SEI STOCKHOLM ENVIRONMENT INSTITUTE

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In this issue

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Large-Scale Biomass Energy Technologies: The Swedish Experience and its Relevance to Africa

by Björn Kjellström and Anders Arvidson, SEI

Biomass fuels were used extensively in Sweden during the second World War but rapidly lost in importance when cheap oil fuel became available after the war. In the late 1970s, however, a renewed interest led to efforts that successfully reintroduced biomass fuels in the Swedish energy balance. Today, 18% of the total Swedish energy demand is met with biomass. The Swedish experience can be of relevance to developing countries in e.g. Africa.

Three reasons have contributed to bring biomass fuels back into the focus of interest in Sweden. One of them was the large increase in oil prices during the 1970s. As a consequence, the cost of petroleum which accounted for 8% of the total imports in 1972 increased to 20% of the total imports in 1980, turning the trade balance negative.

Another important reason was growing concerns about environmental impacts caused by the use of fossil fuels, mainly associated with emissions of sulphur oxides, heavy metals and CO2. These concerns were highlighted by a government committee, the Energy Commission, which in 1978 pointed out that the potential climatic changes caused by increasing CO2 concentration in the atmosphere would require a global reduction of fossil fuel use.

The third reason for the renewed interest in biomass fuels was the political controversy over the future of nuclear power generation in Sweden. After a national referendum in 1980, this led to a parliament decision to limit the number of nuclear reactors to 12 which should all be phased out before 2010. Today, nuclear power supplies about 50% of the electricity demand in Sweden. The phase-out decision in combination with another parliament decision to limit further exploitation of the hydroelectric potential, and the ambition to reduce the use of fossil fuels has made it an urgent task for the government to promote renewable energy sources. Biomass fuels turn out to be one of the renewable energy sources with the largest potential in Sweden.

Successful shift

The efforts to reintroduce biomass fuels in Sweden have been successful. The large-scale use of biomass fuels has increased from about 50 TWh in 1980 to 84 TWh in 1995. This represents a 7% shift of the national energy balance and is one of the best examples of a successful transition from fossil fuels to renewable energy in the industrialised world. Today about 18% (NUTEK, Energiläget 1996) of the Swedish energy balance comes from large-scale biomass. An earlier unused source of biomass fuels, i.e. forestry residue, is now being utilised and has been introduced in a new field of application, district heating. (See: Shifting from Oil to Biomass).

The shift has not been without controversy but has required introduction of new technologies as well as practices in well established industrial sectors during a period when the future energy market was considered very uncertain.

Coordinated government support

The Swedish experience indicates that co-ordinated government support to research, training and investment in new technologies is important for implementation of renewable energy technologies which have to compete with established traditional technologies in an uncertain market. Consistency and stability in the government policy is therefore particularly important.

The incentives that the Swedish government has used to promote the use of large-scale biomass energy include:

- dramatic increase in financial support to energy research;
- establishment of a new government instritution for promotion of energy research;
- subsidies to investments in installations using indigenous fuels; and
- special taxes to discourage use of fossil fuels in some applications.

Most of the change in the energy system towards expanded use of biomass fuels has been achieved within the institutional system already existing in Sweden. People have developed new competence, and new departments within existing institutions have been formed but the overall structure was kept unchanged.

The institutional development would not have occurred without government support and the declarations made by government about a new long-term energy policy focused on promotion of renewable energy sources.

However positive the reintroduction of biomass fuels into the Swedish energy market has been, the present role of biomass fuels could have been even more important had there not been political inconsistencies regarding the Swedish energy policy. This has at times created uncertainty among the actors of the biomass energy arena who have found it difficult to compete with fossil fuels and electricity generation from nuclear power.

Lessons of relevance to Africa

More than half of the total primary energy demand in sub-Saharan Africa comes from biomass. Although often converted today at low efficiencies at household and small-scale industry level, it indicates a significant potential. There is no doubt that large-scale use of biomass fuels could be of large importance for the economic development of many African countries. With proper management of biomass resources, there is a large scope for instance for electric power generation from biomass on a sustainable basis. The easiest way to start would be to increase power generation in the sugar and forest industries. Preliminary studies carried out by the Stockholm Environment Institute in Tanzania and Zimbabwe indicate that sugar mills and saw mills could not only generate all the electricity needed for their operation but also deliver excess power to the national grid. (See: Co-generation of Power and Heat from Sawmills in Zimbabwe)

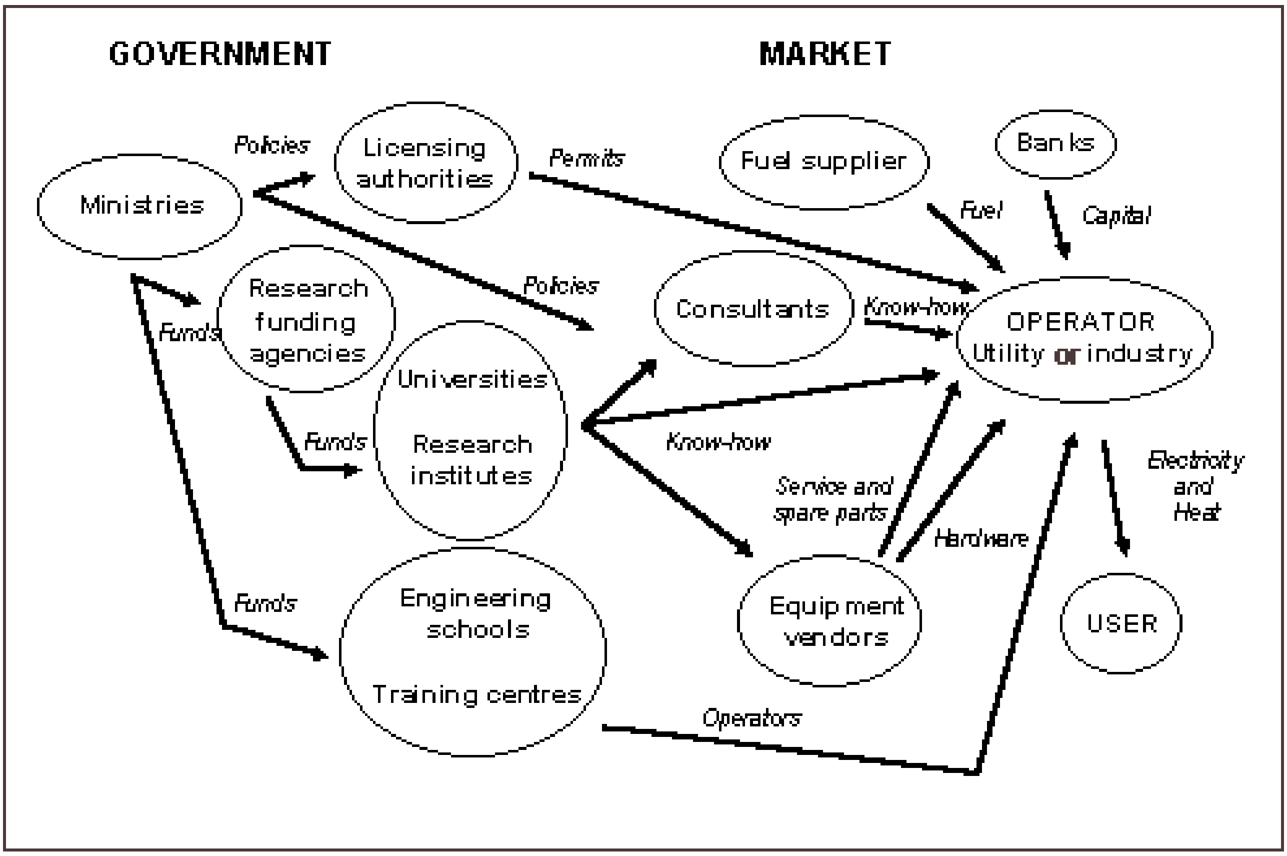
While the technologies for biomass electricity generation are readily available institutional barriers need to be removed in order to utilise the existing potential. The importance of government policy support in this respect can hardly be overestimated. Subsidised electricity prices and rules that prevent private electricity generation for delivery to the national grid are common examples of institutional obstacles to further tap biomass electricity potential in African countries.

Lack of understanding within government institutions and national utilities of the technological opportunities and the advantages of a transition to biomass fuels is another institutional obstacle. Lack of trained operators and local suppliers of spare parts and equipment may also prevent a rapid transition.

What is needed as a first step towards a better utilisation of large-scale biomass energy technologies in African countries is creation of awareness among key decision makers. Long-term energy policies promoting renewable energy technologies must then be established. The actions of the government must be stable to create credibility.

Market for biomass based electricity

Some of the institutional structure involved in promotion of biomass in a country like Sweden might not be needed. It is essential, however, that a market for biomass-based electricity is created by allowing independent power suppliers to sell their surplus to the grid, that a reliable and sustainable fuel supply system is organised and that operators are available locally. Building of local professional competence should be promoted. Initially, this might be achieved by formation of regional centres of competence which are linked to suitable institutions in countries which have made more progress in this area, like Sweden, Finland and Canada.



The figure illustrates how the utilities or industries using biomass fuel for energy conversion to electricity and heat are influenced by actors from both the *government structure, which are directly governed by political decisions, and actors on the commercial markets, which can be influenced by political decisions but base most of their decisions on financial assessments.*

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Shifting from Oil to Biomass - The Case of a Swedish Municipal Utility

Växjö's municipal energy company, VEAB was entirely dependent on imported oil for its heat and power generation until 15 years ago. Today, 80% of the fuel comes from biomass. By 1997, VEAB plans to cover more than 95% of its fuel needs from biomass. Some of the most important factors that have facilitated this process and made biomass commercially viable have been a supportive public opinion, economic incentives from the Swedish State, a large resource base, a collaborative city council and forward and innovative management of the local utility.

It all began during the 1973-1974 oil embargo. Sweden was importing 70% of its oil from the Gulf States. VEAB, Växjö's municipal energy company was entirely dependent on oil for its heat and power generation. This made VEAB actively begin to consider converting one of its boilers at the Sandvik plant to run on biomass. A proposal was put together for the Swedish Board of Economic Defence (ÖEF) that made a grant of 15 million Swedish crowns (SEK) available.

Reasons for the biomass option

Several factors influenced VEAB's decision to choose the biomass option. First, the support from ÖEF meant that the new biomass boiler became profitable almost immediately. Secondly, as biomass was politically acceptable in the municipality, the decision making process moved quickly. Thirdly, there are plentiful local supplies of biomass. Fourth, by replacing oil with biomass in one boiler, VEAB could also reduce its oil reserves by 30%, releasing a large amount of capital. Last but not least, it enabled VEAB to decrease its use of heavily polluting fuel oil.

In 1980, when the 28 MW biomass-run boiler was started, Sandvik became the first district heating plant in the country to commercially use biomass for heat. As it turned out to be a success, ÖEF used the "VEAB-model" when funding other boiler conversions to biomass throughout Sweden.

Success led to further extension

The success of the conversion led VEAB to extend the programme to other oil-fired boilers at the Sandvik plant. In 1982, it was decided that a steam boiler would be converted to burn biomass and peat. About 40% of the investment costs were provided by the Swedish Government through the Oil Replacement Fund. The retrofitting of the steam boiler was completed in 1984 and further reduced Växjö's oil needs and resulted in 80% of the city's heating needs being met by biomass. As in the previous investment, it released capital from reduced oil reserves.

Through these conversions, annual SO_2 emissions decreased by 70% and NO_x emissions were reduced from 220 tons to 170 tons per annum. Additionally there has been a decrease in CO_2 emission, from 170,000 to 40,000, a reduction of almost 80%.

Biomass electricity

Stimulated by the Swedish Government's Biomass for Electricity Fund which subsidises roughly 20% of the capital investment in electricity-generating biomass plants, VEAB is now expanding its biomass programme further. A new facility will increase VEAB's electricity production from 17 to 38% of Växjö's total consumption.

In the process, the company has also created more than 100 jobs in Växjö for lumberjacks, those involved in chipping wood, and transportation of the feedstock. Also by substituting biomass for oil, VEAB has contributed to improving Sweden's balance of payments.

Problems in using biomass

It is clear that VEAB views biomass very favourably, but there are some environmental issues that need to be considered such as the disposal of the wood ash produced in the burning process. At the moment, the ash, which contains an amount of nutrients, is dumped in landfills rather than being returned to the forests. The main reason for this is the concern with the risk that spreading of wood ash on areas other than where the biomass came from could increase heavy metal loads in the topsoil and lead to environmental damage. Biomass producers, on the other hand, argue that as ash is a part of the natural life cycle, returning it to the forest will not result in a net increase in heavy metals.

Some of the disadvantages of the use of biomass are: it cannot be stored for more than a few months; wood chips can selfignite if not properly stored; and biomass is bulky in relation to its calorific content, and therefore uneconomical to transport long distances by road.

VEAB hand in hand with Swedish Energy Policy

The development of VEAB's programme has been closely related to Swedish energy policy, and each of VEAB's investments has been wholly or partially funded by grants from the Swedish State. The first biomass boiler was realised largely for national security purposes, as a result of the 1973-1974 oil embargo. The second biomass conversion boiler also came about partially due to political concerns in light of the rapidly increasing crude oil prices caused by the "second oil shock" in 1979. Additionally, policy makers strongly believed that the world oil reserves were coming to exhaustion.

The latest conversion which is currently taking place is a response to the 1986 Chernobyl accident and a demonstration of Sweden's political will to comply with the 1980 nuclear referendum which stipulated that all nuclear reactors would be phased-out by the year 2010.

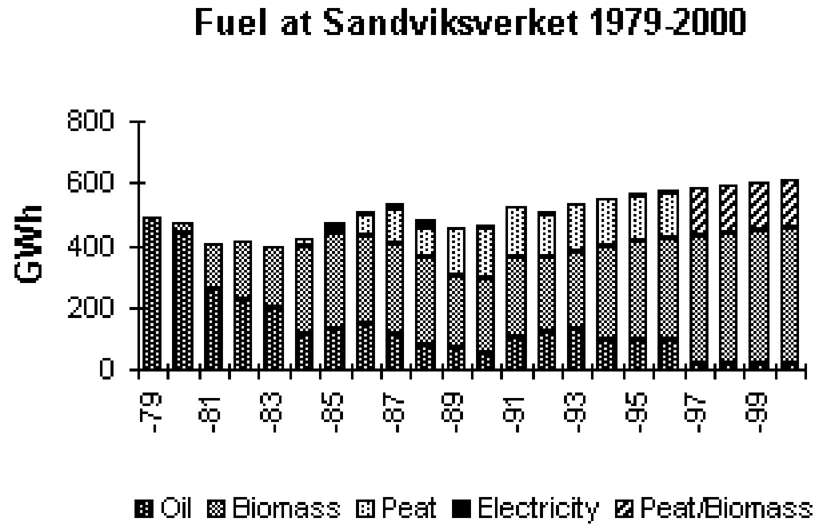
The economics of biomass

Biomass use at VEAB is currently profitable. Last year the company made a profit of 28.5 million SEK selling district heat and electricity on a turnover of 352.6 million SEK. There are several reasons for this. First, the initial biomass investment costs were all subsidised by the Swedish State and the boilers were profitable as soon as they went on line. Secondly, biomass is a relatively cheap fuel compared to oil and other fossil fuels as biomass is not subject to SO_2 and CO_2 taxes. Lastly, supply of biomass has so far outstripped demand, and forestry and sawmill owners are keen to sell biomass residues.

Lessons for others

The experience gained in Växjö has shown that the following criteria are important in realising biomass plant schemes that are commercially successful:

- some form of initial government subsidy;
- full support from local government;
- a forward-looking and committed management of the local utility;
- a regional forest base for a plentiful supply of residues that can be extracted at low cost;
- in order to gain support for biomass energy, clear and concise information to the general public and producers about the environmental and economic costs and benefits have to be provided.



By 1997, VEAB's oil consumption will have declined from over 50,000 tons/year in 1975 to 2,000 tons/year and dependency on national grid electricity will be 62% as opposed to 100% in 1975.

This article is based on the case study *The Use of Biomass Energy - In a Regional Context. The case of Växjö Energi AB* ***by Dr. Ragnar E. Löfstedt, Centre for Environmental Strategy, University of Surrey, Guilford, Surrey GU2 5XH, UK***

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Co-generation of Power and Heat from Sawmills in Zimbabwe

by Fredrik Mellqvist, SEI and Leif Palm, SwedSteam

There is considerable potential for productive utilisation of biomass residue from both sawmill and forestry operations in Southern and Eastern Africa. In an ongoing SEI-project, funded by Sida, the technical, economic and financial feasibility of a biomass-fuelled steam power plant in Chimanimani, a remote area in the Eastern Highlands of Zimbabwe is being investigated. Such a power plant can result in commercial gains for the private sawmill operator, socio-economic gains for the community and a new energy source for the region. Electricity produced from biomass residues could also substitute electricity produced from coal, thus reducing net emissions of CO2.

Zimbabwean energy policy has traditionally emphasised self-sufficiency. However, a series of drought years has threatened the balance between supply and demand. Despite imports of electricity, widespread shortages of power occurred in the late 80s costing the Zimbabwean economy an estimated 10 percent decline in GDP (1). Today, the electricity deficit is estimated at 7 percent. Imports to cover this deficit originate from South African coal-fired thermal power plants and Zambian hydro-power. In 1991, approximately 66 percent of the electricity generated in Zimbabwe was based on coal-fired plants and 34 percent on hydro-power. The national electrical energy development plan further emphasises the development of large-scale coal-fired thermal power plants in Zimbabwe although coal use is a major contributor to greenhouse gas emissions.

Plentiful supply of residue

The Chimanimani region in Zimbabwe provides excellent opportunities for utilisation of residues from forestry and sawmill operations for electricity generation. In fact, very large quantities of biomass residue have not had any productive use so far.

The recovery rate of the saw logs under bark is typically between 40 and 50 percent. The residue is mainly sawdust, chips and slabs. In addition, a lot of bark is generated at the rate of 7 percent of sawmill log input. As an example, the saw log input in the largest sawmill in the region, Charter Sawmill, is 200,000 m3 solid per year. The amount of residue left is considerable - 13,000 m3 of bark, 80,000 m3 of wet chips and sawdust, and 2,000 m3 of dry chips. The thermal energetic value of the residue from this sawmill alone would be around 185 GWh per year, enough to supply a 3 MW power plant, generating about 25 GWh of electricity annually (2). Since altogether five sawmills will be located in the Chimanimani area, the prospect for biomass-fuelled power and heat generation in Chimanimani looks very promising.

Technical, economic and financial feasibility study

A case study on the technical, economic and financial feasibility of a biomass-fuelled combined heat and power (CHP) plant located at Charter Sawmill is presently being conducted by SEI. The overall objective of the study is to verify how biomass residue can be used sustainably for power and heat generation. A lot of effort has been placed on establishing the potential volumes of biomass residue from both sawmill and forestry operations in the area, and the costs of extraction. From a technical point of view, well-functioning CHP-plants in e.g. Scandinavia indicate the effective potential of energy production from this source. Unfortunately, no CHP-plant was found in Southern Africa that could serve as reference for verifying local investment costs.

Effects of tariff structure

The potential of selling surplus electricity to the grid is a main component in determining the economic feasibility of an electricity generation investment that sawmills may want to make. Another one is the demand for steam in the drying kilns or in industrial processes. At present, ZESA, the national electricity utility, is prepared to pay a price in parity with the national average tariff, which is still too low to render many biomass-powered plants attractive from an economic point of view.

Concerning investment costs, one important determinant is the financial solutions available. Zimbabwe is a high inflation country - 25 percent in 1995. It is extremely difficult to give a fair view of the investment's long-term economic outlook without detailed information on the alternative financial constructions, given this high inflation rate.

Environmental effects

A direct global environmental gain of a biomass-fuelled power plant in Chimanimani would be less net emissions of CO2, since electricity generated from coal would be substituted by electricity generated from biomass. But for this activity to be translated into local and social environmental gains it is important to protect natural forests from increasing pressure and avoid soil degradation by disseminating practices of forest management and reforestation.

The sensitivity for environmental issues is growing in the area. The owner of Charter Sawmill, Border Timbers Ltd., for instance, has started to implement a proactive corporate environmental policy. The company has made decisions to replant 5 percent of their estates with indigenous species to recreate natural habitats, and leave the vegetation around streams to minimise removal of silt caused by erosion. Also the authorities have increased their regulatory demands by opposing the practice of burning biomass residue directly infield and by demanding more advanced types of incinerators.

Considering the large amount of sawmill residue either burnt in inefficient incinerators at the sawmills or burnt directly infield, there is significant potential for increasing the local power generation and at the same time improving the environmental conditions under which biomass is used in the Chimanimani region.

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(1) Peter Robinson, 'Governments, utilities and donors: reflections on experience in Zimbabwe and South Africa', in Anton Eberhard and Paul Theron, eds., International Experience in Energy Policy Research and Planning, Elan Press, Cape Town, 1993, p 172.

(2) Data used is 8,500 hours in operation and a power plant that can convert

14 percent of thermal energy into electricity.

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The Need for Research on Modernised Biomass in the Global Energy Economy

by Robert H. Williams, Center for Energy and Environmental Studies, Princeton University, USA

The potential climate change and local air pollution benifits of some modernised bioenergy technologies, the possibilities that some modernised bioenergy technologies can compete with coal, and the potetnial contributions biomass energy can make in promoting rural development have lead various groups to project major potential contributions to world energy from biomass energy in the future (Dessus, 1992; Johansson et al., 1993; Lashof and Tirpak, 1990; Kastler, 1994, WGII, 1996). Despite these prospective benefits, large-scale use of biomass for energy has been challenged on various grounds - especially competition with food production and the setting aside of land areas for natural habitat preservation.

The potential for land-use competition is a reflection of the fact that biomass production is an inefficient way to harness the sun's energy. While some modern biomass energy options have good prospective economics despite this inefficiency, its high land-use intensity implies that for biomass to become a major contributor to a modern energy economy, it will be necessary to overcome potential obstacles associated with competing uses for the land.

While preliminary scoping studies indicate that in many regions potential conflicts with food production could be minimised if agricultural production could be modernised, so doing requires increasing chemical and energy inputs to food production. In principle, low-cost biomass energy made available in rural areas could attract industry to rural areas that could generate the incomes needed to pay for the intensification of agricultural production. But how would this dynamic work in practice? And could agricultural expansion via intensification be made more environmentally desirable than expansion that involves putting more and more marginal lands into food production? The potential for conflict with land set-asides for preserving biological diversity has received less attention than the potential for conflict with agricultural production.

The potential for land-use competition, especially with food production and the setting aside of land areas for natural habitat for preservation, warrants more careful scrutiny on a region-by-region and country-by-country basis. Assessments are needed of the land use issues associated with biomass energy farms or plantations, giving attention to scale issues (e.g. what is the appropriate mix of large-scale plantations and small-scale farm forestry, given the socioeconomic-cultural context of the region?), and highlighting the key socioeconomic, cultural, and environmental issues that must be addressed to make plantation energy viable where it is feasible.

Deforested and otherwise degraded lands have been identified as promising candidates for establishing biomass plantations (Johansson et al. 1993). Broad-brush assessments indicate that degraded land areas suitable for reforestation in developing regions are large in aggregate.

But the potential for using such lands for energy plantations must be much better understood. Part of what is needed is a region-by-region assessment of degraded lands that might be considered for biomasss energy plantations or energy farms - indicating total potential areas, prospective yields, distribution by sub-region and size of typical land plots, socioeconomic-cultural conditions, and key technical challenges that must be addressed. In addition to such assessments, field research is needed on a region-by-region basis to identity and develop technical strategies for restoring these lands to the point where they can be used productively and sustainably for biomass energy purposes.

Considering the large potential benefits relating to rural development, climate change, and local air pollution, together with the concerns that have been raised about large-scale development of modernised energy (especially plantation-based biomass energy), a substantial research effort is called for to address these concerns. If such research activities could be launched in the near term, the issues involved could be much better understood before large-scale commitments to biomass plantation development were made.

There is time to do the needed research because modernised biomasss energy industries will be launched largely via the use of residues over the course of the next decade or so, and because where natural gas is readily available, biomass energy will have difficulty competing until natural gas prices are much higher than at present. But this should not be reason to delay undertaking the needed studies. These biomasss energy plantation assessments are needed in the near term in order to give prospective industrial developers a sense of the long-term market potential. The extent to which developers will consider the bioenergy option seriously depends sensitively on what they think the long-term markets will be.

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Publications

Solar Heating in Cold Regions - A technical guide to developing country applications

by Jean-François Rozis and Alain Guinebault

Targeting mainly technicians, architects and designers, this book provides technical guidance to the design and production of solar installations in regions where heating is a major issue. In fact, about half of the population in developing countries live in regions defined as cold, where average annual temperatures are lower than 10 degrees C.

The book covers case studies of passive solar techniques in developing countries, describes typical installations, shows how to produce, size and install them and also tackles the underlying theory of solar heating.

1996. ISBN 1 85339 329 0. 167 p. Intermediate Technology Publications 103/105 Southampton Row, London WC1B 4HH, UK.

Nordic Energy Systems - Historical Perspectives and Current Issues

edited by Arne Kaijser and Marika Hedin

In many industrialised countries the challenges as regards electricity systems have changed. While previously focus was put on meeting growing demands by increasing supply and transmission networks, the challenges of today are more institutional in nature i.e. increasing the system's overall operational efficiency where the challenges are legal and organisational

This book explores the historical roots of the Nordic electricity systems with special emphasis on institutional structures and the relations between the establishment of the present energy systems and the role of industry. It goes on by exploring present institutional changes due to the deregulation of electricity markets, growing environmental concerns, and increasing energy trade across national borders. Contributions were made by historians, social scientists and utility managers from Nordic countries.

1995. ISBN 0-88135-164-4. 246 p. Science History Publications/USA.

Energy Utilities and Institutions in Africa

by G. Elfaki Ali, I. A. R. Elgizouli, B. A. Okech and P. M. Nyoike

This book illustrates the features and problems in the energy sector of Sub-Saharan Africa. It is based on research carried out in Kenya and the Sudan. Questions of structure and process within energy utilities, their financial and technical performance, their ability to formulate and implement policies and strategies in fulfilment of their responsibilities and their technical and managerial competence and skills are covered.

1996. ISBN 1-85649-459-4. 203 p. Zed Books Ltd., 7 Cynthia Street, London N1 9JF, UK in association with the African Energy Policy Research Network (AFREPREN) P.O. Box 30979, Nairobi, Kenya.

Comparing energy technologies

by OECD/IEA

A major reason why current methodologies for comparing energy technologies have developed is the internationally agreed mission to mitigate further green house gas emissions. This OECD/IEA publication summarises and discusses current methodologies for comparing energy technologies, Life

Cycle Analysis (LCA) being one major issue. Case studies exemplify governments' implementation of these methodologies in their Energy R&D programmes.

Besides giving an up-to-date picture of the commonly used methodologies the publication highlights the underlying difficulties in applying them effectively. How does one formulate the criteria for selection? What are the appropriate boundaries of analysis? What are the managerial goals for the national energy sectors except curbing future green house gas emissions - should for example unemployment be included?

The work is published under the responsibility of Robert Priddle, Executive Director at IEA. A total of ten authors have contributed.

1996. ISBN 92-64-14 660-1. 336 p. OECD/IEA Head of Publications Service, OECD, 2, rue André-Pascal, 75775 PARIS CEDEX 16, France.

Rural Energy and Development - Improving Energy Supplies for Two Billion People

The World Bank

For nearly two billion people in developing countries, the search for energy is a daily grind. These people have neither electricity nor gas nor oil to cook their food. This report describes in detail the plight of these two billion. Its message is however, that there are now many ways in which their situation can be improved.

In recent years the World Bank's work in energy has largely been focused on making existing energy supply and consuming industries more efficient, opening them to competition, and encouraging private sector participation. Appreciating this important job, it is also recognised that reforms will fail in the long-run if they do not benefit the whole population. Improving rural energy is therefore seen as an important goal in itself.

The message from this book is that through a combination of better technology and decades of experience, we are now able to tackle the problems of rural energy better than ever before. The report draws on the experience of many experts in government, industry and non-governmental organisations.

1996. ISBN 0-8213-3806-4. 118 p. The World Bank Development in Practice Series. The World Bank, 1818 H Street, N.W., Washington, D.C. 20433, U.S.A., Telephone: (202) 477-1234, Fax: (202) 477-6391, World Wide Web: http://www.worldbank.org, E-mail: books@worldbank.org.

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The World Solar Summit took place in Harare, Zimbabwe on September 16-18, 1996. Representatives from 100 countries, organisations such as UNESCO, FAO and UNDP, NGOs and private companies met and declared their genuine interest in supporting the increased use of new and renewable sources of energy. The World Solar Declaration including the World Solar Programme 1996-2005 was approved, a sign of the political commitment to actively pursue the use of renewable energy in the world.

The Harare Declaration on Solar Energy and Sustainable Development recognises the commitment of the signatories to further promote the use of renewable energy to enhance economic and social development, maintain mechanisms that will speed and facilitate the use of renewable energy through international co-operation, and to use existing international funding mechanisms to support renewable energy development.

The vision is to rapidly increase the use of renewable energy and to improve energy efficiency in order to achieve a sustainable energy path with economic and social development for the world's population.

The World Solar Programme 1996-2005, consisting of 300 high priority regional, national and strategic projects of universal value, is expected to be a "solar highway" leading to sustainable development.

The Programme will be executed under the leadership of the World Solar Commission over the next ten years. A detailed structure for the Programme will be negotiated and developed over a nine-month period following the Summit.

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