African Technology Development Forum

ATDF JOURNAL

VOLUME 2, ISSUE 2

INNOVATION; TECHNOLOGY; TRADE; DEVELOPMENT

"I shall make electricity so cheap that only the rich can afford to burn candles"

(Edison, T. A)

INSIDE THIS ISSUE:

http://www.atdforum.org/

JUNE, 2005

INSIDE THIS ISSUE

Source of cover picture: NASA

LIGHTING UP AFRICA: ENERGY FOR DEVELOPMENT

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Abstract

Energy is vital to poverty reduction, improving the quality of life, driving economic development and creation of employment. This paper provides a glance at Africa's energy resources, energy production and consumption patterns and some of the policy trends. The paper also suggests some alternative options of improving access to commercial energy and ensuring Africa's energy security.

Introduction

The relationship between energy and poverty is one that is often ignored until fuel shortages, blackouts and price increases remind us of the link. Energy is central to reducing poverty, whether poverty is seen as material deficiency, measured in terms of income or consumption, or quality of life, measured in terms of exposure to risks.

For instance, indoor air pollution caused by open cooking fires increases the risk of pneumonia, chronic obstructive lung diseases and headaches [1]. According to the World Health Organization, "half the world's population is exposed to indoor air pollution, mainly the result of burning solid fuels for cooking and heating... [globally accounting] for 36% of all lower respiratory infections and 22% of chronic obstructive pulmonary disease" [2].

History also shows that the industrial revolutions were partly driven by increasing access to improved energy services. Countries with greater access to advanced energy resources (largely coal) grew faster [3]. Similarly, a recent survey found that rural electrification benefited even homes that were not connected, in terms of longer business hours, improved health and education services, and greater access to information (e.g. television). Electricity was cheaper, safer, cleaner and better than kerosene lighting and charcoal heating (e.g. pressing irons) [4].

Indeed, the electrification of additional rural farms in Mkushi, Zambia, is credited with driving agricultural performance by reducing the cost of irrigation and supporting [crops] farming throughout the year. Zambia's non-traditional exports have increased by over 212% in 10 years, accounting for about 34% of total exports in 2004, despite mineral production hitting a new high [5]. Other benefits of commercial energy include easy processing of food, and extension of business/service hours, among others.

Energy firms employ thousands of highly qualified and experienced individuals, contribute greatly to the revenue base of the country (e.g. corporate income tax or government tax on fuel) and to development (e.g. inbuilt rural electrification taxes). For instance, the major African oil exporters, such as Angola, Algeria, Libya and Nigeria, rely heavily on the energy sector for economic growth. Furthermore, there are also indirect benefits through backward linkages such as with firms that supply products and services to the energy sector.

Over the past few years, energy issues have received little attention in development planning, especially among development agencies. The Millennium Development Goals are unlikely to be attained without access to reliable energy. The just released Africa Commission Report acknowledges the role energy plays in development in several places. Similarly, the African leaders, through the African Energy Commission, emphasized that "Africa must harness its energy resources and make them available to meet the energy needs of its peoples in order to be able to develop and provide an alternative to deforestation and use of firewood." However, energy does not seem to receive the attention it deserves.

Poverty reduction in Asia has been associated with increase in trade, most of which was driven by increased foreign direct investment (FDI). Destinations that had the necessary infrastructure and services (including energy) and skilled labour attracted most of the FDI. As discussed later, it is not surprising that Asia's energy production and consumption grew the faster between 1980 and 2001 than that of Africa or South America, within the same period.

The provision of even diesel powered hammer mills could enable farming rural communities to process their crops in a short period of time and encourage them to store some of their harvests. Many people already struggle to provide modern lighting by using batteries to power television sets, florescent tubes and bulbs. Whether we agree or not with the assertion that commercial energy is vital in fighting poverty, industrial growth and wealth or job creation, at least we know there is demand for commercial energy services.

1. Africa's exploitable energy resources

Africa is estimated to have at least 112 billion barrels of proven oil reserves and at least 14 trillion cubic metres of proven natural gas reserves [6]. In addition, the continent has over 50 billion tones of proven coal reserves, technically exploitable hydro-energy capacity of about 1,888 TWh/y (TW = terawatt or one million megawatt) and abundant biomass [7]. The exploitable hydro energy capacity in Congo D.R. alone is thought to be higher than the installed electricity capacity in the US. In addition, Africa is one of the major producers of uranium, an input for generation of nuclear power.

One of Africa's most abundant renewable energy resources is sunlight. With the equator dividing the continent in half, lengths of daylight vary marginally all year round. In addition, the continent has a number of hot-springs and other exploitable geothermal resources, wind and biomass.

These energy resources are unevenly distributed across the continent. Most of the petroleum reserves are concentrated in the northern and western parts of Africa while most of the exploitable hydro-energy resources are concentrated in central Africa. Similarly, most the confirmed coal reserves are found in southern Africa while economically exploitable geothermal resources are located in eastern Africa.

Technically, Africa has sufficient exploitable energy resources to meet its energy needs. The continent is a net-exporter of energy resources, especially petroleum and uranium. For instance, in 2004, Africa produced about 9.3 million barrels of oil per day but is estimated to have consumed only 2.6 million barrel a day [6].

2. Africa's energy consumption

The energy consumption pattern, on the other hand, is very worrying from a developmental perspective. About 60% of Africa's energy requirement is met by biomass alone (primarily wood) while petroleum and electricity meet only about 33%. In contrast, biomass meets only 14% of the global energy consumption while petroleum and electricity meet about 60% (see table 1).

Table 1. A comparison of Africa and world energy consumption patterns

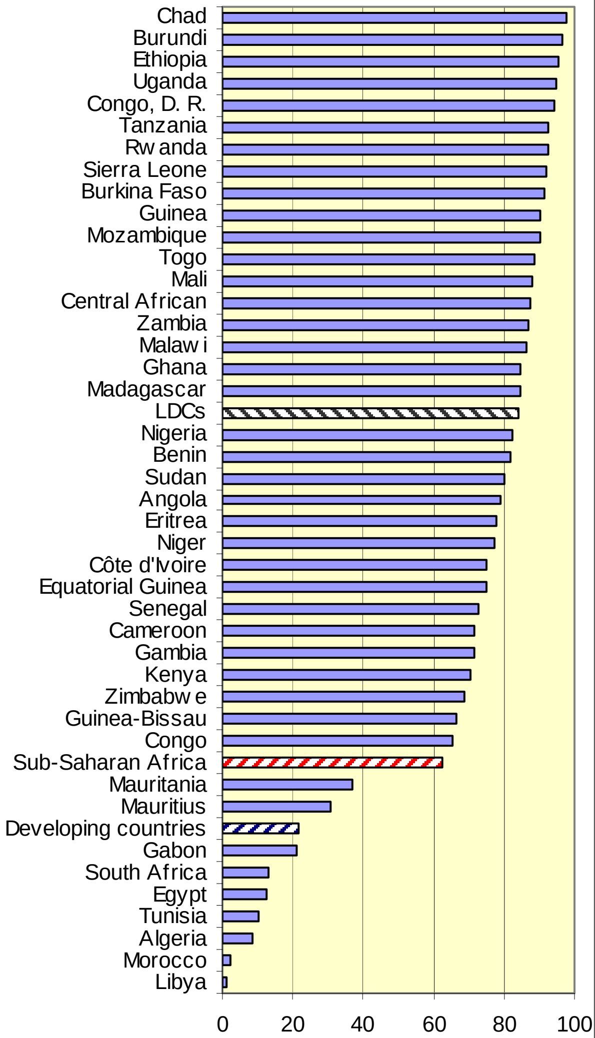
Source	Africa (%)	World (%)
Biomass	59	14
Coal	4	7
Electricity	8	16
Gas	4	16
Heat	-	3
Petroleum	25	44

Source: International Energy Agency

At a country level, biomass makes up more than 90% of the energy consumed by about 12 countries. About three 3 countries (Algeria, Libya and Morocco) derive less than 10% of their energy requirements from biomass. Most African country's dependence on traditional energy resources is above the average for SSA and developing countries (see figure 1).

It is, therefore, not surprising that only 17% of the population in sub-Saharan Africa has access to electricity. That figure drops to about 5% in rural areas [8]. In other words, Africa, with 850 million people, consumes almost the same amount of electricity as United Kingdom, with 60 million inhabitants. Africa's average electricity consumption per capita is about

Figure 1. Traditional fuel consumption (% of total energy)



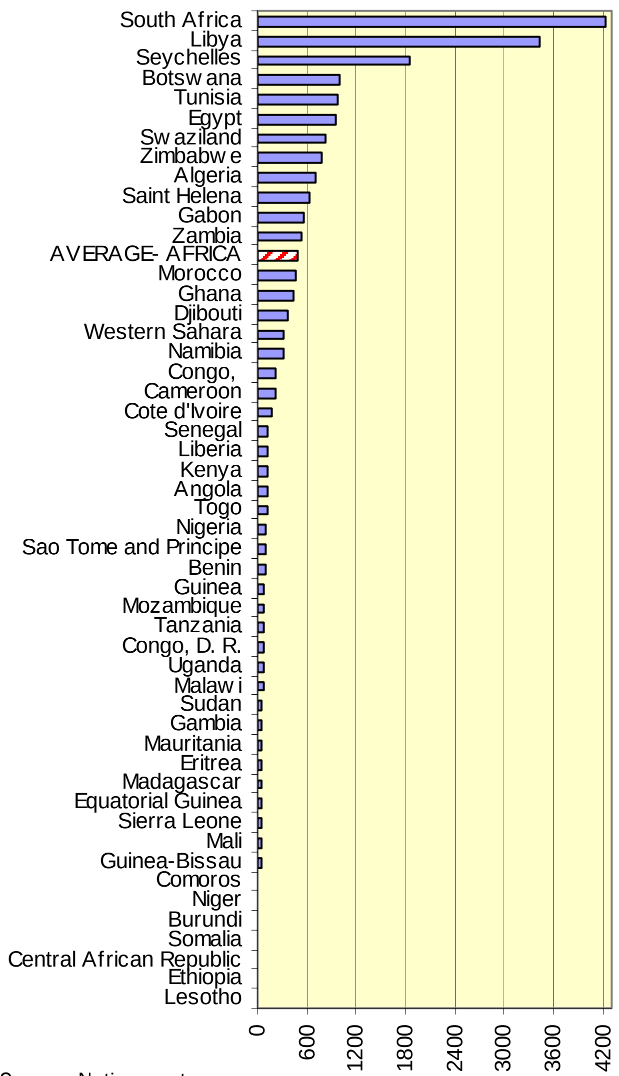
Source: UNDP, HDR 2004

15% that of the world average. About 12 countries have electricity consumption per capita above the African average (see figure 2). More importantly perhaps, four countries - South Africa, Egypt, Libya and Algeria- account for nearly 80% of the electricity consumption in Africa even though these countries have only 13% of Africa's population.

From a global perspective, Africa's share of commercial energy consumption is small. Africa consumes about 3.3% of the global oil even though its production share of global oil is 11.4%, and its consumption of natural gas is about 2.6% even though it production share is 5.4% [6]. Similarly, Africa consumes only 3.8% of global coal although its world production share is 5.4% (see a comparison of consumption by energy source of developing regions in table 2).

In terms of sectors, about 50% of commercial energy of Southern Africa is consumed by the industrial sec-

Figure 2. Electricty consumption (in KWh/capita 2001)



Source: Nationmaster

Table 2. Share of global energy consumption (as a percentage of total).

	Oil	Gas	Coal	Nuclear	Hydro
Africa	3.3	2.6	3.8	0.5	3.2
Asia	28.9	13.3	50.7	17.5	23.1
LAC	6.0	4.2	0.7	0.8	21.5

Source: BP, 2005.
Note LAC; Latin America and the Caribbean

tor and about a third goes to transportation [8]. In contrast, transportation accounts for a much greater share in Central, East and West Africa than in Southern Africa, - an indirect indicator of a small industrial base. Further, residential activities account for about a quarter of energy consumption in North Africa.

Africa's energy consumption per capita has remained almost constant between 1980 and 2001. However, Africa's energy intensity (*the amount of energy required to generate a given economic output*) remains one of the highest, almost twice the world average. Congo D.R., Ethiopia, and Nigeria are among the most energy intensive countries (see figure 3).

Over the same period, the energy intensity of the US, UK and Canada have decreased partly due to the increasing shift toward services from manufacturing and promotion of energy efficient production systems. However, energy intensity may vary widely especially when countries experience economic and political crisis, such as in the case of Congo D.R. and Mozambique, reflecting both a difficult to acquire energy resource or the limited energy is spent on economically unproductive activities.

Africa's low energy consumption per capita may be explained by the low economic growth and, to a lesser extent, high population growth. As Table 3 shows, Africa's real GDP grew on average at about 2% per annum between 1980 and 2001 while that of Asian and LAC grew at about 6.8% and 2.1% per annum, respectively. Africa was the only region where population growth outpaced economic growth and GDP per capita fail.

Table 3. Regional average annual growth rates, 1980-2001

	Energy consumption	Electricity consumption	GDP	Population
Africa	*2.5*	*3.1*	*2*	*2.5*
Asia	5	7.7	6.8	1.7
LAC	2.9	4.5	2.1	1.8

Source: US Department of Energy, 2003

3. Meeting the escalating energy demand in Africa

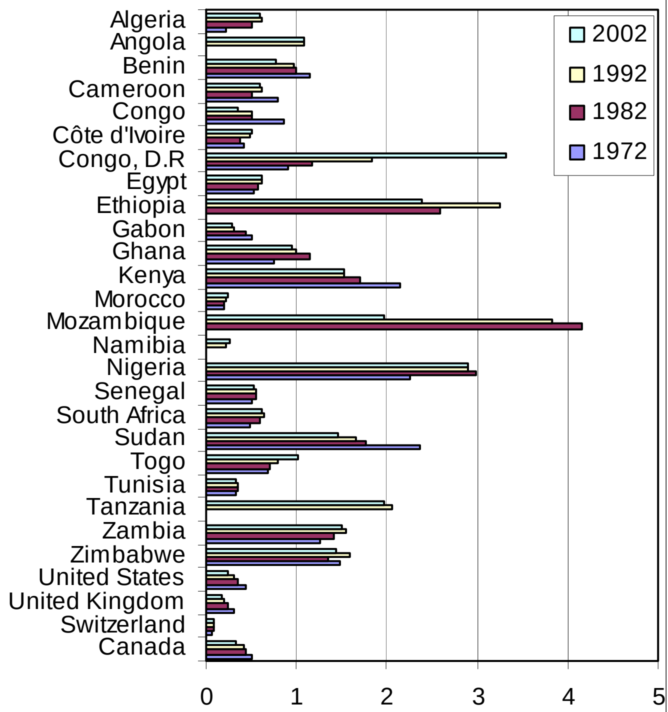
Albert Einstein is quoted saying "[w]e can not solve problems by using the same kind of thinking we used when we created them". Some of these problems include limited investment in innovation (especially energy-related R&D), infrastructure, public awareness and diversification efforts. Africa is experiencing its best growth rate in recent times (since 1995) and energy should facilitate as well as be part of the growth.

The choice of energy technology

Although there are several energy technologies, the choice may be influenced by natural energy resource endowment, comparative costs of deploying and maintenance of the various options, technological base of the country, consumer needs, political ambitions and environmental considerations, among others. For example, South Africa and Congo D.R generate most of their electricity from coal and hydro resources, respectively, due to the existence of such resources in their respective countries.

Figure 3. Energy intensity of selected countries

(Kg OE per 1 dollar of GDP)



Source: UNCTAD Database of Statistics

The need for clear and consistent energy policies

Following the oil crisis of 1973 and the fall in sugar prices, many African countries considered production of ethanol to reduce their dependence on and the import bill of oil. Zimbabwe's experience highlights the problems associated with technology transfer and the need for clear and predictable policies to allow corporate planning. Triangle Ltd, a private sugar production firm, decided in 1975 to use surplus molasses to produce ethanol. A Germany firm agreed to supply only a "turn-key" project. However, several automatic controls had to be discarded in favour of manual operation to suit the capabilities of the local workforce [9].

By the mid 1990s the plant was producing about 40 million litres per year and a blending ration of 13:87 (ethanol to gasoline) had been attained, slightly lower than the target ratio of 15:85. Ethanol production increased incomes of about 150 cane farmers, facilitated acquisition of advanced technologies and consumed molasses, formerly a waste product. This success was partly based on a ready and influential customer- National Oil Corporation of Zimbabwe - which bought the ethanol and sold it to various oil distribution firms.

In contrast, Kenya's success was short lived even though its 60,000-litres per day ethanol plant created employment for about 1,200 people. Although the failure was partly blamed on drought and pricing, the lack of government commitment and clear production, blending and marketing policies accounted for much of the failure.

Irrespective of the energy 'mix' of the country, a sound energy policy should at least:

⇒Seek to maintain stable energy supply and, indirectly prices

⇒Set predictable regulatory and fiscal incentives

⇒Set clear, quantifiable and verifiable targets

⇒Encourage diversification, investment and efficiency, and

⇒Promote innovation and technological upgrade and development.

The need for policy stability and clarity is more important especially following the current liberalization of energy markets in Africa and Africa's environmental and trade commitments enshrined in international agreements.

4. The way forward

Rural electrification; the need for sustainable and cheap energy

The challenge of increasing access to electricity for rural areas, from its current 5%, is daunting. However, African countries have unique opportunities of accessing a wide range of established and emerging energy technologies to exploits their abundant natural energy resources.

Given a choice, she would prefer a gas or electric cooker to give her lungs a break from polluted air and her back from carrying loads of firewood.

Solar energy is currently promoted as an easy to deploy, use and manage energy technology. Several countries, including Ghana, Kenya, South Africa, Zambia and Zimbabwe, have included solar energy in their programmes in an effort to provide wider access to electricity lighting. This has to be viewed as 'quick-fix' as its economic viability and sustainability (without long-term government subsidies) remains unknown [10].

However, emerging technologies promise to cut down the cost of production of solar panels and may bring them within the reach of some communities or national programmes.

Biogas technology exploitation remains low in Africa despite its potential as a source of heating (cooking) and electricity generation. In South Africa, a school with 1000 students depends on two 20-cubic metre digesters fed by an 8-toilet block and cow dung. The biogas generated, about 16 cubic metres per day, is used for cooking in the domestic science classroom and running a modified 5 horse power diesel engine which in turn drives a 2 kW AC generator. "The unit energy costs over a 15 year lifecycle are lower than solar electrification, and can be markedly cheaper than grid power, should the grid have to be extended to this location" [11].

India and China are among the few countries that employ biogas for community electrification [12]. Communities with high cattle populations could easily use the dung to produce biogas for power generation. In addition, recent improvements in biotechnology could soon make it possible to generate biogas or capture it from landfills. In this case, the electricity or gas is a bonus as the slurry is used as a fertilizer.

A school biogas plant powers a four-plate cooker and an electric generator

Source: AGAMA

Mini-hydro power plants: There are several small hydro power plants in many African countries. However, it is not as highly promoted as solar power despite the fact that the initial investment is comparatively low, maintenance costs are minimal, economically sustainable, and the expertise and materials are locally available.

Countries could employ local knowledge and student research projects to identify potential hydro-energy resources for small electricity generation plants. This could lead to the development of reliable maps and stimulate entrepreneurs, with adequate public support, to develop commercial energy ventures.

Exploiting other energy resources: Other energy resources, such as bio-ethanol/diesel, coal, gas, geothermal, nuclear and petroleum, should be considered, depending on national resource endowment, technological expertise, public perception and national experience. The diversification of energy sources is important to ensuring energy security of countries. For instance, countries that are prone to severe droughts have seen their hydro power production drop (e.g. Ethiopia, Kenya and Uganda) during droughts or periods low rainfall.

Countries, such as Angola and Nigeria, burn valuable gas from their oil wells that could be harnessed to generate electricity for a good proportion of their population. Kenya, because of its growing demand for electricity, is encouraging the exploitation of its geothermal resources that are generally not affected by rainfall variations. Others may wish to emulate such diversification efforts.

African experience with bio-ethanol and bio-diesel, and cogeneration of electricity from agricultural raw materials is well established. Countries such as Kenya, Malawi, Mauritius and Zimbabwe have, to varying degrees of success, developed power plants or refineries. Mauritius' experience shows that with supportive legislation and government incentives, generation of electricity from bagasse is commercially viable. For example, "[t]*he gross revenue derived from sale of electrical energy represent [ed] 90% of that derived from processing of cane into sugar by the millers in Mauritius"* in 2000 [13].

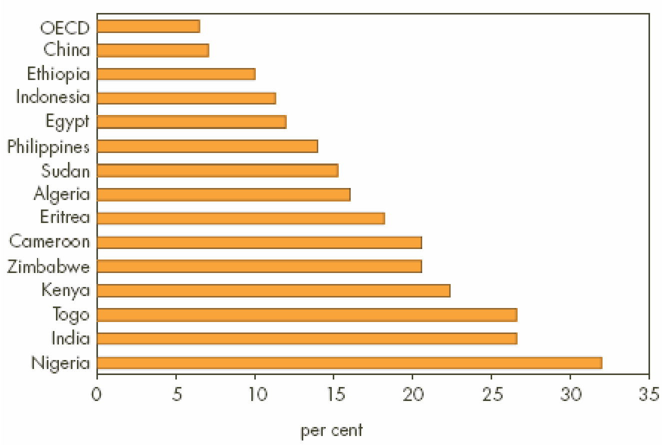
Africa, with its high dependency on agricultural commodities, could pass legislation that requires petroleum refineries to use a given percentage of bio-ethanol produced from crops, such as sorghum, sugar cane and maize. For instance, the US Senate passed a bill in June 2005 that requires refineries across the country to use about 30 billion litres of ethanol a year by 2012 [14]. The major beneficiaries of such a policy are farmers and processing plants, and those employed due to expansions and development of new facilities that will process the extra ethanol.

For Africa, the technology does not need to be fancy but practical and useful. There are many studies to determine if filtered soy oil could somehow be tweaked to run in a car [15]. For Africa, finding a way to make it safe to run hammer mills, water engines, irrigation pumps and power electricity generators could improve the lives of rural communities.

"And God said, 'Let there be light' and there was light, but the Electricity Board said He would have to wait until Thursday to be connected." (S. Milligan– Indian Humorist)

Curing Africa's chronic blackouts: The cost of electricity blackouts in African is not known. The 2003 electricity blackout that plunged part of US and Canada into darkness is estimated to have cost about $6 billion [16]. The number of blackouts in many African cities could easily accumulate into several lost labour-days or weeks. A businessman put it simply: "The worst part is not knowing when the blackouts will hit. When you least expect it, everything comes to a standstill" [17] Unreliable energy supply may account for the low levels of private investment Africa attracts and economic productivity of its limited industries, needed to reduce poverty.

Figure 4. Electricity losses of selected countries



Source: Energy Outlook 2002: Energy and Poverty, IEA

African countries have also some of the highest levels of electricity losses (see Figure 4). Such losses may be due to illegal and dangerous connections by people who live close to the electricity grids (that are denied the service) and unpaid bills. Countries with losses of over 20% are losing revenue that could be used to expand energy services.

Regional integration of grids: Although some of the measures above may help light up Africa, curing Africa's chronic blackouts is critical to industrial development. Bilateral and regional integration of electricity grids could provide a quick and reliable fix (where blackouts are due to limited electricity supply and load shedding). There are already several electricity pools or initiatives in Africa [18]. For example, Eskom's proposed 40,000 megawatts (worth $50 billion) hydro power plant on the Inga river, Democratic Republic of Congo, will feed a pan-African electricity grid to western and northern parts of Africa, and from there to southern Europe.

Blackouts due to load-shedding and overloads of the grid would be reduced by such regional projects. The rest will require investment in modern infrastructure to detect faults, improvement in public awareness to reduce or eliminate illegal connections and theft of public property (e.g. transformers), improvement in revenue collection and development of technical expertise needed to ensure reliability.

Reducing the impact of price volatility: Many African countries began searching for new energy alternatives following the 1973 oil crisis, partly credited for the decline of some African economies. That enthusiasm disappeared with fall in prices. As oil prices have continued to climb new initiatives are in the offing but very little is concrete. At risk, is Africa's overall growth potential as only a handful of oil-exporting countries are benefiting from the windfall in 'petrol dollars'.

African countries have to consider energy efficiency in the development of their transport, housing and industrial development. For instance, the lack of mass public transport into and out of African cities is a major drain on national resources (in increasing petroleum import bill) and make transportation of already under-paid workers expensive. This may include improving the efficiency and comfort of railway networks as an alternative passenger transport system, phasing out of up to 12-seater buses, development of central cooling and heating systems of larger buildings, among others.

Energy efficiency: Mass transport options for Africa?

Top; Cuban "Camel"; **bottom:** Belgian bikes and streets
Source: http://ohbike.org and http://www.cubaheritage.com

Given the small size of African economies, they may wish to develop common or regional oil stock reserves. Since, African economies may not witness economic prosperity or crisis at the same time, such a reserve may regionally cushion those hardest hit by price increases and provide them with time to put into place national measures to cushion the impact. Such a mechanism may have the added advantage of fostering political and economic cooperation, enabling countries to tap into refining capacity of others and the development of common petroleum-related standards.

Marketing alternative energy technologies: The marketing of several energy technologies, such as briquettes (from agricultural remains) and deployment of biogas, remain a major challenge. Several African countries (e.g. Ethiopia, Ghana, Kenya, Malawi, Senegal Zambia, Zimbabwe) have produced or produce briquettes. However, production remains low and marketing is very poor in some of the countries.

It may be wise to locate demonstration units closer to the target population and/or industry and to sensitize the public of the benefits and limitations of the technology. Such awareness could attract political and industrial interest. For example, the ability of briquettes to compete with or replace charcoal may be influenced by the availability of briquettes at public market places and their costs and user benefits. Like all other products, alternative energy technologies have to be marketed efficiently and effectively if they are to make a meaningful impact.

Conclusion

Continuous investment in energy-related research and development, and the creation of energy courses in polytechnics and universities has to be part of national energy policies. Indeed, introducing courses on the design of solar cookers and panels, electrical wiring of homes and cars, energy efficient technologies and products, and advantages and disadvantage of nuclear and hydro-electric plants, among others, in primary and secondary school programmes could help raise interest and awareness in energy technologies.

Emerging technologies in the areas of nuclear, fuel cell, solar and wind energy also open up new opportunities for business and expanding energy supply in Africa. African leaders should pay more attention to what others are doing. If other countries are scrambling to secure the limited energy resources and investing in new technologies, it may be time to join the race. Even bigger players like the US regard energy as central to their economic and social development.

It may also be easier to acquire emerging technologies, through international R&D agreements, before their commercialization. The cost of establishing a competitive production plant once the technology has matured can be prohibitive to late comers. Africa could either learn along or wait in the hope that once the technology's economic viability is demonstrated business houses will donate it. So far, the later has not worked.

For Africa, energy is a source of income (major source of tax revenue and foreign exchange), a business (a major employer) and a facilitator of development (key input in health, agriculture, transport and education). Any energy policy has to recognize and provide incentives to ensure energy effectively plays its different roles in poverty alleviation, industrial development and wealth creation. Such support may take the form of friendly legislation, fiscal incentives and political awards or recognition to encourage investment, R&D activities and involvement of different players in the energy sector.

References

1. Bruce, N., McCracken, J., Albalak, R., Schei, M., Smith, K. R., Lopez, V. and West, C. (2004) Impact of improved stoves, house construction and child location on levels of indoor air pollution exposure in young Guatemalan children, *Journal of exposure analysis and epidemiology*, S22-S33.
2. WHO (2004) *The World Health Report 2002: Reducing Risks, Promoting healthy Life*. WHO; Geneva
3. Barnett, A. (2000) Energy and the Fight against Poverty, Energy and the "Empowerment" of Livelihoods, Sussex Research Associates Ltd
4. Marge, R. M. (2003) Impacts of Rural Electrification on Poverty and Gender in Sri Lanka World Bank; Washington DC
5. 2005 Budget speech, Ministry of Finance and National Planning, Zambia
6. BP (2005) Putting energy in the spotlight, BP Statistical Review of World Energy 2005
7. WRI (1994) World Resources 1994-1995: A guide to the Global Environment. Oxford University Press, New York.
8. EIA (1999) Energy in Africa, US DOE accessible at http://www.eia.doe.gov/emeu/cabs/archives/africa/africa.html
9. See the thematic background paper for 2004 International Conference for Renewable Energies at http://www.renewables2004.de/pdf/tbp/TBP11-biomass.pdf
10. See O.S. Kalumiana- Rural Energy Access: Promoting Solar Home Systems In Rural Areas In Zambia – A CaseStudy at http://www.afrepren.org/Pubs/articles/wrec/pdfs/kalum.pdf
11. Austin, G. (2003) Biogas energy and sanitation provision in south Africa, AGAMA Energy (Pty) Ltd.http://www.agama.co.za/press_news/ae_biogas.htm
12. Goldemberg, J. and Johansson, T.B. (Eds; 1995) "Energy As An Instrument for Socio-Economic Development" UNDP, New York,
13. Deepchand, K. (2001) Commercial scale cogeneration of bagasse energy in Mauritius, *Energy for Sustainable Development* Vol. 1
14. http://www.washingtonpost.com
15. http://energy.cas.psu.edu/soydiesel.html
16. For review of three estimates see ELCON (2004) The economic impacts of the August 2003 blackout (at http://www.elcon.org/)
17. Madamombe, I. (2005) Energy key to Africa's prosperity: Challenges in West Africa's quest for electricity, Africa Renewal, 18, 6-8
18. WEC (2003) The Potential for Regionally Integrated Energy Development in Africa: a Discussion Document, World Energy Council, London.

VIEW POINT:

FACTORS DRIVING OIL PRICES AND MITIGATING STRATEGIES FOR IMPORTERS

BY RACHID AMUI

Summary

This article looks at why oil prices are on an upward trend and explains some derivatives concepts in managing oil price exposure. A policy to carefully adopt the use of such financial instruments in a risk management strategy can save importers of crude oil or petroleum products from the devastating effects of higher oil prices as well as protect budget plans.

The Demand factor

Crude oil prices continued their random walk in 2004 showing an upward trend and reaching new milestones. Futures prices for West Texas Intermediate (WTI) peaked at $55.17/barrel on October 22 and in London the same day, Brent Crude climbed as high as $51.65 - a staggering 80% higher on previous year's prices. After a brief cooling down period, prices in 2005 have continued their relentless rise, smashing the $60 mark and trading at record highs. Are we in for more records to be set this year or will prices eventually subside? What will the impacts be and what can importing countries do to mitigate their exposure to current prices?

Oil prices are driven by a multitude of factors but the demand factor is the major cause of the current high prices. A rapid expansion of Chinese and Indian economies in particular fuelled by reliance on heavy industries which lack energy-efficient technologies has driven demand to unprecedented levels. In the first half of 2004, China's oil imports alone surged nearly 40% to feed a robust economic expansion. The new wealth created in the country has found a healthy appetite in cars and other modern energy-dependent conveniences. This high demand has propelled China to a position as the world's No. 2 oil consumer after the United States with India occupying sixth place. The IEA estimates that Chinese and Indian demand will continue to grow at almost a million barrels a day - that is almost 40% of total world growth. We are in an era in China's and India's history comparable to the economic growth of the Asian Tiger Economies where oil consumption was significantly increased and also comparable to the 1950s and 1960s when enormous growth in aviation caused the oil market to expand rapidly. The American demand pull also cannot be overlooked even though there has been a shift from energy-sapping industries like manufacturing to more service-oriented jobs, which has resulted in the share of fuel in consumer spending in the USA declining from 7.2% in 1980-1981 to around 5% now. The reality is that the 200 million cars on America's roads including the gas-guzzling sports utility vehicles are consuming 11% of total world production. A fall in production intensity has not necessarily affected consumption intensity which therefore adds additional pressure on world demand.

Unfortunately attempts to boost production to keep pace with demand have their limitations because of dwindling spare capacity in OPEC and non-OPEC producers: both groups are operating at full capacity. For that reason, the imbalance in supply/demand and low stocks to counteract supply disruptions has created a tight market that will quickly respond to accurate and inaccurate information on shortfalls in production. Investments in capacity may be the key to subdue rising price but higher prices for OPEC reduce the urgency to encourage investment. Furthermore, there is a lag period of investment and bringing oilfields on-stream which makes it clear for now that the demand factor alone will continue to keep prices buoyant well above the $22-$28 target range that OPEC introduced in 2000 (and which it "temporarily" suspended in 2005, with OPEC officials commenting that, just to compensate for the lower value of the US$, it would have to be replaced by a 30-38 $ price range). A new lower floor target of $40 has been proposed by some OPEC members whilst some analysts still believe we are in for further average price increases in the coming years.

After repeated IMF warnings, the impact of high prices has begun to hit the global economy showing in rising consumer price indices, falling consumer demand and slower growth in the first quarter of 2005. In Africa, the transport sector which forms the backbone of any economy is particularly vulnerable to high oil prices. High fuel prices in the transport sector have led to massive demonstrations as a result of producers, transport companies and retailers all increasing their prices in an attempt to recover some of their costs. Sometimes artificial shortages are created by fuel distributors leading to even higher black market prices. The dependence on fossil fuels for transportation accounts for up to 65% of the total commercial energy use in some countries and exposure to sudden price increases has a profound effect on the economy. Also exposed are industry, agriculture and utilities depending on petroleum products. Governments have tried to play a role in reducing the burden on the consumer but it is evident that the increased oil bill, usually being the biggest cash flow item in the budget running into millions of dollars, puts an enormous pressure on public spending and cannot be sustained.

Strategies for importing countries

A few years ago, governments of African oil importing countries could have used rather simple hedging schemes to save their economies from crumbling. Then, prices were normally in a fairly steep backwardation, with prices quoted for two-three years forward 5-10% below current prices, something of which importers could benefit. Also, price volatility was not very high, so options were affordable. Both have changed now. For example, in early May 2005, WTI prices for July delivery were about the same as for December 2007, and even after that they remain very high.

Nevertheless, while this may not be the best time to lock in future prices, governments of oil importers should still consider the possibilities of risk management instruments in organized exchanges or negotiating risk management contracts privately over the counter (investment banks, financial institutions, trading companies, energy producers etc). Importers must be proactive in managing their exposure in order to reduce potential balance of payment problems and overcome budget deficits.

The diverse instruments available requires a careful selection of which instrument is most appropriate to shift the risk you are exposed to and a good knowledge of how it operates. A futures contract guarantees the holder the price that was paid for when the contract was bought. To illustrate how a hedge will work in practice consider a country which plans to purchase crude/refined products sometime in the future. To successfully reduce the risk of unexpected high prices a position is taken in the futures market that is equal and opposite to a position at risk in the anticipated physical market. The futures position taken in this case will be a long futures position where the hedger is looking to buy into the future to hedge the possibility of price hikes. Setting up a futures contract however requires a margin account to be set up and frequent cash calls when the market is moving against the position you have taken. It may therefore not be appropriate but other possibilities exist.

Options give you more flexibility in managing your price risk. Buying an option will cost you a premium (like an insurance contract), but gives you the right to exercise buy the underlying asset at a certain price known as exercise or strike price and a specified quantity by a certain date; but the buyer is under no obligation to do so. It is this distinguishing feature about options and the ability to participate in favourable market moves that makes it attractive to use in a risk management programme. An importing country wishing to protect its planned budget expenditure on crude oil imports as a result of rising oil prices may choose to pay the upfront premium to buy June Brent crude oil at $x on or before July xx. Buying a call option will lock in price level at which purchases can be made while still participating in price declines. When market price is above the exercise price, the seller is then obligated to sell the required amount of crude oil specified by the contract. The buyer can also allow the option to expire when the market price is lower than exercise price and buy directly from the market incurring only the loss of premium.

Swaps and other over the counter instruments can be used as an alternative to options and futures. In a swap, the commodity does not change hands, but an exchange of periodic payments between two parties with one side agreeing to pay a fixed price and the other side paying a variable price. The payments are calculated as the difference between the fixed and variable multiplied by a notional volume specified in the swap contract. The variable price is usually linked to an agreed upon market index, normally Platt's Oilgram, NYMEX or IPE.

Hedging using any of the above instruments will give oil importing countries more stability in planning, and reduces exposure to the demand pull by China, India and America that has pushed oil prices to current high levels. It is not gambling with the nation's coffers, but simply a way to safeguard future plans.

THE NUCLEAR POWER OPTIONS FOR AFRICA

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Abstract

Nuclear power is today only a small part of Africa's energy supply, but its contribution will grow in the future. The article elaborates on challenges associated with expanding nuclear electricity production in Africa, on possible ways forward, and on the range of assistance that the International Atomic Energy Agency can provide. For all its Members States, the Agency can assist in building national capabilities in overall energy analysis and energy strategy development. For countries wishing to pursue a nuclear power programme, it assists in planning, evaluating options and infrastructure development. Finally it assists at the stage of deployment and subsequent operation. For near-term progress in Africa, it will be necessary to bridge the gap between the economies of scale that favor large nuclear plants and the smaller electrical grids and capital capabilities of many African countries. Possibilities are, first, new small and medium-size reactor designs and, second, integration of electricity grids among neighboring countries

Introduction

Of the 440 nuclear power plants operating around the world today, just two are in Africa – Koeberg-1 and Koeberg-2 in South Africa. Koeberg-1 started operation in 1984 and Koeberg-2 in 1985. Both are 900 MW(e) PWRs.

⇒ Of the 24 nuclear power plants currently under construction around the world none is in Africa.

⇒ However, of the handful of promising new reactor designs now reaching the prototype stage, an important one is African – South Africa's Pebble Bed Modular Reactor (PBMR)

That is the situation now. But what are the possibilities for the future? First, let us look at electricity demand. It is clear that to reach the goals of sustainable development both electricity consumption and electricity production will have to increase significantly in Africa. Table 1 shows electricity consumption per capita for selected countries and regions, including several African countries. In general, values are highest for the Nordic countries, which have abundant hydroelectricity and long cold dark winters; for the small oil-rich countries; and for the geographically big OECD countries (Australia, Canada and USA). The lowest values are for countries in Africa, which had an overall average consumption of 514 kWh/cap in 2002. The African average is only 22% (one fifth) of the world average and 6% (one sixteenth) of the OECD average.

Table 1: Electricity consumption per capita for selected countries and regions.

	kWh/cap-yr
	2002
Ethiopia	27
Nigeria	72
Kenya	121
Ghana	300
Vietnam	383
India	421
Indonesia	428
African average	514
Egypt	1,120
China	1,208
Jordan	1,443
Latin American average	1,534
Turkey	1,559
Thailand	1,682
Islamic Republic of Iran	1,801
Mexico	1,832
Brazil	1,843
Argentina	2,082
World average	2,373
Chile	2,745
Poland	3,217
Hungary	3,545
South Africa	4,542
Russia	5,350
Italy	5,447
Saudi Arabia	6,103
United Kingdom	6,158
Korea	6,495
Brunei	7,316
France	7,366
Austria	7,453
OECD average	8,046
Japan	8,220
Belgium	8,314
Taiwan, China	8,841
Bahrain	9,649
Australia	10,502
United Arab Emirates	11,920
USA	13,228
Kuwait	15,102
Sweden	15,665
Canada	16,939
Iceland	27,764

Table 2 shifts the perspective from overall electricity consumption to nuclear power, and particularly to countries with plans to expand nuclear power significantly. The greatest projected nuclear power growth rates are in several developing Asian countries where annual electricity consumption per capita is currently small, specifically China, India and Pakistan. From the perspective of these countries, as shown in Table 2, expansion over a period of 30-50 years is needed to increase nuclear capacity by a factor of ten. Might a comparable future role for nuclear power be possible in Africa, and what possible technological and policy adjustments to current trends in nuclear power development would be most responsive to the needs of African countries? Might the PBMR, or some other innovative new nuclear power system, represent a technological leap-frogging opportunity for Africa, i.e. an opportunity to move directly to the next generation of nuclear power technology without repeating all the intermediate steps travelled by industrialized countries with long-established nuclear power programmes?

Table 2. Per-capita electricity consumption and projected nuclear power growth in selected countries and in Africa.

Country	Years	Annual electricity consumption, kWh/capita	Installed or projected nuclear power capacity, GW(e)	Projected growth in nuclear power capacity
China	2002	1,208	5.3	6-7 times
	2020		32-40	
India	2002	421	2.6	11 times
	2022		29	
Pakistan	2002	384	0.42	10 times
	2030		4.2	
Russia	2002	5,350	21	2 times (100%)
	2020		40-45	
ROK	2005		16.8	57%
	2015		26.4	
USA	2002	13,228	99	11%
	2020		~ 110 (?)	
Africa	2002	514	1.8	0-128%
	2020		1.8-4.1	

1. Nuclear Power Globally

There are 440 nuclear power plants in operation worldwide. In 2004, nuclear power supplied 16% of the world's electricity. This percentage has been roughly stable since 1986, indicating that, during the last 18 years, nuclear power has grown globally at the same rate as total electricity use. There are 24 new nuclear power plants currently under construction.

Most operating plants are in industrialized countries. 79% are in the OECD, 12% are in Russia and non-OECD Eastern European countries, and only 8.6% are in non-OECD developing countries. New construction, however, is concentrated in the developing countries. They account for 58% of the plants under construction. Russia and the non-OECD Eastern European countries account for 29%, and the OECD for only 13%.

Current expansion, as well as near-term and long-term growth prospects, is centred in Asia. Of the 24 reactors under construction, 16 are located in Asia. 21 of the last 31 reactors to have been connected to the grid are in the Far East and South Asia.

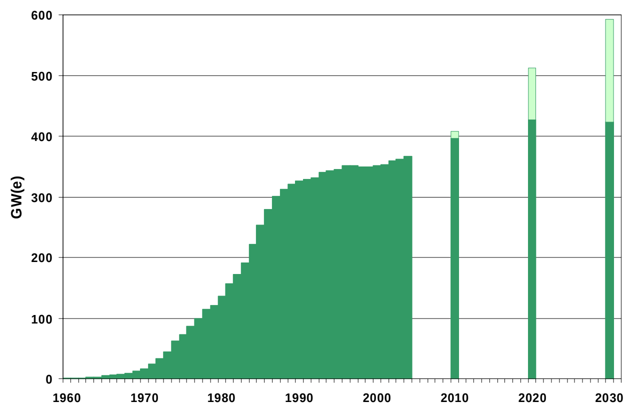
2. Rising expectations

After several years of having described global nuclear power development as 'on a plateau', IAEA Director General Mohamed ElBaradei shifted in 2005 to the phrase 'rising expectations' to describe the current global outlook for nuclear power. One reason is the announced nuclear power expansion plans of several key countries as shown in Table 2. In addition to these countries, in Western Europe excavation work began in 2004 for Olkiluoto-3 in Finland, a European pressurised water reactor (EPR) that will be the first construction start in the region since 1991. Also Electricité de France selected a site for a demonstration EPR, with construction expected to begin in 2007.

Revised Projections

A second indicator of 'rising expectations' is the upward revisions in new medium-term nuclear power projections released in 2004 by both the OECD International Energy Agency (IEA 2004) and the IAEA (IAEA 2004a). The IAEA publishes two updated projections each year – a low projection, which assumes that no new nuclear power plants are built beyond what is under construction or firmly planned today, and a high projection, which incorporates additional reasonable planned and proposed nuclear power projects beyond those already firmly in the pipeline. Figure 1 shows the updated 2004 projections together with the history of nuclear power expansion since 1960. The low projection was adjusted upwards for the fourth year in a row, reflecting an increasingly bullish outlook for nuclear power. The high projec-

Figure 1. Historical growth in worldwide installed nuclear power capacity, 1960–2004.



Source: IAEA 2004a

Note: IAEA's latest low and high projections through 2030 (low projections: dark green bars; high projections: light green bars).

tion was also adjusted upwards in 2004, although by a smaller amount.

Africa, however, is only a small part of the projected increases in nuclear power capacity on the right side of Figure 1. In the low projection, no new nuclear capacity is anticipated in Africa up to 2030. In the high projection an additional 5.4 GW(e) is anticipated to bring total capacity to 7.2 GW(e). Given Africa's low current installed nuclear power capacity, even this represents a quadrupling of capacity.

3. New Environmental Constraints

New environmental constraints, or more specifically, their economic impacts, provide a third reason for 'rising nuclear power expectations'. Russian ratification of the Kyoto Protocol in November 2004 triggered the Protocol's entry into force 90 days later — on 16 February 2005. Its limits on greenhouse gas (GHG) emissions should improve the economic competitiveness of all energy sources with low, or no, GHG emissions, including nuclear power and renewables. For nuclear power, GHG emissions are only 2–6 grams of carbon per kilowatt-hour for the full fuel chain (including construction of all facilities) — about the same as wind and solar power, and one to two orders of magnitude below gas and coal fired power. In the past, the low GHG emissions of nuclear power and renewables were irrelevant to private investors, as the virtual absence of restrictions or taxes on GHG emissions meant there was little economic value to their avoidance. Investors must now take into account the cost of GHG emissions, which will improve the competitiveness of new nuclear power plants relative to fossil fuel alternatives, notably coal-fired and natural gas-fired power plants. In May of this year the price of carbon emission permits rose to $86 per tonne of carbon in the European market, up substantially from earlier European values of the order of $30-40 per tonne of carbon prior to the Kyoto Protocol's entry into force.

Rising Energy Needs and Rising Energy Prices

Rising expectations for nuclear power are also driven by long-term projections showing persistently growing global energy demands. All independent analyses and forecasts project large increases in the century ahead — as a result principally of population and economic growth in today's developing countries.

Different countries face different demands and have different opportunities. For nearly all of them, the best energy strategy involves a mix of different energy sources, and for nearly all of them the best mix is different. It depends on national energy needs and how fast they are growing. And, as countries develop economically, final energy use generally shifts towards electricity. At the point of use, it is cleaner, more convenient and more flexible. Each country's energy mix also depends on national preferences and priorities as expressed in national policies. How countries trade off among considerations including environmental quality, jobs, occupational hazards, energy security and energy costs is at least partly a matter of national preference, and thus an area of legitimate disagreement — even where there is agreement as to the relevant facts.

But while every country's situation is different, we are all ultimately drawing from the same global resource base, whether it's oil underground or land available for biomass. So while we may choose differently from our neighbours, we are all affected by each other's choices. Prices are one measure of how each country's choices affect others, and recently rising prices suggest increasing competition in the foreseeable future for the same barrel of oil or the same cubic metre of natural gas. There may still be a lot of oil and gas in the ground, but increased prices suggest that no country can count on them being available indefinitely when needed.

4. Nuclear Power Economics

The answer to the question, "Is nuclear power economic?" is, "It depends." It depends on what indigenous energy resources a country has, on the available infrastructure and human resources, on the cost of the alternatives to nuclear power, on applicable environmental constraints, and on the country's energy security policies. Because new nuclear power plants are relatively expensive to build but relatively inexpensive to operate, it also depends on whether the investment environment requires short-term returns. Where governments are direct investors, they can generally take a longer-term view than can private firms in a liberalized market. Governments can also directly incorporate into their energy investment choices non-market considerations like energy security or environmental impacts.

IAEA Assistance: Energy Planning, Infrastructure Development and Deployment

A number of recently published global sustainable development scenarios show a substantial expansion of nuclear power. For example, the 'SD Vision Scenario' of the OECD International Energy Agency (IEA 2003) projects global growth in nuclear energy by a factor of 14 by mid-century, to approximately 5000 GW(e) in 2050. Much of this expansion takes place in developing countries, including African countries.

Such an expansion will require the development of nuclear power programmes in countries that do not now have them. For a country to introduce nuclear power, it needs to pass through three main steps: energy planning, infrastructure development and then deployment. The Agency assists Member States with each of these steps. It provides tools and assistance for energy planning; it supports infrastructure development; it provides support for effective deployment once a deployment decision has been made; and it provides a forum for assessing innovative nuclear energy systems (INSs) as a part of the Agency's International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO).

With respect to energy planning, the IAEA helps interested Member States, often developing country Member States, build their capabilities for energy planning and analyzing energy systems. The Agency develops and transfers planning models tailored to the special circumstances of these countries. It transfers the latest data on technologies, resources and economics. It trains local experts. It jointly analyzes national options and interprets results. And it helps establish the continuing local planning expertise necessary to chart national paths to sustainable development. The IAEA is the only UN agency doing this kind of capacity building for overall energy-environment planning. Table 3 summarizes the basic energy models the Agency has available for transfer and training.

Demand for the Agency's models and services is growing due to increasingly complex energy systems, market liberalization, privatisation and environmental concerns. Thirteen country studies were completed in the past year, in Bulgaria, China, Haiti, India, Indonesia, Republic of Korea, Lithuania, Mongolia, Nigeria, Pakistan, Philippines, Sri Lanka and Vietnam. In 2005 we are beginning two new regional technical cooperation projects – one in Asia (with 13 countries) and another in Europe (three countries) – as well as six national projects: Azerbaijan, Columbia, Ghana, Guatemala, Nicaragua and Nigeria. A continuing project on Sustainable Energy Development in Sub-Saharan Africa includes Burkina Faso, Democratic Republic of the Congo, Ethiopia, Kenya, Mali, Mauritius, Niger, Namibia, Tanzania, Uganda, Zambia and Zimbabwe.

Table 3. Principal IAEA energy analysis models

Model	Full name	Description
MAED	Model for Analysis of Energy Demand	Evaluates future energy needs based on development scenarios in a country or region
WASP	Wien Automatic System Planning Package	Identifies the optimal long term expansion plan for a power generating system within constraints defined by the user
MESSAGE	Model of Energy Supply Systems and their General Environmental Impacts	Optimises among alternative energy supply strategies for a country or region
ENPEP	Energy and Power Evaluation Program	Simulates alternative energy supply strategies for a country or region
FINPLAN	Model for Financial Analysis of Electric Sector Expansion Plans	Assess the financial viability of plans and projects
SIMPACTS	Simplified Approach for Estimating Impacts of Electricity Generation	Estimates environmental impacts and costs using minimum data input

The Agency also conducts regular inter-regional training workshops -- held last year in the USA in partnership with the Argonne National Laboratory and in Europe at the International Centre for Theoretical Physics in Trieste – as well as regional training courses (two in 2004), national training courses (nine in 2004), and 'training the trainers' courses. One of the next regional training courses is expected to take place in Addis Ababa, Ethiopia in the Fall of 2005. The number of people trained in these courses has risen steadily in recent years and last year reached a record high of 231 energy professionals from 43 countries. The number of countries using Agency models is now 102.

After energy system analysis and energy planning, the Agency also provides assistance to interested Member States if and when they decide to start a nuclear power programme. A recently published document, for example, on Nuclear Power Programme Planning: An Integrated Approach (IAEA 2001) covers activities from the beginning of conceiving a programme up to the stage of a decision by the country to proceed with a project feasibility study at a specific site. It is addressed principally to developing countries that do not have nuclear power plants in operation or under construction, but are seriously considering the option – perhaps based on the sort of strategic analysis described above.

The Agency also provides guidance on proven engineering and management practices in establishing and enhancing a variety of infrastructure dimensions. Nuclear power infrastructure includes the institutional framework and legislation within which nuclear facilities operate and the industrial, economic, social, technical and scientific capabilities to enable the secure and efficient development, management and operation of nuclear power facilities. Given the infrastructural requirements for nuclear power, and given the current front-loaded cost structure of new nuclear power plants themselves, a country wishing to introduce nuclear power is faced with substantial initial requirements. The up-front infrastructure investments seem particularly daunting if a country initially needs only a relatively small amount of power from nuclear energy. The Agency has work underway to define the minimum infrastructure requirements, and the specific associated institutional or administrative steps. There is also growing interest in regional cooperation, and interconnected grids, shared facilities, shared education and training programmes, shared expertise in safety and operation, and shared skilled labour pools are all possibilities worth exploring, depending on the specific situation. The IAEA is preparing documentation on all.

With respect to the deployment stage, the Agency can assist with identifying technical possibilities and requirements prior to developing appropriate specifications. Agency assistance also covers the economic and financial analysis of potential nuclear power projects, and building up the necessary 'human resource' base through support for education, training and integration into the shared expertise of the global nuclear community. It can help in reviewing tenders and proposed designs. It can help with training and other preparations for plant construction, commissioning and safe operation. And it can provide training on a range of plant simulators to help trainees understand the fundamental behaviour of different nuclear power plant designs. The Agency also provides assistance in connection with some socio-political dimensions – effective communication with the public, for example, and information for policy-makers on broader international energy developments.

In all these dimensions, the Agency is very much aware that 'one size does not fit all'. Developing countries, and particularly those initiating nuclear power programmes, have different needs and situations than exist in countries with established programmes. Moreover, each new nuclear power country's situation is different from the others. The Agency's job is to help each interested Member State take full advantage of the global expertise and experience that has been built up, but also to facilitate the customizing of that experience and expertise to the particular interests of each Member State.

In addition to direct assistance, the Agency publishes a full range of technical documents that distil much of the world's accumulated expertise on all dimensions of nuclear power. They include guidance on planning, human resource development, regulation, construction, safe and efficient performance, full life-cycle planning, decommissioning, spent fuel and waste management. The IAEA maintains advisory groups that continually identify areas where it would be useful for the Agency to add to the existing body of knowledge, and help us assemble the appropriate talent and expertise. The publications are then a generally available resource.

Economies of Scale vs. Small- and Medium Size Reactors (SMRs) and Regionalization

Economies of scale argue for larger and larger nuclear power plants. Economies of scale also exist at the national level, as the greater the number of nuclear plants supported by the national infrastructure, the lower is the per unit (or per kilowatt-hour) cost of that infrastructure. However, economies of scale are only valuable where there exist the capital and electricity demand to take full advantage of them. And in many countries of Africa the necessary capital and electricity demand do not exist. For these countries, however, there are at least two routes by which a nuclear power plant might become part of a least-cost energy strategy that might be calculated using the IAEA models described above.

First is the option of small or medium-size reactors (SMRs). Small and medium-size reactors allow a more incremental investment than is required for a big reactor, and they provide a better match to grid capacity in countries with smaller grids. Consider the example of India, which has the most plants under construction of any country in the world. Six of the eight Indian plants under construction fall within the Agency's definition of small and medium-size. Four are 'small' (less than 300 megawatts), and two are 'medium-size' (between 300 and 700 megawatts). Although India is hardly a small country, its electricity sector has until recently been characterized by the development of smaller separate grids rather than a single integrated grid. SMRs have been well suited to these smaller separate grids. As a second constraint on power plant size, India's indigenous industry has until recently been able to manufacture turbines with a maximum rating of about 500 MW. Both these constraints are currently changing, and India is in the process of integrating its originally separate grids and taking on bigger nuclear power projects. In 2002 it began construction on two 1000 MW(e) WWERs (water cooled water moderated power reactors).

In addition to the Indian designs, several advanced SMR designs around the world are moving towards implementation. The Russian Federation already has a licensed design available for construction: the KLT-40, a 60 MW (e) reactor that can be floated and transported by barge, takes advantage of Russian experience with nuclear powered ice-breakers and submarines, and can also be used for district heating or seawater disalination.

The Republic of Korea has decided to construct by 2008 a one-fifth-scale demonstration plant of its 330 MW(e) SMART pressurized water reactor, which will also include a demonstration desalination facility. And South Africa recently approved initial funding for developing a demonstration unit of the 168 MW(e) gas cooled PBMR, due to be commissioned around 2010. Since the analyses done with the IAEA models described above generally have a planning horizon of around 20 years, the PBMR and other advanced SMR designs would be reasonable options to include in such analyses.

The second option, regionalization, has already been mentioned above. For several neighboring countries, each may find that nuclear power in not part of its least-cost energy strategy when the analyses are done separately. But when the least-cost strategy is analyzed for the group of countries taken together, it might turn out to include nuclear power. Regionalization can also generate advantages in terms of energy system efficiency and reliability. In most of the OECD, and particularly in the European Union, where grids are generally large enough to accommodate large additions, the trend is still toward greater grid integration for greater efficiency and reliability. Regionalization and integration may well be a desirable approach for some developing countries that do not individually have the capital access and grid size to take full advantage of nuclear power's economies of scale, but may collectively have the necessary capital access and grid size.

Innovation for Future Growth

If any technology is to survive and flourish in this century, continual innovation is essential, and it important that nuclear power innovations, research and development take full account of developing countries – both those with and those without existing nuclear power programmes. Innovation and R&D needs are different for developed and developing countries. And although today's developing countries may well dominate future markets for nuclear power plants, it is the developed countries that currently have the most R&D resources and expertise. An important challenge is thus to bring their resources and expertise to bear on the future needs of the developing countries through international cooperation.

Currently there are two principal multinational initiatives promoting international cooperation in nuclear power innovations. One is the U.S. initiated Generation IV International Forum (GIF). The other initiative is the IAEA's International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO). It is open to all IAEA Member States and currently has 23 members: Argentina, Armenia, Brazil, Bulgaria, Canada, Chile, China, Czech Republic, France, Germany, India, Indonesia, Republic of Korea, Morocco, Pakistan, Russia, South Africa, Spain, Switzerland, The Netherlands, Turkey, Ukraine and the European Commission. INPRO's overall objectives, looking ahead 50 years, are:

- to help to ensure that nuclear energy is available to contribute in fulfilling, in a sustainable manner, energy needs in the 21st century,
- to bring together all interested Member States, both technology holders and users, to consider jointly actions required to achieve desired innovations in nuclear energy systems, and
- to create a process that involves all relevant stakeholders.

INPRO recognizes the importance of taking into account the special circumstances and needs of different developing countries – for example the common lack of strong technical and industrial infrastructures and the sometimes isolated and small grids. A number of the concepts of special interest to INPRO try to address these issues, including SMRs without on-site refuelling. In addition to the SMR advantages cited earlier of smaller incremental investment requirements and greater suitability for small grids, SMRs without onsite refuelling have two other potential advantages. For such reactors all unloading of spent nuclear fuel, and all loading of fresh fuel would be done in a supplier country with a full fuel cycle, and the spent fuel would remain the responsibility of the supplier country. The first advantage is that this would remove the need for each developing country to build a final repository for high-level nuclear waste. A second advantage is that an SMR, where all loading and unloading of fuel is done in a supplier country that already has a full fuel cycle, may well be more proliferation resistant than reactors with on-site refuelling. Given currently heightened concerns about nuclear proliferation, the more proliferation resistant a nuclear system is, the less international political resistance there may be to introducing it in countries currently without nuclear programmes.

A related alternative is that of straightforward fuel leasing. In this case refuelling occurs on-site, but the fuel is continually owned by the supplier country, and the spent fuel is the supplier country's responsibility. Again this would remove the need for each developing country to build a final repository for high-level nuclear waste. Although no such leasing arrangements currently exist for nuclear power reactors, there are precedents in the system of the former Soviet Union and its European customers prior to 1990, and in past leasing arrangements for research reactor fuel. The closest current approximation is the arrangement recently negotiated between Russia and Iran whereby the former will take back fuel it supplies to the latter, after the fuel has been used in the Iranian reactor now under construction.

If and when SMRs without on-site refuelling become available on the market, they would create the possibility of leasing arrangements covering not just fuel, but the reactor itself. And the leasing concept could be extended even further to leasing 'services' in the case where, for example, a barge-mounted SMR is used to supply electricity, heat and/or desalinated seawater while the supplier retains responsibility, not just for the fuel and reactor, but also for the full operation of the plant. Fuel leasing and other multilateral approaches to the nuclear fuel cycle to increase proliferation resistance are examined in detail in a recent report by a specially appointed group of experts to the IAEA Director General (IAEA 2005).

In its initial phases INPRO has developed a methodology for the holistic assessment of innovative nuclear energy systems (IAEA 2004b) that includes a focus on institutional and infrastructure arrangements that will make the initial adoption of nuclear power systems by aspiring countries simpler. The INPRO methodology can be used to analyse the appropriateness of alternative mixtures of reactor types and fuel cycles for the long term sustainability of using nuclear energy to generate electricity, desalinate seawater, produce hydrogen or generate process heat.

Current INPRO activities include:

- a joint assessment, based on a closed fuel cycle with fast reactors, carried out by China, France, India, Korea, Russia and Japan;
- an assessment of an INS for hydrogen production, by India;
- a study on the transition from LWRs to a Generation IV fast neutron system, by France;
- an assessment of the introduction of a nuclear block of 700 MW(e), by Argentina;
- an assessment of an INS for country with a small grid, by Armenia; and
- an assessment of the comprehensive DUPIC fuel cycle in the area of proliferation resistance, by the Republic of Korea.

The current stage of INPRO, labelled Phase 1B, will also identify the areas where the next stage (Phase 2) can be most effective. It is expected that these will include facilitating cooperation in joint research into technical, institutional and infrastructure developments that can prepare the route for an easier and more effective application of nuclear power systems in the future.

Conclusion

Each country faces a different set of variables when choosing its energy strategy, and energy decisions cannot be made on a 'one size fits all' basis. Nor can nuclear power be described as categorically 'economic' or 'uneconomic'. It will always depend on the situation and the alternatives. New nuclear power plants remain most attractive in countries and regions where energy demand growth is rapid, alternative resources are scarce, energy supply security is a priority, and nuclear power is important for reducing air pollution and greenhouse gas emissions.

New nuclear power plants will also always be part of an energy mix, complementing other energy sources, including renewables. In Africa, the first energy-related task of sustainable development is often defined as bringing energy, particularly electricity, to the millions of people without it. For the rural poor, the best promise may indeed be that offered by off-grid renewables, and the efforts underway for realizing that promise as quickly and broadly as possible should be applauded. However, rural electrification can complement those efforts, and for the urban poor, and the needs of ever expanding cities, the mix needs to include large centralized power generation to match large centralized power demand. Nuclear power can play an important role.

Nuclear power will certainly be a part of Africa's energy future. At the International Ministerial Conference on Nuclear Power for the 21st Century organized earlier this year by the IAEA in Paris and hosted by the Government of France in cooperation with the OECD/Nuclear Energy Agency, a number of African countries

Table 1: Electricity consumption per capita for selected countries and regions.

spoke eloquently of the importance to them of maintaining and developing the nuclear power option. Moreover, the conference's final statement concluded, "a vast majority of participants affirmed that nuclear power can make a major contribution to meeting energy needs and sustaining the world's development in the 21st century, for a large number of both developed and developing countries".

At least for the intermediate term, however, the extent of nuclear power's contribution in Africa will depend, at least in part, on the speed with which smaller advanced reactor designs like the PBMR are brought to market and the ability of neighboring countries to consider joint planning and investment strategies to realize mutually beneficial improvements in grid efficiency and reliability.

References

IAEA (International Atomic Energy Agency) (2001), Nuclear Power Programme Planning: An Integrated Approach, IAEA-TECDOC-1259, IAEA, Vienna 2004 (http://www-pub.iaea.org/MTCD/publications/PDF/te_1259_prn.pdf).

IAEA (International Atomic Energy Agency) (2004a), Energy, Electricity and Nuclear Power Estimates for the Period up to 2030, July 2004, Reference Data Series No. 1, IAEA, Vienna 2004 (http://www.iaea.org/OurWork/ST/NE/Pess/assets/RDS1-24%20AG.pdf).

IAEA (International Atomic Energy Agency) (2004b), Methodology for the Assessment of Innovative Nuclear Reactors and Fuel Cycles, IAEA-TECDOC-1434, IAEA, Vienna 2004 (http://www-pub.iaea.org/MTCD/publications/PDF/te_1434_web.pdf).

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MICROPROCESSOR-BASED CHARGE CONTORLLER FOR HOME PHOTOVOLTAIC SYSTEM

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Abstract

The charge controllers currently in use in most solar home systems (SHS) in Africa require intensive manual battery monitoring and maintenance regimes for the user or field technicians. In addition, the most widely used charge controllers in the African set-up are analogue systems, which are very rigid in the adaptation for local conditions such as temperature compensation or seasonal irradiation variation. From the maintenance point of view, this presents some significant technical problems for the end-user, particularly our villagers in the rural and remote communities. Reliability and compatibility due to circuit complexity and use of non-available components have also meant repair and maintenance in the field has been a major problem. Costs involved in the hardware development of such charge controllers are quite large. In this work, we design a charge controller based on the microprocessor, which offers increased reliability, reduced cost, reduced complexity in the number of electronic components and increased monitoring and regulative functions. This controller is designed for simplicity by using a commonly applied domestic embedded systems microcontroller - the Motorola 6811 series. The advantage of using a microprocessor based system is that it is possible to alter the general parameters and specifications of the charge controller by simply altering the voltage parameters in the software via a user interface. For researchers and maintenance technicians the controller is designed for easy interface to a data logger or a portable computer to check for battery and panel performance history whilst away from the site.

1. Introduction

The predominant use of lead acid batteries in home photovoltaic systems in remote areas, where this energy resource is widely used, is due to their easy availability and low cost. However, these batteries require an aggressive charging and discharging regulation regime. System failures due to battery failure have led to high system cost and maintenance problems making the technology unattractive. An effective charge control system to prevent battery damage is necessary to counter these negative perceptions.

Charge controllers currently in use are mostly analogue based controllers and in the African setting suffer from the following problems:

- Most of the charge controllers manufactured in developed countries have complex hardware and are difficult to repair. Throwing away or sending back the controller to the manufacturer for repair is not a practical solution, especially in rural areas where the majority of the users are.
- System performance cannot be monitored with analogue charge controllers.
- Monitoring of battery abuse by the consumer in small Energy Supply Companies is difficult. This is especially so when dealing with scattered villages.

Difficulty in adjusting control parameters since the control system is hardware and not software based.

Experiences in the field have also shown that microprocessor based system currently on the market have not addressed these problems adequately. Problems related to repair, durability, monitoring and local conditions optimisation still remain. However, under the programme of providing solar photovoltaic (PV) electricity services through energy services companies (ESCOs) in rural areas, local community technicians are now being trained in the skills of installing, maintaining and repairing solar PV systems.

2. Motivation

In this work, we design a charge controller based on the microprocessor, which offers increased reliability and monitoring functions, and reduced cost and complexity. This controller is designed for simplicity by using a commonly applied domestic embedded systems microcontroller, the Motorola 68HC11 and easily replaceable power MOSFET transistors for switching. The estimated retail cost of this new model to the consumer is of the order of US$ 40.00 which fares comparably well to current market charge controllers at an average cost of US$ 100.00. In addition, circuit complexity is transferred to the software, which is easier to redesign, and the analogue circuit is confined to switching. An added incentive of using a microprocessor-based system is the possibility to alter the general parameters and specifications of the charge controller to suite local conditions by simply altering the voltage parameters in the software via a user interface.

For researchers and maintenance technicians, the design incorporates easy interface to a data logger or a portable computer to check for battery and panel performance history whilst away from the site.

3. System overview

Figure 1 below gives an overview of the system of a solar home system. The solar panel converts solar radiant energy into electrical energy, which is stored in chemical form by using batteries. Appliances such as radio, television and light bulbs are connected to the battery. The charge controller serves the duo process of managing the system so that the battery is protected from overcharging and over discharging. Lead acid batteries suffer from effects of sulphation of the plates if abused by over discharging resulting in a shorter life span. The charge controller manages to achieve the task of regulating the system by monitoring the battery state of charge, which is related to the voltage levels of the battery. When the battery is overcharged the panel is disconnected and when over discharged the load is disconnected. The controller operates with four set points, which are voltage levels triggering action. These are load disconnect, load reconnect, panel disconnect and panel reconnect.Fig. 1. General solar home system

Figure 1. General solar home system

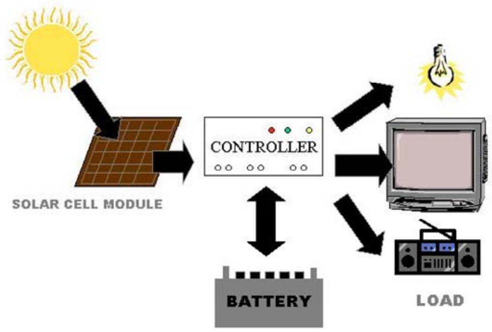
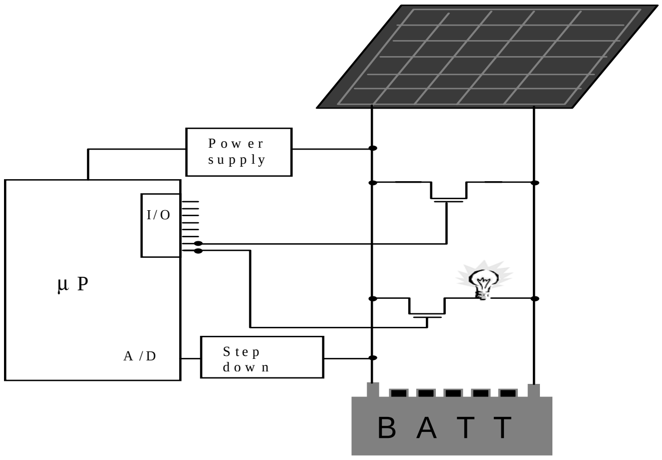


Figure 2. General charge controller function



4. Hardware design

4.1 General function

Figure 2 below represents a block diagram of the hardware design of the microprocessor based charge controller. The microcontroller monitors the voltage of the battery through its analogue to digital (A/D) port imbedded in the chip. To match the reference voltage specification of the A/D, a step down circuit matching the maximum voltage of the battery to that of the A/D is used. The microcontroller then decides on the action to be taken based on the battery voltage it records by checking the set points recorded in its memory.

If the voltage is such that the panel is to be cut off, it sends a high signal via one of the pins on the input/output (I/O) port. This in turn switches the Power MOSFET connected to the two terminals of the solar panel, thus effectively short circuiting the solar panel. The resultant is effectively divert the charging current that flows to the battery. If the microcontroller signals a low to the power MOSFET, the solar panel is open circuited. Therefore, the current from the panel charges the battery.

In the case of the discharge control, the power MOSFET acts as a switch with the signal from the microprocessor as the control. If the battery is overly discharged, the transistor is sent a LOW, cutting off the load. If the load is to be reconnected, the transistor is sent a HIGH.

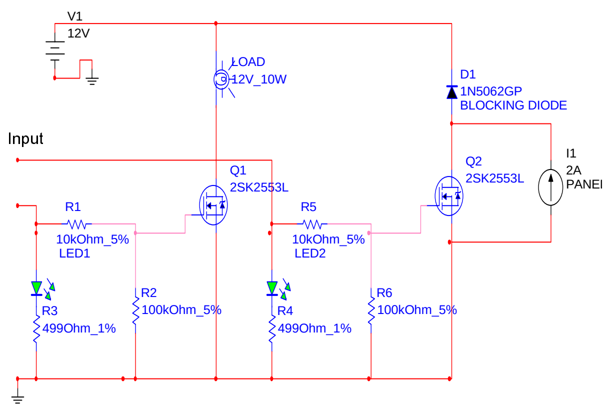
The panel or the battery supplies power for the charge controller. A power supply circuit has to be incorporated in order for the microprocessor to operate according to its specifications. Since the supply from the two sources is already DC, a voltage divider and a Zener diode arrangement are enough to attain the desired regulated power supply.

4.2 Switching Circuit

The analogue circuit in Figure 3 is the switching circuit required to control the charging and discharging. Two power MOSFETS are used as switching devices for both the panel and load control. Each transistor is controlled by a digital 0 to 5 volt signal from the microcontroller to its gate. The use of MOSFETs prevents the need of incorporating buffer circuits between the digital and analogue circuit because current is not drawn into the gate. Resistors on the input are set at values that correctly bias the gates and in this case the situation is identical for both switching circuits.

For the discharge control, the load is in series with the transistor while in the charging control the solar panel is in parallel. To prevent short circuiting the battery or damaging the panel with reverse current from the battery, a blocking diode D1 is included. Of particular importance is the use of MOSFETs, which are easily replaceable because they are the highest cause of failure in most charge controllers. To protect the MOSFET from excess

Figure 3. Circuit diagram of switching circuit



current, one needs to insert a fuse between the load and the power transistor.

4.3 Controlling circuit

The Motorola 68HC11 microcontroller, which is widely used in embedded systems, is ideal for the task of both monitoring the battery and controlling the system. Important features include an on board analogue to digital converter, imbedded input and output interface ports, on chip EPROM and RAM. The circuit is simply an interface between the microcontroller and the components of the system. The battery is monitored through the analogue to digital port, whilst the control signals are output through bits 0 and 1 of the output port B. Inputs by the user are interfaced through the input port A, using a keypad. An LCD display is connected for the user to monitor the status of the system.

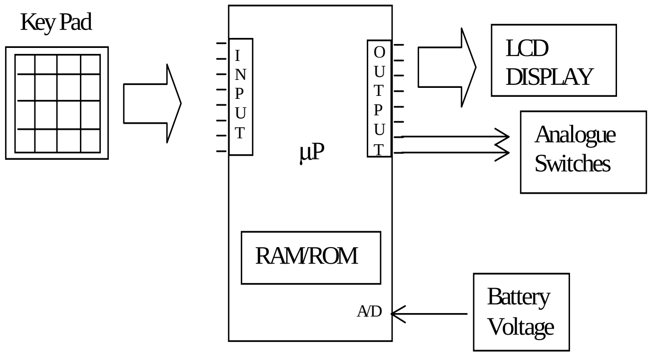
5. Software design

The programme running the system is simply a monitor programme of the various inputs and outputs. On power up, a hardware initialisation routine checks and initialises the hardware status before settling into standby mode. Once it is switched to control mode, it performs a continuous loop of checking the battery voltage and deciding on what course of action to take as a result. This is accomplished by comparing the battery voltage with the preset values stored in the memory. A control vector is then sent to the output port, switching the appropriate transistor into the required state. The algorithm can be summarised by the following:

1. Check battery voltage
2. If battery is overly discharged then disconnect load, loop to 1.
3. Check if load is disconnected
4. If load is disconnected check if reconnection criteria is met

    4.1 If criteria is met, reconnect load, loop to 1

Figure 4. µP control circuit schematic



    4.2 Loop to 1

5. If battery is overcharged, disconnect panel, loop to 1
6. Check if panel is disconnected
7. If panel is disconnected, check if reconnection criteria is met

    7.1 If criteria is met, reconnect panel, loop to 1

    7.2 Loop to 1

8. Loop to 1.

Other features incorporated into the software include data logging in which routinely and automatically checks the voltage at noon, every day, and stores the result in RAM for future retrieval. Set points can be changed via the user interface and stored in the allocated memory location. The number of cycles a particular battery has gone through and an estimation of lifetime based on history is an option. For the purpose of system maintenance, the programme records all disconnections and reconnections thus giving an indication of the state of the battery or user abuse.

The programme was developed in C and converted into assembly using the Windows based Integrated Development Environment. In this environment, a step by step execution using dummy output ports is possible before loading the programme on to the EPROM of the kit.

6. Implementation

The charge controller, in design stage, has been tested for functionality. The switching circuit, when interfaced to a microcontroller, successfully performs all the necessary functions using the digital signals. A variety of similar power MOSFETS were used in the same circuit without appreciable deficiency in the performance. This ensures that finding replacement parts for the most vulnerable part of the controller, the transistors, will be easier than in most commercial controllers. The microprocessor system was implemented using a simulator kit, which was fed to the programme via an adaptor connected to a PC. Programme execution for the basic monitoring routine managed to detect battery voltage and control the system. For this test, the panel, battery and load used were at the roof of the physics building at the University of Zambia.

Incorporation of special features software has been achieved. However long term monitoring and data acquisition tests will require a complete prototype and longer periods of time to test.

7. Conclusions

A microprocessor based charge controller has been designed and tested. The benefits of this design are to have a charge controller easy to maintain and repair, but still with the functional sophistication imbedded in the software to allow for monitoring of the performance of the entire solar electric system. In addition, this design enables easy parameter adjustment for local conditions and can be adapted for remote control monitoring.

References

M. MUSELLI, G. NOTTON and A. LOUCHE, "Design of hybrid photovoltaic power generator, with optimisation of energy management", J. Solar Energy Vol. 65, No. 3, 1999.

DAVID SPIERS and JIMMY ROYER, "Guidelines for the use of batteries in photovoltaic systems", Neste oy and CANMET, Paino Center Oy, Sipoo, Finland, 1998.

STEVE OUALLINE, "Practical C Programming,- 3rd Edition", O'Reilly and Associates, Philadephia, USA, 1993.

MARK HANKINS, "Small Solar Electric Systems for Africa", Commonwealth Science Council & Motif Creative Arts Ltd., Nairobi, Kenya, 1991.

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IN THE NEWS

ITER: The need for cheaper, reliable and clean energy

The International Thermonuclear Experimental Reactor (ITER), an international collaborative project involving China, the European Union, Japan, Russia, Korea and the United States, promises to deliver cleaner and cheaper energy. The plant which France will host is estimated to cost of about 10 billion euros, generate 10,000 jobs and will serve as a demonstrative plant for development of commercial plants, possibly by the mid of this century.

Nuclear fusion, mimicking the process the sun uses to produce energy, is perceived as a cleaner approach to production energy than nuclear fission and fossil fuels. The deal reached on Tuesday may accelerate national research efforts on nuclear fusion.

Why the farce?

First, it will mark a technological milestone. In order to fuse light atoms (hydrogen isotopes) to make heavier ones, heat in excess of several millions of degree Celsius is required.

Secondly, about 1 kg of fusion fuel will produce energy equivalent to that generated by 10 million kilograms of fuel.

Thirdly, unlike nuclear fission, the waste decays much faster.

Not everyone agrees it is the best way to spend the money or that it will work. However, if it does not work this time, it will surely work one day. (28 June 2005.

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The Upgrade of Kenya's oil refinery

The upgrade of the Kenya Petroleum Refineries Limited (KRPL) may increase the prices of oil products. The plant, which is owned by the Government (50%) and BP, Shell and ChevronTexaco, would cost about $200 million to modernize.

The Mobil Oil Kenya Managing Director Robert D Paterson said the investment will increase the cost of fuel as KRPL has a low processing capacity and can not match the larger and modern plant in the Gulf region. However, KRPL is partially protected by a rule that requires oil marketer to purchase 70% of their oil requirements from KRPL. (Eastern Standard- 30 June, 2005)

Indeed, it is estimated that KRPL processing cost per ton increased from about $2.7 (1993-1998) to about $5 (1999-2003), making imports cheaper than locally refined oil products.

GIS AND RURAL ELECTRICITY PLANNING: A CASE STUDY UGANDA

Elizabeth Kaijuka, IT POWER– Uganda

Abstract

Sustainable development is literally fuelled by the electricity sector. In Uganda, the electricity sector has experienced dramatic market liberalization changes in recent years. The *Power Sector Reform* was characterized by the unbundling of the main government utility, Uganda Electricity Board (UEB), which had a monopoly, into three companies that were created to introduce competition and liberalize the electricity industry. This led to the creation of a regulatory body. A rural electrification fund, agency and board were also formed to subsidize rural electricity investments. This is part of the Government of Uganda's new holistic approach to long-term energy planning.

This paper discusses the use of Geographical Information System (GIS) in the planning process for rural electrification. The aim is to identify patterns of demand and priority areas of need. By creating a demand-side scenario, electricity can then be supplied to targeted areas. A cross-sectoral view is taken to examine the energy demand patterns using physical data and available country statistics that are then incorporated into a GIS master database. The initial priority demand-side sectors targeted, in terms of energy needs, are education and health. As a result of this preliminary work, areas can be identified and targeted for rural electricity investment, which include off-grid renewable energy plants such as small-scale hydropower schemes.

Introduction

The pace of rural electrification over much of the developing world is painfully slow, and Uganda is no exception. This comes as no surprise since rural communities not only have low population densities but they are often the poorest, which results in high capital and operating costs for electricity companies. Attracting investors for rural electrification projects, especially in politically uncertain, least developed countries (LDCs), is the overriding challenge.

Typically, in a LDC like Uganda, before even arriving at a technological solution, the financial and economic costs first have to be justified. New innovative technologies come after cost considerations since the means justify the end. Trends show that a project will last only as long as its financing,. making financial viability one of the first priorities for rural electrification projects. Although necessity is the mother of invention, scarce resources do not leave any room for expensive options, however innovative they may be. So before any new renewable energy technologies (RETs) can be adopted in Uganda, a host of cost-benefit decisions have to precede the final technology selection, which certainly has to be the least-cost option.

The planning process firstly needs a defined 'Rural Electrification Criteria' that is specific for the country's situation. In Uganda, the proposed indicative rural electrification master plan can broadly be condensed into three steps:

1. In the first instance, a case has to be made for grid-based or off-grid planning.
2. This would be justified by a financial and economic cost/benefit analysis in order to identify and prioritize possible electrification projects.

Finally, a technology selection can be made to suit these specific conditions.

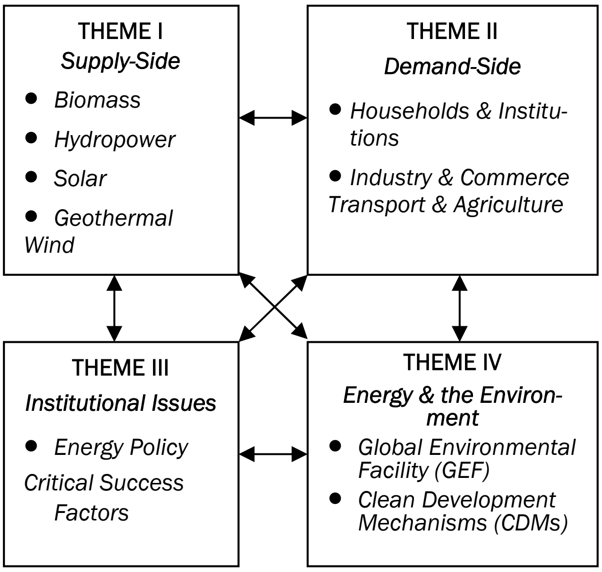
Positive political will is crucial to the success of the planning process and this has already been addressed in Uganda's 'Rural Electrification Strategy and Plan Covering the Period 2001 to 2010' by the Ministry of Energy and Mineral's Development. Currently, grid electricity access in rural areas stands at less than 2% with grid access of 5% for the whole country. The minimum aim for the Rural Electrification Strategy and Plan is a rate of 10% by 2012 which translates to 400,000 new rural consumers (Ministry of Energy and Minerals Development, 2001). The primary objective is to reduce inequalities in access to electricity and associated opportunities for increased social welfare, education, health and income generation.

Regarding global impacts, Uganda completed an inventory of it greenhouse gas emissions and is therefore obliged to meet its commitments as a signatory to the UN's Climate Change Convention (UNCCC). The promotion of renewable energy is therefore another important element of the Government of Uganda's rural electrification strategy and this gives it the opportunity to benefit from internationally sponsored projects via organizations like the Global Environmental Facility (GEF).

Methodology

A rational and systematic approach is needed for rural electricity planning in Uganda. With GIS this can be provided in the form of geo-referenced data, using Global Positioning System (GPS) coordinates, that allows displays of tabular and spatial information to assist decision-makers. The planning process is very complex and multifaceted so a simplified approach needs to be taken. For the purposes of this study, consider the whole problem in its entirety to be divided into four interrelated themes, which contain the following topics:

This paper presents the demand-side aspect of rural



infrastructure in Uganda for electricity planning. Taking a country-wide view, the initial demand-sectors targeted are health centers, schools, households and rural trading centers. These could then provide a priority-ranking pattern based on estimated load profiles and/or benefit points allocated to each 'demand center'.

Many other inter-related aspects arise out of the four themes during this process, and it is within this context that the following questions are applied to rural electricity planning in Uganda:

- **What are the institutional structures set up for rural electrification?**
- *(Theme III – Institutional Issues)*
- **What are some of the critical success factors affecting the planning process?** *(Theme III – Institutional Issues)*
- **What are the energy demand patterns in Uganda?**
- *(Theme IV – Demand Side)*
- **What are the possible off-grid renewable energy options?**
- *(Theme II – Supply Side)*
- **Institutional Structures**

Uganda's Electricity Act of 1999 aims at reforming the power sector by introducing competition and liberalizing the electricity industry Ministry of Energy and Minerals Development, 2002). In order to make electrification affordable to the rural population, the government will subsidize electrification projects, however, the criteria and level of subsidization are still in the process of being determined. The project is being financed by the World Bank and the GEF through a multi-sectoral program called Energy for Rural Transformation (ERT) and its overall goal is to increase electricity access in rural areas from 1% to 10% by 2012.

It is therefore planned that the electricity tariffs will reflect the supply costs in order to guarantee the financial viability of rural electrification investments, and this is to be regulated by an Electricity Regulatory Authority (ERA). An autonomous body, the Rural Electrification Agency (REA) has also been set up, under the Ministry of Energy and Minerals Development (MEMD), to implement rural electrification policies and manage the Rural Electrification Fund (Government of Uganda, 1999). They are responsible for awarding subsidies to investments in rural electrification projects in Uganda. Under this ERT program, the role of the Ministry is one of overall coordination, monitoring and evaluation. The Private Sector Foundation will play the role of the facilitator who will develop business plans and after the business plans have been developed, they will then apply to REA for a subsidy. In this way, the Government of Uganda is looking to achieve their goal through a public/private partnership.

Critical Success Factors

Critical Success Factors (CSFs) are described by the Energy Technology Support Unit (ETSU) (part of the UK Government's Department for International Development (DFID)), as key features of renewable energy programs that need to be put in place to maximize the possibility that a project will succeed. They use their experience and knowledge of various energy projects worldwide to categorize these CSFs. Universal CSFs are the ones which form essential features which include: the use of proven designs or performance guarantees; the existence of an acceptable economic and financial package; thorough market surveys and clear indication of social need. They state that checks should be put in place to determine project compatibility with the medium-term energy strategy and to ensure that legislative, political and regulatory frameworks are favorable (Department for International Development, 2005).

Some more specific CSFs that can be applied to Uganda's case during the electricity planning process are cost recovery and community involvement:

2.1. Cost recovery

Cost recovery is one of the most decisive and crucial factors determining long-term effectiveness of rural electrification programs. The whole operation needs to be profitable in the long-term in order to be ultimately sustainable. Dependence on high initial subsidies in investment costs might lead to eventual extortionate tariffs for the unsuspecting and poor rural customer in order for the supplier to recover the loss incurred by reduced or no subsidy. In Uganda, Priority Rural Electrification Project (PREP) packages are initially being prepared for bidding to the private sector in order to test the market before embarking on countrywide schemes.

2.2. Community involvement

Cost-saving opportunities, therefore, need to be exploited from the beginning of the planning process. In order to create a win-win situation, a two-way approach needs to be taken such that increased income generating activities would be created as a consequence of improved access to electricity. That way, the rural consumer will be able to afford to pay his/her electric bills and the supplier can in turn afford to provide a decent service and make a modest profit. Rural communities in Uganda could be mobilized under their Local Councils to brainstorm new income-generating activities that would arise from electrification based on their natural resources and workforce.

Energy Demand Patterns

In Uganda, the ever-growing demand for electricity exceeds actual consumption and this is suppressed by limited supply. The situation is exasperated further by recurrent load shedding that is imposed almost daily on urban consumers in the capital city, Kampala, where demand is greatest. Their electric supply is rationed while their electricity bills are on the increase thus they are forced to pay more for a lesser service. It would therefore make practical sense to look at the demand that already exists in the country then design a targeted supply system to match it.

A cross-sectoral view is taken to examine energy demand patterns for Uganda using geo-referenced data, and to get a literal picture of the situation on the ground. A 'demand center' can be interpreted as any physical structure that would require electrification. With a goal of kick-starting development, the initial focus is on prioritizing provision of electricity to schools and hospitals, powering a few small enterprises, mobile telecommunications, as well as providing domestic electricity. This analysis is based on available country statistics from the Uganda Bureau of Statistics (UBOS) and physical data that are then incorporated into a GIS database to create a base-case demand scenario. (At this stage of the analysis, agricultural productivity and business activity input would be useful to add but that data is not yet readily available).

As shown on the maps developed (Figure 1 to Figure 7), the existing demand pattern for Uganda is clear: most activity in the country clusters along the existing electric grid as a lifeline for power.

Figure 1. shows the electric transmission network and some 33 kV distribution lines including some of the proposed extensions for the suggested PREP (Priority Rural Electrification) areas.

Figure 2. shows this electricity grid and the road network combined. We can see that the power lines roughly follow the road network, and this is particularly true in the rural parts. Ideally, under full coverage, these two networks should match.

Figure 3. shows the population distribution by region. From this we can see that there are a few isolated pockets of densely populated areas. Kampala, being the capital city, is the most densely populated region and North-Eastern Uganda is the least populated because it is a semi-desert region.

Figure 4. shows the population distribution along the grid and we can see that there are still many highly populated areas out of reach from the grid. Such areas would therefore be good candidates for off-grid planning.

Figure 5. shows some energy demand centers such as schools and village trading centers.

Figure 6. shows distribution of health centers (HC) around the country which have been aggregated into four levels. At the highest level, there are hospitals, which take the highest energy load priority; then HC IVs, which would use powered medical equipment; down to HC IIIs and HC IIs which require basic electricity supply.

Figure 7. shows the distribution of energy demand centers along the electric grid, including population density, schools and village trading centers. Their combined demand pattern shows the congestion along the electric grid.

These preliminary results could then provide the basis for a priority-ranking pattern. Once the demand scenario has been set, estimated load profiles or benefit points can then be allocated to each 'demand-centre'. These points could then be summed up within each administrative boundary at either district, county or parish level to give a priority pattern.

Supply Options

4.1. A case for off-grid options in rural Uganda

On the ground, the rural terrain and settlement patterns in Uganda are some of the major obstacles to electricity infrastructure planning. Typically, a village is identified by its trading center where most business activity is centered. These trading centers are usually along the main road and are often distributed sparsely and randomly, with many miles between villages. Beyond the road network and in between the trading centers, are the rural households, which are buried in the midst of farmland or plantations or natural vegetation following no particular layout plan. The natural terrain can also sometimes be mountainous and seem impenetrable. In these remote, hard to reach areas where grid supplies are impractical, people generally meet their energy needs for lighting and cooking by using wood fuel or charcoal.

These areas would almost certainly benefit from small-scale off-grid renewable energy plants such as mini-hydro. Their standards of living would be elevated to socially and politically acceptable levels, and it would also be environmentally beneficial by removing the dependence on woody biomass.

4.2. Potential small-scale hydro schemes

Uganda is at the heart of the Great Lakes region of East Africa. Not only does it co-host the world's biggest freshwater lake, Lake Victoria, it also boasts the source of the mighty River Nile that starts at the waterfalls in Jinja and runs all the way through the country, up to Egypt. In addition, there are plenty more rivers and lakes that spill over from these making it a very lush and fertile country. Hydropower is an abundant natural resource over much of rural Uganda.

Consequently, Uganda's electricity supply system is dominated by hydropower nearly 100 times greater than any other source. The total estimated electric potential for hydropower in Uganda is estimated to be in excess of 2000 MW compared with the current power generation of less than 250 MW (Government of Uganda, 1999). There are therefore plenty of potential sites for small-hydro schemes, which are, as yet, under-developed.

Small-scale hydro installations in rural areas could then offer considerable financial benefits to the communities served, particularly where careful planning identifies income-generating uses for power. Their simplicity means that small-hydro schemes not only provide renewable energy, they are also extremely cheap to maintain, given basic training.

The main advantage of a small hydro-scheme is that it does not require a dam or storage facility to be constructed; it simply diverts water from the river, channels it into a valley and 'drops' it into a turbine via 'penstock' (pipeline). This type of hydro generating would thus avoid the damaging environmental and social effects that larger hydroelectric systems can cause. It would seem that for Uganda's rural population who are materially poor but have a great wealth of nature at their disposal, this most basic, self-sustaining and least-cost method of power generation could prove to be the most innovative of all.

References:

1. Ministry of Energy and Minerals Development (MEMD), Republic of Uganda (2001), "Rural Electrification Strategy and Plan Covering the Period 2001 to 2010"
2. Government of Uganda (1999), "Uganda Power Sector Restructuring and Privatization, New Strategy Plan and Implementation Plan"
3. Ministry of Energy & Minerals Development (MEMD), Republic of Uganda (2001), "National Biomass Energy Demand Strategy 2001 to 2010 "
4. The World Bank (2001), "Energy for Rural Transformation, Project Appraisal Document"
5. Department for International Development (DFID), Knowledge and Research, "Energy Project Summaries", http://www.dfid-kar-energy.org.uk
6. Ministry of Energy and Minerals Development (MEMD), Republic of Uganda (2002), "The Energy Policy for Uganda

Acknowledgements

I wish to thank Engineer Dr Albert Rugumayo, Ministry of Energy and Minerals Development, Uganda, for his guidance and invaluable input. The views expressed in this article are those of the author.

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Previously, she was the resident GIS expert for the Energy Group at the Princeton Environmental Institute (PEI) of Princeton University. While there, she helped to develop new methods for modeling hydrogen infrastructure development in the US using GIS and was sponsored by the US Department of Energy (DOE) as a research scholar. at Princeton.

She has received several awards including the 'Individual Bursary Award' (1999) by the British Royal Academy of Engineering for outstanding candidates, a gold 'CREST' award from Imperial College, London for Creativity in Science and Technology and an Academic Scholarship. She hold a bachelors and Master's degree in Engineering Science, Oxford University

Figure 1: The electricity grid - Transmission Network and some 33kV Distribution lines plus proposed extensions.

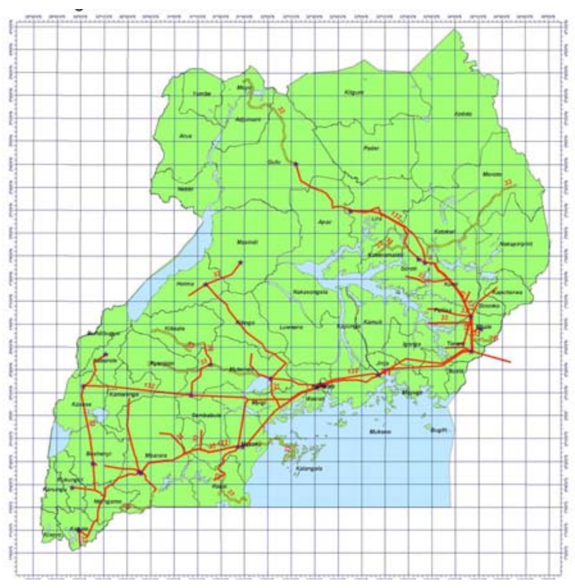


Figure 2: The electricity grid roughly follows the road network; under full coverage these should ideally match.

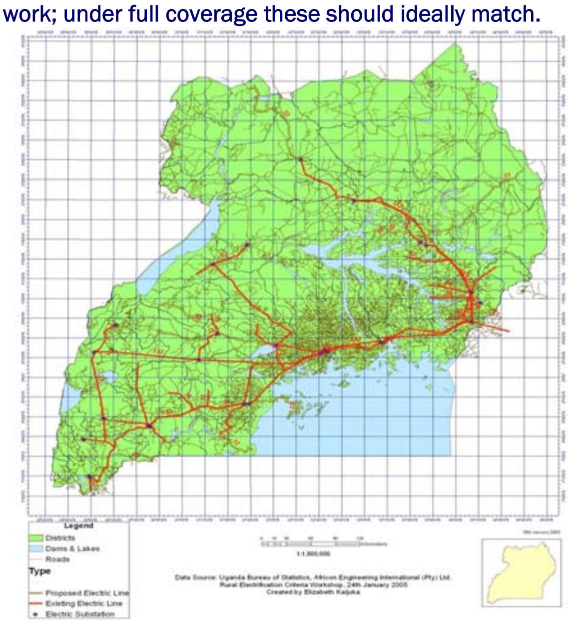


Figure 3: Population Distribution - a few pockets of densely populated areas; Kampala is the most densely populated region, Eastern Uganda the least densely populated region.

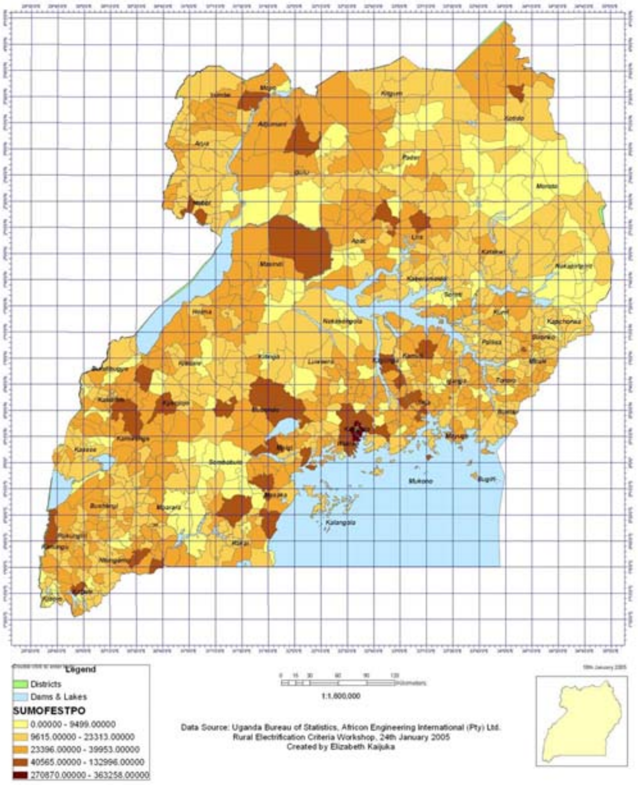


Figure 5: Some demand centers - schools and village trading centers

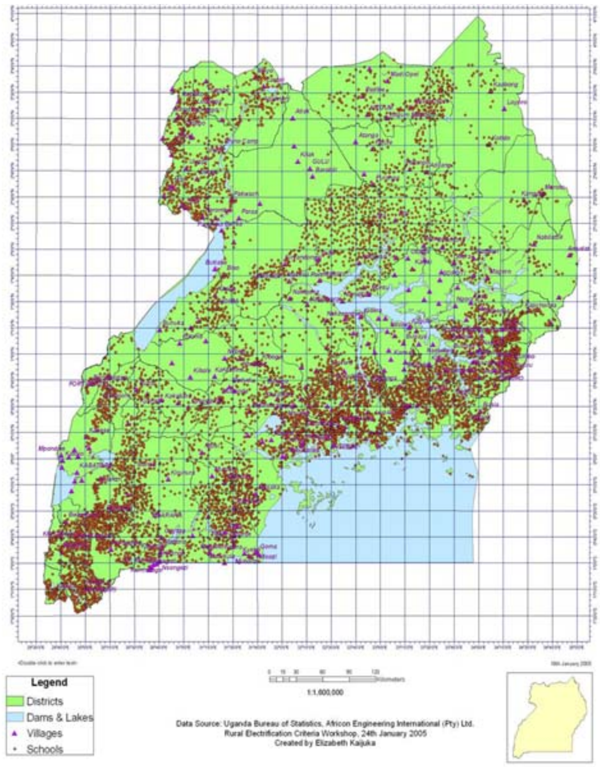


Figure 4: Population density is highest along the electricity grid; still many highly populated areas out of reach.

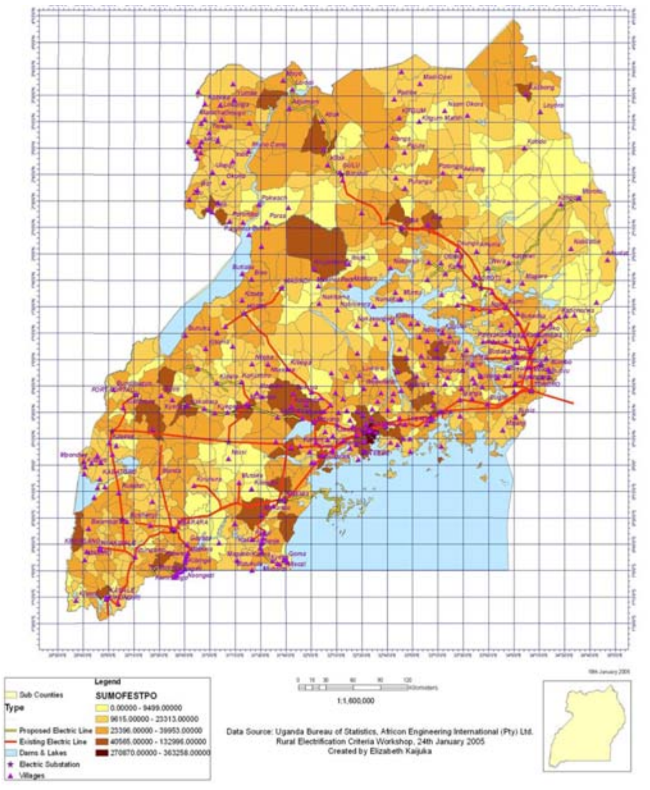
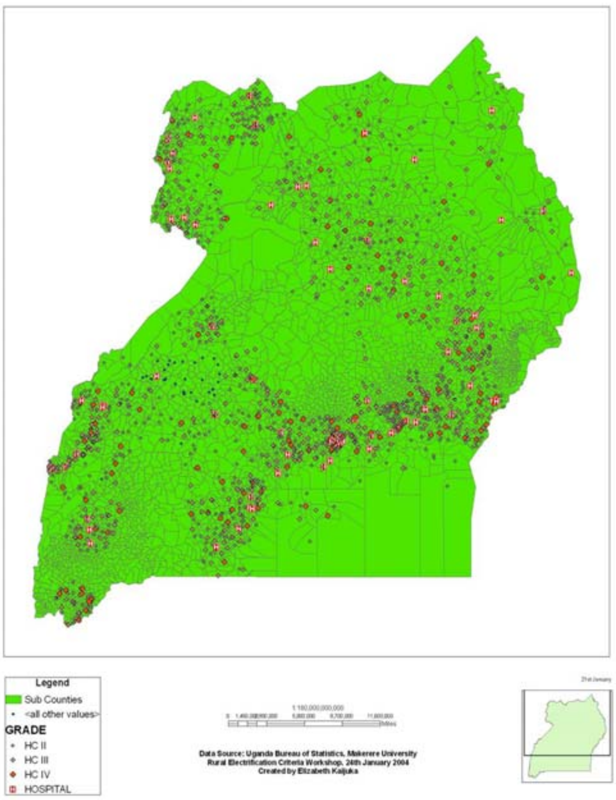


Figure 6: Health Centers



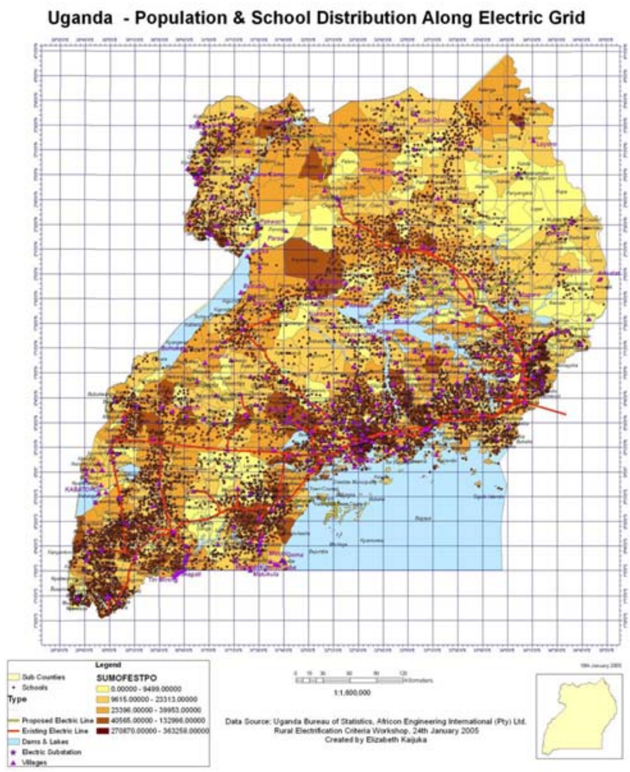


Figure 7: The Demand Pattern - most activity congregates along the Electricity Grid

The Akosombo dam, one of Africa's large hydropower plants is both a reminder of Africa's aspirations to industrialize and untapped potential. Its contribution to the economy of Ghana may not be disputed but not all its promises: transport, irrigation and fishing, to name afew, are yet to be realized.

ENERGY CONFERENCE ANNOUNCEMENTS

The Power Generation Summit.

19-21 September 2005,

Grand Hotel Huis ter Duin,

The Netherlands

For information:

http://www.powergenerationsummit.com/

PowerAfrica

24-26 October, 2005

Sandton Convention Centre

Johannesburg, South Africa

For information:

http://www.powerafrica.co.za

4th World Wind Energy Conference & Renewable Energy Exhibition

Melbourne, Australia, 2-5 November 2005

presented by WWEA and REGA

For information:

http://www.wwindea.org/

INTERNATIONAL SOLAR COOKERS CONFERENCE AND FOOD PROCESSING

Granada, Spain, 12th to 14th of July 2006.

http://www.solarconference.net/

Oil Africa 2006

The 2nd Sub-Saharan OIL, GAS, PETROCHEM Exhibition and Conference

Cape Town International Convention Centre

March 22-24, 2006, Cape Town,

South Africa

The enzymatic hydrolysis and fermentation of pretreated wheat straw and bagasse to ethanol

Muhammad Ibrahim Rajoka

Abstract

Saline sodic soils have been used for production of biomass using salt tolerant perennial grasses, namely *Leptochloa fusca* (kallar grass) followed by lesser tolerant plant, namely, Panicum maximum to provide biomass throughout the year for production of single cell protein, celllases hemicellulases and ethanol. The concentrated enzyme titers obtained after growth of C. biazotea on kallar grass using sodium nitrate as nitrogen source could saccharify alkali-treated wheat straw, bagasse, carboxy methyl cellulose and alpha-cellulose to monomeric sugars (› 88% theoretical yield) but not kallar grass straw. In simultaneous saccharification and fermentation studies, 94 and 90 % theoretical yield of ethanol from wheat straw and bagasse from 10% carbohydrates in both substrates were achieved compared with alpha-cellulose, which supported 96 % theoretical yield of ethanol.

1.Introduction

Photosynthesis is the most efficient method for harnessing solar energy for biomas production. The global production of lignocellulosic (LC) material from the land is about 120-150 billion tons dry matter/annum, some 302 billion ton oil equivalent (TOE) or more than four times the world's yearly total energy consumption [1]. In Pakistan, LC materials are the most important components of the renewable biomass and contributed 17.7 million ton oil equivalent (MTOE) per annum fuel wood, animal waste, cotton sticks and other crop residues in year 2002-2003 against anticipated demand of 83.7 MTOE. During the recent decades, Pakistan has experienced fairly good economic growth but the country is still at a low level of economic development and in coming decades, will need large inputs of energy in order to sustain the pace of its economic development. Presently, 68% of primary energy needs of the country are met by commercial fuels (oil, natural gas, coal, hydro- and nuclear- power) and 32% by traditional fuels (fuel wood, crop residues and animal wastes). Since Pakistan is a resource deficient country so it has to rely on imports to cover about one third of her primary energy demands [1].

Vast areas of salt affected wasteland available in Pakistan can be utilized for the production of energy crops by growing the salt tolerant plants for the economic production of fuel and other products. Because of its C-4 system of photosynthesis, a high tolerance to salinity and sodicity, and associative nitrogen fixation, *Leptochloa fusca* L. kunth (kallar grass) is able to produce (with a production cost of $3.0/metric ton) 50 ton biomass/ha and could be a cheap source of capturing solar energy in developing countries [2].

Grasses, trimmings of lawns, other agriculture wastes, industrial, domestic, food and urban solid wastes are currently over produced (over 43 million tons per year, 2) but under utilized. Recycling these wastes would not only aid in pollution abatement but can also serve as a vital source of energy and food for the future. The use of wastes for methane or ethanol production will reduce overall cost and make the process economically viable.

The removal of lead or toxic aromatics used in gasoline as octane boosters has provided new application and markets for alcohol to enhance octane rating and provide an alternative liquid fuel. Ethyl alcohol is gaining increased acceptability as fuel as it burns clean and can be quite easily blended with gasoline. Molasses has been used in our laboratories to produce ethanol using *Saccharomyces cerevisiae* at bench scale, as well as in continuous culture [1] at industrial scale. But the cost of molasses is increasing rapidly and distillers are concerned by the price hike. Other attractive alternative is the readily available lignocellulosic (LC) biomass, which has a considerable promise as a raw material for liquid fuels, and certain petrochemical intermediates, as this is renewable.

Utility of cellulose in LC biomass is tremendously enhanced if it is first hydrolyzed to glucose and other soluble sugars that in turn can be used for making sweeteners, single cell protein (SCP), energy materials (alcohol) or other fermentation products. For production of ethanol from LC biomass, one of the designed processes is enzyme/acid hydrolysis followed by fermentation to ethanol. Acid hydrolysis has been commercialized but it has drawbacks of low yield of ethanol, extensive corrosion problem or energy intensive if acid hydrolysis is carried out with diluted acids at 180°C. Increasing knowledge of enzymes and their mode of action as well as their recent applications have greatly expanded the prospect for enzymatic process [3]. The major attribute of the enzymatic approach is its potentially high saccharification efficiency observed by many workers [4,5]. For saccharification of pretreated substrates, co-operative action of a complex of exo-glucanase or cellobiohydrolases (EC 3.2.1.91), endo-glucanase (EC 3.2.1.4) and ß-glucosidase (EC 3.2.1.21) is involved in breakdown of complex carbohydrates present in LC biomass (Rajoka *et al.* 1998), the end product is glucose which can be sequentially fermented to ethanol. *Cellulomonas* spp. have been widely used for production of cellulases from LC biomass [6] and their enzymes have been extensively used in saccharification and ethanol production studies from agricultural residues [7]. In this study concentrated cellulases and hemicellulases were used to saccharify LC and cellulosic substrates. Wheat straw and bagasse, which were easily saccharified, were converted into ethanol using simultaneous saccharification and fermentation to ethanol. Information has been added on the kinetics of its production from LC biomass.

2. Materials and Methods

2.1 Materails. α-Cellulose, cellobiose, Sigmacell 100, Larchwood xylan, *p*-nitophenyl-ß-D Glucopyranoside (pNPG), *p*-nitrophenyl-ß-D-xylopyranoside (pNPX), *p*-nitrophenyl_ß-D-cellopyranoside (pNPC), carboxy methyl cellulose, Na-salt (CMC, low viscosity with degree of substitution 0.78), were purchased from M/S Sigma Chemical Company, St. Louis, MO 63178 USA. All other chemicals were of analytical grade. Kallar grass straw, and wheat straw were obtained from Biosaline Research Substation (BSRS), near Lahore. Bagasse was a gift from Crescent sugars mills, Faisalabad.

2.2 Organism*.* Strain of *Cellulomonas biazotea* NIAB 442, collected from Nuclear Institute for Agriculture and Biology, Faisalabad, Pakistan, was maintained on Dubos salt-α cellulose solid medium containing (g/l) K_2HPO_4 0.5 g, $NaNO_3$ 4 g, KCl 1.0 g, $MgSO_4$ $7H_2O$ 0.5g, $FeSO_4.5H_2O$ 0.0 1 g, α -cellulose 10 g, yeast extract 2 g (pH 7.3), and agar 20 g. *Cellulomonas biazotea* was cultured in Dubos salt-cellobiose yeast extract medium overnight at 30°C in Erlenmeyer flasks as described previously [6] and used at 10% (v/v) basis to inoculate the growth medium. A thermotolerant mutant of *Saccharomyces cerevisiae* ATCC 26602 [8] was used as ethanologenic organism. It was maintained on the medium described previously [3]. The strains were cultured routinely every fortnight. For preparation of inoculum, a loopful of culture from slant was transferred to the inoculum medium containing basal salts and 1% (w/v) glucose at 30 °C.

2.3 Preparations of Lignocellulosic (LC) substrates: Lignocellulosic (LC) substrates were air dried after rinsing with tap water. The dried biomass was made into a 55-mesh powder by grinding in an electric grinder. The powdered biomass was given alkali pretreatment separately with 10% NaOH keeping biomass alkaline solution ratio at 1:10. The treated substrates were autoclaved for 15 min, washed to neutralize and again dried in the oven at 80 °C. The dried biomass had 10% moisture content. The LC biomass was analyzed for car-bohydrate content as described previously [4]. Kallar grass straw, wheat straw and bagasse contained 78.0±6.0, 88±7.5 and 84 ± 7.6 % total carbohydrates

2.4 Growth studies with *C. biazotea*: Enzyme production in all strains of *Cellulomonas* spp. from CMC, α-cellulose or Sigma cell 100 (0.25-1.5%) indicated that 1% (w/v) concentration was (in liquid medium) optimum for biosynthesis of all enzyme activities observed [7]. Enzymes were produced with 1% cellulose + hemicellulose in kallar grass biomass in 1 litre Erlenmeyer flasks with 200 ml of culture medium. Flasks were inoculated with 20 ml overnight culture of test organism with OD of 10 x 0.3, prepared as above. The culture flasks were incubated at 30 °C on a gyratory shaker (100-revolution min^{-1} for 72 h. The unused substrate was removed by filtra-tion through Cheesecloth.

Cells were harvested by centrifugation (4°C, 15 min, 12000 g), and the supernatant used as extra cellular fraction. Cells were suspended in chilled McIlvain's phosphate buffer (pH 7), and disrupted by probe sonication in two bursts of 1 min with Braun sonicator 2000 at low density with at least 60-second intervals between disintegrations. The sonication vessel was cooled in crushed ice throughout. Supernatant from this disruption was used as the intracellular enzyme preparation. In some experiments, the pelleted samples were resuspended in a minimum volume of buffer and dialyzed at 4°C overnight to remove sugars remaining from the growth medium and soluble products of cellulolytic action formed during growth, both of which might interfere with the product. The enzyme activities in the extra cellular (soluble), and intracellular were assayed for cellulase and xylanase enzymes.

2.5 Enzyme assays: Endo-glucanase (CMC-ase), exo-glucanase or cellobiohydrolase activities were determined as described previously [6,9,10]. For endo-glucanase, the total reaction mixture of 3 ml contained 1 ml of carboxymethyl cellulose Na salt (CMC, 1% w/v) 1 ml phosphate citrate buffer (50 mM pH 7) and 1 ml of appropriately diluted enzyme. After incubation for 30 min at 40 °C, the reducing sugars were estimated as glucose equivalent by the dinitrosalicyclic acid (DNS) method [11].

Filter paper (FP-ase) activity was determined under similar conditions as described above except that 6x1 cm What man no. 1 filter paper was used as a substrate in place of CMC. Xylanase activity was also determined under similar conditions as above except finely powdered Larchwood xylan (Sigma) suspension was used as a substrate. The reducing sugars were measured as xylose equivalents by the DNS method [2]. The units are international units (µM reducing sugars equivalent glucose or xylose/ml or specific activity was determined.

ß-Glucosidase, ß-xylosidase or cellobiohydrolase was assayed according to method described previously [2, 6] with some modifications. The total assay mixture of 3 ml consisted of 1 ml of the substrate (5 mM pNPG, pNPC or pNBG)), 1.0 ml buffer and 1.0 ml of suitably diluted enzyme. The reaction was initiated by addition of activated enzyme (enzyme incubated for 10 min at assay temperature and called activated enzyme) followed by incubation at 40°C for 10 min. The reaction was terminated by addition of 3 ml of sodium carbonate (2%) and the para-nitrophenol liberated was determined as absorbance at 410 nm. Cellobiase was determined from glucose released from 1 mM cellobiose by glucose oxidase method. One unit of activity defined as micromoles of product (para -nitrophenol or glucose) formed per minute per ml of enzyme preparation. Protein was estimated according to method of Lowry et al. [12] with bovine serum albumin.

2.6 Saccharification studies: Portions of 0.2, 0.375, 0.5 or 0.625 g of bagasse, kallar grass straw, wheat straw or CMC were dispensed into 50 ml Erlenmeyer flasks. One ml phosphate citrate buffer (pH 7) containing 0.02 ml of tween 80 was added to each flask. They were incubated at 40°C in shaking water bath incubator along with 4 ml of concentrated enzyme preparation whose pH was brought to 7 with 1 N HCl. The crude enzyme was obtained from C. biazotea grown on 1.25% kallar grass straw liquid culture and concentrated. For the latter, the extra cellular and intracellular preparations (the later prepared in one tenth of original volume) were mixed, dialyzed and concentrated by ultra filtration (with Amicon concentrator fitted with cutoff size membrane of 10 kDa) to contain 10 mg/ml protein and assayed to possess desired enzyme activities. Duplicate flasks were harvested periodically and properly diluted aliquots were used to determine reducing sugars measured as glucose using dinitrosalicylic acid method..

2.7. Ethanol production studies: For ethanol production studies (a) five, and 7.5 g of alkali treated wheat straw, or bagasse, 0.5 g of yeast extract and 0.25 ml of Tween 80 were added to a 250 ml Erlenmeyer flasks separately with 10 ml of buffer of pH 5.0 and salts [(K_2HPO_4 10 g, $MgSO_4$ $7H_2O$ 5 g, $(NH_4)_2SO_4$ 5g and yeast extract 2 g (pH 5.0)], medium and autoclaved. Eighty ml of a predetermined cellulase preparation (pH 5) were added and incubated in a reciprocal shaker at 100 revolutions per minute for 4 h. Ten ml of an overnight culture of *S. cerevisiae* mutant was added and the flasks were reinucbated for various times. b) Ten and 12.5 g of wheat straw, and bagasse, 2.5 g yeast extract and 0.25 ml of tween 80 were added to 250 ml Erlenmeyer flasks containing 10 ml of buffer of pH 5.0 and salts as above. The flasks were autoclaved and 80 ml of concentrated enzyme preparation were added to produce a working volume of 90 ml. After incubation for 4 h, 10 ml culture of *S. cerevisiae* mutant was added and the flasks were reincubated for specified times . The experiments were repeated in (a) and (b) but with same concentration of α-cellulose (c).

Duplicate flasks were harvested. The insoluble substrate was centrifuged and supernatant was assayed calorimetrically to assay for sugars using dinitrosalicylic acid, glucose was measured using glucose oxidase kit, cell mass determined gravimetrically and ethanol was determined using Perkin Elmer gas chromatograph equipped with FID detector using chromos orb 101 column at 151°C. N_2 was used as a carrier gas while injector and detector was 200 and 220 °C respectively. Concentrations were calculated using ethanol as standard.

3. Results and discussion

The enzymes were prepared after growth of C. biazotea on 1% (w/v) carbohydrates in alkali treated kallar grass in Dubos-slats medium containing 0.4% sodium nitrate (pH 7.3) for 72 h at 30°C. The extra cellular and cellular fractions prepared as described in Materials and Methods were mixed and concentrated to contain 32.0, 10.0, 11.0, 10.0, 200.0, 11, and 25 IU/ml for endoglucanase, exo-glucanase (FPase), ß-cellobiohydrolase,, ß-glucosidase, xylanase, cellobiase and ß-xylosidase respectively (Table 1). Representative figure for saccharification of 5 (Fig. 1a) and 12.5% (Fig1 b) CMC, α-cellulose, kallar grass, bagasse and wheat straw is presented (Fig.1). These enzyme titers showed high saccharification of wheat straw, bagasse and α--cellulose (>90%) and markedly enhanced carbohydrate productivities (Table 2). In saccharification studies, when the reaction mixture contained above units of CMC-ase, FPase, ß-glucosidase, cellobiase and ß-cellobiosidase/ml, a high saccharification was an expected proposition [13]. The concentration of FPase in the reaction mixture (containing 12.5% substrate suspension) was 64 IU/g substrate. Normally 15-40 units/g substrate have been found to cause 80-90% saccharification [13]. Since the enzyme concentration was up to 3- times higher than the recommended dose, a high saccharification rate was expected [4,7]. This finding is consistent with finding on saccharification values obtained with other cellulases [3, 14, 15]. At high substrate concentration, low saccharification rate has been reported even when 40 IU FPase/g substrate, was used [13]

In ethanol production studies, the saccharification was carried out for 4 h and then fermentation was brought about by adding an inoculum of *S. cerevisiae*. The contents were incubated at 40°C with shaking at 100 rpm (Fig. 2). At predetermined intervals of time, duplicate samples were harvested and assayed for ethanol (p), reducing sugars (s) and cell mass (Fig.2) from 12.5% concentration of wheat straw (a), bagasse (b), and α--cellulose (c). *S. cerevisiae* utilized the sugar produced from the substrates present in the fermentation vessel, for synthesis of cell mass and ethanol. After 25 h, the culture reached the stationary growth phase and fermentation was terminated.

The final concentration of FPase and ß-glucosidase was 64 and 57.6 IU/g substrate each compared against (ca) 30 IU/g substrate found optimum for conversion to glucose [4]. The maximum yield of ethanol was 5.3, 4.8 and 6.12 from wheat straw, bagasse and α-cellulose respectively ca 6.4 % produced from glucose. These values are markedly higher than those reported by previous authors [3, 14-16].

An increase in the amount of straw in the reaction medium from 5% to higher concentration limited the degree of saccharification and glucose yield in the saccharified syrup. This was due to difficulties which were encountered in stirring the biomass, thereby decreasing the ethanol production rate [13]. In the present study, this trend was not visible, as the hydrolytic products did not significantly inhibit the growth of the yeast as was reflected in high cell mass yield (9.0 g/litre) comparable with that formed on glucose and that reported by Szczodrak [13] while fermenting 10% wheat straw whereas ethanol yield is comparable with that reported by Szczodrak [13]. In the present studies, the cellulase used had optimum enzyme activity at 40°C and *S. cerevisiae* mutant shows $Y_{p/s}$ comparable to one at 30°C, better performance as far as ethanol production is concerned was reached.

Table 1. Enzyme activities of *C. biazotea* cellulase preparations made up to protein concentration of 5 mg/ml compared with the activity of enzyme preparation with 1 mg/ml protein content. Activities have been expressed in IU/ml

Enzyme	Fermentation broth (1.0 mg/ml)	Concentrated (5 mg/ml)
Endoglucanase	7.0	32.0
FPase	2.4	10.0
Xylanase	50.0	200.0
ß-Gucosidase	2.1	9.0
Callobiase	2.4	10.0
ß-Xylosidase	6.0	25.0
ß-Cellobiosidse	2.8	11.0

Table 2. Productivity of reducing sugars (Q_{RS}, g per l per h) from 5.0 , 10.0 and 12.5 % CMC, a-cellulose, wheat straw, kallar grass and bagasse using concentrated cellulase and hemicellulase preparations

Substrate	Q_{RS} (g per l per h) from substrate concentrations		
	5%	10%	12.5%
CMC	5.6	13.0	16.0
α-Cellulose	4.9	11.8	12.5
Kallar grass	2.6	6.2	6.4
Wheat straw	3.2	7.5	8.5
Bagasse	2.7	6. 7	7.9

Table 3. Comparative kinetic parameters for production of ethanol from 5 and 7.5.5% wheat straw, bagasse and α-cellulose using cellulases[a] from *C. biazotea* and cultures of *S. cerevisiae* thermotolerant mutant

Kinetic Parameters	Wheat straw	Bagasse	α-cellulose	Wheat straw	Bagasse	α-cellulose
	-------------------5%---------------			---------------7.5%-----------		
μ (h^{-1})	0.21	0.19	0..23	0.24	0.23	0.26
$Y_{p/s}$ (g/g)	0.49	0.48	0.50	0.48	0.47	0.50
Y_t (mg/ml)	53.00	24.00	25.50	37.00	36.00	38.00
Y_t	85.00	80.00	96.50	67.30	60.00	100

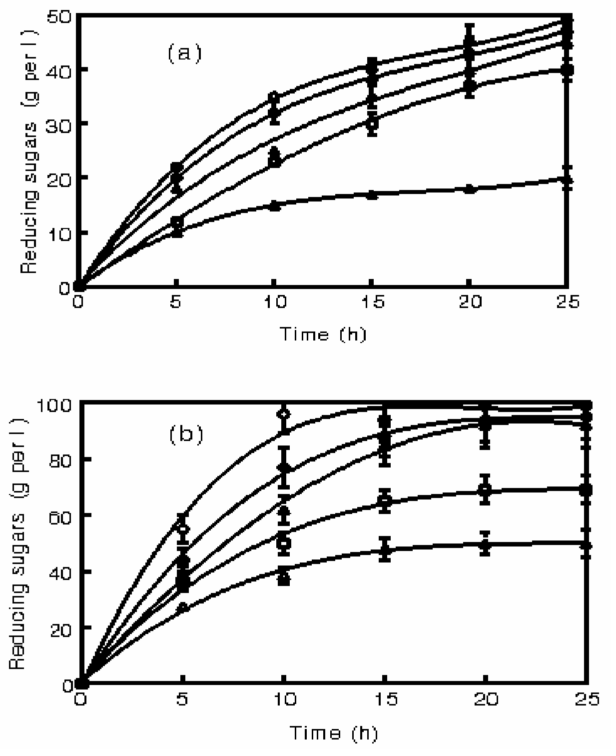
C. biazotea was grown on 1.25% alkali treated kaller grass straw [7] to prepare enzyme filtrates which were concentrated and assayed to contain desired enzyme activities (Table 1) and * μ (h^{-1}) growth rate; $Y_{p/s}$ ethanol yield; Y_t, theoretical yield (calculated on the basis of total cellulose and hemicellulose content); % Y_t, percent theoretical yield, were determined as described previously [7,8]. Wheat straw and bagasse had 88 ± 1.0 and 84- ± 1.5%

The cost of production of ethanol from molasses in Rs. $0.31/litre (96.4% ethanol) from a 200 m³ fermentor, its cost from LC biomass is calculated to be $0.42/litre because of enzyme production and substrate preparation costs. The gate price will be reduced if spent-lignin is used for energy generation and SCP (which has all amino acids required for experimental animals), is sold as poultry feed supplement, then production price of ethanol from LC biomass will be comparable to that from molasses.

The liquid fuel production technologies may yield 2.0 to 2.5 ton oil/ha by growing oil yielding plant on fertile lands while ethanol production can reach 2.0-2.3 ton/ ha from kallar grass grown on saline lands. Though energy efficiency of ethanol producing system is smaller. For instance, energy input for producing biomass is 12 MJ/kg of ethanol produced. The energy input or processing technologies is 12MJ/kg of ethanol compared as energy content of ethanol 28-29 MJ/kg of ethanol + 3.5-3.8 MJ/kg ethanol by product energy produced in the form of single cell protein +17 MJ/kg of spent waste energy produced from lignin or extraction of chemicals [1].

For reducing the cost of saccharification, we isolated genes coding for cellulases from C. biazotea and first cloned in E. coli and subsequently in yeast, Saccharomy-

Figure 1 Kinetics of production of reducing sugars from CMC (O), α-cellulose (●) kallar grass straw (Δ), wheat straw (▲) and bagasse (Í) during saccharification process respectively. Cellulases and xylanases were produced using 1.25 % kallar grass in shake flask cultures using optimized Dubos salt medium [7]. Clear supernatant was obtained by centrifugation and was concentrated using Amicon concentrator fitted with 10 k Da cut-off size membrane. The saccharification was brought out with concentrated enzyme preparation containing 64 and 57.6 IU of FPase and ß-glucosidase/g substrate respectively. Error bars show standard deviation between duplicate readings.



ces cerevisiae to see their expression with an express aim of introducing cellulolytic character in yeast for large scale production of enzymes with concomitant production of ethanol in a single step and development of new processes using plant raw materials or their products. The yeast harboring genes secreted the gene products in the culture medium, and performed post-transnational modification. We intend to improve this trait by cloning the cellulase genes under the influence of strong promoters to achieve hyper production of these enzymes for commercial exploitation. Our ultimate objective is to chromosomally integrate cellulase genes [17] under the influence of a strong promoter and also transfer plasmid borne genes coding for industrially important proteins for their co-production from inexpensive agro-industrial wastes. Fermentative ethanol production from kallar grass can give 4.5 X 10^8 gallon per year. Micro-organisms such as genetically *S. cerevisiae* could be tailored to produce variety of enzymes as co products with ethanol; 5% of cell protein would produce up to 145, 000 kg of enzymes as co products. These enzymes cold include enzymes for large markets such as detergent industry, the textile industry, the food industry, and the wood pulp industry and biocatalyst-based industries for novel chemical; with the availability of new markets, the value of these enzymes could exceed the current value of ethanol itself.

Conclusions

Concentrated enzyme syrup saccharified CMC, alpha-cellulose, wheat straw, bagasse and kallar grass to reducing sugars with high saccharification rates. In combined saccharification and fermentation, alpha-cellulose, wheat straw and bagasse hydrolysates were converted into ethanol with 94, 90 and 86% theoretical yield of alcohol respectively. Energy from biomass is an important way to improve security in energy supply for the future. The bioenergy sources are decentralized, cheap, renewable and suitable for continuous energy supply and for their conversion into various more valuable secondary energy carries.

References

1. Rajoka, M.I., Tabassum, R., Ahmad, M., Latif, F., Parvez, S. and Malik, K.A. (1996) Production of biofuels from renewable biomass. In: Procced. Asia-Pacific Solar Experts Meeting (Ed. Akhtar, P.; Eds. National Institute Silicon Technology, Islamabad, Pakistan).pp. 44-67.

2. Rajoka, M.I., Bashir, A. and Malik, K.A. (1997) Mutagenesis of *Cellulomonas biazotea* for enhanced production of xylanases. Bioresource Technology, 62, 99-108.

3. Bollok, M., Reczey, K. and Zacchi, G. (2000) Simultaneous saccharification and fermentation of steam-pretreated spruce to ethanol. Applied Biochemistry and Biotechnology, 84-86, 69-80.

4. Latif, F., Rajoka, M.I. and Malik, K.A. (1994) Saccharification of *Leptochloa fusca* (kallar grass straw) by thermostable cellulases. Bioresource Technology, 50, 107-111.

5. Wayman, M., Chen, S. and Doan, K. (1992) Bioconversion of waste paper to ethanol. Process Biochem, 27, 239-245.

6. Rajoka, M.I., Bashir, A., Hussain, M.R.A., Ghauri , M.T. and Malik, K.A. (1998) Mutagenesis of *Cellulomonas biazotea* for improved production of cellulases. Folia Microbiologica,. 43,15-22.

7. Rajoka, M.I. (1990) Production of biofuels from lignocellulosic biomass produced on saline using Cellulomonas spp (as cellulolkytic organisms,, a Ph.D. thesis submitted to University of the Punjab , Lahore.

8. Rajoka M.I., Ferhan, M. and Khalid, A.M.(2005) Kinetics of ethanol production by a thermotolerant mutant *of Saccharomyces cerevisiae* in a microprocessor controlled bioreactor. Letters in Appl.ied Microbiology 40, 316-321.

9. Hanif. A., Yasmin, A. and Rajoka, M.I. (2004). Induction, production, repression and derepression of exoglucanase synthesis in *Aspergillus niger*. Bioresour. Technol. 94, 311-319.

10. Rajoka, M.I. (2004) Influence of various fermentation variables on exo-glucanase production in *Cellulomonas flavigena.* EJB Electronic Journal of Biotechnology, 7, 256-263.

11. Miller, G.L. (1959). Use of dinitrosalisylic acid (DNS) for determination of reducing sugars. Analytical Chemistry 31, 426-428.

12. Lowry O.H., Roseborough, N.J., Farr, A.L. & Randall, R.J. (1951). Protein measurement with the Folin phenol reagent. Journal of Biological Chemistry. 193, 265-275.

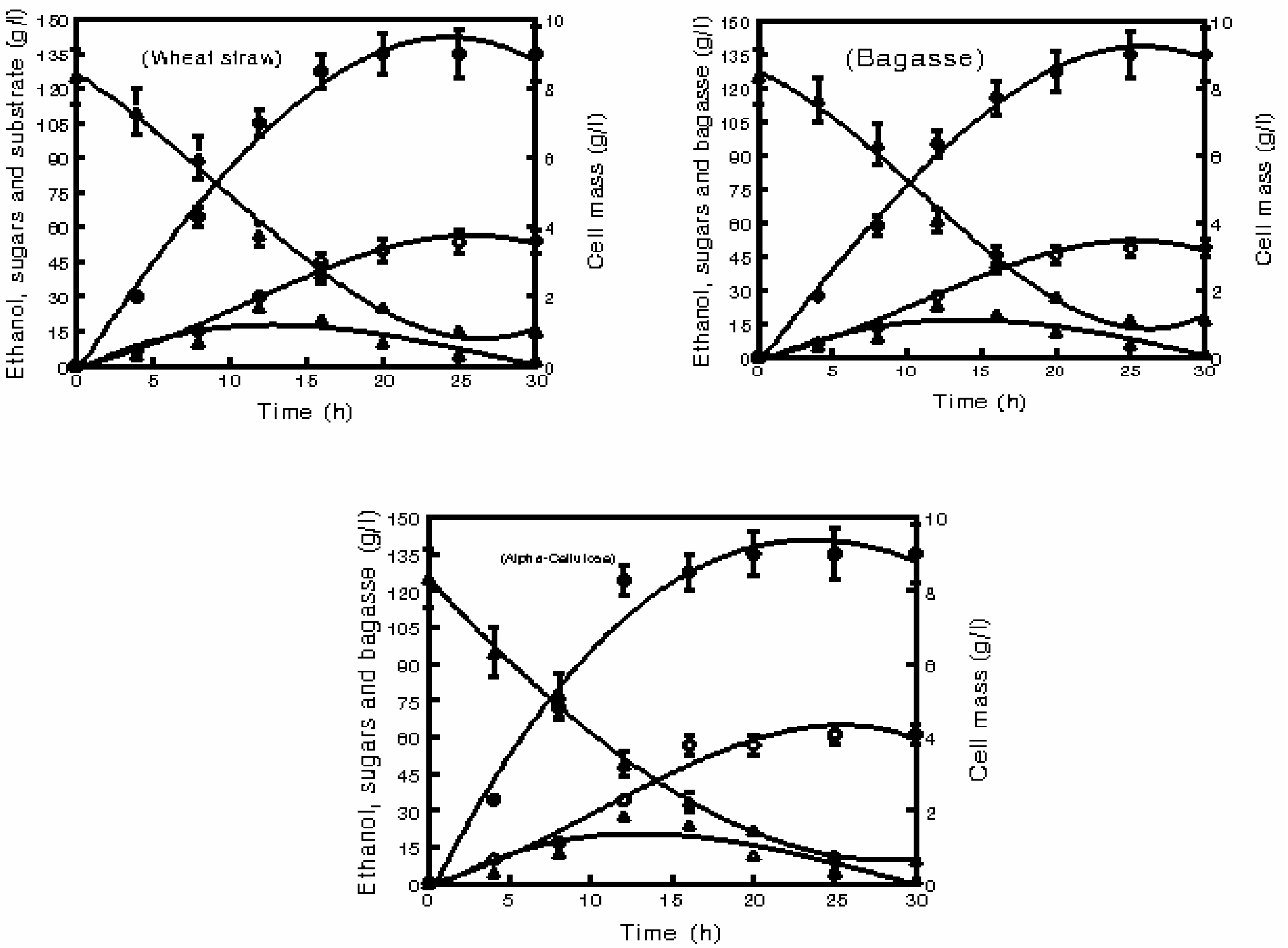
13. Szczodrak, K.J. (1988) The enzymatic hydrolysis and fermentation of pretreated wheat straw to ethanol. Biotechnology and Bioengineering, 32, 771-776

14. Hari Krishna, S. and Janardhan, Reddy, T. and Chowdary, G.V. (2001) Simultaneous saccharification and fermentation of lignocellulosic wastes to ethanol using a thermotolerant yeast. Bioresource Technology, 77, 193-196

15. Sedlak, M. and Ho, N.W. (2004) Production of ethanol from cellulosic biomass hydrolysates using genetically engineered *Saccharomyces* yeast capable of cofermenting glucose and xylose. Applied Biochemistry and Biotechnology, 113-116, 403-418.

16. Doran,J. B., Aldrich, H. C. and Ingram, L.O. (1994) Saccharification and fermentation of sugarcane bagasse by *Klebsiella oxytoca* P2 containing chromosomally integrated genes encoding the *Zymomonas mobilis* ethanol pathway. Biotechnology and Bioengineering, 44, 240-247.

Figure 2. Kinetics of ethanol (O), cell mass (●) production, accumulation of total reducing sugars (Δ) and solid substrate (▲) in the fermentation broth during combined saccharification and fermentation process respectively. Cellulases and xylanases were produced as above in shake flask cultures. The saccharification was brought out for 4 h and the syrup was inoculated with yeast mutant culture. Error bars show standard deviation between duplicate readings.



VIEWPOINT:

BIOMASS AND BIO-FUELS: ALTERNATIVE ENERGY; SOURCES.

C. OBURA BARTEL

The total amount of oil in the world is estimated at 4 trillion barrels. Only half of this is recoverable according to experts. Given the current rate of global consumption ofs 22 billion barrels per year. We are left with about 45 years to enjoy our Sport Utility vehicles and current way of life. Energy in the near future is set to be very costly as oil reserves become depleted and companies invest in new technologies to drill in more cumbersome sites or environmentally sensitive ones such as Alaska and the Caspian Basin.

In developing countries the range of inputs that sustain urban life is enormous. Along with population growth, urbanisation and industrialisation, economic development is one of the principal factors that are intensifying energy and water consumption. In developing countries, biomass fuels provide between 25 and 90 percent of domestic energy supplies. In smaller cities in Africa, a large share of energy needs is still met by biomass fuels. The local impact of biomass fuel on nearby forests is severe. The demand of wood resources in cities has caused 100 km or more of deforestation around cities in Africa. As countries urbanize, demand for energy increases and traditional fuels such as wood or charcoal are replaced by oil or electricity. Despite the potential for energy efficiency in cities, urban energy demand and fossil fuel consumption continue to grow.

Incentives

Many countries have undertaken studies and developed policies to address the negative economic, social and environmental effects of natural resource extraction and depletion which almost inevitably involve changes in the mix and level of taxes and subsidies. Fiscal and monetary policies can have implications on the use of natural resources, and have significant and varied environmental impacts. However, these impacts and the potential for promoting sustainable development through fiscal restructuring are rarely used in developing countries. Although there has been a widespread recognition of the negative environmental consequences of the extraction and depletion of natural resources on water, air and energy resources, many developing countries have conducted limited amount of country specific empirical study. Some empirical work has, however been done in this area, notably by some NGOs and the World Bank.

What is the USA doing?

In The United States, the Energy Policy Act of 1992 (EPAct) was passed to reduce US reliance on foreign petroleum and improve air quality. Officially known as Public Law 102-486, EPAct includes provisions that address all aspects of energy supply and demand. Several parts of EPAct were designed to encourage use of alternative fuels which are not derived from petroleum that could help reduce dependence on imported oil and build a self-sustaining alternative fuel market including through regulatory activities that focus on building an inventory of alternative fuel vehicles (AFVs).

Kyoto Protocol

The entry into force of the Kyoto Protocol under the UNFCCC - coupled with a growing number of voluntary initiatives to reduce greenhouse gas emissions - has set the world onto a path towards a more sustainable energy future.

Among recent policy recommendations related to climate change, the International Climate Change Taskforce has proposed that the UK G-8 Presidency promote initiatives such as a “G8+” Climate Group that would “agree to shift their agricultural subsidies from food crops to biofuels… while implementing appropriate safeguards to ensure sustainable farming methods are encouraged, culturally and ecologically sensitive land preserved, and biodiversity protected.

The benefits of biofuels

The production of biofuels – clean-burning, carbon-neutral fuels derived mainly from agricultural crops – has a number of benefits: it displaces the need for fuel imports and increases energy security; promotes job creation, diversification and rural development; and reduces greenhouse gas emissions, thus helping combat global warming. The greatest potential for the production of biofuels can be found in the South; whereas developed countries, in meeting their Kyoto commitments, potentially provide the greatest markets.

The drawbacks

Biodiesel is the logical contender for best sustainable transport fuel - the limitation being the amount of land required to grow the energy crops. However some fear that biofuels could become both a humanitarian and environmental disaster. According to George Monbiot, those who worry about the scale and intensity of today's agriculture should consider what farming will look like when it is run by the oil industry. Moreover, if we try to develop a market for rapeseed biodiesel in Europe, it will immediately develop into a market for palm oil and soya oil. Oil-palm can produce four times as much biodiesel per hectare as rape, and it is grown in places where labour is cheap. Planting it is already one of the world's major causes of tropical forest destruction. Soya has a lower oil yield than rape, but the oil is a by-product of the manufacture of animal feed. A new market for it will stimulate an industry that has already destroyed most of Brazil's cerrado (one of the world's most biodiverse environments) and much of its rainforest.

Go to page 41.....

Kafue Gorge Regional Training Centre: hydropower training in Africa and beyond

By Kaela Siame (KGRTC)

This is a highlight on the role of Kafue Gorge Regional Training Centre in meeting the needs in hydropower training by offering training to operations and maintenance personnel at all levels.

Background of the Kafue Gorge Regional Training Centre.

The SADC Region is rich in hydropower and potential hydropower resources, and Zambia has more than 60 years of experience with such technology. Today Zambia has more than 1608MW of installed hydropower capacity, of which Kafue Gorge Power Station alone has 900MW.

In December 1987, a joint Zambian and Norwegian team made an investigation of the training needs in Southern Africa Development Community (SADC) countries. In their report it was recommended that the training centre that ZESCO had started at Kafue Gorge Power Station, for training of the corporation's personnel in main power stations and control centres should be rehabilitated and re-opened as a Regional Training Centre.

A decision was taken to support the development during the years 1989-92 of the new training centre, called Kafue Gorge Regional Training Centre (KGRTC). The project, financed by ZESCO, NORAD and Sida, comprised rehabilitation and expansion of the existing training centre, and implementation of a number of training courses for hydropower station personnel in SADC countries. During the project period training fees and course participants' accommodation were paid by the project. The intention was to gradually make KGRTC self-sustaining economically.

A subsequent training needs assessment survey (YEAR?), financed by Sida, revealed a higher and some what different need for specialized training in the power sector than that previously report in 1987.

ZESCO, NORAD and Sida therefore approved funding for 1993-95 period allowing a programme that included 5 of the defined courses from the training needs survey. These five courses were implemented in the second phase.

Meeting the changes in power utility management

Currently, many electrical power utilities are unbundling and streamlining their services. Within these exercises staff may be required to change their jobs and/or enter into a different profession altogether. The change has not spared most of the utilities in Africa. Zambia Electricity Supply Corporation (Zesco) Ltd, a giant power utility in Zambia provides a good example. One interesting story to recount is of a young woman who had to go through a complete career change and is working in the second largest hydropower plant in Zambia, as a plant operator after undergoing a Plant Operations course at Kafue Gorge Regional Training Centre (KGRTC) in Zambia.

There is a growing demand for electricity and the need to meet this increasing demand with reliable power resource. This means that hydropower will most certainly play an important role in the supply of energy in the future.

As there is an increasing number of units and larger capacities interconnected in a complex power system, together with the necessity to consider environmental aspects, financing and profitability, imply an increased demand of highly qualified personnel to operate plants and networks. The Kafue Gorge Regional Training centre is required to provide this training and necessary skills update in hydropower operations and maintenance.

The case of Joyce

One course participant, Joyce, worked in the hotel industry before she joined ZESCO Ltd in 1998. She was recruited by the human resources department and doing catering services from 1998 to 2001. She worked at the guesthouse as a chef and later as a ZESCO Club officer in Kariba Town. The changes in ZESCO forced her to move to operation duties in the power plant .

After a one year of in-house orientation, she was identified for training in hydropower plant operations at Kafue Gorge Regional Training Centre in 2002. She followed a 13 weeks course in hydropower plant operations and a nine months practical in-house training. At present she is works as a plant operator at the second largest power station in Zambia –Kariba North Bank with installed capacity of 600MW+.

The course in Hydropower Plant Operations provides hydropower production background to participants whose career is in operations and who work within the hydroelectric power plant. Equipment and procedures of the Kafue Gorge Power Station are used as a reference for the training. The centre has two ABB simulators that mimic the hydropower plant operations. One is conventional and the other is computerized.

The practical approach that the centre has incorporated in the courses have received encouraging reviews from participants. The training on the simulators helped participants grasp the operations activities much faster. This is so, as mistakes are allowed on the simulator, though not encouraged, but are expensive in industry. The training on the simulators gives more flexible learning as scenarios can be changed at will by the instructor. Faults are simulated and the reactions from the operators are monitored. The participants are also attached to normal shifts at the power station. The practices at Kafue Gorge Power Station which is within the vicinity of the training centre reinforced the knowledge learnt so well, such that, when she went back to her workstation, she was a totally transformed worker. (May be you just separate the practical part from the simulation ones in stead of mixing them)

The participants who come to the training centre are given increased knowledge of techniques and modern methods of plant operations and maintenance planning. The courses further stimulate the participant's personal developments and skills and tie theoretical and practical knowledge by arranging visits to other power stations and some industries. Study tours are undertaken to hydropower plants, major substations and control centres. The tours offer course attendees to familiarize themselves with different types of power stations, operation activities and common problems in hydropower utilities.

There is increased mutual understanding of operation and maintenance problems and the centre makes it possible for the exchange of experiences between the participants with the various disciplines of hydropower operation. The participants are further given close cooperation with all major hydropower personnel in the region and a forum for sharing knowledge and experiences.

Evaluation and certification of participants

The training centre conducts evaluations of each of their course components, which enable attendees to respond openly about the course topics, materials, and instructors. Thus far, the courses have generally received favourable response from participants. This method of evaluation has also been used to improve on the course contents and duration in a number of courses. Deliberate follow up visits to utilities after training and needs analysis has also been used to identify needs and training gaps in hydropower operations in the region.

The Training centre at present is offering a number of courses. Several new courses have been introduced since inception to meet the needs of utilities in the region and other industries that find these courses of interest. A few non-engineering course have also been introduced to assist technical and non-technical personnel

KGRTC has earned an international reputation in provision of excellent training in hydropower in addition to providing good accommodation and conferences facilities and is ISO 9001:2000 certified for quality training provision.

The Centre has this year scheduled to run the following Courses for the best utilization of both water and energy resources in hydropower generation, water utilities, mining, manufacturing and other service providers.

KGRTC shall endeavor to provide training in hydropower operations and maintenance to maximize the efficient utilization of water resources both as a renewable energy resource in hydropower and more significantly as support to life through courses for the hydropower utilities and water related applications respectively.

The centre has a Sida Scholarship for women empowerment, which allows female participants on all courses at KGRTC to pay only 50% of the course fee.

Apart from running scheduled courses, KGRTC has capacity to run tailor made courses both at the center and clients' premises.

1. We train at least 160 course participants every year and are all regional based. We have trained participants from the whole SADC region and now spreading to East and West Africa.
2. We are accredited to the Technical Education Vocational and Entrepreneurship Training Authority (TEVETA) and certify our in-service skills training courses. We are going into cooperation with the local universities CBU and UNZA to go that way.
3. I have added a last statement as follows to be included on the last page "The course fees are inclusive of accommodation, meals, tuition and certification. The Centre has well furnished self-contained flats which are air conditioned and all have DSTV and an excellent restaurant."

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Selected highlights and courses on offer

1. At least 160 course participants are trained every year
2. Most participants are from the SADC region and some from East and West Africa.
3. Accredited to the Technical Education Vocational and Entrepreneurship Training Authority (TEVETA) and certify all in-service skills training courses. Developing cooperation with the national universities.
4. The course fees are inclusive of accommodation, meals, tuition and certification. The Centre has well furnished self-contained flats which are air conditioned and all have DSTV and an excellent restaurant."
5. Female participants pay half the fee.

	COURSES	START DATE	FINISH DATE	COURSE FEES (US$)	
				Male Participants	Female Participants
1	Basic Hydraulics (BH)	24-Jan	28-Jan	1,500	750
2	Fluid Flow and Centrifugal Pumps (FFCP)	7-Feb	11-Feb	1,500	750
3	Machinery Vibration Monitoring and Analysis (MVMA)	21-Feb	25-Feb	1,500	750
4	Dam Safety Monitoring (DSM)	7-Mar	18-Mar	3,000	1,500
5	Plant Operations (PO)	4-Apr	1-Jul	6,500	3,250
6	Customer Services (CS)	4-Apr	8-Apr	2,000	1,000
7	Maintenance Routines (MR)	18-Apr	15-Jul	6,500	3,250
8	Strategic Management (SM)	25-Apr	29-Apr	2,000	1,000
9	Control Room Operations (CRO)	9-May	15-Jul	6,500	3,250
10	Substation Operations and Maintenance (SOM)*	9-May	27-May	3,000	1,500
11	Environmental Assessment and Information Management (EAIM)	13-Jun	24-Jun	2,000	1,000
12	SCADA Systems Management (SSM)	20-Jun	24-Jun	1,500	750
13	Hydraulics and Turbine Regulations (HTR)	11-Jul	22-Jul	2,000	1,000
14	Shift Charge Operations (SCO)	11-Jul	16-Sep	6,500	3,250
15	Hydro Power Plant Operations and Control - Simulator (HPOC)	18-Jul	29-Jul	3,000	1,500
16	Distribution Systems Operations (DSO)	18-Jul	5-Aug	3,500	1,750
17	DC Power Systems Maintenance (DCPSM)*	25-Jul	29-Jul	2,000	1,000
18	Turbine Dynamics and Operations (TDO)	15-Aug	26-Aug	3,500	1,750
19	Industrial Safety and Fire Risk Management (ISFRM)	22-Aug	2-Sep	2,500	1,250
20	Generation Maintenance Management System (GMMS)	22-Aug	9-Sep	3,500	1,750
21	Programmable Logic Controllers (PLCs)	29-Aug	16-Sep	3,500	1,750
22	Customer Services (CS)	5-Sep	9-Sep	2,000	1,000
23	Maintenance Management Systems (MMS)	19-Sep	23-Sep	1,500	750
24	Financial Management in Utilities (FMU)*	26-Sep	30-Sep	2,000	1,000
25	Power System Operations (PSO)	26-Sep	14-Oct	3,500	1,750
26	Transformer and Switchgear Maintenance (TSM)	17-Oct	4-Nov	3,000	1,500
27	Power System Protection (PSP)	24-Oct	11-Nov	3,500	1,750
28	Substation Operations and Maintenance (SOM)*	7-Nov	25-Nov	3,000	1,500
29	Strategic Management (SM)	7-Nov	11-Nov	2,000	1,000
30	Energy Management (EM)	21-Nov	25-Nov	1,000	500

What to do with the windfall gains of African oil exporting countries

Viewpoint
Lamon Rutten

Compared to the previous decade, oil prices have been very high in 2004, and everything indicates they will remain high in the foreseeable future – well above the 20-25 US$ a barrel reference price on which most governments of African oil exporting countries have been basing their budget decisions until recently. Windfall gains for African oil exporters in 2004 were more than US$ 30 billion (compared to 2003 export revenue), and the situation is expected to be even better in 2005. Of this, more than US$ 14 billion accrued to governments, in the form of higher royalties, taxes and direct export revenue for state-owned enterprises. This is a very significant amount: compare it for example with the total amount of foreign direct investment into Africa in 2002 of US$ 11 billion, bilateral grants of around US$ 10 billion, or worldwide World Bank lending for fossil fuel projects that year of some US$ 2.5 billion.

The traditional advice to these governments is that they should save the "surplus" revenue – put it into a stabilization fund which is invested safely in the western capital market, for use in future bad years. For example, in 2004, Managing Director of the IMF Rodrigo de Rato cautioned African countries against squandering the current windfall from oil sales. Mr. Rodrigo de Rato said for countries rich in mineral resources like Nigeria, "a key priority for them is to avoid boom-bust cycles as oil prices rise and fall. This will require that much of the revenue windfall from high prices be saved and incorporated into a medium-term fiscal framework aimed at achieving fiscal and debt sustainability."

I would argue that this is misguided advice. Boom-bust cycles should be avoided, but saving much of the revenue windfall is not a requirement for this. The stabilization fund strategy has by and large failed its promises in the past, and more importantly, Africa has considerable investment needs that can be met by this surplus revenue. The governments of African oil exporters should re-inject at least part of their revenue surplus into strategic investments in Africa's future. Indeed, policy should take the "Dutch disease" risk into account. But why is it that foreign investors would not cause Dutch disease effects, but local investors would? One cannot call at the same time for new investments in Africa, or more aid, and at the same time tell African governments to save oil windfall gains abroad to avoid inflation ! What it really boils down to is trust: can the current generation of Africans be trusted with money, or should it be saved for use by future generations?

One can legitimately argue that in the past, African governments have shown to be very poor at investing oil revenue. Earlier oil booms have resulted in many a white elephant and heavy debt burdens. Exactly for this reason, I would argue for a novel approach: the governments of Africa's oil exporters should put part of their surplus capital (preferably, adding up to several billion US$) into a professionally managed investment fund; non-African oil exporters can be invited to voluntarily contribute to the fund. While governments provide the capital, they would have no influence on investment decisions. There is no lack of African nationals working at high levels in the world's financial market, including in the large western investment banks, and recruiting high-calibre staff to manage such a fund professionally, remote from political interference and according to the highest standards of integrity, will not be difficult.

The investment fund would have the following characteristics:

- Operate like an independent venture capital, mezzanine finance or project finance fund (in effect, the most effective way to move forward would be to have a series of investment funds, including one or more Islamic ones, focussing on different types of risk)
- Under professional management
- Invest wherever in Africa there are viable projects
- Focus on African energy- and transport-related projects
- High-risk, high-reward, long-term perspective
- Go for high leverage and Public-Private Partnerships.
- Give critical feedback to policy makers.

The investment fund would invest in infrastructure and services critical for Africa's growth and competitiveness. This includes the large projects identified in the framework of NEPAD, as well as many smaller projects, for example in transport-related infrastructure, energy distribution networks and trade-related services. In the 1990s, the returns on private investments in Africa were more than 20% (higher than in Asia and Latin America), indicating that there is a large pool of potential projects worth investing in. "Investment opportunities in Africa are reported to offer some of the highest rates of return on investment, even on a risk-adjusted basis." (Arunma Oteh, Treasurer, African Development Bank, at a September 2004 Corporate Council for Africa / US Exim conference)

The ownership of the fund by many of the continent's largest economies will give it an important comparative advantage compared to the (much smaller) western investment funds that now exist, in that political risk factors will play a much reduced role. This will, in effect, allow the fund to leverage its own capital, mitigating the risks in a project and thus attracting supplementary new funds from the western (and Middle Eastern) capital market.

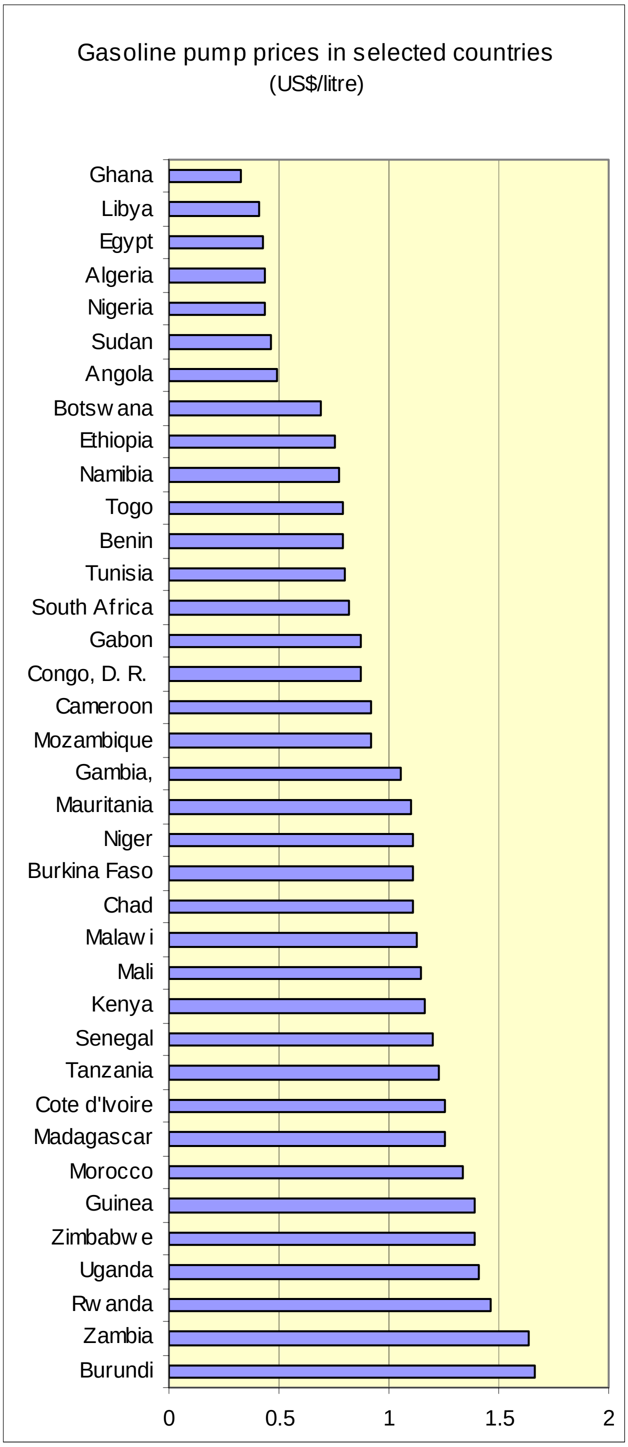
While not all investments will be successful, it can be expected that the returns from this strategy will easily exceed that of putting "surplus" funds on western bank accounts. Why deposit Africa's funds on these bank accounts, from which they are lent to western investors who use them to reap the benefits of Africa's economic potential? And by investing in Africa's economy and trade infrastructure as a whole (rather than just in their own countries), African oil exporters support regional integration in the continent and create new opportunities for their non-oil exporters (in other words, they will promote the diversification of their economies). Importantly, the creation of a fund of this nature will signal to western capital providers that African leaders believe in the future of their continent, and are willing to put their money where their mouth is. The creation of such a fund can considerably boost Africa's growth and competitiveness, even in the short run, making it more likely that the continent can reach the growth rates necessary to meet the Millennium Development Goals. After the high hopes of independence faded away, African leaders have been quite timid. The current oil windfall gives them the opportunity to show that they are ready to take their continent's future in their own hands.

Africa's oil wealth, social justice and development; One of the complex chemical equations that Africans have been trying to balance for a long time without much success. Will they get it right this time?

Oil mining in Southern Sudan (Source: Sudan Tribune)

Talk to ATDF: Your gasoline pump price

Are gasoline prices cheapest in Ghana and most expensive in Burundi.



In the press: The scramble for Africa

The original Scramble for Africa

The original Scramble for Africa took place in the late 19th century, when Britain, France and Germany competed to carve Africa into colonies. Today corporations from the US, France, Britain and China are competing to profit from the rulers of often chaotic and corrupt regimes. Our investigations in three African countries rich in resources - Angola, Equatorial Guinea and Liberia - show how British-based companies have negotiated deals that critics say are against the interests of some of the poorest and most traumatised people on earth. The Guardian's inquiries focus on a big gas project in Equatorial Guinea; plans to exploit Liberia's diamonds, and western banks' readiness to provide Angola with huge oil-backed loans.

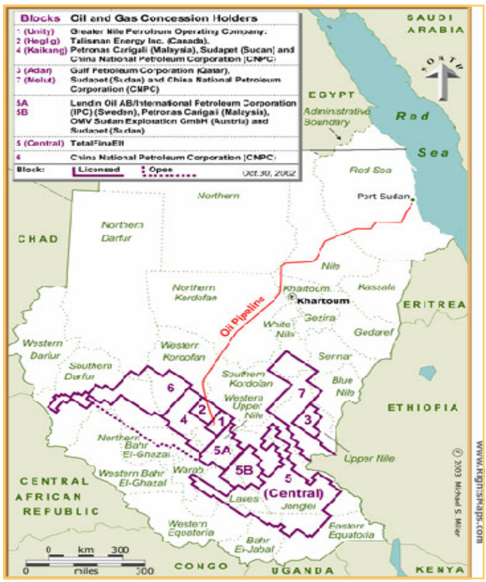
In Equatorial Guinea, BG plc (formerly the British Gas state company) has closed a deal with the regime of President Teodoro Obiang to buy up the country's production of liquefied natural gas for the next 17 years. Britain's HSBC bank has been accused by a US Senate committee of helping Mr Obiang move cash from the country's oil revenues into financial "black holes" in Luxembourg and Cyprus. The country is threatened with repeated coups by outsiders keen to get their hands on the oil wealth. In Liberia, which has been beset by civil war, LIB, a private London bank, was behind attempts to monopolise alluvial diamond production and the country's telecommunications. The UN and the World Bank have criticised the schemes as secretive and against the country's interests. LIB has now withdrawn. And in Angola, the victim of an even more destructive internal war, one of the UK's leading development banks, Standard Chartered, has been accused of damaging the country's economy by providing record multibillion dollar loans which give a stranglehold over future oil production.

A succession of scandals has already revealed how oil wealth was looted in billions from the former Abacha military regime in Nigeria with the assistance of western banks and bribes paid by US oil firms. In Sudan and Chad, Chinese companies are moving in, backing and arming military rulers and building pipelines. And in France, the then state oil company Elf has been accused in corruption investigations of having paid kickbacks and encouraged regimes to run up debts as part of a deliberate "African strategy". Congo-Brazzaville, the fourth-largest sub-Saharan oil producer, was dominated by Elf, and now has the highest per capita debt in the world. Global Witness says in a 2004 report: "Oil wealth [there] has left a legacy of corruption, poverty and conflict."

By David Leigh and David Pallister in "Revealed: The New Scramble for Africa" at http://www.globalpolicy.org/

Source: Guardian June 1, 2005

Sudan: The new front?



Continues from page 35....................

Trade negotiations

International trade in biofuels is currently very limited, due in part to tariff barriers., The expansion of biofuels production also ties into the ongoing WTO agriculture negotiations, in particular discussions related to the review of the Green Box (subsidies without a trade impact, including for environmental purposes). In addition, as biofuel production increases, more land and crops will be used to grow the requisite feedstock. This will create complex interactions with the production of other commodities, including food production.

If demand rises for biofuels, prices for all crops may increase, leading to less need for subsidies and higher prices on the global market. In effect, a transfer of resources to rural areas and exporting countries is likely to take place. New export opportunities might also open up for developing countries currently unable to compete with subsidised developed-country agricultural products, despite their comparative advantage in this area. These linkages are poorly understood, and require much more research given their potential role in the transition to a sustainable energy future.

1. Meeting the Climate Challenge." Recommendations of the International Climate Change Taskforce. Institute for Public Policy Research, UK. Center for American Progess, US. The Australia Institute. (January 2005)

2. Fuel for nought: George Monbiot biofuels = disaster, Guardian (UK), 23 Nov 2004

ATDF: MEET OUR NEW EDITORIAL MEMBERS

ATDF is honoured to welcome Appolinaire Djikeng, Roger Pfister, Dele Young, Kaumba Godfrey Chinyama and Bathsheba Okwenje to the the ATDF Editorial and Steering Committee.

For detail visit http://www.atdforum.org/article.php3?id_article=11

Dr. Appolinaire Djikeng

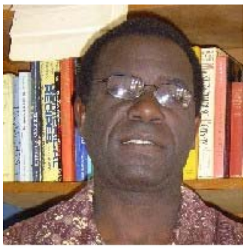
Djikeng works on Molecular Biology/ Parasitology of the regulation of gene expression of pathogens causing diseases in sub-Saharan Africa. At TIGR, Dr. Djikeng is currently leading a program on functional genomics of three pathogens organisms namely, Trypanosoma brucei (responsible Human sleeping sickness), Leshmania major (responsible for leishmaniasis) and Trypanosoma cruzi (the South American trypanosomiasis). Dr. Djikeng completed post-doctoral training at the Yale School of Medicine (New Haven, CT, USA).

Dr. Roger Pfister

Roger Pfister is a Scientific Assistant at both the Network for International Development and Cooperation (NIDECO) of ETH Zurich and the University of Fribourg, Switzerland. He is also a Visiting Research Fellow at the Centre for International and Comparative Politics at the University of Stellenbosch, South Africa. He received his PhD from Rhodes University in Grahamstown, South Africa. His main research interests are (South) African foreign policy and international relations, as well as issues of communication in Africa.

Dr. Kaumba Godfrey Chinyama

(BSc MSc PhD CPhys MInstP)



Dr. Chinyama is the Head of the Department of Physics in the School of Natural Sciences at the University of Zambia (UNZA) and member of ten committees and boards of the School of Natural Sciences, among others, and member of the UNZA Senate. He also served as the President of the University of Zambia Lecturers & Researchers Union between 2000 to 2002. Dr Chinyama is involved in research in materials for solar energy applications & photovoltaic (PV) systems, and in semiconductor quantum-well structures for opto-electronic device applications and currently coordinates a five-year project on selective surfaces for solar energy applications and PV systems.

Dele Young

Dele Young is Project Manager for the Technology Transfer Office (TTO), SGT Inc., at the Goddard Space Flight Center (GSFC). He is responsible task management, strategic planning, performance metrics, and software release management for technology transfer activities.

Ms Bathsheba Okwenje

Bathsheba Okwenje is a communications and information specialist working with the United Nations on social mobilization and public health issues. Prior to the UN, Sheba worked in New York City as a Creative Producer for a technology company and a producer for a New York based start-up Company.

Sheba has produced documentaries, given media literacy lectures, created a bi-monthly arts forum and co-founded a company providing alternative information for pre and post natal women.

Science in the news

Tired of taking off your shoes for airport security checks?

DuPont , US, has a solution - a floor mat that scans passengers' footwear for explosives and drugs as they walk over it.

The scanner uses a technique known as nuclear quadrupole resonance to detect contraband concealed in footwear. A series of superconducting alloy coils spread across the surface of the mat produce radio frequency pulses to excite nuclear spins in chemical compounds found in explosives or drugs. The same coils are then used to pick up the characteristic resonance produced by these compounds.

However, in order to produce a strong enough signal, radio signals from several coils have to be synchronised. The key is to space the coils at just the right distance apart, and to time the pulses so that they overlap and reinforce one another.

DuPont says passengers could be given a more thorough check by having them stand up against another vertically oriented scanning plate as well. The company's patent makes no mention of any possible health and safety issues.

Source: Newscientist

Shifting sand to engulf productive land in Africa.

Scientists from Oxford University report that the immense dunefields of the Kalahari could be stirred up by global warming and warn that large areas of currently productive land could become engulfed by shifting sands.

The team, led by Professor David Thomas, urges politicians in the region not to pursue development policies that might exacerbate the coming problems, turning currently semi-arid areas into desert.

The Oxford team took data from three different computer models that are used to forecast likely climate change over the course of the next century.

The southern dunefields of Botswana and Namibia become activated by 2040, while the more northerly and easterly dunes in Angola, Zimbabwe and Zambia begin to shift significantly by 2070. By the end of the 21st Century, all the dunes from South Africa to Zambia and Angola are likely to be reactivated.

Source: BBCNEWS/NATURE

Fire ants: Natural self-cloning?

The sperm of the male ant appears to be able to destroy the female DNA within a fertilized egg, giving birth to a male that is a clone of its father. Meanwhile the female queens make clones of themselves to carry on the royal female line.

The result is that both the males and females have their own, independent gene pools, leading some to speculate whether each gender ought to be technically classified as its own species.

Many insects, including most bees, wasps and ants, sexually reproduce in order to create both queens and sterile female workers. Males are created when a female egg goes unfertilized. Unlike humans, whose males require genetic input from a father, these male insects simply have less genetic material than the females.

Fire ants:

However, the sterile workers carried one maternal and one paternal set of chromosomes while the queens carried only maternal genes and the males carried only paternal genes.

The fire ant queens produce two types of eggs: one that carries the full complement of maternal genes and develops without fertilization into future clones of the queen, and a second group that carries only one set of chromosomes and is fertilized with sperm from a male. Of this latter group of eggs, most develop into sterile workers.

Something similar is known to happen in some fish, amphibians and insects, in which the paternal genes can be eliminated from a developing egg. But it is unusual for maternal genes to be wiped out. The researchers don't know why this happens, but they speculate that it is the outcome of an extreme case of conflict between the sexes.

Source: Nature