power industry regarding the use for energy generation and equipment fabrication..

In this scenario renewable resources are used to satisfy most of the Mexican power demand up to the year 2025. Applying the assumptions made by several authors [IEA 1997, Palz 1994, IEA 1998, Borja 1998, CONAE 2003, Manzini 1999], a strong participation of renewable energies in the power industry is possible from a technical, economic and institutional point of view. Table 4 shows the hypothesis employed.
From Table 4 can be observed that hydroelectricity doesn’t need to grow as fast as most of the other “newer” renewables, because most of the actual (and future) installed capacity is still from this source.

Table 4. Specific hypothesis employed in Renewable and Transition scenarios, showing the AAGR of installed electricity capacity for various renewable sources.

SOURCES	TRANSITION SCENARIO AAGR
• Hydroelectricity	5.2%
• Solar Photovoltaics	25.9%
• Municipal Solid Waste	41.7%
• Biomass	42.0%
• Wind	39.2%
• Fuel cells	42.3%

RESULTS

Figure 1 shows the primary energy consumption in the Mexican power sector in each scenario. The different energy paths up to 2025 are due mainly to the different technology efficiencies encountered on each scenario.

In the Official scenario the energy needed to satisfy demand is less than in the other scenarios because of the larger efficiencies of natural gas feed technologies such as combined cycle power plants (up to 50%). Trend and Renewable scenarios have very similar global power efficiencies in 2025. Finally, in the Transition scenario, global power efficiency is intermediate in 2020, but shows a deterioration in 2025.

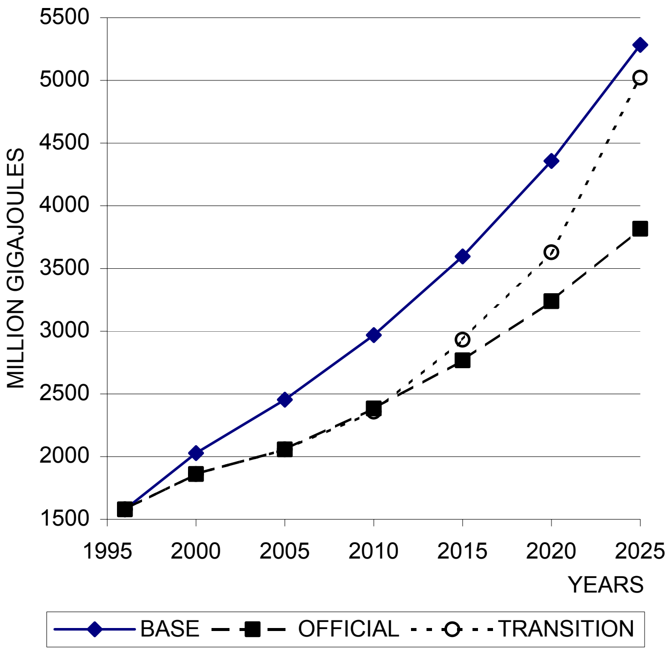

Fig. 1. Primary energy consumption in the Mexican power sector between 1996 and 2025 for three different scenarios.

CO_2 EMISSIONS

Figure 2 shows the predicted evolution of CO_2 emissions for each scenario. The best scenarios for reduction of CO_2 emissions are the ones based on increased use of renewable energies, that is, the Transition scenario. The Transition scenario has 64% fewer emissions than the Trend scenario. The Official scenario consumes less energy and has a 50% reduction in CO_2 emissions. (See Fig. 2).

In the Transition scenario CO_2 emissions are 1.4 times greater than base year emissions with an AAGR of 1.1%. The Official scenario has an AAGR of 2.3%, with 1.9 times more emissions than 1996. The Trend scenario is the worst, having an AAGR of 4.8% and 3.8 times more emissions than the base year. In the Transition scenario, after 2020 the amount of CO_2 starts to drop, unlike either of the other scenarios. This means that using this scenario, it is possible to have, in the long-term, both economic growth and dropping level of CO_2 emissions.

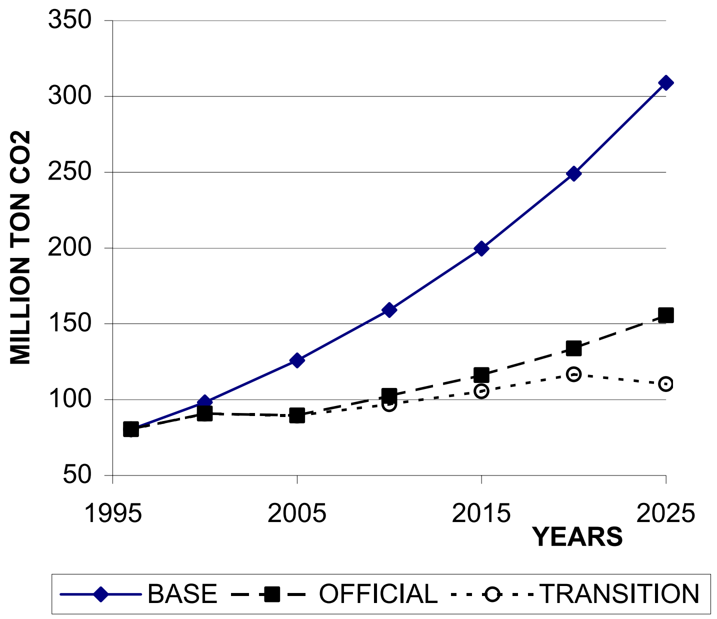

Fig. 2. Carbon dioxide emissions in Mexican power sector between 1996 and 2025 for three different scenarios.

CONCLUSIONS

Regarding CO_2 emissions, the Renewable and Transition scenarios, which prioritise renewable energy sources, are the most favourable. These scenarios produce 69% and 64% fewer CO_2 emissions, respectively, than the Trend scenario in 2025, while the Official scenario has 50% fewer emissions. In relation to CH_4 emissions, the Renewable and Transition scenarios are the second least harmful, producing 177% and 277% more CH_4 emissions than Trend scenario in 2025. The Official scenario is the worst, emitting 1028% more methane than the Trend scenario by the year 2025.

The Official scenario shows important advantages in terms of reductions in energy consumption and CO_2, NOx and SOx emissions. From this point of view, the recent reform in the Mexican power sector has positive environmental results. Nevertheless, it is still not the best scenario in environmental terms, particularly regarding climate change. The favourable results given in the Transition scenario show that **the use of renewable energies is the best energy policy choice to reduce CO_2** emissions. Moreover, our results show that the Transition scenario is the only scenario in which it is possible to have both long-term economic growth and dropping level of **CO_2** emissions.

This study clearly shows that while the current long term trend in the Mexican Electric sector is to reduce renewable sources in the energy supply mix, the possibility exists to dramatically increase their role by 2025. In the Trend scenario the energy produced by renewable sources is only 3%, and in the Official scenario this figure is 7%. In the Renewable and Transition scenarios these numbers are 74% and 68%, respectively.

As our results show, maybe we underestimated the Bioenergy participation in the energy mix, but its presence resulted more important than fuel cells or solar thermal electric, there is room also to consider other forms of Bioenergy as biogas from landfills, or gasification of organic waste from municipal solid waste, etc. Our results suggest that a complete review of the technical and economic potentials of Mexico's renewable energy resources and of the barriers to realize these potentials is needed in order to make better policy decisions regarding energy and the environment, which in turn can lead to sustainable development.

We need participation from all renewable sources in order to have a sustainable electricity sector, that according to OLADE criteria is a when renewable installed capacity is more than 50%, in order to be able to begin operating firewood power plants in the near future, its just about time to start planting trees for energy crops.

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WORKING GROUP 2: GENERATION OF ELECTRICITY

International Seminar on Bioenergy and Sustainable Rural Development
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ELECTRICITY FROM BIOFUELS IN LATIN AMERICAN SUGAR MILLS: SLOW TAKE-OFF OR LOST CHANCE?

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SUMMARY

Two real cases and eight study cases of sugar mills in Nicaragua, Honduras and Cuba are reviewed, with the purpose of identifying practical limiting factors to expanded co-generation and round-the year generation of electricity based on biomass fuels. Biomass availability, technology and equipment for steam and power generation, manpower, transportation, capital requirements, and access to the market are analyzed.

It is concluded that limiting factors are not physical or technical, but financial and institutional. Access to fresh capital and difficulties to arrive at adequate Power Purchase Agreements are the main barriers to overcome in order to realize the sugar mills potential for supplying power and energy to the national grids. Some alternatives to overcome these barriers are suggested.

Key words: sugar industry, co-generation, biomass, Power Purchase Agreement.

1. INTRODUCTION

Biomass-based electricity generation is not a new issue for sugar industry. Given its ample availability of biomass residues and high demand of mechanical and thermal energy, cogeneration of heat and power is a basic need for every sugar mill.

In Latin-America, most sugar mills built in the sixties and seventies were designed –and operated- to fulfill their needs of steam and power during the milling season, using bagasse as their main source of energy. “Unbalanced mills” needed some additional fuels – usually fuel oil or fuelwood -, and “well balanced mills” used up all the bagasse they produced, with small surpluses left over for start-up in the next season. Regularly, no attempt was made to achieve high efficiency levels in bagasse burning or electricity co-generation, since a profitable market did not exist, neither for surplus bagasse nor for electricity sales.

This situation begun to change during the late seventies, as oil prices soared and the hard currency costs of oil imports became an increasingly heavier burden for many Latin-American countries. By the early eighties the possibility to generate electricity using biomass at sugar mills was the object of many feasibility studies and even full-fledged projects, all around the Region.

Since the very beginning, two main, diverging approaches were followed:

- low-investment, medium efficiency, proven technologies based on Rankine cycle and burning available fuels such as bagasse, cane residues and fuelwood were proposed to foster electricity generation, extending it to cover most or all of the off-season, and
- high-investment, high efficiency, new technologies such as improved burning in fluidized-bed boilers, or biomass gasification coupled to combined-cycle schemes (gas and steam turbines) were suggested as a way to maximize power generation for the national power grids.

Most sugar mills owners tended to favor the first approach, since it fitted with little financial and technical effort into their standard practices and equipment. But most energy planners and researchers felt it better to try the higher efficiency options, which in the long term should be more sustainable (and also, allegedly, more profitable).

In the meantime, a rather hot debate took place, regarding electricity prices. State-owned power companies stated that the marginal cost of new hydro plants should be the upper limit for additional power to be supplied into the national grids by sugar mills. But sugar industry pretended at least the actual cost of fuel oil or diesel oil fueled utilities. An agreement was never reached, even if in many cases the national power companies could not meet the increasing demand for electricity and had to enter into costly Power Purchase Agreements (PPAs) with privately owned, diesel or natural gas fired plants which were hastily set up when power shortages and delayed hydro projects forced them to look for independent power suppliers. This was the case in the late nineties all over Central America, and also became the fashion in Brazil in the first years of the new century.

The main subject of this paper is to review and analyze the reasons for this lost opportunity: to identify the main factors that in practice have hindered the use of biofuels as a real alternative for electricity generation by the Latin-American sugar industry.

2. REAL CASES

Perhaps the earliest Latin-American proposals for expanded electricity generation in sugar mills appeared in Nicaragua, around 1981. Several alternatives were briefly analyzed by the Instituto Nacional de Energía (INE), making clear that co-generation during milling season could be competitive if medium pressure (42 Bar), high efficiency boilers were available and extraction-condensing turbines installed. But since no mill had this type of boiler, nor plans for boilers replacement, the idea was put aside “for the meantime”.

In 1982 feasibility studies were commenced for a new mill. Based on a standard Cuban design, with 7,000 ton/day crushing capacity, the new plant was to have 4 boilers producing 180 t/hr of steam at 42 Bar. The power house would take 3 back- pressure turbines, 4 MW each, enough to attend the mill power demand, but not to supply the electricity needed by irrigation system.

Because 15 to 20% bagasse surplus could be achieved with these new boilers, alternative schemes were analyzed to make full use of this excess fuel and maximize installed power. The chosen solution incorporated a fifth boiler and a 12 MW extraction-condensing turbine, needed to burn all available bagasse and make use of surplus steam during the milling season.

Moreover, it included a 9 MW low pressure condensing turbine to close the steam cycle, making it possible to operate the power plant at 24 MW in the off-season. To provide fuel for this 5-month period, forest plantations were planned on the non irrigated "corners" left by the central-pivot irrigation systems and other non-irrigated lands. Highly optimistic yield forecasts suggested that 5,000 ha would be enough to produce some 225,000 t/yr of air dried wood, allowing to operate the power plant for 330 days/yr.

Since installed power capacity for the whole national system was around 300 MW at the time, this sole project would increase it by 12%, and could generate around 24% of all Nicaraguan electricity.

The new, state-owned sugar mill "Victoria de Julio" was constructed and began operations in 1985. Forest plantation started in 1983, reaching some 3,000 ha by year 2000. But a Power Purchase Agreement (PPA) was never signed by INE, the state-owned power company. The sugar mill asked for a price equivalent to the cost of substituted oil (around 67 US$/MWh) while INE offered the estimated marginal cost of future hydro-power plants still on their drawing boards, i.e. 32 US$/MWh. Negotiations dragged along the years, temporary agreements were made and broken, until the mill bankrupted and closed operations in 2002, with the condensing turbines still in their crates.

In the meantime, a privately-owned sugar company (Nicaragua Sugar Estates) took interest in the concept, installed a new boiler and power plant, and started in 1990 an afforestation plan. During 1999 –in the middle of an energy supply crisis- the firm signed an agreement to generate up to 19 MW for the national power grid in the off-season, burning fuel oil provided by INE. In 2002, it begun to replace fuel oil by wood chips obtained from 6,000 ha of its eucalyptus plantations. The concept worked for the "Nicaragua Sugar Estates", even if it did not for the "Victoria de Julio"; in the same country, at the same time, with the same technology.

3. STUDY CASES

Between 1998 and 2001 FAO Technical Cooperation Program executed two projects focused on dendroenergy issues in Honduras and Cuba: TCP/HON/6713 and TCP/CUB/8925. One of their objectives was to assess the actual and potential role of forests and other biomass resources for energy production.

Comprehensive studies performed by national technical teams with the assistance of international experts found that fuelwood and charcoal were the most important source of energy for the residential sector in both countries. It was also noted that forest resources were used below its potential, leaving ample opportunities to substitute for other commercial energy carriers.

Several study cases were conducted at profile level within the sugar industry, aiming to assess the potential for enhanced cogeneration in the milling season and extended generation in the off-season, using Bagasse (BG), Cane Harvest Residues (CHR) –leaves and tops- and fuelwood (FW) as fuels. Results are summarized in Table 1.

Table 1 excludes one case with a more complex array involving four sugar mills, one sugar refinery and one alcohol distillery coupled to a power plant, which is currently under study in Cuba. In this case, a new power plant (about 45 MW) would use surplus BG and CHR from the mills and feed low pressure steam to the distillery. In the off-season, BG and CHR would be supplemented by FW.

Table 1. Cogeneration and Expanded Generation Profiles in Sugar Mills

Site / COUNTRY	Net Generation		Investment Total	Investment Specific	Direct Operational Costs (1)	Pay-back time
	M W	MWh/yr	US$	$/MW	$/MWh	*Years*
AYSA	4.7	18,945	52,000	11	12 ~ 40	0.8
Tres Valles	6.5	26,035	1,380,000	212	12 ~ 42	1.8
AZUNOSA	24.0	46,871	4,820,000	201	8 ~ 21	5.9
La Grecia	1.0	3,600	240,000	240	n. d.	1.2
HONDURAS	36.2	95,451	6,492,000	179		
FNTA 1	5.0	35,330	2,660,000	532	29	2.6
FNTA 2	15.0	55,296	3,220,000	214	26	1.5
30 Noviembre	11.0	86,400	6,500,000	591	28	2.7
A. Martinez	7.0	53,700	4,020,000	574	28	2.1
CUBA	38.0	230,726	16,400,000	477		

(1) includes fuel procurement / transportation / preparation, plus op. & main. of power plant .
Sources: FAO, 1998 and FAO, 2000, modified.

Even if data from the study cases above can be considered only as approximated and may have 20% margin of error on costs and investments estimates, pay-back time is mostly below 3 years, a very attractive figure in present times.

4. LIMITING FACTORS

One of the first conditions required by the national power companies everywhere is that prospective independent producers give some guaranties of their capability to keep a regular, more or less constant delivery of power to the national grid. Thus, **availability of biomass fuels,** sufficient to sustain around-the-year generation was one of the main concerns in both countries. In all study cases it was found that *bagasse and cane harvest residues* were just enough to extend generation for two months per year, so *fuelwood* as a supplementary fuel would have to be used. Table 1 presents only those cases where enough FW resources could be found for sustainable production within economic radius of transport, namely 120 km. Readily accessible sawmill residues and land-clearing debris were considered a first supply option, taking advantage of their very low procurement cost. Native forests were found to be quite productive, low-cost and sustainable sources, if properly managed. Due to its higher cost and delayed availability, plantation fuelwood was accounted for as a last option.

A first technological limiting factor was the **type and condition of existing boilers**. The mills with low pressure steam generators (below 28 Bar), as well as those with old boilers which replacement was not planned in the short term were excluded from the analysis, because of its low efficiency and poor performance. Since the lack of condensing or extraction-condensing turbines was the rule, the addition of this type of machines was the main investment requirement, jointly with additional transformers and wood processing equipment. To keep investment costs within acceptable levels, available second-hand turbo-generators were selected in most cases, often sacrificing some points in the efficiency equation in favor of ready access and low cost.

Manpower, both in quantitative and qualitative terms was generally judged as adequate to run extended generation schemes. Boilerhouse maintenance schedules, which regularly take several months per year in the sugar industry, could be accommodated in roughly one month. It was also found that **transportation equipment** was always enough to haul supplementary fuels (CHR and FW) during the off-season, when it usually stands idle or queuing for repairs.

Investment capital was felt as the main limiting factor by most mill owners and managers, in spite of the comparatively reduced amounts envisaged. This is not surprising when the poor financial performance of the sugar industry as a whole is taken into consideration. After twenty years of very low international prices and stagnated demand for raw sugar, most sugar companies are heavily indebted and fighting hardly to survive.

The main obstacles to undertake the production of electricity for the national grid were always the **uncertainty about electricity prices** and the **difficulties to negotiate PPAs** in favorable terms, or at least in such terms as required to ease the way for sugar mills to enter into the electrical market. Lengthy discussions and several seminaries were held with representatives of the electricity sector, with little –if any- practical results. Engineers and economists in the national power companies planning departments agreed, in principle, with the technical feasibility of some proposals, but decision-making bodies rejected the idea of out-of-the-business companies operating as reliable and profitable electricity producers. They preferred dedicated power plants, owned and operated by their colleagues, burning commercial, standard fuels.

5. OVERCOMING THE BARRIERS

According to the cases analyzed in our work, the limiting factors for co-generation and extended generation of electricity in the sugar industry are not of a physical or technical nature: biomass resources, technology and equipment for steam and power generation, fuel transportation and other ancillary equipment, as well as qualified manpower are already existent in (or easily accessible to) most sugar mills. It appears that the main barriers are financial and institutional.

Financial Barriers

On one side, the scarcity of investment funds originated in their own cash-flows and the burden of their debts mean that most mills cannot cope with the financial requirements that are needed to undertake this new line of business, even if it offers very short pay-back periods. Sugar industry was not a favorite client for commercial banks in the last years, and had to look for financing from state banks, in more or less concessional terms, just to stay alive. State subsidies for sugar production, either in direct form or in the way of high import taxes, have been another survival aid to the industry in most Latin American countries. Understandably, access to fresh commercial financing for new ventures is not easy for sugar companies: this is a first barrier to overcome.
A second barrier to be lifted, probably the heaviest, is the fact that power companies seem quite reluctant to enter into PPAs with sugar industry. If medium term contracts at reasonable prices were signed in advance, the mills could walk into a bank and ask for credit, offering the signed PPA as a collateral, so overcoming the financial barrier. But the power company wants to see proofs first: proofs of mills capability and reliability to supply energy to the grid and fit into the interconnected system -and not “just for a while”-.

This fact acts as a negative feed-back in the process of decision taking by sugar companies, placing them in front of an iron dilemma: either they accept the low prices currently offered, take the investment risk and start operations in order to demonstrate capability and reliability as independent power producers, in the hope to negotiate a better PPA some years ahead, or leave it aside and miss the chance.

Another opportunity could exist if new partners would be interested to get into the business, venturing fresh capital and taking some of the risks. This could be an interesting option for diversified holdings with interests in energy intensive industries such as cement or mining, provided a free market exists for electricity, private supply contracts between independent producers and consumers are allowed, and transportation tariffs are reasonable. By investing in amplified generation schemes in sugar mills, the new investors could celebrate supply contracts with the mills, buying power and energy blocks tailored to their needs at a mutually profitable price. Thus, the price barrier and the PPA barrier would simultaneously be by-passed, at least partially.

Institutional Barriers

Reluctance to integrate independent power producers (IPPs) in Latin-american grids is a serious barrier. It is an inheritance of past decades, where state-owned companies were viewed as a “natural monopoly”, and also a prime national asset. Managers and technicians formed in these traditions might accept that, in the present state of affaires, the existence of such producers is a necessary evil, but do not tend to consider them as a permanent component of the national system. This is a fact, well reflected by most Development Master Plans issued in the last two decades, where small and medium thermal units keep seeping into the systems while big hydro projects are deferred, and biomass recedes towards a distant horizon.

Modernization of the electricity market, coupled to de-regulation and new legal frames have opened ways that in several countries allow IPPs to enter into the market, with the exception of Cuba, a country that keeps centralized ownership and operation of power plants, transportation and distribution grids. But an open, fluid, competitive market for small blocks of power and energy is not yet a reality in most countries. This constitutes another important barrier for small, prospective IPPs like sugar mills.

6. CONCLUSIONS

Biomass-based electricity co-generation and generation is slowly taking-off in Latin-American sugar mills. A few successful cases appear here and there, mostly in the manner of marginal undertakings in those mills with integrated sugar refineries.
But in spite of the dire need to replace oil imports and to expand power supply in Latin America, many readily available opportunities are and have been lost.

Commercially established technology using available low-cost biomass fuels, coupled to marginal investments to allow for extended generation in the off-season seem to be an appropriate solution, if the goal is interconnection of sugar mills to the national grid. Efficiency levels are low, but this is not so important when fuel is cheap. Taking into consideration that maturing time for this type of projects is usually below two years, erection and start-up take less than one year, and pay-back time is usually below three years, it can be concluded that this approach offers fast response and great flexibility.

The main barriers to overcome are financial (scarcity of investment funds within the sugar industry, difficulties to get loans from commercial banks, little interest from the part of new private investors) and institutional (reluctance of public companies to buy power from independent producers, complicated or unclear rules to access the electricity market). Many opportunities were lost in the last two decades, and will also be lost in the future if these barriers are not lifted.

WORKING GROUP 2: GENERATION OF ELECTRICITY

International Seminar on Bioenergy and Sustainable Rural Development
- 5th LAMNET Project Workshop – Mexico 2003

LA BIOMASA EN COSTA RICA: UNA FUENTE LIMPIA PARA LA GENERACION DE ELECTRICIDAD

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RESUMEN

El crecimiento de los precios del petróleo y los efectos externos que producen las fuentes de energía basadas en el uso de combustibles fósiles, paralelo a los crecimientos acelerados en la demanda por energía, hacen necesaria la búsqueda de nuevas opciones energéticas con un menor impacto en el medio, económicamente rentables y que en general permitan satisfacer la demanda por energía; en particular la búsqueda de opciones basadas en energías renovables limpias y no convencionales se ha fomentado crecientemente.

El artículo considera con particular atención la generación de electricidad con fuentes basadas en biomasa y muestra con interés especial el proyecto desarrollado para aprovechar los desechos sólidos de un relleno sanitario histórico de la ciudad de San José, Costa Rica.

La primera parte del artículo presenta un panorama general sobre el sector eléctrico costarricense, algunas características de la demanda y la importancia que representa para el sector algunos derivados de la biomasa en la producción de energía. En la segunda parte del artículo, se pasa revista al tema del sector eléctrico nacional, se presenta brevemente el marco institucional en que se rige así como algunas de las características de la generación eléctrica nacional.

En la tercera sección del artículo, se aborda el tema de los desechos sólidos como producto del consumo en todos los sectores de la economía, y la problemática tanto de índole económico, social y ambiental que ello representa. Se presenta el caso del Relleno Sanitario Río Azul donde actualmente esta en construcción una planta Biotermica que permite el aprovechamiento y la utilización de los residuos para la generación eléctrica de una manera segura y amigable con el medio ambiente. Finalmente se incluye una sección sobre las principales conclusiones en este tema.

1. EL SECTOR ENERGÍA EN COSTA RICA

El sector energía de Costa Rica, al igual que en muchos países en desarrollo presenta características muy particulares. En cuanto al sector residencial, el último Plan Nacional de Energía (2002-2006) manifiesta un escenario medio en el cual se espera que la población del país crezca a un ritmo más lento que el PIB, esto implica la obtención de un incremento anual importante del ingreso per-cápita, el cual crecerá a una tasa promedio de 2,9% anual. Esta mayor disponibilidad de recursos permitirá a las familias costarricenses mejorar su nivel y calidad de vida, en parte por la adquisición de diferentes aparatos de uso doméstico, lo cual, a su vez, se reflejará en un mayor consumo de energía, tanto a nivel rural como urbano.

Los energéticos más importantes para el sector lo componen la electricidad, leña y el gas licuado de petróleo (GLP); mientras que sus principales usos se refieren a la cocción de alimentos, refrigeración, iluminación y calentamiento de agua. A futuro se espera una sustitución cada vez más fuerte de la leña por el gas licuado o la electricidad. Para los próximos 15 años, podría esperarse que el consumo de energía del sector residencial crezca a una tasa anual promedio cercana al 2,24% (DSE, 2001)

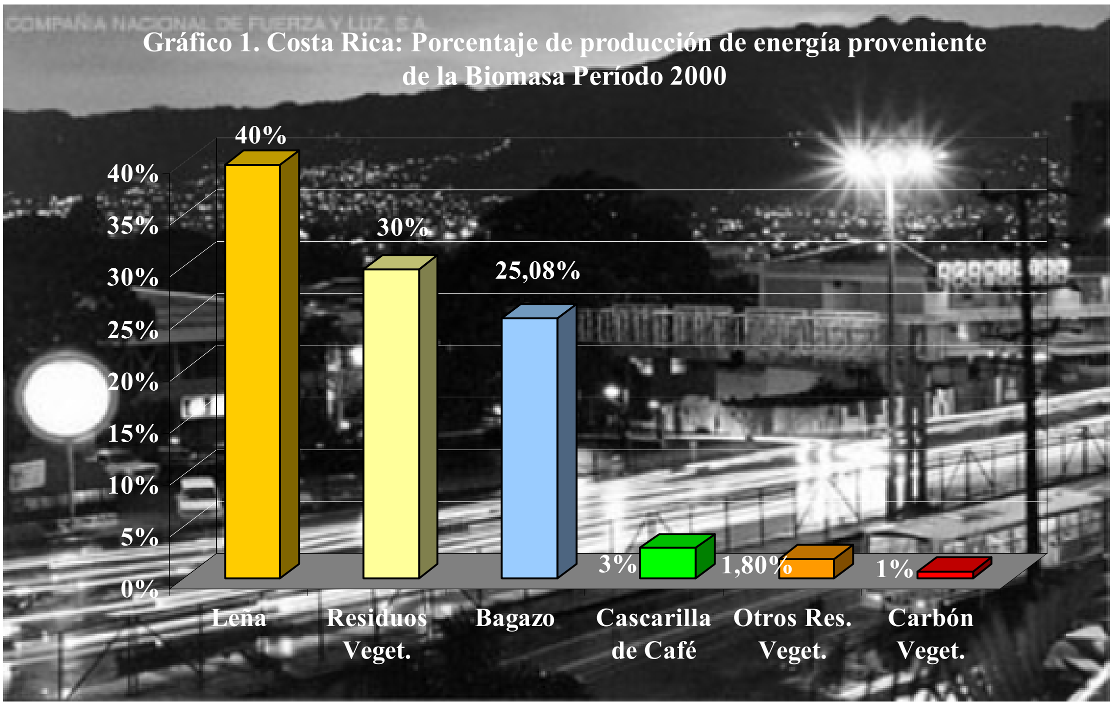
El sector comercial emplea principalmente energéticos como la electricidad, el GLP y en menor cantidad el kerosene, producto que ha sido sustituido por las dos primeras fuentes energéticas. Históricamente, los consumos de electricidad y gas licuado por unidad de valor agregado, han mostrado una tendencia creciente porque ambas son fuentes limpias, de abastecimiento oportuno y competitivas. En el caso de la electricidad, este coeficiente ha aumentado rápidamente (DSE, 2001).

En el sector trasporte, el consumo de energía depende fundamentalmente del número de vehículos en circulación, de su recorrido medio y su consumo específico. Como lo plantea el IV Plan Nacional de Energía, en un escenario económico y de población, es de esperar que se incremente el número de vehículos en circulación. Se estima que el parque automotor crecerá al 2,2% anual entre 2000 y 2015, debido a que crecerán el ingreso disponible per cápita y la población. Por lo tanto, se espera que en el año 2015 el país cuente con 199 vehículos por cada 1000 habitantes, mientras que en la actualidad se dispone de poco más de 143. Dado lo anterior, se espera un crecimiento la demanda de energía por este sector en aproximadamente un 4,4%.

Finalmente, el sector agropecuario costarricense es poco consumidor de energía, debido a la poca mecanización de los procesos que se llevan a cabo en él y como no se plantean grandes cambios hacia el mediano plazo su consumo de energía crecerá a tasas menores (2,4%) que la actividad económica sectorial, por lo que a futuro no se esperan grandes cambios en esta estructura de consumo.

A pesar de lo anterior y debido al crecimiento de los precios del petróleo y los efectos externos que producen las fuentes de energía basadas en combustibles fósiles, el uso de nuevas opciones para satisfacer la demanda y en particular opciones basadas en energías renovables limpias se ha crecientemente fomentado. Este artículo considera con particular atención las fuentes basadas en biomasa y muestra con interés especial el proyecto desarrollado para aprovechar los residuos en un relleno sanitario histórico de la ciudad de San José.

El gráfico1, presenta la importancia relativa de varias fuentes de bioenergía utilizadas en la producción de energía. Del total de las fuentes de producción de energía primaria, éstas representan aproximadamente un 33% del total de la energía primaria producida en el año 2000, según los datos del Balance Energético Nacional. Estas fuentes en su totalidad proporcionaron al país en el 2000 un total de 25412 terajulios de un total de 70256 terajulios que en su totalidad proporciono la energía primaria ese año. La primera fuente en importancia lo presenta la leña con un 40% (10113 terajulios), seguido por un 30%(7568 terajulios) de residuos vegetales y un 25,08% (6373 terajulios) de energía proveniente del bagazo. En menor proporción la cascarilla de café representa un 3% (737 terajulios) y, otros residuos vegetales y el carbón vegetal presentan el 1.8% (458 terajulios) 1% (163 terajulios) respectivamente.



Fuente: Elaboración propia con base en datos del Balance Energético Nacional, 2000.

2. EL SECTOR ELÉCTRICO

En Costa Rica la producción de energía eléctrica se encuentra principalmente a cargo del Instituto Costarricense de Electricidad (ICE) quien genera aproximadamente el 84% del total de la energía producida, siendo uno de los principales actores que conforman el marco institucional del sector, paralelo a ICE existen siete empresas distribuidoras y algunos productores independientes.

Dos organizaciones adicionales intervienen en el sector, la primera es la Autoridad Reguladora de los Servicios Públicos (ARESEP), ente regulador del sector, quien tiene la Autoridad para fijar lo precios de compra y venta de la energía así como las tarifas; además de velar por el cumplimiento de las normas de calidad, cantidad, continuidad, confiabilidad, oportunidad y prestación óptima. La otra organización se refiere al Ministerio de Ambiente y Energía (MINAE), ente rector del sector, quien otorga las concesiones para actuar en el mercado eléctrico.

En materia de estructura de mercado, el sector eléctrico costarricense se compone por un oligopolio regulado en generación eléctrica, un monopsonio en cuanto a compra de energía, un monopolio en cuanto a transmisión se refiere y un oligopolio en distribución y comercialización de la electricidad.

El Sector eléctrico esta constituido por el Instituto Costarricense de Electricidad (ICE), la Compañía Nacional de Fuerza y Luz (CNFL), subsidiaria de ICE, cuatro cooperativas de electrificación rural[4], dos empresas municipales, la Junta Administrativa del Servicio Eléctrico de Cartago (JASEC) y la Empresa de Servicios Públicos de Heredia (ESPH), y varias firmas de generación privada. Estas empresas brindan el servicio a cerca de un millón de clientes en todo el país, por medio de alrededor de 1500 Km. de líneas de transmisión y distribución (Villa y Mora, 2001). Los sistemas eléctricos están unidos por el Sistema Nacional Interconectado (SIN), teniendo como resultado una cobertura cercana al 97 % de la población.

Costa Rica cuenta con una importante dotación de recursos naturales para la producción de electricidad con fuentes renovables como la hidroelectricidad, la geotermia, la energía solar y eólica, a las que el país ha dedicado importante cantidad de recursos en investigación, capacitación de mano de obra y estudio de proyectos (Vargas y Jiménez, 2000). Recientemente se ha comenzado a incursionar en el potencial en términos de biogás, que proporcionan los desechos, para generar electricidad.

El sistema interconectado costarricense depende en gran parte de la energía hidroeléctrica, en este caso representa el 83 % (5684,10 GWh) del total de energía generada en el año 2000, tal y como se observa en el gráfico 2. La energía geotérmica sigue en orden de importancia representando 14 % (937.5 GWh), seguido por la generación eléctrica por medio del aprovechamiento del viento que representa un 3 % (182.7 GWh) la cual es una fuente de energía que se emplea recientemente en el país. La generación a gas aporta aproximadamente un 1 % (51.1 GWh) de la oferta total, y la cogeneración y el diesel representan un 0.11 % (7.3 GWh) y 0.33 % (22.9 GWh), respectivamente.

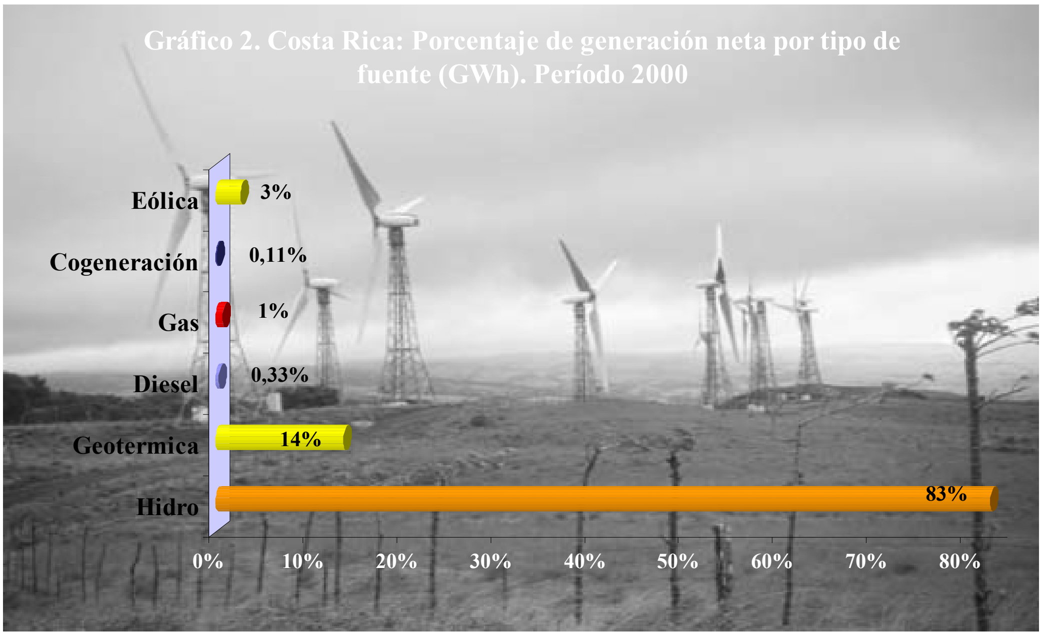


Gráfico 2. Costa Rica: Porcentaje de generación neta por tipo de fuente (GWh). Período 2000

Fuente: Elaboración propia con base en datos de CEPAL, 2000.

[4] Actualmente existen cuatro cooperativas de electrificación rural: Coopelesca, Coopeguanacaste, Coopesantos y Coopealfaro, las cuales conforman el Consorcio cooperativo denominado CONELECTRICAS.

Como se puede apreciar, Costa Rica ha centrado su abastecimiento energético en fuentes renovables, especialmente la hidroeléctrica, incursionando recientemente en fuentes renovables no tradicionales de energía como la solar y biomasa, sobre ésta última se dedica la siguiente sección del artículo. Ese esfuerzo se ha materializado en una estructura energética centrada, en más de tres cuartas partes, en energía renovable (Jiménez y Vargas, 2000). En el caso de la energía eólica, está representa un componente importante dentro de la oferta total del país y su desarrollo se ha dado en un período relativamente corto (1995-1999).

La generación privada por ley se concentra en fuentes renovables, donde destaca básicamente la fuentes hidroeléctrica de micro y pequeñas centrales inferiores a 20 MW de capacidad instalada, algunas opciones de cogeneración en verano con bagazo y la fuente eólica con tres parques de generación (Vargas, 2002).

3. LA BIOMASA COMO FUENTE DE GENERACIÓN NO CONVENCIONAL

Uno de los principales problemas tanto de índole económico, social y ambiental que enfrentan todos los países a nivel local es la generación de desechos sólidos[5], como producto del consumo en todos los sectores de la economía. Los procesos de producción y consumo generan excesivas cantidad de materiales, que usualmente terminan siendo desechos a los que no se les da el adecuado tratamiento o ubicación para su deposito final. En algunos casos, aunque existen posibilidades de ser tratados, recuperados o reciclados, no existe una adecuada organización local o gubernamental que facilite este tipo de procesos.

En la Agenda 21, se presenta claramente como los costos de tratamiento de desechos crecen rápidamente producto de la repleción de los vertederos tradicionales, la aplicación de controles ecológicos más estrictos y el aumento de la cantidad de desechos de mayor persistencia, especialmente en los países industrializados. Esos costos podrían duplicarse o triplicarse para fines del decenio.

La recolección y tratamiento de los desechos implica, por un lado, altos costos al ubicarlos en un lugar que no genere problemas a la población, tales como enfermedades, malos olores, contaminación de acuíferos, deterioro del paisaje, etc,. Por otra parte, la mala ubicación de los mismos puede generar también costos por el tratamiento de enfermedades y recuperación de daños ambientales, entre otros.

Los desperdicios sólidos son muy diversos, y esto hace su reutilización un poco compleja, ya que debe llevarse a cabo mediante varios procedimientos, según la naturaleza del material. La cantidad de desperdicios sólidos llega entonces a constituir una seria carga económica para las municipalidades del país, pero estos materiales encierran en sí una gran cantidad de energía y de sólidos que pueden ser utilizados por el hombre.

A medida que se modifica la economía de los servicios de eliminación de desechos, su reciclado y la recuperación de recursos están resultando cada día más rentables. En los futuros programas de gestión de los desechos se deberían aprovechar al máximo los enfoques basados en el rendimiento de los recursos, para controlar la producción de desechos (Agenda 21).

[5] La Agenda 21, en su Capítulo 21 define desechos sólidos como todos los residuos domésticos y los desechos no peligrosos, así como los desechos comerciales e institucionales, las basuras de la calle y los escombros de la construcción.

En el escenario anterior, varias organizaciones costarricenses, entre ellas organizaciones privadas, gubernamentales y locales se han comprometido a sacar el mayor provecho posible a los desechos sólidos que el área metropolitana ha generado y acumulado por mas de tres décadas. Como se presenta más adelante, la idea es aprovechar esos desechos para la generación de electricidad (actividad que resulta rentable en este caso), y reducir al mínimo los impactos ambientales y los peligros potenciales para las comunidades aledañas.

En la reutilización de los desechos lo importante es reducir la contaminación ambiental y los costos energéticos, humanos y financieros del proceso (Fournier, 2000). Sin embargo, debe tenerse claro que aunque resulte económicamente rentable la utilización de los desechos sólidos o de cualquier otra índole, lo importante es la reducción y el cambio en los patrones de producción y consumo de manera que se logre una plena utilización de los recursos y un menor desperdicios de los mismos.

En la actualidad muchos procesos productivos incorporan medidas eco-eficientes o eco-amigables con el ambiente para reducir al mínimo los residuos depositados en el ambiente y lograr un uso óptimo de los recursos empelados. De igual forma debe trabajarse para que el sector residencial, pueda incorporar en su forma de vida actividades como la separación de residuos y el reciclaje, para reducir los efectos en el ambiente producto del consumo de bienes y servicios, pero es de gran importancia que paralelo a ello, se creen las condiciones institucionales necesarias para que lo anterior pueda llevarse a cabo.

3.1 Proyecto Biotérmico Río Azul

El Relleno Sanitario de Río Azul entró en operación en 1973. Desde esa época, se han depositado más de 4 millones de TM de residuos sólidos. Durante gran parte del período de operación (más de un 60%) la colocación de residuos se realizó sin ningún tipo de criterio técnico, sin respiraderos para el biogás producido y sin tratamientos para el lixiviado[6] generado (Mora, 2000).

Este sitio da servicio a 12 municipalidades del Área Metropolitana, sin embargo, desde algún tiempo se prepara el cierre técnico de ahí que se espera gradualmente reducir el recibo de desechos (para el año 2000 se depositaban un promedio de 1.300 a 1.500 ton/día) (www.netsalud.sa.cr, 2000).

Durante el año 2000, y producto de la cooperación conjunta de varios actores como la Federación Municipal Regional del Este (FEDEMUR), la WWP[7] y la Compañía Nacional de Fuerza y Luz, trabajan arduamente en la recuperación del relleno y en un proyecto que permitirá extraer energía eléctrica del biogás generado en la descomposición de los desechos que han sido depositados en el lugar desde hace tres décadas.

FEDEMUR, ha venido trabajando fuertemente en la recuperación del vertedero de Río Azul, mediante el control y planificación, con acciones de cubrimiento diario, control de gases, control de insectos, control de fauna nociva y tratamiento de lixiviados, dando solución al grave problema producto del mal manejo de los desechos sólidos en el relleno.

[6] Líquidos producidos por la descomposición de la basura.
[7] Empresa privada que se encarga de la recolección de desechos en el área Metropolitana y el deposito de los mismos.

En un período relativamente corto de tiempo, esta organización ha logrado mantener una buena relación con la comunidad, ordenando y capacitando a los buzos[8], dar mantenimiento a áreas clausuradas, inspeccionando, monitoreando y llevando adelante un programa de control ambiental, se avanza hacia la construcción de un Parque ambiental en el lugar.

La obligación de FEDEMUR es cumplir con todas las condiciones que CNFL ha considerado necesarias para poder extraer el biogás del lugar, entre ellas, la compactación adecuada y estabilización de los terrenos.

Actualmente, el relleno se encuentra en proceso de cierre y tiene un sistema de ventilación pasiva, y conducción de lixiviados. Por esta razón es necesario crear las estructuras (en general se trata de pozos de extracción activa), que permitan la salida de estos gases, y su disposición segura, mismos que luego servirán para la extracción del biogás hasta la central de generación. La Figura 1, presenta parte del relleno en una de las etapas que consiste en cubrir con arcilla los desechos para cerrar las salidas de aire, además, se observa algunas de las chimeneas que permiten la ventilación del relleno.

Figura 1. Vista del Sello de Arcilla y Chimeneas

La generación de energía eléctrica mediante la combustión del metano, en motores de combustión interna, se perfila como una opción que permite además, brindar un adecuado mantenimiento al Parque Ambiental que se está creando en el Relleno Sanitario de Río Azul. Por ello, se debe proceder a efectuar una adecuada extracción del gas, de forma tal que se garantice la salud de la población vecina.

Así mismo, se realizó un convenio para la concesión del biogás del relleno Sanitario de Río Azul, firmado entre el Ministerio de Salud, Comisión Nacional de Emergencias y CNFL, el 13 de diciembre de 1995, que faculta a CNFL la explotación del recurso para fines energéticos. Este proyecto requiere de una inversión de $3.6 millones que serán manejados bajo el sistema BOO, donde el contratista hace la inversión (empresa inglesa SARET), pone los equipos y los opera, y a CNFL le corresponde comprar la energía. Se espera que el proyecto comience a generar electricidad a finales del 2003.

Se estima que el Relleno Sanitario de Río Azul podría generar hasta 4000 kilovatios de energía eléctrica por un período sostenido, reduciendo a su vez el peligro que implica la migración del metano acumulado, lo que significa un incremento de 4000 kilovatios dentro del sistema eléctrico nacional. El tiempo de generación eléctrica con gases sería de diez años. Cada Kilovatio hora costará unos $0.49. Además es una planta económica y podrá estar en operación todo el tiempo (Aguilar, 2003).

[8] Los "buzos" o recuperadores son personas que ven el relleno sanitario su fuente de ingreso económico. Ellos trabajan recuperando del basura y vendiendo materiales que pueden ser reciclados, como botellas de vidrio, latas de aluminio, papel, cartón,, metales, etc.

Cada tonelada de residuos depositados pueden proveer de unos 200m^3 de biogás, estimando una composición de los desechos de un 50% de material orgánico y un 80% de aprovechamiento del mismo.

Con esto CNFL se convertiría en la primera en poseer una planta biotérmica en Latinoamérica. El atractivo en esta planta es que elimina el problema ambiental que hay en el lugar y aprovecha el biogás producido por la basura para generar energía. Por su parte, los equipos empleados para la extracción y conversión del biogás en electricidad pueden ser deslazados con facilidad y la empresa adjudicada se compromete a retirarlos del lugar una vez finalizada la vida útil del relleno en términos energéticos.

Figura 2. Vista del relleno en recuperación

El aporte de la planta no se limita al campo de la generación sino que extiende sus beneficios al aspecto ambiental, minimizando la contaminación provocada por los desechos el relleno, dándoles un mayor provecho para el desarrollo y la salud del país.

De hecho se trabaja en un plan de Gestión Integral de desechos completo, que incluye al menos siete tareas generación, segregación, reciclaje, almacenamiento, recolección y transporte, disposición final y tratamiento, incluyendo actividades paralelas como programas de reforestación para la recuperación paisajística y programas de educación ambiental. Como muestra la Figura 2, se presenta una de las secciones del relleno en recuperación, la arcilla ha sido cubierta con pastos y se ha iniciado la reforestación con especies nativas de la zona y resistentes a las condiciones del lugar.

Otro aspecto importante es que este proyecto le permitirá a CNFL colocar certificados por reducción de emisiones de gases invernadero, los cuales actualmente se encuentran en proceso de negociación con Holanda.

3.2 Características técnicas

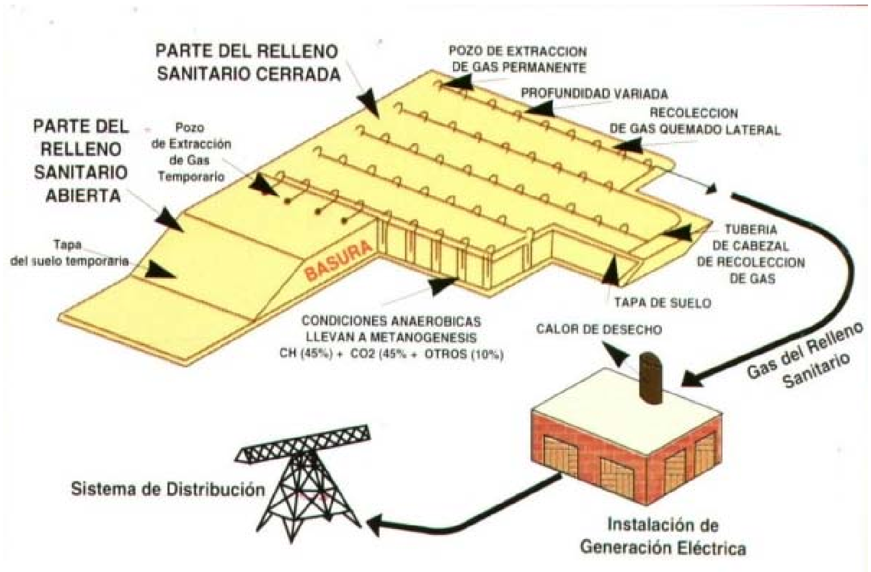
La propuesta técnica de desarrollo, propone una obra de mitigación utilizando el gas metano como combustible, para minimizar el impacto ambiental y social provocado por los desechos del Relleno Sanitario de Río Azul (Aguilar, 2003).

Esta propuesta consta de dos etapas:

- *Proyecto Piloto*. La cual se caracteriza por ser principalmente una fase de investigación y un plazo de ejecución menor a un año, estimándose que el Relleno Sanitario de Río Azul podrá generar energía eléctrica por un período sostenido, reduciendo a su vez el peligro que implica la migración del metano acumulado en un proyecto piloto permitirá explotar el comportamiento de las variables y generar 3 MW.

- *Proyecto Biotérmico Río Azul*. Con base en los resultados obtenidos de la fase anterior, se estima que el proyecto a una escala mayor podría generar hasta 4 MW.

Figura 3. Esquema BOO del proyecto



El Proyecto consta de un sistema de recolección de gas, constituido por una combinación de pozos profundos, una planta de generación que constará 3 a 4 unidades motor/generador (la salida mínima esperada para cada generador podría ser de 1 MW), un sistema de distribución eléctrica, sondas de monitoreo del gas ubicado 4 sitios del Río Azul, con un sistema de muestreo trimestral (responsabilidad de la Administración del Relleno).

4. CONCLUSIONES

Luego de haber presentado las características de las opciones de biomasa y en particular lo relacionado al aprovechamiento del gas generado mediante los residuos del relleno sanitario de Rió Azul, queda claro que las oportunidades para la ampliación de la oferta de fuentes alternativas limpias de energía son bastante importantes en países donde la biomasa y los residuos están en aumento.

Las necesidades de fomento a este tipo de fuentes requieren de acciones institucionales claras que permitan poner en acción a diferentes organizaciones y sobre todo, que desarrollen capacidades de adquisición y adaptación de nuevas tecnologías. Dichos cambios en el marco institucional deben de privilegiar la introducción de dichas fuentes como procesos de aprendizaje institucional y tecnológico en el mediano y largo plazo.

El proyecto concreto de Relleno Sanitario de Rió Azul es una alternativa sana y limpia que permite explotar fuentes de energía alternas para Costa Rica y que significan convertir en actividades económicas rentables, depósitos de basura o de residuos que de lo contrario llevarían peligrosas consecuencias para las poblaciones locales. Al respecto, es necesario crear espacios de competitividad para dichas energías y permitir que el consumidor pueda ampliar las opciones de abastecimiento, mejorando la diversidad y la seguridad del sistema eléctrico (Vargas, 2002).

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SIGLAS Y ABREVIATURAS

ARESEP	**Autoridad Reguladora de los Servicios Públicos**
CEPAL	**Comisión Económica para América Latina y el Caribe**
CINPE	**Centro Internacional de Política Económica**
CNFL	**Compañía Nacional de Fuerza y Luz**
DSE	**Dirección Sectorial de Energía**
ESPH	**Empresa de Servicios Públicos de Heredia**
FEDEMUR	**Federación Municipal Regional del Este**
GLP	**Gas Licuado de Petróleo**
ICE	**Instituto Costarricense de Electricidad**
JASEC	**Junta Administrativa del Servicio Eléctrico de Cartago**
KWh	**Kilovatios Hora**
MINAE	**Ministerio de Ambiente y Energía**
MV	**Megawatts**
SIN	**Sistema Nacional Interconectado**
TM	**Tonelada Métrica**
UNA	**Universidad Nacional de Costa Rica**

WORKING GROUP 3: GASIFICATION

International Seminar on Bioenergy and Sustainable Rural Development
- 5th LAMNET Project Workshop – Mexico 2003

WORKING GROUP 3: SUMMARY

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Within the working group session on gasification more than 20 participants of the International Seminar on Bioenergy and Sustainable Rural Development discussed crucial topics of the two main gasification technologies, namely the thermochemical and the biochemical conversion of biomass.

It is commonly agreed upon that biomass can play an important role in a sustainable future energy supply due to its availability in abundant quantities around the world throughout the year. However, the application of biomass should be shifted from its traditional low-efficiency applications for heating to high-efficiency applications for heat and power production (CHP). Gasification of biomass has the potential to contribute to this aim, as it converts a solid renewable fuel to a gas that can be used in modern conversion devices for electricity and heat production such as gas turbines or engines. Among the advantages of gasification technologies are the high efficiency for electricity production, good prospects for the use in CHP applications as well as a cost-effective reduction of emissions with respect to biomass combustion.

In the last 10 years good technical progress has been made in the field of thermochemical biomass gasification, although at a commercial level major achievements still have to be attained. Today only heat gasifiers constitute a commercially viable technology. A new market area is the application of gasifiers for the pre-treatment of biomass fuels in order to use these fuels for cofiring in existing power plants. This concept has been commercially demonstrated for coal-fired and natural gas-fired power plants in the Netherlands, Finland, Austria and the USA. Thereby, this new market area could pave the way for future applications in integrated gasification combined cycle systems (IGCC). This IGCC concept is regarded as the potential future star of all biomass gasification applications and as the final concept of biomass-to-electricity systems due to its high overall conversion efficiency at low emission levels. Up to date the IGCC concept has been demonstrated with success in Värnamo, Sweden. However, the Värnamo pressurized gasifier was mothballed after positive operation results as the capacity of the IGCC unit was too small for commercial operation and the future of this demonstration plant has not been decided upon.

In the field of thermochemical biomass gasification the R&D focus currently is on the gasifier itself, a better understanding of the gasification process for various kinds of fuels and the cleaning of the produced gas. The latter includes the important aspect of tar removal from the gas which is required for application in gas turbines and engines as well as the reduction of the ammonia content in the gas due to NO_x emission constraints.

Finally, the applications of thermochemical gasification technology today include hundreds of small-scale systems in India and China for heat and electricity production at local level which are in operation at farms and small industries.

On the other hand, anaerobic digestion (AD) as the second main biomass gasification technology means the bacterial breakdown of organic materials in the absence of oxygen. This biochemical process produces a gas principally composed of methane and carbon dioxide. Anaerobic digestion provides the opportunity for decentralised production of renewable energy from waste. Additional benefits offered by AD plants include the strengthening of closed loop recycling management systems, the reduction of emissions from manure storage as well as the production of a valuable organic fertiliser. Therefore, the income revenue of AD plants not only relies on energy sales, but on fertiliser sales and gate fees for waste disposal, thereby creating further sources of income in the agricultural sector.
However, today only a very small fraction of the potential for AD applications is used in Europe. This is due to economical as well as legal constraints. The actual costs for electricity from biogas produced by AD are significantly higher than conventional electric power costs and AD sites are complex systems which interact with a variety of laws and regulations involving different authorities. For this reason, AD technology still requires supportive legislative framework conditions including financial incentives in order to stand the chance to become an important element for the future supply of sustainable energy. In Europe countries like Denmark, Germany, Austria and Sweden promote effective mechanisms to produce biogas from organic wastes by political measures.

An impressive success story is currently on its way in China where anaerobic digestion applications are experiencing a tremendous up-take. In 2002, 1.7 million households became new biogas users and there were 11 million biogas digesters in operation. Additionally, about 2000 medium-scale AD plants are used for the treatment of waste from large livestock farms and the total number of household water treatment plant amounts to 110000. This development is actively supported by the Ministry of Agriculture through its Biogas Construction Plan in Rural Areas of China (2003-2010). The implementation of this ambitious plan will result in significant progress in the field of biogas technology and it will lead to about 50 million rural households in China using biogas as their daily fuel by 2010.

In Mexico, however, up-to-date experiences with AD plants used for the digestion of cow and pig manure were less successful. The electricity production costs were greatly exceeding that of conventional plants and the acceptance of the biogas technology by rural communities was rather low. It was therefore concluded by the participants of the working group, that close links shall be established between AD experts from China, Europe and Mexico aiming at the transfer of suitable best-practice experiences in order to stimulate the development of this technology in Latin America.

WORKING GROUP 3: GASIFICATION

International Seminar on Bioenergy and Sustainable Rural Development
- 5th LAMNET Project Workshop – Mexico 2003

SMALL-SCALE COGENERATION – A NEW TAR-FREE GASIFIER

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INTRODUCTION

Interest in biomass gasification has increased during recent years because of environmental benefits associated with these fuels. Wood gasification to fuel commercial engines is considered to be one of the most promising techniques for an efficient production of electricity from biomass at a small or medium scale.

Unfortunately most of gasifiers produces wood gas incompatible with engine manufacturers specifications (up to 30 ppm tar and char vs. less than 10 ppm), so a very expensive and no profitable purification is needed.

As result of a demanding study and a long experimentation, a novel type of downdraft gas producer was designed and constructed. Relevant project features are:

a) a high oxide-reduction temperature matching the theoretical optimum level of 1500°C in the throat area,

b) the elimination of cold veins in the oxide-reduction zone,

c) an efficient heat recovery,

d) a proved and economic cleaning gas system.

The performances of the producer gas were evaluated coupling the gasifier with a 40 kW_e cycle Otto engine electricity generator.

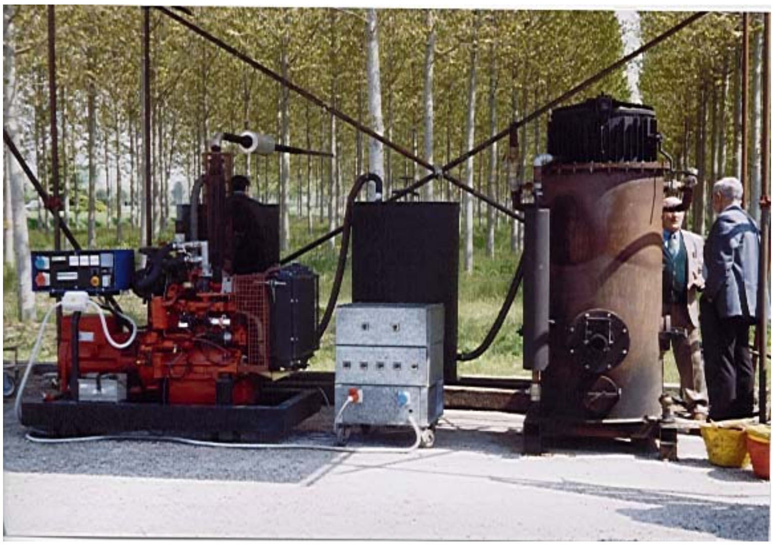
THE GAS PRODUCER

The gasifier, the gas filtration system and the generator set are shown in Fig. 1.

The gas producer unit is constituted of two cylindrical coaxial metallic structures. The section where the actual wood gasifying process occurs is made of a high temperature and chemical corrosion proof steel in order to resist the compounds developing during the process. The biomass, preferably blocks several centimetres long, is introduced at the top by a semiautomatic feeder.

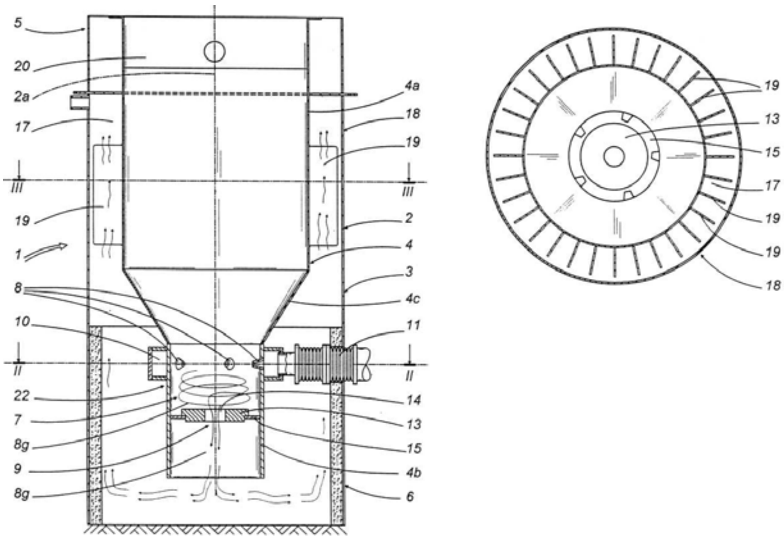
Coming down, the biomass passes through a drying zone, a pyrolisis zone and then gets into the core of the gasifier. Here the fuel meets an air stream, introduced by wall tuyeres opportunely oriented.

Fig. 1: Gasifier, gas filtration system and generator set



In this zone the gasification process is carried out at high temperatures (about 1400-1500°C) in order to assure the cracking of any possible tarry residue. The gases are drawn off from the bottom and flow upward in the interspace between the two coaxial structures. The external one is coated by an insulating material, while the internal is provided with radial fins as recuperator to improve the energetic balance of the gasification reaction and to reach the above mentioned temperatures. (Fig. 2).

Fig. 2: Scheme of the gasifier



For the achievement of the temperature uniformity trough the whole reaction zone, a necessary condition for the full cracking of the tars, cold points should be avoided as they could also stress the metal walls. This is obtained by tuyeres oriented so as to send an air stream properly directed in the oxidation zone, delimited at the bottom by a transverse grate. In such way the ash particles settle on the metallic wall of the reactor. This layer, whose surface is in a fuse state, drops and continuously re-forms, thus protecting metal walls from thermal aggression and mechanical stress.

The gas leaves the gas producer at a moderate temperature and is practically tar free. Final cleaning, mainly from dust, is carried out by a very simple and cheap three stages system, made up of a cooling and scrubbing unit, a demister and a final filter.

The cooling unit is a cylindrical tank filled with an inhomogeneous cheap material (expanded clay). The gas is cooled and scrubbed countercurrent by water. The used water is cooled and recycled. A cylindrical tank filled with the same inhomogeneous material constitutes the demister while the final filter is a steel cylinder filled with wood chips or sawdust.

The gasification tests were performed using different biomass. Characteristics of typical samples are reported in Tab. 1

Tab. 1: Characteristics of biomass

		Robinia	Forest residues	Wood wastes
C	(%wt mf)	51.2	51.3	51.8
H	(%wt mf)	5.7	6.1	6.1
N	(%wt mf)	0.5	0.4	0.3
Ash	(%wt mf)	1.0	1.3	0.6
Moisture	(%wt)	16.3	23.1	21.3

The size and shape are very important for the behaviour of biomass in the gasifier as to the movement, bridging and channelling. Also the thickness of the oxidation zone and the pressure drop depend on these characteristics. Sizes about 6x6x4 cm are recommended; 30 percent of sawdust in the feed or sawdust pellets can be processed.

Moisture affects the heating value of the gas and the steadiness of the gasification process because it absorb heat to vaporise. Maximum allowable limits are 20 - 25%. In any case most of the water vaporises in the pyrolysis section of the gasifier and it is condensed at the top of the reactor and collected.

Biomass was successfully gasified with steady operation condition. Tab. 2 reports some composition of the producer gas. Always tar and dust content was lower than 2 ppm

Tab. 2: Composition of the producer gas

Test n°	Compostion of the gas % vol.						Tar+ash ppm
	CO	H_2	CO_2	CH_4	O_2	N_2	
1	16.6	14.7	18.4	0.31	0.2	50.6	< 2
2	14.7	11.2	19.7	0.19	1.7	52.4	< 2
3	13.2	13.2	20.3	0.15	1.3	51.7	< 2

INTERNAL COMBUSTION ENGINE AND ELECTRIC GENERATOR

The internal combustion engine is a 4 stroke full-diesel engine. Its conversion from diesel to producer gas was performed:

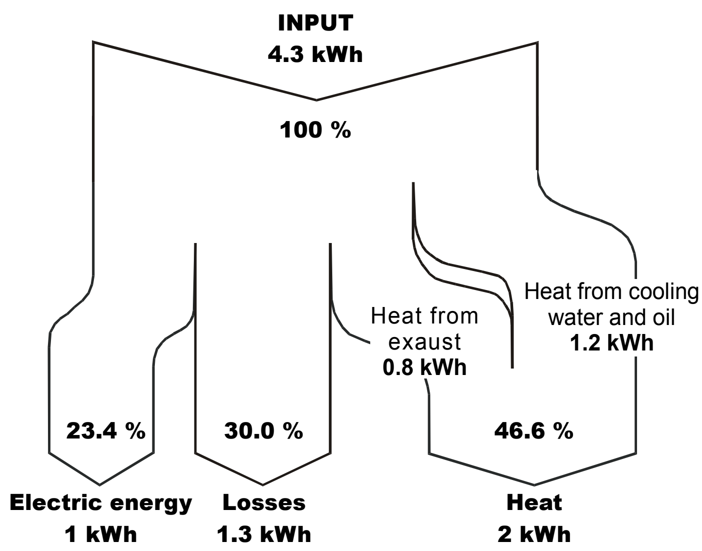
- decreasing the compression ratio from 17:1 to 11:1
- substituting the injectors with spark plugs and the injection pump with a distributor
- installing a special carburettor on the intake manifold.

The electric generator is a brushless AC electric generator:

Output	380 V, 40 kW_e
Frequency	50 Hz
Cos φ	0.8
Speed	1500 rpm

In addition to electricity, thermal energy can be produced recovering heat from cooling water, lubricating oil and exhaust. Up to 2 kW_t per 1kW_e can be obtained. Heat can be used to warm as well as to cool using an absorption chiller. A rated balance of the process is depicted in Fig. 3

Fig.3: Rated energy balance (per kWh_e)



CONCLUSION

By the collaboration between University of Sassari, NET S.r.l., and Mont-Ele S.r.l., a novel tar free gasifier based on the Imbert technology, was constructet and tested. A clean (tar and dust less than 2 ppm) low heating value gas was produced with a 75-80% efficiency.

The architecture of this downdraft fixed bed permits:

- maximum flexible matching capability with a wider range of waste wood conditions,
- lower costs of production by the use of standard components,
- guaranteed quality and stability in the produced gas according to the engine specifications,
- modular and flexible design which can be easily adapted to varying installation sites,
- reduced management costs.

Coupling the gasifier with a cycle Otto 40 kW alternator, electricity was produced with yields of 1 kWh_e per 1.3 kg of woody biomass (moisture 15%). Up to 2 kWh_t can be recovered using a cogenerative engine.

This gasifier can provide a competitive source of power in particular in developing countries where fuels handling is difficult, but also in developed countries with abundant biomass resources such as waste wood, sawdust, nutshells etc., in order to produce a costs reduction. The immediate production program covers the range 12-150 kW_e.

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WORKING GROUP 3: GASIFICATION

International Seminar on Bioenergy and Sustainable Rural Development
- 5th LAMNET Project Workshop – Mexico 2003

DEVELOPMENT OF BIOMASS CONVERSION TECHNOLOGY AND INDUSTRY IN CHINA (ANNUAL REPORT 2002)

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Nowadays, development and utilization of renewable energy resources has good opportunities. Chinese Ministry of Agriculture (MOA) is promoting the “energy agriculture” policy, which focuses on biomass resources development.

Biomass resource in China is characterized by many variety, huge quantity and wide distribution. In terms of technological feasibility and economics, biomass that can be used for energy purposes is divided into 5 types: energy crops, agricultural straw, agricultural residue, forestry residue, human and livestock waste, industrial organic waste water, and urban organic waste. In China, biomass is the major source of household fuel for rural people with a long history. With the urbanization of rural area, intensivelization of agricultural production, and modernization of farmers’ lives, because of its “renewability” and the development towards scaled, efficient, and clean utilization technology, biomass must play an important role in meeting energy demand, environmental protection and sustainable development.

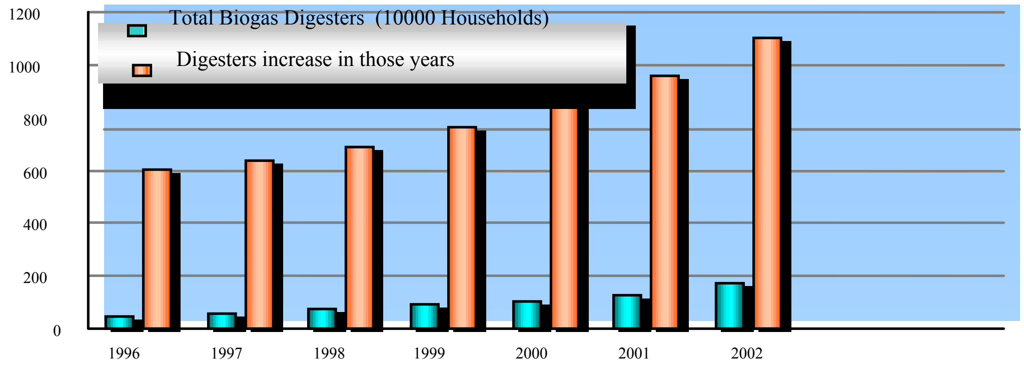
Presently, technologies on biomass conversion widely used in China include: biogas, straw gasification and central supply, gasification and electricity generation, direct combustion for heating, briquetting, and bio-fuel, etc.

1. Biogas industry plays an important role in rural energy and environment construction in China

1.1 Biogas industry develops into a new stage

In 2002, the central government invested 410 million RMB Yuan on rural energy construction. Local investment on rural energy also increased, more than 10 provices, such as Hebei, Liaoning, Hunan, Guangxi, Hainan, and Yunan, provided special fund for biogas dissemination. The total amount of local investment on small commonweal projects was 180 million RMB Yuan. In 2002, 1.7 million households became new biogas users, and there were 11 million biogas digesters in China, increased by 45.4% since 1999 (see figure 1). In 2002, there were 1859 large- and medium-scale biogas plants, which is purposed on treating wastes from large livestock farms, increasing 5000 compared with 2001. The total capacity was 870,000 m^3, which produced biogas of 230 million m^3 and treated 46.56 million tons of waste water per year. 15,000 biogas digesters for household waste water treatment were built in 2002(estimated), adding up to 111,000 in China. The total capacity was 4.34 million m^3, which treated 360 million tons of waste water per year.

Figure 1: Installed Biogas Digesters in China (1996 – 2002)



1.2 New features and trend of biogas industry

Currently, biogas industry comprises of design and construction, biogas appliance production and supply, and after service. The production capability can meet the demand of construction of 300 large- and medium-scale biogas plants and 1.5 million biogas digesters and accessories.

- Strategy of "leading enterprises and brand products" has made good achievement.

  Jiangxi Provincial center for Rural Energy and Environmental Protection Technology Development and its instrument factory increased their sales by 50% in 2002, and became the enterprise in the field with the widest market coverage. With its advantage on capital, technology, and management, Beijing Hebaiyi Ecological Energy Science and Technology Develop Company was named the only □□enterprise for household biogas digester accessories by the Ministry of Agriculture. The largest gas apparatus enterprise in China, Zhongshan Huadi Gas Apparatus Company setup the Department of Biogas Apparatus Development. Because of its advantage on capital and technology, the company rapidly developed biogas stoves and accessories with good performance/price ratio.

- The product is upgraded and quality improved

  Based on its advantage on research, production, and technology, Luohe Yuli Instrument Company selected biogas barometer as its new point and developed metal membrane barometer. Jiangxi Provincial center for Rural Energy and Environmental Protection Technology Development produced erosion-proof biogas transmission component. Beijing Hebaiyi Ecological Energy Science and Technology Develop Company developed adjustable cleaners that combines dehydrate, desulfate, pressure control, and pressure display together. Most of the enterprises that manufacture biogas stoves were paying attention to the product quality, design of stove structure, and improvement of product appearance.

- Technics and engineering technology is improved

  Construction of household biogas digesters has been industrialized and commercialized. Researches on large- and medium-scale biogas plant, equipment and post-treatment technology has made new achievement. Tsinghua University developed the 3-generation anaerobic fermentation techniques: ECSB and internal circulation reactor.

ECSB has been practically used in China, and reached the world leading level. Institute of Biogas Science of Ministry of Agriculture, Shanghai Mingxing Energy conservation and Environmental Protection Engineering Company, Hangzhou Energy and Environment Engineering Company, Beijing Academy of Environmental Protection, Center for Energy and Environmental Protection Technology Development of Ministry of Agriculture, Department of Environmental Science and Engineering of Tsinghua University, and Beijing Meihuaboda Environmental Engineering Company are capable to design large- and medium-scale biogas plants. Besides, research and development of biogas generators also made good achievement.

- Level and capability of after service are improved incessantly

Government bidding and purchase has promote the enterprise cooperation and the industry development, and therefore guarantee users' rights. Some strong enterprises catch the good opportunity to establish and perfect their own sale and after service system while supply biogas stoves into the market, which has dramatically improved the level of after service. In the process of promoting industrialized management of household biogas digesters, some new management patterns such as township biogas association were created.

- System of biogas industry standards is improved

Improvement of system of biogas standards has basically met the demand of development of biogas construction. Standards for Design, Construction, and Use of North Model of Household Rural Energy Engineering, Standards for Design, Construction, and Use of South Model of Household Rural Energy Engineering, and the National Standards for Household Biogas Stoves GB3606-83, which fully reflect the upgrade of biogas stove technology, have been issued and implemented. Other relevant standards are to be issued or being worked. Institute of Biogas Science of Ministry of Agriculture and Center for Biogas Product and Equipment Quality Test of Ministry of Agriculture have been doing a lot of work on the formulation, modification, and extension of biogas-related standards.

1.3 Planning of Biogas Construction Development provided good opportunities to biogas industry development

The 2003-2010 Biogas Construction Plan in Rural Area of China, formulated by the Ministry of Agriculture, clearly stated that the government will actively promote the development of biogas industrialization, which provided excellent opportunities to the industry development. According to the plan, 11 million household biogas digesters will be constructed by the end of 2005, and then there will be totally 20 million in China: 1/10 of rural households will be biogas users. In 2010, 50 million rural households (20% of the total) will use biogas as daily fuel. Meanwhile, the government will support the construction of large- and medium-scale biogas plant in "vegetable basket" livestock feeding base in the suburbs of cities in East coastal area and some other large and medium cities. 2500 biogas plants are to be constructed by 2005, which can supply biogas to 300,000 households; 5000 in 2006-2010, supplying 600,000 households. Implementation of such a great plan will strongly promote the progress of biogas technology and enable the biogas industry go to a new stage.

2. Biomass technology made good progress

2.1 Framework of standard system has been established, and relevant standards are gradually formulated

Biomass resource here mainly refers to crop straw. From the view of current situation of biomass utilization in China, some of the biomass technology has not been mature enough to be widely applied. The technical limitation and management problem are serious for them to be applied in large scale. Further experiments are necessary to decrease conversion cost and improve the quality of products. At present, a framework of standardization system has been established. Perfection of industrial standards ensures the biomass utilization to develop in order.

2.2 Products variety is diversified and technology advanced

With the urbanization of rural area, intensivation of agricultural production, and modernization of farmers' lives, because of its "renewability" and the development towards scaled, efficient, and clean utilization technology, biomass must play an important role in meeting energy demand, environmental protection and sustainable development. Presently, technologies on biomass conversion widely used in China include: biogas, straw gasification and central supply, gasification and electricity generation, direct combustion for heating, briquette for fuel, and bio-fuel, etc.

The existing village-level straw gasification and central supply plants can normally supply fuel gas to 100~1,000 households. The thermal conversion efficiency is more than 70%, the thermal value of fuel gas more than 4600kJ/Nm^3, and CO and O_2 content is less than 20% and 1%, respectively. Compared with old straw gasification system, the new ones have better performance, especially for carbonization gasification systems, and operation is more steady. However, the problems of low thermal value and high tar treatment cost are still existing.

China is researching and developing two types of biomass gasification system for electricity generation: fixed bed gasification and electricity generation system, and fluidized bed gasification and electricity generation system.

Biomass direct combustion is used for heating and drying. As a effective approach to consume large amount of crop straw, this method has promising prospect.

The prominent problem of biomass briquetting machine is that the press screw and sleeve do not have enough long life.

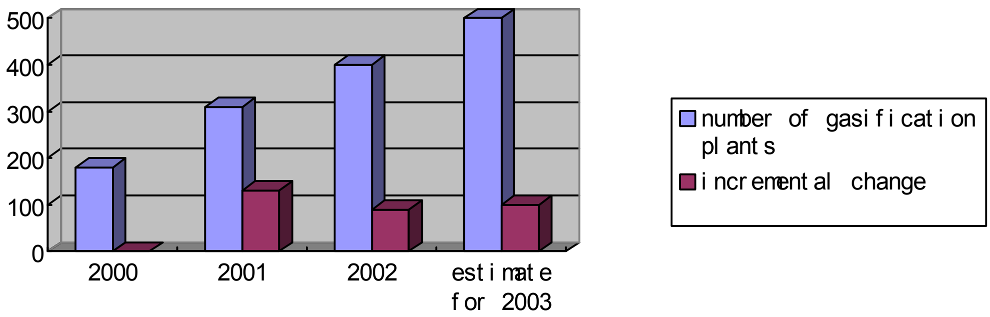
Technology on biological liquid fuel from biomass is now a research project funded by the State Planning Commission and Ministry of Science and Technology.

2.3 Industrialization process is seeking turning point

In recent years, industrialization of biomass conversion technology in China made a good achievement, and some enterprises and research organization able to conduct technology development, equipment production, and plant construction occurred. The involved fields are: biological liquid fuel from biomass, biomass gasification, biomass briquetting and fuel gas drying, biomass direct combustion boiler, etc. In particular, companies in the field of biomass gasification equipment production and technological service developed very fast, and industrialization and socialization of small-scale biomass boiler has achieved good progress.

By the end of 2002, there were more than 400 biomass gasification and central supply plants in China, which produced 150 million m^3 of fuel gas per year and involved equip manufacturing output of 900 million RMB yuan (Figure 2). There are more than 40 companies and research institutions able to undertake the design and construction of crop straw gasification and central supply plants in China. There are 15 biomass gasification and electricity generation plants in operation. 5 organizations are able to design and construct biomass gasification and electricity generation plants. Among them, Guangzhou Energy Institute of Chinese Academy of Science is the best.

Figure 2: Installed Gasification Plants in China (2000 – 2003)



Biological liquid fuel mainly refers to bio-ethanol. China has issued national standards: *Denaturalized Fuel Ethanol* and *Vehicle Ethanol Gasoline*. The State Planning Commission has approved 4 demonstrative projects, in Heilongjiang Province (200,000 tons per year), Jilin Province (600,000 tons per year), Henan Province (300,000 tons per year), and Anhui Province (60,000 tons per year), respectively. These projects produce fuel ethanol from old grain, and petroleum industry use the ethanol to produce vehicle ethanol gasoline and sell in local gas station.

Trend of Gasification Plant Development in China

Chinese Academy of Agriculture Engineering and Beijing Taitiandi Energy Technology Development Company are undertaking a National 863 Project "Fuel Ethanol from Sweat Sorghum". The technology uses sweat sorghum as raw material and produce fuel ethanol through biological conversion technology. The project is established on the base of biomass conversion technology, agricultural residue recycling technology, and ETBE (non-pollution ethanol gasoline additive) conversion and synthesis technology. Straw briquetting machine developed by Henan Agriculture University has been manufactured in certain scale. Beijing Laowan Biomas Science Company has developed efficient biomass grain fuel automatic combustor and a series of stoves, characterized by high efficiency and environmental protection.

Development of renewable energy technology and industry in China has made good achievement under the help of international organizations such as UNDP, FAO, UNIDO, ESCAP, WORLD BANK and cooperation with other countries. We are willing to carry out better and more effective cooperation with Latin countries to serve the whole world.

WORKING GROUP 4: BIOMASS RESOURCES

International Seminar on Bioenergy and Sustainable Rural Development
- 5th LAMNET Project Workshop – Mexico 2003

WORKING GROUP SUMMARY

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The widespread use of bioenergy, under appropriate technologies, may combat actual social inequities and alleviate poverty, as this rather cheap and secure energy source would be accessible for most people, in particular for the rural poor. Although "appropriate" technologies seem available, transition to renewables at a broad scale is been delayed because major economic groups are still benefiting from fossil fuel use.

National economies should be guided by their energy budget rather than by their financial budget. Sustainable development issues should focus on community level. Without local development, there is no true development.

Many renewable energy programs in Mexico are subject to frequent changes in government policies. Implementation of policies for bioenergy projects need to last beyond changes in government. The Brazilian model for promoting biofuels could be taken as a first example for Mexico.

Developing countries can greatly benefit from the sustainable use of biomass as an energy source. In Senegal, for example an intergrated government project has been able to assure the use of 860.000 ton/yr of woodfuel in a sustainable way and 19.000 improved cookstoves have been installed since the starting of the project.

Detailed studies show that fuelwood is not a major cause of deforestation worldwide. In fact, the fuewood gap theory (FAO) has no consistent evidence so far.

GIS are very useful tools for assessing bioenergy possibilities at multiple spatial scales, as they may help in estimating national overall biomass productivities, while priorizing specific locations where actual fuelwood shortages might appear.

The carbon mitigation potential from the use of bioenergy is a key issue in order to achieve the transition from fossil fuels, as this environmental service may provide extra financial benefits.

Main conclusions:

The more intense use of biomass resources represents several challenges for the preservation of the resource in the long term. Assessing and assuring the sustainable use of biomass resources is therefore critical.

Multi-scale spatially explicit approaches provide very useful options to accomplish the previous goal globally, as biomass use patterns and trends are site specific.

Assessing the carbon mitigation potential of biomass energy resources is now an essential issue to be addressed in the transition from fossil fuels to renewables, as global policy mechanisms trying to prevent further increasing in GHG emissions are actually in the process of implementation.

WORKING GROUP 4: BIOMASS RESOURCES

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FOOD SECURITY, BIOENERGY AND RURAL DEVELOPMENT IN THE DEVELOPING WORLD

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ABSTRACT

Major adjustments are needed in agricultural, environmental and macroeconomic policy, at both national and international levels, in developed as well as developing countries, to create the conditions for sustainable agriculture and rural development (SARD). The major objective of SARD is to increase food production in a sustainable way and enhance food security. This will involve education initiatives, utilization of economic incentives and the development of appropriate and new technologies, thus ensuring stable supplies of nutritionally adequate food, access to those supplies by vulnerable groups, and production for markets; employment and income generation to alleviate poverty; and natural resource management and environmental protection. 14.3. The priority must be on maintaining and improving the capacity of the higher potential agricultural lands to support an expanding population. However, conserving and rehabilitating the natural resources on lower potential lands in order to maintain sustainable man/land ratios is also necessary. The main tools of SARD are policy and agrarian reform, participation, income diversification, land conservation and improved management of inputs. The success of SARD will depend largely on the support and participation of rural people, national Governments, the private sector and international cooperation, including technical and scientific cooperation. (Agenda 21, Chapter 14, 14.2)

RURAL UNDERDEVELOPMENT AND BIOENERGY

Energy use in most countries is unsustainable in the short and long terms, from both natural resource and environmental points of view. In rural areas throughout the developing world, the situation is more critical. The main - and often only - sources of energy for household use and food production are diminishing supplies of woodfuels, along with biomass residues and human and animal power. Dependence on these traditional energy sources is associated with poverty, health risks and human drudgery.

In global terms, woodfuels represent about 7% of the world's total primary energy consumption, most of which (76%) are used in developing countries, where about 77% of the world's population live. The rest (approximately 5400 PJ) are used in developed countries, where they represent only 2% of total energy consumption. (WEC, 1999-2003)

This contribution rises to 14% in developed countries if other biofuels are considered, however, thus reaching a broadly similar share to other conventional energy sources, such as coal, gas and electricity. (IEA, 1997). In the developing countries, wood energy represents 15% of total primary energy consumption, although this figure conceals important differences at the sub-regional and national levels. For example, there are 34 countries where woodfuels provide more than 70% of the energy needs and the dependence of 13 countries is 90% or more. (WEC, 1999-2003)

In developed countries, wood energy contributions also vary considerably from country to country. In Europe, for instance, countries like UK, Belgium and Germany make relatively little use of woodfuels, while in countries such as Finland, Sweden and Austria, forest energy provides up to 17% of their demand. France is the largest user in the EU in absolute, but not in relative terms. It should also be noted that in many countries, especially those of the former USSR, there is virtually no information on wood energy. (WEC, 1999-2003)

Of the approximately three-quarters of the total woodfuel consumption accounted for by developing countries, about 44% is concentrated in Asian countries, and this is a fair indication of the important role played by trees and forests in meeting the energy needs of this region. (WEC, 1999-2003)

Developing countries must be assisted to meet their energy requirements in agriculture, forestry and fisheries, as a means of achieving sustainable development. They will have to accomplish a transition from the present energy supply of mainly fuelwood and other biomass fuels and animal and human power to a more diversified resource base, increasingly utilizing renewable energies and a more modern use of biomass, to attaining sustainable livelihoods and improving the living conditions of rural populations.

POVERTY AND BIOENERGY

Poverty levels had being increasing constantly in the last years. The effects of globalisation and increasing economic integration have led to the rich getting richer and the poor getting poorer in the last 20 years. UN statistics provide evidence of the widening gap between rich and poor: In nine years, the income ratio between the top 20% and the bottom 20% has increased from 60:1 to 74:1. Eighty countries have less revenue than they did a decade ago.

The assets of the 200 richest people exceed the combined income of 41% of the world's total population. The assets of the top three billionaires are more than the combined GNP of all least developed countries and their 600 million people or their income is more than the GDP combined of the 48 less developed countries in the world. (WB, 2000/2001)

The overall consumption of the richest fifth of the world's people is 16 times that of the poorest fifth. About 840 million people are malnourished. Nearly 340 million women are not expected to survive to age 40. Nearly 160 million children are malnourished. More than 250 million children are working as child labourers. (Human Development Report 1999)

Of the world's 6 billion people, 2.8 billion live on less than $2 a day, and 1.2 billion on less than $1 a day. (Global Poverty Report, 2001). Meanwhile the 25% of the world population received the 75% of the global generated income. (WB, 2000/2001)

Economic growth is projected as the road to overcome global poverty. With economic growth of $100 the rich 20% of the world population pocket $83 and the poorest 20% get $1.40. Global economic growth is therefore a highly inefficient way to help the global poor. (Achaean, 2000)

Wealth extraction causes poverty, and poverty causes hunger.

Statistics on the inability of people in developing countries to satisfy basic human needs corroborate the enormous scale of poverty and highlight its breadth and complexity. For example: (HDR, 1999, 2000,2001).

From the 4 600 millions of people living in the Third World:

- 968 millions lack access to safe water; and
- 2 400 millions lack access to sanitation (HDR, 1999, 2000,2001).
- 2000 millions do not have access to less spensive basic medicines like penicillin.

In comparison with industrialised countries:

- infant and child mortality rates in developing countries are more than five times higher;
- the maternal mortality rate is 440/thousand alive
- the proportion of births attended by trained health personnel is 56% and only 29% in the poorest countries.

Sustainable Energy is fundamental to the great challenges facing the world at the beginning of the 21st century: how to eliminate the obscene levels of poverty without further polluting the planet or worsening climate change

Two billion people have no access to electricity and up to three billion depend on bio-mass (wood, charcoal and dung) to meet their household energy needs. The UN Commission on Sustainable Development has called access to Sustainable energy a "prerequisite" for halving poverty by 2015.

Energy is the lifeblood of human society and economics. It cooks the food society eats. It heats the buildings humans' use for work and daily life. It powers the industries. And for a majority of the world's people, turning on a light switch is something that rarely, if ever, requires conscious thought.

There for is so amazing the figure that points out that over two billion people in the developing world today have no modern energy services. Eighty per cent of people in sub-Saharan Africa have no electricity.

The world's greatest child killer, acute respiratory infection will not be tackled without dealing with smoke from cooking fires in the home. Children will not study at night without light in their homes.

Gender disparities have continued. Poverty has a woman's face. Of the approximately 1.3 billion people living in poverty, 70% are women. Increasing poverty among women has been linked to their unequal situation in the labor market, their unequal treatment under social welfare systems, their lack of access to health and education services, and their lack of status and power in the family. (See Annex I)

The undervaluation of women is reflected in the undervaluation of their work and in the absence of recognition of the contribution that they make. On average women work longer hours than men in nearly every country. Moreover, women support 53% of the total burden of work in developing countries, and 51%, in industrialized countries.

Around a half of the total work time of both men and women is spent in economic activities in the market or in the subsistence sector. The other half normally is devoted to unpaid household or community activities. In industrialized countries men's total work time is spent roughly two-thirds on paid activities and one-third on unpaid activities.

But for women, the situation is the opposite. In developing countries, more than three-quarters of men's work is in market activities. As a result men receive a much larger share of cash income and recognition for their economic contributions. Conversely, most of women's work remains unpaid in non-marketed or subsistence activities and is thus unrecognized and undervalued. If unpaid activities were treated as market transactions at prevailing wages, global output would increase by US$16 trillion. This represents a 70% increase in the officially estimated global output of US$23 trillion. US$11 trillion of this increase would correspond to the non-magnetized, "invisible" contribution of women.[9] (HDR, 1995*)*

[9] See Chapter 4 of the Human Development Report (HDR, 1995) "Valuing women's work".

Women are the major users of traditional and biomass energy resources for household and income-earning activities, and they also play major roles in the use of modern energy by households:

Biomass fuels account for 80% of all household fuel consumption in developing countries, mostly for cooking, which is done primarily by women. Women have practical interests and applied expertise in the burning properties of different fuels, fire and heat management, fuel-saving techniques, and the advantages and disadvantages of different fuels and stoves.

Given women's crucial roles in and contributions to food security, any efforts to reduce food insecurity worldwide must take into consideration the factors and constraints affecting women's ability to carry out these roles and make these contributions, with a view to removing the constraints and enhancing women's capacities.

Access to resources is essential to improving agricultural productivity of both men and women farmers and to promote sustainable development. Because women play crucial roles in agricultural production, improving productivity will depend to a great extent on ensuring that women farmers, as well as men farmers, have sufficient access to production inputs and support services. While both men and women smallholders lack sufficient access to agricultural resources, women generally have much less access to resources than men.

The causes of this are rooted, to a great extent, in: gender-blind development policies and research; discriminatory legislation, traditions and attitudes; and lack of access to decision-making. Worldwide, women have insufficient access to land, membership in rural organizations, credit, agricultural inputs and technology, training and extension, and marketing services.

Access to basic, clean energy services is essential for sustainable development and poverty eradication, and provides major benefits in the areas of health, literacy and equity. The Millennium Development Goal of halving poverty will not be achieved without energy to increase production and income, create jobs and reduce drudgery.

POVERTY, FOOD SECURITY AND BIOENERGY

One of the most dramatic aspects of the food security problem is the extent of famine, hunger and starvation. While some progress has been made in averting famine, especially in China, Asia, these horrifying conditions persist throughout the world. Their occurrence is commonly attributed to drought and other natural disasters, but war, civil unrest and political and economic instability have far greater importance. In the 1990s and the beginning of the actual decade, hunger and malnutrition resulting from civil strife were and are serious problems in many parts of the world including Europe (particularly former Yugoslavia), Asia (for example, Afghanistan), the Near East (Iraq) and most extensively Africa.

Tragically, wars often affect not only the countries in turmoil but also those that provide hospitality to the refugees who flee their homes in terror. Their arrival more than doubled the population of the resource-poor region, which welcomed them as best it could. The influx placed overwhelming pressure on local resources and necessitated a major international effort to prevent an increase in nutrition and health problems among the local people as well as to contain these problems among the refugees.

As well as producing supplies of food and fibre, agriculture also affects other aspects of quality of life. Agriculture can support the vitality of rural communities through maintaining family farming, rural employment, cultural heritage and sustainable development. It also can make positive contributions to biological diversity, recreation and tourism, soil and water systems, bioenergy, landscape, food quality and safety, and the welfare of animals - but none of these outcomes are automatic, they often require policy mechanisms to facilitate them.

The term multifunctionality reflects these diverse elements although the relative importance of the various functions of agriculture differs between localities, regions, countries and groups of countries.

The basic fact that agriculture serves multiple functions is widely recognised. As early as 1992, world governments at the Rio Earth Summit recognised the: "*multifunctional aspect of agriculture, particularly with regard to food security and sustainable development*". (Agenda 21, Chapter 14).

In March 1998 the OECD stated: "*Beyond its primary function of producing food and fibre, agricultural activity can also shape the landscape, provide environmental benefits such as land conservation, the sustainable management of renewable natural resources and the preservation of biodiversity, and contribute to the socio-economic viability of many rural areas.... Agriculture is multifunctional when it has one or several functions in addition to its primary role of producing food and fibre.*" (OECD Declaration of Agricultural Ministers Committee).

A key function of agriculture is to ensure secure and stable supplies of food. Yet, food insecurity is still a major problem, particularly in the developing world.

Today more than 800 million people throughout the world still lack sufficient food to meet their basic nutritional needs. Progress is weak, given the scale of the challenges. For example, achieving the food security targets of the World Food Summit requires a four- to sevenfold increase in commercial energy. This will, obviously, not happen under a "business as usual" approach.

The world already grows more than enough food to feed everyone. About a billion people now don't have enough food to meet basic daily needs, but that's not because there's not enough food. There's more food per capita now than there's ever been before -- enough to make everyone fat. There's enough to provide at least 4.3 pounds of food per person a day: two and a half pounds of grain, beans and nuts, about a pound of fruits and vegetables, and nearly another pound of meat, milk and eggs.

People starve because they're victims of an inequitable economic system, not because they're victims of scarcity and overpopulation.

It's a myth that most of the food is grown in the rich countries. The US, for instance, is the world's biggest food importer. US exports of corn and other grains for human food to reduce malnutrition and starvation are another myth. Most US grain exports go to feed livestock, not humans. Much of it is also used as feedstock for industry. (See Annex II-III) (Food or Fuel, 2002)

The capacity exists to produce sufficient food for all people in the world. (Aneex V) This requires, however, an increase in food production, particularly in low-income, food-deficit countries. According to the World Food Summit Draft Plan of Action, *"production increases need to be achieved while ensuring both productive capacity, sustainable management of natural resources and protection of the environment"* (UN, 1999). Sufficient food production alone will not guarantee food security, however, unless action is also taken to ensure access to food by all people.

Economic liberalization and privatisation are major features of Structural Adjustment Policies (SAPs), which aim at the rationalization of fiscal and monetary policies and the creation of a macro-economic environment favourable to economic growth. SAPs focus on the reduction of public spending and price supports, liberalization of markets, reduction and elimination of agricultural and food subsidies and the elimination of marketing and transportation controls. These measures are likely to have a negative impact on small and poor farmers. Cuts in social services and the increase in food prices adversely affect the more vulnerable parts of the population, particularly women and children, and place a disproportionate burden of work on women who must make up for the services that have been cut.

Paradoxically, the rural people who produce the world's food also make up the majority of the worlds poor and are among those most vulnerable to food insecurity.

Approximately 70 percent of the world's poor are women. The trends towards economic and trade liberalization and privatisation which are intended to boost agricultural production and the economy may well result in increasing food insecurity.

A range of different policies attending agriculture, energy and trade developments - which could vary depending on levels of development - should therefore be crucial for implement by governments to pursue real food security objectives. For example, the possibility of being able to exempt life-forms from patenting if this conflicts with the maintenance of traditional farming practices that are important for food security (such as saving seed from one season to the next).

Future food security will mainly depend on the interrelationships between political and socio-economic stability, technological progress, agricultural policies and prices, growth of per capita and national incomes, poverty reduction, women's education, trade and climate variability

Policies on the ownership of land, and regulations to control its use have important implications for biomass conversion to energy. Legislation regarding property rights - both of land and of produce, such as biomass from forests - is generally weak in the developing world, especially in Africa, and is considered an important barrier to the healthy development of sustainable bioenergy production and use.

Planners and policy makers need to be able to link energy requirements with specific objectives of agricultural and rural development, such as food security, agro-industry development, and sustainable farming practices. This requires specific studies and data indicating the energy intensiveness of different farming techniques for important food and other crops.

Agricultural productivity is closely associated with direct and indirect energy inputs, and policies are required to consolidate this relationship for the benefit of farmers. Agricultural development plans in most African countries are designed and implemented with little or no regard to this association, thus missing opportunities to enhance production in both quantitative and qualitative terms. Energy development plans rarely take into consideration the present and future energy needs of agriculture, and most rural electrification programmes are mainly directed to households.

Energy price policies seldom regard the economic conditions of rural populations. If rural development is to be achieved, energy inputs must be made available, and this might require special efforts from the society as a whole - e.g. subsidizing energy inputs in order to maintain the expected low costs and high quality of agricultural produce, as generally demanded by urban populations.

Policies promoting social equity between rural and urban populations and between men and women, particularly in rural areas, are generally non-existent, leading to migration, injustice and social instability. In energy terms, what is needed is a reduction in human drudgery (e.g. water and fuel collection) and better services. Facilitating energy and other inputs required by agriculture represents greater recognition, in both economic and social terms, of the vital role played by Africa's rural people in feeding society.

In order to promote food security strategies with the necessary energy inputs, policies and methodologies should consider the critical linkages between agricultural production, agricultural-based industries (food, beverage, tobacco, and textiles), distribution and commercialisation, and the rest of the economy. Agricultural growth is the most important contributor to manufacturing and service activity in the Third World, not only stimulating agro-industries, but the rest of the economy as well. In this context, energy from biomass is an added benefit.

The design and implementation of almost all sustainable agriculture and rural development field activities will require some form and amount of energy input. In many cases, this energy input is not considered, leading to unsatisfactory solutions from both the environmental and energy efficiency standpoints. It is necessary to "energize" agricultural practices.

Low-input farming techniques, such as integrated pest management, low-tillage cultivation, use of residues, green manures, and other organic fertilizers, may play an important role in sustainable agricultural development. There are several local success stories and new initiatives in low-input, high-yield agriculture. However, the energy implications of these techniques have yet to be systematically documented. More research is needed to enable clear comparisons with well-established high-input methods.

Unfortunately, most sectoral plans are carried out in isolation from other sectors. Integration is particularly important when developing policies and plans for energy in agriculture, due to the close interlinkages. To a great extent, this problem arises as a result of the lack of priority given by the energy sector to rural areas in general, to the lack of a "lobbying" capacity among farmers, and to the lack of mandate and of technical expertise on energy in the agricultural.

A key form of intervention in the bid to increase rural people's access to energy is financing. Many renewable technologies best suited to provide energy services to remote rural areas use traditional fuel, but have a prohibitive initial capital cost. At the same time, many developing country governments are actively promoting the replacement of woodfuel by subsidising other energy sources.

However, the success of such fuel substitution programmes basically depends on two factors largely beyond government control: economic growth and the corresponding increase in personal incomes that would permit consumers to switch fuels. The substitution process in many countries is hampered by high import costs resulting from the inefficient procurement of small quantities and the increase for prices in the privatised sectors.

POVERTY, BIOENERGY AND CLIMATE CHANGE

Climate change, may affect the physical availability of food production by shifts in temperature and rainfall; people’s access to food by lowering their incomes from coastal fishing because of rising sea levels; or lowering a country’s foreign exchange earnings by the destruction of its export crops because of the rising frequency and intensity of tropical cyclones.

It is generally accepted that climate change is the result of human activity including industrial output, car exhaust, and deforestation. These types of activities increase the concentrations of carbon dioxide, methane, nitrous oxide and other greenhouse gases (GHGs) in the atmosphere (IPCC, 2001).

If the current trend in carbon emissions continues, temperatures will rise by about 1 degree C by the year 2030 and by 2 degree C by the next century. This increase, however, will probably have different impacts in different regions. Agricultural impacts, for example, will be more adverse in tropical areas than in temperate areas. Developed countries will largely benefit since cereal productivity is projected to rise in Canada, northern Europe and parts of Russia.

In contrast, many of today’s poorest developing countries are likely to be negatively affected in the next 50 – 100 years, with a reduction in the extent and potential productivity of cropland. Most severely affected will be sub-Saharan Africa due to its inability to adequately adapt through necessary resources or through greater food imports

Some groups are particularly vulnerable to climate change: low-income groups in drought-prone areas with poor infrastructure and market distribution systems; low to medium-income groups in flood-prone areas who may loose stored food or assets; farmers who may have their land damaged or submerged by a rise in sea-level; and fishers who may loose their catch to shifted water currents or through flooded spawning areas

At the same time, the world faces another great challenge: the prospect of a climatic catastrophe if present trends of fossil fuel consumption continue. Heat-trapping gases such as carbon dioxide and methane that keep more of the sun's warming energy in the earth's atmosphere cause climate change. (Annex IV)

And this is primarily caused by the industrialized world's fossil fuel consumption, although developing country emissions are rising quickly. Per capita emissions of developed country citizens are far higher than those of people living in developing countries: the average American produced 20 tones of CO2, compared to an Indian average of less than one tone.

The Intergovernmental Panel on Climate Change projects a substantial global temperature rise and sea level increase, and more extreme weather events such as floods, hurricanes, drought and heat waves. Those most vulnerable to these changes live in the developing world.

Developing countries will feel these impacts most acutely, even though they also have the least responsibility for climate change. A range of effects consistent with climate change has primarily triggered the current famine in Southern Africa. Extreme weather events are growing stronger and more frequent, as recent years have shown abundantly in events ranging from the Orissa Cyclone in India and floods in Mozambique to Hurricane Mitch in Central America. Most tellingly of all, the people of Tuvalu a tiny small island state in the South Pacific have started negotiations with New Zealand for the evacuation of their entire population. Rising sea levels are Stalinizing the country's low-lying cropland and making it unusable. Tuvalu is a sign of how things can develop.

There is a huge potential for renewable energy to provide clean, appropriate and efficient energy to the world's poorest. Millions can be lifted out of poverty without costing the earth, with the help of clean sustainable energy

The role of renewable energy sources and of bioenergy, in particular, in carbon sequestration and substitution is increasingly of interest in the context of the Climate Change Convention. The international institutions like FAO should strengthen their assistance to countries in strengthening their institutional and human capacities to implement rural energy programmes and in the implementation of bioenergy programmes within the framework of the Kyoto Protocol.

Agriculture is itself responsible for about a third of greenhouse-gas emissions. Activities such as ploughing land and shifting ('slash and burn') cultivation for agricultural expansion release CO_2 into the air. Much of the 40% of human caused methane comes from the decomposition of organic matter in flooded rice paddies. About 25% of world methane emissions come from livestock. In addition, agriculture is responsible for 80 percent of the human-made nitrous-oxide emissions through breakdown of fertilizer and that of manure and urine from livestock. However, agriculture's GHG emissions can be largely reduced, and much can be done to lessen their effect on production and on the livelihoods of farmers, especially in developing countries. (FAO, 2003).

It seems so unfair that agricultural activities, responsible for generating food would compete with the environmental pollution created by industrial processes. The eternal debate among development and survival. The developed countries should also understand the real impact of their emissions into the atmosphere and finally implement the international agreements already signed for that purpose.

It is clear, that farmers in the developing world will have to receive assistance in adopting coping mechanisms that withstand climate variability through activities such as the use of drought-resistant or salt-resistant crop varieties, the more efficient use of water resources, and improved pest management. Changes in cultivation patterns can include the reduction of fertilizer use, the better management of rice production, the improvement of livestock diets and the better management of their manure. In addition, national governments have an important role to play in enforcing land use policies which discourage slash and burn expansion and extensive (rather than *intensive)* livestock rearing, as well as raising the opportunities for rural employment. (FAO, 2003)

Carbon sequestration can also be a means through which agriculture can make a positive contribution towards mitigation, and will be of growing economic and environmental importance in the context of the Kyoto Protocol. It is estimated that for the next 20 to 30 years, cropland contribution to carbon sequestration lies within the range of 450 – 610 million tones of carbon per year. By applying improved land management practices (better soil fertility and water management, erosion control, reversion of cropland in industrial countries to permanent managed forests, pastures or ecosystems, biomass cropping, conservation tillage, etc.), the role of agriculture as a major carbon sink and as a compensating mechanism for agriculture’s contribution to GHGs can be greatly enhanced. (FAO, 2003)

Agriculture can also play a role in reducing the burning of fossil fuels. It is said that up to 20 percent of fossil fuel consumption could be replaced in the short term by using biomass fuel. In Brazil 6 million cars are running partly on alcohol derived from sugar cane. China already has 10 million dung digesters, which provide a clean cooking fuel and an organic fertilizer. Fast-growing grasses, oilseeds and agricultural residues offer great potential as energy alternatives. It is important to note that these bioenergy initiatives also have a positive impact on rural socio-economic development. But for the implementation of these and other clean technologies, the developing countries will have to attain real access to the technologies sources.

PERSPECTIVES FOR THE FUTURE

The "energizing" of the food production chain - both quantitively and qualitatively - based on diversified sources and a better use of commercial energy is one key to achieving food security and improving the living conditions of rural populations. However, breaking the current energy bottleneck must also be sustainable - environmentally sound, socially acceptable and economically viable.

The challenge is also an opportunity. By using the potential offered by renewable energy sources, agro-ecotechnologies, and innovative institutional and financial arrangements, rural areas could "leapfrog" to more sustainable energy systems and food security. These rural areas could become examples to other sectors of society, both in developing and industrialized countries.

There is, however, a danger. The energy sector is undergoing a rapid shift toward high-energy efficiency, renewable energy sources, lower intensity industry and energy recycling. It is supposed that agriculture will also have to move towards greater sustainability thanks to techniques such as organic farming, improved water and soil management, integrated pest management, mechanization and biotechnology.

The challenge in the medium term is to harness these changes for the benefit of the rural poor. If not, there is a real risk that rural populations will be excluded from the shift to sustainability, and left to face either chaos in rural areas or massive emigration to urban centres. And then agriculture will never accomplish the major carbon sink role agriculture is supposed to play.

The basic needs of the two billion poor people who lack access to modern energy services should be covered in a way that does not further damage the environment. This aim demands to identify two key challenges for energy planners and policy makers:

Challenge number 1: Energy for cooking and food security.

The first energy priority of poor people is how to meet their household energy needs. Poor people spend up to a third of their income on energy, mostly to cook food. Around three billion people in the developing world use biomass, such as wood, dung, charcoal and agricultural residues, for cooking and, in cold regions, heating.

Due to poverty and a lack of appropriate alternatives, many will continue to rely on biomass as their primary energy source for cooking in the foreseeable future. There is urgent need to establish and maintain a sustainable supply of wood and charcoal to people on a very low income. This action demands widespread and sustainable reforestation programmes, which directly involve communities.

Women, in particular, devote a considerable amount of time to collecting, processing and using traditional fuel for cooking, often spending up to three hours per day and walking up to ten kilometers to gather 35 kg of firewood time which could be spent on child care, education or income generation. Reducing the amount of firewood or dung used through simple affordable technology, such as more efficient stoves, is vital.

Every year 1.8 million people die of illness related to smoke for cooking fires. Smoke is a major factor contributing to acute respiratory infection, the greatest single cause of under-five- year-old deaths. Simple, low-cost solutions to deadly indoor air pollution can be available, including chimney stoves, smoke hoods, switching to cleaner fuels and improved ventilation

Challenge 2: Getting electricity to the rural poor

A major challenge will be to provide electricity to the rural poor. Electricity is needed to power small industry and enterprise, run health clinics and light schools. Without it rural poverty will never be eradicated.

The conventional approach to electrification tends to marginalize rural communities who are located far away from the grid. As rural population densities are generally low, the cost of energy supply is high compared with densely populated areas. Electricity companies, either public or private, have almost no incentive to provide services to these areas.

The present alternatives for decentralized rural electrification are either through diesel or renewable energy sources. Renewable energy has distinct advantages over diesel as it has much lower running costs, uses local energy sources, does not run out, is much cleaner and does not contribute to global warming.

Where centralized approaches have failed to reach the poorest communities, there is a need for a new approach based on small-scale sustainable energy options.

Decentralized energy options can:

- make efficient use of local energy resources e.g. hydro, solar, biomass, wind.
- can avoid the negative environmental and social impacts of large-scale projects, and remove dependency on costly supplies of fossil fuels or grid power
- make use of and develop indigenous manufacturing and technical capability
- harness the energies and resources of the community
- be controlled by local communities and their organizations, enabling them to identify their own needs.

Although Agenda 21 has no specific energy Chapter, energy issues are raised throughout the document, in the context of topics such as protection of the atmosphere, consumption patterns, environment, sustainable agriculture and rural development.

Many countries are moving toward renewable energy in rural areas. At national level, some financial schemes are finding their way into national and international policies and strategies, in response to declining government intervention and the reduction of subsidies, cost-reflecting pricing of energy carriers. New neoliberal ´policies liberalized energy markets, energy services leasing systems and cooperative arrangements, not always benefit the rural poor. In almost all the cases, the increase of prices severely affects the already poor services. Privatisation not always produces efficient services.

At the international level, the ratification by 159 countries of the Framework Convention on Climate Change creates opportunities for new energy programmes leading to higher levels of sustainability. Nevertheless, International financing through the Global Environment Fund and others, directed specifically to a net reduction of greenhouse gas emissions, has to increase substantially to really pursue the goal of sustainability.

ENERGY DEVELOPMENTS AND INSTITUTIONS

FAO's energy activities emphasize the need to develop and promote technologies and strategies for the utilization of renewable sources of energy adapted to the socio-economic needs of rural populations.

FAO's technical assistance activities recognize that agriculture, forestry and fisheries have a double role and potential as energy consumers and as energy producers in the form of renewable bioenergy. An integrated approach for the assessment, planning and implementation of energy and sustainable rural development is taken in its technical assistance activities.

All steps in the food chain require energy and a systematic approach is taken to its "energization". Renewable energy applications, such as photovoltaic systems, are promoted specially in relation to enhanced agricultural productivity and other income generation activities. Networking is promoted, such as the Latin American and Caribbean Working Group on Rural Energization for Sustainable Development, the Regional Wood Energy Development Programme in Asia or the Sustainable Rural Environment and Energy Network for the Whole European Region.

ENERGY SYSTEMS AND APPROACHES

Special emphasis is placed on bioenergy that plays a key role in the present energy scenario in rural areas and has a high potential as a modern energy carrier. Wood energy data and projections are a major component of FAO's energy activities. FAO has gathered information on the dynamics of woodfuel flows and has been providing multi-disciplinary approaches and technical expertise in the field of bioenergy.

Attention is placed to the energy function of the sugar industry, as one of the diversification strategies of that sector and to the production of low cost transport fuels to contribute to urban food security.

FAO has also promoted awareness and better use of work animal technology. It has also implemented field projects aimed at: a) increasing the supply of biofuel (through multipurpose tree plantations and sorghum species, agroforestry FAO schemes, community forestry, utilization of agricultural residues); b) reduce the woodfuel consumption and increase energy efficiency (improved stoves and charcoal making techniques); c) promote renewable energy applications (to enhance agricultural productivity and for rural services such as electricity); d) improve market and trade mechanisms; e) foster gender equality; f) address health problems and g) promote bioenergy for combined heat and power.

It has conducted activities on energy planning and training at the, regional and national levels such as the Regional Wood-Energy Development Programme for Asia, the assessment of the future energy requirements of agriculture in African countries and the organization of energy planning and training at the, regional and national levels such as the Regional Wood-Energy Development Programme for Asia, the assessment of the future energy requirements of agriculture in African countries and the organization of energy planning and training at the, regional and national levels such as the Regional Wood-Energy Development Programme for Asia, the assessment of the future energy requirements of agriculture in African countries and the organization of National Consultative Meetings on Energy for Rural Development.

A significant number of projects have been implemented in fields such as wood energy, bioenergy, biogas, and solar drying, illumination and water lifting. Agricultural engineering solutions to promote fuel saving cropping systems (conservation tillage, zero tillage), human and work animal energy, efficient energy and water use in irrigation, and energy efficient fishing vessels are other areas of attention. In the crop specific area, technology transfer of new drought and saline tolerant sweet sorghums for alcohol production are pursued.

The particular characteristics of the energy and environment linkages in rural areas are assessed; animal and agro and agro-industrial residues, their valorisation and the protection of local environmental quality are also topics of attention and network support. Outstanding challenges are the development and implementation of rural energy policies and programmes with concerted action of all interested parties: farmers, local and national governments, the private, finance and d international institutions. Remaining an urgent and critical matter is the physical and economic accessibility to sustainable forms of energy by the poorest rural and peri-urban populations for income generation and subsistence activities.

CONCLUSIONS

STRATEGIES FOR SUSTAINABLE DEVELOPMENT

Strategies for sustainable development through planned energy inputs must rely on a convergence between national development policies and goals and locally perceived and identified priorities. Critical issues concern:

General framework

- Energy must be seen as an integral part of overall developmental goals and other sectoral development plans and strategies
- Policies should correct the "energy deficit" in rural areas, where consumption is below subsistence level and barely cover cooking, heating and illumination needs
- The food security/energy nexus must be assessed to identify the best technological and economic strategies for meeting energy needs in food production. Sustainability will depend on integration of food security and energy policies.
- Specific policies and programmes should be targeted to rural women, children and other groups responsible for collection and use of energy, mainly fuelwood

Access to Technology

- Although rural areas have the right to use all energy sources, policies should facilitate the transition to renewable resources, such as bioenergy, solar and wind energy - they are reliable, locally available, adaptable to small and medium scale energy requirements, and environmentally friendly
- Upgrading the efficient use of biomass energy resources - including agricultural residues and energy plantations - offers job opportunities, environmental benefits and enhanced rural infrastructure
- New energy programmes for sustainable rural development should be based on sound planning and preparation of human and technical resources.

Institutionalised Support

- The potential benefits of privatization should not overcome the important role that the government intervention should have in establishing priorities and adopting policies that can benefit the rural poor. Government action is still needed to redistribution of resources, create relevant legislation, regulations, overall policy guidance
- Rural energy usually has to be supported by institutional backing. All concerned sectors - technical ministries, NGOs, public and private industry and financial institutions - should be mobilized around a common policy framework and strategy
- National energy plans should converge with locally defined priorities - local farmers' and women's organizations and local authorities should participate fully in identifying, developing and implementing rural energy plans and programmes

Sources for Financement.

- There is a major problem concerning reductions of government support for the rural energy transition.
- Small scale investment is also needed for renewable energy schemes in rural areas - this calls for innovative approaches such as microfinancing, cooperative systems, end-service payment, equipment leasing and flexible loans
- Governments could not remove to conventional energy sources - benefiting the poorest sectors. Additionally new subsidies should be introduced to develop non-conventional energy sources.

This paper has look at the basic nexus among poverty, food security and bioenergy in the developing world. The paper calls for comprehensive and well-articulated framework to identify obstacles goals, strategies, policies and programmes that can help to reduce poverty using the energy sector as a focal point. The paper has assesses briefly the link between food security and bioenergy and its impact on poverty and called for specific strategies to be employed targeting the energy transition from the actual consumption model to a more sustainable and developed one.

Annex I

Gender disparities

• Women's participation in the labor force has risen by only four % points, from 36% to 40%, despite a 60-70% increase in female adult literacy and school enrolment between 1970 and 1990.

• Women have access to a disproportionately small share of credit from formal banking institutions. In Latin America and the Caribbean, women constitute only 7-11% of the beneficiaries of credit programmes; in Africa only about 10% of small-scale credit is accessed by women.

• Women in general receive much lower average wages than men. In part this is because many women work in the informal sector or in inherently low-paying jobs, but also because women are often paid less than men for equal work. The average female wage is only three-fourths of the male wage in the non-agricultural sector.

• In developing countries, women still constitute less than a seventh of administrative and managerial positions. Globally, women occupy only 10% of all parliamentary seats and only 6% of cabinet positions. In 55 countries, there are either no women in parliament or fewer than 5%.

• Throughout the world women face unequal treatment under the law, and often face violence and abuse as both girls and women.

Source: Energy after Rio. Prospects and Challenges. Chapter 2. Energy and Major Global Issues. 1997.

Annex II

1. The US and the other industrialised countries are the world's major food importers, importing 71% of the total value of food items in world trade (Handbook of International Trade and Development Statistics 1994 (New York and Geneva: United Nations Conference on Trade and Development, 1995), table 3.2).
2. The US imports about $1.5 billion worth of beef a year (Food and Agriculture Organisation, FAO Trade Yearbook 1995, vol. 49 (Rome: FAO, 1996), 160, table 12).
3. The US imports 54% more in farm commodities than it exports (FAO Trade Yearbook 1995, table 6), much of it from countries where the majority lack a healthy diet. The US is in fact the biggest food importer the world has ever seen.

Sources: The Myth of Scarcity
http://www.foodfirst.org/pubs/backgrdrs/1998/w98v5n1.html
12 Myths About Hunger
http://www.foodfirst.org/pubs/backgrdrs/1998/s98v5n3.html

From Food or Fuel, 2002

Annex III US exports.

- For every one-ton of US corn exported in 1996 to one of the 25 countries with the world's most serious malnutrition problems (Category 5 countries, with at least 35 percent of the population undernourished), 260 tons were exported to a wealthy Organization for Economic Cooperation and Development (OECD) country.
- 20 percent of the total US corn crop is exported; two-thirds of these exports go directly to the 28 industrial OECD countries, where it is mostly used for feeding animals.
- 76 percent of the corn used in the US is used for animal feed.
- Less than three-tenths of one percent of total US corn exports went to the poor Category 5 countries in 1996.
- Less than three percent of total US corn exports in 1996 went to the 24 Category 4 countries (where undernourishment affects at least 20 percent of the population).
- More US corn goes to make alcoholic beverages in the US than is exported to feed the hungry in the world's 25 most undernourished countries combined.
- About one-third of the total US soybean crop is exported; 70 percent of US soybean exports went to 28 industrial OECD countries in 1996.
- No soybeans were exported to Category 5 countries in 1996, while 17.8 million metric tons went to OECD countries.
- In 1998, a year of record-low soybean prices, the 25 most undernourished countries received less than 0.027 percent of total US soybean exports.

Sources: “Feeding the World?"
http://www.iatp.org/foodsec/library/admin/uploadedfiles/
Feeding_the_World_The_Upper_Mississippi_River_.htm

"The U.S. Department of Agriculture estimates that more than a billion bushels of corn went unused last year [2000]." -- University of Wisconsin
http://www.news.wisc.edu/view.html?get=6810
from Food or Fuel, 2002

Annex IV Cars figures

- 70 million motor vehicles were on the world's roads in 1950.
- 630 million motor vehicles were on the world's roads in 1994.
- 1 billion motor vehicles are expected to be on the world's roads by 2025, if the current growth rate continues.
- 50 million new cars roll off the assembly line each year -- 137,000 a day.
- 27 tons of waste are produced in the manufacture of the average new car.
- 11 million cars are junked annually in the US.
- The average car emits 12,000 pounds of carbon dioxide each year.
- Underinflated tires can waste 5% of a car's fuel.
- 2 billion gallons of gasoline could be saved annually if 65 million car owners kept their tires properly inflated.
- 85% of auto fuel is consumed just to overcome inertia and start the wheels turning.
- SUVs (Sports Utility Vehicles) and light trucks generate 2.5 times more emissions than the standard cars.
- 33,000 natural gas vehicles were in use in the US in 1993.
- 75,000 natural gas vehicles were in use in the US in 1998.
-

By Josh Sevin

Sources: World Resources Institute; Environmental Working Group; 50 Simple Things You Can Do to Save the Earth; Amicus Journal; L.A. Times; U.S. Department of Transportation; Earth Communications Office; Amicus Journal; Wall Street Journal,
From Food or Fuel, 2002

Annex V

The World Declaration on Nutrition produced by the FAO and World Health Organization (WHO) International Conference on Nutrition (ICN) held in Rome in December 1992 reviewed the current nutrition situation in the world and set the stage for markedly reducing these unacceptable conditions of humankind. Reaching the ICN goal is possible. Most of the work will need to be done in the developing countries by their own people. However, cooperative work across nations and across disciplines is also essential.

The ICN declaration goes on to state:

1. ... We recognize that globally there is enough food for all and that inequitable access is the main problem. Bearing in mind the right to an adequate standard of living, including food, contained in the Universal Declaration of Human Rights, we pledge to act in solidarity to ensure that freedom from hunger becomes a reality. We also declare our firm commitment to work together to ensure sustained nutritional well-being for al] people in a peaceful, just and environmentally safe world

2. Despite appreciable worldwide improvements in life expectancy, adult literacy and nutritional status, we all view with the deepest concern the unacceptable fact that about 780 million people in developing countries - 20 percent of their combined population - still do not have access to enough food to meet their basic daily needs for nutritional well-being.

3. We are especially distressed by the high prevalence and increasing numbers of malnourished children under five years of age in parts of Africa, Asia and Latin America and the Caribbean. Moreover, more than 2 000 million people, mostly women and children, are deficient in one or more micronutrients; babies continue to be born mentally retarded as a result of iodine deficiency; children go blind and die of vitamin A deficiency; and enormous numbers of women and children are adversely affected by iron deficiency. Hundreds of millions of people also suffer from communicable and non-communicable diseases caused by contaminated food and water. At the same time, chronic non-communicable diseases related to excessive or unbalanced dietary intakes often lead to premature deaths in both developed and developing countries.

Sources: UN. The World Declaration on Nutrition. International Conference on Nutrition (ICN). 1992,

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WORKING GROUP 4: BIOMASS RESOURCES

International Seminar on Bioenergy and Sustainable Rural Development
- 5th LAMNET Project Workshop – Mexico 2003

INTEGRATED RENEWABLE ENERGY FARMS FOR SUSTAINABLE DEVELOPMENT IN RURAL COMMUNITIES

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ABSTRACT

Current approaches to energy are unsustainable and non renewable. Furthermore energy is directly related to the most critical social issues which affect sustainable development: poverty, jobs, income levels, access to social services, gender disparity, population growth, agricultural production, climate change and environment quality and economic and security issues. Without adequate attention to the critical importance of energy to all these aspects, the global and regional social, economical and environmental goals of sustainability can not be achieved.. More than 2 billions people have no access to modern energy sources, most of them are living in rural areas. Food and fodder availability, is very closely related to energy availability.

In order to meet challenges, the FAO, of the United Nations, in support of the Sustainable Rural Environment and Energy Network (SREN) has developed the concept for the optimisation, evaluation, and implementation of integrated renewable energy farms (IREF) for food and water supply as well as for development rural communities.

An Integrated Renewable Energy Farming system based largely on renewable energy sources (solar, wind, biomass, hydro) and seeks to optimise energetic autonomy and ecologically semi-closed system while also providing socio-economic viability and giving due consideration to the newest concept of landscape and bio-diversity management. Ideally, it will promote the integration of different renewable energies, promote rural development and contribute to the reduction of greenhouse gas emission.

The implementation of IREF has been started in the year 200 and this contribution is aimed to discuss the latest achievements and the possibilities of their introduction in different climatic zones for water and food supply as well as energy supply for light, cooking, powering of machines, cars, sanitation and other needs. This will insure employment, education, training, mobility and development, for both developed an developing countries.

WORKING GROUP 4: BIOMASS RESOURCES

International Seminar on Bioenergy and Sustainable Rural Development
- 5th LAMNET Project Workshop – Mexico 2003

BIOMASS RESOURCES OF MEXICO AND THE ELECTRICAL RESEARCH INSTITUTE (IIE) ACTIVITIES ON THIS TOPIC

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ABSTRACT

This article describes the research and development work on biomass to energy conversion performed in the Electrical Research Institute (IIE) with the focus on conversion technologies, biomass resources, and biomass supply in Mexico. The objective of IIE activities is to propose studies and projects that really influence in the national energetic context. Thereby, IIE has great experience and puts great effort in research and development on biomass to energy conversion by developing processes, systems and methodologies focusing on ecological benefits and sustainable development. There are great biomass resources in our country, equivalent to 45% of end energy consumption of the year 2000. In agreement with the energy potential quantified with a methodology developed in the IIE, the following biomass resources can play an important role in Mexico's future energy supply: animal Wastes, Agricultural Wastes, Wood, Bagasse, Forestry Wastes, Waste Waters and Municipal Solid Waste. To identify with more precision their importance, a detailed analysis to consider factors such as technologies, resources and biomass supply has to be performed, which should be supported by national biomass energy conversion programs and linked with ecological protection and sustainable development initiatives.

OBJECTIVE

To show and analyze the research and development work performed on biomass utilization and conversion to energy in the Electrical Research Institute (IIE). This work has the objective to propose studies and projects with high relevance in the national energy context including its impact on environment protection.

INTRODUCTION

Today, the energy contribution (3.6%) of biomass in Mexico is accounted for solely by Wood and sugarcane Bagasse, without considering other important biomass resources such as forestry wastes, wastewaters, municipal solid waste, animal and agricultural wastes. In a recent study made in the IIE, it was found that the energy potential of biomass in our country, is equivalent to 442.1 peta calories or to 45% of the end energy consumption, taken as a reference the National Energy Balance of the year 2000.

There are two important factors, that determine the biomass viability to employ it as a fuel, one is the biomass to energy conversion technologies, and the other is biomass resources inventories.

CONVERSION TECHNOLOGIES

There are basically two types of biomass to energy conversion processes, the thermo-chemical process and the microbiological process. The first one is represented by conventional combustion, pyrolysis, gasification and liquefaction, producing gaseous, solid and liquid fuels, which can be converted to energy by conventional technologies. The second type refers to alcoholic fermentation and anaerobic digestion. By means of the action of microorganisms these processes produce ethanol and biogas. Alcoholic fermentation was used to produce spirit beverages for a very long time, and anaerobic digestion, also called anaerobic fermentation, takes place naturally as part of organic matter decomposition contained in municipal wastes, animal and agricultural wastes and municipal solid wastes.

BIOMASS RESOURCES

Biomass resources can be of two types, natural and artificial. The first one generally refers to wastes, and the second type to materials exclusively generated for the conversion to fuels and later to energy.

The potential biomass resources in Mexico are of a wide variety, and in the same manner information resources are of a wide variety. This implies large efforts to compile information and involve government offices that are concerned with this information such as the National Institute of Geographic and Data (INEGI).

Table 1. Parameters required for the evaluation of the biomass power potential in Mexico.

Source	*1*	*2*	*3*	*4*	*5*
Wood	No of Inhabitants	Fracción de habitantes que usan leña	Consumo per cáp-año	Poder calorífico de la leña	
Bagasse	Superficie de caña de azúcar cosechada (Ha/año)	Rendimiento de cosecha (Ton/Ha)	Fracción de bagazo en caña	Poder calorífico del bagazo	
Forestry Wastes	Producción anual de madera	Producción de residuos de aserradero	Poder calorífico de los residuos		
Agricultural Wates	Superficies cosechadas (maíz...)	Producción de residuos por Ha cosechada	Poder calorífico de los residuos		
Animal Wastes	No de cabezas de bovinos...	Producción de residuos por especie	Producción de biogás por unidad de residuo	Poder calorífico de biogás	
Municipal Solid Waste	No habitantes	Tasa de generación de residuos	Fracción de residuos en Rellenos	Producción de biogás por unidad de residuo	Poder calorífico de biogás
Waste Waters	No habitantes	Tasa de generación de DBO en aguas per cápita	Producción de biogás por unidad de DBO	Fracción de agua tratada anaeróbicamente	Poder calorífico del biogás

For energetic potential evaluation of biomass, IIE has developed a methodology based on the knowledge and definition of 24 basic parameters. Through an adequate analysis of these parameters (summarized in table 1), it was possible to elaborate a methodology for the quantification of potential biomass energy resources.

In table 2 the theoretical contribution from the most important biomass resources determined by the IIE methodology is summarized. These results emphasize the importance of biomass as an energy resource in Mexico, today contributing with 3.6% to the total energy supply. Therefore, good opportunities exist to propose well supported projects in order to realise major biomass contributions to the Energy National Inventory.

Table 2. Energy Potential of Biomass in Mexico.

Biomass Resource	*Biomass Energy Content Petacal/year*
Wood	58.7
Bagasse	16.7
Forestry Wastes	1.4
Agricultural Wates	144.6
Animal Wastes	219.7
Municipal Solid Waste	0.02
Waste Water	1.0
Totals	442.1

Note: 1 petacal = 10^{15} cal

BIOMASS RESOURCES AVAILABILITY

Biomass resources for energy conversion are in competition with other traditional uses:

Wood is used mainly for food preparation and cooking, home and water heating, and lighting. This competing use is prevalent in rural areas, 25 million mexicans consume 17 million tonnes of wood per year.

Sugar cane bagasse is generated in 63 sugar cane factories located in 15 states in the national territory, with an average sugar production of 4,668,500 tonnes (1996-1997). Sugar cane bagasse content is between 24 to 30% in weigh. Bagasse is also used by paper companies in our country making it impossible to convert all the bagasse to energy .

Forestry Wastes*.* In agreement with the National Institute of Geography and Data (INEGI), there are 63.7 million ha tropical and conifer forest in Mexico, 80 % of which is communal and social property, 15% private property and 5% federal property. 54% of this land corresponds to cool and temperate weather forest, and 46% to warm weather tropical forest. In 1995, 85% of the wood production was carried out in five states. The wood industry used 75% of national wood production, paper industry used 19%, and 6% of wood production was used for fuel and railroad construction.

Agricultural Wastes. Crop production in Mexico on 14 million ha produces more than 31 million tonnes of crop products. Agricultural wastes with energy potential considered in this article are: rice, coffee, cereal straws and leguminosas like barley, wheat, rice, oats, lentil, peanut, rye, cotton, and maize. Many of this crop wastes are used as forage and animal food. Traditional practices make their collection, handling, and use as fuel for energy production difficult.

Animal Wastes. 107.8 million hectares are used for animal production in Mexico. Bovine production uses 84 million hectares for pasture. In 1995, 3,685,000 tones of meat, 1,412,000 tones of bovines, 1,283,000 tones of chicken meat and 922,000 tones of pig meat have been produced. Meat from lambs and similar species amounts to 1.8% of the total national meat production. 90% of the national chicken meat production takes place at 1,500 farms with an average capacity production of 60 thousend/cycle, whereas 10% takes place in 5,000 farms with an average capacity of 25 thousands of chickens/cycle. The production of pig meat concentrates in the states of Jalisco, Sonora, Guanajuato, Yucatan, Puebla and Michoacan, comprising 71% of the national total. Pig production is performed with three different production processes: technified (30%); semitechnified (30%), and family or backhouse production (40%). Today, there are about 50 thousand specialised facilities engaged in pig production activities and 400 thousand family operations.

Municipal Solid Waste (MSW). The national generation of wastes in 1997 was considered to be 82,680 tons daily. Only 35% (28.900 tons per day) are deposited at controlled sites, whereas the rest (53.700 ton/d) is taken to open dumps, noncontrolled or clandestine. In all the country 22 landfills operate satisfactorily; the other sites do not fulfill the minimum norms. MSW can be taken advantage of for the generation of energy by means of two processes, by combustion and recovery of biogas. The incineration processes are expensive and the organic matter content and the waste moisture make their use difficult.

The production of biogas seems to be the most viable option, but until now no municipality has taken advantage of biogas as power plant fuel.

Waste Waters. In agreement with the national Hydro-Program (1995-2000), annually 7,3 km3 of municipal waters (231 m3/seg) are generated, of which the public sewage system only collects 5,5 km3 (174 m3/seg). This means that of 1,8 million tons of organic matteronly 0,15 million tons are treated suitably.

IIE BIOMASS PROJECTS

Biomass to energy conversion projects started in the second half of the seventies with the IIE operation, focusing on biogas generation from cattle dung in anaerobic digesters, as a part of the Integrated Energy Systems Project for Mexican Rural Application.

Early in the eighties, IIE performed an evaluation of wood consumption as a fuel in the Mexican rural areas.

During 28 years, IIE has carried out successfully development projects, such as processes, systems and methodologies for biogas production from biomass by anaerobic digestion, with applications in the rural, municipal and industrial context, as:

- Family Digesters.
- Small Farm Digesters.
- Anaerobic Treatment of Market Waste.

- Acidogenic/Methanogenic Anaerobic Treatment of Waste Water From Citric acid Industry.
- Anaerobic/Aerobic/Anoxic Treatment of Municipal Waste Waters.
- Laboratory Methanogenic Assays of Municipal Solid Waste Samples in Landfills.
- Feasibility Studies of Electricity Generation in Sanitary Landfills and Open Dumps.
- National Inventory of Methane Emissions from Wastes as a Green House Gas.
- Projects of Electricity Generation from Biogas Production in Sanitary Landfills.

Some important results of these projects are:

- Anaerobic digester prototypes for rural and small scale farms waste treatment, including contamination control and self supply energy generation for farms
- Development of Anaerobic/Aerobic municipal wastewater treatment process, with 50 – 60% less energy consumption and with the same magnitude of sludge waste reduction.
- Development and laboratory tests of Acidogenoc/Methanogeic Fluidized Bed Anaerobic Treatment of Citric Acid Industry Wastewater. This treatment reduces the organic contamination of this wastewater by over 95%, and leads to the additional benefit of a biogas generation with a very high methane content.

In the nineties, IIE started to work in projects on electricity generation from biogas produced in landfills. In 1991, a Feasibility Study for Electricity Generation With Biogas Produced in Mexico City Landfills was performed.

To cappy out these projects, it was necessary to develop methodologies and laboratory methanogenic test with municipal solid waste deposited and sampled in the landfills. In the same way, the Potential Energy Landfills Evaluation Methodology was developed to predict biogas and energy production of landfills, including an economic and financial analysis.

In 1991, IIE put in operation a biogas pilot plant installed in Mexico City Santa Cruz Meyehualco landfill, in cooperation with the Federal Electricity Commission, Light and Power Company and the Mexico City Government. In 1995 a study was performed titled Biogas Emissions Evaluation and Characterization of Electric Power of the Prados de la Montaña Landfill, as a response to the National Commission of Energy and a petition of the Mexico City Government.

In the last three years, following a opetition of the Mexican Energy Minister, the IIE carried out the project ‘Demonstration Plant of Electricity Generation With Biogas Produced in a Sanitary Landfill’. The objective project was to look for the main barriers against the development and implementation of this technology in our country. One of the main goals of the project was the realization of the *First International Colloquium on Landfill Gas Conversion to Electricity in Mexico* in October of year 2002 in Aguascalientes City.

The results of this project indicating existing barriers can be summarized as follows:

- Short and limited time administration of municipal authorities.
- The law in this matter, enclosed these projects in the Energy Self Supply Scheme. This implies that private investors and municipal authorities form a complicated association by 15 to 20 years partnership.
- Lack of financing to carry out feasibility field assessment studies.
- Resistance to the projects by landfill operator companies.
- Slow processing of generation permissions, interconnection contracts and expensive electricity transportation.
- Lack of real incentives for environmental protection for private investors, and lack of legal rules for Carbon Bonds negotiation.
- Private investors uncertainty, lack of guarantees.
- Lack of investors incentives, innovation funds, etc.
- Little interest of first level government authorities to promote this projects.
- Lack of information on waste landfills and open dumps.

A result of the *First International Colloquium on Landfill Gas Conversion to Electricity in Mexico* was to stimulate the interest of some municipal authorities to apply this technology in their cities, giving a good future of these projects for the conversion of biomass to energy, with the additional benefit of methane emissions mitigation.

CONCLUSIONS.

- IIE has made concerted efforts in the field of the investigation and development of biomass, developed processes, systems and methodologies for power conversion and investigated their impact on the environment and on sustainable development.
- There are a lot of biomass sources available in Mexico (mainly wastes) with the potential to cover 45% of the total energy consumption (2000).
- Being an oil producing country, the potential of biomass has been purposely underestimated in Mexico.
- No long term National Program for biomass use as an energy source exists in Mexico.
- Advantages of biomass comprise energy supplies as well as socio-economic, political, economic and ecological aspects, such as the conservation and rational operation of the forests, control of greenhouse gas emissions, civil security, deforestation, etc.
- According to the methodology developed by IIE the following biomass resources can play a significant role in Mexico: Cattle or animal wastes, Agricultural wastes, Wood, sugar cane Bagasse, Waste Waters and Urban Solid Wastes.

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WORKING GROUP 4: BIOMASS RESOURCES

International Seminar on Bioenergy and Sustainable Rural Development
- 5th LAMNET Project Workshop – Mexico 2003

ENVIRONMENTAL AND SOCIO-ECONOMIC IMPACTS OF CHARCOAL PRODUCTION IN KENYA

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ABSTRACT

Every day, nearly seven thousand tons of charcoal is used in households and small commercial enterprises in Kenya. This charcoal is produced from roughly 80,000 m^3 of wood, which is harvested primarily from arid and semi-arid lands (ASAL) that constitute over two thirds of Kenya's land mass. Charcoal production and consumption on this scale has far-reaching environmental and socio-economic implications. However, not all of the impacts associated with charcoal are negative. While many people posit that the charcoal trade harmful to the environment because of the impacts that charcoal production can have on woodlands as well as the emissions that are associated with wood pyrolysis, there are also benefits associated with charcoal in the form of rural employment and reduced levels of indoor air pollution relative to fuel wood, the primary source of residential energy for rural Kenyans. In addition, charcoal can be produced from trees harvested on a sustainable basis or made from carbonized biomass waste products, which occur in abundance in many less developed countries. Focusing only on charcoal's negative attributes can lead to incoherent policies that are doomed to fail. This is evident in Kenya, where charcoal production and transportation is illegal, despite the daily deliveries of thousands of tons of charcoal to Nairobi and other cities and towns.

Charcoal's illegal status leads directly to corruption and bribes that producers and suppliers must pay to local officials and police in order to get their product to market; these costs are passed onto consumers. It also leaves the government out of the revenue steam because it does not impose stumpage fees or taxes at any point of the supply chain. Finally, despite current attitudes and practices, charcoal production is not inherently environmentally destructive – arid woodlands are resilient ecosystems that can support repeated harvests with proper management practices. The competing costs and benefits of different woodland management regimes, different methods of charcoal production, and improved stoves for end-use require careful analysis in order to create policies that best serve charcoal producers and users as well as the environment on which they depend. In this paper, I will review some of the current research on a range of issues associated with charcoal in Kenya. I will discuss the public health and social welfare issues associated with the charcoal life cycle. I will also examine the environmental impacts of charcoal and present an analysis of greenhouse gas (GHG) emissions associated with charcoal production and use.

BACKGROUND

Charcoal production - Charcoal is a wood product that is made by heating wood in the absence of sufficient air for full combustion to occur. Heating releases the wood's volatile compounds, leaving behind a relatively lightweight and clean-burning fuel that is 70-90% carbon. Charcoal can be produced by a range of methods, from simple earth kilns to brick or metal kilns and retorts that capture condensable volatile compounds or combust them as gases, using the heat generated to drive the charcoal-making process (FAO, 1987). In an earth-mound kiln, the most common method of making charcoal in sub-Saharan Africa, between five and ten tons of wood are needed to make 1 ton of charcoal: a mass-based conversion efficiency of 10-20%. In these circumstances, between 60-80% of the wood's energy is lost in the production process. The efficiency of the process depends on a number of variables: scale of production (production can range from less than a hundred kilos to tens of tons), moisture content and size of the wood, and time taken for the burn (which also depends on the scale of production, ranging from 2-10 days). The skill and techniques of the producers also affects the process, however this is harder to quantify and is difficult to separate from environmental and economic conditions.

Using special kilns or retorts can reduce energy losses to only 30 or 40%. However, this equipment is expensive relative to traditional methods. It is not likely to be widely adopted in developing countries without additional incentives, particularly in regions where wood is accessible for little or no financial cost, as is the case in Kenya's unregulated charcoal industry.

Charcoal consumption - Charcoal is the principal woodfuel in urban areas of many less developed countries. There are a number of reasons why people in dense urban settlements favor charcoal over wood: it has a higher energy density, it burns more cleanly (which reduces exposure to harmful pollutants), and it is easier to transport, handle, and store. Charcoal can be purchased in small amounts and charcoal-burning stoves are quite inexpensive, making it more attractive than LPG or electricity. In addition, many people favor charcoal because it is considered a more modern fuel than wood, and is thus a kind of status symbol. In Kenya, all of these factors play a role. In addition, there is growing evidence that charcoal, commonly considered an urban source of residential energy, is becoming an increasingly popular fuel among the rural population (Kituyi, Marufu et al., 2001a; Ministry of Energy, 2002). This will be discussed in detail below.

Charcoal in Kenya - Recent studies estimate that Kenyans produce and consume between 2.4 and 2.9 million tons of charcoal annually (Kituyi, Marufu et al., 2001b; Ministry of Energy, 2002). There is very little trade in charcoal, thus production and consumption are balanced. Kenya's level of consumption is one of the highest in the world.
Table **1** shows consumption data in the ten largest charcoal-using countries in the world listed in order of net consumption. Six of the top ten charcoal producing countries are in sub-Saharan Africa. Kenya ranks fourth in consumption behind Brazil, Nigeria and Ethiopia and it ranks second in consumption per capita after Zambia.[10]

[10] **Brazil, which leads the world in charcoal consumption, stands well apart from most other charcoal producing nations because, unlike countries in sub-Saharan Africa, charcoal is used as a major industrial input. While other countries listed in**
Table 1 rely heavily on charcoal as a residential fuel, charcoal contributes little to household energy needs in Brazil (see census data in Government of Brazil, 1991).

Table 1: Charcoal consumption statistics from the world's top-10 charcoal consumers (all data are for 2000)[a]

Country	Charcoal consumption (tons)	Population	Fraction of world consumption	Consumption per capita (kg per person)[b]
1. Brazil	12,063,000	170,100,000	31%	71
2. Nigeria	3,057,000	126,910,000	8%	24
3. Ethiopia	2,907,000	64,298,000	7%	45
4. Kenya	2,475,000	30,092,000	6%	82
5. India	1,654,000	1,015,923,000	4%	2
6. D. R. Congo	1,418,000	10,273,300	4%	28
7. Thailand	1,222,000	60,728,000	3%	20
8. Egypt	1,196,000	63,976,000	3%	19
9. Tanzania	1,165,000	33,696,000	3%	35
10. Zambia	1,040,000	10,089,000	3%	103
World total	*40,615,004*	6,054,117,000	*100%*	7

[a] Population data are from the World Bank’s development database (http://devdata.worldbank.org/dataonline/). Charcoal data are from the UN Food and Agriculture Organization’s (FAO) on-line statistical database (http://apps.fao.org/page/collections? subset=forestry) with the exception of Kenya. The FAO reports annual Production, Imports, and Exports, but not Consumption. The latter was calculated by assuming Consumption = Production + Imports – Exports (neglecting the possibility of stockpiling). Data for Kenya are taken from (Ministry of Energy, 2002). The FAO report Kenya’s charcoal consumption for the year 2000 to be only 640,500 tons, however the recent national survey, based on household level observation estimates it to be roughly 2.4 million tons: nearly 300% higher. Many other discrepancies exist in national-level charcoal data. See, for example, (FAO-WETT, 2002), which lists a range of charcoal data and sources for 22 African countries. As with Kenya, some of the FAO’s estimates differ by a factor of two or more with other sources of data.

[b] This indicates a national rate of consumption, rather than consumption among those people reporting use. Aggregate consumption figures like this can be misleading and are reported here simply for comparison across charcoal using countries. It is more important to quantify consumption among people reporting use, which will be discussed below.

Kenyan charcoal is produced by manual laborers who carbonize, on average, 80,000 m^3 of wood daily.[11] Production is scattered in thousands of locations, primarily in arid and semi-arid woodlands, which constitute over two thirds of Kenya’s total land area. Recent years have seen changes in the origin of charcoal supplied to urban demand centers. As discussed above, charcoal in Kenya is primarily a household fuel. Rural and urban households together accounted for over 80% of charcoal consumption 2000. Commercial, industrial, and institutional consumers account for the balance; this includes restaurants, businesses, small-scale industries like metal workers, and schools.

[11] This is based on an annual charcoal consumption of 2.4 million tons in the year 2000 (Ministry of Energy, 2002). Kituyi et al. assuming that wood to charcoal conversion efficiency is 12% (based on the mass of charcoal produced per unit of air-dried wood). With air-dried wood (20% moisture content), one ton of charcoal requires roughly eight tons (or 12 m^3) of wood. Pennise et al. (Pennise, Smith et al., 2001) found that large earth kilns in Kenya, with initial charges of 15-25 tons of wood, can operate at over 25% efficiency (wet basis) with well-dried wood (less than 20% moisture). At that efficiency, producing one ton of charcoal requires less than 4 tons of wood. However, efficiencies from earth kilns measured in the field are normally somewhat lower. Kituyi et al. (Kituyi, Marufu et al., 2001b) assume 17% mass-based conversion efficiency for wood at 30% moisture, or 6 tons of wood per ton of charcoal produced.

As a result of rapid urban population growth and changing patterns of rural consumption, in the past two decades charcoal use has increased at a rate that far exceeds general population growth. Unfortunately, data is not available to observe the pattern of growth in detail, only to mark two points in the past two decades. Household energy surveys at the national scale are infrequent. The first such survey was performed by the Beijer Institute in 1980 with funding from Dutch and Swedish development organizations (O'Keefe, Raskin et al., 1984; Hosier, 1985). A second survey was completed in 1997 (Kituyi, Marufu et al., 2001a; Kituyi, Marufu et al., 2001b) and a third was done more recently, in 2000, with the results released in late 2002 (Ministry of Energy, 2002). During the long gap between the initial survey and the more recent work, there were a number of village and/or community-scale surveys, but nothing at a scale that indicates how the trend of charcoal consumption evolved on a national level. Despite the absence of interim data, the surveys reveal some interesting trends in household energy demand.

Table 2: Changes in Kenyan Charcoal Consumption: 1980-2000[a]

	1980	2000	% Change (1980-2000)
National Population (Millions of people)	16.6	30.1	81%
Urban	2.7	10.0	276%
Rural	14.0	20.1	44%
Inflation adjusted GDP per capita (2000 USD)	237	231	-3%
% of URBAN households reporting charcoal use	82%	82%	0%
Average per capita consumption in URBAN households reporting use (kg/cap-yr)	175	152	-13%
% RURAL households reporting charcoal use	16%	34%	113%
Average per capita consumption in RURAL households reporting use (kg/cap-yr)	110	156	42%
Total URBAN charcoal consumption	0.4	0.9	135%
Total RURAL charcoal consumption	0.3	1.1	308%
Commercial/institutional charcoal consumption	0.1	0.4	315%
National Charcoal consumption (Million tons)	0.8	2.5	223%
Real cost of charcoal (2000 KSh/kg) [b]	6-8	8-11	33-38%
Real cost of kerosene (2000 KSh/l)[c]	38	33	-13%

[a] Data for 1980 come from the Beijer Institute study and 2000 data come from the MoE survey report (Hosier, 1985; Ministry of Energy, 2002). Socio-economic data come from the World Bank's development database (http://devdata.worldbank.org/dataonline/).

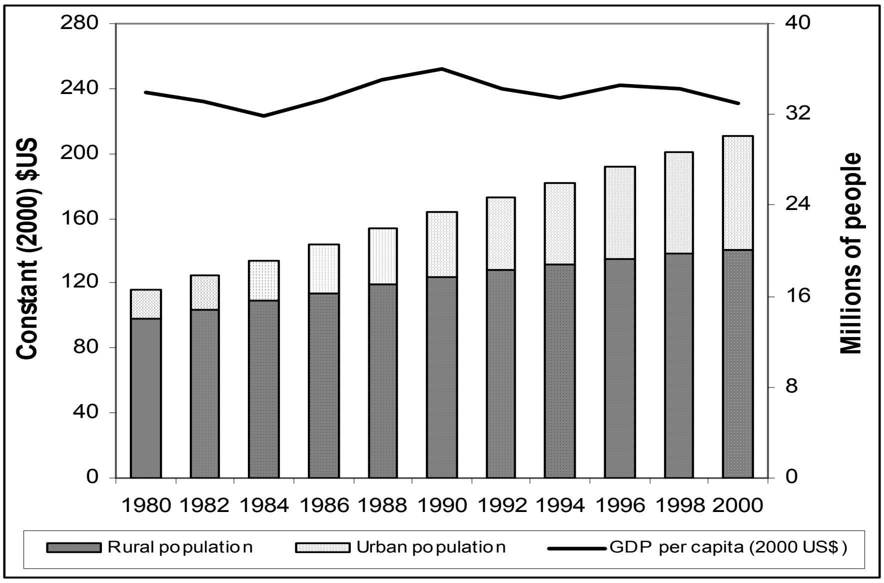
[b] Retail charcoal prices depend in the quantity purchased, which ranges from large sacks of 30-40 kg to small tins of 1-3 kg.

[c] This value represents the inflation adjusted average price at urban service stations. For peri-urban and rural consumers, who often buy kerosene in small quantities from retail shops, the price per liter is somewhat higher, while in remote areas the unit price may be as much as 300% higher than the price reported here.

Table 2 is based on the results of the 1980 Beijer Institute survey and the 2000 Kenyan Ministry of Energy (MoE) Survey.[12] It shows how the patterns of charcoal consumption has changed in the two decades between surveys. In addition, some key socioeconomic indicators are included as points of reference. In the twenty years between the two surveys, charcoal consumption increased by over 220% while the total population increased by only 81%. Charcoal is commonly considered an urban fuel, and it is possible that urban population growth can explain the increase in consumption. Kenya, like most countries in sub-Saharan Africa, has experienced very high rates of urban population growth. Figure 1 shows the country's population growth over the twenty years in question. It also shows per capita GDP in constant $US, indicating that little economic growth has occurred.

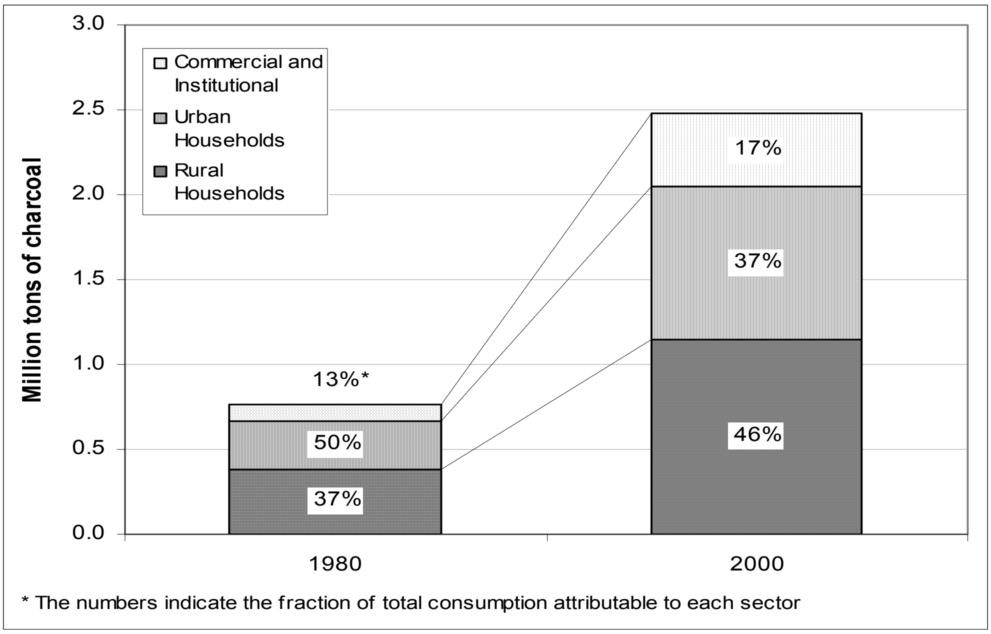
In 20 years, Kenya's urban population has increased 276%. At first glance, it would seem that the growth in urban population alone could explain the increase in charcoal consumption, however the results of the MoE survey tell a more interesting story. First, while the fraction of urban households using charcoal has remained the same (82% of households), the average consumption among urban charcoal users has actually decreased by 13%. This decrease is probably a reflection of two factors: the increasing use of alternate cooking fuels like LPG and electricity and the widespread dissemination of improved charcoal-saving stoves (see below). The survey also indicates that the fraction of rural households using charcoal has doubled since 1980. Moreover, the average level of charcoal consumption among rural households has increased by over 40%, so that there is no difference between the average quantity of charcoal consumed by urban households and rural households. As a result of this growth in rural charcoal consumption, the rural sector is now a larger consumer of charcoal than the urban sector, consuming 46% of charcoal produced in Kenya in 2000. Figure 2 shows the growth of charcoal consumption within the three main sectors of charcoal consumers: urban households, rural households, and commercial and industrial consumers.

Figure 1: Kenya's urban and rural population and per capita GDP (1980-2000)



[12] The results of survey work by Kituyi et al. (Kituyi, Marufu et al., 2001a; Kituyi, Marufu et al., 2001b) show patterns of charcoal consumption that are similar to the MoE results with some important differences. However this analysis focuses on the MoE results because they are presented in a form that makes them directly comparable to the results of the original Beijer Institute Survey.

Figure 2: Kenya's charcoal consumption in urban and rural households and the commercial sector (1980-2000)



Thus, according to the latest survey from the MoE, between 1980 and 2000, annual charcoal consumption in Kenya increased from roughly 800,000 tons to nearly 2.5 million tons, *with over 50% of the increase attributable to increased consumption among rural households*. Roughly 30% of the increase is attributable to increased consumption in urban households, while the remaining increase is due to increased consumption among commercial, industrial and institutional users.

Disaggregating charcoal consumption in this way provides some important information about the nature of changing charcoal demand. However, in order to create more effective policies, additional information is needed regarding the cause of such changes. This is particularly important because of the socio-economic and environmental impacts associated with charcoal. Some of these issues have been used to justify Kenya's flawed policies, while others are ignored. A discussion of some of the more relevant issues follows.

SOCIO-ECONOMIC IMPACTS

Employment and revenue - Sources estimate that the charcoal industry in Kenya employs 40-50 thousand people and generates roughly US$ 300 million in annual revenues (Mugo, 1999; Kantai, 2002). The exchange of cash in this sector rivals the revenues generated by international tourism in Kenya, one of the highest priority industries in the country.[13] The illicit nature of charcoal has several socioeconomic impacts. First and perhaps most importantly, it makes it impossible to administer stumpage fees so that the cost of replacing the woodland resource is not internalized in the price of charcoal. Thus trees are removed with no regard to the environmental impact of their removal. This can lead to over-harvesting of trees and deforestation, which is discussed in more detail below. A second consequence is that the failure to legalize and regulate the industry leads to a loss of potential revenue that

[13] According the World Bank (World Bank, 2003), Kenya's international tourism receipts for 1999 were US$ 304 million in 1999.

the government could derive in the form of taxes and/or concessions for producers, transporters and sellers. With more logical policies in place, these revenues would help pay for the costs of regulation. In contrast to petroleum-based fuels and electricity, which the government taxes at a rate of 16-35%,[14] the government receives no revenue from charcoal consumption. Thirdly, the illicit nature of charcoal production leads to potentially exploitative working conditions for charcoal makers: the people who harvest and split trees, establish kilns, and burn the wood to make charcoal. Charcoal making tends to be an option of last resort for many people – particularly for charcoal made from arid and semi-arid woodlands, where 90% of Kenya's charcoal originates (Mugo, 1999). Charcoal making is considered a lowly occupation that few people with an alternate means of livelihood choose to pursue. The illegal status of charcoal production reinforces that sentiment, leaving producers no means to organize or create cooperative networks that would improve their working conditions and their bargaining power with transporters and wholesalers.

While no data exists on the exact level of employment within the charcoal industry, surveys estimate that between 40 and 50 thousand people rely on the charcoal trade for some part of their livelihood. The trade is split between producers, small and large transporters, wholesalers and retailers (Mugo, 1999). Research indicates that the largest share of revenue flows to producers, indicated in Table 3. However, this is misleading because producers outnumber other participants in the charcoal trade. Data is not available from Kenya to determine the number of participants at each point in the supply chain, however it is possible to draw lessons from research in Senegal (Ribot, 1998).

Table 3: Cost analyses from two studies of charcoal supplied to Nairobi

Cost break-down per bag	MoE study [a]		Mugo study [b]	
	KSh/bag	% of total price	KSh/bag	% of total price
Producer price	150	41%	100	25%
Transport costs	83	23%	129	32%
Wholesaler's cost (production + transport)	233	64%	229	57%
Wholesaler's selling price in Nairobi	300	82%	330	83%
Wholesaler's *margin*	67	18%	101	25%
Retailer's selling price (selling by the sack)	365	100%	400	100%
Retailer's *margin* (selling by the sack)	65	18%	70	18%

The MoE analysis assumes charcoal originated in Nyahururu, 180 km from Nairobi.
Mugo's analysis assumes the charcoal originates 200 km from Nairobi in an area that typically supplies charcoal to Nairobi.

14 The MoE survey reports that kerosene, as a "subsistence" commodity, has the most favorable tariff structure of petroleum-based products. It is taxed at 16%. In contrast, LPG is not VAT-exempt, and is taxed at a rate of 22%. Electricity has numerous taxes associated with it. These vary with the level of consumption, but hover between 30 and 35%.

In Senegal, roughly 35% of the revenue generated goes to charcoal makers, which is similar to the results of two studies shown here. Charcoal makers outnumber urban retailers by 4:1 and outnumber urban wholesalers by 39:1. Thus, the profits that charcoal makers derive is split among many people, making individual profits, on average, far smaller than profits earned by urban wholesalers. Small-scale retailers see a similar dilution of profits. While the proportions are unlikely to be exactly the same, this pattern is probably similar in Kenya.

Though the majority of Kenya's charcoal currently originates in state-owned ASAL regions, there have been successful efforts producing charcoal from private farms and plantations. One frequently cited example is the East African Tanning Extract Company (EATEC). This firm grew *Acacia Mearnsi* (Black Wattle) to extract tannin from its bark as an input in the leather curing process. With the exception of the bark, the entire tree is a by-product of tannin production. To supplement its income, the firm produced charcoal from the debarked trees. Though their feedstock was obtained at zero-cost, EATEC provides some lessons for the viability of private charcoal production. Using EATEC as a model, but accounting for wood feedstock purchased at market rates rather than obtained for free, the Kenyan MoE study found that private industry could produce charcoal for sale to wholesalers at the same price as charcoal produced on public lands indicated in Table 3 (100-150 KSh.30 kg sack). Furthermore, the charcoal is produced in large brick kilns so that worker safety is enhanced, efficiency is improved (30% by mass), and emissions could be controlled if desired. Each production run takes roughly two weeks and 36 person-days of labor, which indicates the job creation potential (Mugo, 1999; Ministry of Energy, 2002).

Charcoal and Public Health - Charcoal consumption is associated with both positive and negative health impacts. The emissions from cooking indoors with solid fuel: wood, charcoal, crop residues, dung and coal are a leading cause of death and illness worldwide.[15] The largest impact of solid fuel combustion arises from the emission of particulate matter (PM). High exposures to PM are associated with a number of ill health outcomes including acute respiratory infection (ARI), which is one of the leading causes of death in children under five worldwide. In addition to ARI, exposure to emissions from solid fuel combustion is associated with chronic obstructive pulmonary disease and some types of cancer[16] as well as increased incidence of asthma, tuberculosis, cataracts and elevated risk of carbon monoxide (CO) poisoning. The latter is particularly relevant for charcoal.

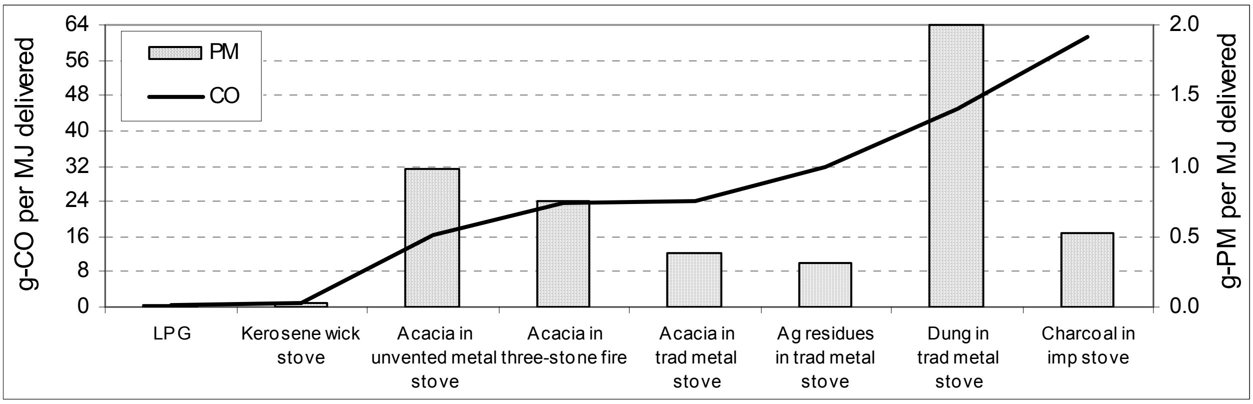
Pyrolysis removes most of the moisture and volatile compounds originally present in wood. Thus charcoal, on average, burns with fewer PM emissions than a comparable quantity of wood. However, it is still more polluting than most liquid or gaseous fuels. In addition, charcoal is 75-90% carbon. Carbon combustion involves an initial reaction where CO is formed. Thus CO is emitted at higher rates from charcoal combustion than from a comparable wood fire.

Figure 3 shows emission factors of CO and PM measured in a number of wood and charcoal stoves.

[15] The WHO's latest World Health Report (WHO, 2002) estimates that indoor pollution from solid fuel combustion is responsible for nearly 3% of the global burden of disease, with impacts concentrated in developing countries and falling disproportionately on women and children.

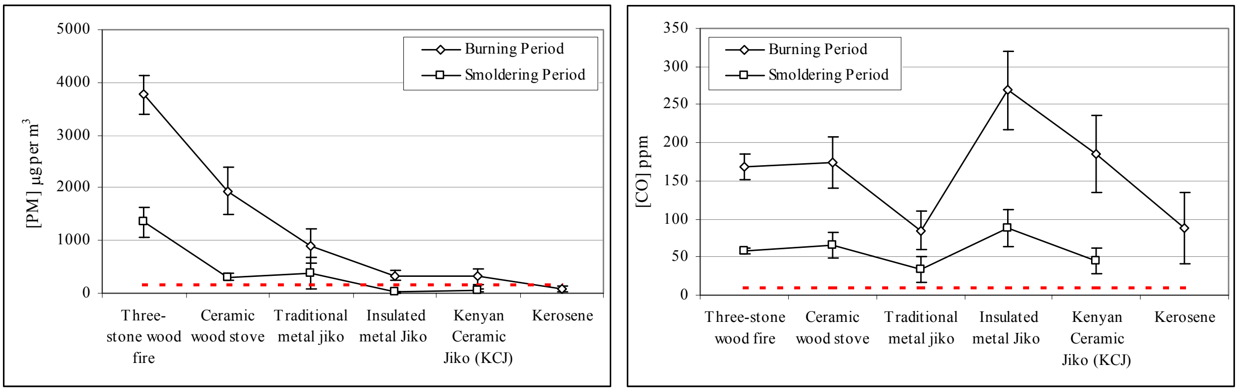
[16] Biomass combustion emissions contain carcinogenic compounds and exposure to them is a suspected cause of cancer, but the epidemiological evidence remains inconclusive (Bruce, Perez-Pedilla et al., 2000; Ezzati and Kammen, 2002a).

Figure 3: Emissions of PM and CO from common Indian stove/fuel combinations (Smith, Uma et al., 2000).



This graph shows emissions factors of stoves measured in simulated conditions. The entries are selected from a study of 28 stove-fuel combinations and are arranged in order of increasing CO emissions (dark line measured on left axis). PM is represented by the shaded bars and measured in the right axis. There is little correlation apparent between CO and PM emissions across stove-fuel combinations. The emission factors are defined in terms of energy delivered, which accounts for the energy content of the fuels and the efficiency of the stove. The graph was created by the author based on data from Smith, Uma, et al. (2000).

Figure 4: Concentrations of PM (left) and CO (right) measured in Kenyan households (Ezzati, Kammen et al., 2000).



These plots show average indoor concentrations of PM and CO from multiple measurements of 38 different households in rural Kenya. Each plot has two lines: one showing concentrations during burning periods (diamonds) and one showing concentrations during smoldering periods (squares), which are systematically lower. The error bars indicate standard errors. The PM data are arranged in descending order, with improved charcoal stoves resulting in considerably lower PM concentrations than woodstoves, but this pattern does not repeat for CO. The improved charcoal stoves result in CO concentrations that are as high, or higher, than the CO concentrations that result from wood stoves. Interestingly, kerosene is associated with the lowest PM concentrations, but the CO concentration arising from kerosene is comparable to most other stoves. Each plot also shows the USEPA's standard for concentration of each pollutant (dashed line). The standard set by the US EPA for PM is 150 □g/m^3 for a 24-hour period and CO is 9 ppm for an 8-hour period. Wood and charcoal stoves clearly exceed the PM standard under burning conditions (some also do so under smoldering conditions), while the CO standard is exceeded by all stoves under both conditions.

While emissions are important in assessing health impacts, indoor concentrations of pollution are a more direct way of predicting exposure to harmful pollutants. Indoor concentrations are a function of emissions from the stove as well as environmental factors and individual behavior that affects both the stove and the indoor environment. One study measured the concentrations of pollutant in dozens of rural Kenyan households using several different types of wood and charcoal stoves (Ezzati, Kammen et al., 2000). The authors found significant differences in the indoor concentrations PM and CO in households using open wood fires, closed wood stoves and different types of charcoal stoves. These differences are illustrated in Figure 4.

Environmental impacts

The public health and socio-economic aspects of the charcoal trade discussed above need to be balanced with the environmental impacts associated with its production and consumption. These impacts can be crudely split into impacts on forest cover and impacts arising from atmospheric pollution. The two are inter-related, but for simplicity, they will be discussed separately.

GHG emissions - All combustion of solid fuels results in the emission of carbon dioxide (CO_2), but in non-ideal conditions, many other compounds are also emitted. In fact, the same processes of incomplete combustion that lead to the emissions of health damaging pollutants like PM and CO also cause emissions of greenhouse gases. When solid fuels are burned in simple household stoves, the fuel can not mix sufficiently with air, and is not fully combusted. Hundreds of compounds are emitted including compounds that affect the radiative balance of the earth's atmosphere like methane (CH_4), which is 22 times more effective trapping heat than a molar equivalent amount of CO_2. Other compounds emitted from solid fuel combustion include CO, non-methane hydrocarbons (NMHCs), and nitrogenous compounds in trace amounts – all of which impact the atmospheric radiative balance more than an equivalent amount of CO_2 (IPCC, 1996).

Biomass fuels like wood or charcoal may be grown in a sustainable cycle such that harvested trees are replaced by an equivalent amount of biomass so that stocks are not depleted in the long-term. In that case, CO_2 released by combustion is effectively "removed" from the atmosphere by photosynthesis as stocks of biomass are replenished. However, the other greenhouse gases released by incomplete combustion are not removed from the atmosphere by photosynthesis. Thus, even if the CO_2 released by wood or charcoal combustion is fully removed from the atmosphere by newly grown biomass, processes of incomplete combustion inherent in small-scale household technologies ensure that the process is not greenhouse gas neutral (Smith, Khalil et al., 1993; Smith, Uma et al., 2000; Bailis, Ezzati et al., (2003)). Many of the gases released can contribute to climate change.[17] In addition, when biomass is not harvested sustainably, some of the CO_2 released must also be assessed in the impact on the climate.

[17] Of the gases released in biomass combustion, only CH_4 and N_2O are currently mandated for control under the Kyoto Protocol. However, CO and NMHCs also have a warming effect (IPCC, 1990; IPCC, 1996). In comparison to CO_2, CH_4, and N_2O, they are shorter lived, their warming effects are less direct and are more dependent on local conditions. Thus their warming effect is less certain, but still a concern.

Table 4: Emission factors for charcoal stoves compared to wood and fossil fuels from current literature (g per kg dry fuel)

Pollutant	Charcoal: end-use (three different sources)			Charcoal: production (two different sources)		Other fuels: end-use LPG	Kero. (wick)	3-stone fire
CO2	2411	2740	2258	1802	1594	3085	2943	1536
CO	275	230	211	223	253	14.9	62	60
CH4	7.9	8.0	2.41	44.6	38.6	0.05	1.1	2.8
TNMOC	10.5	4.0	0.54	92.6	10.9	18.8	19.2	8.0
N2O	0.2	0.04	--	0.15	0.1	0.15	0.10	0.07
TSP	2.4	--	--	30.4	16.1	0.51	0.7	0.9
Source	a	b	c	d	c	a	a	a

Sources: [a](Smith, Uma et al., 2000), [b](Smith, Khalil et al., 1993), [c](Brocard, Lacaux et al., 1996), [d](Pennise, Smith et al., 2001)

In Kenya, charcoal is preferred over wood because it is burns with a slow and steady heat amenable for cooking some of the local staple foods, which require long simmering times. Charcoal is better suited to long slow cooking, because, as discussed above, the characteristics of charcoal combustion are quite different than wood. Smith et al (Smith, Uma et al., 2000) found that charcoal has a lower combustion efficiency than wood or fossil fuels.[18] As a result of its lower combustion efficiency, charcoal emits more CO than firewood, but it also tends to emit more CH_4.

Moreover, charcoal end-use only includes half of the global warming impact. Unlike unprocessed firewood, charcoal includes substantial "upstream" emissions. The pyrolysis process drives off many volatile compounds and in most cases, these pollutants are simply vented into the atmosphere. Including charcoal production in the analysis of greenhouse gas emissions nearly doubles the amount of CO, CO_2, and N_2O and increases the amount of CH_4 and NMHCs by factors of nearly 6 and 9 respectively, relative to charcoal end-use alone (Pennise, Smith et al., 2001).

Table 4 shows mass-based emissions factors reported in the literature for charcoal production and end-use. Emissions from simple wood fires, LPG and kerosene are included for comparison.

Table 5 lists the same emissions aggregated into a single measure of global warming impact using a range of aggregation methods. Firewood and commonly used fossil fuels are included for comparison. Figure 5 depicts the same results in terms of energy delivered to the pot, which accounts for energy content of the fuel and efficiency of the stove (see Smith, Khalil et al., 1993; Brocard, Lacaux et al., 1996; Smith, Uma et al., 2000 for the methods of calculation).

18 Smith et al. define a parameter called *nominal combustion efficiency* NCE which is a function of the emission ratios measured for each carbonaceous species: CO, CH_4, NMHCs, and PM. The average of three measurements for charcoal yields an NCE of 83% while wood in an open fire exceeds 90%. LPG and kerosene (wick stove) are each 98% efficient.

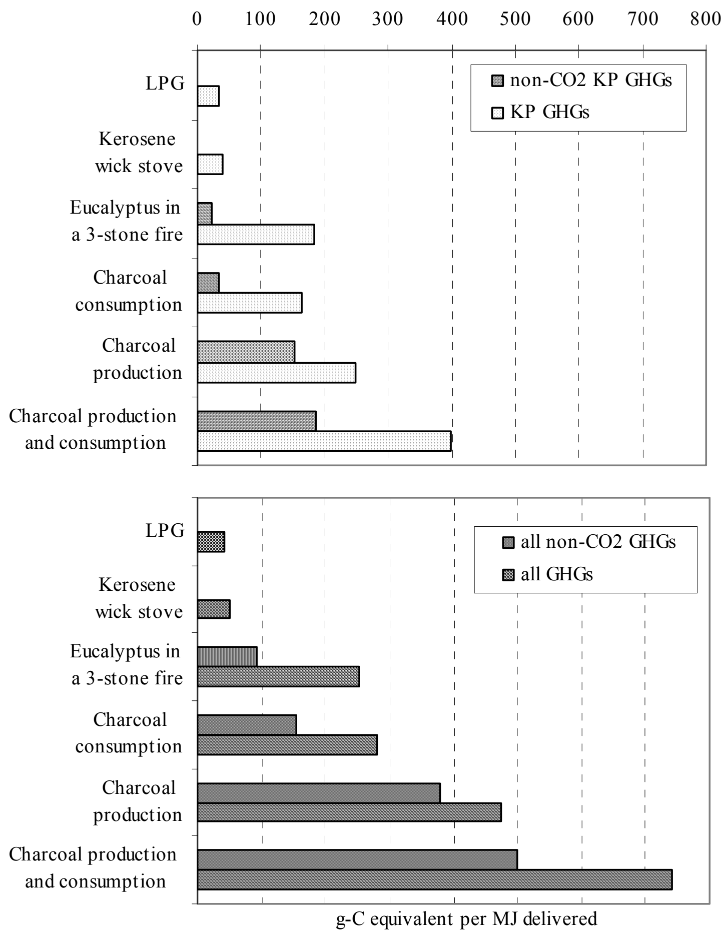
Table 5: Warming Impact by fuel for combinations of GHGs (g-C per kg fuel: 20-yr GWP)[a]

Global warming impact	Gases included in the calculation	*LPG*	Kerosene wick stove	Eucalyptus 3-stone fire	Charcoal consumption [c]	Charcoal production [d]	Production + consumption
Non-CO2 KP[b] GHGs	CH_4, N_2O	--	--	61	178	784	962
KP[a] greenhouse gases	CO_2, CH_4, N_2O	869	840	480	836	1275	2057
All non-CO2 GHGs	CH_4, CO, NMHCs, N_2O	--	--	241	793	1955	2573
All GHGs	CO_2, CH_4, CO, NMHCs, N_2O	1048	1113	660	1450	2446	3812

GWP or *global warming potential* is a measure of the warming impact of a gas relative to an equivalent amount of CO_2 (see IPCC, 1996).

KP = Kyoto Protocol [b] Charcoal consumption is from (Smith, Uma et al., 2000) [a] Data for production is from (Pennise, Smith et al., 2001)

Figure 5: Global warming impact of charcoal, wood, and common fossil fuels (g-C per MJ delivered 20-year GWP)



The upper plot in Figure 5 depicts the impact of the Kyoto Protocol gases only. Both the "renewable" (non-CO_2) and the non-renewable cases are represented. The lower plot depicts the net impact of all greenhouse gases emitted by the fuel, again accounting for CO_2 uptake in a "renewable" scenario.[19] The plots show that the global warming impacts of household fuels strongly depend on the methods of analysis. If all greenhouse gases are included as in the lower graph, biomass fuels are considerably more polluting than fossil fuels. If we consider only Kyoto Protocol gases, charcoal and wood used unsustainably have a larger impact than fossil fuels. However, if fuels are harvested sustainably so that CO_2 is absorbed by new tree growth, wood has a smaller impact, but charcoal still matches fossil fuels in terms of greenhouse gas emissions because of its high CH_4 emissions.

When charcoal production is included in the analysis, charcoal performs far worse. In every scenario, charcoal production emissions increase the net impact of charcoal by roughly a factor of two. The comparison with fossil fuels is not entirely fair, because they also involve emissions upstream, but these are not properly quantified in the Kenyan context. Nevertheless, it is instructive to see the effects of charcoal production relative to its end use.

Finally, it is useful to examine how the greenhouse gas emissions from charcoal compare to other sectors in the Kenyan economy. Table 6 shows the outcome of this estimate. Using national consumption data for wood and charcoal from the MoE survey and emission factors listed in Table 6, the net impact of wood and charcoal combustion is on the same order as industrial activities. This calculation uses only gases currently in the Kyoto Protocol and includes charcoal production as well as consumption. The net results show that woodfuels are a significant contributor to Kenya's total greenhouse gas emissions. Woodfuel emissions range from 3.3 to 12.6 Mton C depending on the degree to which fuels are harvested sustainably. In contrast, petroleum consumption, coal-burning, and cement manufacturing result in less than 2 Mton C emissions. Though the industrial emissions only include CO_2, it is likely that in the current Kenyan energy economy, aggregate woodfuel emissions are comparable to, if not well above, total emissions from industrial activities *even if wood is harvested on a sustainable basis*. Clearly, emissions reduction strategies and CDM activities must target both traditional and modern energy sectors

Table 6: Comparison of wood and charcoal to emissions from the petroleum sector and other industries in Kenya (2000)

	Consumption in metric tons (2000)	Emission factors (kg-C in 20 year CO_2 equivalent units per ton fuel)		Net Global Warming Impact (tons C in 20 year CO_2 equivalent units)	
		KP non-CO_2 gases	KP all gases	Renewable	Non-renewable
Firewood	15,730,000	61	480	966,000	7,556,000
Charcoal	2,476,000	962	2057	2,382,000	5,092,000
Total woodfuels				3,348,000	12,648,000
WRI data (2000)[a]					
Solid fuels					76,000
Liquid fuels					1,649,000
Cement Manufacturing					214,000
Total "modern" sector					1,940,000

[a] Industrial emissions are from the World Resources Institute's on-line database of environmental indicators (WRI, 2002). The most recent greenhouse gas data available is for 1996. 1996 emissions were scaled with inflation adjusted GDP growth (~5%) to estimate emissions in 2000.

[19] Table 5 explains the gases that are included in each scenario. Obviously, LPG and kerosene can not have non-CO_2 scenarios.

Deforestation - Charcoal is often blamed for the loss of forest cover in Kenya and other countries where charcoal is heavily used. While most rural firewood consumers do not cut living trees for their energy supplies, preferring to gather fallen branches and dead wood, charcoal makers harvest live trees, sometimes selectively and sometimes indiscriminately. However, deforestation, like many contemporary socio-environmental issues, exists in a complex and interdependent relationship with social, cultural, economic and political forces that tie local actors to global market forces and distant seats of power and influence. It is tempting, among policy analysts and politicians, to try to reduce deforestation to a single cause in order to arrive at an efficient solution to the "problem". In Kenya, it is true that a lot of charcoal reaching the market was harvested from deforested land, but the charcoal is often a secondary cause of land clearance. Land that is cleared for cultivation or development must first be cleared of tree cover. Charcoal making represents an attractive source of secondary income from newly cleared land, though in many cases it is not the primary factor influencing clearance. Much of Kenya's deforested land would have been cleared in the absence of charcoal production. In addition, land that is cleared specifically for charcoal production can revert to secondary forest under the right management regime. Similarly, agroforestry techniques can be employed to ensure that cultivated land maintains a high degree of tree cover with useful tree species.

Currently in Kenya, nearly all of the primary upland forest has been cleared, privatized or placed under protection by the state so that charcoal making has been pushed to the marginal ASAL regions (Mugo, 1999; Kantai, 2002). Ecological research has shown that these regions are resilient and that tree cover returns in a reasonable time period under a range of management regimes (Chidumayo, 1993; Hosier, 1993). However, just as land can be managed in a way that is favorable for the reestablishment of tree cover, it may also be managed in a way that prevents trees from returning, which leads to permanent deforestation. Thus, in the case of charcoal production, the permanent loss of tree cover depends not only on the actions of initial charcoal makers; it also depends on a range of other actors and structural factors. For example, pastoralists may graze their animals too soon or too often after trees are harvested, which can prevent new trees from establishing from shoots or seed. The likelihood of permanent tree loss also depends on cultivators, who may occupy the land after it is cleared, and the farming techniques they employ.[20] Subsequent charcoal makers also have a role – returning to harvest from the same area too frequently may deplete both soil nutrients and the seed bank, reducing the likelihood of trees returning in the long-term.

Ultimately the real impact of charcoal trade on forest cover becomes a question of policy. In Kenya, the current policy, which has banned charcoal production from public lands since 1986 with the aim of reducing forest loss, is a clear failure. Policies can and should be redesigned to address both demand side management and supply-side impacts. Demand can be tempered by dissemination of improved stoves. Kenya has one of the most successful stove programs in sub-Saharan Africa, with roughly 1.5 million stoves disseminated. While this is an impressive number, over half of the households reportedly using charcoal still do not use improved stoves. With fuel savings of roughly 30% observed (Kituyi, Marufu et al., 2001b), the potential for demand reduction on a national scale remains very large. As charcoal becomes increasingly popular among rural consumers, the need for new stove design and dissemination efforts to meet changing patterns of demand remains.

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[20] Fire, an important tool in dryland agriculture, plays a similar role as grazing livestock. Burning too early or too often after harvesting trees can kill new shoots and seedlings. On the other hand, fire can help some species of trees to reestablish by suppressing ill-adapted competitors.

As this paper discusses, there are numerous positive and negative impacts associated with Kenya's growing demand for charcoal. Increased consumption may result in reduced incidence of ARI if consumers substitute charcoal for wood, but it will also result in higher levels of CO exposure and increased greenhouse gas emissions. Charcoal has the potential to create jobs in the rural economy, but the current policy framework reinforces charcoal making as an illicit occupation, discourages entry into the trade and prevents producers from making investments in efficiency. Finally, increasing rates of charcoal consumption do represent a threat to Kenya's forests, but this is more the result of poorly designed policies than of the inherent destructiveness of charcoal production. Charcoal production can be done in a sustainable way, but only if the trade is legalized (Matiru and Mutimba, 2002). These issues require policies that address them directly, rather than attempt to wish them away, as the current policy does.

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WORKING GROUP 4: BIOMASS RESOURCES

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FOREST RESOURCES FOR ENERGY: ENVIRONMENTAL AND SOCIAL DIMENSIONS IN FOUR COUNTRIES IN LATIN AMERICA

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ABSTRACT

An analysis is made of the impact on forests due to the extraction of fuelwood and of shortage situations for some users, on the basis of nine case studies carried out between 1998 and 2003 in Honduras, Mexico, Cuba and Argentina. The conclusions are: not all fuelwood extraction causes a negative impact on forests; physical shortage of fuelwood seldom occurs; trees-out-of-the-forest are an important source of fuelwood and should be accounted for when assessing wood supply; and shortage due to inaccessibility occurs at local scales, arising from social causes. To properly assess the impact of fuelwood use on forest resources it is necessary to know the amount of consumed wood, utilized species, ways of extraction, actual sources, and trees growth rates. Local scale studies are needed in order to detect shortage or accessibility situations.

Results from TCP/FAO/HON/6713, TCP/FAO/CUB/8925 from the Food and Agricultural Organization of the United Nations (FAO), Programa de Acción Forestal Tropical in Mexico (PROAFT), and Programa Social Agropecuario in Argentina (PSA) are presented in this paper.

INTRODUCTION

In Latin America the use of wood for energy is of great importance, in urban as well as in rural locations. The high demand of forest fuels, in many cases much higher than that of sawn wood and other industrial woods, has risen great concern regarding the use of woodfuels as a cause of deforestation or forest degradation.

It has also been considered that people using fuelwood and charcoal could suffer from a shortage of these diminishing woodfuels. In this paper, an analysis is made of the impact on forests due to the extraction of fuelwood and of shortage situations for some users, on the basis of nine case studies carried out between 1998 and 2003 in Honduras, Mexico, Cuba and Argentina. All of them were based on the hypothesis that fuelwood extraction caused negative impact on the forests and/or there was a shortage situation.

ENVIRONMENTAL IMPACT

Honduras

The patterns of consumption, extraction and supply of fuelwood indicate that negative impacts on forest resources can vary from medium to low in the three studied cases:

In the case of *Tegucigalpa*, there could exist degradation in *Quercus* forests that are exploited solely for fuelwood (Table 1). Analysing the most consumed fuelwood types it is evident that *Pinus* forests are not greatly affected by fuelwood extraction, as pine fuelwood comes from sawmill residues and thinnings

In *San Lorenzo*, a medium city, there exists a special situation of risk, due to the use of mangroves as a source of fuelwood, above all because live trees are cut from the base. However the supply-demand balance shows that it is a medium risk, as the annual productivity of mangroves is slightly higher than the current consumption of mangrove fuelwood (Table 1). The fuelwood obtained from secondary forests does not produce a reduction of their cover, because of the ways of extraction and also because their rate of growth is higher than the rate of consumption;

In the rural department of *Lempira*, fuelwood use causes a low or null impact on the natural forests, as the amount is low and it is extracted mainly from branches of anthropic vegetation such as coffee plantations and grazing areas.

Table 1. Patterns of consumption, extraction and supply of fuelwood in Honduras[1]

Case	Fuelwood consumption (10^3 m3/year)	Type of Fuelwood	Vegetation type	Supply-demand balance (10^3 m3/year)[2]
Tegucigalpa City (Central District)	**190.5**	• **24% from sawmill residues** • **49% from residues of pine forests thinning**	• **76% *Pinus* and *Quercus* forests**	**No data**
San Lorenzo 66City	**18**	• **Mangrove: 100% from cutting of live trees** • **Secondary forest: mainly from branches**	• **54% mangrove** • **46% secondary forest**	• **Mangrove +2** • **Secondary forest +10**
Four towns in Lempira Department[3]	**3**	• **87% from branches of dead trees**	• **74% anthropic vegetation** • **26% natural forests**	**No data**

1. Source: Arias 1999
2. Supply (m3/yr) = forest area (ha) x medium annual increase [MAI] (m3/ha/yr)
3. Four towns in Lempira are Cololaca, La Virtud, Tambla, and Guajiniquil.

Cuba

The *Guantanamo province* has a very high fuelwood and charcoal consumption, due to the fact that in the last ten years, in Cuba people went back to the use of woodfuels, in the face of Kerosene and LPG shortages (Table 2.). It could be expected that this situation would impact negatively on the natural forest resources. However, 75% of the woodfuels come from anthropic formations, such as live fences, grazing areas, coffee plantations and "marabusales", and it can be said that the use of woodfuels cause a minor impact. Even more, as the "marabu" is an invasive arbustive species, its use as fuel appears to be an adequate alternative to control it. To sustainably produce the remaining 25% of consumed woodfuel, it should be enough that 46 thousand hectares of native forests, with 3 m3/ha/yr MAI, be dedicated to this type of use, in the vicinity of main centers of consumption.

Analyzing the impact at the municipal scale, in *Cienfuegos*, the pattern is similar to that of Guantanamo, with low to medium impact on natural forests. To produce woodfuels in sustainable manner in this municipality, it would require three thousand ha of forests.

Table 2. Patterns of consumption and extraction of woodfuels in Cuba[1,2]

Case	**Fuelwood consumption (10^3 m^3/year)**	**Type of fuelwood**	**Species used for woodfuel**	**Vegetation type**
Guantanamo Province	• 548	**98% from branches and dead trees**	• **30% *Dichrosthachys cinerea* (Marabú)** • **24% *Gliricidia sepium*** • **8% *Coffea arabica***	• *75% from anthropic vegetation*
Cumanayagua Municipality, Cienfuegos	• **30**	**90% from branches and dead trees**	• 12% *Acacia farnesiana* • **7% *Citrus* sinensis** • **6% *Coffea arabica*** • **5% *Dichrosthachys cinerea***	• **71% from anthropic vegetation**

1. Sources: Núñez et al 2001, Montesino et al 2001
2. Woodfuels are fuelwood and charcoal

Mexico

In the three analyzed areas of the southeast of Mexico, it is apparent that productive capacity exceeds to a large extent the volume of extracted fuelwood (Table 3).

As the fuelwood is obtained from branches and/or dead trees, and, with the exception of Chiapas, the larger part is taken from areas of secondary vegetation, grazing areas, coffee plantations, live fences, it is concluded that fuelwood production does not cause a negative impact neither on natural forests nor over other wooded lands.

Table 3. Patterns of consumption, extraction and supply of fuelwood in Mexico[1]

Case[2]	**Fuelwood consumption (10^3 m^3/year)**	**Type of fuelwood**	**Vegetation type**	**Supply-demand balance (10^3 m^3/year)[3]**
Pajapan Municipality, Veracruz	**8**	• **97% from branches and dead trees**	• **85% anthropic vegetation** • **9% mangrove** • **6% evergreen rain forest**	**+11**
Calakmul Municipality, Campeche	**36**	• **100% from branches and dead trees**	• **61% anthropic vegetation** • **39% semi-deciduous forest**	**+5,500**
Chiapas communities	**2**	• **89% from branches and dead trees**	• 41% anthropic vegetation • 59% natural forest	+21

1. Sources: Arias et al 2000, Arias 2002.
2. Veracruz includes the Pajapan "Ejido" and the Communal Area, Campeche the Calakmul Municipality. Chiapas ommunities are Las Nubes, La Fortuna and Jerusalen.
3. Supply (m3/yr) = forest area (ha) x medium annual increase (m3/ha/yr) [MAI]

❑ Argentina

The analysis of the Argentine case is at village scale, a group of ten families settled on 20 hectares. Their situation is quite paradoxical, for they live in a region of high wood production yet they do not have enough fuelwood of their own (Table 4). Currently, they have just 6.5 ha covered by native secondary forest with a total stock of 1700 m3, enough to supply themselves for ten years, on the basis of a "mining type" exploitation.

Table 4. Patterns of consumption, extraction and supply of fuelwood in Argentina[1]

Zone	**Fuelwood consumption (m^3/year)**	**Vegetation type**	**Supply-demand balance (m^3/year)[2]**
Yacutinga village	• **170**	• **semideciduous forest** • **secondary vegetation**	• **-133**

1. Source: Arias y Bacalini 2003
2. Supply (m3/yr) = forest area (ha) x medium annual increase (m3/ha/yr) [MAI]

FUEL SHORTAGE OR FUEL INACCESSIBILITY

Of the five cases presented, where the productivity of fuelwood was evaluated, only in the Argentine case there exists physical shortage of wood in the scale under analysis. Although in the others there are no limitations in the supply due to insufficient production, in three Mexican locations there are problems of inaccessibility: Pajapan and Jicacal in the Pajapan municipality and X´pujil in the municipality of Calakmul. The problem of inaccessibility in these cases is in account of not owning enough land. Yacutinga village in Argentina, could be added to this group, because the main problem is that the users do not own enough land to produce the fuelwood.

In Pajapan there are 500 families that did not receive land, as the agrarian partition is over. In Jicacal, the larger part of the families did not receive land and have to extract fuelwood from the mangroves, whose use is regulated by other communities. In X´pujil, the recently arrived families do not own land. In Yacutinga village, each family owns less than two hectares of land and people make a living as rural workers with very low income levels, which prevents them from buying fuelwood from the neighbouring areas or paying for its transportation from distant places.

The cases of Pajapan and X´pujil can be analyzed in the context of the classification by “Priority Municipalities for Fuelwood Sustainability in WISDOM” (Masera et al 2002). In this map Pajapan is considered as “high priority municipality”, with “largest average fuelwood consumption, the largest number, density and growth of users, the lowest fuelwood balance, and the largest percentage of indigenous population”. But the physical balance of supply-demand of our case study places the municipality in a condition of minor priority, since forest productivity is sufficient to sustain twice the current population, which could happen in no less than 25 years (INEGI 1992, INEGI 1997). Taking in account that in Pajapan and Jicacal towns fuelwood is inaccessible for many families, it is correct to place these in a high priority situation, although for a different reason than those considered in WISDOM.

On the other hand, the Calakmul municipality is classified in the map as a “mid-low priority”, while in fact 85% of the families of X´pujil have no access to fuelwood resources.

This shows that in detailed studies, situations can be detected that differ from those found with diagnostic methods in a regional or national scale. In all cases effective access to fuelwood resources is restricted by reasons of social nature, that should be attended to in a specific manner.

CONCLUSION

The analysis made at different scales (provincial, municipal, town and village level) in urban as in rural communities leads us to conclude that:

Not all fuelwood extraction causes a negative impact on forests. Only in three cases (Tegucigalpa, San Lorenzo, Yacutinga) there is evidence of negative impact on forest resources. A sizable fraction of the total volume used can be obtained in sustainable ways, while another part can be causing deforestation or forest degradation.

The knowledge of the amount of fuelwood used is not enough to estimate its impact on forest resources. This assessment needs full knowledge of the wood´s origin (vegetation types, species), the way it is extracted and the productivity of the forest resources subject to exploitation.

Physical shortage of fuelwood rarely occurs. In most cases it was found a highly positive supply-demand balance.

Trees-out-of-the-forest are important for fuelwood supply. In nearly all the cases analyzed, a high percentage of fuelwood is obtained from vegetal formations that are not considered "forest" in the forest inventories at regional or national scale. Accordingly, it is essential that these non forest formations be duly evaluated when assessing fuelwood supply.

Shortage due to inaccessibility does occurs at local scale. Although evaluation of fuelwood supply at municipal scale may result in a positive balance, local situations are found where inaccessibility due to social causes generates actual fuelwood shortages for some parts of the population. It is advisable that studies aiming at identifying possible shortage situations be made at local scale.

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WORKING GROUP 4: BIOMASS RESOURCES

International Seminar on Bioenergy and Sustainable Rural Development
- 5th LAMNET Project Workshop – Mexico 2003

A MULTISCALE ASSESSMENT OF WOODFUEL HOT SPOTS: A CASE STUDY FOR MEXICO

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1. INTRODUCTION

The large and widespread utilization of woodfuels in Mexico is associated to a host of environmental and socioeconomic impacts. Understanding national woodfuel use current patterns and trends will allow assessing these impacts, and help to achieve a sustainable use of this major energetic resource. However, the patterns of woodfuel production and consumption are rather complex and very site specific, complicating the development of a national perspective (Mahapatra & Mitchell, 1999; RWEDP, 1997 and 2000). National-level data are too aggregated to provide the sense of local variance, while local studies are too fragmented and discontinuous to convey the general picture.

Recognizing the site specificity of woodfuel use associated impacts should drive the thinking that there is a general fuelwood crisis to the assumption that critical areas vary from area to area. For example, regarding environmental impacts, even in regions with an overall negative woodfuel demand/supply balance, not all the places face woodfuel scarcity, and, similarly, regions with overall positive balance may include deficit areas with serious impact on natural resources (FAO, 1981; RWEDP, 1997 and 2000). Although the spatial variation in the patterns of woodfuel use and its associated impacts, current planning is still based on aggregate statistics at the national level that leads to inefficient policies and give poor guidance, or by the other side, on detail studies at the project level which presents severe problems for integrating the information at the national level (Masera *et al*, 1998).

Little is known, for example, about the amounts, extent, geographical location and dynamics of wood supplies: from plantation strategies, to traditional wood collection and harvesting methods. In these regards, one should realize that obtaining exact measures of woodfuel deficits (i.e., like the studies conducted using the traditional fuelwood gap model (De Montalambert & Clement, 1983; Newcombe, 1984)) presents severe methodological and financial challenges, particularly considering the scarce resources normally allocated to this specific sector (ESMAP, 2001). More feasible approaches are those oriented to identify problematic or potential areas within a country based on identifying woodfuels patterns and trends. In a second step, more in-depth analyses can be conducted, allowing a more efficient use of scarce available resources and better results.

There is an urgent need for spatial explicit approaches that help in strategic planning. The main feature of this kind of approaches must be their ability to follow hierarchical analysis through multiple spatial scales, from a national priorization, to the identification of those critical areas at a resolution consistent with the implementation of targeted policies. When recognizing key patterns of woodfuel use, spatial explicit multiscale approaches may facilitate the application of a set of tools directed to improve the sustainability of woodfuels use.

The Center for Ecosystems Research (CIECO) of the National University of Mexico (UNAM), in cooperation with the Food and Agriculture Organization of the United Nations (FAO), have developed the Woodfuel Integrated Supply/Demand Overview Mapping (WISDOM) (Masera *et al*, 2003a), a spatially explicit method for identifying woodfuel priority areas or "hot spots". WISDOM is based on geographic information system (GIS) technology, which offers new possibilities for integrating statistical information about production and consumption of woodfuels. WISDOM attempts to integrate existing information and reduce the collection of costly new data.

In this article we apply the WISDOM approach to Mexico. Subsequently we explore the possibility of identifying concrete areas for intervention at the project level, based on an accessibility analysis within the "Purhépecha Region" of Michoacan State.

2. The WISDOM APPROACH

The Woodfuel Integrated Supply/Demand Overview Mapping (WISDOM) is a spatial-explicit planning tool for highlighting and determining **woodfuel priority areas** or "woodfuel hot spots". We recognize that woodfuels are connected to a set of interrelated socio-economic and environmental issues, and thus woodfuel hot spots can be defined in terms of its relevance for consumption patterns, production, and potential environmental impacts.

Woodfuel hot spots can be thus established according to a number of criteria set by the users. For example, in identifying areas with potential large social impacts, zoning can be done according to the number and density of woodfuel users and the scarcity of woodfuel resources. Studies looking at potential degradation caused by woodfuels use, will try to identify regions where woodfuel consumption is high, resilient, and increasing, where woodfuel supply is at risk, due to loss or degradation of natural vegetation, and where the demand-supply balance indicates a deficit or is likely to develop such condition in the near future.

WISDOM does not replace a detailed national biomass demand/supply balance analysis for operational planning but rather it is oriented to support a higher level of planning, i.e. strategic planning and policy formulation, through the integration and analysis of existing demand and supply related information and indicators. More than absolute and quantitative data, WISDOM is meant to provide relative/qualitative values such as risk zoning or criticality ranking, highlighting, at the highest possible spatial detail, the areas deserving urgent attention and, if needed, additional data collection. In other words, WISDOM should serve as an ASSESSING and STRATEGIC PLANNING tool to identify priority places for action.

WISDOM is based on:

- **Geo-referenced data bases**. A core feature of the approach is the spatial base on which the data is framed. The analysis and presentation of results for all modules is done with the help of a Geographic Information System (GIS).

- **Minimum spatial unit of analysis at sub-national level**. The spatial resolution is defined at the beginning of the study, on the basis of the wanted level of detail (national study, regional study) and as constrained by the main parameters or proxy variables that will be used to "spatialize" the information. In most cases the existing demographic data, such as census units, and land use/land cover data represent the main reference for the definition of the spatial base, which will be in all circumstances sub-national and preferably below state level.

- **Modular and open structure**. WISDOM consists of three basic modules: a demand module, a supply module, and an integration module. The first two modules require different competencies and data sources. Once the common spatial base of reporting is defined, each module is developed in total autonomy using existing information and analytical tools and is directed to the collection, harmonization, cross-referencing and geo-referencing of relevant information existing for the area of study.

- **Adaptable framework**. As mentioned before, the information of relevance to wood energy comes from multiple sources and is often fragmented and poorly documented, ranging from census data to local pilot studies or surveys, to projected estimates with unknown sources. Proxy variables may be used to "spatialize" discontinuous values. In synthesis, WISDOM tries to make all existing knowledge at work for a better understanding of woodfuel consumption and supply patterns.

The benefits of WISDOM include:

- ✓ Provides a consistent and **holistic vision** of the wood energy sector over the entire country or region and helps to determine **priority areas** for intervention.
- ✓ Constitutes an open framework and a **flexible tool** meant to adapt to existing information related to woodfuels demand and supply patterns.
- ✓ Allows the **definition of critical data gaps** resulting from the thorough review and harmonization of wood energy data**.**
- ✓ Promotes **cooperation and synergies** among stakeholders and institutions (Forestry, Agricultural, Energy, Rural development, etc.). In this, WISDOM will combat the fragmentation (of information, of responsibility) that so heavily limits the development of the sector.
- ✓ Allows to concentrate the actions on circumscribed targets and thus to **optimize the use of available resources** (human, institutional, financial, etc.).
- ✓ Enhances the **political recognition** of the real inter-sectoral role and priorities of the wood energy by policy makers.

The use of WISDOM involves five main steps (figure 1):

1. Definition of the minimum administrative spatial unit of analysis:
The analysis should be carried out at the lowest administrative level for which demographic, social and economic parameters are available. In this step, spatial and statistical data are linked through a "map attribute table", which has a database structure and contains the basic geographic attributes and identifiers of all individual elements of the digital map (identity codes and names, area, perimeter, coordinates, etc.). The table can be expanded as needed by the addition of thematic attributes referring to the same set of map elements.

2. Development of the DEMAND module:
The main challenge of this module is to find either direct or proxy variables, available at the minimum subnational unit selected, that can be used to estimate consumption levels and their spatial distribution.

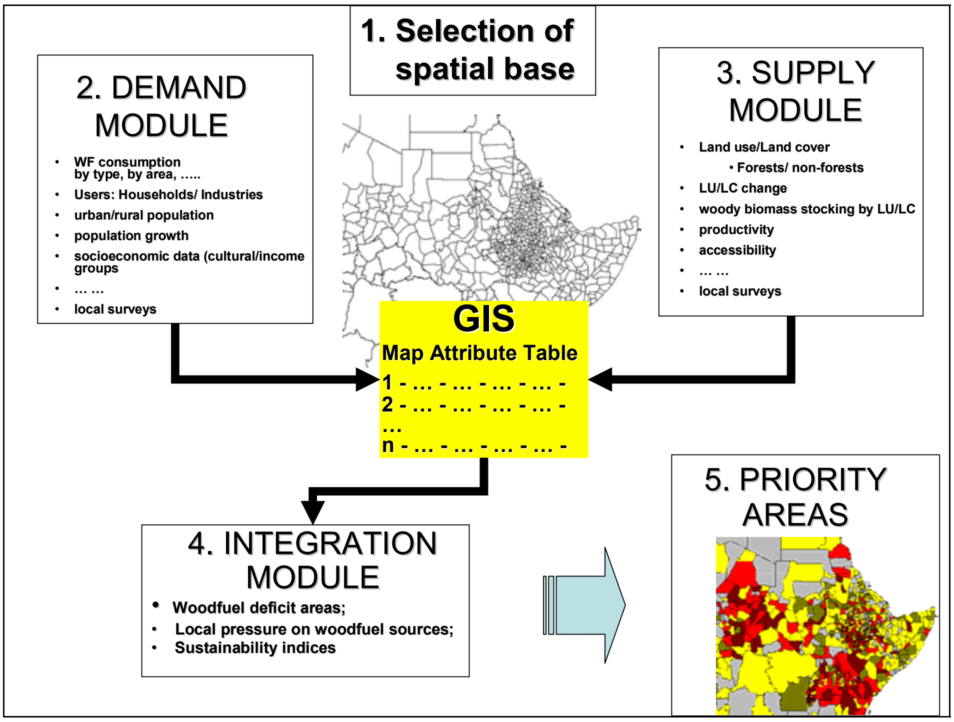
These variables should be disaggregated, if possible, by fuel type (fuelwood, charcoal, others), by sector of users (households, industrial, others) and by area (rural, urban), since each has a particular impact on sources and sustainability of supply, calling for separate lines of analysis.

3. Development of the SUPPLY module:
This module provides a spatial representation of all woodfuel sources, their stocking capacity, their change over time, and their productivity. The main, and often the only, sources of information for developing this module are national forest inventories. A weak point of these data sources is that they do not differentiate woodfuels from other types of commercial or usable timber, overestimating the real woodfuel supply. Moreover, inferred data based on detailed surveys might be used regarding non forest land use classes, as forest inventories do not cover these areas. As mentioned earlier, the scope of WISDOM is not operational planning, for which quantitative precision is essential. Thus, with the scope of identifying priority areas where the demand-supply balance reveals a possible deficit, the supply module may concentrate mainly on land use and land use change, and may use indicative biomass productivity indices based on ecological characteristics.

4. Development of the INTEGRATION module:
This module is used to integrate the information from the demand and supply modules. The integration is done through the combination of the variables related to woodfuel consumption and supply that have been systematized for each minimum administrative unit of analysis.

5. Selection of the PRIORITY areas or "woodfuel hot spots":
The last step of the methodology is the identification of those areas where action, or further investigation, is needed. This final objective may be achieved either by multivariate statistical procedures or by grouping some selected variables form the three modules into an overall index (Fuelwood Priority Index) which allows the priorization of each minimum administrative unit in terms of woodfuel demand, supply or both.

Figure 1. WISDOM Steps



3. MEXICO'S CURRENT PATTERN OF WOODFUEL USE

Biofuels represent 9% of total energy demand in Mexico. Fuelwood accounts for 37% of total residential energy use and more than 80% of the energy demand in the rural sector. Total fuelwood use accounts for three times the total commercial timber legally harvested in the country. Approximately 25 million people use fuelwood for cooking, boiling water or heating. Fuelwood is either collected or bought from local markets, and comes from commercial and non commercial forest areas, little from agricultural areas. Fuelwood demand is concentrated on rural areas and small towns. The patterns of fuelwood use are extremely diverse, with a high heterogeneity in terms of users and potential environmental impacts across the country (Masera *et al*, 1998; SENER, 2001).

4. WISDOM ANALYSIS FOR MEXICO

4.1 Assumptions and scope of the WISDOM analysis for Mexico.

When conducting the WISDOM analysis for Mexico, some prior assumptions were made taking into account the availability and reliability of data.

- Only forest areas were included in the analysis. The fuelwood supply coming from non-forest areas was not considered.
- Only fuelwood was considered in the analysis.
- Fuelwood production coming from forest areas was assumed to be equivalent to total biomass productivity by forest type This leads to an overestimation of the actual fuelwood supply.
- Only exclusive fuelwood users were taken into account. The INEGI census does not distinguish mixed fuel users (e.g. users of fuelwood and LP gas), although they represent a significant percentage of total fuelwood users (31% in 1990 (Díaz, 2000)). As there is no reliable direct estimate of this group of users as a separate sector, this study accounts only for the exclusive fuelwood users. Some underestimation in the fuelwood demand patterns should be expected.
- The analysis focused on the residential sector.

4.2 Step 1: Determining the minimum spatial unit of analysis.

The "municipio" (county: 2nd sub-national level) was selected as the minimum administrative unit of analysis for conducting WISDOM. A geo-referenced data base that covers the whole country and is articulated into the state and national level is available from the Mexican National Bureau of Statistics (INEGI). A total of 2,436 units were identified and incorporated into a GIS. For each unit, basic information such as: coordinates, area, and perimeter are available.

4.3 Step 2: Developing the demand module.

The INEGI census -currently available electronically at the "municipio" level - was used as the basic source of information for the module. The census includes general socio-demographic variables as well as variables related to the quality of living of the Mexican population. The average per capita fuelwood consumption by major ecological zone was estimated based on local surveys. Besides these two sources of information new variables were calculated for the completion of the demand module (Table 1).

Table 1. Variables used in the demand module

Original Variables from the National Census (1980/1990/2000)	• Population (urban, rural, total). • Total number of households. • Number of households that use exclusively fuelwood. • **Number of exclusive fuelwood users.** • **Percentage of population belonging to an ethnic group.** • Socioeconomic index.
Original Parameters from Surveys	• Average per capita fuelwood consumption by major ecological zone (temperate, tropical dry, tropical humid, semi-arid and wetlands).
New variables calculated	• **Saturation of fuelwood users** (percentage of exclusive fuelwood household users). • Annual fuelwood consumption (estimated as per capita fuelwood consumption times number of exclusive fuelwood users). • Annual fuelwood consumption coming from forests (estimated as per capita fuelwood consumption coming from forest times number of exclusive fuelwood users) • **Average annual growth rate of exclusive fuelwood Users** (1990-2000). • **Density of fuelwood users** (exclusive fuelwood users per km^2, using the total municipality area).

Note: All these variables are disaggregated at the “municipio” level. In bold are the variables selected for the determination of “woodfuel hot spots”.

The annual fuelwood consumption coming from forest areas was estimated using a factor that varies by major ecological zone. This factor was estimated based on local studies (Del Amo, 2002; Masera *et al*, 1997; Masera *et al,* 1993). For tropical regions of México for example, about 20% of fuelwood consumption comes from non forest areas, which may include farmland trees, abandoned or regrowth areas due of shifting cultivation practices, and other places. In this case, the factor was set to 0.8. More detailed surveys covering all the ecological zones need to be conducted in order to obtain a more precise estimate of these proportions. The annual fuelwood consumption coming from forest is used at the integration module for calculating the fuelwood balance over forest areas.

4.4 Step 3: Developing the supply module.

To estimate the total woody biomass production from Mexican forests, average biomass productivities (in ton/ha/yr) for each of the major forest types was assumed and incorporated into the supply module. The distribution of the resulting biomass forest productivities within the country was calculated using a simplified vegetation map (7 classes), reclassified from the original National Forest Inventory vegetation map (69 classes) for the year 2000. A more detailed analysis of forest productivities, for example, using climate and soil conditions will be needed for a more accurate estimate of total biomass production at the “municipio” level. More over, conversion factors are needed to quantify the actual amount of fuelwood production as a fraction of the actual woody biomass productivity calculated. See Table 2.

Table 2. Variables used in the supply module

Original Variables from the National Forest Inventory (2000)	Area by each LU/LC class (ha).
Original Parameters from Surveys	Total aboveground biomass productivity by forest class (ton/ha/yr).
New variables calculated	Total forest area (ha) -includes temperate, tropical, shrubs, mangroves and other forests -. **Aboveground biomass production from forests** (ton/yr).

Note: All these variables are disaggregated at the “municipio” level. In bold are the variables selected for the determination of “woodfuel hot spots”.

4.5 Step 4: Developing the integration module.

The information gathered in the supply and demand modules was combined to get a series of new variables -or indicators-. This procedure was done iteratively during the development of WISDOM, as some demand variables depend on variables from the supply module (e.g., per capita fuelwood use) and vice versa.

Two main integrated variables of interest at the “municipio” level derived were:

- **Fuelwood Balance** (forest biomass productivity - fuelwood demand coming from forests) in ton/yr.
- **Pressure on Forest Resources** (fuelwood demand coming from forests / total forest area) in ton/ha/yr.

4.6 Step 5: Identifying priority “municipios”.

The last step of the analysis was the determination of fuelwood “hot spots”. Four main sub-steps were necessary for achieving this task:

4.6.1 **Selection of a robust set of variables associated to fuelwood consumption and supply by “municipio” to be used in setting priority municipalities:**

Six uncorrelated or poorly correlated variables were selected from the original pool of ten variables: a) total number of exclusive fuelwood users: b) saturation of fuelwood users (proportion of households that use exclusively fuelwood); c) user density (number of exclusive fuelwood users / total municipality area); d) percentage of people belonging to an ethnic group; e) discrete annual growth rate of exclusive fuelwood users (1990-2000); f) fuelwood balance (total forest productivity - annual fuelwood consumption coming from forest areas).

4.6.2 Ranking of "municipios" in 5 groups in terms of each of the individual variables:

For each of the six variables selected, "municipios" were grouped and ranked into 5 categories, reflecting the acuteness -or priority- of the problem. The ranking was done by dividing each of the six selected variables in five intervals or "natural groups". The objective of the priority ranking was to find municipalities that show: high fuelwood demand, high density and growth of fuelwood users; high resilience of fuelwood consumption (defined here as household's attachment to fuelwood use for cooking due to social and cultural aspects); and few or insufficient woodfuel resources.

4.6.3 Construction of an integrated fuelwood priority index (FPI) by "municipio":

Based on the priorization of each "municipio", for each of the six variables selected, an overall fuelwood priority index was constructed as follows:

$$FPI_j = \sum_{1}^{6} I_i * P_i$$

where,

FPI_j = woodfuel priority index for each "municipio" "j"
Ii = index for each of the six variables used in the analysis -6 in total-, ranging from 1 to 5, according to the priority of the "municipio" in terms of the specific variable.
p_j = weights, set to 1 in our case.

4.6.4 Ranking of "municipios" in 5 groups according to the FPI:

With each "municipio" being assigned a numerical index that integrates the different concerns regarding fuelwood consumption and availability of resources, the final step was a regrouping into the five categories defined in the previous section: from low priority to high priority.

4.7 Results

Conducting a WISDOM analysis for Mexico allowed the categorization of 2402 "municipios" (out of 2436) in five groups according to their level of priority. The analysis showed that, from these 2402 "municipios":

- ❑ 262 "municipios" → High priority
- ❑ 388 "municipios" → Mid-high priority
- ❑ 462 "municipios" → Medium priority
- ❑ 677 "municipios" → Mid-low priority
- ❑ 613 "municipios" → Low priority

A statistical analysis was conducted to corroborate the significance of these groups. An overall ANOVA confirmed that the five groups were statistically different at a 95% confidence level.

Table 3 shows the six variables used in the construction on the FPI index by group of ranked "muncipios". It can be seen that high priority "municipios" show a high number of exclusive fuelwood users; a high percentage of houses that exclusively use fuelwood; a high density and growth of exclusive fuelwood users at the household level; a high resilience of fuelwood consumption (in terms of social and cultural aspects); and few or insufficient woodfuel resources from forests.

Table 3. Characteristics of each priority group of "municipios" according to selected variables.

FPI Groups	Number of Fuelwood exclusive users	Saturation of fuelwood users (%)	User Density (A) (users/ km2)	Indigenous population (%)	Growth Rate of fuelwood users (%)	Fuelwood Balance (ton/yr)
High priority	15,217 (987)	86,1 (0.8)	1.02 (0.04)	68.2 (1.9)	1.8 (0.2)	20,816 (2112)
Mid-high priority	11,628 (664)	72,1 (1.2)	0.61 (0.04)	43.7 (1.9)	1.2 (0.2)	68,390 (13,733)
Medium priority	9,765 (587)	59,7 (1.3)	0.38 (0.02)	23.3 (1.4)	0.0 (0.1)	120,299 (18,343)
Mid-low priority	5,880 (279)	41,3 (1.1)	0.22 (0.01)	6.4 (0.6)	-1.4 (0.2)	144,756 (15,555)
Low priority	2,436 (118)	17,8 (0.7)	0.05 (0.00)	0.8 (0.1)	-4.4 (0.2)	543,977 (60,067)

Note: Standard error values are shown in brackets. Smallest "n" for any variable: 2401.

Figure 2 shows that the most critical states according to the percentage of their area covered by high priority "municipios" are Veracruz (60 "municipios"; 26,4% of its area); Puebla (53 "municipios"; 19,1% of its area); Hidalgo (14 "municipios"; 15,3% of its area); and Estado de Mexico (10 "municipios"; 14,9% of its area). The number of "municipios" ranked as "high priority" on the state of Oaxaca rises to 63, but they represent only 9,3% of the total area. This type of considerations should be made in order to categorize national priority areas for intervention or further investigation. Moreover to the inclusion of high priority "municipios" inside state boundaries, it is useful to recognize their distribution in aggregated areas, which may correspond to a continuum of site specific characteristics according to WISDOM modules parameters. The complete list of ranked "municipios" is posted as an annex in Masera *et al* (2003b).

Figure 2. Priority "municipios" in terms of fuelwood use and availability of fuelwood resources, Mexico 2000.

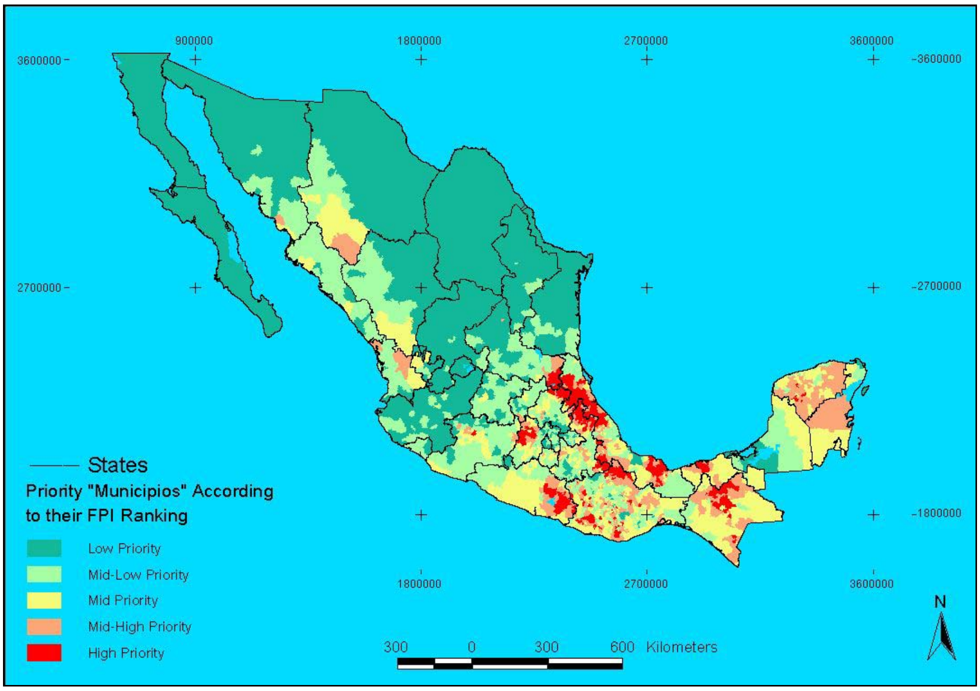


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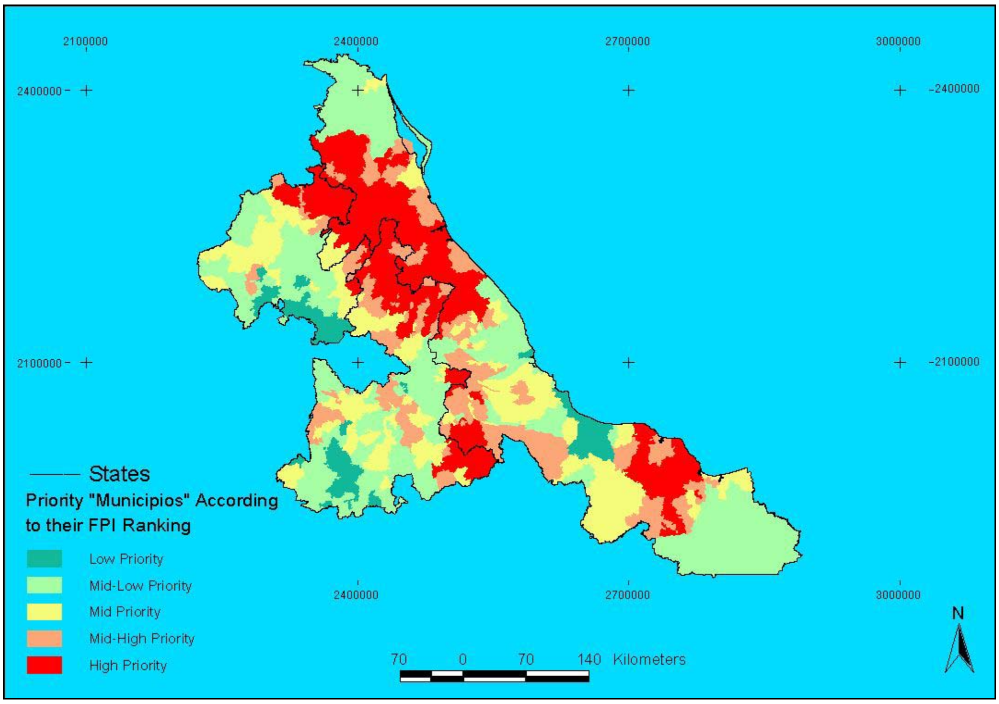
Figure 3 shows a detail of the central Mexican gulf region, comprising the “municipios” of Veracruz (left), Hidalgo (top right) and Puebla (bottom right). Extreme deforestation through the last three decades over this area has reduced considerably the supply of woodfuels, driving a major number of “municipios” to a critical situation. When reviewing the WISDOM database for Veracruz. We also see high growth rates of fuelwood users in critical “municipios”. Policy design at this scale should then consider these two variables as key factors in woodfuel scarcity over the entire region.

Figure 3. Priority “municipios” in terms of fuelwood use and availability of fuelwood resources, Mexico 2000. Detail for Central Gulf



5. ADDRESSING PRIORITY AREAS AT THE LOCAL LEVEL: AN ACCESSIBILITY ANALYSIS

The WISDOM analysis carried out for Mexico allowed the identification of 262 high priority “municipios”, distributed over few aggregated areas. However, this should be just a first level of analysis. Accessibility studies may contribute to recognize priority areas at higher resolutions within the regions and “municipios” identified by WISDOM. Assessing the accessibility to fuelwood sources due to physical restrictions (i.e. slope, distance) and legal restrictions (i.e. protected areas) may allow helping to recognize those fuelwood sources areas more critical in terms of pressure by people’s demand. Accessibility studies not only restrict the fuelwood supply potential, but help quantify this pressure when considering the number of fuelwood users which can access limited portions of the whole forest area. In this section, we conduct an accessibility analysis over the “Purhépecha” Region of the State of Michoacan, using a GIS.

The following example attempts to: 1) estimate the potential forest areas accessible for fuelwood users of the "Purhépecha" Region, and 2) categorize those accessible forest areas, according to the pressure exerted by local people's demand. The assumptions of the model are as follows:

- All of the human settlements censed by INEGI at year 2000 (isolated country households, small towns and villages) were incorporated as starting points for fuelwood gatherers.
- Displacement velocities through the terrain are a function of the slope and the geographic barriers only.
- Only walking fuelwood gatherers, with or without draft animals, were considered.
- All fuelwood gatherers walk 60 minutes or less (120 minutes for our second example), from their starting points and back.
- The different forest land covers were unified as one target area.

All human settlements were incorporated into a Geographic Information System (GIS) of the "Purhépecha" Region. The mean displacement velocities of walking fuelwood gatherers at different slopes were reestimated based on Puentes (2002) (Table 3). Corresponding velocities were used to create a "cost-distance" map, so called because movement through space can be considered to incur cost (in this case, because of increasing slopes; see table 3). Time buffers of 30 minutes and 60 minutes radius around each settlement were calculated using the cost-distance map. Buffers were then overlapped to a forest extent map of the "Purhépecha" Region. The resulting intersections were considered as those areas potentially accessible from settlements by walking fuelwood gatherers. The results shows that 40% of the total forest areas (121,000 ha) is accessible at 30 minutes. This value rises to 80% when considering 60 minutes buffers (242,000 ha) (table 5).

Table 4. Mean displacement velocities of fuelwood gatherers.

Slope	**Displacement velocity (seconds spent per meter walked)**
0º - 8.5º	0.8
8.5º - 16.7º	1.2
16.7º - 24.2º	2.1
24.2º - 35º	4.5
35º - 45º	9

Source: Reestimated values from Puentes (2002).

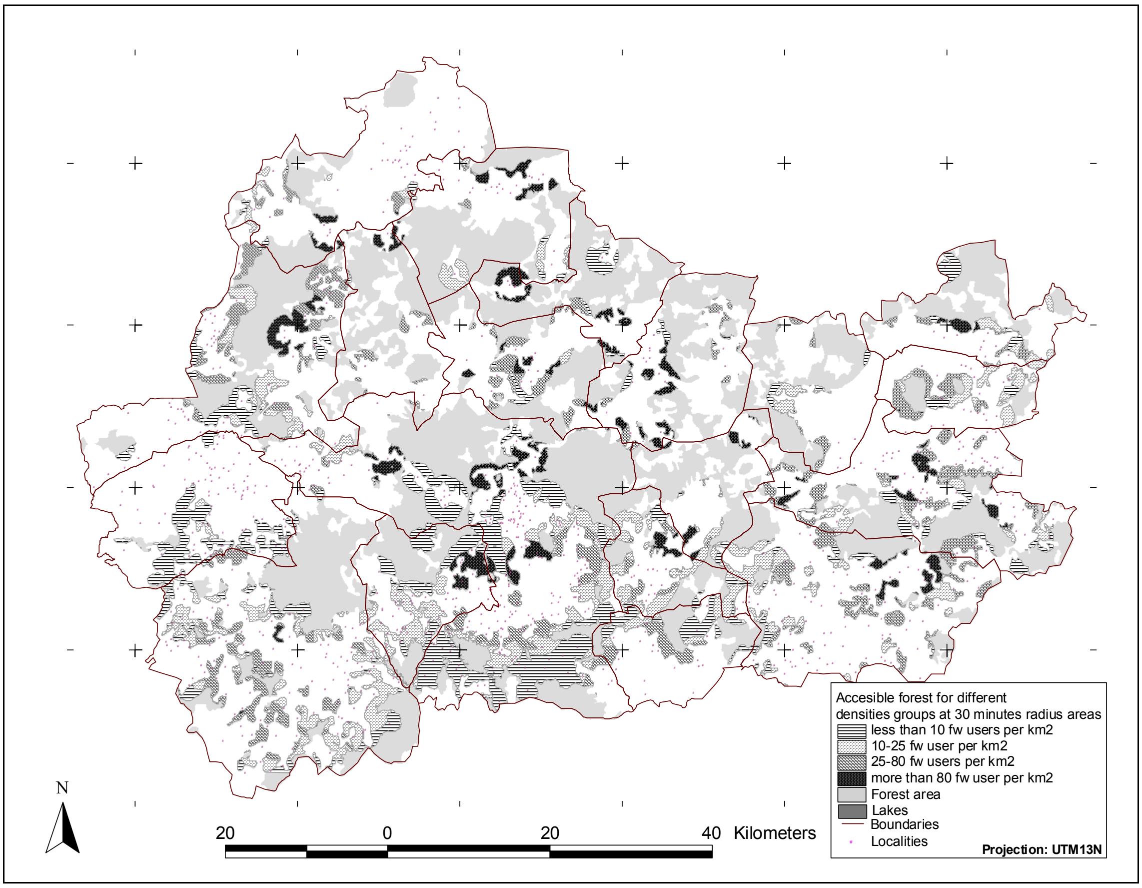
Table 5. Accessible forest areas of the “Purhépecha” Region by walking fuelwood gatherers.

	Area (ha)	**Percentage**
Total Forest Area of the “Purhépecha Region”	301397 ha	100%
Accessible forest areas at **30 minutes** radius areas around each settlement.	120867ha	**40%**
Overlapped accessible forest area with four population densities		
Less than 10 FW users per km^2	38,490 ha	**31,9%** of 40%
10-25 FW users per km^2	34,984 ha	**28,9%** of 40%
25-80 FW per km^2	30,710 ha	**25,4%** of 40%
More than 80 FW users per km^2	15,984 ha	**13,2%** of 40%
Accessible forest areas at **60 minutes** radius areas around each settlement.	241,757 ha	**80%**
Overlapped accessible forest area with four population densities		
Less than 10 FW users per km^2	113,706 ha	**47%** of 80%
10-25 FW users per km^2	51,656 ha	**21,4%** of 80%
25-80 FW per km^2	46,903 ha	**19,4%** of 80%
More than 80 FW users per km^2	27,291ha	**11,3%** of 80%

Figure 4 shows the potential forest areas (texturized surfaces) accessible for fuelwood extraction within the “Purhépecha” Region considering a 30 minute radius area around each settlement. Out of this range, under the model assumptions, the forest remains inaccessible for walking fuelwood gatherers (plain light gray).

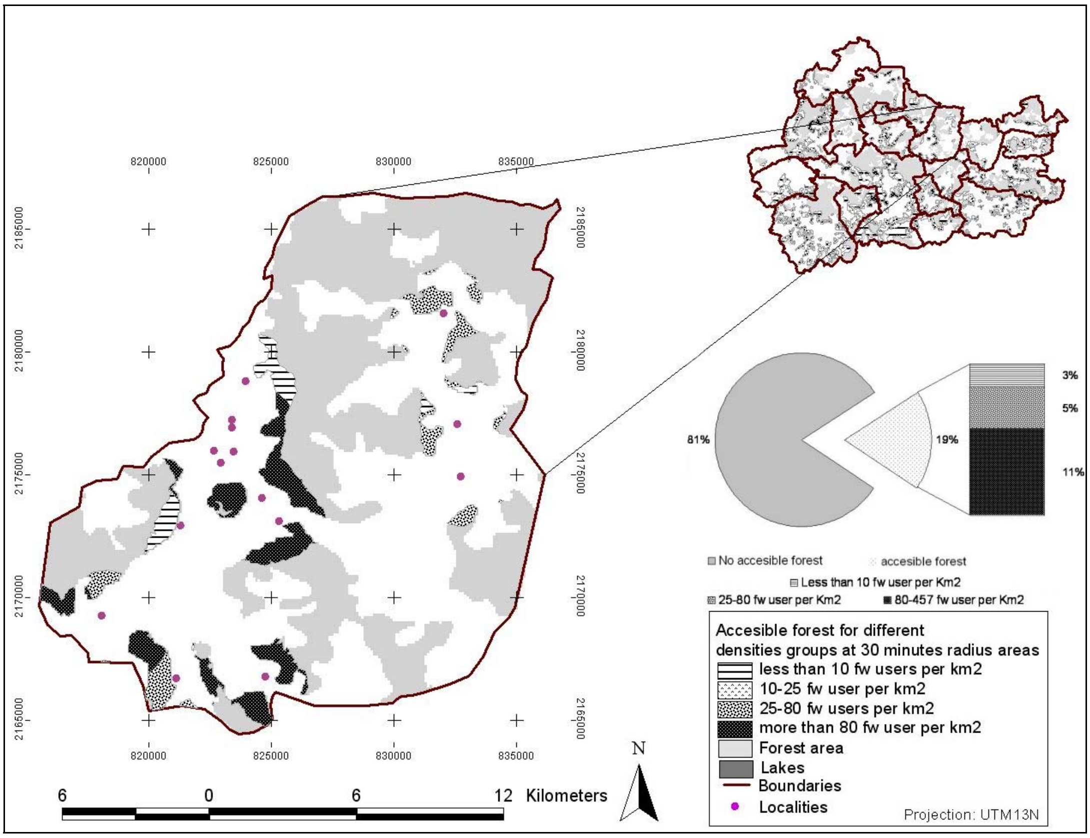
For categorizing those accessible forest areas, according to the pressure exerted by local people’s demand the following method was followed. Circle areas of 3 Km radius around each settlement were selected. These areas were then divided by the number of fuelwood users in each corresponding locality so as to calculate their densities. A reclassification in four groups was made considering new calculated intersection densities (due to the overlapping of primary densities for all 3Km circles). Finally, this fourth density range map was overlapped to the accessible forest for identifying priority areas within the accessible forest. Figures 4 and 5 show the accessible forest areas for each density group (one texturize surface for each group). Dark areas represent the highest priority sites, considered by the model as prone to degradation because of the pressure (i.e. density) exerted by local fuelwood users. All dark areas sum almost 16,000 ha, corresponding to 13% of the total accessible forest of the region (table 5). This new priorization lays on the assumption that fuelwood demand is concentrated over more populous settlements and their close forest areas. It is important to remark that this kind of analysis only identifies priority areas with respect to an expected situation. Local surveys for quantifying forest harvesting on degradation as a cause from fuelwood extraction practices should be made in order to identify areas at risk from fuelwood shortages, based on site-specific information.

Figure 4. Accessible forest areas of the “Purhépecha” region at 30 minutes radius areas around each settlement.



Accessibility analyses, as any mathematical model, need continuum improvement. More sophisticated analyses may include the use of friction functions of velocity displacement according to land cover classes; fuelwood gatherers using motorized vehicles; registry land data; fuelwood market dynamics; small industrial woodfuel demand; woody biomass productivities by forest type; and biomass/woodfuel conversion factors. Most of the new assumptions must be made using local data from site-specific surveys. When considering these recommendations, accessibility analyses should be used as a needed link in a logical hierarchical approach, which goes from localizing priority “municipios” at a national level, to selecting community forest areas where action is needed.

Figure 5. Accessible forest areas of "Nahuatzen", in the "Purhépecha" region at 30 minutes radius areas around each settlement.



6. CONCLUSIONS

Most developing countries with high rates of woodfuel consumption also lack the financial resources needed for the design and implementation of appropriate policies to combat woodfuels scarcity and its associated environmental impacts (e.g. deforestation). Multiscale assessments of woodfuel priority areas appear as an attractive option for concentrating government resources to critical areas. Risk zones are those were action should be taken. National policy planning should be carried out considering those critical areas identified at the broadest scale (Figures 1 and 2). Practical implementation of policies should then be taken considering the specific areas identified at the minimum level of analysis. In other words, we need to go from planning to action following the emergent properties and characteristics that appears for each successive scale of analysis.

Considering the Mexican example: a national priorization using WISDOM allowed the identification of 262 "municipios" out of 2402, leading to a reduction of target areas of almost 90%. Following the hierarchical framework stated above, an accessibility analysis was conducted over the "Purhepecha" region. This region is conformed by a group of "municipios" classified by WISDOM as mid, mid-high and high priority. This new priorization allowed the identification of those forest areas, within critical "municipios", under pressure because of their accessibility by fuelwood gatherers.

Woodfuels multiscale assessment helps in identifying areas where intervention is most needed, optimizing those government resources designated for the sector. This is a contribution to the sustainable use of woodfuel resources as increases the feasibility of implementation of national plans.

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WORKING GROUP 4: BIOMASS RESOURCES

International Seminar on Bioenergy and Sustainable Rural Development
- 5th LAMNET Project Workshop – Mexico 2003

SALICORNIA *PACIFICA*: UNA ALTERNATIVA ENERGÉTICA SUSTENTABLE

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RESUMEN

El "vidrillo" *Salicornia pacifica* planta halófita que desarrolla en las marismas costeras del Estado de Sinaloa y que tiene un potencial probable en mejoramiento del ambiente, alimenticio y como fuente para la obtención de biocombustibles, es contemplada como una alternativa de aprovechamiento, considerando su posible domesticación. En este estudio se reportan datos preliminares que incluyen: habitat natural, características de la especie, parámetros físicos y químicos del suelo y agua donde se desarrolla, así como de los componentes físicos y químicos del follaje. La planta desarrolla en áreas de esteros ubicadas entre manglares y tierra firme. Se describe como *Salicornia pacifica* dispuesta por sus características taxonómicas en la Familia Chenopodiaceae de la División Spermatophyta. Los suelos de su crecimiento son arenosos y migajonosos, alcalinos con altas concentraciones de sales, pobres en materia orgánica y de baja fertilidad. Los análisis bromatológicos de las partes tiernas y maduras del follaje muestran diferentes valores con porcentajes medios de proteínas y grasas y alta digestibilidad *in vitro*. Los análisis proximales en semilla otorgan valores medios en grasas. Hasta lo analizado, este estudio indica la posibilidad de utilizar a la Salicornia *pacifica* como forraje y/o para la producción de aceite vegetal.

ABSTRACT

Salicornia pacifica "vidrillo" halophytic plant from coastal lands of Sinaloa State with a probable potential in environmental enhancement, feeding and like a source to obtain biological fuels, is visualized as improvement alternative, considering its possible domestication. This paper present preliminary information about natural habitat, Species atributes, physical and chemical soil, water and foliage parameters. This plant grows better between mangrove areas and firm-land. It´s taxonomic named *Salicornia pacifica* belonging to the Chenopodiaceae Family of the Spermatophyta Division. Salicornia growing soils are alkaline sandy and loamy soils with high salty concentration, poor in organic matter and low fertility. Bromathological analysis show different values in fresh and mature plant parts considered, with medium percentage in oils and proteins and high digestibility *in vitro*. Seed proximal analysis show medium values in oils. Perspective actually about foliage and seed analytical results show probable foddery and/or oil use with this plant.

INTRODUCCIÓN

El cambio climático es ya un hecho reconocido por todos. En México se comienza a tener una mayor conciencia del potencial que ofrece el aprovechamiento de residuos urbanos, desechos de animales y de biomasa. La cuantificación de éstos es una tarea complicada y no existen en México datos precisos, salvo las estadísticas que presenta anualmente el balance nacional de energía en el que consignan las cantidades consumidas de leña y bagazo de caña. El uso de la energía de la biomasa como porcentaje de la energía total en el país es de 3.7% (Secretaría de Energía, 1996).

La utilización de energías alternativas más limpias, se presenta como la única manera de mantener un nivel de vida alto, además de un equilibrio con el medio ambiente. Una de estas energías renovables y limpias la constituyen los llamados biocombustibles, que aunado al aumento del precio de los combustibles fósiles en el futuro, pueden tener un potencial económico significativo.

El biodiesel es un biocombustible líquido que puede obtenerse a partir de aceites vegetales. Es posible la obtención de aceites a partir de más de 300 especies vegetales, fundamentalmente a partir de semillas y frutos. El aceite se obtiene normalmente por compresión y extracción. Una operación adicional, la transesterificación, permite obtener ésteres que se pueden aplicar en motores diesel.

El coste de producción de los biocombustibles es actualmente aproximadamente el doble del coste de la gasolina o diesel, pero sería posible abaratarlo cultivando grandes extensiones con plantas potenciales de suelos salinos y áridos, que puedan ser regadas con agua de mar y procesando las materias primas en empresas especializadas.

La domesticación y aprovechamiento de plantas que crecen en condiciones difíciles, son aspectos prometedores, por ejemplo la agricultura con agua de mar ha tomado dos direcciones: en la primera, algunos investigadores han atemperado a especies con tolerancia a la sal entre los cultivos convencionales, tales como la cebada y el trigo; otros investigadores han tratado de domesticar plantas tolerantes a la sal, silvestres, llamadas halófitas, para su uso como alimento, forraje y producción de aceite. Nuestra aproximación se centra en este último punto. La información pertinente de plantas que desarrollan en ambientes salinos como *Salicornia bigelovii,* ha mostrado las bondades de ese vegetal como una oleaginosa de alto valor alimentario (Ayala y O`Leary, 1995; Glenn, 1998; Grattan et al, 1999; Lu et al, 2000; Ortega –Nieblas et al,2000).

Salicornia bigelovii es una planta tolerante a la sal que se puede cultivar en áreas costeras y ser utlizada para forraje o para la producción de aceite de alta calidad. Se caracteriza por alcanzar alturas promedio de 50 cm, con vástagos suculentos verde-articulados y flores minúsculas. Las semillas desarrollan en pequeños hoyos en las axilas de las ramas y pesan cerca de 1 mg y germinan directamente en el agua. El desarrollo de las semillas maduras en *Salicornia*, ocurre en un lapso de aproximadamente siete meses, si la planta se siembra en diciembre, puede ser cosechada en julio (siguiendo los criterios de siembra del arroz) (Barreras-López et al, 2000; Charnock, 1988).El contenido de la sal en los suelos puede estar en 30% o más alto.

Cuando la planta se macera para la producción de aceite, puede producir hasta 30%. El aceite de las semillas de la especie *Salicornia bigelovii*, contiene el siguiente perfil de ácidos grasos:

Palmítico	6.9%
Esteárico	2.3%
Oléico	*14.1%*
Linoléico	73.1%
Linolénico	2.4%
Otros	1.2% (Mota-Urbina, 1990)

El litoral sinaloense cuenta con 656 kilómetros, 221,600 hectáreas de lagunas litorales y 57,000 hectáreas de aguas continentales. En el área de lagunas litorales se alojan 12 bahías, 15 esteros, 14 marismas, 2 lagunas, una desembocadura y una boca de río (Gobierno del estado de Sinaloa, 1991). En el área de influencia de las marismas predominan halófitas como los vidrillos *Suaeda* y *Salicornia* (Flores-Campaña et al, 1990). *Salicornia pacifica* representativa de la región, es una planta que por su probable potencial en mejoramiento del ambiente, como alimento y para la obtención de aceites para su conversión a biocombustibles se le ha contemplado como una alternativa de aprovechamiento, considerando su posible domesticación (Siordia et al, 2000).

Los suelos donde se desarrolla esta planta, se caracterizan por ser de texturas migajonosas y arcillosas, con pHs alcalinos que oscilan de 7.6 a 8.6 (Siordia et al,2000).

Debido a que se tiene poca información ecológica, química y física de esta especie (*Salicornia pacifica),* en este proyecto se reportan las características de la especie, los parámetros físicos y químicos de los suelos donde se desarrolla y resultados de los análisis de componentes químicos del follaje.

METODOLOGIA

Colecta de plantas y suelo.

Se hicieron recorridos hacia las playas Ceuta, para la toma de muestras. En el caso de *Salicornia*, se colectaron plantas completas y otras cortadas al nivel del cuello de la raíz. Las muestras de suelo de aproximadamente 2 Kg fueron dispuestas en bolsas de plástico etiquetadas.. Se describió además el ambiente de la vegetación circundante.

Descripción taxonómica.

La caracterización de los ejemplares botánicos colectados, se realizó en el herbario de la Escuela de Biología de la Universidad Autónoma de Sinaloa, utilizando los manuales correspondientes (Shreve y Wiggins, 1964; Standley 1920-6).

Análisis físicos y químicos de suelo.

Las muestras de suelo tomadas de 0 a 30 cm de profundidad, fueron secadas, molidas y tamizadas en malla de 2 mm de poro para las siguientes determinaciones: textura, color del suelo, densidad aparente, porcentaje de humedad, porcentaje de sales solubles, pH, conductividad eléctrica, cationes y aniones solubles, fósforo, capacidad de intercambio catiónico, porcentaje de materia orgánica, porcentaje de nitrógeno y sales intercambiables (Black, 1965; Gandoy-Bernasconi, 1991; Ruiz-Bello y Ortega-Torres, 1979; Personal del Laboratorio de Salinidad de los E.U.A., 1974; Velasco-Molina, 1983).

Análisis bromatológico del follaje y semilla..

La determinación de porcentaje de humedad, se realizó por secado en horno a la presión atmosférica. Las cenizas totales se midieron por incineración a 550^0 C considerando diferencias de pesadas para la obtención de porcentaje. El porciento de grasa se obtuvo con el método Soxhlet. La proteína cruda en porcentaje fue determinada por el método Kjeldahl de conversión del nitrógeno y la fibra cruda por digestión e incineración (AOAC, 1980; Egan et al,1993).

Digestibilidad in vitro

La digestibilidad in vitro se realizó utilizando el equipo DAISY II de la compañía ANKUM. La digestibilidad en vitro de forrajes con este equipo es similar a la técnica tradicional de Telley y Terry. (Pollard et al 2002)

RESULTADOS

Condiciones naturales

La vegetación de las áreas estudiadas corresponde a vegetación de marisma, ubicada en esteros entre el bosque de mangle y la porción continental (Figura 1). Representante típica de lo que se denomina humedales costeros (Rzendowski, 1983).

Figura 1. *Salicornia pacifica* en su hábitat natural

Descripción taxonómica

La Especie colectada se describió como *Salicornia pacifica* (Figura 2), pertenece a la Familia Chenopodiaceae del Orden de las Caryophyllales en la Clase Magnoliopsida de la División Spermathopyta y se caracteriza por ser una planta arbustiva perenne, recostada, erecta o postrada. Con uniones estrechas en nodos de 2 a 5 mm de espesor; las hojas reducidas a un collar perfoliado con los extremos opuestos, estas a menudo oscuras, glabras, cenizas o verdes; ramas de 1 a 10 cm de longitud, terminando las últimas con uniones de 1.5 a 2.5 mm de largo, generalmente más anchas que largas; flores con 4 o 3 sépalos fusionados, con dos estambres, no simultáneos en la floración; las semillas cubiertas con pelos blancos, derechos o adheridos.

Figura 2 Etapas en la formación y maduración de la semilla en *Salicornia pacifica*

Características físicas y químicas de suelos.

Los resultados del análisis de suelos y agua, se presentan en las tablas 1 y 2 e indican en suelo el predominio de texturas arenosas y migajonosas de coloraciones cafés a grises pálidos, con pHs alcalinos oscilando de 7.8 a 8.4, su conductividad eléctrica es alta debido a las altas concentraciones de sales solubles donde predominan los iones cloruro y sodio, pobres en materia orgánica, nitrógeno y fósforo y su CIC es baja oscilando de 11.6 a 17.08..

Tabla 1. Análisis Físicos de suelos de marisma en la Bahía de Ceuta (Profundidad 0-30 cm)

Muestras	Textura	Color del suelo		Densidad aparente (g/mL)	Espacio poroso %	% humedad
1	Arcillosa	10 Yr 4/2	10Yr 6/2	1.04	43.80	53.0
2	Migajón-limosa	10 Yr 3/2	10 Yr 6/2	1.53	37.15	26.0
3	Arcillo-limosa	10Yr 4/2	10Yr 5/2	1.23	41.15	48.0

Tabla 2. Análisis Químicos de suelos de marisma en la Bahía de Ceuta (Profundidad 0-30 cm)

Muestras	pH 2:1	CE ds/cm	Ca meq/L	Mg meq/L	Na meq/L	K meq/L	Cl meq/L	CO_3 meq/L	HCO_3 meq/L
1	9.2	62.1	20.2	106.5	415.6	12.0	5822	0	37.5
2	8.9	70.3	35.0	130.0	706.5	15.0	675.0	0	45.0
3	8.6	71.3	25.0	140.0	611.9	10.0	633.5	0	29.5

Tabla 2. Continuación

Muestras	M.O. %	N %	P-PO_4 Kg/ha	CIC meq/100g	Cationes intercambiables			
					Ca meq/100g	Mg meq/100g	Na meq/100g	K meq/100g
1	0.11	0.005	17.0	37.0	1.8	25.6	7.7	1.85
2	0.57	0.028	10.0	36.6	2.2	24.0	8.6	1.80
3	0.52	0.028	17.0	34.4	1.2	24.8	6.5	1.90

Análisis bromatológico y Digestbilidad *in vitro*.

El contenido de proteínas del follaje es del 12%. La concentración de cenizas es elevada, arriba del 25%. El contenido de grasa es elevado, más del 5%.
Su contenido de fibra cruda no es elevado y por consiguiente el porcentaje de elementos libres de Nitrógeno (E.L.N.) es aceptable por ser una porción energética y digestible de la materia seca.
La digestibilidad del follaje de la Salicornia es elevada (80.87%), sin embargo, habría que determinar la materia orgánica, por el alto contenido de cenizas. (Tabla 3).
La semilla, en base natural, tiene un nivel medio de aceite (4%) y alta fibra cruda (37%), por lo que habría que determinar su contenido en grasas, libre de testa. (Tabla 4)

Tabla 3. Resultados del Análisis Bromatológicos y Digestibilidad *in vitro* de materia seca de muestras de follaje de *Salicornia pacifica* obtenidas en la Bahía de Ceuta (2001-2002)

Muestras	M.S[1]	P.C[2]	Cenizas	E.E.[3]	F.C[4]	E.L.N[5]	D[6]
2001	30.67	12.18	26.05	5.92	17.30	38.55	---
2002	20.59	12.76	35.17	5.37	12.06	34.64	80.87

[1] M.S. Materia Seca
[2] P.C. Proteína Cruda
[3] E.E. Extracto Etéreo.
[4] F.C. Fibra Cruda
[5] E.L.N. Elementos Libres de Nitrógeno.
[6] D. Digestibilidad.

Tabla 4. Resultados del Análisis Químico Proximal de materia seca de semilla en base natural de muestras de *Salicornia pacifica* obtenidas en la Bahía de Ceuta (2002)

Muestra	M.S[1]	P.C[2]	Cenizas	Grasa	F.C[3]	E.L.N[4]
2002	92.33	2.71	8.43	4.16	37.58	47.12

[1] M.S. Materia Seca
[2] P.C. Proteína Cruda
[3] F.C. Fibra Cruda
[4] E.L.N. Elementos Libres de Nitrógeno.

CONCLUSIONES

De los resultados obtenidos se puede concluir:

- La planta estudiada pertenece a la Especie *Salicornia pacifica.*
- Su crecimiento se ubica en áreas de humedales costeros entre vegetación de manglar y de cactáceas.
- Los suelos donde se desarrolla son de naturaleza arenosa y migajonosa, alcalinos con altas concentraciones de sales y baja fertilidad.
- El contenido de proteínas del follaje es adecuado para el mantenimiento del ganado.
- La digestibilidad del follaje de la Salicornia es elevada.
- La semilla, en base natural, tiene un nivel medio de aceite.
- Lo anterior indica la posibilidad de utilizar a la Salicornia *pacifica* como forraje y/o para la producción de aceite vegetal.

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WORKING GROUP 5: SMALL-SCALE APPLICATIONS

International Seminar on Bioenergy and Sustainable Rural Development
- 5th LAMNET Project Workshop – Mexico 2003

WORKING GROUP SUMMARY

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The key elements identified for achieving sustainable solutions to household energy and health are:

- Understand user needs and conditions influencing the use and management of biomass for cooking, heating and small industries.
- Determine from the BEGINNING the measures of project impact and establish a baseline with which to compare on periodic basis during and beyond project timeframe.
- Take advantage of regional synergies, such as those between Mexico and various countries in Central America; some countries have more experience with indoor air pollution and health monitoring, while others have recent experience with technology development that is participatory, user responsive while focused on technology performance and efficiency.
- Include economic incentives to stimulate technology adoption. If dependence on full subsidies is to be reduced, people need to see a tangible benefit for changing behaviour. Health concerns may or may not be sufficient for self-replicating technology dissemination.
- Involve participatory processes for ensuring that technological solutions satisfy user needs, and fostering ownership of long-term maintenance responsibilities.
- Involve multiple disciplines in technology promotion and transfer, including in particular anthropology and other social sciences that enable a solid understanding of human behavior and preferences.
- Implement comprehensive planning, emphasizing complementary or synergistic activities, such as reforestation and water resource management.
- Innovate with micro-credit and finance mechanisms, including revolving funds at community level, to stimulate establishment of micro-entrepreneurs in cottage industries including tortilla-making, pottery, brick-making, bakeries, etc.
- Finance not only for technology but for planning and social processes and research (e.g. socio-economic and health impacts).

- Ensure proper DOCUMENTATION. Many lessons learned are lost for lack of documentation. Documentation should reflect the perceptions of the women and men who have participated in the projects, as these perspectives are often not captured through simple project assessment.
- Structure an approach to promotion that includes awareness-building (e.g. of health impacts, time and economic burdens, environmental impacts, and possible solutions); promoter development; and follow-up strategies including monitoring of measurable indicators.
- Consider various technological alternatives to inefficient use of biomass. These include improved biomass stoves, biomass gasification, solar stoves and ovens, biogas, LPG where appropriate, etc. The appropriateness of each of these options will depend in large part on their responsiveness to the needs and traditions, their ability and willingness to pay, their flexibility in making changes, and the social processes involved in transferring the technology.
- Be aware of risk when continuity of program support is lost. Implies emphasis on building local capacity, promoters, financial incentives and credit mechanisms.
- Include rural inhabitants as key participants in seminars of this nature.

Next steps…

- Establish an information network among participants of the International Seminar on Bioenergy in Morelia, in particular the participants of the working group session on small-scale applications.
- Develop an inventory of current and planned small-scale biomass/biogas projects in Mexico.
- Seek to build collaborations among participants and with other institutions.
- Develop project concepts that take an integrated approach, for possible funding (including under EPA's Partnership for Clean Indoor Air).

WORKING GROUP 5: SMALL-SCALE APPLICATIONS

International Seminar on Bioenergy and Sustainable Rural Development
- 5th LAMNET Project Workshop – Mexico 2003

FOGÓN RECICLADOR DE CALOR (FORECA)

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RESUMEN

Los fogones rústicos son muy ineficientes desde el punto de vista energético, ya que sólo aprovechan una mínima parte del calor que se les suministra. Estos fogones rústicos no permiten reaprovechar el calor generado al quemar leña o algún otro combustible.

Con el fin de aprovechar al máximo el poder calorífico de los combustibles se ha diseñado y experimentado un modelo de fogón que permite reciclar o reaprovechar el calor varias veces. Este fogón asemeja una escalera o un altar con varios niveles, en los cuales se pueden colocar varios utensilios de cocina, para aprovechar el calor durante más tiempo y en un mayor numero de etapas.

Este modelo de fogón reciclador ha sido desarrollado y evaluado en una comunidad rural de Chiapas, durante los años 80, precisamente en la zona actualmente ocupado por el EZLN, y ha tenido resultados muy alentadores: ya que ha permitido reducir el consumo de leña a menos de la mitad de lo anteriormente consumido.

Este modelo es susceptible de ser adaptado a las condiciones específicas de cada región, y seguramente será un coadyuvante para un desarrollo rural sustentable.

INTRODUCCIÓN

Una forma sustentable para poder contar con mayor cantidad de recursos energéticos, durante más tiempo, es reducir el consumo de los mismos, para que no se agoten tan rápidamente. En las viviendas, se necesitan energéticos, entre otros, para cocinar y calentar el agua de la ducha. Cuando se utilizan fogones s rurales convencionales, se desperdicia mucho calor, ya que este se aprovecha sólo una vez. En cambio, utilizando el modelo descrito en este trabajo, se puede reaprovechar el calor, por lo menos tres veces, haciendo rendir la eficiencia y eficacia energética en más del doble.

Este resultado se encontró durante la realización del proyecto de investigación titulado -"*Salud Comunitaria y Desarrollo Integrado. Tecnologías Apropiadas para el Trópico Cálido Húmedo, caso: Chiapas, México*", financiado por el Instituto Politécnico Nacional durante los años 1988-1990, producto del cual se publicó el libro titulado *Chiapas, Tecnologías Ambientales Socialmente Apropiadas*, en donde se mencionan con mayor detalle las características de dicho fogón.

ANTECEDENTES

El fogón más primitivo utilizado en el medio rural mexicano y del mundo consiste en esencia en tres o más piedras que sirven de soporte al comal, la cazuela, la olla u otro aditamento sobre el cual se cocinan los sagrados alimentos. Los fogones primitivos (figura 1) tienen muchos inconvenientes, dentro de los cuales se encuentran los indicados en el cuadro 1.

Cuadro 1. Inconvenientes de los fogones primitivos

1. Son **inseguros**, ya que es fácil que un animal o un niño empujen accidentalmente las piedras, dejando caer líquidos o sólidos calientes sobre alguna persona, provocándole quemaduras graves.
2. Son **peligrosos**, ya que puede originar incendios cuando las chispas viajan y prenden fuego en algún objeto combustible cercano.
3. Son **poco higiénicos**, puesto que dejan escapar mucho humo dentro de la cocina, provocando enfermedades respiratoria y de los ojos de las personas ahí presentes.
4. Son **incómodos**, ya que al estar al nivel del suelo, hay que agacharse para colocar o manipular los utensilios de cocina.
5. Son **poco eficientes** desde el punto de vista energético, debido a que la mayor parte del calor utilizado se escapa por las orillas, y no se puede reutilizar.

Fig. 1. Fogón primitivo

Para subsanar la mayoría de estos inconvenientes se empezaron a desarrollar fogones que muestran las mejoras indicadas en el cuadro 2. La figura 2 muestra un croquis de un fogón convencional.

Cuadro 2. Características de los fogones convencionales.

1. Se conforma el fogón con tres muros de ladrillos o piedras pegadas con mortero, dejando sólo un lado descubierto para introducir ahí la leña, lo cual lo hace **más seguro**, ya que no deja caer las ollas, ni deja escapar tantas chispas.
2. En la parte superior de los muros se coloca una placa metálica, que hace las veces de comal, sobre el que se cocinan las tortillas o se colocan las cazuelas u ollas para cocinar o calentar líquidos, de una manera **menos peligrosa**..
3. El fogón se coloca sobre una mesa, posiblemente de madera, pero que está cubierta con material incombustible, tal como la tierra, y de esta manera, se manipulan los utensilios sin necesidad de agacharse, de una manera más **cómoda.**
4. Se coloca una chimenea en el extremo más alejado de la boca del fogón, para que el humo viaje hacia el exterior de la cocina, sin contaminar la cocina, de una manera más **higiénica**.

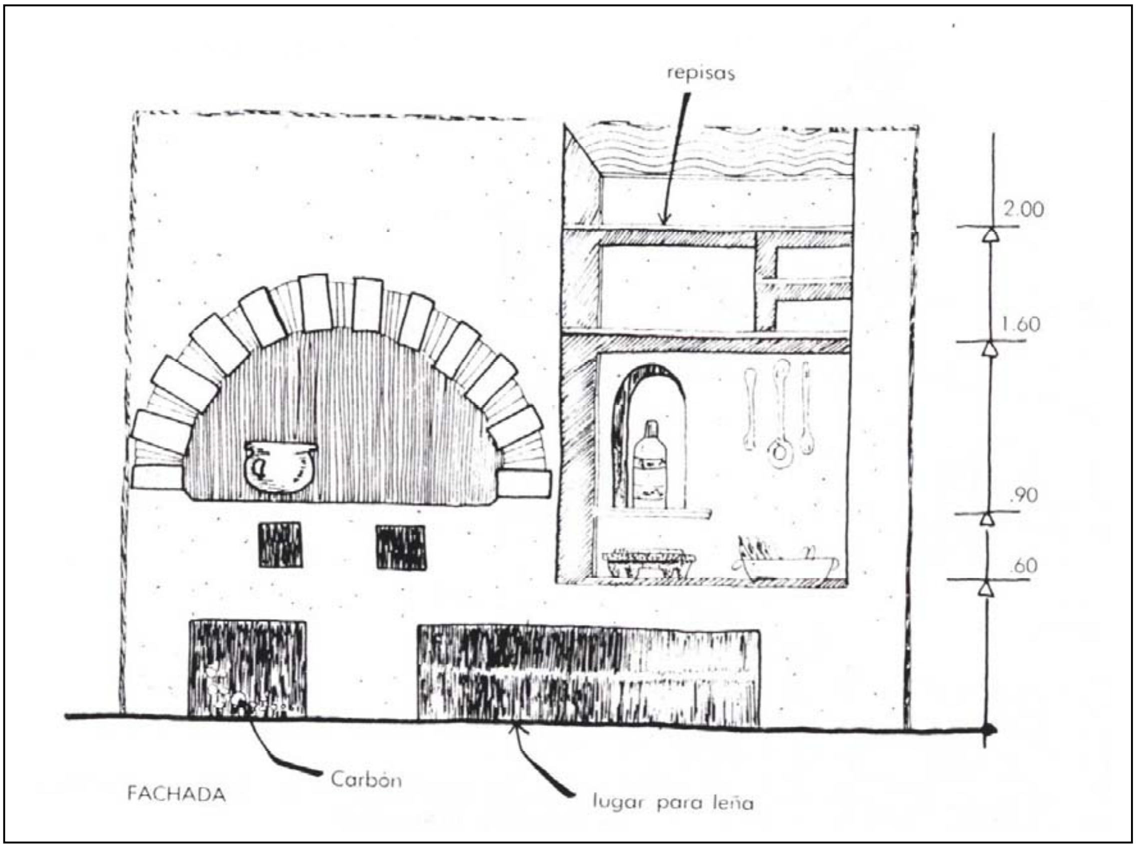

Fig. 2. Fogón convencional

OPCIONES AVANZACAS

Con la preocupación del agotamiento de los recursos forestales, se desarrolló en Guatemala un fogón denominado "LORENA", nombre derivado de LOdo y aRENA, el cual esta fabricado precisamente con estos materiales (figura 3).

Consiste esencialmente en un cubo de lodo y arena, en el cual se cava a partir de una de las orillas, para dejarle un túnel a través del cual circula el calor generado por la leña quemada en la boca del citado túnel. A cierta distancia se abren hoyos en la parte superior para que ahí se coloque un comal, una olla o una cazuela. Al final del túnel se instala una chimenea que permite salir el humo y calor residual hacia fuera de la cocina.

Este modelo ya permite reciclar el calor varias veces y constituye un avance notable respecto al fogón primitivo. Según reportes de Organizaciones No Gubernamentales (ONGs) guatemaltecas, este fogón resulto un éxito y sonaba muy interesante para reproducir esa experiencia en nuestro país.

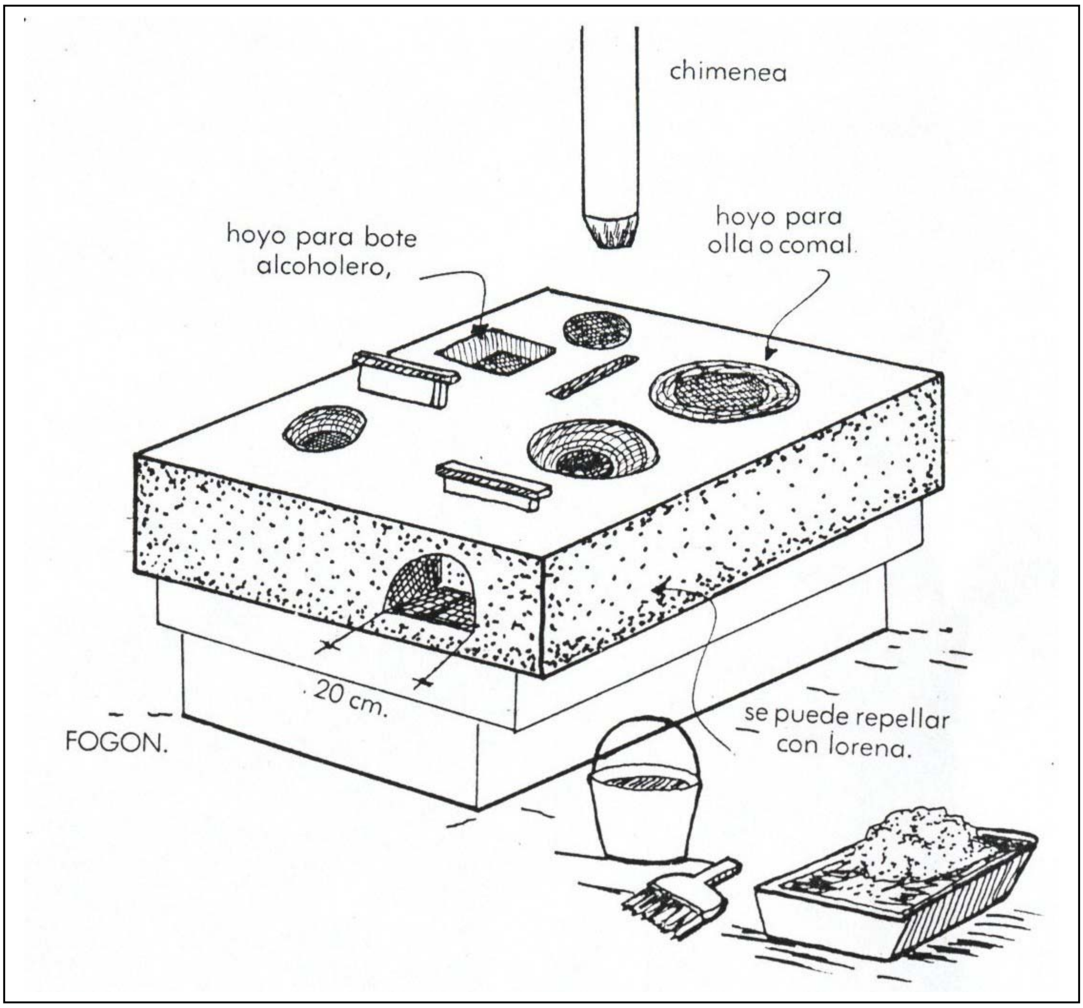

Fig. 3. Fogón Lorena

En Chiapas, dentro de la zona de estudio de nuestro proyecto de investigación, se construyeron algunos prototipos de este fogón Lorena, el cual resulto no tan atractivo como teóricamente se esperaba. Se le notaron varios inconvenientes indicados en el cuadro 3.

Cuadro 3. Inconvenientes del Fogón Lorena:

1. Es difícil de construir, ya que se requiere de un material especial, el barro, para poderle dar una forma adecuada.
2. El barro, si no es de la mejor calidad, se cuartea o se colapsa.
3. Si la abertura para colocar la olla, la cazuela o el comal no es exacta, habrá fugas de calor, o bien se calienta muy poca área.
4. Esos hoyos deberán estar siempre cubiertos, ya sea con la misma olla, comal o cazuela, o bien con otra cubierta, para evitar fugas.
5. El calor tiende siempre a subir, por lo que a veces se regresa en la boca del túnel, y no circula a lo largo de todo el fogón.

Al notar estas limitaciones, dentro de nuestro proyecto de investigación nos propusimos desarrollar un fogón que no tuviera estos inconvenientes

FOGÓN RECICLADOR DE CALOR (FoReCa)

Basándose en la idea del fogón Lorena, nos propusimos desarrollar un modelo mucho más versátil y fácil de construir, operar y mantener. Los principios físicos de funcionamiento del FoReCa son indicados en el cuadro 4.

Cuadro 4. Principios de funcionamiento del FoReCa

1. El fuego proveniente de la combustión de leña o algún otro combustible es producto de la reacción de compuestos orgánicos con el oxigeno, formando CO2. Este gas, por ser la reacción exotérmica, está caliente, y tiende a subir.
2. El gas caliente transfiere parte de su calor a las vasijas colocadas arriba, calentando al contenido de esos recipientes.
3. Si se conduce al gas caliente a través de un ducto sobre el cual se colocan varios comales o recipientes, calentará el contenido de lo que se coloque ahí.
4. En el primer comal, el calor está más concentrado, por lo que conviene colocar ahí las tortillas a cocinar o calentar, para que sea más rápido.
5. En el segundo comal el calor estará menos concentrado, por lo que conviene colocar ahí la olla de los frijoles, el arroz o el guisado que requiere de más tiempo, con calor moderado.
6. En el tercer comal, se puede colocar la cafetera, o el agua para el té, para conservarla caliente, pero no demasiado.
7. Posteriormente se puede colocar un gabinete en el que se podrá secar, cocer o ahumar, lentamente, vasijas de barro, carne u otro producto que se considere conveniente.

Las características físicas esenciales del FoReCa son indicadas en el cuadro 5.

Cuadro 5. Características del Fogón Reciclador de Calor (FoReCa)

1. Se coloca el FoReCa sobre una base constituida por un material no flamable, tal como tierra compactada o arena, la cual puede ir colocada sobre un cajón montado sobre una base o mesa.
2. El FoReCa estará conformado por dos muros laterales escalonados, (en forma de escalera) y un muro trasero, construidos con tabique, tabicón, adobe, piedra o algún otro material no flamable, pegado mediante mezcla de arena cemento, o mortero.
3. Sobre el muro escalonado se coloca una lamina que hará las veces de comal para cocinar tortillas en su primer escalón, y en los siguientes dos escalones, esta lamina servirá de apoyo para colocar la cazuela de los frijoles o arroz, o la olla para calentar el café, el té u otro producto.
4. En la parte baja interior del FORECA se puede colocar una charola para recoger las cenizas de la leña que se ha quemado, y para meter o sacar leños ardiendo.
5. Junto al muro trasero se coloca la chimenea metálica, que permite salir al humo y gas caliente.
6. Justo arriba de la chimenea, pero aun dentro de la cocina, se puede colocar un gabinete compuesto por una caja metálica con puertas, dentro del cual se pueden colocar charolar conformadas por tela gallinero, sobre la cual se puede colocar carne a ahumar, o cerámica a cocer.
7. Si se desea, también se puede hacer que la chimenea que sale del gabinete no suba de manera vertical, sino que vaya rodeando, de manera inclinada, para extraer aun más calor al gas caliente y calentar así el interior de la cocina.

Con el gabinete indicado se puede reciclar el calor hasta seis o siete veces, permitiendo ahorrar mucha leña y otros combustibles. Esta es una manera inteligente de ahorrar, y de hacer que rindan más los recursos.

Cabe mencionar que se construyeron primero unos prototipos en un centro comunitario de salud y en una escuela, donde los habitantes de la comunidad Amparo Agua Tinta, en el municipio de las Margaritas, Chiapas, (lugar actualmente ocupado por el EZLN) pudieron observar su funcionamiento y método de construcción, lo cual sirvió de ejemplo para que varias personas con iniciativa, construyeran su propio modelo, acorde a sus necesidades.

De las mediciones de consumo de leña con éste modelo de FoReCa, se vio que el consumo de combustible disminuyó a menos de la mitad de lo normal. Esto alentó a más personas a construir su propio modelo, cumpliendo con el objetivo de la investigación, que era “desarrollar tecnología ambiental socialmente apropiada”, que ayudara a conservar en buenas condiciones al ambiente y la salud de los habitantes del lugar, resolviendo el problema de escasez de combustibles, de deforestación, de erosión de suelos, y de enfermedades de los ojos y pulmones por el humo en la cocina.

En la Figura 4. se muestra una perspectiva del FoReCa, en donde se utilizan las siguientes claves.

A- Charola movible, donde se coloca la leña a quemar y se conservan las cenizas.

B- Muro de material no flamable, como tabique, tabicón, adobe u otro.

C- Comal de metal, movible, uno por cada escalón

D- Chimenea metálica, puede ir inclinada o vertical

E- Gabinete para secar o ahumar productos

F- Chimenea de salida del humo y calor remanente.

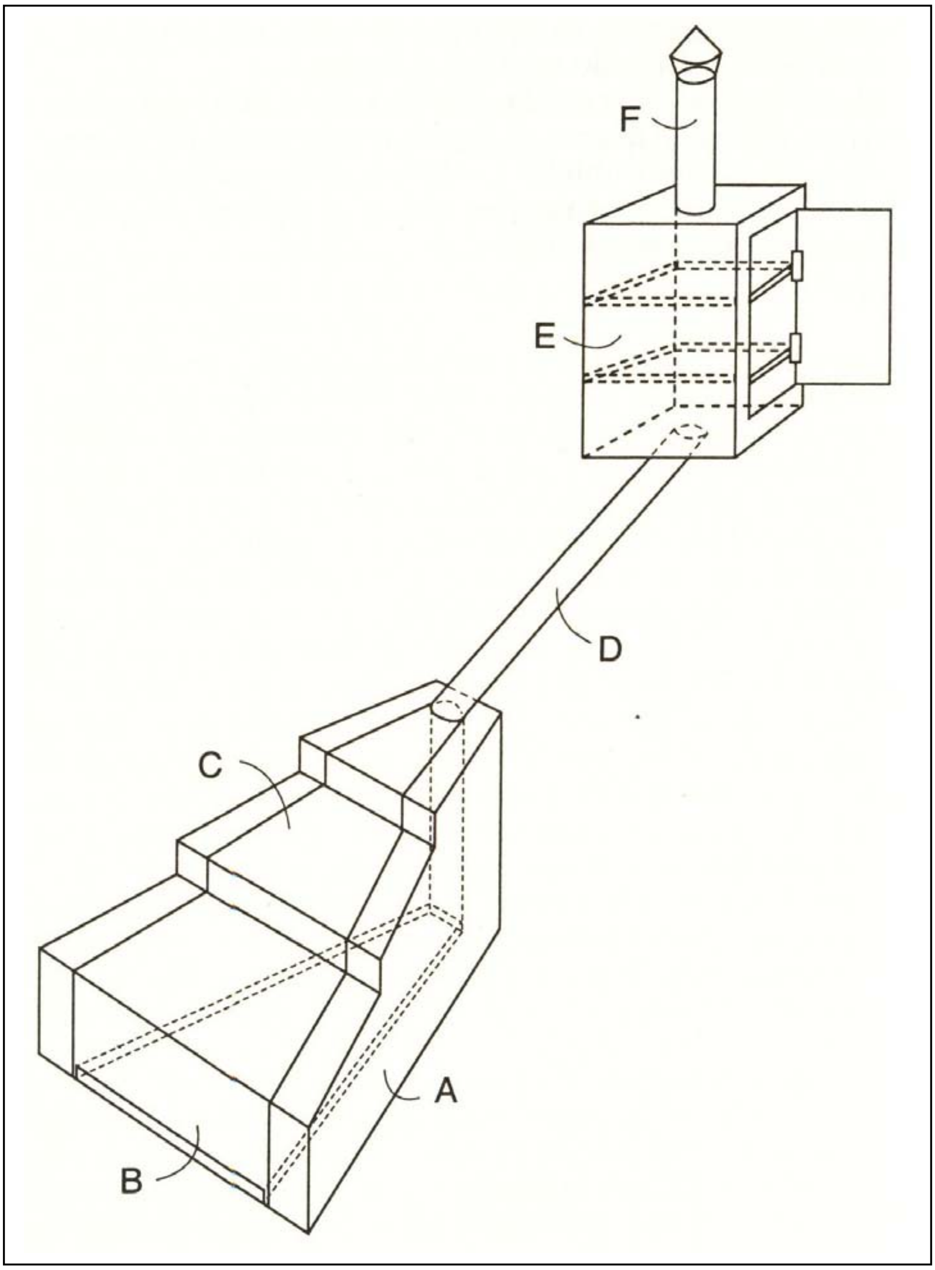

Figura 4: Vista en perspectiva del FoReCa

Además de este fogón, se desarrollaron en la misma investigación otras dos tecnologías ambientales socialmente apropiadas, una para captación y almacenamiento protegido de agua pluvial, y otra para eliminar excretas mediante una letrina mejorada con trampa lumínica de insectos y un extractor solar de aire, las cuales también vienen detalladas en el libro *Chiapas. Tecnologías Ambientale Socialmente Apropiadas,* citado en la bibliografía.

CONCLUSIONES

Durante la realización de la citada investigación, se notó que varias personas de la comunidad se interesaron en el fogón y empezaron a reproducirla con y aun sin asesoría nuestra, lo cual nos causo sorpresa y gusto a la vez, ya que lo que nosotros estábamos buscando era precisamente desarrollar tecnologías apropiadas, para que los miembros de la comunidad se las apropiaran, (aun sin pagarnos regalías), para que las sintieran propias, y pudieran irlas mejorando, por si mismos, tal como debe ser la tecnología apropiada.

Creemos que los miembros de la comunidad comprendieron la importancia de esta tecnología y por eso la empezaron a reproducir, muchas veces con mejoras, adaptándolas a sus particulares gustos, intereses y necesidades. Pero siempre respetando los principios físicos que la hacen funcionar

Una de las mejoras que detectamos, fue que hicieron convertible el primer escalón, ya que le introdujeron una parrilla metálica, la cual podría servir para asar carne o nopales. El inconveniente de esta parrilla es que el calor escapa por los lados y ya no permite reutilizar mas al aire caliente.

Sin embargo, los resultados obtenidos en general fueron muy promisorios, y esperamos que este FoReCa se siga extendiendo, con sus respectivas adecuaciones no solo en Chiapas, sino en todo el campo mexicano y mundial.

Consideramos que con la utilización sabia de los recursos, con el reciclaje ecológico será factible alcanzar el tan buscado desarrollo sustentable de nuestra sociedad.

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WORKING GROUP 5: SMALL-SCALE APPLICATIONS

International Seminar on Bioenergy and Sustainable Rural Development
- 5th LAMNET Project Workshop – Mexico 2003

NUEVOS RESULTADOS DE LA ESTUFA SOLAR RURAL DE CONCENTRACIÓN DE 2.3 kWth DE POTENCIA UTIL.

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RESUMEN

El presente artículo muestra los nuevos avances y resultados en la evaluación de la estufa solar rural de concentración. Este trabajo se inicio en 1999 y desde esa fecha hasta la actualidad se han modificado varios elementos del equipo (la estufa), para mejorar su rendimiento y prolongar su vida estimada de operación de 30 años, así como la construcción de una segunda estufa.

El equipo desarrolla entre 250 a 300 ° C en la superficie del contenedor y punto focal de incidencia, donde 360 espejos planos de 10X10 cm^2 de superficie los cuales se orientan sobre dos ejes focales de concentración, con dos motores de CD (Corriente Directa) se tienen también el seguimiento solar, uno para acimut y otro para altitud, con una torre de foto sensores, se dispone de un módulo solar fotovoltaico de 5 W- pico para operar al sistema con autosuficiente energética, mediante un banco de Condensadores Electrolitos.

Desarrollando un alto factor de calidad (relación de potencia útil solar/potencia eléctrica consumida para el seguimiento solar), y una alta eficiencia, aunque depende, tanto el factor de calidad, como el rendimiento, de las condiciones de radiación solar (relación entre la componente directa del sol y la componente difusa). Evita la quema de leña en cantidades importantes, lo que ayuda a la reducción de emisión de CO_2 a la atmósfera.

Tiene un peso aproximado de 200 kg. y una superficie total de 7.6 m^2. Puede esterilizar, desalar agua de mar, hervir agua para desinfectarla y cocer el maíz y el frijol, elementos básicos de la dieta mexicana. Cuenta con un contenedor de 13 litros de aceite reciclado automotriz, que da una autonomía energética de 30 a 60 minutos, dependiendo de las condiciones ambientales de temperatura ambiente, de la velocidad del viento y de lo que se desee cocinar.

Para zonas rurales no electrificadas y de alto índice de radiación solar, puede ayudar a mejorar la calidad de vida al aplicarse en centros comunitarios, escuelas albergues, así como ayudar a centros de salud, dada su versatilidad de aplicaciones puede ayudar a un desarrollo sustentable en los países en desarrollo.

Este proyecto ha sido apoyado económicamente por tres sectores, el sector industrial por medio de Industrias H. Steele y Cia S.A., el sector académico de la ESIME-IPN y el sector de Investigación por el CINVESTAV-IPNEs su genero de operación, autonomía energética, temperaturas alcanzadas, almacenamiento de aceite, eficiencia, figura de mérito y posibilidades de esterilizar, desalar agua y cocer maíz y frijol, hace innovador este equipo internacionalmente y brinda la posibilidad de desarrollarse masivamente.

INTRODUCCIÓN

El desarrollo rural sustentable involucra muchos factores; nivel económico del país, marginación, idiosincrasia (hábitos y costumbres), grado de electrificación, acceso a las comunidades, acceso o infraestructura de centros de salud, hábitos en el régimen alimenticio, disponibilidad de la energía, infraestructura educativa, contaminación por quema de madera, tipo de vivienda y ubicación geográfica de las comunidades rurales por apoyar, entre las más importantes.

México es uno de los países que cuenta con un alto índice de radiación solar en el mundo (5.2 kW-h/m^2-día)[1], dado que, tiene también uno de los 5 desiertos y las ¾ partes de su territorio nacional es considerada zona árida o semi–árida. De aquí que, desarrollar equipo solar encaminado hacia estas comunidades, haga importante la estufa rural solar de concentración presentada en este artículo, como apoyo al desarrollo sustentable.

El consumo de leña por persona estimada en México es del orden de 1.26 toneladas/persona - año[2] sumado al tiempo que se invierte para su colección, esto cuando se cuenta con el producto proximo, pero si hay que invertir un día o más de una jornada laboral para colectar la leña con sus implicaciones de deforestación, horas hombre invertidas, quema de esta dentro de la casa y producción de CO_2 a la atmósfera, se puede concluir que los equipos a utilizarse deberán mejorar la calidad de vida por una parte y por la otra reducir la degradación del media ambiente al reducir la producción de gases que acentúen el efecto invernadero.

Ante este panorama nacional y también típico de los países alternativos que se encuentran entre los trópicos (Cáncer y Capricornio), además de contar con altos índices de radiación solar o más específicamente un alto índice de componente directa de la radiación solar comparada con la componente difusa del sol, hace imperativo desarrollar equipo que pueda mejorar la calidad de vida de las 3,067 comunidades no electrificadas del país y coadyuvar a la mitigación del efecto invernadero, que día a día empieza a acentuarse con fenómenos meteorológicos de cambios climático globales, manifestados en el años del niño y de la niña entre otros. La experiencia de estufas solares en México se remonta a 1955 cuando los ingenieros consultores Duffie, George Lof introducen 30 estufas solares para prueba en campo en Monterrey y Torreón desarrollada por la Universidad de Wisconsin [3] (figura 1).

Figura 1 Estufa solar tipo sombrilla invertida plateada modelo Wisconsin # 2

Los resultados después de un mes de trabajo y sumado a un estudio financiado por la Fundación Rockefeller en comunidades Indígenas de USA se concluyo que:

1. El aspecto socio - cultural y las costumbres milenarias de cocinar dentro de las casas con el fogón de tres piedras predominaban sobre la innovación tecnológica de la estufa solar.
2. Obligar al ama de casa a volverse astrónoma para ajustar la posición de la estufa cada hora, distraía sus ocupaciones.
3. Los destellos de la estufa fuera de foco, lastimaban la vista del usuario con su correspondiente desanimo para seguirla utilizando.
4. En países tropicales, la posición de la estufa es casi horizontal en varios días al año, lo que origina que el fondo de la estufa se ensucie de cochambre dentro del proceso de cocción.
5. La estufa semi - parabólica, presenta dificultades ergonométricas y origina sombra del usuario en su operación.
6. Lo frágil de la estufa originaba que el aire, los animales o niños jugando la derribaran ocasionado daños irreparables de la sombrilla invertida.
7. La obstrucción de los rayos del sol por nubosidad, originaba una interrupción en el proceso de cocción.
8. En las zonas rurales se trabaja muy temprano en el campo y se retorna al hogar ya por la tarde, ambas condiciones no son muy apropiadas para aprovechar el solar.
9. La dieta mexicana de comer maíz y frijol, demanda forzosamente un alto consumo de energía que las estufas solares convencionales inferiores a 500 W, no cumplían las expectativas deseadas. La composición fotográfica de la figura 2 muestra algunas de estas estufas, de caja y parabólicas del orden de 600 W

Estufa tipo caja de Portugal

Estufa SK2 en Africa

Estufa SK 2 en exposición.

Figura 2: Composición fotográfica de tres estufas menores de 1 kW de potencia solar aprovechable.

En la siguiente composición fotográfica de la figura 3, se muestran estufas solares de mas de 1 kW de potencia solar aprovechable.

Figura 3 Muestra de dos trabajos de estufas solares en Egipto y en Centro América, con potencias útil mayores al kW.

Con todos estos antecedentes, se trabajo en el prototipo de estufa solar rural de concentración como respuesta a la necesidad de aprovechar un recuso tan abundante en México como es la Energía Solar.

DESARROLLO

La figura 4 muestra el prototipo desarrollado, donde se aprecia una vista frontal de la estufa solar rural de concentración con sus diferentes elementos necesarios para su operación: dos motores de CD, el módulo solar Fotovoltaico, los 360 espejos planos de 10X10 cm^2, todo el peso de 200 kg esta sustentado en un muñón esférico, toda la estructura es de aluminio que garantiza una larga vida.

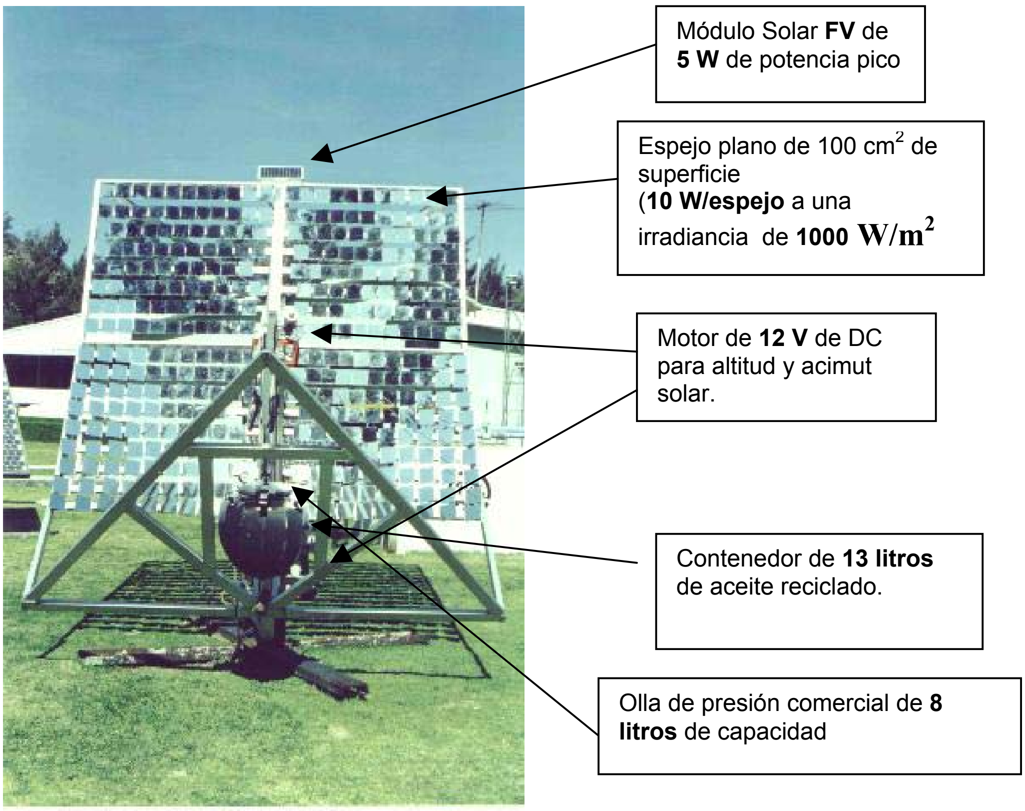


Figura 4 Vista frontal de la estufa solar rural de concentración de **2.6** $\mathbf{kW_{th}}$ aprovechables.

Las condiciones ambienta son determinantes para la eficiencia de la estufa solar rural de concentración, específicamente el viento y las condiciones de irradiancia en lo referente a la componente difusa y directa de la radiación solar a lo largo del día. También influye el tipo de producto que se quiere cocer, recordemos que el grado de libertad de la estufa es de 360 ° para el ángulo acimut y de 30 ° a 90 ° para el ángulo de altitud solar como se ilustra en la figura 5.

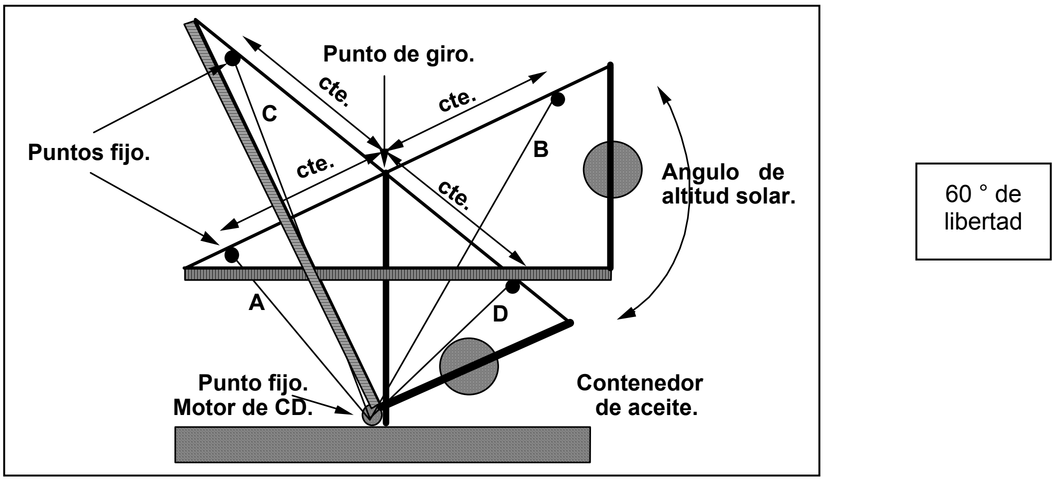


Figura 5 vista esquemática de la estufa solar rural con 60 ° de libertad en el ángulo de altitud solar.

La siguiente composición fotográfica de la figura 6 muestra diferentes aspectos operativos de la estufa solar rural de concentración, donde alcanzo 120 ° C con una irradiancia de 950 W/m^2 a una presión de 1.05 kg/cm^2.[4]

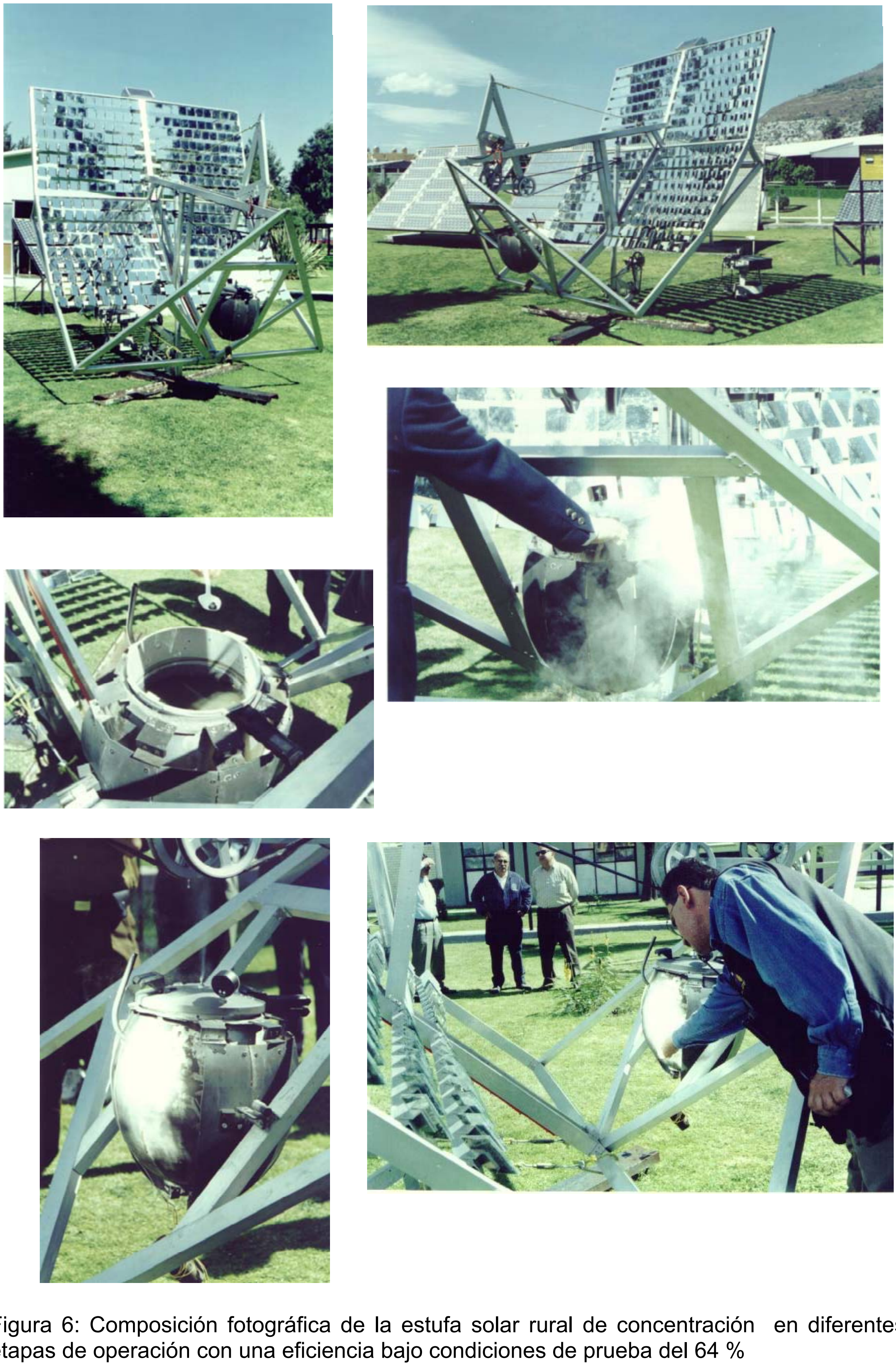
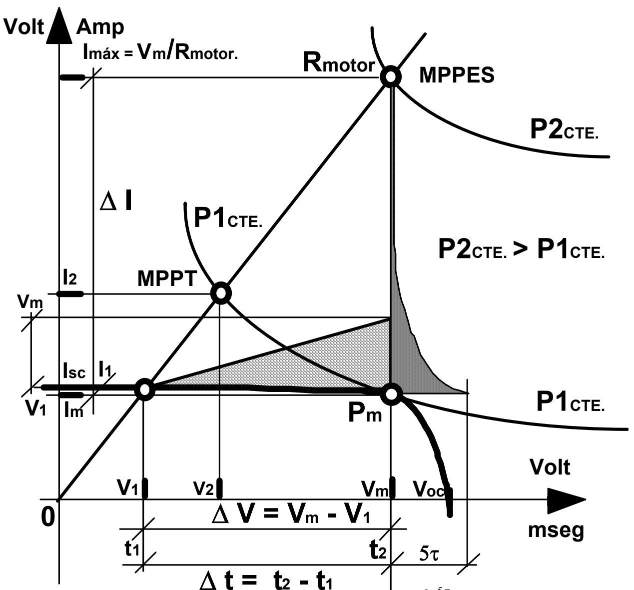


Figura 6: Composición fotográfica de la estufa solar rural de concentración en diferentes etapas de operación con una eficiencia bajo condiciones de prueba del 64 %

NUEVOS RESULTADOS

No se había desarrollado la autonomía energética con el módulo solar fotovoltaico de 5 W para el seguimiento solar experimentalmente[4], solo se había desarrollado en teoría, tampoco se había evaluado en condiciones de baja irradiancia directa o una alta irradiancia difusa. Si las condiciones de componente directa son bajas, la eficiencia decrece hasta el 30 % dado que se mide con respecto a la cantidad total del recurso solar incidente

Se ha desarrollado un nuevo concepto de MPPES (máximun power point energy sorage) en sistemas solares fotovoltaicos, el cual se base en almacenar energía en un banco de Condensadores Electroliticos de 78,000 □fd, 104,000 □fd y 182,000 □fd. En la figura 7 se tiene una composición de dos gráficas, en una se tienen los ejes de I-V para visualizar el concepto de MPPT (Seguimiento del punto de potencia máximo), sin embargo también se han superpuesto los ejes de V- t para indicar el almacenamiento de energía y su transferencia al motor de DC. De aquí que sin romper el principio de conservación de la energía se tengan 5 W-p fotovoltaicos, es posible mover dos motores de 32 Watt c/u correspondiendo al seguimiento de altitud y acimut solar.



$$\frac{1}{2}CV_m^2 = \int_0^{5\tau} \frac{V_m^2}{R_{motor}} \exp\frac{-2t}{\tau} dt$$

MPPES
(Maximun Power Point Energy Storage)

Figura 7: Gráfica del seguimiento del punto de potencia máxima y del punto de almacenamiento de energía máximo, MPPT y MPPES.

El sistema de tracción es mediante juego de poleas con motores de DC, han dado muy buen resultado teniendo como valor de desplazamiento de 6.5 minutos para 180 ° de carrera en lo referente al ángulo de acimut solar, el ángulo de altitud es más lento por la cantidad de trabajo que debe desarrollar obteniendo 10 minutos para dar los 60 ° de libertad en el seguimiento de altitud solar.

Se ha medido las diferentes constantes de tiempo de descarga de los bancos de almacenamiento de energía, siendo del orden de 0.38 segundos, 0.5 segundos y de 0.9 segundos, para los diferentes valores de capacitancias.

Se dispone de una configuración tipo H para el control de los motores de DC con lo que se puede hacer girar la estufa para cualquier latitud del globo terrestre.

Se tienen bajo prueba diaria los dos motores trabajando con este concepto, dando resultados muy satisfactorios que se mencionaran en las siguientes conclusiones.

CONCLUSIONES

La eficiencia de la estufa solar para dos condiciones de evaluación ha sido determinada de 30 al 64 %, siendo este margen consecuencia del contenido de radiación directa y el contenido de radiación difusa, por una parte y por otra, debido a las condiciones de viento y temperatura ambiente.

La estufa solar rural presente un alto factor de calidad, si definimos a este como el cociente de la potencia útil térmica entre la potencia útil del módulo solar FV, dando un factor de 520 unidades.

Con 5 W FV es posible evitar que se quemen a la atmósfera en condiciones optimas 5.32 Ton/año o bien quemar 2.97 Ton/año de leña.

El valor de venta del equipo instalado se ha contemplado de $ 30,000.00 pesos MN o bien de USD $ 3,000.00

Se estima una vida pormedio de 30 años sobre la cual se han determinado los valores de costo de la energía y costo del watt pico instalado.

El costo equivalente de la energía térmica a eléctrica en condiciones óptimas es del orden de 0.30/kW-h pesos MN o **USD ¢ 3.0/kW-h**.

El costo del **W-pico** instalado para esta aplicación es de $ 13.0 pesos MN o de **USD $ 1.30**, para 5.23 horas pico de radiación solar directa [1]

Este proyecto ha dado la pauta para proponer una estufa solar urbana de concentración, donde se almacene energía térmica en aceite y se disponga de una autonomía energética independiente de las condiciones de radiación solar (similar a la de un sistema solar fotovoltaico)

Trabajar y evaluar la estufa en el área experimental de la Ciudad de México es muy inapropiado ya que existe mucha bruma y nubosidad que limita el funcionamiento óptimo del equipo, además la facilidad de que cualquier lluvia ligera ensucie severamente a los espejos reduciendo su reflectancia.

La estufa rural no supera dos inconveniente, expone al usuario al rayo del sol, Si es que requiere de hacer una preparación directa de los alimentos y Si no hay sol, no hay comida.

Se requieren del orden de 2,000,000, de estufas solares para diferentes regímenes alimenticios, este trabajo permite cubrir ciertas expectativas que demande el tipo de producto a cocinar.

Sé esta trabajando en 3 opciones electrónicas para el seguimiento solar.

No usa baterías recargables, ni controlador de carga, típicos en un sistema solar fotovoltaico.

Se están haciendo programas de trabajo para definir recetas típicas de la cocina mexicana en las zonas rurales.

Es necesario trabajar con equipos novedosos que ayuden a mejorar las condiciones ambientales hoy, para garantizar un mejor futuro para las generaciones del mañana.

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WORKING GROUP 5: SMALL-SCALE APPLICATIONS

International Seminar on Bioenergy and Sustainable Rural Development
- 5th LAMNET Project Workshop – Mexico 2003

A SIMPLE MODEL FOR THE DEVELOPMENT OF "ACADEMICAL RESOURCES" FOR RENEWABLE ENERGY AND SUSTAINABLE RURAL DEVELOPMENT

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ABSTRACT

A simple model is described for the education of experts on renewable energy techniques, which are the basis for the so called sustainable rural development. An essential concept pertaining to the model is the idea of "critical mass", defined at three levels of intervention: scientific, technical and technological.

The following thesis and definitions were suggested from the working experience on two rural villages, there trying to develope so called "rural appropiate technology".

Thesis 1. *The sustainable rural development (SUSDEV) requires the rural renewable energy technology (RENTEC), based on direct and indirect solar techniques. Bioenergy belongs to this last one.*

(In this context "technics" refers not only to physical instruments, but also to procedures both conceptual and material, while "technology" implies the complex system composed of scientific institutions, industrial and commercial enterprises, technical instruments, resources, social groups, all of which are responsible for the social application of the technical instruments developed within a scientific context.)

Actually, neccessary for the achievement of SUSDEV is the existence of inexhaustible sources of energy. The renewable sources of energy are precisely of this kind when their utilization is performed in a renewable mode. Cutting trees without reforestation is a counterexample.

It could be argued that nuclear energy is inexhaustible energy, but it is incompatible with SUSDEV due to social peace as well as economical and environmental impact.

Thesis 2. RENTEC could be generated through the close interaction between three social subjects: a) the rural people, b) local and regional centers of rural techniques, and c) academic institutions for education and research.

Some experiences suggest that it is possible to link the energy neccessities of the rural people with some suitable academic institutions for education and research, located in the neighborhood. Then, for logistic reasons, the establishment of local and regional centers of rural techniques are needed. These centers could be modeled as composed of personnel coming from both the rural people and the academic institutions. Several designs could be imagined, but they rest upon the fact that there is always a basis of local inventors in the rural village.

A key component of the so called "scientific method" process, which is the feedback relationship between the practical behaviour and the theoretical design of the technical instruments, is realized through the interaction of the three social subjects described above.

The development of "academical resources" for RENTEC is a very important by-product of the process. Actually, without this by-product the whole process could be interrupted, while its realization is a precondition for its acceleration and extension.

Thesis 3. *Diffusion and adaptation of RENTEC could be attended by different kinds of enterprises: rural people collectives, private, governmental.*

Diffusion and adaptation of RENTEC is probably the most difficult part for SUSDEV, not withstanding other social, economical, political and cultural barriers. Models and practice are much needed here.

Thesis 4. *A key element for development, diffusion and adaptation of RENTEC is the concept of critical mass.*

The concept of critical mass is borrowed from nuclear physics and is indispensable for any self sustainable process.

Definition 1. **Scientific critical mass** (m_C): minimun set of persons, equipments, organizations, capable to identify and solve problems associated to scientific questions arising originally from SUSDEV.

Sometimes in theoretical physics m_C could consist of a single person sitting on a desk, provided with paper and pencil and a library by the side. But this could hardly be the case when scientific problems are ever arising demanding immediate solutions, associated to the development of RENTEC for SUSDEV. The situation is more like in the example of a laboratory where both experimentalists and theoreticians work together with people from the nearby workshop, for the solution of a scientific problem that originally arose from the testing of a novel theory. It is well known then that the solutions of some problems leads to another problems, and so on. The laboratory has m_C when the problem solving could continue indefinitely, and more scientists get trained during the process as well as more technical equipment is generated. A situation of steady or explosive growth is then achieved (the chain reaction) on scientific personnel and instruments. (This equipment could eventually reach the stage of industrial application, but that is another story.)

Example: solution of the problem of heat transfer in an improved biomass stove.

Definition 2. **Technical critical mass** (m_t): minimum set of persons, equipments and organizations capable to solve any original or new problem arising from SUSDEV, requiring a technical solution by way of equipment or procedures.

Example: development of a new improved biomass cook stove.

Definition 3. **Rural technological critical mass** (m_T): minimum set of persons, equipments and organizations capable to diffuse and socially adapt RENTEC.

Example: a successful program to develope and to adapt improved woodstoves on the *purépecha* region.

Observations

1) The diffusion of RENTEC could be economically supported at the beginning by the oil revenues of the nation. In this sense oil "buys" part of the transition from non renewable and exhaustible sources of energy to renewable sources of energy. This requires, of course, a national policy for the transition both for the rural and urban sectors, which is a neccessary condition for SUSDEV. As a corollary a new scientific and technological policy would also be needed.
2) "Academical resources" for RENTEC and SUSDEV could be developed building m_C , m_t and m_T.

WORKING GROUP 5: SMALL-SCALE APPLICATIONS

International Seminar on Bioenergy and Sustainable Rural Development
- 5th LAMNET Project Workshop – Mexico 2003

THE ORIGINS OF THE JUNTOS GASIFIER STOVE (Short Version)

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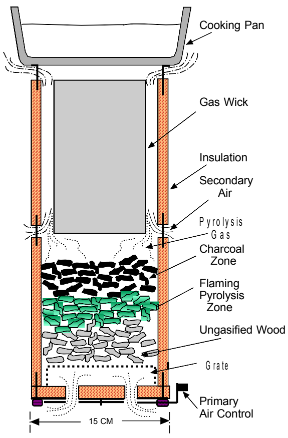
The heating of biomass can cause chemical decomposition ("pyrolysis") that releases gases that can subsequently be burned as "secondary combustion." This process occurs nearly simultaneously in regular fires, making the two stages difficult to see or to control. But when the gases are generated but not burned immediately, the pyrolysis process is more easily understood, seen, and controlled. This is informally known as "gasification." Commercially viable gasification has long been understood and used in industry and even in transportation, but not for small applications such as a household stove.

In 1985, while visiting South Africa, gasification expert Dr. Thomas B. Reed awoke one night thinking of a very small gasifier for the domestic stove needs of impoverished people. For ten years he worked to develop the IDD (Inverted Down-Draft) natural convection gasifier stove. In 1995 Dr. Ronal Larson joined the effort with a focus on the gasifier's capacity for producing charcoal as a valuable by-product in a household stove. After testing and publications (see fig. below-left) but no real success for applications, they stopped that work in 1995. However, in 1998 Dr. Reed began work on a smaller, forced convection model with a fan.



Reed-Larson 1995

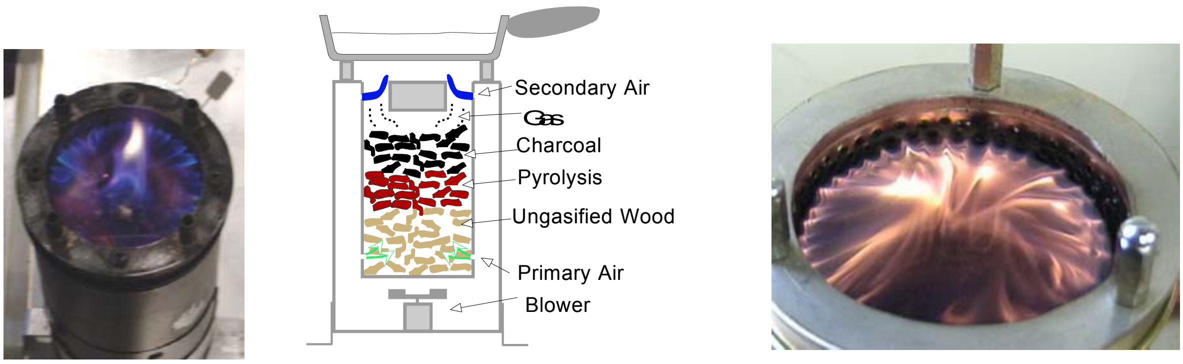
Anderson 2002-a

Anderson 2002-b – (Gasifier slides out)

In 2001, Dr. Reed lit his early prototype forced-air gasifier stove on a kitchen table for Dr. Paul S. Anderson and two others to see. Sufficiently impressed, Dr. Anderson started experimenting with natural convection gasifier stoves. He received on loan from Dr. Reed the original IDD gasifier, learned much from the "Stoves List Serve," and subsequently devised numerous modifications that resulted in the Juntos stove concepts. Those modifications (some are visible in the figures above) include different stackable units (including a modified "rocket stove") in a heat column over a gasifier unit with an airpipe, with smaller holes for entrance of secondary air, with pre-heated secondary air, with a tapered chimney, and with independent structural components for the stove body. The Juntos gasifier chamber is removable and, therefore, can be emptied to save the resultant charcoal, re-loaded with biomass, re-lighted, and re-inserted into the heat column. Design improvements are continuing specifically toward applications for communities in Africa.

Meanwhile, Dr. Reed returned to his forced-air designs with the intention to make a stove for the affluent North American camper market. He was highly successful and produced in early 2002 the "WoodGas Camp Stove" that has a battery-powered fan and can produce an impressive blue flame for sustained periods (figs. below). Some relatively minor modifications are necessary for Dr. Anderson's intended applications in Africa.

The efforts of Drs. Reed and Anderson are brought together by the not-for-profit Biomass Energy Foundation (BEF) in its application to the Shell Foundation for funding assistance for the Juntos Gasifier Stoves Project. The target area is southern Africa where Dr. Anderson has been teaching and researching geography education for four years as a Fulbright Professor and as a Rotary University Teacher Grantee, and ironically where Dr. Reed first conceived the household-size gasifier stove. *(6 May 2002)*



Three figures (a, b, c) showing the BEF forced-air WoodGas Camp Stove by Dr. Thomas B. Reed, 2002.

SEMINAR ORGANISERS

LABORATORIO DE BIOENERGÍA
CENTRO DE INVESTIGACIONES EN ECOSISTEMAS (CIECO), UNIVERSIDAD NACIONAL AUTÓNOMA DE MÉXICO

and

GRUPO INTERDISCIPLINARIO DE TECNOLOGÍA RURAL APROPIADA
GIRA A.C.

The Bioenergy Laboratory of the Centro de Investigaciones en Ecosistemas, National Autonomous University of Mexico (UNAM) together with GIRA A.C. are undertaking a joint research and development program on biomass energy for sustainable rural development.

The program started in 1995, departs from an interdisciplinary, systemic and participative approach to technology generation, adaptation, and dissemination, and focus on:

- *small scale applications* for household energy use and small industries. The group has extensive expertise on the development and dissemination of efficient woodburning cookstoves and small-scale kilns for pottery production.

- *analysis of regional supply-demand biomass resource flows* and their energy and environmental implications.

- *identification of priority regions for the development of bioenergy*. Together with the Wood Energy Program at FAO our group has developed the WISDOM (Woodfuel Integrated Supply-Demand Overview Mapping) methodology, oriented to provide a spatial representation of current woodfuel use patterns and resources and to identify “hot spots” according to a set of specified criteria.

- *assessment of mitigation options for climate change*, including the implications of bioenergy for carbon sequestration and substitution. The group has co-developed the model CO2FIX, currently in use in more than 70 countries worldwide, for the examination of carbon sequestration of forestry projects; a bioenergy module is under development to estimate the carbon substitution associated to bioenergy projects.

- *training courses and capacity building* in bioenergy

The Laboratory has also a *cookstove experimental facility* where to test an improve current cookstove models and designs.

Partners:

We have on-going collaborative projects with the Renewable and Appropriate Energy Laboratory, University of California, Berkeley; Instituto de Ingeniería, UNAM, Instituto Nacional de Ecología (INE), and other institutions.

For more information about the group activities, projects and publications, contact the site: http://bioenergia.oikos.unam.mx

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ANES

THE ASOCIACIÓN NACIONAL DE ENERGÍA SOLAR

The *Asociación Nacional de Energía Solar* (ANES) is a non-profit Mexican Civil Association which has been actively engaged in advancing knowledge, science, technology, policy and education needed for the efficient use of the renewable sources of energy and the development of systems for its applications in benefit to all the Mexican population. The ANES is the Mexican Section of the International Solar Energy Society (ISES), the world´s foremost membership organization in the field of renewable energy. This Mexican and global community which ANES-ISES embodies is of enormous importance in advancing research toward the well-being of mankind in a clean environment and a market acceptance of renewable energy systems. Among all clean sources of energy, biomass has a tremendous relevance due to green plants are true solar collectors which could cover thousands of squared kilometers at low costs. Recent studies have clearly shown the effect of burning fuels on global climate change, ambient pollution, depletion of the ozone layer, terrific accidents (petrol spills in seashores, explosions and poisoning in buildings and homes, etcetera) and other problems. Dependence on conventional energy sources harbours many detrimental effects, whether socially, politically, environmentally or in terms of development and equitable access to resources (fortunately, Sun owns to everybody). ANES strives to find sustainable energy alternatives and has the following objectives:

- To provide and organize a forum to promote the discussion of ideas.

- To compare and exchange results of technical options.

- To propagate (spread) and promote the use of Solar Energy and its solar radiation expressions, and other indirect forms as biomass, wind energy and hydraulics.

- To care for the quality of the scientific and technologic development in Mexico in the solar field.

- To urge the use of solar energy, and other renewable energy equipment .

- To participate and contribute in a firm and definite way in the state organisms that generate the energy policy of the country. This participation should be done with solid technical and scientific arguments. ANES wants to assume an active responsibility, besides being a consulting organism.

In order to get the forgoing, ANES has assumed the following activities:

- Held an Annual Solar Energy Congress, publishing the corresponding Proceedings, books leaflets of short courses on related topics, Workshops and Industrial exhibits. Also, ANES publishes *The Solar Magazine* and the *Solar Bulletin* and has the very active web site ***www.anes.org***

- Provides targeted information to congressmen to introduce them to what Renewable Energies are.

- Looks for its growth through the creation of new Chapters all over the country .

- ANES pursues partnerships with other organization to strength its strategies scope. Several examples are: the Agreement with CONAE (Energy Saving Commission), where ANES acquires the commitment of organizing and promoting events to increase the use of Renewable Energy; Other example its participation in COFER. ANES president is the Technical Secretary of the Consulting Council to Promote Renewable Energy (COFER). Another one is an Agreement with Sandia Laboratories within the Mexico Renewable Energy Program which main objective is the promotion of the productive use of renewable

- ANES through its Industrial Affairs Secretary keeps in touch with the incipient Renewable Energy industry and is working with them to develop strategies to improve this industry and impulse the commercialization of their products.

ANES promotes several technical and scientific meeting, in cooperation with other associations. Such is the case of the present *International Seminar on Bioenergy and Sustainable Rural Development*.

FAO AND ENERGY

The Food and Agriculture Organization of the United Nations was founded in 1945 with a mandate to raise levels of nutrition and standards of living, to improve agricultural productivity, and to better the condition of rural populations. Today, FAO is one of the largest specialized agencies in the United Nations system and the lead agency for agriculture, forestry, fisheries and rural development. An intergovernmental organization, FAO has 183 member countries. Since its inception, FAO has worked on various energy-related issues, viewing energy as a key input to alleviate poverty and hunger. Lately it also recognizes the role of agriculture and forestry as major sources of renewable energy in the form of biomass. The following are some of the most important areas of action of FAO in the energy policy and technological fields:

- support sustainable fuelwood and other biomass supply and demand systems
- promote energy efficiency in agriculture
- assist countries in the design and implementation of rural energy policies
- promote renewable energies such as solar, wind and biomass
- advocate for the bioenergy producing role of agriculture
- encourage the nexus between energy, agriculture and climate change
- promote activities in the wood energy and agro-energy fields
- support the productive uses of renewable energy
- establish linkages between the energy and the agriculture sectors

FAO and BIOENERGY

DRAFT Elements for an FAO Interdepartmental Programme

The Issue

Bioenergy[21] issues and biofuels[22] have been on FAO's agenda for decades. In the context of the mitigation of climate change, biofuels have gained renewed attention.

It is considered that:

- current energy systems in industrialized countries are largely based on the use of fossil fuels;
- in most developing countries, woodfuels still constitute the largest single source of energy, mainly for cooking and heating;
- world-wide, more than 50 percent of the wood consumed is used as fuel, for some developing countries fuelwood represents over 80 percent of wood consumed;
- sustainable production and utilization of biofuels enhance rural livelihood systems and substitute fossil fuels, thus contributing to climate change mitigation.

However, in many countries the following can be noted:

- lack of understanding and appreciation of the potential of biofuels as potentially clean, affordable and environmentally friendly sources of energy by policy-makers at national and international levels;
- biofuels are neglected in political, economic and social agendas and are not integrated into energy statistics and national energy planning;
- current regulatory, institutional, and legal restrictions hamper the development of biomass energy;
- neither forestry nor agriculture agencies give due attention to the development, management and utilization of biomass energy resources;
- little attention is given to the introduction and distribution of modern, efficient and clean bioenergy production systems.

[21] Bioenergy is understood as energy generated through biofuels. (Traction) energy provided through human or animal work, important in many countries, is in this context excluded.
[22] Biofuels are fuels of biological and renewable origin, such as: fuelwood, charcoal, livestock manure, biogas, biohydrogen, bioalcohol, microbial biomass, agricultural waste and by-products, energy crops, and others.

The results are that:

- reliable national resource and production data on biofuels to support policy-making processes are often not available;
- a large part of rural populations in developing countries barely cover their energy subsistence needs, let alone have access to energy for enhancing their productive activities;
- efficiency levels of biofuel utilization, in particular for fuelwood, charcoal, agro-residues and livestock manure are generally low, especially in the domestic and small-scale industries sectors (cooking stoves, charcoal kilns, etc.).
- incomplete combustion of biofuels due to traditional technology results in low efficiency rates and can lead to health hazards and burden the environment (emissions).

FAO's View

Production and use of biofuels as energy source are linked to a host of issues, such as agriculture and food security, land use and rural development, sustainable forest management and biodiversity conservation, and mitigation of climate change. Bioenergy has to be seen in its relation to poverty, population development and health. The fact that women and children in many rural areas spend a good portion of their working day in search for fuelwood, reflects the need to look at bioenergy in the context of gender roles and survival strategies for the poorest of the poor.

To be resolved are imbalances between household economy and environment, between conservation and consumption of biofuels and between present and future needs of societies. In the meantime, ways of producing and distributing conventional energy are changing as a result of new approaches like privatization, decentralization, trade liberalization and globalization.

FAO's Comparative Advantage

FAO has a long-standing global mandate from its member countries on the promotion of renewable energies within the agricultural, forestry, and related energy demanding and/or producing sectors. FAO avails of the necessary multidisciplinary expertise in the different areas of agriculture, forestry and economy to comply with this mandate. For many years, FAO has been developing multidisciplinary approaches and providing technical expertise in the field of energy, in particular, bioenergy. A database on production, trade and flow of woodfuels at country level has been regularly maintained since 1961, representing one of the most complete time series available.
Through its normative work and field projects, FAO has developed methodologies and definitions, management and analysis of databases, assisted member countries in the development of nationally and regionally specialized bioenergy studies, and of energy policies.

FAO's Role

The main FAO Divisions active in the bioenergy field are: SDR, FOP, AGP, AGA, AGL, AGS, ESC.

The immediate objectives of FAO's bioenergy programme are to contribute towards a

- partial substitution of fossil fuels through biofuels;
- more rational, efficient, and clean utilization of biofuels.

To achieve this, FAO strives to:

- continue to acquire, compile, analyse and disseminate data and information on bioenergy through the established energy information systems;
- strengthen information and cooperation networks on bioenergy issues (Forest Energy Forum, Bulletin of the Latin American Working Group on Energization for Sustainable Rural Development, Wood Energy News of the Regional Wood Energy Development Programme in Asia [RWEDP], wood energy web site, SD Dimensions web site and other newsletters);
- address the status and future of wood energy within the regional outlook studies, as well as at the global level;
- disseminate information and experiences through publications, electronic means and conferences, country missions, training workshop and seminars;
- raise awareness and knowledge of policy-makers and decision-makers on the role of sustainable generation of bioenergy for socio-economic development, in particular of women, the rural environment, as well as for the mitigation of climate change;
- assist member countries in strengthening their institutional and human capacities to implement bioenergy programmes and to introduce economically and environmentally sustainable woodfuels supply systems;
- assist member countries in the implementation of bioenergy programmes within the framework of the Kyoto Protocol to attain sustainable production and efficient utilization of biofuels;
- apply the experiences gained in certain projects and areas, e.g. the Regional Wood Energy Development Programme in Asia (RWEDP) to other countries and regions;
- promote the adoption and integration of bioenergy issues and actions into national agriculture, forestry, energy and environment policies, plans and programmes;
- develop partnerships with other bi and multilateral organizations (as well as with NGOs and the private sector);
- increase collaboration with agroindustries with bioenergy production potential (e.g. heat and power from sugar and rice mills; multipurpose crops for alcohol production).

Latin America Thematic Network on Bioenergy – LAMNET
Contract number: ICA4-CT-2001-10106

The project 'Latin America Thematic Network on Bioenergy – LAMNET' is engaged in setting-up a trans-national forum for the promotion of the sustainable use of biomass in Latin America, Europe, China and Africa. Currently, the global network LAMNET consists of 48 institutions (Knowledge Centres and SMEs) from 24 countries worldwide, thereby involving a large number of members with excellent expertise in the field of biomass.

LAMNET supports the elaboration of recommendations for the development and implementation of policy options for the promotion of biomass and bioenergy as well as the identification of commercially available and reliable biomass technologies worldwide.

The web site of this global network on bioenergy was established early in 2002 under www.bioenergy-lamnet.org. It provides detailed information on the objectives, activities and scientific publications of this trans-national forum as well as the contact details of all network members. Further dissemination activities of the LAMNET project include the publication of a periodic newsletter (2 issues per year), a project database providing information on the energy demand and the energy resources in Latin America and other selected emerging economies as well as the organisation of several bioenergy workshops.

LAMNET project workshops organised in 2002 include a Conference Related Event on the occasion of the 12th European Conference and Technology Exhibition on Biomass for Energy, Industry and Climate Protection in Amsterdam on 19 June 2002, a workshop on 'Biomass, Rural Energy and the Environment' in Durban organised one week prior to the WSSD in Johannesburg (August 2002) as a joint event of the three Thematic Networks CARENSA, SPARKNET and LAMNET and a workshop on 'Bioenergy Policies and Innovative Bioenergy Technologies' in São Paulo and Brasilia, 2-4 December 2002.

With respect to bioenergy technologies and systems it is the main objective of the LAMNET project to identify currently available, efficient, cost-competitive and reliable bioenergy technologies which provide opportunities for the conversion of biomass to energy services in Latin America, Europe, Africa and China. Relevant technologies and systems are selected on the basis of maturity of the technology, cost-effectiveness, simplicity of maintenance, social acceptability and the impact on development. Moreover, opportunities for international co-operation, technology transfer and joint-ventures in the field of bioenergy technologies are identified and promoted by the LAMNET network.

Finally, the analysis of the current energy policy framework and support for the elaboration of policy options for the promotion of the sustainable use of biomass follows three main lines within the framework of this global network on bioenergy:

- Involvement in major international events and initiatives focussing on Renewable Energies and Sustainable Development
- Monitoring of the national/regional policy frameworks and the elaboration of advice and recommendations for the development and implementation of policy options for the promotion of bioenergy in close cooperation with the national network members
- Active networking with other organisations, institutions and multilateral initiatives engaged in the field of Renewable Energies and Sustainable Development

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