SESAM/ARTES/DAAD AFRICAN ALUMNI

UNIVERSITY OF FLENSBURG, GERMANY

Sustainable Energy Systems and Management

SESAM

African Alumni Workshop Accra/Kumasi

May 05-09, 2008

Application of Renewable Energy in Fuelling Sustainable Development in Africa

Compilation and Edited

by

Evans Mensah Hervie

Workshop Organizer in Accra/Kumasi

SESAM

International Institute of Management

University of Flensburg

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Germany

SESAM

Bulding Bridges between North and South

Supported by

Deutscher Akademischer Austauschdienst

www.uni-flensburg.de/sesam

Group Photo after the Opening Ceremony in Accra

Group Photo at the Closing Ceremony in Kumasi

Acknowledgements

I am delighted to present the proceedings of African Alumni Workshop 2008, Accra/Kumasi Ghana with abstracts, papers of SESAM/ARTES/DAAD alumni.

This international workshop has been made possible by the immense support received from DAAD. Therefore my special thanks go to DAAD German Academic Exchange Service. I am also grateful to Dr. Heike Eldermann-Okinda, DAAD Country Director in Ghana who immeasurably supported the local organizer in Ghana. My sincere thanks to the experts from Kwame Nkrumah University of Science and Technology, (KNUST) College of Engineering, Energy Centre, the German Ambassador to Ghana HE Dr. Marius Haas, HE Honourable Kwame Amporfo Twumasi, Deputy Minister of Energy and all the special invited guest.

I would also like to thank

-SESAM/ARTES/OLDENBURG/BONN Alumni for their valuable contribution in exchanging their professional experiences and being agents of change in their professional endeavours for the Renewable Energy and Environmental African Alumni network.

And last but not the least my thanks goes to Mr. Evans Mensah Hervie and his team who hosted us comfortably in Ghana and for their hard work and enthusiasm before and during the workshop which made it possible for successful organization and documentation of proceedings including final editing for their time and consuming efforts.

Accra/Kumasi Ghana 09 June 2008

Dr. Dieter Klein

Workshop In-Charge

SESAM, University of Flensburg

NOTE

Kindly note that, submissions by some of the authors were incomplete at the time of compiling this report. May you need further information on their presentation, kindly contact me via my e-mail address: **evanshervie@yahoo.com**

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AFRICAN ALUMNI WORKSHOP OF UNIVERSITY OF FLENSBURG

SESAM-Sustainable Energy Systems and Management

"Application of Renewable Energy in Fuelling Sustainable Development in Africa"

Accra/Kumasi, Ghana 5.-9. May 2008

Paper on: "APPLICATION OF RENEWABLE ENERGY FOR FUELING SOCIO-ECONOMIC DEVELOPMENT IN OFF-GRID COMMUNITIES IN GHANA"

BY HONOURABLE KWAME AMPORFO TWUMASI

DEPUTY MINISTER FOR ENERGY, GHANA

Salutation,

Distinguished Ladies and Gentlemen, it was with great pleasure that I accepted the invitation from the organizers of this all-important meeting to present a paper on the application of renewable energy in fueling socio-economic development in off-grid communities in Ghana.

In discussing this subject, I intend to present an overview of the potential and current state of renewable energy development. I will conclude by discussing the challenges, policies and strategies that the Government has put in place to encourage the development and utilization of renewable energy for both on-grid and off-grid applications.

Mr. Chairman, the main sources of energy supplies in Ghana are biomass, petroleum products (hydro carbons) and hydropower. It is not strange that biomass in the form of firewood and charcoal constitutes about 69% of the country's total energy use, primarily for cooking and heating due to its extensive availability and relative low cost. It is however clear that while biomass will continue to dominate our energy use for the foreseeable future, we need to modernize and improve its forms of use and make its utilization sustainable in the future.

Mr. Chairman, another indigenous energy resource is hydropower which though accounts for only about 6% of total energy supply contributes about 60% of the electricity supply to the economy. The hydroelectric plants at the Akosombo and Kpong Generating stations have installed capacities of 1020 MW and 160 MW respectively. Additional 400 MW is currently under construction at Bui on the Black Volta. The remaining 40% of the demand supply is met from thermal power plants and electricity imports.

Ladies and gentlemen, all the crude oil and petroleum products used in the country for the thermal power plants and for the transport sector are imported. Recent oil discovery in the country is yet to be exploited.

Even though Ghana is endowed with abundant renewable energy resources such as solar, wind, biofuel and small hydro, their contribution to the energy mix has been very negligible.

Ladies and Gentlemen, the consumption landscape of energy in Ghana shows that most of the modern forms of energy are consumed in the urban areas. Access to electricity in

Ghana is now about 56%, however only about a fifth (20%) of this is in the rural areas. The situation is similar in the petroleum sector where almost all the consumption is in the urban areas except for kerosene which is estimated to be about 82% in the rural areas and used largely for lighting. The trend is similar for LPG where the penetration in the rural areas is less than 1%.

For the traditional energy sources such as firewood and charcoal, over 60% of urban households rely on charcoal while over 80% of rural folks use firewood for cooking and water heating.

Ladies and Gentlemen, you will agree with me that the availability of modern energy services particularly to rural areas of the country has the potential to promote the growth of agro-based and other small-cottage industries, create employment and thereby stimulate socio economic growth and create wealth especially in the rural areas.

Ladies and Gentlemen, you will also agree with me that poverty alleviation is not only about improving income generation and creation of wealth, but has in addition, the provision of basic social facilities such as schools, potable water supply, improved sanitation, telecommunication, quality healthcare, among others.

The government is determined to transform the rural areas by providing the infrastructure required for development. A key component of which is the delivery of reliable energy supply services without which these facilities cannot be effectively used for development.

The Ministry of Energy is embarking on a Rural Electrification Scheme aimed at providing electricity services to all communities in the country by 2020. Over 3,000 communities have so far been connected to the national electricity grid under the National Electrification Scheme in 1989.

Government has streamlined the National Electrification Scheme to accelerate rural access to electricity. All outstanding works in 300 communities under SHEP would be completed in 2008. in addition, five communities without electricity in each district would be connected to the national electricity grid this year.

Mr. Chairman, you will agree with me that some encouraging achievements have been made so far in the rural electrification effort. However, these have been very expensive for government. As we go further into the remote rural areas, it is becoming even more expensive to provide electricity services through grid extensions only. It is therefore the policy of my Ministry to explore least-cost or cost-effective options of providing electricity services that will still address the basic issues in rural social and economic development. These issues include the following: provision of clean water, vaccine refrigeration in health clinics, education, telecommunications, lighting, entertainment and the operation of other domestic appliances such as fridges and TV sets.

Ladies and gentlemen, the use of solar, wind and biogas for off-grid electricity generation has been effectively demonstrated and proven to be viable options for applications such as water pumping, lighting, radio and TV, street lighting and battery charging. In rural health centers, vaccine refrigerators and medical equipment can be operated with energy derived from renewable (solar wind and biomass). It is also possible to produce liquid fuels from energy crops such as sugar cane, Jatropha to substitute gasoline and diesel for powering automotive and stationery engines for the agro-based industries in rural communities.

At present there are over 4,000 solar PV systems installed in about 30 rural communities in the country for various applications.

With regards to the development of small hydro and wind energy systems, the potential in the country is largely untapped. These schemes could be operated as mini-grid networks or interconnected to the national electricity grid where applicable.

Mr. Chairman, although there exists abundant potential of renewable energy in Ghana, which offers significant opportunities for investment, there are significant challenges for their development.

By far, the greatest challenge is that those who need access to the modern forms of energy in our country are the poor who live in the rural and peri-urban areas. These are also the people who can least afford to pay for energy services. We therefore face the challenge of providing relatively high cost modern energy services to consumers who do not possess the requisite ability to pay.

Most renewable sources of energy especially wind and solar systems are not competitive with conventional sources of power for bulk generation largely due to the state of the present technology. The high initial cost of these systems makes them unattractive. On the basis of least cost development therefore, most renewable have not been adjudged to be justifiable.

Therefore, in order to promote and develop renewable energy systems, the Government has the challenge, not only to adopt appropriate measures towards reducing the initial capital cost of renewable energy systems, but also to identify areas where connection to the grid cannot be economically justified.

Mr. Chairman, another major challenge is the unavailability of local technological support to produce renewable energy conversion systems and maintain the facility when installed. This is particularly serious in the case of solar photo-voltaic (PV) systems imported from the developed countries where the technology is widespread. In the absence of local capacity and support, most solar projects have not been sustainable. Ladies and gentlemen, while I have used solar energy as an illustration, the issue cuts across the entire renewable sector.

In spite of the challenges in developing renewable sources of energy in the past, the present Government is taking the following pragmatic measures to allow for their exploitation.

1. The NPP Government intends to establish a Rural Electrification Agency that will be solely responsible for providing cost effective rural electrification options including renewable energy throughout country.

2. The Government has secured assistance from the World Bank under the Ghana Energy Development Access Project (GEDAP) of the Ministry of Energy to provide up to 50% grant financing through the Rural Banks to households in remote rural communities to acquire Solar Home Systems and Solar Lanterns.

3. GEDAP is also providing partial subsidies and long term loans of up to 50% to private developers for the development and deployment of mini-grid and grid-connected renewable energy systems in the country to eliminate the macro economic policies that discriminate against the markets in renewable energy.
4. A Renewable Energy Law which will create an enabling environment for private participation is being developed for enactment by parliament before the end of the year.

5. Government has also secured financial assistance from the Spanish Government for the supply and installation of solar PV systems to remote public institution in the country. This project will commence before the end of the year.

6. The Minister of Energy is presently working with UNIDO to develop the first mini-hydro plant in Ghana. Civil works for this project is expected to commence this year.

7. With regards to local participation and capacity building, Government intends to encourage local participation in the design and delivery of renewables particularly in solar, small hydro and wind in order to build local capacity. The Government is also committed to supporting the development of private solar energy supply and service infrastructure.

Mr. Chairman, let me take this opportunity to thank the German government and DAAD in particular for their support in building local capacity for the design, delivery and management of renewable energy systems in Africa. This conference is a clear demonstration of their contribution to human resource development in Africa. I am proud to note that my Renewable Energy Expert in the Ministry is a product of DAAD. I will however appeal to DAAD to consider increasing the intake of prospective students as in the case of Asia.

Mr. Chairman, in summary, I have endeavoured to show by this brief presentation the potential of renewable sources of power in Ghana. I have also discussed the challenges that confront the development of renewable energy in Ghana and the policies being pursued by the Government to promote the sector.

The Government of Ghana is committed to ensuring the availability, adequacy and reliability of power delivery in the country. To this end the Government intends to make the development of renewable energy, one of its cornerstones in the sector and will create the required enabling environment to attract both local and foreign investment into the sector.

THANK YOU

Honourable Kwame Amporfo Twumasi

Deputy Minister for Energy, Ghana

I – Objective and Workshop Programme

Universität Flensburg	Application of Renewable Energy in Fuelling Sustainable Development in Africa African Alumni Workshop Accra/Kumasi Ghana 5.-9. May 2008	SESAM Building Bridges between North and South
Capacity building through information sharing for strategic promotion, dis-	Supported by DAAD **D**eutscher **A**kademischer **A**ustausch**D**ienst	semination and wider application of RE technologies within the African context

Workshop Goal and Objectives:

Under the overall goal of life long learning and capacity building to expand the human resource base in Africa this workshop intends to **provide scientific inputs, information sharing and exposure for strategic promotion, dissemination and wider application of Renewable Energy Technologies within the African context.** This event gives the chance to African SESAM/ARTES and Oldenburg Alumni to achieve the following objectives:

- Get some **scientific subject matter updating** and exchange country specific/individual work **experience**;
- Start **cooperation and collaboration** with relevant German (and other) development organisations, governments as well as non government initiatives and private business in the renewable energy sector;
- Set a **signal** for the **relevance of renewable energy resources** and **capacity building** in fostering socio-economic development within the African countries, while preserving the environment;
- Initiate and intensify **alumni networking** within the African Continent, where African Alumni will be able to collaborate amongst themselves and create linkage with other partner organisations inside and outside the continent.

- By electing coordinators/facilitators and setting up national and regional structures alumni could form national or international consultancy groups who would advice and work in projects in the field of renewable energy and environment.
- Such Alumni groups could assist each other in their manifold information needs, and might be a window of advertisement for potential SESAM students, giving them first hand information before they come to Germany.

- Actual SESAM students could be offered the chance to do their research term in a relevant organisation and context, having an alumnus or an alumna as their local supervisor.

Organization in Accra/Kumasi, Ghana:

The opening ceremony was held in Accra and the details of where participants lodged and the centre where the opening ceremony took place could be found below:

Accommodation including breakfast and supper in Accra where the alumni lodged was at Catters Hostel, East Legon, Adjacent to Emmanuel Eye Clinic, P. O. Box CT1539, Cantoments, Tel +233 (0) 244 216 937 or 243 325 050.

Accommodation including breakfast and sometimes supper in Accra where the experts from University of Flensburg lodged was at KNUST Guest House at Ringway Estate, Osu, P. O. Box GP4100, Accra, Tel +233 (0) 21 286 384/5, Fax + 233 (0) 21 286 383

The conference centre for the opening ceremony where participants had their tea breaks, buffer lunch and supper was at Erata Hotel, Ouagadougou Avenue, Okponglo, East Legon P. O. Box KIA 9968, Airport-Accra, Tel +233 (0) 21 515 192-4, Fax +233 (0) 21 505 119. www.eratahotel.com

The panel sessions where alumni made presentation in their current area of profession took place in Kumasi at KNUST Campus.

Accommodation including breakfast, tea break, buffer lunch and supper was at Engineering Guest House, Tel +233 (0) 51 630 78 Fax + 233 (0) 51 636 44.

Contact person for help and assistance in Accra/Kumasi;

Evans Mensah Hervie: evanshervie@yahoo.com mobile: +233 (0) 275 361 988

Moderators/Rapporteurs for SESAM/ARTES Alumni Workshop

Monday, 5th May 2008 Erata Hotel, Okponglo, East Legon Accra

Time	Activity	Moderator/ Rapporteur
9.00 -9.30	Registration of Participants – Workshop secretariat	
	Opening and welcoming – Chair: Evans Mensah Hervie, Ghana	Evans
9.30	**Opening Prayer** by Rev. Jerry Aidoo of Victory Bible Church International-Prophetic Centre	
9.30-10.00	Welcoming Note – Workshop program & Organizational Matters Dr. D. Klein – Workshop In-charge, University of Flensburg –Germany Mr. Evans M. Hervie – Workshop Organizer – Ghana	
10.00-10.15	**Honorable Twumasi Ampofo** Deputy Minister of Energy – Ghana: The Application of Re-newable Energy in Fuelling Socio-economic Development in Off-Grid Communities in Ghana	
10.15-10.30	Welcoming speech H.E. Dr. Marius Haas, German Ambassador to Ghana	
10.30-11.00	**Welcoming speech Dr. Hagan**, Ghana Institute of Engineers	
11.00-11.30	Tea/Coffee Break – Exhibition: Renewable Energy Companies	
	Plenary 1 – Chair: Dr. Mfundisi Kelebogile, Botswana	Dr. Mfundisi
11.30-12.00	DAAD Country Representative Dr. Heike Edelmann-Okinda: Strategies adopted by DAAD to motivate energy and environment alumni play important roles in the development of the energy sector of their various countries	
12.00-13.00	Lunch Break – Exhibition: Renewable Energy Companies	
13.00-13.30	**Prof. Dr. A. Schlaepfer**, SESAM/University of Flensburg/Germany: Climate change – impact on developing countries and possible coping strategies	
13.30-14.00	**Prof. Akuffo**, KNUST –University of Science and Technology/Kumasi: Lessons learnt from the dissemination of PV home system for off-grid power in rural areas	
14.00-14.30	**Prof. Brew-Hammond**, KNUST**:** The development of the energy centre of KNUST in becoming one of the core centre for energy development in Ghana and Africa	
14.30-15.00	**Dr. Mfundisi Kelebogile**, Botswana leads discussions on the plenary 1 presentations	

15.00-15.30	Tea/Coffee Break	
	Plenary 2 – Chair: Wilsdom Ahiataka Togobo, Ghana	
15.30-16.00	**Dr. A.K. Ofosu Ahenkorah,** Exec. Secr. Energy Commission: Policies being adapted by the Government of Ghana through the Ghana Energy Commission to enable the RE private business sector to take up the challenge as engine for the promotion of RE in Ghana	
16.00-16.30	**Mr. Kofi Marfo**, Consultant Biofuel: Government Policies and Framework to be put in place to propel commercial production and application of Biodiesel as an alternative to Diesel Fuel in the phase of escalating crude oil price, using Ghana as a case study	
16.30-17.00	**Dr. Moses Mensah**, KNUST: Status of biofuels in Ghana - Trends in development of test methods, standards and national policy	
17.00-17.30	**Wilsdom Ahiataka Togobo**, Ghana leads discussions on the plenary 2 presentations	
18.00	Welcoming dinner at Erata Hotel – Exhibition: Renewable Energy Companies	

Tuesday, 6th May 2008 - Participation in the WB conference on "Lighting Africa" at La Palm Royal Beach Hotel, Accra

Time	**Activity** (acc. to WB conference program)	
	I. Opening Ceremony	**Rapporteur**
9.00	***Welcome Remarks*** • *Ministry of Energy, Ghana* • *Monique Barbut, CEO and Chairperson, Global Environment Facility* ***Keynote Address***	
10.30-11.00	***Break***	
	II. Lighting Industry Overview	
11.00-12.00	• Industry Trends *Dr. Arne Jacobson, Professor, Humboldt State University-Confirmed* • Why is the Off-Grid Market Attractive? Lighting Opportunities in Africa *Rory Stear, Freeplay* Questions and Answers	
	III. Successful Market Entry Strategies in Africa	Rapporteur
	• Unilever: Personal Products Ms. Gail A. Klintworth, Chairperson, Unilever, S. Africa • MTN: Mr Ebenezer Asante, Sales and Distribution Executive, MTN Ghana • Grameen Bank: Mr. Dipal Birua, Deputy Managing Director • Coca-Cola: Mr. Murray Loggie, General Manager, Ethiopia-Confirmed Questions and Answers	
13.30-15.00	Lunch - Industry Trade Fair Open	
	IV: Market Research: Modern Lighting Services in Africa	Rapporteur
15.00-17.00	• Modern Lighting Services in Africa: Market Assessment Results Melissa Baker, Research International • Business Approach for Delivering Improved Off-Grid Lighting Services Rodd Eddy, Senior Director, Sustainability Off Grid. OSRAM • Making a Difference Mr, Leo Blyth, Solapak • Perspectives on Successful Lighting in Africa Mr. Thama-ini Kinyanjui, SolarElectro Questions and Answers	Rowland
	V. Wrap up	
	Reception in Development Marketplace & Industry Trade Fair Exhibitions	

Wednesday, 7th May 2008 - Participation in the WB conference on "Lighting Africa" at La Palm Royal Beach Hotel, Accra

9.00-9.30	VI. Welcome	
	VII. Roundtable Discussion: Financing Options for Off Grid Lighting Companies	Rapporteur
9.30-11.00	• Lighting Africa Strategy to Enhance Commercial Finance: *Kyle Kelhofer, IFC* • Micro-Finance and Lighting: *Patricia Kawagge, Finca Uganda* • Investing in Development: *Richenda Van Leeuwen, Senior Advisor Good Energies* • The Role of Carbon Finance: *Ashok Sarkar, Sr. Energy Specialist, Energy Sector Management Assistance Program, The World Bank* *Questions and Answers*	??
11.00-11.30	Break	
	VIII: Building Better Businesses in Africa: The Developm. Marketplace Experience	Rapporteur
11.30-13.30	Presentations by 3 former DM winners on how they expanded their DM grants to successful business models o Solar Tuki-Nepal: *Mr. Prachet Shrestha* o Village Reach-Mozambique: *Mr. Craig Nakagawa* o Chardust-Kenya: Mr. Elsen Karstad, Director, Chardust Ltd	
13.30-14.30	Lunch Development Marketplace and Industry Fair Open	
14.30-19.00	**Transport from Accra to Kumasi** for the continuation of the African Alumni Workshop	
19.00	Dinner at Kumasi - KNUST	

Thursday, 8th May 2008 KNUST Kumasi

Time	Panel	Parallel Panel
	Presentations 20 min. each plus 10 min. discussion on guiding questions + on lessons learned	
	Panel 1: Promotion & Dissemination of Renewable Energy Technologies	
	Chair: George Obeng	
9.00 -10.30	**1. Finias B. Magessa (Tanzania):** Promotion & Dissemination of Renewable Energy Technologies in Tanzania	
	2. Alemayehu Zelelke (Ethiopia): A new approach for wider dissemination of Biogas in Ethiopia	
	3. John Kuteesakwe (Uganda): Viable strategy for scaling up the dissemination of improved stoves among the poor in Africa	
	4. Aimé H.T. Ngongang (Cameroon): Production of biofuel from Jatropha Curcas: A promise for improving the socio-economic conditions of rural population in Africa	

10.30-11.00	**Tea/Coffee Break**
	Panel 2: Potential of RE in Power Generation
	Chair: Michael Commeh
11.00-12.30	**5. Dr. Kelleh Gbamuru Mansaray (S. Leone):** Photovoltaic Energy for sustain-able rural development in Sierra Leone
	6. Nelson Asanji (Cameroon): Small hydropower potentials in Cameroon and the practical experiences of Cameroon's privatization in the electricity sector
	7. **Wisdom A. Togobo (Ghana):** Comprehensive analysis of Mini-Hydro potential in Ghana
12.30-13.30	**Lunch Break**
	Panel 3: RET - Rural Electrification and Development
	Chair: Wisdom Togobo
13.30-15.00	**8. Wilson K. Mbony (Cameroon):** The Role of Renewable Energy in the Energy Security of Cameroon: A Case Study of Yaoundé
	9. Rowland Okereke (Nigeria): Challenges and Prospects of Market Expansion for Renewable Energy Technologies in Tanzania
	10. Billa Sylvester (Cameroon): Environmental and socio-economic impacts of crude oil refining and distribution
15.00-16.00	Visiting KNUST - College of Engineering workshops
15.30-16.00	**Tea/Coffee Break**
16:00-18.30	**Excursion** and tour to Historical Site – Ashantehene Palace at Menshia, Kumasi
18.30	**Dinner at KNUST GH**
	Panel 4: Policy & Strategies for Renewable Energy Technologies / Role of RE for Power Generation & Energy Security
	Chair: John Kuteesakwe
20.30	**11. George Obeng (Ghana):** Solar PV Rural Electrification: Assessing the Impacts on Off-Grid Rural Enterprises in Ghana
	12.KwameKoussougbo(Togo): Solar energy as an approach of solution to energy crises in Togo
	13. Michael Commeh (Ghana): Is Wind Energy the Option for Solving Ghana's Energy Crisis?

Friday, 9th May 2008. Place – KNUST, Kumasi

Time	**Panel 5: RETs Application in Institutions and for Employment Creation**
	Chair: Rowland Okereke
9.00 -10.30	**14. Evans Mensah Hervie (Ghana):** Application of Biogas in Educational Institutions for the Production of Cooking Gas – Case Study at Valley View University
	15. Michael Commeh, Ahmed Hassan, Don Amrago (Ghana): Efficient cook stoves – R&D to date
	16. Philip Mensah (Ghana): A study in the various solid waste management options in the Atwima Nwabiagya District
10.30-11.00	**Tea/Coffee Break**
	Panel 6:RET and Environmental Conservation
	Chair: George Obeng
11.00-12.30	**17. Dr Kelebogile B. Mfundisi (Botswana):** Constraints and opportunities for Bioenergy production in Southern Africa
	18. Dr. El Fadil Adam Ahmed Bashir (Sudan): *Renewable Energy Applications in the Sudan*
	19. Samuel Amos –Abanyie (Ghana): Applicability of passive and low energy cooling techniques in Ghana
	Winding up, lessons learned and discussions from 7 Workshop panels Review of the workshop results in the light of the key topics of the workshop Preparation of workshop report
12.30-13.00	**1. Dr. Dieter Klein (SESAM):** Update on SESAM; overview on alumni work and DAAD support; follow up and monitoring of participants' alumni activities
13.00-14.00	**Lunch Break**
	Plenary 3: Alumni Internal Meeting (all alumni are invited)
	Rapporteur: Aime/Magessa
14.00-15.30	2. **Group work:** Task on perspectives/activities and institutionalization of African alumni – challenges and opportunities 3. **Presenting an Action Plan** for future Networking and Collaboration within and outside Africa (electronic version)
15.30-16.00	**Tea/Coffee Break**

15.30-16.00	**Tea/Coffee Break**
	Plenary 4: Evaluation and Closing
	Rapporteur: Evans Mensah Hervie
16.00	**Evaluation of the Workshop** – Dr. D. Klein (SESAM) with DAAD questionnaire **Closing of the Workshop** – Address from Professor Momade, Provost College of Engineering, KNUST **Closing remarks** – Prof. Schlapfer, Director SESAM/University of Flensburg **Issuing Certificates** – Professor Momade, Provost College of Engineering, KNUST **Remarks from Alumni** Representative **Vote of Thanks** – Workshop Organizer/Coordinator
19.00	**Farewell Dinner**

Saturday 10.5.2008: Travel back to Accra at **8 am** for flight departure

III Welcome Note

Welcoming note- Workshop Programme

Dr. Dieter Klein

International Institute of Management

SESAM-Sustainable Energy System and Management, Germany

Welcoming workshop participants

Personal introduction:

Greetings from Flensburg in spring time – month of May

Lecturer with SESAM/ARTES since 1984 (co-founder – greetings from Prof. Rehling and Wulf Boie)

In-charge project leader for the Alumni workshop on behalf of the University of Flensburg

First time in West Africa (worked before in East Africa: Kenya, Ruanda, Malawi, Zambia, Tanzania, South Africa)

Greetings to: (official welcoming later by officials)

18 Alumni from SESAM/ARTES+Uni Oldenburg and Bonn > safe trip/visa trouble, from 10 African countries

Representatives from:

- Government of Ghana:

- German Embassy: Botschafter Herr Dr. Marius Haas

    - KNUST University of Science and Technology Kumasi (working contacts ongoing since 1991 based on an agreement between the two universities)

- DAAD – Frau Dr. Heike Edelmann-Okinda

- Various small industries and development agencies

Thanks

Thanks to DAAD for financing and to Evans Mensah Hervie for organising

Context and Background of the Workshop:

Energy affects all aspects of development. It is an important means in achieving sustainable development and fighting poverty in developing countries. This is also taken care for by the EU Africa Partnership on Energy.

Thus addressing energy issues with a focus on Renewable Energy sources and technologies requires a combination of many aspects, bundled together in well trained experts, who develop and implement various strategies in spreading the use of renewable energy sources and technologies.

Within this understanding, the SESAM/ARTES master course at the University of Flensburg, has been putting their efforts in training experts to take up the above challenge. About 230 students of SESAM (and formerly ARTES) from 55 countries and all continents have been trained so far. Equipped with a Masters Degree they returned to their home countries to demonstrate as alumni in practical terms the added value they gained.

Taking into account that each developing country has its unique characteristics, still these countries are facing many common problems in enhancing their energy sectors. Challenges range from disparity in primary energy mix, shortage of energy supply to meet the ever increasing demand, lack of supporting regulatory and institutional framework, low access to modern energy service especially for rural people, the need of financial support to develop renewable energy technologies etc.

While each developing country applies different approaches to respond to aforementioned challenges, sharing experiences among SESAM/ARTES alumni/experts is one way to assist in identifying and adopting the best practices to confront such challenges through capacity building and training.

Alumni of SESAM and ARTES have been contributing positively in the energy sectors in their home countries. They are working with a range of organizations such as government agencies, development organizations and NGOs, as well as the private sector.

Sustainable development is best assisted by capacity building, constant updating and sharing of knowledge relating to research findings, changes in technology, work experience, economics of technologies, environment protection and societal reactions towards such changes. Therefore such topics are the corner stones of the SESAM/ARTES course of study the university of Flensburg, but also of the Alumni concept of life long learning.

A brief history of SESAM/ARTES course and its alumni work

After piloting the curriculum as a postgraduate Masters course from 1984 to 1989,

The ARTES program was supported by DAAD since 1990 providing around 11 scholarships per year as well as assisting in various aspects of alumni work based on the funds from BMZ.

1990 - 2000 ARTES (116 graduates), ARTES newsletter
2000 - 2008 SESAM (112 graduates up to date)

from 2009 Energy and Environmental Management combined course with Master of Engineering degree in Energy and Environmental Management

Within the last 6 years 3 alumni workshops have been conducted:

2002 Alumni workshop in Bangkok	> start of community website and electronic database
2004 Summer School Bonn/Flensburg World Renewable Energy conference	> intensifying alumni work, foundation of first country alumni association (FAEM Nepal, Yogi Kayastha)
2006 Asian Alumni workshop in Bali	> initiation of an Asian Alumni network (workshop in Nepal, May 2008)
2008 Africa Alumni workshop Accra/Kumasi	> initiation of an African Alumni network/ sector network of RE (Flensburg, Oldenburg etc.)

It is from this background that 2 African SESAM graduates took the initiative to propose a work-shop as a forum, where Alumni have the opportunity to enrich their knowledge as well as share their expertise.

In close cooperation we planned and organized this event. Starting about a year ago a survey was done amongst the 70 African SESAM/ARTES alumni to find out about their whereabouts, interest, willingness and possibility to participate and actively contribute to such a workshop. There was positive feedback of about 30 alumni from 12 African countries (Ghana, Nigeria, Togo, Cameroon, Tanzania, Ethiopia, Rwanda, Burkina Faso, Sierra Leone, Niger and Uganda).

They showed their interest of participating actively in such a workshop by presenting a paper from their working experience, scarifying their time and assist in the organization and conducting of the event.

Based on this positive feedback a proposal was drafted to request assistance from the DAAD alumni program. In January this year we got the approval from DAAD to assist this workshop financially.

Workshop Goal and Objectives:

Under the overall goal of life long learning and capacity building to expand the human resource base in Africa this workshop intends to provide scientific inputs, information sharing and exposure for strategic promotion, dissemination and wider application of Renewable Energy Technologies within the African context. This event gives the chance to African SESAM/ARTES and Oldenburg Alumni to achieve the following objectives (slide):

get some scientific subject matter updating and exchange country specific/individual work experience;

start cooperation and collaboration with relevant German (and other) development organisations, governments as well as non government initiatives and private business in the renewable energy sector;

set a signal for the relevance of renewable energy resources and capacity building in fostering socio-economic development within the African countries, while preserving the environment;

initiate and intensify alumni networking within the African Continent, where African Alumni will be able to collaborate amongst themselves and create linkage with other partner organisations inside and outside the continent.

By electing coordinators/facilitators and setting up national and regional structures alumni could form national or international consultancy groups who would advice and work in projects in the field of renewable energy and environment.

Such Alumni groups could assist each other in their manifold information needs, and might be a window of advertisement for potential SESAM students, giving them first hand information before they come to Germany.

Actual SESAM students could be offered the chance to do their research term in a relevant organisation and context, having an alumnus or an alumna as their local supervisor.

Workshop topic, sub topics and didactic concept:

a) Workshop topic:

Application of Renewable Energy in Fueling Sustainable Development in Africa

Sustainable development is the "development which meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development). In other words, sustainable development can be viewed as a strategy that manages all assets, natural and human resources, as well as financial and physical means for increasing long-term wealth and well-being of the people.

Renewable Energies can definitely contribute to this end and this workshop wants to lead a step forward in the said process by capacity building through information sharing for strategic promotion, dissemination and wider application of Renewable Energy Technologies within the African context.

b) Subtopics:

Based on the feedback on needs and inputs identified in the said survey, the workshop addresses seven subtopics:

Policy & Strategies for Renewable Energy Technologies (RETs)

Promotion & Dissemination of RETs

Potential of RETs in Power Generation

RETs and Rural Electrification and Development

Role of RETs for Power Generation & Energy Security

Application of RETs in Training Institutions and for employment creation

RETs and environmental conservation with a focus on biofuels

Policy & Strategies for Renewable Energy Technologies (RETs)

One of the main barriers in resolving the energy challenges in developing countries is the lack of supporting energy policies and strategies to have a wider and faster spread of the use of RETs for the benefit of the majority of the population in these countries. Addressing this topic in the alumni workshop allows exchange of experience between participants from different countries. This will contribute to discuss and identify proper energy polices and strategies to be applied and various innovative approaches in providing incentives to support renewable energy development in their home countries.

Promotion & Dissemination of RETs

Despite financial difficulties, most governments of developing countries are trying to promote the use of Renewable Energy Technologies. This is often done with the support of developing partners. Since each country has its modalities on promoting such technologies for her people, sharing experience on this topic will allow alumni to learn from the experiences of other countries on the issues pertaining to the use, promotion and dissemination of renewable energy technologies across the African continent.

Potential of RETs in Power Generation

The African continent is blessed with an abundant amount of renewable energy sources, ranging from hydro, wind, solar, biomass to geothermal. However, in almost all countries, this massive potential has hardly been tapped to stimulate socio-economic activities. With high level of greenhouse gas emission which has become a huge environmental concern, it is of paramount importance for experts within the continent to vigorously seek innovative ways on how such massive potential of renewable energy sources can be utilized for power generation. It is from this understanding that the African alumni will be able to share ideas on how best countries in Africa can utilize the potential of renewable energy.

RETs and Rural Electrification and Development

Access to electricity in developing countries is a major concern. Absence of electricity is a major impediment in the fight against poverty in developing countries. This translates into the demand that poverty reduction strategies should be tied up with access to electricity in rural areas where the majority of population in African countries lives. Getting grid connected electricity to all rural areas is quite an unrealistic alternative due to high cost of connecting the widely dispersed rural dwellers. Among the feasible options for rural electrification is the use of renewable energy technologies such as solar PV which can produce electricity in a decentralized way. During this workshop alumni will have the chance to participate in the ongoing WB conference on “Lighting Africa” to hear and discuss issues pertaining to electrification by the use of renewable energy technologies for development in rural and urban areas.

Role of RETs for Power Generation & Energy Security

As cited above and given their potential, renewable energy resources have a very big potential of being a major contributor in the energy mix, in particular when it comes to electrical power, heating and cooling, in most countries in Africa. During the workshop alumni will be able do deliberate important issues around the role of RE contributing to higher energy security in respective African countries.

Application of RETs in Training Institutions and for employment creation

Effective promotion and dissemination of renewable energy technologies is achieved through well trained manpower. Thus training institutions form a very important aspect of capacity building within the African continent. During the workshop alumni will be able to share experience on the application of RETs in training intuitions and evaluate its effectiveness in promotion and dissemination of knowledge about RETs.

RETs and environmental conservation with a focus on biofuels

The price of crude oil on the world market keeps on increasing. When the proposal for this workshop was handed in to DAAD in July last year it was at $70 - currently it stands at around $144 per barrel.

African governments spend huge foreign exchange to import crude oil in order to get diesel oil among others. Biofuels could be a source of energy in poor countries. However there is also the danger of reduced food production due to the use of land for growing biofuel plants. Presently we experience worldwide the increase of prices for food, so during this workshop alumni should not only learn about strategies in improving the dissemination of bio-fuels but also discuss about problematic side effects of the wide spread growth of bio-fuels on the environment and the food resources.

c) Didactic concept of the Workshop:

The following workshop didactics are employed to address, elaborate and discuss these topics in order to achieve the above mentioned goal and objectives within the five days.

Eight key note plenary sessions to present the state of the art by representatives from Ghanaian Government, the German Embassy, DAAD, University of Science and Technology Kumasi as well as University of Flensburg, representatives of development cooperation, business and NGOs of the energy sector (including an exhibition).

The participation of 1½ days in the World Bank Conference on “Lighting Africa” gives the alumni the unique chance to meet relevant people from various organisations and industries and hopefully get motivated to also participate sometimes in the Development Marketplace competition.

In twelve parallel workshop panels presentations of the alumni are delivered based on the detailed country and individual work experience within the 7 sub-topics mentioned.

Discussions based on guiding questions after the plenary key notes and panel sessions intensify the knowledge transfer and prepare for the wrap-up of workshop results, highlighting lessons learned and recommendations in the final report.

In a small exhibition during the workshop days alumni projects will be displayed and invited Ghanaian, German and international bodies/companies will also be welcomed to demonstrate their activities.

Finally, in an internal meeting of alumni (from Flensburg, Oldenburg and Bonn) networking, future collaboration and activities will be discussed with the aim to establish national and/or regional African alumni clubs/associations on the matter of renewable energy and sustainable development.

Myself (Dr. Dieter Klein) and Mr. Evans Mensah Hervie MSc., act as facilitators of the overall event. The participating alumni will act as rapporteurs/ moderators of the various plenary and panel sessions, preparing a protocol and submit it to the workshop secretariat focussing on lessons learned from the presentations and the discussions.

4. Expected Outcomes of the workshop:

It is hoped that the contacts, knowledge, attitude and experience gained from this workshop will enhance the current professional development of the alumni-participants so that they can meet the manifold challenges and act as innovators and active change agents in their home countries and work places towards accelerating the use of renewable energy technologies and fostering sustainable development.

Besides that it is expected that this workshop stimulates the Alumni to collaborate actively with relevant organisations in the energy and development sector - especially with German development organisations and private business - in their home country. Based on an internal survey done during this workshop the increased number of contacts and concrete collaborations will be followed up and published in the alumni newsletter on community website (monitoring is already done in Asia).

Finally it is also expected that due to intensified networking, display of workshop results in the SESAM community website and the media echo of this workshop, the number of highly qualified and motivated applicants from Africa for the SESAM course will increase on the long run.

By setting up structures for the African Alumni work it is expected that the elected country and regional African Alumni coordinators will enhance the sustainability of the SESAM alumni network by organising further country and regional events on their own and/or in collaboration with their mother university.

Welcoming note- Organizational matters

Evans Mensah Hervie

Workshop Organizer

SESAM/ARTES Alumni from the University of Flensburg, Alumni from University of Oldenburg and Bonn from Germany have come together to organized this memorable 1st SESAM/ARTES African Alumni Workshop in Accra, Ghana. This workshop is been organized in collaboration with Kwame Nkrumah University of Science and Technology (KNUST), College of Engineering, the Energy Centre. Immense support was received from DAAD office in Accra, Ghana notably the country director Dr. Heike Edelmann-Okinda. Partners for this workshop in Ghana are the Ministry of Energy, Ghana Institution of Engineers and Energy Commission.

In all 18 Alumni from 10 different countries African countries have arrived in Ghana to attend this workshop. The new director of SESAM (Sustainable Energy System and Management) Professor Dr. August Schlaepfer and Dr. Dieter Klein a lecturer from University/Project leader were also present from Germany.

This workshop would have a five day fully packed programme which is detailed below:

Activities for the 5 day programme:

First day-Monday:

In the morning of May 05, 2008, which is the opening ceremony, Dr. Dieter Klein and Mr. Evans Mensah Hervie were interviewed on Ghana Television GTV programme-Break Fast Show and had the opportunity to inform the entire nation about the workshop.

The workshop would officially commenced with an opening ceremony in Accra at the Erata Hotel Conference room with about 100 projected participants. Welcoming speeches would be delivered by the German Ambassador to Ghana, His Excellency Dr. Marius Haas, Dr. Eben Hagen and The Deputy Minister of Energy, His Excellency, Honorable Kwame Aporfu Twumasi would deliver detailed paper on “The Application of Renewable Energy in Fuelling Socio-economic Development in Off-Grid Communities in Ghana”.

Our invited guest would also deliver papers.

Below are the names of the invited guest and their corresponding topics which would be delivered during the opening ceremony:

Dr. Heike Edelmann-Okinda- Strategies adopted by DAAD to motivate energy and environment alumni play important roles in the development of the energy sector of their various countries

Prof. Dr. A. Schlapfer- Climate change – impact on developing countries and possible coping strategies

Prof. F. O. Akuffo- Lessons learnt from the dissemination of PV home system for off-grid power in rural areas

Prof. Brew-Hammond- The development of the energy centre of KNUST in becoming one of the core centre for energy development in Ghana and Africa

Dr. A. K. Ofosu-Ahenkorah- Policies being adapted by the Government of Ghana through the Ghana Energy Commission to enable the RE private business sector to take up the challenge as engine for the promotion of RE in Ghana

Mr. Kofi Marfo- Government Policies and Framework Which Should Be Put In Place To Propel Commercial Production And Application Of Biodiesel As An Alternative To Diesel Fuel In The Phase Of Escalating Crude Oil Price, Using Ghana As A Case Study

Dr. Moses Mensah- Status of biofuels in Ghana - Trends in development of test methods, standards and national policy

Exhibition of renewable energy products would be mounted during the opening ceremony by renewable energy companies namely Sustainworld Consultant, Dizengoff Ghana Ltd., and Power World.

Second day-Tuesday:

Participants would have the opportunity to attend a World Bank conference in Accra at La-Palm Hotel on the theme “Lighting Africa”.

Lighting Africa seeks to catalyze access to modern electric lighting for over 250millions poeple in Sub-Saharan Africa without access to grid electricity by 2030. It will help individuals, households, small and medium exterprises and others to get access to cleaner, cheaper and reliable consumer friendly lighting products tailored to their needs and ability to pay. Lighting Africa-managed by the World Bank Group-is working in partnership with a range of partners to include the global lighting industry, local distributors ans service providers, governments, financiers, academia, research organizations and bilateral and multilateral organizations. It aims to break down barriers for industry and accelerate entry into this emerging market area. Lighting Africa is positioned to help capture the US$38 billion spent on kerosine and other fuel-based lighting of which an estimated US$17 billion is spent in Africa alone. The Accra Accord set forth strategic principles for partner collaboration to catalyze improved off grid lighting in Africa.

Some of the subjects to be discussed would be Lighting Industry Overview, Successful Market Entry Strategies in Africa, Market Research: Modern Lighting Services in Africa and there would be an Industry Trade Fair Exhibition.

Third day-Wednesday:

Participants would attend a half day session of the World Bank conference before travelling from Accra to Kumasi, KNUST, College of Engineering to do presentations on alumni field of current research/profession.

Fourth day-Thursday:

Presentations in alumni research/professional area of specialty would be done and invitation is opened to the university community. The presentations which would be moderated by an almunus would be interspersed with discussions and contributions.

There would be an educational trip to the solar laboratory and Technology Consultancy Centre workshop both under college of engineering and a cultural visit to the Asantehene Palace-a kingdom which has being in existence for over 200years.

.Fifth day-Friday (last day):

The Alumni would continue with their presentations and would be winded up lessons learned, discussions from the seven workshop panels and review of the workshop results in the light of the key topics. Dr. Dieter Klein would update participants on SESAM; overview on alumni work and DAAD support; follow up and monitoring of participants' alumni activities. There would also be group work on: Perspectives/activities and institutionalization of African alumni– challenges and opportunities. The days sitting would continue with an Action Plan for future Networking and Collaboration within and outside Africa. The entire workshop would be evaluated by means of a filled in questionnaire by participants and an African coordinator/facilitator would be elected by vote.

The 5-day programme would be rounded up with a farewell dinner where the closing of the workshop and issuing of certificates would be done by Professor F. W. Momade-Provost of College of Engineering KNUST. Closing remarks would be given by Professor Dr. August Schlaepfer-Director of SESAM and the vote of thanks would be done by Frau Barbara Klein.

Alumni would return to Accra on Saturday May 10, 2008 for departure formalities to their various countries

Welcoming speech

Dr. Marius Haas

The Ambassador to the Federal Republic of Ghana to Germany

Honourable Mr. Kwame Amporfo Twumasi, Deputy Minister of Energy

Dear Dr. Klein, Professor August Schlaepfer, University of Flensburg,

Dear Dr. Edelmann-Okinda, DAAD Director

Distinguished guest

I am pleased to welcome you all to the first SESAM/ARTES African Alumni Workshop on renewable energy.

A few months ago a high ranking German delegation visited Ghana on the request of President Kufuor in order to give advice on which energy source may be the best for the country. The background was the idea to install coal plants and Germany is known for the high technology standard with respect to this source of energy. In mid 2008 we expect a Ghanaian delegation to continue the talks in Germany. I just mention this at the beginning to demonstrate which important role energy and energy sources in particular renewable energies play in the German-Ghanaian relations. The more i am pleased to have the opportunity to say a few words at the beginning of the SESAM/ARTES African Alumni workshop. As we all know, renewable energy is a very important topic for African countries like Ghana which has just overcome a major energy crisis. And-Africa is rich in renewable energy resources. Germany is ready to assist Ghana in the energy field and today's ARTES/SESAM workshop is one of the instruments to do that. It aims at finding problem solutions based on the participants' rich experience in the field. I am happy about the fruitful cooperation that exist between the University of Flensburg as well as other German universities and various scientific institutions in Africa and worldwide. I am also pleased that a good part of this workshop will take place at the Kwame Nkrumah University of Science and Technology in Kumasi. I consider it a good gesture to honour this renowned university.

In this age of globalization, international mobility for students, scientists and universities is of ever-increasing importance. Everyone in the "learning community" can benefit from increased mobility and exchange. The SESAM/ARTES programme fit perfectly in this pattern.

It is, however, not the only Ghanaian-German academic programme where the German Academic Exchange Service in being involved. The DAAD with it network of alumni and 60 regional offices worldwide represents an ideal resource and is assisting those universities interested in pursuing the global recruiting the best minds from around the world to participate in graduate schools and research clusters.

A shining example for scientific, academic and institutional co-operation between Ghana and Germany is the long-lasting working relationship with the already praised Kwame Nkrumah University of Science and Technology (KNUST) in Kumasi.

The SPRING programme offering a master degree for spatial planning for regions with growing economies was created in 1986 with the collaboration of the University of Dortmund. Since then, over 150 Ghanaian students have graduated.

The Department of Mechanical Engineering has been sponsored since 2001 with sur-place scholarships.

Another international exchange programme run by the DAAD is the "International Association for the Exchange of Students for Technical Experience" (IAESTE). Every year, about twenty students from Ghana participate and spend several months in German companies.

In 1998, the German Federal Ministry of Education and Research (BMBF) launched the international programme GLOWA which is embedded in the BMBF research framework programme on research for sustainability. GLOWA focuses on the problem of water availability. In Ghana, the GLOWA Volta Project is to provide a full scientific analysis of the Volta Basin and works together with Ph.D. trainees from the Volta Region.

Let me conclude by saying that i am proud of the numerous and diversified cooperation projects between the German Academic Exchange Service and Ghanaian scientific institutions. I am especially pleased that we now have a representative of the DAAD here in Accra, Mrs. Edelmann-Okinda, who started her assignment with a lot of commitment and energy. I would like to wish all of you an effective and fruitful workshop.

I thank you for your attention.

Welcoming speech

Dr. Essel Ben Hagan

Past President

Ghana Institution of Engineers

Your Excellency Dr. Marius Haas, the Germany Ambassador,

Hon. Kwame Aporfo Twumasi, Deputy Minister of Energy,

Our Colleagues from various countries in Africa,

Distinguished ladies and gentlemen,

In several countries, there has been a strong relationship between energy and economic growth. The availability of reliable and sustainable energy supply drives the growth of the economy, whilst a growing economy creates a rise in the demand of energy to support the growth. With the additional impact of growing population, many Sub-Saharan African countries are faced with major challenges in providing the required energy in a reliable and sustainable manner to support their economic growth. There is the need to expand energy supply base and most importantly to diversify the supply sources in these countries. Indigenous renewable energy resources - particularly direct solar radiation, biomass and wind energy – provide an opportunity for African countries to meet this demand in a manner that also addresses policy concerns of security of energy supply and environmental impacts.

Distinguished ladies and gentlemen, the strategies that need to be pursued to promote the integration of renewable energy into the national energy mix in Africa countries include:

i. Capacity building of indigenous engineers and other scientists, and engineering firm;

ii. Facilitating innovation in the energy sector; and

iii. Development of regulatory framework for renewable energy technologies.

African nations require technologically prepared engineering workforce to address the challenges posed by the expansion of the energy sector to include renewable energy. Indigenous engineering firms should participate in the continuing education programmes of professional bodies such as Institutions of Engineers, and other post-graduate training schemes to bring their engineering staff to be more aware of and better able to use new technologies in engineering practice, particularly those related to renewable energy. The benefits of such training to economic growth will be manifested in the increase in the speed at which the nation can adopt modern renewable energy technologies to support the energy sector.

Many countries have experienced considerable socio-economic growth through the adoption of the knowledge-based economy which is derived from the existence of innovative engineers and other scientists that mobilize a variety of factor inputs to create new products, processes and services. As African countries strive to upgrade their relative position in technological development to support economic growth, creating and managing engineering innovation in the energy sector should become a key component of national policy. Research and development are indispensable inputs to innovation, and many studies have confirmed that when high investments are made in research and development, they result in considerable innovation and knowledge outputs to support national economic growth. Research institutions and universities in African countries should be resourced by both the Government and the private sector to develop innovative technologies in renewable energy that can exploit indigenous resources to complement conventional energy supply systems.

Distinguished ladies and gentlemen, it cannot be over-emphasized that the development of a regulatory framework for the generation, transmission, and distribution of renewable energy is necessary to allow renewable energy to effectively compete with conventional energy sources. Ghana's Energy Commission has initiated strategic actions in this endeavour, and I recommend this initiative to other African countries.

It is within this context that I congratulate the University of Flensburg, SESAM/ARTES Africa Alumni and the Energy Centre of Kwame Nkrumah University of Science and Technology for organizing this important Workshop, which seeks to enhance capacity building through sharing of scientific information and exchanging work experiences for the promotion, dissemination and wider application of renewable energy technologies in African countries.

It is our expectation that interactions between participants from various parts of Africa will ultimately contribute to better understanding of renewable energy and their application for sustainable development in all African countries.

I welcome you all to Ghana, and to this workshop, and wish you fruitful deliberations.

Thank you.

IV Guest speakers

Strategies Adopted by DAAD to Motivate Energy and Environment Alumni Play Important Roles in the Development of the Energy Sector of their Various Countries

Dr. Heike Eldelmann-Okinda

Director, DAAD Ghana Office

Mr. Chairman, fellow members of the academic community, distinguished ladies and gentlemen. It is with great pleasure that I'm standing here in front of such an illustrious gathering of DAAD alumni and academics this morning to talk to you about strategies adopted by the German Academic Exchange Service or DAAD to motivate its alumni to play active roles in renewable energy in Ghana. My name is Heike Edelmann-Okinda and I am the resident representative of the German Academic Exchange Service in Ghana.

When I was first told the topic that I was invited to talk about I was quite sure that there is not much to say despite the fact that we are gathering here due to the initiative of a DAAD alumnus and that this alumni workshop is sponsored by DAAD. What more needs one to say, isn't it speaking for itself?

As a typical German I consider myself very conscious about energy and environment: Switching lights off when I am leaving a room, riding the bike to university instead of taking the car, having never more than 21 degree on the Celsius scale in the sitting room in winter – even if it makes you feel like in a station's waiting room, separating waste into paper, plastics, glass, organic waste and further subgroups. But how about DAAD and energy? I did what many people do nowadays when they approach a topic: I googled for "DAAD sustainable energy systems" and within 0,33 seconds I had approximately 42.700 hits – of which I read up to the 40est hit just to give up then: workshops, magazine articles, alumni entries, newsletters, programmes, essay competitions, CVs, conferences, seminar reports and so on.

These entries do not sound like a coherent strategy, but … Just the most recent DAAD press release on "The future of water resource management", dated 30th April 2008, informs on a DAAD invitation for water resource experts from developing countries to the IFAT, a specialists fair on water, waste water and waste management, and it refers to the 2006 founded DAAD sponsored German Alumni Water Network – GAWN, a co-operation between nine German universities and 140 professionals from various developing countries. Perhaps there will be in near future a German Alumni Sustainable Energy Systems Network – let me call it GASEN (following the model of the Asian SESAM network)?

In its capacity as the largest German support organization in the field of international academic cooperation, the DAAD simultaneously fulfils responsibilities in foreign cultural and academic policy, development cooperation policy and national higher education policy. One task of the DAAD is to advance young German academic elites in order to provide them with cosmopolitan qualifications as future leaders and executives in the spirit of international and intercultural experience. At the same time, it supports the academic and scientific progress in developing countries and in the transforming countries of Central and Eastern Europe, mainly by the development of efficient higher education structures.

The activities focus on the continuing education and training of young scientists by awarding scholarships and grants in Germany and by developing partnerships with German higher education institutions. The programs also target academically trained experts and executives working outside the higher education sector. Finally, the establishment of lasting networks in cooperation with the scholarship holders constitutes part of the success of the program. The stays of these students, academics and scientists at German higher education institutions advance the understanding in Germany for the developing countries and the need for development policy cooperation.

The 1992 Rio Conference agreed upon the Agenda 21 as an action plan for the 21st century in order to preserve living conditions for present and future generations through focussing on sustainable development. Let me remind you that the EU has evolved from a coal and steel community and that fossil energy has been integral to the history of the EU. Today the EU deals in its energy policy with the rising global energy consumption and the simultaneously limited fossil resources as well as global climate change. Apart from competition in energy sector major approaches to solve today's energy problems focus on renewable energies. The EU has set a binding target to achieve by 2020 an increase in the use of renewable energy to 20% of all energy consumed, largely by the development of new technologies in renewable energies. How nice would it be to promote at the same time an Africa-Europe Energy partnership, to help Africa switch to low-carbon technologies, developing the continent as a sustainable energy supplier?

The Germany trained and often DAAD sponsored experts, professionals and academics are there and ready for service.

SESAM / ARTES alumni – at their website called "International Agents of Change" - are to be found working in various fields. Many are working in leading and advisory positions in national or international organisations, in ministries or non-governmental organisations. Others work in the private sector businesses or as independent consultants or lecturers in universities. Data collected in 2004 showed that 80 % of the SESAM / ARTES graduates had by then been returned to their home countries and had found jobs – SESAM graduates return home more frequent and faster than graduates of most of the other comparable postgraduate courses – this indicates that they are qualified for the needs of their home countries above average.

However, with DAAD there is no longer "out of sight, out of mind" – and consistently DAAD promotes the exchange of experiences of its alumni through establishing and support of various alumni networks. Without this support small universities like Flensburg would not be able to run such an intensive alumni work as they are able to do it, Flensburg e.g. is in regular contact to approx. 60% of their graduates mainly through workshops and conferences that are DAAD sponsored.

How can SESAM graduates bring renewable energies to the people, asked former DAAD scholarshipholders during a meeting organized by DAAD and ZEF Bonn in 2004. Experts in the field of international development need to be able to work at the same time with new technologies, new organisational structures and management strategies in order to tackle the core problems of environmental degradation, diminishing natural resources and increasing poverty.

Core elements of the professional training for such experts thus have to include participatory development strategies, income-generating activities and the sustainable use of natural resources. An important "tool" in this process is the use of (renewable) energy systems: sustainable energy systems are not a development goal in themselves but represent - together with the changing of attitudes, community mobilisation and the transfer of knowledge - an essential precondition for social and economic development.

Here comes again the DAAD in: development cooperation policy - future leaders - supports the academic and scientific progress in developing countries - continued education and training of young scientists - academically trained experts and executives working outside the higher education sector - establishment of lasting networks in cooperation with the scholarship holders.

Let me now resume my remark on a German Alumni Sustainable Energy Systems Network – GASEN – for Africa – and let me dream of solar collectors, wind collectors – allow me finally to tell you that my Kenyan mother in law runs her farm’s power supply by solar panels bought in Kitale, bought from a SESAM alumni who founded his own company upcountry after having returned back home.

I wish you a very successful workshop in Accra and Kumasi. Thanks for your attention.

Climate Change – Impact on Developing Countries and Possible Coping Strategies

Professor Dr. August Schlaepfer

Director, SESAM-Sustainable Energy System and Management, University of Flensburg

Distinguished guests, ladies and gentlemen I would like to thank you for giving me the opportunity to speak to you. I have been in the position of SESAM Director since the beginning of April this year. So, I am still coming up to speed on the role.

I am delighted to be here in Accra to represent SESAM and get to know the alumni. During the short time I have been with SESAM I have been impressed by the quality of international students attending. Not only do they bring a vast amount of experience but just as importantly all of them are highly motivated and able to communicate with each other, despite the vast difference in cultural backgrounds. To work with such dedicated young people gives me hope that together we can meet the substantial challenges of climate change and we can achieve a more sustainable way of life for ourselves and our children.

Today I would like to talk briefly about climate change and what it means to the world in general and African Nations in particular. I realize that most of you will possess a good understanding of what climate change is, but nevertheless, I think that it provides a good starting point for my talk.

To begin with I will briefly describe the Greenhouse effect: The Earth receives its life-sustaining warmth from the Sun. On its way to the Earth's surface most of the heat energy passes through the Earth's atmosphere, while a smaller proportion is reflected back into space.

The energy warms the Earth's surface, and as the temperature increases, the Earth radiates heat energy (infrared energy) back into the atmosphere. As this energy has a different wavelength to that coming from the Sun, some is absorbed by gases in the atmosphere.

There are four main naturally occurring gases that are responsible for the Greenhouse Effect; water vapour, carbon dioxide, methane and nitrous oxide. Once these gases absorb energy, the gas particles begin to vibrate and they radiate energy in all directions, including approximately 30% of it back towards Earth.

Although most of the greenhouse gases occur naturally in the atmosphere, some are man-made and the most well known of these are the fluorocarbons. Since the industrial revolution, human activities have also resulted in an increase in natural greenhouse gases, especially carbon dioxide. An increase in these gases in the atmosphere enhances the atmosphere's ability to trap heat, which leads to an increase in the average surface temperature of the Earth.

Relatively little changed before the industrial era. However, since about the middle of the 18th century there has been a marked increase in CO2, methane and nitrous oxide in the atmosphere; and this has accelerated even more in the last few decades.

By far the largest contribution for CO2 comes from the use of fossil fuels. The main sources for GHG emissions are electricity generation from coal, followed by transport based on oil. Deforestation also contributes significant amounts of CO2. It is also interesting to have a closer look at the regional distribution of per capita GHG emissions in 2004. Clearly, the Annex I regions have a far larger per capita emissions than the Non-Annex I regions, with the US and Canada leading the negative way.

The increase in oil prices and energy security concerns are contributing to an increase in carbon intensity. Rather than having a big impact on energy efficiency of the more expensive fuels, it has let to increased investment in coal, coal to liquids, and carbon inefficient biofuels, leading to an increase in emissions.

This is a global issue; there is only one earth and one atmosphere and the resources of our planet are finite, as well as the ability of the atmosphere to absorb the waste.

We are in this together – this means one country alone cannot solve the issue of global warming. Unfortunately, it only requires one country like the US to prevent the rest from meeting strong climate targets.

On the one hand, the global community needs to act urgently to halt the rapid rise in global emissions of GHG. This is essential if we are to prevent climate change from reaching very dangerous future levels. The EU is adamant that global warming must be kept to no more that 2°C above pre-industrial temperature.

On the other hand, all sectors of society need to adapt to the climate change that is already occurring, and will continue to get worse until we succeed in bringing emissions under control. For example, adaptation measures include strengthening sea defenses where possible and to develop new types of crops that are more drought resistant.

So, what are the implications of a 2° C target for international climate policy? Clearly, a bottom up approach alone cannot work – we need international coordination. We need to have legally binding targets and trading systems in place. However, this on its own is not enough. It requires a mixture of legally binding targets for richer and more able countries, as well as policies for decarbonization in developing countries; particularly in those fast developing countries such as China and India. To achieve this, very rapid technological change also has to be an essential part of the strategy.

What are some of the key structural elements required? Firstly, decisions need to be reached on how to develop market linked mitigation options for developing countries. Second, it requires legally binding quantitative emission reduction obligations for industrialized countries. Thirdly, non Kyoto industrialized countries like the USA need to participate and have measurable, reportable and verifiable processes in place that are comparable with other developed country negotiations. And lastly, a post Kyoto commitment period with legally binding targets needs to be put in place.

For developing countries it is important to improve national mitigation actions that are measurable, reportable and verifiable. This should be linked to technology, financing and capacity building, which should then also be measurable, reportable and verifiable.

In addition there should be separate negotiations on the reduction of emissions from deforestation.

The economic cost of climate change and the economic advantages of taking decisive action have been highlighted in the Stern report in 2006 and more recently in the Garnaut report in Australia. The IPCC supports the assessment that limiting global warming to 2°C above the pre-industrial temperature is compatible with sustainable economic growth.

Clearly, financial resources and investment to support mitigation and adaptation actions need to be provided. Without substantial investment flows and effective technology transfer it will be difficult to achieve significant emission reductions. Therefore, the level of investment for technology transfer needs to be scaled up to help developing countries address their need for environmentally sound technologies.

In addition enhanced action in the areas of risk management and risk sharing, disaster reduction strategies and international cooperation to support the urgent implementation of adaptation actions is required. The risk management strategy needs to be taken seriously and risk takers will have to be held responsible for the possible consequences of their actions and or in-actions.

Let us now turn to the regions that are especially vulnerable to climate change – and these are: The Arctic, because of the impacts of high rates of projected warming on natural systems and human communities; African nations because of low adaptive capacity to projected climate change impacts; small island states that have a high exposure to projected climate change impacts, and Asian and African megadeltas with large populations and high exposure to sea level rises, storm surges and river flooding. All these regions require special attention and consideration. Today I will however only focus on the African Nations.

Africa is a large and varied continent spanning the tropics, subtropics and warm temperate zones. Common elements across many African countries include population growth, low per capita income and low capacity to adapt to climate change. Many have a history of flooding, droughts, famines, civil unrest, underfunding etc. A large number of African countries have low standard of living and low per capita CO_2 emissions. Clearly, therefore, African Nations need assistance to cope with climate change, as well as assistance in the necessary development to produce improvement in living standards.

Climate change presents a major challenge for biodiversity conservation planning in African countries and the management of key natural assets such as protected areas. This represents an increased risk of habitat loss and degradation. New evidence suggests that adverse impacts of climate change on unique and vulnerable ecosystems is increasing.

The impacts will be felt in the areas of diminishing water resources in some parts or excessive flooding in others. Food security will become a major issue in many more areas of Africa.

Natural resources productivity and biodiversity will be increasingly put at risk There will be increasing impacts on human health; e.g., an increase in vector-and water-borne disease. Coastal zones are vulnerable to sea-level rise, driving people from their homes and there is also the potential for increases in desertification in the interior. There is increasing evidence that low latitude and less developed areas face greater risk; those in the weakest economic position are often the most vulnerable to climate change.

What are some possible strategies for African Nations to combat climate change and at the same time raise living standards? There is a growing awareness that neither adaptation nor mitigation alone can avoid all climate change impacts; however they can complement each other and together can reduce climate change significantly. For obvious reasons African nations have a strong moral claim for assistance. The question is, how do we achieve economic growth using low carbon energy sources?

Mechanisms like the Clean Development Mechanism need to be used more extensively in Africa. It also requires an increase in understanding of the local and regional impacts of climate change. Clearly, in the planning and implementation of energy systems, the possible climatic implications need to be considered carefully.

There are large fossil fuel resources, like oil and gas in some of the African regions; however, the distribution of these resources is uneven and there are climate change issues that need to be considered when exploiting these resources. If anything should be considered it is that African Governments should concentrate on gaining more royalties from the export of their resources like oil and gas and use this income to achieve the Millenium Development Goals. There is evidence to suggest that, in the absence of good governance and prudent monetary and exchange rate policies, resource-rich countries are not necessarily achieving higher rates of growth and more importantly improved living standards.

In terms of energy provision I suggest therefore that the main emphasis should be on the expansion of the renewable energy sector. The objective of economic growth and keeping CO2 emissions low can be achieved through large scale dissemination of renewable energy technologies. The current lack of existing centralised energy infrastructure means that distributed renewable energy power generation will provide a viable economic option for many African Nations.

It is important to understand that energy services rather than just increased energy supply are essential to both social and economic development and to eradicate poverty and hunger, achieve primary education, promote gender equality - empower women, improve health, provide clean water and sanitation and achieve environmental sustainability.

For example, the lack of energy often undermines sterilization, water supply and purification, sanitation, and refrigeration of essential medicines. Electricity can also power machines that support income-generating opportunities such as pumping water for agriculture, food processing, apparel production, and light manufacturing. In short, energy services are the benefits that energy carriers produce for human well being. The energy services will need to be appropriate and sustainable; in other words, a community will need to be able to afford to maintain the energy service provided.

Also essential is that the processes to provide and maintain these services are transparent and that there is accountability built into the process.

Let me give you an example of how one of our former SESAM students' conducted a study of the vulnerability and possible impacts of climate change on infrastructure in the coastal belt of Ghana. He assessed the possible impacts on socio-economic, weather and environmental aspects of the settlement as perceived by local residents; he studied the meteorological trends of the area; he evaluated the professionals' awareness in dealing with climate change-related impacts on buildings and infrastructure development generally; and identified adaptation techniques and strategies that can be used as basis in managing the impacts of climate change on infrastructure in the coastal belt of Ghana.

He determined that there had been significant changes in temperature, precipitation and relative humidity for the last 3 decades and that the shoreline had been receding at approximately 2 meters annually.

In his study he put forward specific recommendations such as the passing of a new legislation that would require the establishment of a setback for all developments in the coastal belt.

He proposed appropriate options for a managed retreat for each of the shoreline segments

And he argued that coastal infrastructure management is likely to entail intergenerational investment programs. He also suggested that further research was required to improve the current understanding of the coastal processes.

This is just a small example of the kind of work students from SESAM have been involved and continue to be involved in using the acquired skills.

The challenges faced by African Nations are substantial. Currently the world still lacks innovative economic, social and political institutional frameworks to provide support for renewable energy development. This lack of a global framework does not help African nations in their quest for a sustainable energy future. It is therefore imperative that Africa will search for solutions for Africa. African nations have the knowledge and resolve to find solutions that are appropriate for them; what they require are financial and technical assistance.
I believe that the former and present SESAM students are well equipped to assist in the work to reduce poverty, address climate change issues and aim for energy security and environmental as well as social sustainability. I am certain that many of them will play a major part providing sustainable energy systems for social and economic development. I believe that they are aware of the challenges and have a passionate desire to work towards delivering sustainable solutions.

I feel confident that the current SESAM students as well as the SESAM alumni are in the process of acquiring or already have the necessary skills to assist in providing sustainable energy solutions for social and economic development in their home countries.

V Alumni presentation

Promotion & Dissemination of Renewable Energy Technologies in Tanzania

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Abstract:

Tanzania is blessed with abundance of renewable energy sources which could be taped to power development of the nation. Deployment and use of renewable energy technologies in rural electrification and development of the country, is not at the right speed to cope with energy needs to power poverty reduction initiatives and strategies. The state utility (TANESCO) is currently electrifying about 36,000 customers per annum. With about 6 million households in Tanzania, where only 10% (about 600,000 households) are electrified, it will take another 150 years to electrify the remaining 90%. A new rural electrification approach is inevitable if we need electrification of the current rural generation. It is encouraging however; new approaches are being adopted by different energy players in the country to foster electrification of more rural communities and facilities.

This paper highlights selected initiatives and activities being employed in Tanzania that are assisting with rural electrification and powering development initiatives in rural areas where grid electricity is not available. Such initiatives and activities include electrification case studies for both health and education facilities by different actors. The paper also highlights approaches used, outputs realized, lessons learned, challenges, and an approach proposal that will ensure sustainable increased access and use of renewable energy services of rural communities in Tanzania.

A new approach for wider dissemination of Biogas in Ethiopia

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Abstract:

Modern sources of energy are simply not available in rural areas while traditional sources are being depleted rapidly thereby depending the rural energy crisis. With less than 2% of Ethiopia's rural population having access to the national grid and 85% of the population living and working in rural areas – the lack of modern energy severely restricts social and economic development. In many parts of the country dung cake and agricultural residue is (rapidly becoming) a commercial energy source, traded on markets while renewable energy sources such as hydro, solar, wind, etc. are available in reasonable quantities though they remain largely untapped. Key issues are the availability, the relative cost of this energy, the sustainability and the environmental acceptability when harnessed for productive use.

The government has embarked upon a national energy access project that aims to increase electricity and other modern energy sources to a much larger proportion of the population over the next ten years. One of the activities recognized is the wide dissemination of biogas plant. For domestic biogas technology to make a difference in the national energy scenario, dissemination has to be on a large scale (provided, of course, the technology proves appropriate). Such approach has a long-term perspective, in which broad sectoral cooperation is critical (Public Private Partnership).

In the perspective of a truly large scale program, a pilot of sufficient size should be considered. A reasonable pilot size, in view of experience in other countries, could be 10,000 installations over a period of 5 years. Based on this the Government of Ethiopia planned to construct 14,000 biogas plants throughout the country within 5 years.

Background

Modern sources of energy are simply not available in rural areas while traditional sources are being depleted rapidly thereby depending the rural energy crisis.

One of the targets of the millennium development goals (MDGs) is to reduce by half the proportion of the people living in abject poverty and those who suffer form hunger by the year 2015 and eradicate poverty by 2025. Another millennium development goal is to ensure environmental sustainability with the target of reducing half the proportion of people without sustainable access of safe drinking water by 2015. In response to the MDGs, Ethiopia, has developed various policy frameworks including the poverty reduction strategies (PRS) targeting economic growth and overall improvement in livelihoods.

An appealing vision would be to increase the energy coverage by a considerable amount through various renewable energy technologies. A possible and effective form of short-term substitution for traditional fuels and technologies that is suitable for rural household cooking and lighting is biogas obtained form agri-residue, human, and animal wastes.

Recognizing the above, he Netherlands Development Organization in Ethiopia (SNV/Ethiopia) conducted a study on the feasibility of a national programme for domestic biogas in Ethiopia. The study revealed a technical potential of about 1.1 million households in four (out of nine) regions (Amhara, Oromia, SNNPRS and Tigray), holding four cattle or more and living within maximum 30 minutes walking distance from a water source.

The study recommended preparing a national programme, initially targeting 14,000 households in the four mentioned regions over a period of five years. The Ethiopian Rural Energy Development and Promotion Center (EREDPC) were identified as the most appropriate lead organization at the national level.

An institutional arrangement was identified that suits the requirement for mass dissemination of domestic biogas. EREDPC and the regional Mines Energy Agencies were selected as lead organizations at the federal and regional levels, respectively. Under the responsibility of these federal and regional level organizations a National Biogas Proragmme Coordination Office (NBPCO) and Regional Biogas Programme Coordination Offices (RBPCO) shall be established. The BPCOs are responsible for the day to day coordination and operational management of the national biogas programme.

Animal husbandry

The livestock population in Ethiopia is the second largest in Africa, and ninth in the world. Livestock includes over 44 million cattle, 30 million small ruminants, 1 million camels and 4.5 million equines. Animal husbandry contributes to the livelihoods of 80% of the rural population. Livestock is an integral part of the farming system and is highly linked to land/soil and water resource management.

This sector too is characterized by a low-input system based on common grazing and the use of crop residues. Common grasslands provide extensive pasture and browse for livestock in most regions, but are particularly important to livestock producers in the eastern regions of Afar and Somali, the southern zones of Bale, Borena and South Omo, and in the western lowlands ranging from Gambella to Tigray. In the highlands, livestock are kept under settled or trans-human systems utilizing crop residues and common pastures and fallow land which have high clover content. Such livestock includes some 14 million oxen providing draught power for the mixed farming system that prevails. Rapidly growing population in the face of limited agricultural productivity, very low rural incomes, ever- increasing fragmentation of agricultural land and consequent environmental degradation are some of the major problems from which the nation is trying to extricate itself.

There is serious degradation related to intensive cultivation, overgrazing, deforestation, soil erosion, poor water control, shortage of livestock feed and fuelwood crisis. These factors interact and lead to a vicious cycle often referred to as "the poverty, food insecurity and natural resources degradation trap"[10].

Energy demand & supply, policy and plans

With less than 2% of Ethiopia's rural population having access to the national grid and 85% of the population living and working in rural areas – the lack of modern energy severely restricts social and economic development. Therefore the government has embarked upon a national energy access project that aims to increase electricity and other modern energy sources to a much larger proportion of the population over the next ten years.

Key issues are the availability, the relative cost of this energy, the sustainability and the environmental acceptability when harnessed for productive use. Except for petroleum, which is wholly imported, Ethiopia is endowed with many types of indigenous energy resources. Renewable energy sources such as hydro, solar, wind, etc. are available in reasonable quantities though they remain largely untapped.

The primary energy resource

The main indigenous sources of energy are biomass, hydropower, fossil fuels, natural gas, coal, geothermal, solar and wind. To meet domestic energy requirements, rural populations use various forms of biomass almost exclusively (e.g.: fuel wood, agricultural residues and animal wastes such as dung). In addition to heavy dependency on biomass, there is limited use of electrical energy and a generally low level of energy consumption. Ethiopia, whose economy depends almost entirely upon subsistence agriculture, has had little need for electrical energy in the past. Most agricultural products ere exported directly with only little processing of those commodities that are consumed domestically. There has been awareness in Ethiopia that to raise the standard of living would require a gradual shift from an agricultural economy to one, which processes agriculture surpluses for foreign export as well as the development of other basic light and heavy industries.

Renewable energy

Hydropower: The hydro resource of the country is said to be of immense potential. The gross hydro potential of the country is estimated at 650TWh/year (CESEN, 1986).

With over 94% of the total consumption supplied by biomass, wood contributing the lion share, Ethiopia is third in the list of countries using traditional fuels[11]. In line with the above, the per capita electric energy consumption in Ethiopia is –even in the regional context, extremely low at 28 KW/year.

Electrification rates are correspondingly low; the national electrification rate is 10% overall, dropping below 1%[12] for rural Ethiopia (average rural electrification in sub-Saharan Africa amounts to 4%). Nearly 90% of the total energy consumption is for residential use with the main purpose being cooking and baking. The recent woody biomass study has compiled data on each regions woody biomass stocks. Standing stock is some 1,187 million tons with an annual increment of 52.5 million tons[13]. Consumption is detailed as some 48.7 million tons. Including dead wood as fuel, there is a sustainable biomass supply of some 60.9 million tons. This suggests there is no overall deficit but that the problem of deficits is local and not national. The margins, however, are very small, as witnessed by the constinuously declining forest cover of the country Out of 482 Woredas surveyed, 336 were consuming more than their annual increment and this is especially the case for Woredas in the highland areas. The demand and supply of construction poles is becoming a serious problem that cannot be ignored in reforestation programmes. Fuelwood burning contributes to deforestation with biomass fuels supplying nearly 95 percent of the country's energy market. The countries forest cover diminishes –quite linearly- with 141000 ha per year over the past 15 years (other sources noting a deforestation rate at 100,000 to 200,000 ha annually). The current national forest cover is claimed to be below 3%.

Traditional Injera baking

Fuelwood consumption was reported to be over 700 kg per capita per year (a WB/UNDP assessment from 1984 mentioning 2 kg/cap/day for cooking only ref 013), whereby metads are often fired with branches, leaves and twigs (BLT) and agricultural residue. Fuelwood supply is getting scarce in Ethiopia as the supply source dwindles, being substituted by other forms of biomass fuels like dung, BLT and agricultural residue.

In 1986-87, the demand for fuelwood exceeded supply by twofold with 42 million cubic metres while supply remained at 24 million cubic metres. By 2000, demand exceeded by four times reaching 58 million m_3 while supply dwindled to 11 million m_3. The alternative use of dung and crop residues as fuel instead of organic fertilizers affects crop productivity significantly when most farmers cannot afford to buy chemical fertilizer. Although data from different sources do not always match, calculations would indicate dung cake use amounts to some 2.5 tons per household per year.

As a result, the cost of domestic energy is high and rapidly increasing. In many parts of the country dung cake and agricultural residue is (rapidly becoming) a commercial energy source, traded on markets. At places, air dried dung cake can sell for as much as ETB 1 per piece of ~ 250 grams. The bureau of Agriculture reported that these prices have tripled over the past four years. Much of the fuelwood, charcoal, dung cake and agricultural waste at the market is transported in and out over large (>30 km are no exception) distances.

Domestic energy in summary

The most prominent issues in Ethiopia's domestic energy sector include:

− Heavy reliance on biomass fuels,

− By tradition a relatively high domestic energy consumption,

− Low levels of renewable energy and/or energy efficiency technology,

− Energy demand in most (visited) areas significantly exceeds the supply.

As a result:

− Fuelwood is over-harvested in many areas, contributing to deforestation of already ecologically sensitive areas,

− Fuelwood and charcoal have been and are rapidly becoming more expensive.

− Households (and to a large extend institutions) cope by substituting fuelwood with dung cake and agricultural residue. The –often painfully obvious- consequences include:

− Massively denuded areas, particularly in Tigray, Amhara and the Rift Valley

− Further degradation of soils, large eroded areas with gullies, further reduction of soil fertility.

− Reducing agricultural productivity, both for cropping as well as livestock.

Development of biogas

When any organic matter such as animal dung, crop residue or kitchen waste is fermented in the absence of oxygen, biogas is generated. Biogas contains combustible methane (~ 60%) along with carbon dioxide and traces of other gasses. This gas can serve as a convenient fuel for a variety of applications such as cooking, lighting and motive power. The bio-slurry that comes out of the plant after the gas is produced can be used –directly or as a composting agent- as organic manure to augment soil fertility. Thus, biogas technology produces fuel without impairing the fertilizer value of the dung. Biogas production is a bio-chemical process occurring in three stages: hydrolysis; acidogenesis and methanogenesis, during which different bacteria act upon the organic matter resulting in the formation of methane and acids. The main factors influencing biogas production are the level of acidity of the feedstock and the temperature. It is well established that biogas plants work best with a near to neutral solution and a temperature of around 35$_0$C. 6.1 Benefits of domestic biogas The benefits of biogas in energy supply, agriculture, health, sanitation, gender and environment are well documented. There are a number of aspects of biogas production that have multiple benefits:

Animal dung and night soil is collected regularly and fed into the biogas plant, this:

− reduces pollution: that leads to a cleaner farm environment;

− reduces human and animal disease: by improving sanitary conditions related to bad sanitation and polluted surface water for both the household and the greater catchment-area, and;

− reduces greenhouse gas emissions: depending on the traditional manure

handling, the improved manure management system can significantly reduce GHG emissions. The generated gas substitutes conventional fuels. In doing so, biogas:

− reduces indoor air pollution: that is caused by incomplete combustion of

conventional fuels is minimized, resulting in a reduction of eye and respiratory illnesses particularly of those most heavily exposed to smoke namely women and children;

− reduces workload: especially in regards to fetching firewood, maintaining the fire and cleaning cooking pots. The use of biogas can reduce workload by 2 to 3 hours per day, particularly the workload of women and children;

− reduces fuel expenses: traditional domestic fuels increasingly become part of the formal economy. Biogas significantly decreases consumption of these traditional sources;

− increases opportunities to use appliances: such as gas lamps and water heaters;

− reduces greenhouse gas emissions: from the conventional energy sources;

− reduces deforestation: by reducing the demand for firewood;

− provides income generation opportunities: by providing an energy source for technologies and activities such as incubators, kilns, lanterns and cooking flame that is a new resource or more cost effective than previous sources.

The residue of the anaerobic process - bio-slurry-, is a potent organic fertilizer. When used in this way it can:

− provide a superior organic fertiliser: in terms of available nutrients and soil

texture, increasing agricultural yields with 20-40%.

− provide a catalyser for composting other agricultural waste: Applying this practice increases the amount and quality of organic fertilizer;

− improve handling safety: of residue due to the fact that the process of digestion followed by composting makes handling of the residue much safer from a hygienic point of view;

− reduce chemical fertiliser costs of farmers: by reducing the amount of synthetic fertiliser used;

− reduce greenhouse gas emissions: through avoiding the application and

production of synthetic fertilizer

− enables farmers to participate in animal husbandry in areas in which discharge regulations would otherwise have been prohibitive: anaerobic digestion reduces odour and environmental load resulting from livestock holding.

These benefits, although not all equally tangible, do not only profit the investor, but have an impact on the community at meso and macro levels as well.

Biogas & Sustainable Development

Sustainable development covers three aspects of society - economic, social and

environmental. Biogas contributes to these three aspects of sustainable development in the following ways:

Domestic biogas digesters contribute to economic development because:

− The expenses for domestic energy are significantly reduced.

− The labour required to maintain traditional energy systems (such as firewood collection) can be used in more directly economically productive

ways.

− Substitution of petroleum products will reduce the countries foreign exchange demand.

− Application of bio-slurry increases the yield and reduces the need` -and

expenses- for synthetic fertilizer.

− A vibrant biogas sector creates significant employment and related economic activities, particularly in rural areas.

− Reduced disease (human and animal) can improve productivity.

Domestic biogas digesters contribute to social development because:

− The reduction in domestic workload, particularly for women and children,

increases opportunities for education and other social activities.

− Respiratory illnesses resulting from indoor air pollution and gastro-enteric

diseases as a result of poor sanitary conditions reduce significantly.

− In rural areas, biogas digesters often initiate innovation (education, sanitation, agriculture).

− Increase awareness of alternative farming and animal husbandry practices and environmental impacts of behaviour.

Domestic biogas digesters contribute to environmental development as follows:

− Substituting conventional fuels and synthetic fertilizer, and changing traditional manure management systems, biogas installations reduce the emission of greenhouse gasses significantly.

− Bio-slurry improves soil texture, thus reducing degradation, and reduces the need for further land encroachment.

− Reduction of firewood use contributes to checking deforestation and reduces forest encroachment.

− Improved manure management practices reduce ground and surface water pollution, odour and improve aesthetics.

History and current status of domestic biogas in Ethiopia

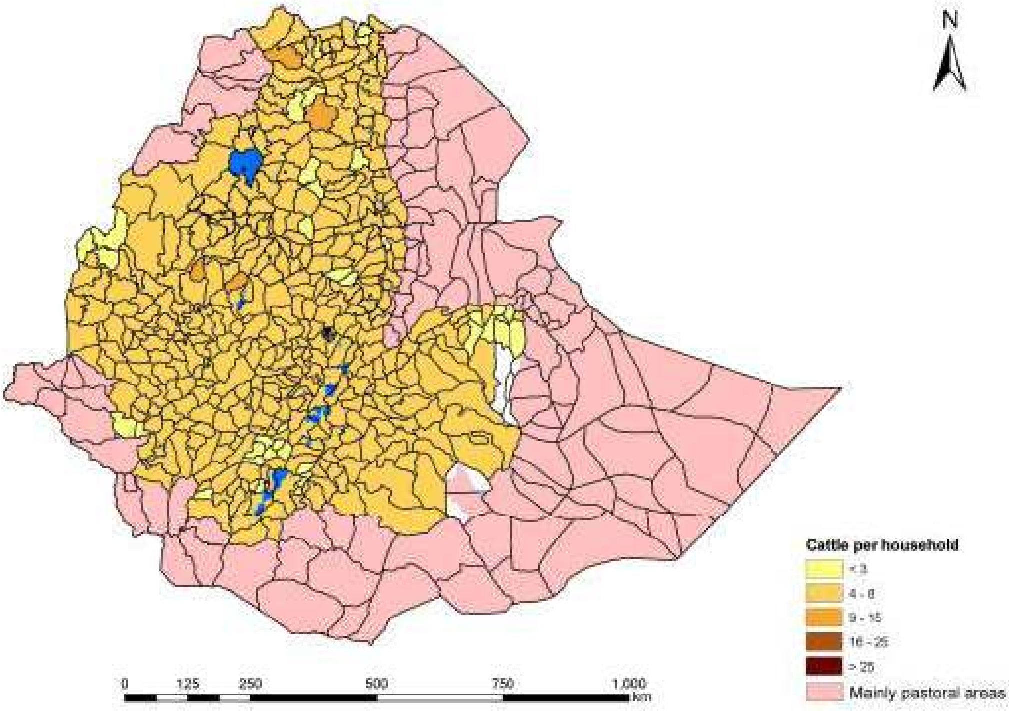
Biogas technology was introduced in Ethiopia as early as 1979, when the first batchtype digester was constructed at Ambo Agricultural College. Attempting to ease the impact of the energy crisis of the 70s, the Ethiopian Rural Energy Development and Promotion Centre introduced new and renewable energy into rural areas of the country[14]. The focus of the programme was (and largely is) foremost on introduction and demonstration pilots. Anaerobic technologies are not widespread in Ethiopia.

In 1991 the EEA reported 103 biogas installations constructed by 9 different institutions / organizations ref 013. Early 2000, reports mention less than 350 household digesters (up to 30m^3), a “small number of institutional biogas installations (up to 100 m^3), 6 community bio-latrines, and 4 bio-digester septic tanks[15]. In addition, EREDPC mentions the introduction of the cheaper “plastic bag” biogas plants[16]. Recently, World Vision Ethiopia introduced biogas under its Appropriate Agricultural Technology Promotion Initiative (AATPI). So far, some 150 plants have been constructed (or are in the process of being so). In all, the total number of domestic biogas plants would be in the range of 600 to 700 installations. Section 2 of the report presents the observations of the study regarding to the visited biogas installations.

Dissemination of biogas in Ethiopia can, in extremis, be grouped in two approaches. The older approach, mainly practiced by government agencies (EREDPC, Bureaus of Energy and Bureaus of Agriculture), could be haracterized as a stand alone, technology driven. The objective often is to pilot / demonstrate the technology in certain areas. The newer methodology, practiced in particular by World Vision, would then be more a development approach in which households are offered a full “development package” that would serve as a springboard towards a “happy and self sufficient” life. The picture presents some observations of both approaches in opposition, and –with the following remarks- largely is self-explanatory.

Benefits of biogas

Biogas installations improve the health situation of families. Most prominently by eliminating indoor air pollution, the main cause of respiratory diseases, and in particular for women and small children who are often close to the cooking fire. Biogas installations further improves the sanitary condition of the farmyard and its direct environment by feeding animal manure directly to the installation and connecting a toilet to the plant respectively. As such, biogas installations directly contribute to the betterment of the two of Ethiopia’s three main diseases in terms of mortality rate.



Potential of biogas

To come to a first estimate on the potential for domestic biogas, the number of households with 4 or more cattle is taken at Woreda level. As substrate, manure of other stabled animals (donkeys, horses) would do equally well. However, avoiding an over-optimistic picture, for the calculation only cattle holding is considered.

The availability of manure as substrate for the installation is not the only technical parameter. Equally important, and much more critical in the Ethiopian context, is the availability of process water. Practically, in view of the considerable amount of water that has to be fed to the installation, the water source should be within 20 to 30 minutes from the farm yard.

In general, in Ethiopia basically on the study area nearly from 11.2 million households 8.7 million households (78%) are keeping cattle. Out of these 8.7 million "cattle holdings", nearly 5 million (55%) are holding 4 cattle or more. Country wide, 71% of the rural households live within 20 to 30 minutes walking from a water source. The "high" technical potential for domestic biogas in the country hence is estimated on some 3.5 million households. On average, 23% of the households in the visited area have access to safe water. The "low" technical potential for domestic biogas in the studied area thus would amount to approximately 1.1 million households.

Limitation

Technical Issue

Domestic biogas installations cannot supply the full domestic energy demand:

− Sedentary farmers may occasionally have reasonably large cattle herds, but the average seams not to exceed the range of 4 to 8 heads per household. Most of these households use fallow land and communal grazing grounds for their cattle during the day, having the cattle on stable during the night only. In addition, the condition of stables is rarely geared towards efficient collection of dung and urine. Hence, the amount of dung available as substrate for the installation seems limited; an average of 20 to 30 kg of dung per day seems a prudent estimate. Gas production, hence; for most potential clients will unlikely exceed 1 to 1.5 m^3 biogas per household per day.

− Domestic energy consumption is typically high. Preparation of daily food – especially injerra baking- is not only energy intensive, but also requires a large amount of energy in a short period of time. The amount of gas that can be stored in domestic biogas installation of simple design is limited –roughly up to about 50% of the daily production.

Non-local materials increase investment costs and maintenance problems:

− To a certain extent, application of “non local” materials cannot be avoided (e.g. cement, most fitting materials). In view of the investment costs, however, significant savings can be made by constructing in stone rather than bricks.

− Many of the appliances (gas taps, stoves, biogas lamp) could be manufactured locally. This may further reduce the costs, but more importantly will increase the chance that smaller and larger repairs can be made locally as well, reducing the “out-of-operation” time considerably.

In relation with the available dung, most installations are over sized:

The proper digester size for typical rural Ethiopian households would be 4 to 6 m^3 rather than the often observed 8m^3 or larger.

Without proper technical back-up, any plant will fail sooner or later:

− However good the initial construction quality, smaller or larger maintenance and repair requirements will sooner of later hamper proper operation of a biogas installation when proper (locally available and affordable) technical back-up installations is not available.

Operational issue

Farmers need proper instruction to maximize the benefits from their investment:

Operation of many of the visited installations could improve:

− in drier periods, part of the thinner liquid discharge can be re-used to mix new input;

− cattle sheds and shed floors can be improved to make dung collection easier and more efficient and to accommodate cattle urine collection;

− maintenance instructions (booklet) could assist farmers in simple maintenance and repair (gas hose, gas tap repair, cleaning stoves, draining water from the pipeline etc);

− bio-slurry can be used as catalyser for composting other agricultural waste, thus increasing the amount of organic fertilizer and making it easier to handle.

Biogas installations as a “stand alone” application are likely to fail:

Households that judge their installation only on its capability to substitute conventional cooking fuels are likely to put less effort in keeping their installation in good working order. Other formal (illumination, bio-slurry fertilizer) as well as non-formal advantages (smoke reduction, improving sanitation etc) should be promoted and appreciated as well.

The plant’s water requirement shall not be underestimated.

A significant share of the visited installations became non-functional when collecting the daily amount of water proved to be too large a burden for the household. A limit of 20 to 30 minutes to reach the water source, as used in other biogas countries, seems prudent

Economic issues

Investment costs for biogas are prohibitive for farmers:

The costs of the visited installations (ETB 8000 to 15,000) are prohibitive for most farmers. Even with a significant reduction of the investment costs, supporting financing facilities will be necessary.

Full subsidy schemes show disadvantages:

− Nearly all visited installations had had a very large or full subsidy component. In some cases, non-functionality could be attributed to little feeling of ownership of the family, which could be induced by the family not having had to pay for the plant.

− In view of the requirement of the country as a whole, a full subsidy approach would be infeasible from a sourcing point of view.

Micro-finance can play an important role in making domestic biogas affordable:

Most visited biogas installations were constructed in a period when micro-finance facilities were not well developed. However, currently micro-finance institutions increasingly adjust lending conditions in such a way that biogas financing becomes a promising opportunity.

Recommendation

Market oriented approach

For domestic biogas technology to make a difference in the national energy scenario, dissemination has to be on a large scale (provided, of course, the technology proves appropriate). Such approach has a long-term perspective, in which broad sectoral cooperation is critical (Public Private Partnership).

Hence:

- EREDPC and the BoEs as coordinating and supervising organizations;
- Financing activities, both credit as well as subsidy channeling, by participating micro-finance institutions.
- Developing good federal, regional and local networks for promotion and extension;
- Construction, after sales service and manufacturing services by the local private sector;
- ID/OS and capacity building support of all actors, at all levels when and where required.

Pilot reasonable sizing

In the perspective of a truly large scale programme, a pilot of sufficient size should be considered. For this:

- The pilot areas could include all four visited regions: Amhara, Oromia, SNNPRS and Tigray, as they all give sign of sufficient potential.
- A reasonable pilot size, in view of experience in other countries, could be 10,000 installations over a period of 5 years. This would imply tentatively 2500 installations per region.
- A domestic energy survey should provide detailed information on the (rural) domestic energy situation.

Therefore, the programme shouldould start with a domestic energy study in confined areas (Woreda level, lower administrative level) to:

- Identify energy demand and supply characteristics
- Livestock keeping characteristics and modalities
- Water availability (and other secondary parameters)
- Enable a correct assessment and screening for potential biogas clients.

The National Biogas Programme Office (within the EREDPC) would formulate the Terms of Reference. The regional Bureaux of Energy will implement the survey, with –where necessary- assistance of the national office.

- To allow efficient and effective implementation and supervision, construction should take place in a limited number (say 5) of Woredas per region (resulting in ~ 500 plants per Woreda). Selection of the initial programme areas should follow the finding surveys as mentioned.
- Construction should take place in batches of 10 to 20 installations within one smaller area (Kebele, village) to create a good environment for commercialization, financing and extension.
- As a result, the pilot would establish between 500 and 1000 domestic biogas cores.
- The pilot shall provide detailed information and justification for the potential and opportunity for succession.

Investment costs

Reduction of plant investment costs seems possible by:

- Proper (smaller) sizing of installations
- Application of locally available materials (fixed dome constructed in stone instead of bricks).
- Development and introduction of a biogas financing facility
- Partial investment subsidy

Technical aspects

Quality management will prove a critical success factor in the programme. Therefore:

- Standardize design, construction and manufacturing services for domestic biogas
- Stimulate / support local manufacturing of appliances (taps, stoves, lamps)
- Introduce a quality management system embedded on the sector standards.
- Certify (training of) biogas constructors and technicians

Financial Approach

Subsidy

Although investment in a domestic biogas installation appears to be modestly economically feasible, in practice the return is highly sensitive to the actual replacement value. This value depends to a large extend to how the household acquires domestic energy. In the five year perspective, a drop in the real value of only € 0.10 would bring the IRR already under the lending rate.

Biogas and the Clean Development Mechanism

The fermentation of animal dung in domestic biogas digesters, and the subsequent application of biogas and bio-slurry, contributes to the global reduction of greenhouse gasses (GHG). As such, the programme will qualify for the Clean Development Mechanism (CDM) of the UNFCCC. In principle, applying domestic biogas could reduce GHG emissions in three ways:

- Substitution of conventional domestic energy sources,
- Modification of the traditional manure management practice

The finance secured through the CDM will contribute the affordability of the technology by the farmers.

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Ethiopian Energy policy

Viable Strategy for Scaling up the Dissemination of Improved Stoves among the Poor in Africa

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Abstract:

Biomass is the most important source of energy for the rural poor in Africa, yet the increasing biomass energy demand is putting a constraint on the environment. One of the solutions undertaken to reduce demand is the dissemination of efficient technologies. But due to minor scale of intervention, the problem is growing more than the solution. It is therefore crucial that scaling up approaches are designed and implemented to ensure that a large proportion of the households are reached. To have a sustainable dissemination of stoves, two considerations are critical: the technology, whose choice must consider the technical, economic and social aspects of the population and the dissemination strategy and the dissemination strategy that should be compliant with the socio-economic framework.

For example, the campaign for selling of stoves to the urban households at a certain price, many not necessarily be very successful in the rural setting where incomes are insignificant and unpredictable, yet the biggest population in poor countries is rural. Since neither a purely commercial approach nor a free distribution of stoves to these rural poor communities is sustainable, an intermediate strategy must be adopted to minimize the negative consequences of each extreme.

Experience from GTZ Uganda indicates that designing a stove from cheap or costless available materials, like clay and grass, and training a critical number of people to become local artisans can lead to a more systematic scaling up of stove dissemination. This is because, the stove materials can be supplied by the client and the artisan builds the stove, leaving the finishing process to the stove owner. In this regard, a small fee can be charged for labor, while nothing is directly charged for the materials.

Introduction

Biomass is critical component of the world energy picture, accounting for almost 15% of the world's energy supply and for developing countries it supplies more than 90% of the their energy supply (Denman, 2006). Traditional biomass (mainly charcoal and firewood) energy dominates the energy supply in Eastern and Central Africa, supplying about 60 – 90% of the total energy supply in most countries (ADB FINESSE/UNEP/IEA, 2006).

The reliance on biomass is a result of poverty. Biomass is the energy source for the poor. This is especially true for traditional biomass energy, which is often collected as "free" fuel (Reddy et al 1997). There appears to be a correlation between poverty levels and traditional biomass use in many developing countries (Karekezi, 2004). As a rule, the poorer the country is, the greater the reliance on traditional biomass resources (IEA, 1998). This is because the alternatives are unaffordable.

Biomass energy is most utilized in form of fuelwood by the domestic sector. The use of fuelwood is most common in poor rural households. Fuelwood is considered the cheapest energy option available to households, although the labor, effort and externalities of fuelwood remain unquantified (Batidzirai, 2006).

The Problem Statement

The widespread use of fuelwood by poor households in rural and urban areas and uncontrolled harvesting will in the long term denude the woodlands. Intensive tree harvesting has led to forest and woodland degradation, leading to unsustainable fuelwood supply (Batidzirai, 2006). In Uganda, the biomass demand already exceeded the sustainable supply by 1995. Regrettably, most of the end-use devices are inefficient, e.g. the three stone fire has efficiency of less than 15%. One of the most important driving factors is the rapid population growth rate, since the consumption of traditional energy depends on population (Nadejda, et.al, 2002).

Efforts have been going on for decades to alleviate the problem of energy crisis, including tree planting and introduction of improved biomass technologies, which have a higher efficient and more environmentally friendly. Improved cookstoves, for instance, are designed to reduce heat loss, decrease indoor air pollution, increase combustion efficiency and attain a higher heat transfer (Karekezi and Ranja, 1997; Masera e al, 2000). However, due to the insignificant scale of intervention in most countries, the problem is growing faster than the solution. The result is the escalation of the energy poverty and deepening of the biomass energy crisis in particular. Consequently, it is neither rational nor sustainable to continue interventions that operate at a minor scale that cannot restrain the crisis in the long run.

The Rational Energy Solution for the Poor

It is therefore crucial to design approaches that are aimed at scaling up the activities to ensure that the largest part of the affected or the vulnerable population realizes the benefits. For instance, the strategy for the dissemination of improved household stoves should target the larger, rather than the negligible proportion of the households.

To have a sustainable dissemination, where the stove penetration meets the least resistance, two considerations are critical: the technology and the dissemination strategy.

The choice of stove for dissemination should put into consideration three major factors: the technical, economic and social aspects. The technical aspects include the stove efficiency, which leads to fuel saving, and is the foundation of the concept of an improved stove; the strength and stability that support the varying food weights; and the durability that enable the user to enjoy the benefits for a reasonable period of time.

The economic aspects include the cost of the stove or the price that the consumer pays; and the production process, which takes into account the availability and cost of the materials and their quantities, the production tools and equipments, and the skills. If the materials are quite expensive or not readily available, and the production tools and equipments are too sophisticated, and the production skills are advanced, the resulting cost implication of the stove is likely not be customer friendly.

The social aspects include suitability, which depends on its flexibility, convenience, ability to cook common foods and accommodate common local pots; the safety, which guarantees that cooking accidents minimized; and the beauty, which is the captivating force the attracts the user.

However, a cross examination of every developing country indicates that there is always a discrepancy in the socio-economic setting among the different sections of the population. In this regard, a social and economic analysis of the different categories of the population cannot qualify the same type of stove to fit all. Although an influx of too many stove designs on the market might be source of confusion, it is, on the other hand, necessary to consider a level of variety in order to cater for the variety of the socio-economic categories. For example, the stove for the urban households may not be affordable to the rural poor; while the stove affordable to the rural poor may not be acceptable to the urban setting, because of its relatively inferior standard.

Remarkably, the strategy applied for the dissemination of the stove is as essential as the choice of the stove. In many instances, the strategy applied for dissemination is discordant with the socio-economic set up. Consequently, a wrong strategy is used to disseminate a wrong stove, or one could say that the strategy is systematically designed to miss the target group! So it is always important to adapt a strategy that is compatible with the socio-economic framework.

For example, the urban population might indeed be able to purchase the stove at a reasonable price due to more reliable incomes and smaller family sizes. They are also used to purchase almost item from the market, hence they will not be repulsed by a stove in the marketplace at a certain reasonable price. In other words, a purely commercialized approach for the urban and the rich consumers is strongly recommended. However, the rural households might find it straining to purchase a big stove at a high price that can cater for their cooking needs, given their low and unreliable incomes, when some of them cannot buy even the food itself.

Recent rural energy and community studies conducted in 2000 and 2001 indicated that where there is shortage of fuelwood, people are willing to use fuelwood efficient stovces and to switch to other fuels. However the cost of procuring such stoves or using these fuels remains a barrier for them (DOE, 2006, ProBEC, 2006).

In other words, the same worth of a stove is subject to different socio-economic interpretation: reasonable price for the urban might mean prohibitive price for the rural.

According to experience from GTZ Uganda, the socio-economic category that has a strong purchasing power is targeted with the metal Rocket stoves. These are disseminated among the higher income households, social institutions like schools, hospitals and prisons, and the business enterprises like the restaurants. The strategy involves identification of credible stove dealers or private companies, training them in the stove design and production, supporting their publicity and marketing campaign, and helping them to access appropriate tools and equipments.

However, to deal with the lowest income category, who are generally the rural poor, and who constitutes the vast majority of the African population, it is necessary to design a stove from cheap available materials, and ensure that the fabrication does not require sophisticated tools and too complex skills. For example a stove made out of clay and grass, and molded using basic tools that are used by the peasant farmers, like the hoe and spade will make the production much more feasible. In Uganda, such a stove is called a Mud Rocket Stove. Furthermore, training a big number of artisans leads to the spreading of the skills across the community, which in turn ensures that the prices are not hiked and the skills don't easily become extinct. For effective implementation process, the GTZ – Uganda operates through NGOs by building their capacity to carry out the activities in the different communities. A combination of these techniques has led to a more systematic scaling up of stove dissemination. This is because, the stove materials can be locally supplied by the client and the artisan builds the stove, leaving the finishing process to the stove owner. In this regard, a small fee can be charged for labor, while nothing is directly charged for the materials. The user does the finishing as directed by the artisan, and the latter demonstrates the firing. The maintenance and responsibility for replacement is left to the stove owner. Since the capacity for construction remains in the community the replacement modalities can be negotiated between the user and the artisan.

By operating through 7 NGOs the GTZ has been able to disseminate stoves in over 340,000 households in Uganda in 5 years using. In the process, lots of capacity for stove building has been generated, and many have turned it into fulltime employment, at times even crossing the Ugandan boarders to the neighboring countries. Finally, the Mud Rocket Stove is indeed reaching the poor.

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Production of Biofuel from Jatropha Curcas:
A promise for Improving the Socio-Economic Conditions of Rural Population in Africa

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Abstract:

The steady world population growth is leading to an increase demand of energy resources as well as a greater consumption of goods that produce huge amounts of wastes. It is estimated that the world has peaked in petroleum production, and world petroleum consumption has outpaced newfound reserves. Depletion of fossil fuel reserves coupled with the high concentration of carbon dioxide (CO_2) in the atmosphere (due to consumption of fossil fuels), and the necessity to safely and economically dispose of wastes in order to keep a healthy environment for future generation have encouraged development of alternative sources of energy and valorization of low quality fuels such as biomass and waste. Biofuels, among other renewable sources of energies offer good alternatives to liquid fossil fuels and have been used successfully in internal combustion engines (transportation, electricity generation, power, etc…) as a blend with petroleum fuels or alone; their application also extends to fueling cooking and lighting devices. Although huge improvements have been made recently toward reducing the cost of commercial scale biofuels production, many producers still rely on subsidies in order to compete with petroleum-based fuels. Moreover, some criteria such as availability, economics, acceptability, environment, technology, and versatility need to be addressed in order for biofuels to supplement or replace petroleum fuels. These criteria are yet to be met; therefore researchers are intensively working on improving the efficiency of producing biofuels.

Unlike lingering commercial scale, small scale production of biofuels, especially in rural Sub-Saharan Africa offers a myriad of opportunities in terms of economic and social development. This paper examines various biofuels (methanol, ethanol, dimethyl ether, Fischer-Tropsch fuels, biodiesel, etc.) and assesses their suitability in the context of rural farming in Africa. A special attention will be given to Jatropha Curcas, a perennial and poisonous shrub, which exhibits a lot of potentials for farmer's level biodiesel production.

Photovoltaic Energy for Sustain-able Rural Development in Sierra Leone

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Abstract:

In Sierra Leone, renewable energy, especially photovoltaic (PV) energy, has become the option of choice as the government struggles to provide electric power to remote communities that have never had electric lights, let alone electric pumps for clean water and irrigation, television or refrigeration.

Sierra Leone is located near the equator and have high levels of sunshine year-around, providing it with a free and abundant energy. The installation of PV demonstration plants and dissemination campaigns will lead to the development of a market structure of a cleaner and efficient energy source for an important economic cluster in Sierra Leone. The development of a local market could result in the local assembly of PV panels with pre-cut silicon cells.

This paper will address the State-of-the-art of Renewable Energy in Sierra Leone and propose a plan for a village electrification demonstration project, significant in magnitude to have an important beneficial impact to Sierra Leone. The main goal of the project is to provide an electricity supply to rural populations in Sierra Leone, where there is no access to either a national or local grid. The project is envisaged to proceed in two phases, with the initial phase addressing linkage building with prospective partners within and without Sierra Leone, and the evaluation of a broad range of alternatives. Demonstration plants will be installed in the second phase.

Introduction

Sierra Leone

Sierra Leone is a small West African country with a population of over five million and covers a total area of 71,740 sq km (27,699 sq mi). The country has a tropical climate, with a diverse environment ranging from savannah to rainforests. Sierra Leone is the lowest ranked country on the Human Development Index and seventh lowest on the Human Poverty Index (Human Development Reports, 2008) and suffering from endemic corruption (Tam-Baryoh, 2008).

Sierra Leone is an extremely poor nation with tremendous inequality in income distribution. While it possesses substantial mineral, agricultural, and fishery resources, its physical and social infrastructure is not well developed, and serious social disorders continue to hamper economic development. Nearly half of the working-age population engages in subsistence agriculture. Manufacturing consists mainly of the processing of raw materials and of light manufacturing for the domestic market. Alluvial diamond mining remains the major source of hard currency earnings accounting for nearly half of Sierra Leone's exports. The fate of the economy depends upon the maintenance of domestic peace and the continued receipt of substantial aid from abroad, which is essential to offset the severe trade imbalance and supplement government revenues.

Sierra Leone is emerging from a protracted civil war and is showing signs of a successful transition. Investor and consumer confidence continue to rise, adding impetus to the country's economic recovery. There is greater freedom of movement and the successful re-habitation and resettlement of residential areas.

The Energy Situation

One of the most serious problems Sierra Leone faces is the shortage, and in many cases, lack of energy (Davidson, 1986). For example, the capital city Freetown has not had constant electricity for over one year. This only benefited those few who sold portable electric generators while leaving the majority of the people in pre-electric times. As a result, even cool storage of medicine is a serious problem in the national capital. Due to lack of energy, almost no industry has survived the last decade. The country has many abandoned plants, manufacturing facilities, and mines because there is no electricity or energy to run them. As a result, one of the most important requirements for Sierra Leone to embark on a development effort is to increase the availability of energy and electricity. This will not only provide energy for the very basic needs of the people, but will encourage investment in the manufacturing and mining sector. Sierra Leone has no exploitable source of conventional energy (there are no known oil or gas deposits in the country). The only coal deposit is lignite which has never been exploited because of its sulphur content (Table 1). With the exception of a few megawatts of electricity generated from mini hydro resources, all primary energy for transportation, electricity generation, industry and agriculture are imported (Table 2). This heavy reliance on imported oil has serious consequence for both the economy and the environment. Depending on the world price of crude oil, the country spends up to 70% of its export earnings on fuel importation (Mansaray, 1998).

This heavy demand on foreign exchange has completely destabilized the local currency over the last decade with attendant consequences on the local price of everything including the fuel itself. The unreliability and high cost of conventional fuel have also had their toll on the environment as the urban population who traditionally use gas or electricity for domestic needs are forced to use fuel wood and charcoal. Crude methods of using fuel wood and charcoal has led to visible deforestation around urban as well as rural areas.

The new government of Sierra Leone is aware of the problem of energy supply and its effect on the economy and the environment. It has made the development of a local primary energy resource base a priority. To this effect, a hydropower generation facility for a total of 50 MW is under construction. However, hydropower potential of Sierra Leone is fragmented with only one site capable of more than 10 MW of power generation. On the other hand, indigenous coal resources cannot be utilized at present due to the lack of expertise and know-how in technologies that are environmentally safe. In addition to the lack of availability of inexpensive energy supplies, the energy utilization efficiency in Sierra Leone is very low because of the old technologies used.

Table 1: Fossil Fuel Overview (Thousand Barrels Per Day)

Fuel	Production, 2005	Consumption, 2005	Reserves, 2006
Petroleum	0	8.43	0
Natural Gas	0	0	0
Coal	0	0	NA
Source: EIA, Oil and Gas Journal, 2007			

Table 2: Electricity Overview, 2003

Consumption (Billion Kilowatt-hours)	0.24
Generation (Billion Kilowatt-hours)	0.26
Installed Capacity (Gigawatts)	0.12
Thermal Capacity (Percent of total)	96.7
Hydroelectric Capacity (Percent of total)	3.3
Source: ECOWAS Energy Data, Statistics and Analysis, 2008	

Need for Alternatives

The Republic of Sierra Leone has endured many of the hardships of a developing country. The climatic conditions are conducive to the spread of diseases such as malaria and guinea worm. A significant percentage of the total population cannot read and write. Much of the population is characterized as living below the poverty line. Much of the working age population engages in subsistence agriculture. Imports exceed exports by fourfold, including oil, machinery and foodstuffs, including its staple, rice, of which sixty percent is imported. Over-harvesting of timber, slash and burn agriculture have resulted in deforestation and soil exhaustion, many natural resources have been depleted. All these conditions have been greatly exacerbated by the war. As the government struggles with these overwhelming issues, (a) preserving the peace and (b) improving the human physical and economic condition appear to be complementary imperatives, without which progress will be unattainable. If these imperatives are to be attained and perpetuated, then (c) economic sustainability achieved through self-sufficiency becomes equally vital.

Recently, Sierra Leone's Minister of Energy and Power concluded that an essential ingredient of self-sufficiency is a pervasive, cost effective source of electricity, specifically, PV energy. The economics was clear. Sierra Leone spends millions of Leones each month to purchase oil, much of which is used to generate electricity. Oil imports deplete the country's very limited funds, every penny of which is sorely needed to rebuild the economy. Worldwide oil prices are higher than they have been in a decade, making matters all the worse. In contrast, the Minister of Energy and Power concluded that once installed, the cost of generating PV energy is a small fraction of that of oil. Thus PV can be a vital element of the economic recovery program. The Minister also noted the dramatic health and environmental benefits which will result from converting oil to solar power.

State-of-the-art of Solar Energy in Sierra Leone

The development of solar energy in Sierra Leone is extremely limited. It can be characterized by:

- Fairly limited research efforts in the universities on improved wood and charcoal stoves, biogas plants, gasification of wastes, solar drying, solar water heating, solar cooking, and solar radiation evaluation. Few studies have also been carried out on hydropower and wind energy.
- Many engineers and researchers with good theoretical background in solar engineering but limited practical experience in this field.
- A lack of manufacturer or committed retailer of solar thermal or photovoltaic systems. All components of the few systems installed in the past have been imported from Europe or the USA.

- Very few isolated field installations, most of them being small PV systems installed by end-users and not incorporating any monitoring or evaluation program. This situation, which is partially due to the lack of local manufacturers or importers to promote solar technologies, can also be explained by the following reasons:
    - In the past the market has been fairly limited because of relatively low oil prices and fairly satisfactory oil availability.
    - The lack of institutional policies and manpower (governmental, bilateral and multilateral agencies) to promote solar technologies.
    - The public awareness on the possible uses of solar systems is very low. Some people use diesel generators for powering a few lights when solar PV systems could supply the same power in a cheaper and more reliable way.

Solar Energy Resources

Predictions of monthly global radiations are available for several locations in Sierra Leone (Massaquoi, 1984). This design tool can be used to size thermal and photovoltaic energy systems and to assess feasibility. The value of the average daily radiations and percentage of possible sunshine for Freetown are given in Figure 1. For all locations the average daily available radiation achieves its peak value in March (mid dry season) and its minimal value in August (mid rainy season). The values of global incident solar energy for these maxima and minima in the Freetown area are 5.1 kWh/day and 3.2 kWh/day, respectively. These values increase for Norhtern and Island locations. The percentage of possible sunshine peaks in December with the value of 67 % in the Freetown area and is very steady during the dry season. This value drops to 19 % in August.

This analysis suggests that energy uses with constant load throughout the year to be supplied by solar (thermal or photovoltaic) systems and no back-up will need to be sized with solar radiation data for August if no storage is accounted for at that time.

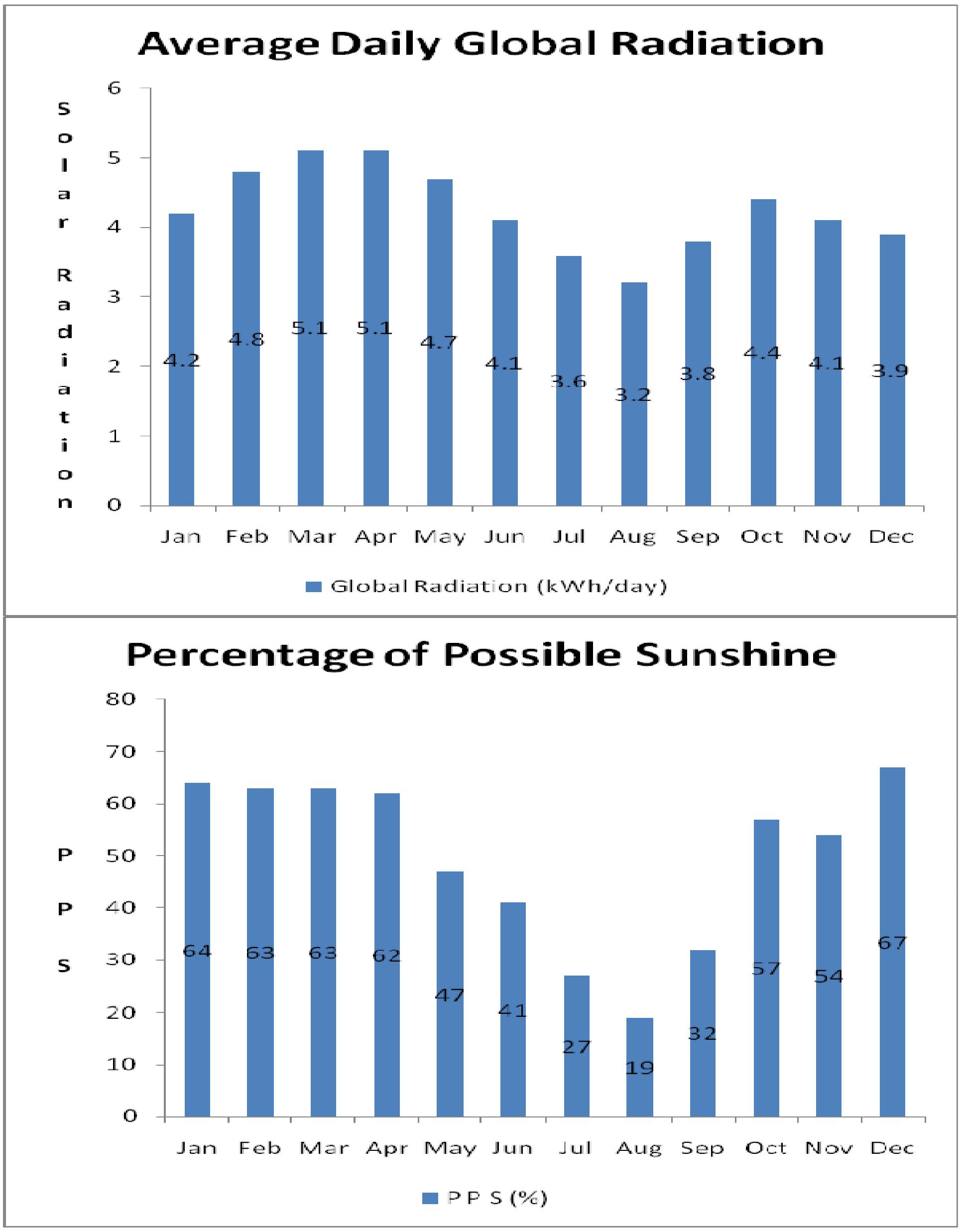

Figure 1: Solar Radiation for the Freetown Area

Proposed Areas for Further Studies

A village electrification demonstration project will have an important beneficial impact to Sierra Leone (Gross, 1999). I envision that such a project will proceed in two phases. In the initial phase a broad range of alternatives will be evaluated, and recommendations will be made on what is best for Sierra Leone. In the second phase, after the action plan is reviewed, modified where appropriate and approved, the plan will be implemented.

After completion of the first two phases and, after the results have been thoroughly evaluated, additional phases of work, involving either dissemination of more renewable energy systems, may be carried out. Said additional phases of work are, however, not included in this paper.

The detailed steps of the proposed project are presented below.

Phase 1: Scope of Work – Alternative Evaluation and Selection

1. Resolve and clarify the Client Organization. Identify the individuals/organization representing Sierra Leone with the authority to make decisions and commitments on behalf of the Republic, i.e., to approve plans, approve intermediary recommendations, resolve any questions arising during the course of the project and determine how community participation shall be accomplished.

2. Develop a set of Written Program Objectives.

3. Identify cultural and regulatory constraints and boundaries, regional, national or local, or constraints/requirements to be imposed by the providers of financing.

4. Conduct research, including literature and personal contact with Private Industry to determine alternative technology options.

5. Prepare a complete report of findings, advantages and disadvantages of alternatives considered when evaluated against the Program Objectives. Recommend a path forward.

Phase II: Scope of Work – Implementation of Prototype Projects

6. Select number, size and location of prototype facility installations; available budget not to be exceeded.

7. Identify additional services and specific terms and conditions required by Client to ensure successful operation of the facilities to be installed.

8. After financing is in place, execute approved contracts.

9. Monitor installation.

10. Train designated local companies, officials and citizens in the installation, use, and maintenance of the PV systems.

11. Evaluate Performance.

Conclusions

This paper explores the possibility of providing electricity supply using PV systems to rural populations in Sierra Leone. PV systems are especially well suited for use in rural areas where large populations remain isolated from existing power distribution networks. The installation of PV demonstration plants and dissemination campaigns will lead to the development of a market structure of a cleaner and efficient energy source in Sierra Leone. PV can provide the power necessary for electric lighting, health clinics, television, water pumping and water purification. PV systems can supply energy for agriculture and other productive uses in rural areas.

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Small Hydropower Potentials in Cameroon and the Practical Experiences of Cameroon's Privatization in the Electricity Sector

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Introduction:

Cameroon which is located in the heart of the Equatorial rainforest has been described as Africa in miniature because of her natural endowments that can be found anywhere on the African continent.

Second only to the Democratic Republic of Congo in hydropower potential, the country disposes of a huge amount of other natural resource base that makes it an earthly paradise.

With all these resources, the country is still battling with common African problems like diseases, poverty corruption and low energy consumption.

Today a number of measures are being put in place to fight against the above mentioned ills in the different sectors of national life in what is commonly called Poverty Reduction Strategy Paper (PRSP).

This paper that aims at reducing Poverty by 2015 with limits set in the Millennium Development Goals (MDG) puts access to energy at the centrifuge. For any meaningful development to take place, the energy sector has to precede all other parameters. Though endowed with all the energy potentials (Hydropower, Solar, Geothermal, Wind, Tidal and Biomass) experience has it that hydropower development is not only the cheapest but the most economically viable option that is sustainable and easy to run.

The ease with which hydropower is developed and managed, depends very much on its availability and ease with which to exploit. Having said this, it is worthwhile noting that like any other African country, Biomass remains the number one energy consumed (65%) followed by Petroleum (21%) and finally electricity (14%). Though electricity appears small, 88.5% of it comes from Hydropower.

Given that the country is exploiting only about 5% of its hydropower potential, measures were then taken to liberalise the electricity sector in order to set in competition and increase the rate of exploitation.

For this to be achieved a number of actors had to be involved in the sector (World Bank, IMF, ARSEL, the Government of Cameroon and AES-SONEL). These institutional players each had defined roles to play.

AES-SONEL the lone company having concession contract with Cameroon in the generation, transmission and distribution retail sales of electricity is the first experience of its kind in Sub Sahara Africa. This particular case is proving to be a handicap as private actors are finding it pretty difficult to enter the sector despite persistent energy shortage and continuous rationing. This happens not to be the only case of greater exception as the tariff system that privileges High Tension consumers to Low Tension consumers is proving to be very uneconomical both in the short and long term.

Yet enough justification had been put forward as to why privatisation was a better option to move things forward. It was noted that there was too much state interference in the day-to-day management of the electricity company, lack of transparency, lack of competition, weak ministerial oversight and high cost. A number of persons were against such a move claiming that this was not enough reason to privatise the company. To put the point through a number of objectives were outlined to foster the need for such a move to privatise:

To make use of private sector investment and to benefit from its expertise, improve service quality, increase access to electricity up to 49% by 2019, to supply electricity at a competitive price, to take advantage of the national hydropower resources and above all to involve the national private sector in the electricity sector.

In an attempt to put into practice the last point cited above, Civil Society Actors are making frantic efforts to enter the sector. Though timid in their attempt, their efforts are worth recommending as they have their own challenges that range from financial to technical.

For now **Rural World Resource International (RWRI)** has identified 25 Potential SHP sites, done pre-feasibility studies on 22 sites with capacities between 25 to 250 KW. The capacity of other three sites ranges between 1MW to 10MW. **African Centre for Renewable Energy and Sustainable Technologies (ACREST)** has realised 2 Pico hydropower and 1 micro hydropower 7.5KW. **Centre for Appropriate Technology (CAT CAMEROON)** is sensitising and building capacities of key local stakeholders (councils, SMEs financial institutions and schools) in renewable energy project development and financing.

Global Village Cameroon is involved in renewable energy and climate change campaigns.

Though small civil society actors are getting in the sector, it can still be noted that an assessment of the situation after privatisation leaves one with the impression that: private sector investment is still hard to attract, most Cameroonians would agree that service quality has not improved as we still have frequent outages, data energy not collected and published by ARSEL, no competition takes place for now as prices keep on increasing, AES-SONEL investment is mostly on heavy fuel projects as government privileges hydropower and private sector actor entry into the sector is still very slow and timid.

Conscious of these challenges a National Energy Action Plan (NEAP) coordinated by AER, facilitated by GVEP, sponsored by ESMAP and UNDP was elaborated through a multi stakeholder workshop and formally approved by the Government of Cameroon in December 2005, with principal aim being the improvement of access to modern energy service in key sectors, as a tool to reducing poverty.

To achieve this, the Government had planned a number of SHP projects, which include: Lom Pangar (56MW), Bini à Warak (75MW), Nachtigal (267MW) Memve'ele (202MW) and Kader (15MW).

No	**Projet**	**Size (MW)**	**Funding 10^9**	**Year of Completion**
1	**Kribi gas thermal station**	**150**	**85**	**Start of 2008**
2	**Lom Pangar**	**50**	**85**	**2010**
3	**Nachtigal**	**280**	**150**	**2010**
4	**Bini à Warak**	**75**	**75**	**2011**
5	**Memve'Ele**	**200**	**180**	**2013**

Source: Poverty Reduction Strategy Paper **(1Euro = 655 FCFA)**

On the other hand the Government is about to embark on a wide electrification project based on solar power.

All these projects pass through the tenders' board of the National Tenders Board Commission.

National and foreign companies are often encouraged to submit for such tenders with the aim to encourage south-south cooperation. It is therefore an opportunity for members of these Alumni to put their expertise at the disposal of needing countries on such projects submitting their bids.

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Abbreviations:

SHP: Small Hydro Power

AER: Agence d'Electrification Rural

ARSEL: Agence de Régulation de Secteur d'Electricité

The Role of Renewable Energy in the Energy Security of Cameroon: A Case Study of Yaoundé

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Introduction:

Cameroon is one of the African countries endowed with enormous energy potentials from various sources yet; the country still suffers from energy shortages. Energy like water contributes to improving on the living conditions of urban and rural people, a challenge that Cameroon has not exploited using its potentials. The major potential energy sources in Cameroon include: Biomass, Biogas, Solar, Hyro, Biofuels, Natural gas and Natural oils. Given these tremendous potentials, Cameroon is fast to complain of energy shortages. At this point, one can easily establish the lack of knowledge or skill, financial resources, and or insufficient political will to exploit these energy potentials to enhance development in Cameroon.

Experience have shown that despite measures taken to refine fuel from natural oil, the price of petroleum products have remain high at the level of consumers. Each time these prices increase, cost of transportation is affected and prices of all consumer commodities will also increase. Biofuels produced from vetegation could be an alternative source of energy for transport. Similarly, an increase in Natural gas prices will affect adversely fuelwood consumption and therefore the natural environment is under pressure leading to degradation. Biomass, Biogas, and Solar systems could mitigate this adversity if put into proper use. Electricity energy constitutes a primary base for household energy consumption and most especially a motor to accelerate economic advancement through industrialisation. The electricity coverage of Cameroon is very weak and the few areas connected have frequent and acute shortage in supply. The inaccessibility of energy in most parts of the country has contributed in its own way to the prevailling poverty in that some development initiatives stop prematurely due to insufficient access to energy.

Despite effort on rural electrification, most of the rural areas remain unelectrified. It is therefore necessary for the development projects in the rural areas to be accompanied by electricification. Currently, electricity is generated mainly from centralised hydro power stations and to some extent from Natural Gas. Solar power, Micro hydro power, Biomass, Biogas, and intensification of electric power generation from natural gas could reduce the current pressure on existing installations that leads to frequent and polonged power cuts.

Cameroon lack know-how, skills, and experience in generating energy from these numerous potentials. The lone specialised training institution graduate only skilled labour to work in the AES SONEL Company, otherwise knowledge in energy can only be aquired out of the country. The few Cameroon trained in daispora will hardly gain employment in this company on one hand and cannot easily start up an energy business hence little motivation for more to go for training in the energy sector. Skill development is required at various levels of the Cameroonian society in order to jointly promote the sector among development priorities.

Financial resources are needed to exploit these huge energy potentials, but Cameroon that is held up in the poverty trap cannot readily provide the necessary finances for this purpose. Reasons could either be that energy generation is not top on the list of development priorities, given that finances are limited. Investing in Energy generation is quite lucrative, thus sorting out investors in energy seems very visible. Capital could also be sorted from donors if they are sure that they money will be ploughed into energy business with corresponding returns.

The politicians will have a big relevance to any development efforts so is the case with the energy sector in Cameroon. The policy on energy or better still, renewable energy will first of all required that sufficient knowledge and information as well as convincing argument should be available to enhance the work of decision makers. If Energy is a vehicle to economic progress and social improvement then, the will of the people is strongly required to enhance the achievement of such objectives at any level.

Finally, by combining, skills, finances, and the political will, we could be confident that access to energy by a majority of Cameroonian shall be a reality. Let us consider the role renewable energy generation particularly from Solar power, Micro hydro power, Biomass, Biogas and biofuels could play at the local level with national impact to complementing energy supply from gigantic installations and systems.

Electricity Energy Supply in Cameroon.

Applied Electricity Services (AES) SONEL is the main provider of electricity in Cameroon. It has to produce a maximum of 1000 MW which is currently its installed capacity. Over 80 percent of its production is generated from hydroelectricity, through three production units; ie the Songloulou and Edea hydro power stations in the southern grid, and the Lagdo plant for the northern grid. The rest is generated from the thermal sources. The power plant project in Kribi which should be completed in 2009, will generate 150 megawatts, in the name of a yet to be known Company. This means that many electricity suppliers will be authorized with the ever increasing demand for electricity energy in the country. (Source: The Post Newpaper, posted on **27 September 2007**)

The World Bank within its new launched initiative called “Lighting Africa” is strieving to light 250 million persons in Sub-Saharan Africa currently living without electricity. This effort is intended to make it possible that one out of every two Africans have access to electricity by the year 2030 (Source: Business Africa, 15th January 2008).

Based on the aforementioned argument, the demand for energy in Cameroon and the subregion will continue to be high. This implies that investing in the energy sector in our region is attractive and the future is expected to remain bright given that African countries and Cameroon in particular will need energy to complement its development efforts.

Challenges and Prospects of Market Expansion for Renewable Energy Technologies in Tanzania

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Abstract:

The importance of modern energy especially electricity to the development of a nation cannot be over emphasized. Extension of the national power grid to all parts of Tanzania is not practically possible in the foreseeable future because of the technical and economic constraints which the country like any other developing country cannot easily overcome.

However, the country is endowed with various renewable energy (RE) potentials in many parts of the country which encourages 'local production for local consumption'. The Government of Tanzania (GoT) having realized the importance of renewable energy technologies (RETs) in rural energy development has been working with development partners and other stakeholders to open up the RETs market for national growth. The Global Environment Facility (GEF) funded transformation of the rural photovoltaic (PV) market in Tanzania being piloted in Mwanza region by United Nations Development Programme (UNDP) is one of such initiatives.

The objective of this study is to collate and analyse views of stakeholders on the challenges and prospects of expanding the market for RETs in Tanzania, with a major focus on the solar PV pilot project in Mwanza Region. That is, to identify the factors that will support replication of such a project in the other regions of Tanzania and countries that share common characteristics so that the much needed electricity is accessed by the rural dwellers for socioeconomic development and poverty reduction.

The study shows that solar PV is one of the options for rural electrification in the country because decentralization of rural electrification by promoting RETs with highest potentials in different parts of the country is necessary. It also revealed the importance of solar PV in stimulating income generating activities, which is very vital in breaking poverty cycle in the society.

It is recommended that awareness programmes for effective market expansion should be extended to the educational institutions. Technical and business capacity building activities should be strengthened. Financial institutions should take keen interest in the RE market development and promotion. Initiatives such as United Nations Development Programme/Ministry of Energy and Mineral Resources (UNDP/MEM) and Swedish International Development Agency/ Ministry of Energy and Mineral Resources (SIDA/MEM) should be gender sensitive and have direct connection with education and poverty reduction.

Addendum

The lessons learnt from this case study in Tanzania could be adopted by countries in Africa for RETs market development which undoubtedly is one of the objectives of this study. Some international organisations are obliged while some others are willing to fund and/or invest in renewable energy development. A well articulated proposal from developing countries like most African countries will attract co-operation and partnership from Organisations in Development Co-operation because of their commitment to Kyoto Protocol and also their obligation to OECD to support the developing world while private investors will be attracted by the business opportunity in the sector.

Nigeria is a country in dire need of energy as lack of it has inhibited socio-economic development for a very long time. The country is endowed with energy resources both conventional resources - crude oil, natural gas, tar sand, coal, etc and regenerative resources such as hydropower, solar energy, wind energy, biomass, etc. What is lacking is clear strategy to harness these resources for the development of the country. Though, belatedly government is opening up the sector for private investment and participation but renewable energy development is yet to get the attention it needed.

ADDENDUM

A1: OPPORTUNITIES FOR RENEWABLE ENERGY DEVELOPMENT IN AFRICA

Most African countries share the same modern energy peculiarity with Tanzania (Okereke, 2007, p1). The study carried out in Tanzania among other things tried to find out how the lessons learnt in the Tanzania RETs market development can be replicated in other African countries that share similar characteristics. Paradigm shift to private and market driven energy development model should be of interest to most African countries because they stand better chance of getting to the grassroots faster and efficiently. First and foremost, stakeholders in the energy sector in general and RETs in particular of individual countries in Africa should form a body (where it is not there already) or strengthen an existing body to develop a strategy for renewable energy market development like the Tanzania Solar Energy Association (TASEA) (ibid, p.47). It will be a platform for knowledge sharing, networking, co-operation and integration among members on one hand, the association and government and development partners on another hand. It is stating the obvious that most African countries are grappling with poverty and modern energy services are more of a luxury than necessity but they can leverage the opportunities available from private and international organizations and agencies to develop and promote RETs market

United Nation Framework Convention on Climate Change (UNFCCC)

This is an international treaty joined by most countries of the world in 1992 to begin to consider what can be done to reduce global warming and to cope with whatever temperature increases caused by the emission of greenhouse gas by mostly conventional energy. The famous Kyoto Protocol adopted in Kyoto, Japan in 1997 by a number of nations with more powerful (and legally binding) measures was a follow up to the treaty which opened opportunities for among other things worldwide interest for renewable energy development. "In order to give Parties a certain degree of flexibility in meeting their emission reduction targets, the Protocol developed three innovative mechanisms - known as Emissions Trading, Joint Implementation and the Clean Development Mechanism (CDM). These so-called 'market-based mechanisms' allow developed Parties to earn and trade emissions credits through projects implemented either in other developed countries or in developing countries, which they can use towards meeting their commitments. These mechanisms help identify lowest-cost opportunities for reducing emissions and attract private sector participation in emission reduction efforts. Developing nations benefit in terms of technology transfer and investment brought about through collaboration with industrialized nations under the CDM"[1]
Clean Development Mechanism (CDM): This is a mechanism that will positively impact on the RETs development in the continent in the shortest possible time if adopted by individual countries of Africa. It is a market based trading mechanism which delivers subsidies to the developing world in return for lower emissions of greenhouse gases, the subsidies offset the cost of reducing GHG emissions, thereby encouraging less developed countries to emit less GHG than they otherwise would (Wara, 2006, p.6).

The prospect of using CDM to attract partnership from the developed world for RETs market development to Africa has been there for sometime now but less attention has been given to it. Whoever wins the US election is willing to sign-on to GHG emissions reduction and by extension more opportunity to invest on RETs development all over the world. This is the time to formulate both country and regional strategy for utilization of CDM to develop RETs and promote clean environment.

Multilateral Organizations

These organizations are created for the common good of there member countries and territories. Of interest here are the ones involved in energy development and environmental issues. They carry out various functions such as capacity building, investment support, policy strengthening, institutional support, awareness creation, etc. In this category are Global Environment Facility (GEF), World Bank, United Nation Development Program (UNDP), United Nation Industrial Organization (UNIDO) etc. Almost all countries in Africa are members of GEF and they funded the project in Tanzania which is the basis of the field study in Tanzania by the author. Other African countries can partner with them to replicate similar projects which will in no small way deepen the development of renewable energy and reduction of greenhouse gas emission among other multiplier effects like poverty reduction and improved standard of living. Any eligible individual or group for GEF funding may propose a project, which must meet two key criteria: It must reflect national or regional priorities and have the support of the country or countries involved, and it must improve the global environment or advance the prospect of reducing risks to it and project ideas may be proposed directly to UNDP, UNEP, or the World Bank[2]. UNIDO has an elaborate program for renewable energy development among which is small hydropower projects[3]. The United Nations set a target that OECD member countries should commit 0.7% of their GNI[4] as aids to the developing countries of the world and this opens a window of opportunity for African countries to make real case for renewable energy development which trickles down to the grassroots instead of the old fashion support for good governance and other intangible issues which benefits only international consultants and corrupt political leaders.

Bilateral Relationships

Every country in Africa has a strong tie with at least one developed country in the world. Over time the developed countries have been giving development aids which laid much emphasis on good governance and related issues to the developing countries like those in African continent but it seems not to have yielded the desired results. However, the time for partnership with the developed countries for the development and promotion of renewable energy in Africa is now. The trickle down effect of this partnership will be enormous to the continent and the rest of the world.

1 http://unfccc.int/kyoto_protocol/items/2830.php [05.04.08]
2 http://www.gefweb.org/interior.aspx?id=76 [April 15, 2008]
3 http://www.unido.org/index.php?id=o81105 [April 15, 2008]
4 http://www.oecd.org/document/8/0,3343,en_2649_33721_40381960_1_1_1_1,00.html [April 15, 2008]

Although, it is a fact that development aids from developed countries are guided by their national interests but it is also germane that development of renewable energy and reduction of GHG emissions that cause global warming is in the interest of all the nations of the world. In this direction, the Federal Government of Germany is a pioneer; this august event is one of such partnership and SESAM/ARTES program funded by DAAD has done much to build capacity for renewable energy and clean environment expertise in Africa. Two other laudable projects supported by German government in Africa are: GTZ commissioned extensive study for potentials for biofuel development in Tanzania and pilot Private-Public-Partnership model for stand alone Solar Home System for rural electrification in South Africa. These other bilateral agencies – Department for International Development (DFID), United States Agency for International Development (USAID), Danish International Development Assistance (DANIDA), Swedish International Development Agency (SIDA), Canadian International Development Agency (CIDA), Japanese International Cooperation Agency (JICA), etc have shown varied level of support to African countries where they have strong relationships towards RETs development.

Regional Synergy

In Africa, there are many sub-regional and regional bodies like Economic Community of West African States (ECOWAS), Southern African Development Community (SADC), Common Market of Eastern and Southern Africa (COMESA), Economic and Monetary Community of Central Africa (CEMAC) as well as others at the continental level such as African Union (AU), New Partnership for Africa's Development (NEPAD), African Energy Commission (AFREC), African Development Bank (AfDB), etc which could work individually and collectively to develop renewable energy market in Africa among other of their programs. A visit to the websites of most of these bodies showed that RETs development is given little or no attention yet in their scheme of things. Development partners advocate for regional integration and will support proposals under this framework to develop and promote renewable energy and reduce GHG emissions in different regions of Africa. Knowledge sharing and capacity development could result to market expansion for RETs in all countries of Africa. Some examples of shared or common initiatives in this regard are West African Power Pool; common standards for RETs equipment and accessories by countries in East Africa; etc.

Private Partnerships

Most African countries have formulated policies to promote renewable energy. Policy formulation is area of strength of most governments in Africa but the real problem lies with the implementation. To overcome this difficulty, the private sector should be involved in renewable energy development policy implementation in Africa for a better result. These private bodies are NGOs, Foundations, investors and fund providers like E+ Co, International Finance Corporation (IFC), African Finance Corporation (AFC), etc. There are many NGOs in Africa that are carrying out outstanding programs in renewable energy development, sustainable development and other safe environment issues.

They could do more if they develop affiliations and cooperation among themselves and other worldwide organizations that are willing to work with them in these areas. Some big manufactures of RETs have foundations that support poor countries of this world to acquire RETs and open up the markets for business. African entrepreneurs can develop capacity to tap from international funds for RETs and other spheres of business available for private investors.

A2: RENEWABLE ENERGY DEVELOPMENT IN NIGERIA

Nigeria has a total population of 141, 356,000[5] as at 2004. It is an independent state in West Africa with a total area of 923,768 km², estimated GDP (ppp) for 2007 of USD 294.8 Billion and GDP per capita is USD 2,200[6]. The nation is a member of sub-regional, regional and international organizations such as ECOWAS, APPA, AU, UN, IAEA and OPEC which offers opportunity for it to play an active role in their energy agenda.

Nigeria Energy Profile

Energy need and supply of any society directly relates to the socio-economic development of that society. Developed and industrialized nations utilize the greater percentage of the world energy resources for their industrial, commercial and domestic needs whereas developing nations use less energy resources because bulk of the energy needs are for domestic purposes. Nigeria is endowed with many types of primary energy resources both finite and renewable energy resources. Nigeria's estimated proven oil reserve as at January 2006 is 35.88 billion bbl, oil production of 2.44 million bbl/day[7] Nigeria has four refineries for domestic consumption of petroleum products with installed capacity of 445,000 bbl/day (Nigeria, 2003, p.10) but low capacity utilization due to poor management. Estimated proven natural gas reserve as at 2006 is 5.015 trillion m³ and estimated production in 2005 is 21.48 billion m³ [8]. The country holds an estimated 30 billion barrels of oil equivalent of tar sand reserve and 639 million tones of proven coal reserve (Nigeria, 2003, pp. 15-17). A technical potential for large scale hydropower is 10,000 MW; that of small scale hydropower is 734 MW and presently 32% of power to the national grid comes from hydropower (ibid, p.23). Over 60% of the population use fuelwood for cooking and other domestic needs. Commercial electricity is generated mainly from hydropower, steam plants and gas turbines in Nigeria. The installed capacity for electricity generation, which is 98% owned by the Federal Government stood at 5881.6 MW but available generated capacity hovers between 2,600 MW and 3,000 MW because of depreciation of the plants some of which are 40 years old and poor management, while transmission and distribution losses accounted for about 28% of electricity generated. Electricity consumption per annum is estimated at 16.88 billion kWh[9] in 2005 and per capita per annum is about 120 kWh.

5 http://hdrstats.undp.org/countries/data_sheets/cty_ds_NGA.html [April 12, 2008]
6 https://www.cia.gov/library/publications/the-world-factbook/print/ni.html [April 12, 2008]
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Some of the key energy related governmental organizations are Energy Commission of Nigeria (ECN); Nigerian National Petroleum Corporation (NNPC); Power Holding Company of Nigeria (PHCN) which is presently being unbundled into eight generating companies, eleven distributing companies and a transmission company in line with Electric Power Sector Reform Act 2005 of Nigeria; Nigerian Electricity Regulatory Commission (NERC); Nigerian Coal Corporation (NCC); Bitumen Development Agency (BDA); Nigerian Nuclear Regulatory Authority (NNRA).

Renewable Energy in Nigeria

The Nigerian Energy Policy is very explicit on renewable energy development in Nigeria. There are two energy research centres - National Centre for Energy Research and Development, University of Nigeria Nsukka and Sokoto Energy Research Centre, Usman Danfodio University, Sokoto that carry out research mainly on renewable energy development in the country. UNIDO has established a regional centre for small hydropower project (SHP) in Abuja under the supervision of ECN and has funded two SHP in Enugu and Waya Dam. In 2006, Lagos State government kicked-off rural electrification project using solar PV in an island-based village called Bishop Kodji[10]. The Solar Electric Light Fund (SELF) has collaborated with the Jigawa Alternative Energy Fund (JAEF) to carry out rural electrification project using solar PV in the rural areas of Jigawa State[11]. There are other isolated renewable energy projects all over the country but the impact is still very insignificant. A platform is needed in the country to bring stakeholders like government, development partners, experts, researchers, nongovernmental organizations and investors together to forge a common position to promote renewable energy. Through extensive consultation and negotiation, an actionable blueprint could be developed for institutional framework, awareness creation and capacity building among others to open up the market for renewable energy development.

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7. http://www.gefweb.org/interior.aspx?id=76 [April 15, 2008]

8. http://www.oecd.org/document/8/0,3343,en_2649_33721_40381960_1_1_1_1,00.html [April 15, 2008]

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10. http://www.treehugger.com/files/2006/08/nigeria_launche.php [April 14, 2008]

11. http://www.unido.org/index.php?id=o81105 [April 15, 2008

Environmental and Socio-Economic Impacts of Crude Oil Refining and Distribution

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Abstract:

The production, distribution and use of energy are fundamental for the economic development of any country. These activities are always accompanied by environmental and socio-economic changes, some of which are adverse and detrimental to the overall development objectives. Given that some of these changes cannot be completely avoided, it is important to look for ways of minimizing the adverse environmental and socio-economic impacts often generated in the course of acquiring energy. For instance, downstream activities of the petroleum sector like the refining of crude oil and distribution of petroleum products in most developing countries have generated severe negative environmental and socio-economic impacts. It is often difficult to assert whether the presence of oil wells in an area is a blessing or a curse as people living in oil producing and refining areas are often targets of environmental and social problems rather than direct beneficiaries of the fruits these energy activities.

Cameroon is one of the third world countries that largely depend on oil for its foreign earnings and as an important domestic fuel. The crude oil is principally refined and stored in the coastal towns of Limbe and Douala respectively, from where it is distributed to other parts of the country or exported to foreign countries. However, the resulting build up of petroleum and petroleum waste matter in the Douala and Limbe coastal areas where the National oil refining company Ltd (SONARA) and the Cameroon petroleum Depot Company (SCDP) are located, has generated severe adverse environmental and socio-economic impacts that must be redressed.

The study area covers the coastal region from Douala to Limbe along the coastline of Cameroon . It is a complex and diversified environment in terms of natural resources and human activities from which socio-economic development has either benefited or suffered. This area contains sandy and rocky beaches, dunes, coastal forest, mangroves, islands, and agro-plantations and industrial zones. The area offers nursery grounds for fisheries and other aquatic species as well as peculiar recreational and tourist sites. The indigenous people of this region consider this coastal environment and its resources to be of profound spiritual and cultural importance.

One of the resources whose exploitation and distribution in this area has severely affected its people, their environment and socio-economic status is petroleum. The problems identified and analysed in this work include among others water pollution, forest degradation and damages to recreational resources, damages to fishes and aquatic ecosystems, damages to natural landscape and cultural heritage, health problems, mass rural-urban exodus, uneven income distribution and low access to basic social services.

Given that the refining and distribution processes generate most of the problems, the first part of the work is centred on how these processes are carried out in the country. At each level of these processes, the study identifies these changes, comes up with strategies of combating existing damages and ways of improving refining and distribution mechanisms.

The study reveals that there is need to improve the distribution network, storage conditions, security, waste disposal and treatment systems in the refinery and petroleum depots. It is through this that the adverse impacts can be minimised for many more Cameroonians and the world at large to benefit from this energy activity.

Sustainable Use of Solar Photovoltaics in Rural Ghana: Barriers, Measures to Remove Barriers and Policy Implications.

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Abstract:

In off-grid rural Ghana, solar photovoltaic (PV) systems have demonstrated their potential for meeting basic electricity needs. However, the use of rural PV systems is plagued with barriers, which pose a challenge to sustainability and access widening. This study examined two main public rural solar PV projects that operated on fee-for-service. The purpose was to identify, analyse and make recommendations for the removal of barriers to the sustainable use of solar PV at the household and enterprise levels. The study was based on a cross-sectional survey conducted in six districts and five regions of Ghana. Using Pareto's analysis, the study identified and ranked the barriers facing rural households as: unavailability of solar PV components on the local market, high price of parts/components, limited government support and lack of end-user financing. At the enterprise level aging/defective batteries and power fluctuation due to low sunshine hours during the rainy seasons prevented extension of working hours after sunset. To remove the barriers there is the need to establish local sales outlets through enhanced public-private partnership, introduce temporary subsidies for repair and maintenance targeting the poor, build local capacity to reduce system failure and introduce measures to make monthly fees affordable to poor consumers.

Keywords: Solar PV; Sustainable use; Barriers; Off-grid rural communities; Ghana.

.1. INTRODUCTION

The policy of the government of Ghana is to achieve universal access to electricity by 2020. However, access is unevenly distributed and highly skewed in favour of the urban population. Out of the 3,701,241 households in Ghana (Ghana Statistical Service, 2002), access to grid-electricity by households is currently about 54% with rural access being only 24.9% compared to 81% in urban households (Ghana Statistical Service, 2005). According to Munda and Rossi (2005), grid extension to remote rural areas is found to be expensive because of low population density, lower consumption and hence lower revenue per km of grid. As an important element of government's energy policy, solar photovoltaic (PV) is being promoted to expand electricity access for socio-economic development, particularly in poor rural areas (World Bank, 2003). Solar PV systems have largely demonstrated their potential for meeting the expectations of off-grid rural communities (Lorenzo, 1997).

Currently, over 1.0 peak megawatt (MW) capacity of solar PV systems have been installed in Ghana through public-private sector projects for rural clinics, schools, community water supply, households and micro-enterprises. Although solar PV systems are cost-effective alternatives, particularly for low voltage applications, high installed system cost, lack of market, lack of information, lack of appropriate financing for market scale-up etc. are barriers that impede expansion in poor developing countries (Basnyat, 2004; Johansson et al, 2004; Sawin, 2004; WCRE, 2004).

Despite considerable deployment of solar PV systems in Ghana through fee-for-service approach to overcome the barrier of high installed system cost, there is relatively little research on the local challenges facing off-grid rural consumers during the use of solar PV systems. There are uncertainties with regard to the barriers to the sustainable use of rural PV systems at the household and enterprise levels. In this paper, barriers are defined as structures and systems that prevent or discourage action and benefits (Stuhlman, 2006). Though barriers such as physical barriers are necessary for physical safety, in general barriers are not good when they discourage service and other forms of positive activity (Ibid). The results available indicate that the use of solar PV in off-grid rural communities is plagued with barriers, which must be carefully researched. Without a clear analysis of the barriers to the use of rural PV systems in Ghana, potential users may not accept the technology as an appropriate alternative. In this regard, the poor may also see solar PV as an inferior alternative to the grid.

Two public solar PV rural electrification projects are studied for the identification and analysis of barriers to the use of rural solar PV systems. They are the Spanish/Ministry of Energy Solar PV Electrification Project and United Nations Development Programme (UNDP) - Global Environment Facility (GEF)/Renewable Energy Service Project (RESPRO). These projects were implemented between 1998/99 and the year 2003 in off-grid rural and peri-urban communities in Ghana using the fee-for-sevice approach. The objectives of this paper are three fold: First, to analyse the barriers to the sustainable use of solar PV in rural households and micro-enterprises in Ghana; second, to suggest measures to remove or reduce the barriers; and third, to make recommendations for policy and planning of future public solar PV electrification projects.

2. STUDY AREAS AND METHODS

To determine the barriers to the use of solar PV in rural households and micro-enterprises, cross-sectional surveys of 96 solar-electrified households and 22 solar-electrified enterprises were conducted from November 2005 to February 2006 in six districts and five regions of Ghana. The study areas were the following off-grid rural communities: Kpentang, Kpenbung, Kambatiak, Bamong, Kintango, Chintilung, Tojing, Gbetmanpaak, Jimbali, Najong No.1 and Pagnatik in Bunkpurungu Yunyoo district (Northern region); Kpalbe in East Gonja district (Northern region); Tengzuk in Talensi-Nabdam district (Upper East region); Wechiau in Wa-West district (Upper West region); Kpassa in Nkwanta district (Volta region); and Apollonia in Tema district (Greater Accra region). Pre-testing of the questionnaires was carried out in the Nkoranza district of Brong-Ahafo region. Figure 1 below, is the map of Ghana showing the study areas.

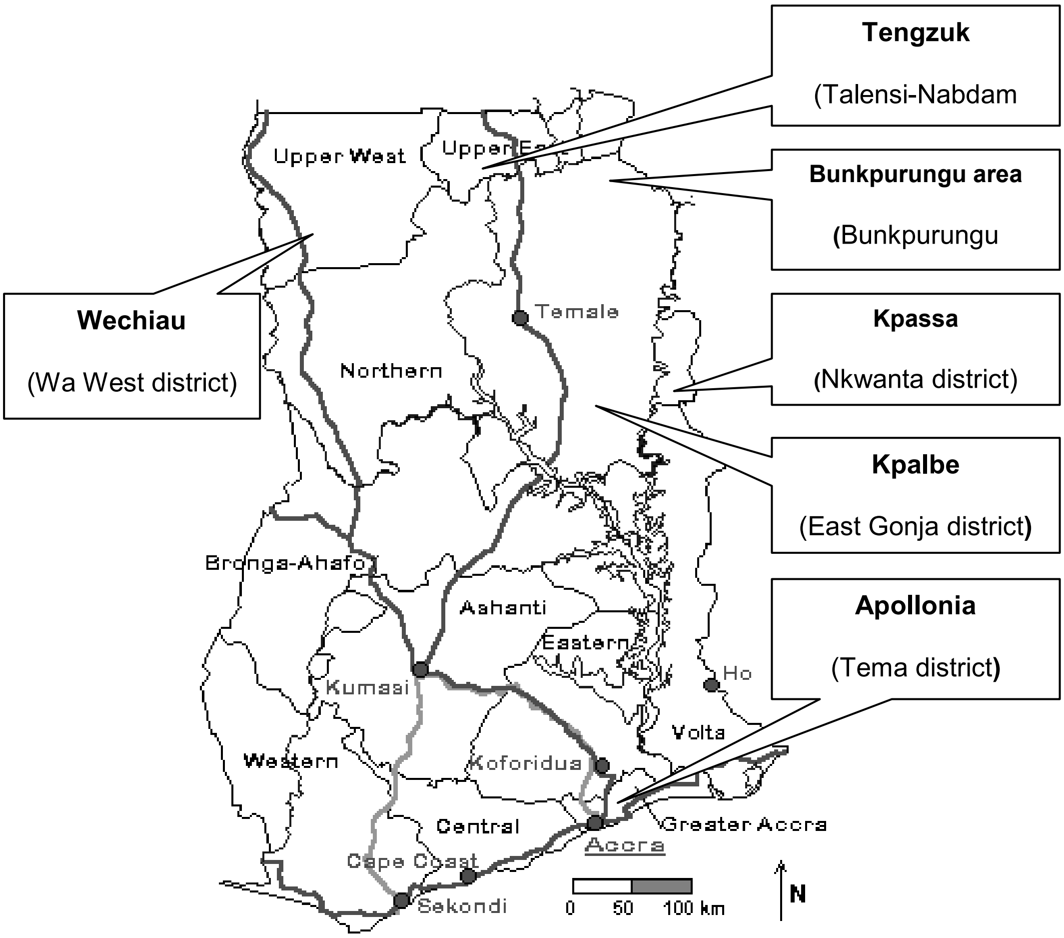

Figure 1: Map of Ghana Showing the Study Areas

In each of the communities research assistants who speak the local language were engaged in the administration of the questionnaires. The household and enterprise-level questionnaires contained 192 and 91 variables respectively.

In view of the homogeneity of the end-uses of the PV systems - mainly for lighting, radio and television - the selected sample size (N=118 households and enterprises with 5 percent standard error) is statistically adequate for analysis. Several authors consider sample sizes ($N \geq 30$) as statistically large samples (McClave and Benson, 1988; Spiegel and Stephens, 1999). However, most social researchers would probably recommend a sample size of at least 100 as adequate for statistical data analysis (Singleton et al, 1993).

Separate lists of beneficiaries were used to select the households and enterprises in a systematic sampling. In each sampling, the first case was randomly selected by drawing slips of paper with numbers from the first cases based on calculated sampling fraction (actual sample size divided by total sample population). Subsequent cases were systematically selected using the sampling fraction to determine the interval of selection. From the lists of the beneficiaries, PV systems (50Wp and 100Wp) that have been operational for over three years were selected. This criterion was based on the assumption that over a three-year period, PV systems and components (car battery, regulator and fluorescent lamp etc.) would have gone through a cycle of operation and maintenance (O&M) and beneficiaries would have learned lessons worth studying. The purpose of the questionnaire was to gather ex-post information on the barriers to the use of solar PV systems in off-grid rural Ghana.

2.1 Data Analysis

In order to analyse the data, SPSS 11.0 for Windows was used. The data were cleaned by visually cross-checking the data base with the individual questionnaires to find out wrong entries; and by using box-plot to identify extreme values and outliers. Pareto analysis was used to identify and analyse the most important problems (barriers) associated with the use of solar PV at the household and enterprise levels. Statistical significance was computed at $p<0.05$.

3. RESULTS

3.1 Characteristics of the Surveyed Households and Enterprises

In the surveyed households the mean age of the respondents was 40-49. About 92 percent of the respondents were married, 4 percent single; 2 percent separated; 1 percent divorced and another 1 percent widowed. The mean household sizes were about 8.3 members. An average of 5 children per household was recorded. Majority of the respondents were farmers (59 percent), followed by teachers (20 percent) and traders (9 percent). The household heads had no education (29 percent), primary (15 percent), secondary (12 percent) and tertiary (22 percent). Visual inspection of the houses revealed that the solar-electrified houses were constructed with mud/earth materials and thatch roofs.

The enterprises surveyed were generally small-scale employing less than 6 people. They were mainly shops engaged in the sale of groceries (village supermarket), chemicals (drugs), tailoring, drinking bars, spare parts, electronic repair and video show business. However, grocery shops, chemical shops, drinking bar and tailoring were the predominant enterprises in all the communities. Enterprise owners were predominantly males (91 percent). Their ages ranged between 20 and 49 years.

They have been engaged in their businesses for 4-15 years. Their monthly estimated earnings varied by size, type, season and geographical location. Their earnings ranged from about ¢1,000,000 (US$ 108) per month in tailoring business to over ¢4,500,000 (US$ 490) per month in spare parts business.

A summary data on the characteristics of the surveyed households and enterprises are provided in Tables 1 and 2.

Table 1: Household Characteristics and Socio-Economic Data

	Solar-electrified Household
Average HH size	8.3
Average no. of children (≤ 14 yrs)	5
Age of Household head	40-49
Occupation of HH head (%)	
Farming	59.4
Trading	9.4
Artisan	2.1
Teaching	19.8
Public Service	5.2
Others	4.2
Level of Education of HH (%)	
No Education	29.2
Primary	14.6
Middle	10.4
JSS	4.2
Secondary	11.5
Tertiary	21.9
Others	8.3
Estimated Monthly Income	
% up to US$ 1 per day	17%
% between US$1 and US$ 2 per day	42%
% above US$ 2 per day	41%
Monthly fee-for-service	
50 Wp PV system	¢15,000 (US$ 1.63)
100 Wp PV system	¢25,000 (US$ 2.72)
Dwelling type	Modern/Traditional
Average monthly household expenditure on kerosene	¢28,839.11 (US$3.13)
Average monthly expenditure on dry-cell batteries	¢24,796.83 (US$ 2.70)

Source: Fieldwork, 2005 *US$ 1 is equivalent to ¢9200(Ghanaian cedis).

Table 2: Summary Data on Surveyed Enterprises

		Grocer	Chemical Selling	Tailoring	Drinking bar	Spare parts	Electronic repair	Video centre	Total
Solar-electrified Enterprise	Ent. size	2	3	5.5	2	2.5	3	-	
	Age of	30-39	30-39	30-39	40-49	20-29	30-39	-	
	Male	12	2	2	1	2	1	-	20(91%)
	Female	-	1	-	1	-	-	-	2(9%)
	%	12(54.5	3(13.6%)	2(9.0%)	2(9.0%)	2(9.0	1(4.5%)	-	22 (100%)
	Monthly	¢2,000,0 US$ 217	¢1,500,00 US$ 163	¢1,000,000 US$ 109	¢2,000,00 US$ 217	¢4,500	¢1,500,000 US$ 163	- -	

Source: Fieldwork, 2006 US$ 1 = ¢9200 (cedis) in 2006

Note:

Monthly fee-for service was same as paid by household beneficiaries.

3.2 Analysis of Barriers

Table 3 displays the count (frequency) of responses by type of barrier to the use of solar PV. Pearson chi-square test of the responses by each type of barrier shows significant values of 0.000 ($p<0.05$) indicating differences in responses to each type of barrier. Since all the respondents were users of solar PV, the observed difference in the responses are likely to be real and not due to chance.

Table 3: Barriers to the Use of Solar PV by Household

	BARRIERS TO THE SUSTAINABLE USE OF SOLAR PV						
	MOST SEVER	MORE SEVERE	SEVERE	SOMEWHAT SEVERE	LESS SEVERE	NOT RANKED*	TOTAL
LACK OF END-USER FINANCING	11	12	11	28	13	21	96
LIMITED GOVERNMENT SUPPORT	22	7	19	13	13	22	96
HIGH PRICE OF COMPONENTS/ PARTS	12	21	25	17	11	10	96
HIGH MONTHLY SERVICE FEES	14	10	8	9	14	41	96
UNAVAILABILITY OF SOLAR COMPONENTS ON THE MARKET	32	28	14	12	7	3	96
LACK OF TRAINED TECHNICIANS	5	11	10	13	16	40	96
LACK OF INFORMATION	3	4	6	4	22	57	96

Source: Field data, 2005

*Not ranked = response was not ranked among 1-5 rankings in which 1=less severe and 5= most severe.

3.2.1 Weighted Mean Score

To provide a clear picture to reflect the rankings of the barriers, the results in Table 3 were further analysed by using a barrier ranking of 1-5, with 1 being less severe; 2 being somewhat severe; 3 being severe; 4 being more severe and 5 being most severe. Adding the individual weighted responses and dividing by the sum of the weights, the mean severity scores were obtained as shown in Table 4. The mean severity scores were calculated as follows: For example considering the response: Unavailability of solar components on the market**,** the weighted responses are (32x5) + (28x4) + (14x3) + (12x2) + (7x1) = 345. The sum of the weighting factors equals 5+4+3+2+1 = 15. The mean severity score was calculated by dividing the 345 by 15 to obtain a score of 23.0. The calculations of the severity scores of the other barriers follow the same steps.

Table 4: Barriers to the Use of Solar PV by Weighted Mean Scores

BARRIERS	MEAN SEVERITY SCORES
1. UNAVAILABILITY OF SOLAR COMPONENTS ON THE LOCAL MARKET	23.0
2. HIGH PRICE OF SOLAR PV COMPONENTS	17.6
3. LIMITED GOVERNMENT SUPPORT	15.6
4. LACK OF END-USER FINANCING	13.7
5. HIGH MONTHLY SERVICE FEES	11.1
6. LACK OF TRAINED TECHNICIANS IN THE COMMUNITY	9.4
7. LACK OF USER INFORMATION ON COSTS AND BENEFITS	5.3

Source: Field data, 2005

3.2.2 Pareto's Analysis

Using Pareto's analysis, Figure 2 demonstrates the barriers identified by the study. The length of a bar stands for (or is proportional to) the mean severity score. More severe barriers (longest bars) are positioned to the left of less severe barriers. The Pareto chart revealed that by far the factors accounting for at least 60 percent of the problems were: (1) Unavailability of solar components on the local markets

(2) High price of solar PV components

(3) Limited government support

(4) Lack of end-user financing

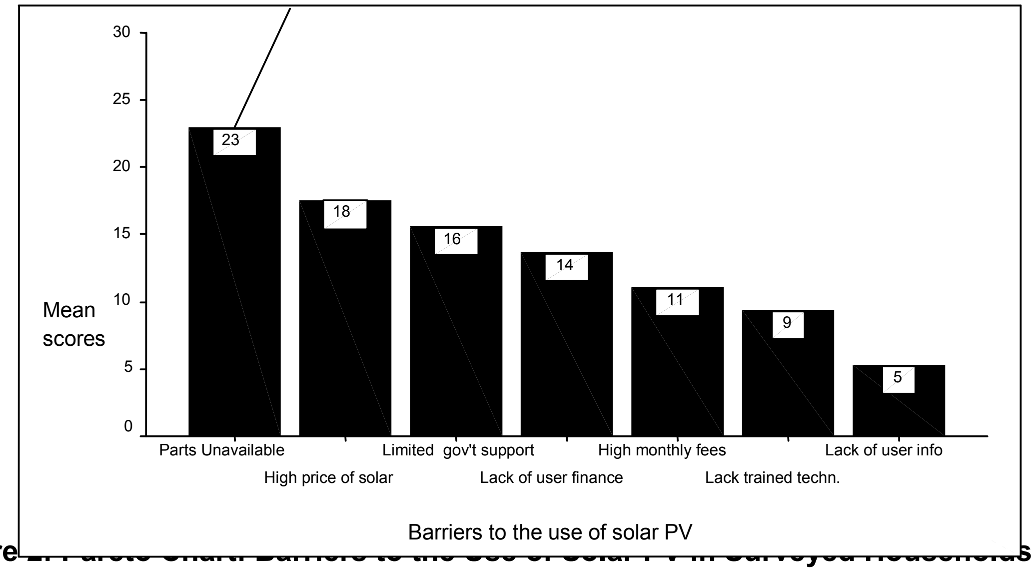

Figure 2: Pareto Chart: Barriers to the Use of Solar PV in Surveyed Households

3.2.3 Unavailability of Solar PV Components/Parts on the Local Market

Figure 3 indicates that all the communities responded that solar components were not available with the exception of Kpassa, where 14 percent of the solar-electrified households reported of local availability, while 11 percent responded that solar PV components were not locally available.

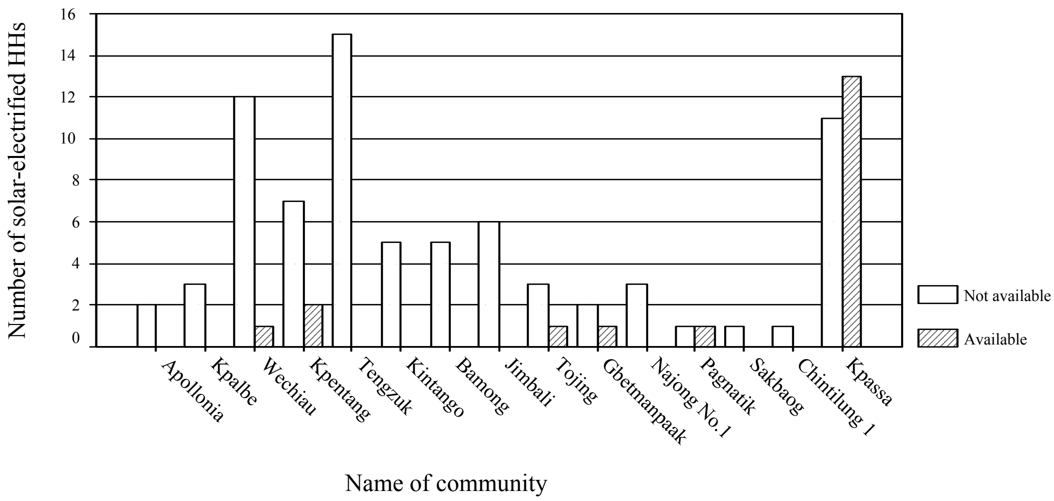

Figure 3: Availability of Solar components on the Local Market by Community

3.2.4 High Price of Solar Components

Evidence from the study revealed that high price of solar components on the local market was a barrier to the use of solar PV. The selling price of car batteries used in Solar PV was about ¢500,000 - ¢800,000 (US$ 54-87) and compact fluorescent lamp (CFL) was being sold at ¢40,000 - ¢120,000 (US$ 4.4 - 13).

Compared to the price of incandescent bulbs used in grid-electrified households, solar PV lamps were expensive.

Figure 4 depicts the prices of 5-10 watts solar dc lamps sold at ¢40,000-¢120,000 (US$ 4.4-13) and 20-100 watts incandescent bulbs sold at ¢3000 – ¢25,000 (US$ 0.33-2.72).

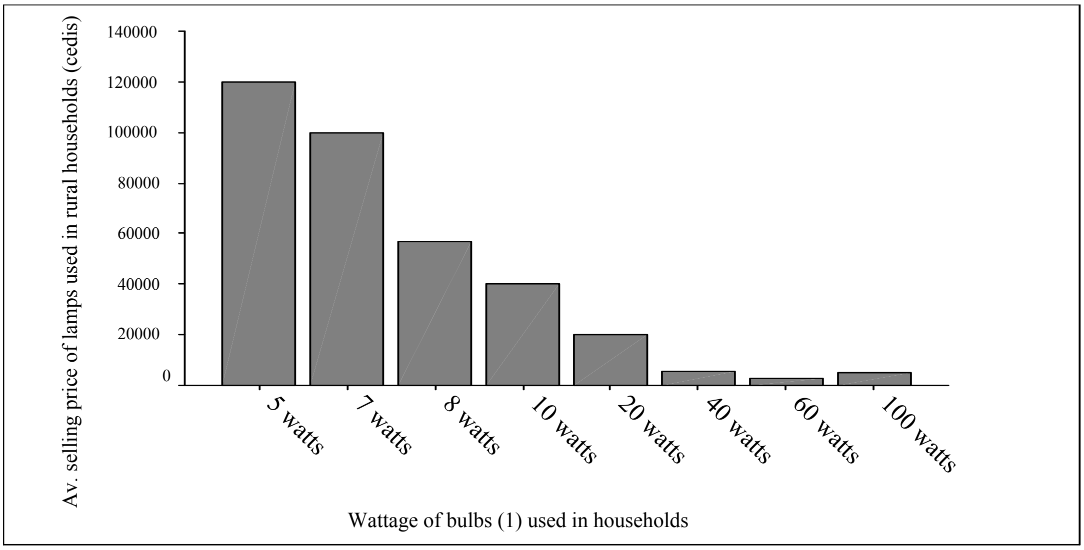

Figure 4: Prices of 12V DC Solar Lamps (5-10W); 230V, AC Lamps (20-100 W).

3.2.5 Limited Government Support

With a mean severity score of 15.6, limited government support was ranked as the third severe barrier to the use of solar PV in the surveyed communities. The results presented in Table 4 indicated that about 50 percent of the solar-electrified households reported it was severe to most severe (23 percent said most severe; 7 percent said more severe; and 20 percent said severe). About 14 percent considered this a less severe barrier, while 22 percent did not rank it as a barrier.

3.2.6 Lack of End-User Financing

From the weighted mean scores presented in Table 4, lack of end user financing scored 13.7 and was ranked the fourth barrier. From the results in Table 3, about 35 percent said lack of end-user financing spans from severe to most severe; 21 percent said it was somewhat severe; while about 14 percent said it was less severe. Of the 96 households with solar PV, only 21 (22 percent) did not rank end-user financing as a barrier (Table 3).

3.2.7 Faulty Component Parts at the Enterprise-level

Frequent occurrence of faulty system components can affect the sustained interest of end-users to use solar PV systems to enhance their income generation opportunity after dark. When asked about problems affecting the use of solar PV in the enterprises, the responses revealed that the PV system components causing most problems to the solar-electrified enterprises were batteries and regulators. Overall 86 percent of the reported problems were on batteries and regulators as shown in Figure 5.

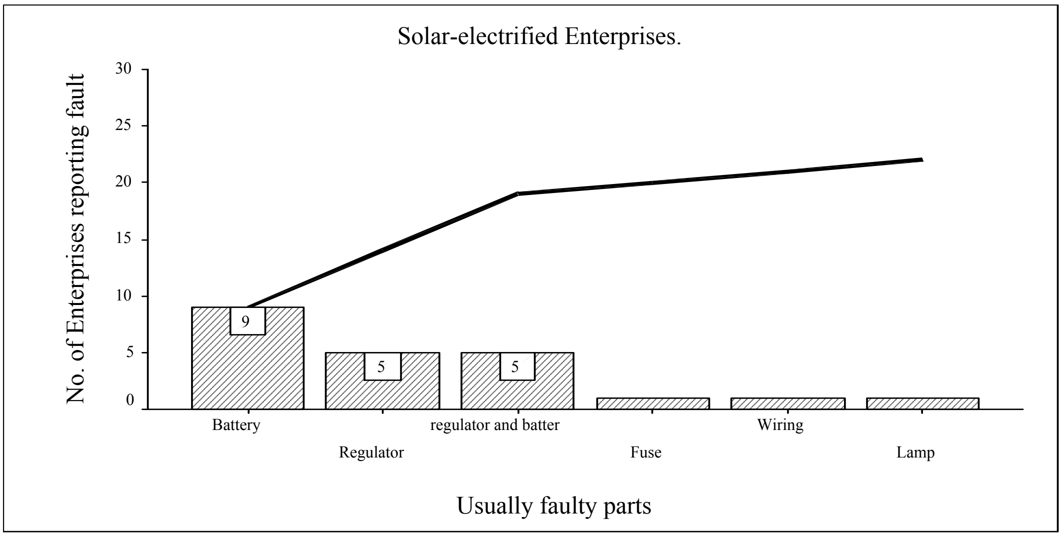

Figure 5: Faulty Parts of Solar PV at the Enterprise level.

3.2.8 Factors Limiting the Extension of Working Hours by Rural Enterprises

Using Pareto's analysis, the factors that limited the enterprises from extending their working hours and hence the possibility of gaining additional income are analysed. The results in Figure 6 revealed that the principal factor that prevented the solar-electrified enterprises from extending their working hours was power fluctuation in the evening during the rainy seasons in June-August. This is indicated by the response: lamp off during low sunshine hours.

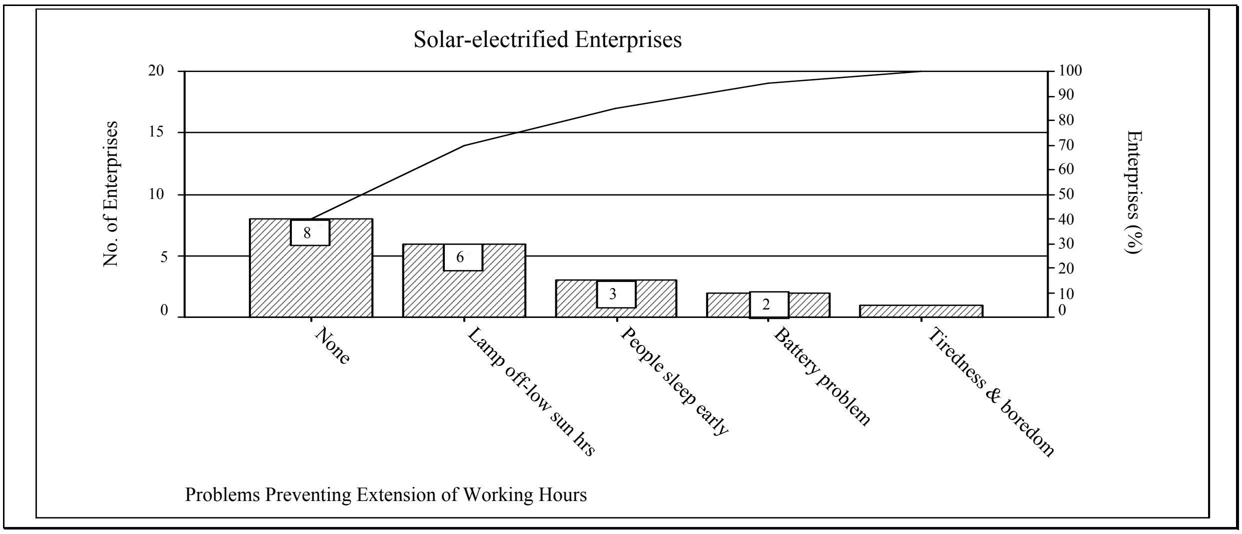

Figure 6: Problems Preventing the Enterprises from Extending Working Hours

4. DISCUSSION

It is worth bearing in mind that some specific impediments can prevent the development of new markets for the widespread use of solar PV. Such impediments are barriers that can prevent the effective use of solar PV to improve quality of life of the rural poor. It is to note that the barriers identified by this study are not universal, but situation-specific. Barriers are situation-specific in any given region or country (Beck and Martinot, 2004). By tabulating the responses to the question on barriers, the initial results did not provide a clear picture to reflect the rankings of the barriers. There was therefore the need to further analyse the barriers using weighted mean scores and Pareto's chart. **U**sing Pareto's analysis the few important barriers were analysed. Whenever a choice has to be made between a number of alternative directions for action, Pareto's rule of separating "the vital few" from "the trivial many" is applied (Juran, 1988; Mind Tools Ltd, 1995-2006; SkyMark, 2006).

The Pareto chart revealed four barriers, namely, unavailability of solar components on the local market, high price of solar PV components, limited government support and lack of end-user financing. These findings contribute to earlier studies that have reported that high price of solar PV systems, lack of market, lack of information and lack of financing, among others, impede the expansion of solar PV electrification in poor developing countries (Basnyat, 2004, Johansson et al, 2004; Sawin, 2004; WCRE, 2004). Although, high per unit price of solar PV electricity is also reported as a barrier to expansion (Gustave, 2004; WBGU, 2004; Weingart, 2000), beneficiaries of fee-for-service PV projects have been paying subsidised flat rates in a month. It is however, agreed that costs are declining with growing market volume.

Basic solar PV components such as batteries, lamps, and regulators were scarce in the surveyed communities. Resaons may be due to lack of established markets and limited sales outlet (Cabraal, et al., 1996; Martinot, et. al, 2001). The local trading in solar PV components has not been very encouraging because of low patronage. Therefore component parts were not readily available on the local market. Unavailability of solar components is therefore the first barrier to tackle. Overcoming this barrier will yield the highest benefit to prospective users of solar PV in off-grid rural communities.

The study also revealed that high price of solar components on the local market was a severe barrier to the use of solar PV. From the results, due to the higher prices of car batteries (60-70Ah), which were sold at about ¢500,000 (US$ 54) and a typical CFL lamp sold at ¢40,000 (US$ 4) with some as high as ¢120,000 (US$13), it is likely that some of the low income consumers switched back to kerosene lanterns as they could not afford the replacement costs of about US$3 per month. Compared to the price of incandescent bulbs (US$ 0.33-2.72) used in grid-electrified households, the solar dc lamps were costly.

The study results revealed that about 17 percent of the solar-electrified household heads earned up to US$ 1.08 per day or US$ 30 per month. Comparing this income level to the maintenance cost of approximately US$ 3 per month, one could infer the financial pressure on the poor, who earned up to US$ 1.08 per day, if they have to allocate a substantial part of their agricultural-based income to the maintenance of PV systems. It is worth bearing in mind that poor households should not need to spend more than one tenth of their income to meet elementary individual energy requirements (WGBU, 2004). As the price of the components rises, low income and less enthusiastic consumers are likely to fall out of the market, leaving the high income earners or more enthusiastic users (Baumol and Blinder, 1988). On the basis of the scoring method, high price of solar components on the market should be the second barrier to remove. The removal of this barrier will produce bigger benefits to off-grid rural communities and other stakeholders.

In general, rural people see most community projects as government intervention to provide goods and services for socio-economic development. Consequently, a change in incentive enjoyed within a project is interpreted as a withdrawal of government's support services. In the surveyed communities, the solar-electrifed households felt deceived by the project implementers (known as government officials), because they could not sustain their support services: monitoring visits and replacement of component parts, particularly the batteries. This situation was interpreted as a withdrawal of government's support services. In this context, lack of such support services can be misinterpreted as a denial of basic electricity services from government.

Again, the study revealed that over half (56 percent) of the solar-electrified households reported of the lack of end-user financing as a barrier. Other studies have reported of lack of financing as a barrier to the expansion of renewables (Basnyat, 2004; Johansson et al, 2004; Sawin, 2004; WCRE, 2004). Inadequate financing of solar PV projects is among the main constraints inhibiting its widespread use in poor rural communities. This issue is more pronounced in the rural communities because of the low income levels of end-users who are mostly peasant farmers.

In the surveyed communities, about 60 percent of the beneficiaries were farmers who earned an average income of about ¢377,000 per month (US$ 1.32/day). This average income is close to the absolute poverty line of US$ 1 per day (Human Development Report, 2005; Sachs, 2005; World Bank, 2006). Lack of end-user financing is therefore the fourth barrier to tackle. Overcoming this barrier will yield some benefits to the rural poor to improve their quality of life.

At the enterprise level, about 86 percent of the reported problems were on batteries and regulators. Therefore priority attention must be focused on these components to improve system reliability and sustainability. The factors that limited the enterprises from extending their working hours and hence the possibility of gaining additional income were also analysed. From the results the principal factor that prevented the solar-electrified enterprises from extending their working hours were: aging batteries and power fluctuation in the evening, particularly during the rainy seasons of June-August. The consequence is that majority of the solar-electrified enterprises combined solar PV and kerosene lantern. The data suggest that system efficiency and continuous supply of power are prerequisite for extension of working hours and additional income generation after sunset.

5. MEASURES TO REMOVE BARRIERS

From the perspective of this study, the following measures can contribute to remove or mitigate the barriers to the sustainable use of rural PV systems:

- Financial and fiscal incentives (e.g micro credits, soft loans) to motivate the private sector to open retail outlets at the local market. The establishment of sales outlets through enhanced public-private partnership in rural communities can increase the prospects of access to scarce replacement parts (e.g. dc lamps,regulators,lamp fittings, wet batteries).
- Periodic visits by local government representatives (District Assemblies) for firsthand information on utilisation so as to allocate financial resources towards system management and sustainability.
- Temporary short-term subsidy, particularly for the replacement of batteries and repair of regulators, targeting poor households.
- Consistent technical and entrepreneurship-related training of skilled adults in the communities.
- Subsidised monthly fees (up to US$ 3 per month) covering consumption and maintenance, particularly for the rural poor who earn up to US$ 1 per day.

6. POLICY IMPLICATIONS

To ensure the sustainability of solar PV rural electrification projects, there is the need for institutional support and role playing in the management of PV systems at the community level. A sufficient requirement for sustainable use of solar PV systems should include a joint action of household members backed by institutional structures to facilitate the provision of information on good operating practices, maintenance costs and responsibilities. End-users need to understand that good operating practices minimize recurring costs and can enhance battery life (Cabraal et. al, 1996). A focus on an effective approach to sustainability should include strategies that would respond to the differing ability to maintenance. In this regard, low income households should be assisted with costs reduction instruments e.g. capital grant to defray PV system costs, affordable monthly fee-for-service (up to US$3 per month).

Though lack of technicians was not among the 'vital few' barriers, it was however, ranked as the sixth barrier to the sustainable use of solar PV systems. The data suggest that human resource development is an essential component for sustainability. Capacity building aimed at human resource development should include the retraining of technicians on quick response to faults and quality service delivery. Furthermore, rural technicians should be provided with financial incentives to diversify their income sources in order to commit themselves to the maintenance of PV systems. The creation of a community-based organizational framework (e.g. Energy Development Agency) by the Ministry of Energy in collaboration with the Energy Commission and the District Assemblies will clarify the question of who should be responsible for monthly user-fee collection, routine maintenance, and end-user education and the form they should take. A concerted effort on these actions would yield the benefits expected from the sustainable use of public solar PV systems.

7. CONCLUSIONS AND RECOMMENDATIONS

This study established and ranked the major barriers to the sustainable use of solar PV in rural Ghanaian households in the following order: unavailability of solar components on the local market, high price of solar PV components, limited government support, and lack of end-user financing. At the enterprise level the principal factor that limited enterpreneurs from extending their working hours with the possibility of gaining additional income after sunset were aging/defective batteries and power fluctuation in the evening during the rainy seasons. This made majority of the solar-electrified enterprises to combine the use of solar PV and kerosene lantern.

Measures to remove the barriers include among others the establishment of sales outlets through enhanced public-private sector support services, periodic visitations by local autorities for first hand information on utilisation so as to allocate financial resources towards system management, temporary subsidies for maintenance and repair, capacity building and affordable monthly fees. To support income generation in rural enterprises there is the need to put in place mechanisms to ensure system efficiency and continuous supply of power to achieve extended working hours after sunset and additional income generation.

For future deployment of rural solar PV systems, a sufficient requirement for sustainable use, particularly at the household level should include a joint action of household members backed by institutional structures to facilitate the provision of information on good operating practices, maintenance costs and responsibilities. A focus on an effective approach to sustainability should also include strategies that would respond to the differing ability to maintenance and repairs, which vary between enterprises and households. Low income households, in particular, should be assisted with cost reduction measures to encourage uptake and widening of access.

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Solar Energy as an Approach of Solution to Energy Crises in Togo

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Abstract:

The challenge of development will bring Africa to face four great risks related to energy:

- Risks of exhaustion or rarefaction of fossil energies;

- Risks of warning of the climate associated with intensive use of fossil energies;

- Civil and military nuclear risks;

- Risks finally of competition of use of grounds which a too intensive use of cultivable soil for energy production would involve.

"To define a good energy strategy for a sustainable development, it is essential to keep in mind this overlap of the risks of the mean and long terms".

Among the risks referred to above, only the "development by energy sobriety" appear likely to avoid major ruptures, insofar as they make it possible to push back the expires of the whole risks of the long term.

From an economic standpoint, studies show that the sober scenarios favourably compare themselves with the scenarios of energy abundance. This economic advantage is explained by the fact that the production and the distribution cost of energy are very often very definitely higher than the cost of measurements of energy saving.

The physical exploitable potential of renewable energies is almost unlimited and it is the point from where it is necessary to start to take up the challenge. Even if the associates' costs with their exploitation impose limits, for certain isolated needs, these resources constitute the best answer.

For more massive uses, apart from the great traditional hydropower, one sees all the interest to develop the research and development and the experiments to arrive at a reduction of the costs, significant for wind for example, and drastic for the photovoltaic.

INTRODUCTION

Togo as many countries in African have to face an energy crisis.

Today more than 85% of Togolese living in rural area do not have any source of electricity apart from batteries whose cost price is excessively high. Indeed, less than 7% of the rural households has access to the electric services by inter-connected or local network; they are concentrated in the largest boroughs. 5 to 10% of the other households have a generator or use a battery of car to satisfy the electric needs.

In the cities the situation was degraded because of the political and socio-economic context since the Nineties. The only supplier of electricity does not manage to satisfy the demand. 90% of the electricity are imported of Ghana and Côte d'Ivoire. The cities do not have any more electricity 24 hours a day.

The energy policy of Togo envisaged in her development plan the supply of electricity to all the social layers of the main towns and some big villages.

Vis-à-vis this challenge, which are the incurred risks and which must be the room for manoeuvre?

The case of Togo is not isolated. The majority of the African countries live the same situation; that is why in the following discussion one will insist on the global case of Africa.

RESULTS AND DISCUSSIONS

One of the main challenges witch the African continent is confronted today is that of an access of its population – still in rapid growth – to the development.

The energy requirements and environmental problems which will result from this, is that africain countries will have to face simultaneously four great risks strongly related to energy and which present a global characteristic for all the continent.

- Risks of exhaustion or rarefaction of fossil energies, coal, oil, natural gas, risks somewhat forgotten these last years but which are considered nowadays because of the brutal rise of the oil prices;
- Risks of warming of the climate associated with intensive use of fossil energies;
- Civil and military nuclear risks (accidents , transports and storage of waste , risks of proliferation);

- Risks finally of competition of use grounds which a too intensive use of cultivable soil for energy production would involve.

By admitting these risks like inescapable (“one does not make omelette without breaking eggs ’’), some African countries can choose a “development by energy abundance ’’ by cumulating, with elevated levels, the risks which are not distinguished from / to each other by a reduction or an increase .The risks are not independent from to each other .

Other countries can access these risks with their right values and choose a “development by energy sobriety ’’which while trying to rebalance energy policies gives a priority to the control of the evolution of the energy demand.

Eight years later, the analysis that Benjamin DESSUS, of the national centre of scientific research – France, made is still relevant today and well applicable to Africa .Talking about the risks, he said, I quote : “to define a good energy strategy for a sustainable development, it is essential to keep in mind this overlap of the risks of the mean and long terms.

This remark appears particularly founded during this current period when the climate warming and the rise of the oil prices push the governments to have an attraction for the nuclear power without a sufficient taking into account of the consequences that can occur with means and longs terms.

To illustrate these two options chosen by the two categories of country one can compare the world energy scenarios in the long term produced since the Nineties, on the one hand by the IIASA on behalf of the world council of energies and by CNRS on the other hand (NAOH) scenario : new energy options).

Although it showed through this comparison that it is much by volume of energy than by the more or less large call to such or such type of energy resources that scenarios are different, renewable energies occupy, especially in the case of sober scenarios, a dominating place far from nuclear power, coal, oil and the gas.

By what precedes, it is obvious that, as DESSUS underlined it, it is with the ell of the four great risks of total nature it is relevant to judge the room for meneuver available to humanity (not to say Africa) in order to build and exploit energy systems for its development without jeopardizing seriously and irreversibly this development by its own activities.

Among the risks referred to above, only the “sober ’’scenarios appear likely to avoid major ruptures , insofar as the make it possible to push back the expiries of the whole risks of the long term .

From an economic standpoint, studies show that the sober scenarios favourably compare themselves with the scenarios of energy abundance.

This economic advantage is explained by the fact that the production and the distribution costs of energy are very often very definitely higher than the costs of measurements of energy saving.

The teaching of the prospective scenarios is thus clear: by basing its economic development on an energy strategy of sobriety, humanity and consequently Africa can avoid, without ruining themselves, the unacceptable bet of the exchange of the risk the ones by the others, or that quite as dangerous, of waiting of technological miracle which would at a cheap rate save the planet and its inhabitants from the mentioned risks.

The strategies with low energy profile are strategies doubly gaining at the same time from economical and environmental point of view.

The question today is not so much any more convince of the validity of the " sober'' strategies but rather of knowing which strategies one should adopt to move in the direction suggested by these scenarios of sober development.

If the few preceding reflexions show extent of the energy challenges associated with sustainable development, they also show there exists tracks of action, based on sobriety, solidarity and imagination to prevent that the essential short-term development do not jeopardize the existence of the future generations and viability of our planet.

The solidarity which is concretized since decades between adjoining countries must be consolidated through sub- regional and regional integration.

The two other tracks of action are badly explored or quasi unexplored by African countries.

The development based on energy sobriety passes by sensitizing, education, the control of the evolution of energy demand and the control of technologies which allow a better use of energy resources.

Imagination must direct African countries towards renewable energy.

The physical exploitable potential of renewable energies (biomass, wind thermal and photovoltaic solar electricity, solar heat, hydropower, geothermic, seas energy) is almost unlimited and it is the point from where it is necessary to start to take up the challenge .Even if the associates costs with their exploitation impose limits, for certain isolated needs, these resources constitute the best answer. For more massive uses, apart from the great traditional hydroelectricity, one sees all the interest to reduction of the costs, significant for wind for example, and drastic for the photovoltaic one.

Togo has a layer of Renewable energies which is still little exploited. According to the ESMAP study (1996), technologies which could be taken into short-term account for decentralized rural electrification are the micro hydropower and Solar Home Systems. Although the hydroelectric potential of the country is enormous any site of micro hydropower was not clearly identified. As for s, their use was limited a long time to the railway street signs, the stations of hertzian transmissions and lighting in some churches or buildings of non governmental organizations.

A study made in 1997 gives an idea of the sensitivity of the equivalent request for electricity compared to the distribution of households.

Table 1: Sensitivity of the equivalent request for electricity compared to the distribution of the households.

Source	Solar lantern	SHS 20 Wp	SHS 50 Wp
ESMAP survey 1996 (rural + urban area)	**30 %**	**40 %**	**30 %**
ESMAP survey 1997 (rural area +)	**10 %**	**35 %**	**55 %**
Global distribution	**20 %**	**50 %**	**30 %**

CONCLUSION

Certainly, the use of renewable energy is based initially on economic competitiveness but the application of the process and their effect on the environment justify multilateral negotiations and detailed research to increase the potential accessible to the populations and to make Africa get out of a rut.

There the co-operation South- South and North- South can and must find a sphere of activities remarkable with technology transfers and financial means coming from north, making it in return profit from the gigantic potential of development of the south, which, with its own means, does not have the capacity to concretize it

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Is Wind Energy the Option for Solving Ghana's Energy Crisis?

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Abstract:

Energy consumption has increased sharply due to increased private sector investment activities, expansion of electricity supply in Ghana. To this end, demand for energy has outstrip supply so much so that, the economy of Ghana suffer decline by 43% due to power outages and load shedding. The worse of all is the recent sharp increase in world crude oil prices, making Ghana a net importer of oil suffer economically. If Ghana's total energy consumption is segmented, a little over 63% comes from biomass (firewood). This scenario tells how much forest is consumed for energy and its corresponding Global warming effect on our planet. It is no wonder Ghana's forest is also depleting very fast in front of our weary eyes. The above overviews make the need of renewable energies to be considered and thus look at wind as one of the possible source to supplement and compliment our rapid growing energy usage.

Wind speeds were measured along the coast from Apam to Keta at 10 and 20 metres above sea level, over period of one year.

Data shows potential wind energy that supply about 1000MW of electricity to the national grid forming about 33% of the total energy supply if implemented.

Keywords: Wind speed, Greenwich meridian, Height, private investors and global warming

Application of Biogas in Educational Institutions for the Production of Cooking Gas – Case Study at Valley View University

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Abstract:

Human excrete could undergo energy metabolism and operation of breathing of micro-organisms under anaerobic environment producing gas which could be an energy resource. This energy resource is known as biogas. Biogas is a high-quality fuel with high calorific value and stable calorific efficiency.

In Ghana faecal matter from factories, institutions etc either goes through a sewage treatment plant with the resultant effluent discharged as waste into an external drain or to a leach field or biological filter. Most often excrete from homes goes into a septic tank, the solid waste settles into a sludge layer at the bottom of the tank and fats float to the top. In between these two scum layers is a clarified liquid which is discharged as waste water to a soakaway or biological filter or leach field. When the final effluent is not discharged properly, it could pollute the environment.

Valley View University is one of the private tertiary institutions in Ghana. With the aim of building an outstanding campus that operates in harmony with the environment, flush water with faecal matter from the girls, boys dormitories and administration through a separation toilet is deposited into a biogas plant. The gas from this plant is piped to a gas stove in the kitchen where it is used for cooking.

This paper highlights the application of gas from the biogas plant for cooking in the kitchen, find out if there are any challenges to this technology and give recommendation on how it could be improved upon for further application in institutions in Ghana.

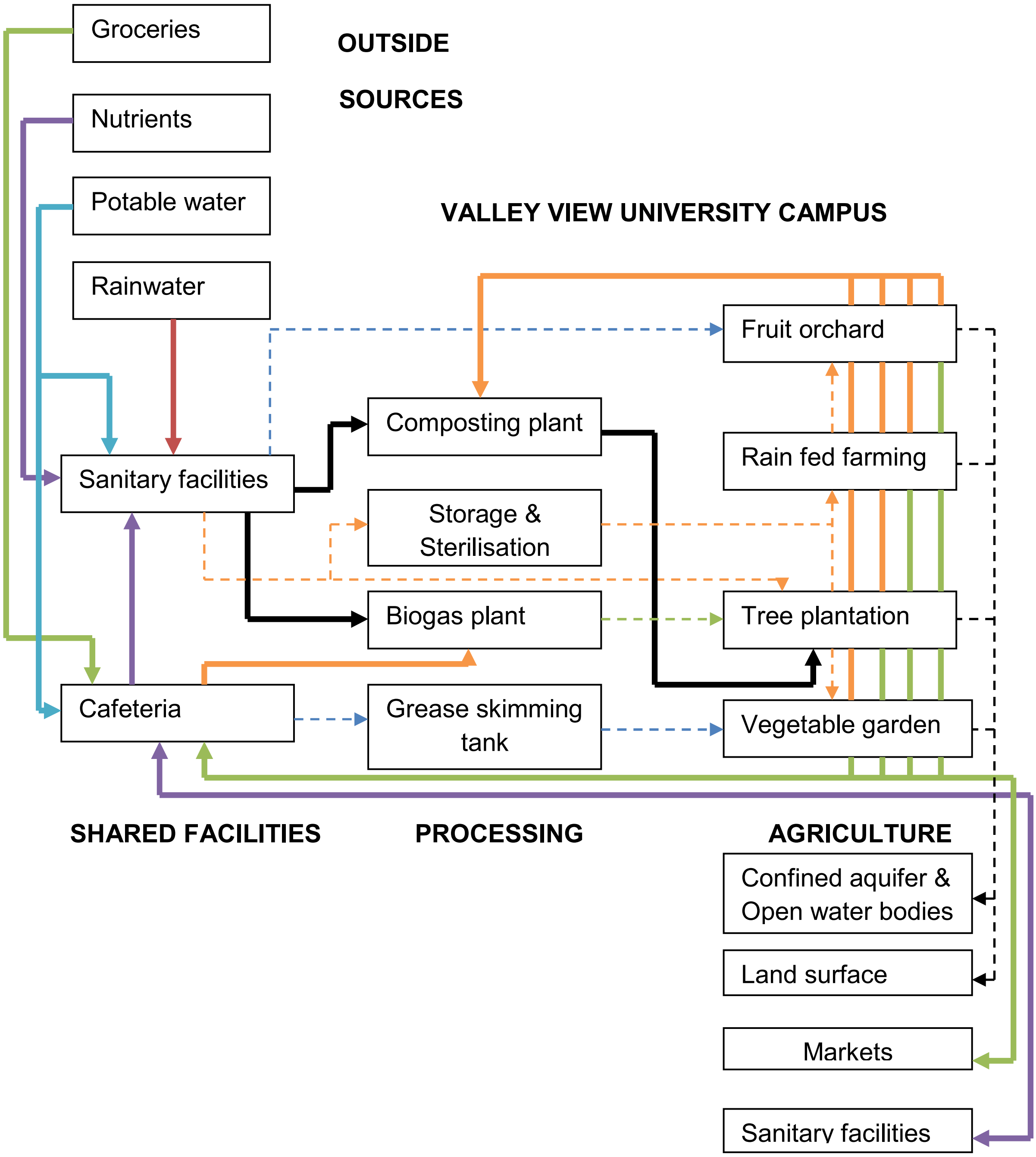
Key words: Biological reaction, Biogas, Sewage Treatment Plant, Septic Tank, Soakaway, Leach Field, Biological Filter

Background on Valley View University:

Valley View is one of the private universities in Ghana located at Oyibi in Accra, the capital of Ghana. It aims at being the first ecological university in Africa.

It population currently is 1500 and its master has been developed using the idea of cycle management to pursue its aim. The master plan includes supply of drinking water, the reduction of water consumption and waste water and the re-use of different kinds of waste water. To the university waste is a natural resource that is why waste water is recycled.

Below the ecological development layout of Valley View University



Source: Ecological Development of Valley View University, 2000

LEGEND

Potable water

Rain water

Grey water

Biogas effluent

Urine

People

Produce and food

Percolation, surface discharge & erosion

Faeces

Organic waste

Biogas plant sizing:

Determination of a biogas plant depends on the quantity, quality and kind of available biomass and on the digesting temperature.

The following should be considered:

Sizing the digester[1]

The size of the digester, i.e. the *digester volume* **Vd**, is determined on the basis of the chosen *retention time* **RT** and the *daily substrate input quantity* **Sd**.

Vd = **Sd** × **RT** [m3 = m3/day × number of days] ....(1)

The chosen/given digesting temperature determines the retention time.

For biogas plant which is not heated, the temperature inside in the digester can be assumed as 1-2 Kelvin above the soil temperature. Although consideration should be given to seasonal variation the digester must be sized for the least favorable season of the year. The retention time should amount to at least 40 days when a plant of simple design is given due consideration. In practise a retention times of 60-80 days or even 100 or more days is also possible when there is shortage of substrate. Gas yield could increase as much as 40% for extra-long retention times.

[1] Rehling, Uwe (2005): Small biogas plant, p.21

How much water has to be added to the substrate in order to arrive at a solids content of 4-8% determines the substrate input.

Substrate input (**Sd**) = biomass (**B**) + water (**W**) [m3/d]..(2)

The mixing ratio for dung (cattle and / or pigs) and water (**B**:**W**) amounts to between 1:1 and 2:3 for most agricultural biogas plant.

Calculating the daily gas production G[2]

The quantity of *biogas generated each day* **G** [m3 gas/d], could be obtained on the basis of the *specific gas yield* **Gy** of the substrate and the daily substrate input **Sd**.

The calculation can be based on:

1. The *volatile solids content* **VS**

G = **VS** × **Gy**(solids) [m3/d = kg × m3/(d×kg)]..(3)

2. The weight of the moist mass **B**

G = **B** × **Gy**(moist mass) [m3/d = kg × m3/(d×kg)]..(4)

3. Standard gas-yield values per livestock unit **LSU**

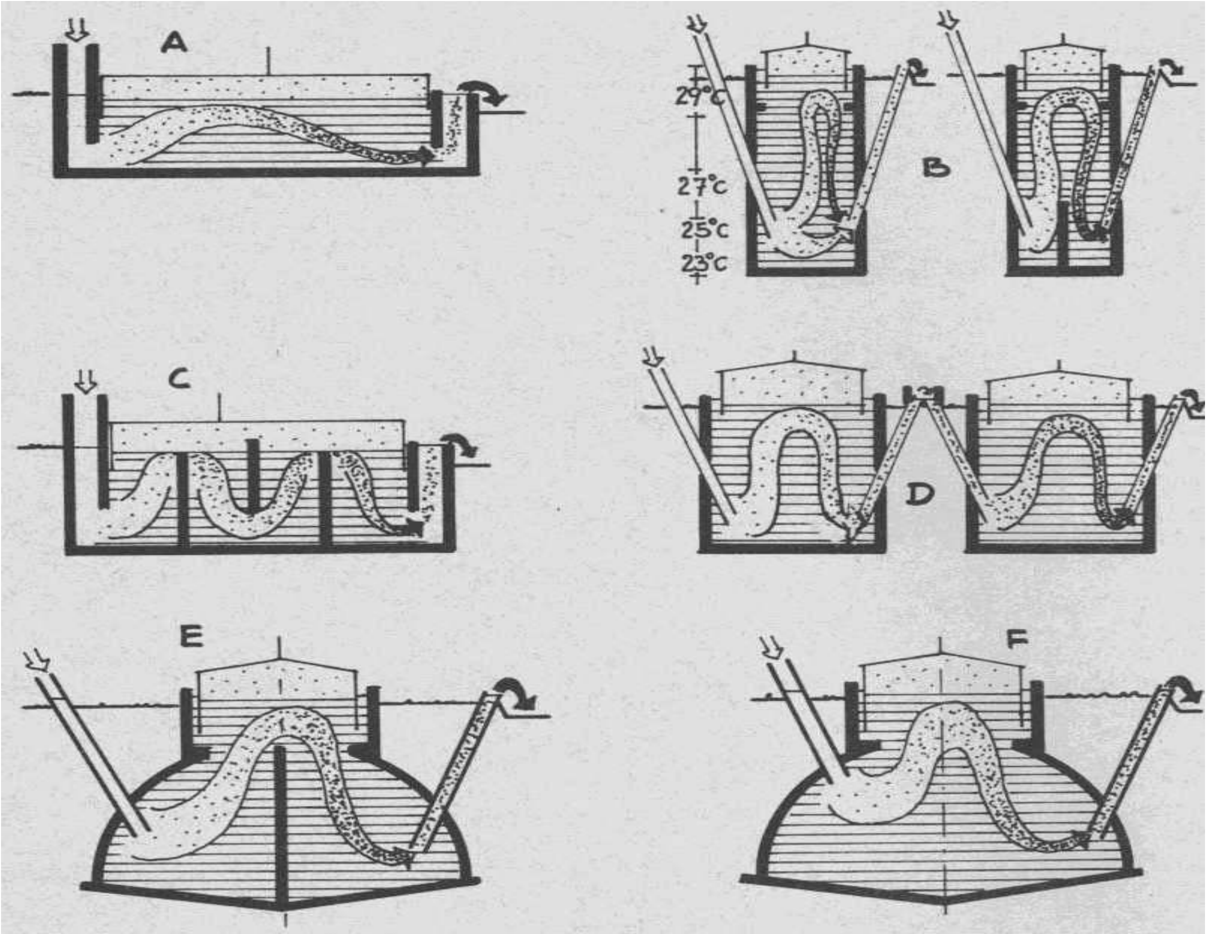
G = number of **LSU** × **Gy**(species) [m3/d = *number*× m3/(d×*number*)]..............................(5)

Types of gas containers:
Generally there are two different types of gas containers. These are:

1. With movable swimming dome (Floating-Drum)
2. With permanent dome (fixed dome)

For the above gas containers, their working principles are the same. The digester is first filled with a mixture. When the gas production commences, the gas is collected in the gas chamber leading to an increase in the digester gas pressure. The digester is refilled with fresh manure daily and water through the inlet pipe resulting in the fermentation of the material in the digester during the retention time. The gas pressure presses out the fermented material through the outlet pipe into the slurry tank.

[2] Rehling Uwe, (2005): Small biogas plant p.22



Path of the fermentation slurry in the digester

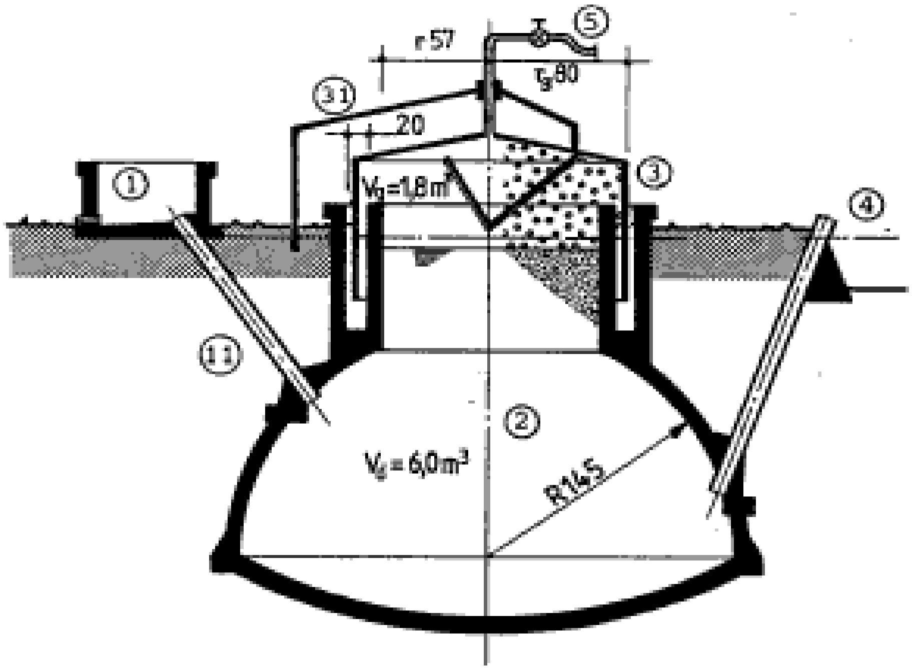
Source: Rehling Uwe, (2005): Small biogas plant p. 32

Floating-Drum Plant:

This consists of a cylindrical or dome-shaped digester and a moving, floating gas-holder, or drum. In the fermenting slurry or in separate water jacket the gas holder floats. An internal and/or external guide frame provides stability and keeps the drum which collects the biogas upright. The gas-holder sinks back if the gas is consumed and the drum moves up whenever biogas is produced.

Size

In order to digest animal and human feces on a continuous-feed mode of operation, i.e. with daily input, for the generation of biogas, the floating-drum plant is chiefly used. It could often be found in a small- to middle-sized farms (digester size: 5-15m3) or in institutions and larger agro-industrial estates (digester size: 20-100m3).



Water-jacket plant with external guide frame.

1 Mixing pit,

11 Fill pipe, 2 Digester,

3 Gasholder,

31 Guide frame,

4 Slurry store,

5Gaspipe

Source:
http://www.fastonline.org/CD3WD_40/BIOGSHTM/EN/APPLDEV/DESIGN/DIGESTYPES.HTML#FIXDOME
(accessed 2008-06-09)

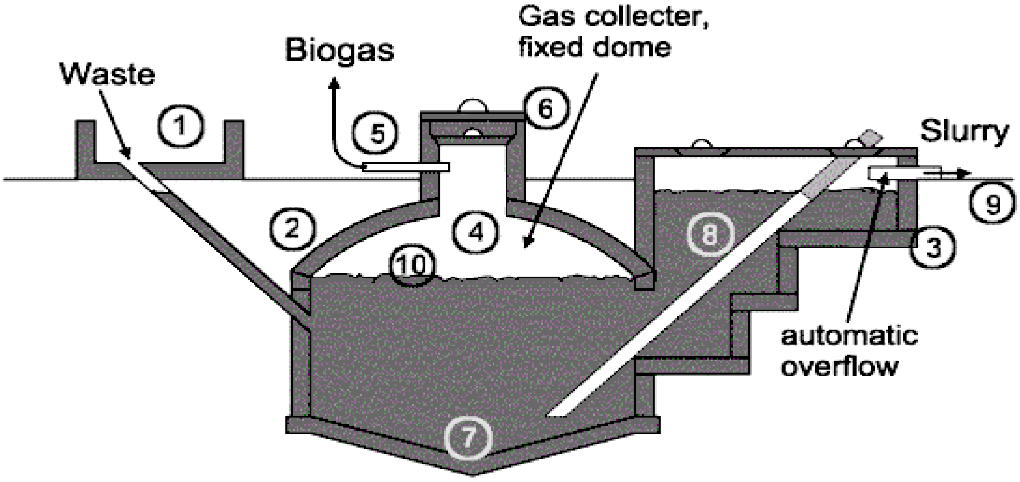
Advantages	Disadvantages
Very simple	The construction cost for the floating-drum is high
Its operation could be easily understood	The steel parts could be corroded for example: in tropical coastal areas, the drum could corrode in about 5years
It has a constant gas pressure	The maintenance cost becomes high due to painting
The volume of gas stored is visible	
There could be only few mistakes during construction	

Fixed dome plant

It is simple as no moving parts exist and its cost is relatively low. It could have a long life of (20 years or more) can be expected as there are no steel parts with the possibility of rusting. Its construction could also save space as the plant is constructed underground, protecting it also from physical damage. While the underground digester is protected from low temperatures at night and during cold seasons, fairly short sunshine and warm seasons take longer to heat up the digester but this is not so in Sub-Saharan Africa where daily temperatures could be high. This condition in Sub-Saharan Africa influences temperature in the digester positively facilitating the bacteriological processes.

Size

Due to economic parameters, the recommended minimum size of a fixed-dome plant is 5 m3. Digester volumes up to 200 m3 are also possible.



Fixed dome plant: 1. Mixing tank with inlet pipe and sand trap. 2. Digester. 3. Compensation and removal tank. 4. Gasholder. 5. Gaspipe. 6. Entry hatch, with gastight seal. 7. Accumulation of thick sludge. 8. Outlet pipe. 9. Reference level. 10. Supernatant scum, broken up by varying level.

Source: http://www.fastonline.org/CD3WD_40/BIOGSHTM/EN/APPLDEV/DESIGN/DIGESTYPES.HTML#FIXDOME (accessed 2008-06-09)

Advantages	**Disadvantages**
It has low construction cost	The frame is not gas tight i.e. sometimes porous and develops cracks
It has no moving parts	The gas pressure fluctuates substantially and is often high
There is no corroding steel parts, hence long life	The digester ha slow temperature
It is constructed underground which does not waste space	
It could create employment locally	

Balloon Plants

This consist of heat-sealed plastic or rubber bag (balloon), combining digester and gas-holder. The inlet and outlet are attached directly to the skin of the balloon and the gas is stored in the upper part. To increase the gas pressure weights could be placed on the balloon. Safety valves are required to prevent the ballon from damage beyound it pressure withholding limit. A gas pump is required if higher gas pressure are needed. Specially stabilized, reinforced plastic or synthetic caoutchouc is given preference since the material has to be weather- and UV resistant.

Advantages	**Disadvantages**
Standardized prefabrication at low cost	Low gas pressure may require gas pumps
Shallow installation suitable for use in areas with a high groundwater table	Scum cannot be removed during operation
High digester temperatures in warm climates	Possibility of mechanical damage
Uncomplicated cleaning, emptying and maintenance	Very few local craftsmen are in a position to repair a damaged balloon.

The Biogas Plant at Valley View University[3]

It is a fixed-dome type and the two digesters are covered with a concrete slab with clay along its periphery to protect the system from gas leakages. Provision has been made through which water could be added if the need arises.
The total volume of the plant is 60m3 with a digester volume of 30m3. Because of the relatively smaller size of faecal matter as compared to the volume of water which carrier matter and the tumbling of this effluent into the digester, mechanical aggregates for mixing or transferring materials into the plant is not required. Its internal temperature is maintained by the stabilisation of ambient temperature with that is the soil. At the time of construction, it was not expedient to add the grey material from the kitchen to the digester. This is currently possible with the installation of shredders as a component of the kitchen sinks and directly piping the discharge into the digester.
Interview with the designer of the plant revealed that, effluent from the digester which is barely water has been tested and approved hence, it is used to irrigate the near-by farm. A non chlorine disinfectant could be added to this effluent (mainly water) and recycled as water to flush the water closets.

[3] Krämer,2007: Diploarbeit p. 17 & 18

Background information for the design of the biogas plant

Location	Mass of manure kg	Population	No. of visits per day
J. J. Nortey Hostel	1.5	136	204
Cafeteria	0.1	800	80
Duplex hostel near cafeteria	2	10	20
Kitchen staff	0.2	15	3
Total			307

source: designer of plant

Water closet cistern is 6 litres

Mixture of manure and water obtained per day= 307*6=1842 litres

Allow 30 days retention for destruction of all pathogens = 55, 260 litres

The biogas obtained daily is piped which has a hydrogen sulphide reduction equipment to the kitchen which prepares daily food for about 300 employee on campus.


A kitchen staff commencing the preparation of rice of the biogas cooker

Benefits (General)

A biogas plant functioning properly has the following benefits to users, society and environment as large:

1. Its functioning will lead to the production of energy (heat, light, electricity)
2. Organic waste are transformed into high quality fertilizer
3. The reduction of files, worm eggs, pathogen leading to the improvement of hygienic conditions
4. Since energy is available for cooking, women who most often go about gathering firewood for cooking will use this precious time for something more beneficial.
5. The gas produced is also clean and will save our women from the smoke related health hazards which results from cooking with firewood. The use of firewood which also results in deforestation would be avoided
6. Cutting down of trees which opens up our vegetation and the soil nutrients are washed away will be completely eliminated
7. Pollution of water bodies from the discharge of faecal matter into them will be eliminated
8. Economic benefit through energy and quality availability of fertilizer which would lead to increasing yield in agriculture
9. Macro-economic benefits through decentralized energy generation using alternative energy source. The biogas produced could be used to power generator to drive pump to pump water into the school reservoir for use by the school.

10. If the biogas obtained is used for commercial food preparation, the cost per unit meal from this system should be less than the corresponding meal prepared from LPG, charcoal or firewood. The cost associated from meal prepared from biogas plant has to do with maintenance of the plant which is done once every 6 months.

Investment

Despite the benefits which could be derived from this system, for developing countries, the rural poor who would drive immense benefit could not afford the investment cost for a biogas plant. Most tertiary schools in Ghana which have boarding house and could derive immense benefit from this system are government owned and they do not have the financial capacity to their own plant unless financial support comes from the government. This development prevent large scale deployment of the plant in these schools which could have lead to immense financial saving for the schools from the purchase of firewood, kerosene, LPG and diesel in running water pumps. In spite of the aforementioned challenge, these school could come together under one umbrella and urge the government to make investment in biogas plant by making a strong case for savings in their allocated budget in the areas of fuel, health, sanitation and environment.

Fertilizer Substitution

In Ghana, all tertiary institutions which have boarding houses have vast stretched of unused land. Foodstuffs are weekly or monthly bought from the local market to prepared food for inmates. With the ever increasing cost of crude oil, prices of these foodstuffs have appreciated remarkably. Research has shown that, the available nitrogen, potassium and phosphorous in the form of organic materials is about eight times as high as that of the corresponding quantity of chemical fertilizer which is in used in developing countries.

After the energy content of the waste and other organic waste material have been extracted, the slugged left is a good fertilizer, which has the capability to of improving general soil quality as well as ensuring higher crops yields. The tertiary institutions with boarding houses could take advantage of this valuation fertilizer and to into farming with the responsibility of e.g. the agricultural department. This is a viable project when implement could lead to some savings on the food budget.

Conclusion:

The biogas plant in Valley View University is serving as a good model for other private tertiary institutions with boarding facility when it comes to serving as an energy source and improving hygiene in the school, it nevertheless need some improvement in the following areas:

1. The bio-degradable material from the kitchen could be shredded and it mixture with water connected directly from the kitchen sinks to the digester as an additional manure for the plant.
2. Non-disinfectant chlorine could be added to the effluent from the plant (which is mainly water) and recycled for use in the water closets.

3. The manure from the piggery farm could be added to the faecal matter from the dormitories and the administration which will improve gas yield as depicted in the table below:

Type of animal	Manure per day kg	Water content of fresh material (% wet base)	Gas yield after complete fermentation of fresh material (l/kg)	Mixing (manure with water)
Cow				1:1
big	15	80-85	40	
middle	10	80-85	40	
small	8	80-85	40	
Calf	4	80-90	40	
Water buffaloe				1:1
big	20	80-85	40	
middle	15	80-85	40	
small	10	80-85	40	
Calf	5	85-90	40	
Pig				1:2
big	2,00	75-80	70	
middle	1,50	75-80	70	
small	1,00	75-80	70	
Poultry				1:3
big	0,15	70-80	60	
middle	0,10	70-80	60	
small	0,05	70-80	60	
Goat				2:3
big	5,00	75-80	50	
middle	2,00	75-80	50	
small	1,00	75-80	50	
Goose	0,15	70-80	50	2:3
Pigeon	0,05	70-80	50	1:3
Horse	15,00	80-85	40	2:3
Camel	20,00	70-85	30	1:2
Elephant	40,00	70-85	20	2:3
Human being				3:7
Adult (Child)	0,40 (0,20)	75-80 (75-90)	70 (70)	

Gas Yield
Source: Rehling, 2005: Small biogas plant p. 16

4. Currently biogas discharge from the stove is slightly weak and the kitchen staffs usually give reference to the LPG stove which has a strongly gas outlet pressure and cooks faster. A standard biogas discharge outlet should be used on the biogas stove since this will improve the performance of the stove. My interview with the installer of the plant reveal that, he now has biogas outlet which could give out gas pressures up to 8 bars
5. A storage facility should be installed to the current installation since there is no gas storage facility and the excess gas and ones produced when school is on recess and the kitchen is not in full operation is discharged off.

Recommendation:

1. Although there has not been any reported case of biogas explosion in Ghana, warning signs should be placed around the plant area to prohibit smoking and people who may use open fires around the plant.
2. Comparatively biogas plant has less maintenance cost, less installed cost compared to a comparative sewage treatment plant. Instead of running a sewage plant with electricity which is an additional cost, biogas plant could rather generate resource for electricity generation. It will also be the appropriate replacement for mechanical sewage treatment plant in our universities since the latter breaks down, it is either repaired late or nor repaired at all with it subsequent environmental problems.
3. This research could be broaden to look at wide range of benefits in relation to biogas plant in schools, hotel, estate homes, industrials etc with lodging facilities.

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http://www.fastonline.org/CD3WD_40/BIOGSHTM/EN/APPLDEV/DESIGN/DIGESTYPES2.HTML#BALLOON (accessed July 30, 2008)

Improving charcoal Stoves efficiency-Ongoing Research Findings

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Abstract:

Firewood as source of energy forms a little 63% of the total energy requirement of the Ghana. With this statistics, the implication in terms of global warming, deforestation and its correspondent health hazards cannot be gainsaid. Various energy efficient stoves had been developed based on indigenous technology and at times through material science technological development and application. Technology Consultancy Centre accessed various charcoal stoves (both indigenous and improved ones) and stagger on an interesting revelations. Agyapa, Ahebenso, Agyinkwa and two other traditional stoves were accessed. From the assessments a combination of Agyapa and traditional Aluminium coal pot gave very exciting results of almost 65% output efficiency and about 45% charcoal usage over the others.

Keywords: Bernoulli Theory, Surface treatment, Thermodynamics, materials selections, extension skills

A study in the various Solid Waste Management Options in the Atwima Nwabiagya District

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Abstract:

Solid waste characterization is being done in the three towns of the Atwima Nwabiagya district of the Ashanti Region (on latitude 6°75N and between 1°45 and 2°00 west). Found in the western part of the Ashanti Region, the district covers an area of 294.84 square kilometres, with Nkawie being the District capital.

The aim of the study is to understand the characteristics of the waste generated in the district in order to find a scientifically proven, long-term waste management option. This will ensure a sustainable approach to waste management in the district.

Values so far gotten from Atwima Koforidua indicate that the average waste generation rate was 0.47 kgday^{-1}pers^{-1} collected from 19 households. The mean daily weight of waste generated in the town is 3.9 metric tones. A projection of waste generation in the town shows that the year 2008, 2009, 2013 and ten years to come (2018) would generate respectively 14433.32, 1482.59, 1668.67 and 1907.99 metrics tones.

The waste composition results from the town (based on the aggregate weight of all waste collected from the study households, once it had been sorted into its component parts) projected over a ten year period is as shown below.

The results so far proves that the study will be an important tool for planning a site-specific as well as a district wide options for solid waste management.

Results from a waste characterization study in Atwima Koforidua

Waste Component	***Per capita waste/day in kg***
Food, garden and yard waste	***0.2966***
Plastics	***0.0278***
Metals	***0.0042***
Paper	***0.0062***
Wood	***0.0016***
Glass	***0.0018***
Textiles	***0.0066***
Others	***0.1250***
Total	***0.4699***

Constraints and Opportunities for Bioenergy Production in Southern Africa

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Abstract:

Production of energy crops is perceived as a potential source of alternative energy for petroleum oil. There is widespread concern about increases in greenhouse gases in the atmosphere resulting from exploitation of fossil fuels. Additionally, petroleum oil prices have increased over the last decade compelling countries around the world to search for alternative sources of energy. Energy crops are a source of renewable energy with reduced green house gas emissions as compared to fossil fuels. However, there are environmental constraints and opportunities for production of energy crops. These have to be addressed before indulging into the business of producing such crops. Countries in southern Africa are buying into the idea of producing energy crops due to both international pressures and the increased energy demands within them. The two main challenges faced by these countries are how to set aside land for production of energy crops without infringing into land available for food production and conservation of natural resources, and how to ensure that there is adequate source of water required for production of energy crops as well as that needed to sustain ecosystem productivity. This paper assesses the opportunities and constraints in land and water resources for production of energy crops in the SADC region using landuse/ landcover data, hydrological and meteorological data, as well as socioeconomic data. Each country in the region differs in terms of landcover, hydro-meteorological and socioeconomic aspect. Therefore, conditions that constrain one country are not necessarily applicable to the other. A regional approach to address land and water requirements for production of energy crops is considered important as compared to planning for production in each country in order to realize the opportunities available for each country.

Key Words: energy crops, fossil fuels, landuse/ landcover, regional approach, water resources

Introduction

Affordable energy services are among the essential ingredients of economic development (Amigun et al. 2006). This could help in eradication of extreme poverty and ensuring environmental sustainability in developing countries as called for by the United Nations Millennium Development Goals. Meeting essential energy needs economically and sustainably requires a balanced energy portfolio that is suited to the economic, social, and resource conditions of individual countries and regions (Renewable Energy 21). Currently, the major source of energy for world economies is petroleum oil, which has become expensive over the last three decades (UN Energy 2007). Although oil importing African countries recorded positive overall GDP growth in the past few years, they are mounting internal and external imbalances. Mounting budget deficits and inflationary pressure in oil importing African countries disproportionately affect the poor because of lower employment prospects and lack of safety nets (UNECA 2007). Additionally, petroleum oil is a major source of carbondioxide, a greenhouse gas of global concern in climate change debates (Agarwal 2006). Therefore, an alternative source of energy such as bioenergy produced from energy crops provides an affordable option for developing countries, especially those in Africa where its potential has not been fully explored.

Bioenergy is energy produced from organic matter or biomass (Agarwal 2006, UN Energy 2007). This can be in the form of bioethanol or biodiesel. Bioethanol is fuel from distilled fermented sugars and starches, and biodisel is methyl or ethyl ester of fatty acid made from virgin or used vegetable oils (Agarwal 2006, Pasqualino et al. 2006). For example, *Jatropha curcus* is a large fast-growing, drought resistant perennial shrub that grows in tropical countries mainly in hedgerows. The seeds yield for Jatropha ranges from 0.5-12 tones/year/ha depending on soils, nutrient and rainfall conditions (Francis et al. 2005). It can yield up to 2700 kilograms of raw oil per hectare. Projects to demonstrate the possibilities of producing biodiesel from Jatropha have started in South Africa, Malawi, Lesotho, Swaziland and Zambia. Other countries in the region are also at a planning stage to embark on bioenergy production projects. However, large scale production of energy crops requires land and water resources. Setting aside land and water resources for production of energy crops is a challenge for developing countries that are also struggling to meet their food security needs and maintain ecosystems productivity. Even developing countries that have relatively high GDPs like Botswana depend on imports to meet their food security needs, and the remaining ecosystems service a lucrative wildlife based tourism industry.

Southern Africa is comprised of countries that varies in terms of landuse/landcover, hydro-meteorological and socioeconomic aspects. This research assesses the availability of land and water resources for production of energy crops using landcover/landuse, hydro-meteorological and socioeconomic data for the SADC region (Figure 1) with particular focus on Botswana, Mozambique and Zimbabwe. The potential energy crops already grown in some countries in the SADC region are Jatropha, sugar cane, maize, and sweet sorghum. Jatropha is especially suitable for degraded land and is drought resistant. Maize can grow in all the selected countries and sugarcane grows well in Zimbabwe and Mozambique, whereas sweet sorghum is commonly grown in Botswana.

Methodology

The research was carried out using secondary data on landcover/ landuse, hydrometeorology, and energy consumption patterns for the SADC countries.

The landcover data for Zimbabwe and Mozambique was provided by the Southern African Development Community (SADC) office in Gaborone, whereas that for Botswana was provided by the Botswana Ministry of Agriculture. All the data on hydrometeorology was provided by SADC. And data on energy trends was downloaded from the US Energy Information Administration website (http://www.eia.doe.gov/emeu/international/energy.html).

Landcover area estimation

The landcover data was processed using ArcView geographic information systems (GIS) tools to extract the information on different landcover types. Area covered by each landcover type was then used to estimate their percentage cover. The landcover types selected for this research were: cultivated area, bushland, bareground, forest.

Hydro-meteorological data processing

Hydro-meteorological data for the years 1996-2006 were obtained in spatial form and ArcView GIS was used to process it to show rainfall distribution patterns over the whole of SADC. Seasonal rainfall data was used to estimate rainfall distribution over the SADC countries at the start and end of the growing season. Simple statistical analysis such as mean values and medians were used to select places with suitable rainfall for production of energy crops.

Water Requirement Satisfaction Index (WRSI) for the region was filtered using median value of all the countries to show places with moderate WRSI. All the places with WRSI above the median value were selected and their spatial distribution displayed on a map.

Results and Discussions

The results from analyzing energy data shows that there is increased greenhouse gas emissions from consumption of petroleum oil in the SADC Countries (Figure 2). Zimbabwe is among the countries in Southern Africa with high emission rates, Mozambique is moderate and Botswana has the least emission rates. Therefore the three countries form a good representative site for assessing the possibility of producing bioenergy crops for both reduction of greenhouse gases and carbon credits.

Landcover/landuse

Tables 1, 2 and 3 show total area covered by the different landcover types in Botswana, Mozambique and Zimbabwe respectively. In Zimbabwe a large area of land (27.5%) is used for cultivation. It is not known whether the land is still used for the intended purpose because of the land reform processes going on in the country. Botswana and Mozambique have relatively high percentage of land under bushland, 22% and 34% respectively. In addition, there is presence of degraded land in Mozambique (0.8%) and Zimbabwe (0.3%) that is suitable for growing *J. curcus*.

The percentage of land used for cultivation in Mozambique is relatively low as compared to the neighboring Zimbabwe. The bushland in Mozambique provide an opportunity to expand agricultural land in the country. This expansion could include land for production of energy crops. Botswana has the least amount of area under cultivation and a large piece of land is bushland. The bushland in Botswana occur in areas with poor sandy soils not suitable for agricultural production resulting in limitation on expansion of agricultural land. The presence of bareground in Botswana is not included here, as it is difficult to determine it because the Kalahari Desert sand covers a large portion (two thirds) of the country (Government of Botswana 2001). A feasibility study for production and use of biofuels in Botswana indicates that rainfall and soil conditions in the country are suitable for production of sweet sorghum and *J. curcus* (Government of Botswana 2007). Therefore, the bushland in Botswana is available for production of the crops. Farmers in Botswana traditionally grow sweet sorghum albeit not for production of energy. Therefore, it is easy to promote sweet sorghum as compared to *J curcus,* because little information is available to farmers about production of the later.

Hydro-meteorological data

Figure 3a and 3b below show a trend in average rainfall distribution over the SADC countries for the beginning and end of the growing season in January and March respectively, from 2000 to 2005. Once in six years Botswana experienced average rainfall of 51-100 mm in the beginning of the growing season. Mozambique always had rainfall above 51mm throughout the six years, and Zimbabwe had 2 in six years average rainfall of more than 51mm for the month of January. For the end of the growing season Botswana had once again one in six years average rainfall more than 51mm. Zimbabwe had 2 in 6 years average rainfall over 51mm, and Mozambique had more than half of the time average rainfall above 51mm. From this result Mozambique has enough moisture for growth of crops in the beginning of the growing season 100% of the time and more than 50% of the time the crops have enough moisture during the end of the growing season. Energy crops such as sugarcane and maize grow well under the rainfall conditions in Mozambique. The situation in Zimbabwe is also relatively suitable for crop production as compared to Botswana as irrigation could be used to supplement rainfall. However, drought resistant crops such as Jatropha can be tried in Botswana. Also sweet sorghum survives under less rainfall conditions found in Botswana though it is currently not used as an energy crop. Its potential as an energy crop in Botswana should be explored. Hybrid sweet sorghum could well enhance food production by attracting investments that boost both food production and biofuel productivity (ICRISAT 2007). The hybrid sweet sorghum provides good grains that could substitute for sorghum, the staple crop in Botswana. This has already an added advantage for farmers in Botswana, since they could grow one crop for multiple benefits.

The results from estimation of water requirement satisfaction index (Figure 4), using maize as a reference crop, also agree with those from the seasonal rainfall distribution. Botswana has a high percentage of crop failure over the whole country as compared to Mozambique and Zimbabwe. The northern portion of Mozambique is good for crop production as it has less amount of crop failure.

This result is only applicable to the growing season of the year in southern Africa, i.e. January to March. Therefore, does not apply to other periods of the year.

Conclusion and recommendation

The research has revealed that Mozambique has a high amount of land available for production of energy crops. Favorable rainfall conditions in Mozambique are suitable for production of sugarcane and maize as energy crops. Degraded land in Mozambique can be used for production of Jatropha at a small scale. Zimbabwe can explore using degraded land for production of Jatropha. And Botswana has to explore growing sweet sorghum as an energy crop as well as jatropha. Farmers in Botswana are already growing sweet sorghum, which makes it easy to promote it as a potential energy crop. More research is needed on *J. curcus* before growing it as an energy crop in Botswana.

Figure 1 Map showing countries in the SADC region

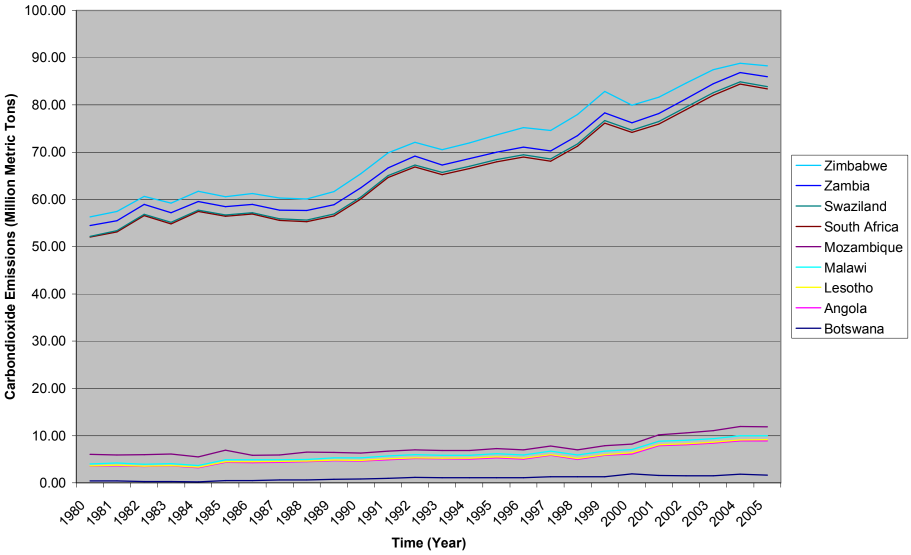
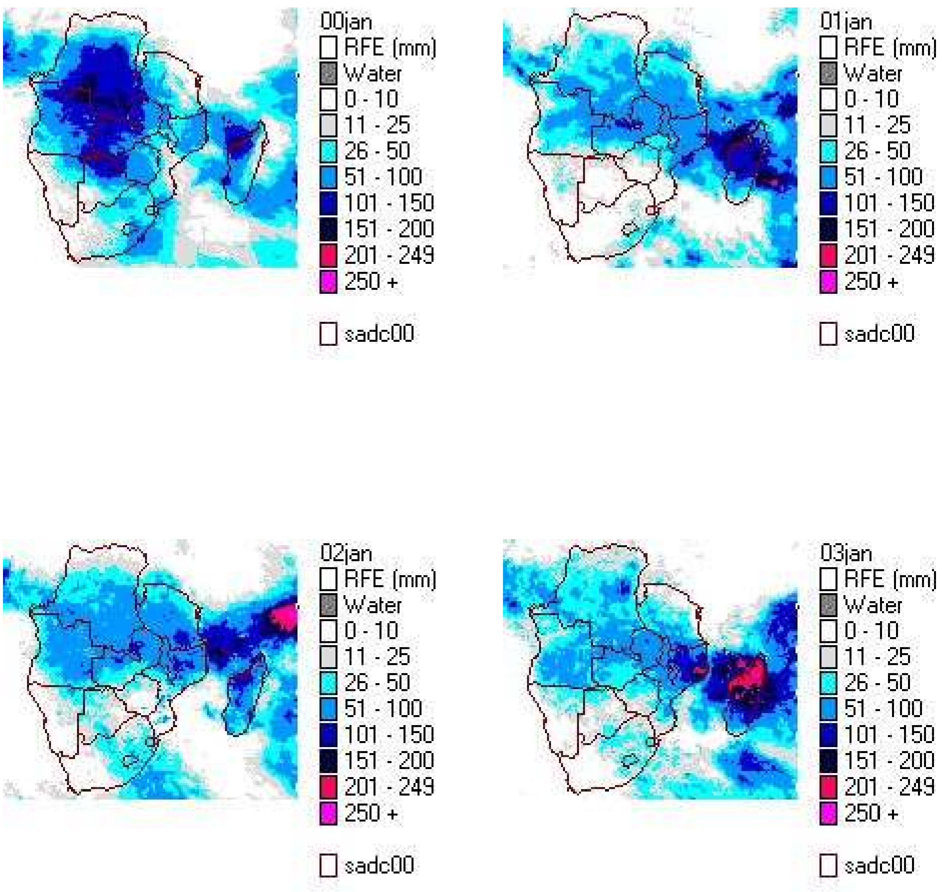


Figure 2 Carbondioxide emissions from petroleum consumption (1980-2005)



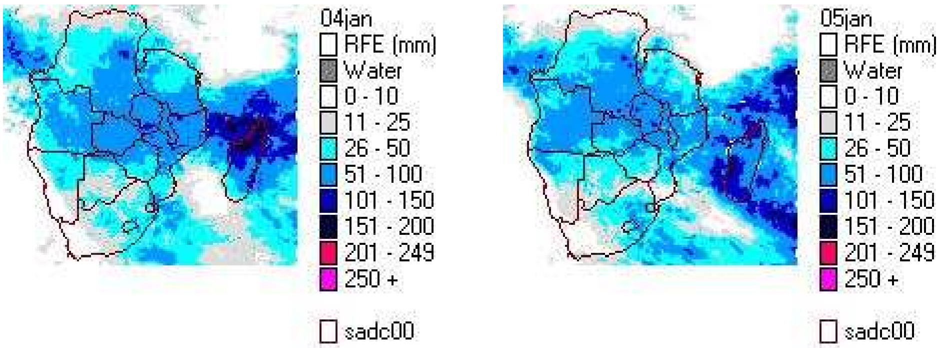
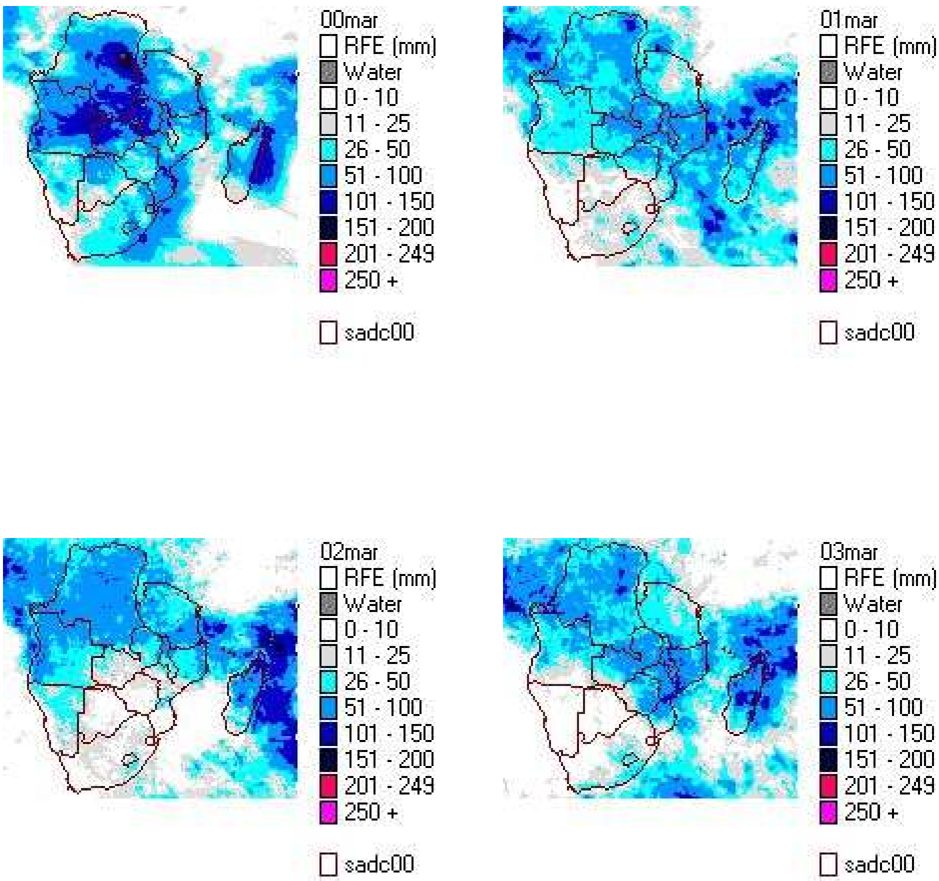


Figure 3a Trends in average rainfall for the beginning of the growing season in SADC countries



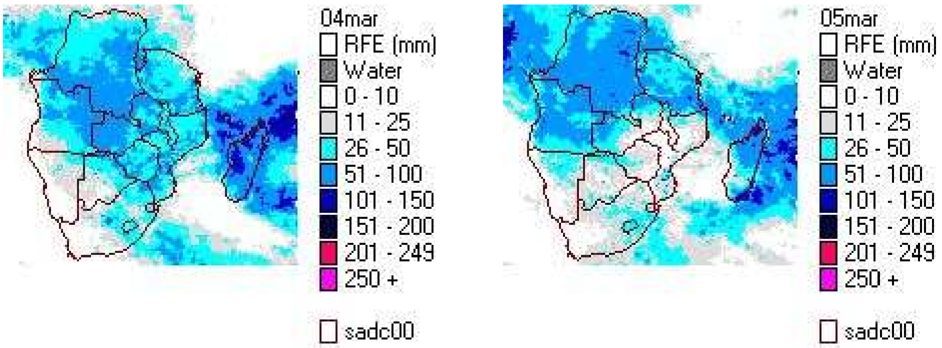


Figure 3b Trends in average rainfall for the end of the growing season in SADC countries

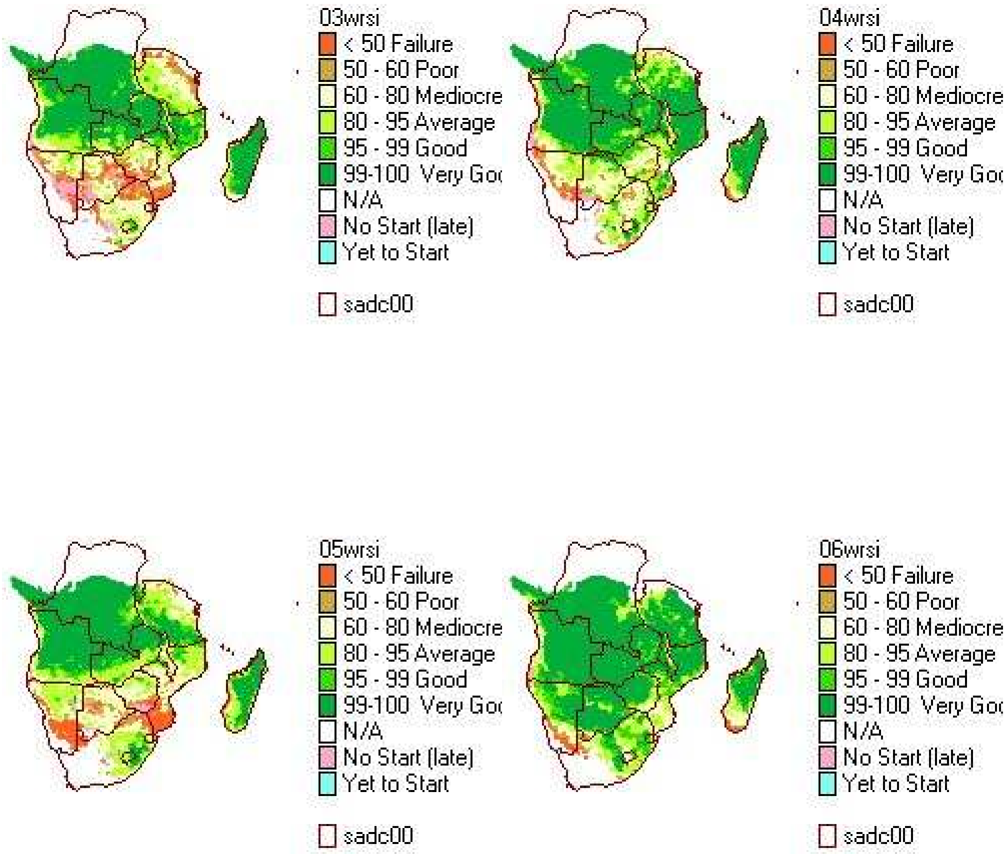


Figure 4 Maize water requirement satisfaction index (WRSI) for SADC countries

Table 1: Area covered by different landcover types in Botswana

Landcover Type	Total Area (km^2)	% Total land
Cultivation	**800**	**0.1**
Bushland	**197665**	**34**
Bareground	**-**	**-**
Forest	**6297**	**1.1**

Table 2: Area covered by different landcover types in Mozambique

Landcover Type	Total Area (km^2)	% Total land
Cultivation	**47942.18**	**6.1**
Bushland	**179233.53**	**22.8**
Bareground	**6341.58**	**0.8**
Forest	**464.06**	**0.06**

Table 3: Area covered by different landcover types in Zimbabwe

Landcover Type	Total Area (km^2)	% Total land
Cultivation	**107049.59**	**27.5**
Bushland	**48906.38**	**12.6**
Bareground	**1006.64**	**0.3**
Forest	**107.84**	**0.03**

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Renewable Energy Applications in the Sudan

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Abstract:

Sudan has one of the best renewable energy resources globally, with solar insulation of about 6.4 Kwh/m^2/day, available allover the year. Efforts to exploit these resources have mainly been emphasized on renewable energy technologies since the establishment of the Energy Research Institute (ERI) in 1972. Solar energy is considered to be one of the most important means of producing and generating both thermal and electrical energy, specifically in remote areas. Rural Solar Energy Development Project which was implemented by the ERI, played a significant role in enhancing dissemination of solar PV systems and establishing good core of knowledge among local small enterprise and artisans. Several solar water pumps have been installed in rural areas and are mostly funded from donations or voluntary organizations. To meet the increasing demand of the PV modules in the Sudan, the ERI inaugurated in 2003 a PV encapsulation and manufacturing units with installed capacity of 2 MW_p of PV modules. An extension of the plant to another 2 MW_p is already operational. Biomass utilization for energy needs in the rural household such as biogas, briquetting and gasification are widely used. Wind energy for water pumping is applied in different region where high potential of wind is available. Solar dryers are developed and used to dry fruits and vegetables. In order to investigate the performance of the dryer several drying tests were conducted. High temperatures were achieved even under low insulation. Compared to traditional drying, the use of solar drying reduces the drying time significantly and improves the quality of the dried products which meet the international markets standards.

Introduction

Sudan's commercially exploitable energy resources consist of hydropower, oil and natural gas. With an area of 2,376,000 km2, Sudan is Africa's largest country which increases the cost of ensuring adequate energy services to all its communities found in different parts of the country. Sudan's population is estimated at 35 million, with at an average annual rate of 2.18%. The energy sector is an important contributor to job generation that would employ the growing number of young people entering the job market every year. The urban population is estimated at 38%, and is expected to grow rapidly in the near future. Consequently, urban energy demand is expected to grow rapidly. While traditionally, it is believed that the bulk of the poor are found in rural areas, the picture is changing with rapid urbanization. A growing number of the poor are now found in urban areas and their need for adequate energy services will need to be addressed by country's policy makers.

Sudan`s energy sources can be divided into two main types: conventional energy and non-conventional energy. Conventional resources include oil & gas, mineral coal and large-scale hydro. Sudan has a long history of developing renewables. Sudan's renewables resources are varied and diverse, due in part to the country's wide range of climates and landscapes. With abundant solar, biomass and hydro resources, is considered an important contributor to its development. A significant proportion of the country's population is reliant on biomass energy. Sudan has one of the best solar energy resources globally, with an insolation of about 6.5 kWh/m2 per day, available all year round. Efforts to exploit these resources have been seriously addressed by the ERI. Although biomass resources are decreasing in the Northern States of Sudan, there are still abundant biomass and forest resources available in the south of the country. It is estimated that geothermal could provide the country with about 400 MW of power generation capacity. Available wind resource data is still not reliable. Sudan which shares the Red Sea coast with other countries could be able to also develop a significant wind power industry. The wind speeds in the rest of Sudan are, however, sufficient for water pumping purposes and a number of pilot wind pumping initiatives have been attempted in the past.

Sudan is an agro-industrial country with fertile soil, plenty of water resources, livestock, forestry resources, and agricultural residues. The energy needs of rural consumers and the urban poor are met by traditional fuels, such as fuel-wood, charcoal and agriculture and animal waste.

Methodology

Status of Renewable Energy

There is an increased use of solar PVs, particularly in the remote rural areas which significantly influence the country's energy balance. However, biomas`s energy resource role in the national energy balance is considered to be substantial as it is important source for rural people. With an estimated current installed capacity of close to 50MW in the sugar industry alone, co-generation could also be an important source of power generation. Because of wind speed uncertainties, it is not clear how important wind power could be to Sudan's electricity industry.

As highlighted earlier, Sudan has vast renewable energy resources. However, in order to ensure that renewables are taken seriously in Sudan's energy plans, it is important to demonstrate the success of renewables.

Solar Energy Technology

Sudan has one of the best solar energy resources globally, with an insulation of 6.5 kWh/m2 per day, available all year round. Efforts to exploit these resources have mainly been addressed by the energy Research Institute (ERI) since its establishment in 1972. The first major trials of solar pumping systems in were started with the World Bank Pumping Project in cooperation with the Energy Research Institute (ERI). The Telecommunication Corporation had also used solar PV to power microwave systems for communication in remote places. Large scale dissemination of solar PV systems had been initiated at the Energy Research Institute (ERI) since eighties as part of donor (USAID, GTZ) financed projects and currently, the World Bank and Community Development Project where several villages were completely powered with solar energy . One of the attractive applications introduced by ERI was solar PV refrigerators for vaccines storage which were adopted by Ministry of Health, WHO and UNICEF as the most reliable and cost effective technology. More than 800 solar vaccines storage refrigerators are currently operational around the country.

A Rural Solar Energy Development Project which was financed by UNDP and implemented by ERI in the North Kordofan State played a significant role in enhancing dissemination of solar PV systems and establishing good core of knowledge among local small enterprises and artisans.

A UNDP-funded PV-Project (PVP) for Sudan, is initiated in year 2000 has been successful in overcoming the barriers associated with solar PV energy use. The project focuses on PV installations in institutions (schools, health clinics, community centers). The project has significant socio-economic benefits in the communities where PV systems have been disseminated. These include improved and longer duration of lighting. The project has created sufficient market penetration of PV systems, to allow the industry to drive itself in the future. This will translate to increased use of PV in rural and remote institutions in the near future. As part of the efforts to remove financial barrier to PV applications, the project has established credit mechanism to assist the target beneficiaries to secure finance from local banks to buy solar systems. During the last five years, the market of solar photovoltaic in telecommunication has increased. Mobile phones operators, Civil Aviation, Sudan Railways and the oil industry are the main users. The installed capacity in 2002 and 2003 increased from 270 KWp to 294 KWp respectively. The use of solar PV in the telecommunication sector is likely to grow in the future, in line with the increased economic development envisaged in the country.

At the beginning of the year 2003, the Ministry of Science & Technology inaugurated a PV Encapsulation and Manufacturing Unit at the Energy Research Institute facilities at Soba, South Khartoum. The unit was paid for using a grant from the Chinese Government. The unit has a production capacity of 2 MWp, of PV modules.

An extension of the plant to another 2 MWp is operational, with grant financing from India. The unit is currently expanding its facilities for assembly of solar PV, pointing to increased growth in photovoltaic installations.

Small scale lighting systems is the most feasible solar photovoltaic application that has high potential particularly in rural and semi urban areas in Sudan. Most of the systems already installed are photovoltaic solar lighting systems in institutions. Lighting systems installed in basic and secondary schools as well as those installed in Khalwas, schools and mosques are dominant, followed by solar photovoltaic systems installed in hospitals and health centres, and systems installed in rural clubs. Lighting of schools is improved the skill of the students as they are be able to study in the evenings. Illiteracy classes and women activities can be conducted as well. In addition, a significant amount of fire wood normally used for lighting in Khalwas will be saved if solar photovoltaic lighting is used instead. This has a positive impact on the social life of inhabitants of rural villages as they will have access to TV programs and can enjoy some social activities together. According to statistics carried out, only 31% of the country population has access to clean water via pipes into dwelling or public taps. About 54% of the population has access to water through reservoir, pumps, wells or rivers and springs. Therefore, there is a niche for photovoltaic solar pumping systems to pump clean potable water for rural villages.

Solar Water Heaters

Research work on solar water heaters started in Sudan in 1970. Some flat plate collectors have been developed. Currently, several solar water heating system was installed by ERI. The system consisted of either imported flat plate collectors or locally made material. A survey to assess the demand for hot water in the industrial, commercial, and household sector was undertaken by the ERI. The findings showed that there is high demand for hot water in the industrial and commercial sectors, but limited demand in the household sector. Based on the results, the Energy Research Institute (ERI) prepared two proposals for installation of solar water heating systems. The locations selected were a soft drink factory and a hotel at Khartoum.

The bulk of the solar water heaters in use are used by high-income households, institutions and large commercial establishments such as hotels. The urban and rural poor have not enjoyed significant benefits from solar water heating technologies. One solar water heating technology that could yield major benefits to the poor is solar pasteurization. Exposure of water in a clear plastic bag to sunlight for a few hours can substantially reduce harmful micro-organisms. Slightly more sophisticated solar waters pasteurizers incorporating some form of distillation can provide potable water for the rural population. The demand for water heaters in the household sector has increased significantly. Solar water heating is a relatively simple technology. However, there is no local company that produces these systems on commercial basis. Solar water heaters are important energy efficiency technology, and can lead to up to 50% reduction in electricity consumption, resulting in significant benefits to both the electricity utility and electricity consumers. The feasibility of solar water heater applications in the industrial scale has been reported in some countries in Africa.

Some companies have demonstrated that solar water heaters have good potential for replacing electric and fossil-fuelled water heaters. They have installed solar water heating system in hotels and industries.

The development of a market for solar water heaters requires the protection of the users by enforcing quality control laws. The demand for hot water in the household sector is seasonal in Sudan. It is mainly needed during the winter months. This is not in favour of solar energy applications, which are more suitable for continuous, constant load. Solar water heaters in the household sector compete with electric water heaters. In addition, the market for electric water heaters is still limited to a small section of the population, the high- income sector.

In the Sudan, like other developing countries, traditional drying has been used for drying of several agricultural products. The traditional drying techniques are specific to each locality and commodity. It is simply carried out by spreading the product on paved ground and occasionally turned to insure uniform drying. These methods seemed to be unsatisfactory for a number of reasons, among these are:

- There is no control of drying conditions over the drying period.
- It is not possible to insure uniform drying.
- Over drying, especially in arid regions, due to excessive exposure to the sun.
- Losses due to contamination with dust, insects … etc.
- Above all, low quality of the dried products.

The use of solar drying under relatively controlled conditions will allow crops dry reasonably rapid to save moisture levels and also ensure good quality of the dried products. It is also allow fruits & vegetables available all over the year, (since their

production are often seasonal) and will go some way to alleviate these problems and will also help to raise the income of the rural farmers. Like other tropical and subtropical countries, Sudan blessed with high level of solar energy with average solar radiation of more than 20 MJ/m^2/day.

The solar dryer consists of a solar air heater, a dryer section where both are covered with transparent foil, and two axial direct current fans power by a single solar module.

The solar air heater and the dryer are covered by a transparent UV stabilized PE plastic foil. Various fruits and vegetables were investigated such as onions, mangoes. The solar dryer was successfully tested under the field condition, where high quality product is obtained. The drying experiments revealed that, the solar dryer leads to a significant reduction in the drying time compared to the sun drying. Furthermore, the dryer can be easily constructed with simple tools and low labour. Loading and unloading of the dryer is found to be quite easy and the assembly can be done by the farmers themselves.

The performance of the solar collector to heat the drying air is assumed satisfactory. The quality attributes of the dried product is significantly improved since it is protected from rain, dust, insects, animals … etc.

Wind pumping

Studies carried out by the ERI on wind energy feasibility in Sudan have indicated a significant potential for wind pumping. Availability of potable water for human use, animal drinking and irrigation is a major priority in the country. Wind pumps can play an important role in providing water especially to isolated communities outside the main grid. Wind pumps have been used in Sudan since 1950, when 250 units were imported and installed in Gezira region and eastern Sudan. As the demand for water grew, the market for diesel pump expanded and, in contrast, lines of supply for imported wind pump parts were severed and no local production was initiated. The wind pump technology gradually faded out. In the 1980s activity in this field was revived. Sixteen CWD wind pumps were installed around Khartoum and in the Eastern and Northern Provinces by The Energy Research Institute (ERI), with assistance from the Netherlands. Three Kijito units were also installed in the Butana region. Some aid agencies installed some Kijito and Southern Cross units in the same period in Eastern and Northern Sudan.

The wind speed map for Sudan indicates an annual average ranging between 6m/s at some Red Sea and Northern Province locations down to 2m/s in Southern Sudan. This was based on Metrological Department readings at a height of 15m. These speeds are sufficient for water pumping.

A more recent investigation for wind power potential in Western and Northern Sudan indicated favourable potential for electricity generation from wind. Higher speeds sufficient for power generation have also been reported on the Red Sea coast of Egypt and the Red Sea coast of Eritrea. High speeds necessary for large scale wind power generation have not yet been fully confirmed in Sudan.

Geographically, the market for wind pumping is seen to cover virtually all of the country, as wind pumps are now designed to pump at speeds as low as 2.5m/s. The main potential beneficiaries of wind pumps are rural communities that currently get drinking water from distant wells, which is a predominant feature in rural Sudan. Rural Water Supply authorities, which use diesel pumps for water supply of limited rural communities. Also rural farmers who are currently dependent on diesel pumps, noting that the grid based pumping support now only a small percentage of the country's arable land. As is the case with other renewables, initial financing is an obstacle for dissemination of wind pumps.

Conclusions and Recommendations

The implementation of the Rural Solar Energy Development Projects, played a significant role in enhancing dissemination of solar PV systems and establishing good core of knowledge among local small enterprise and artisans. These applications have been successful in overcoming the barriers associated with solar PV energy use. As a result, there have been significant socio-economic benefits in the communities where PV systems have been disseminated. In addition these applications have created sufficient market penetration of PV systems, to allow the industry to drive itself in the future. The feasibility of wind pumping at any site depends on the cost of diesel oil and the wind speed at the site. A conducted feasibility study for wind pumping in rural Sudan, indicated that wind pumping was feasible where wind speeds exceed 5m/s. It also showed that if the diesel oil price at the locality exceeds the official price, wind is feasible at even lower wind speeds and a competitive option, not only in comparison to diesel pumping but also to other renewables such as solar pumping.

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Applicability of Passive and Low Energy Cooling Techniques in Ghana

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ABSTRACT:

The paper will assess the applicability of passive and low energy cooling techniques in Ghana. In Ghana, as in many developing countries around the world, a straight forward response to excess heat in buildings has been the adoption of air conditioning. The use of air conditioner has impacts such as increase in the peak electricity demand that is supplemented with conventional energy, and associated environmental problems such as global warming. An alternative technique to reduce dependence on conventional energy use and provide solutions to environmental effects of mechanical air conditioning is passive cooling techniques. The paper will discuss the scientific fundamentals relevant to the various cooling techniques, as well as practical and architectural design issues involved in their application. Generally, the application of low energy cooling techniques is dependent on climate. As such a climatic analysis will be carried out to assess their applicability and use in the various climatic zones (or cities) in Ghana. The identified passive cooling techniques are aimed at challenging building designers to evolve innovative building design solutions. The paper provides a preliminary stage of a much broader study. Further investigations are underway to complement the study.