SWAZILAND NATIONAL ENERGY POLICY PROJECT

Background report on energy efficiency

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1. Introduction

This report is part of the Swaziland National Energy Policy Project (SNEPP) that is being executed by the Ministry of Natural Resources and Energy (MNRE) with assistance from the Danish Co-operation for Environment and Development (DANCED). This project began in August 1999 and will continue through to June 2002. The immediate objective of SNEPP is to develop an implementable national energy policy that considers the economic, social and environmental principles so as to contribute to the sustainable development of Swaziland. The outputs from SNEPP will be a draft national energy policy including solar, wind and hydropower measurements, capacity building of the energy section of MNRE, and increased awareness of energy issues among the different stakeholders in the energy sector.

SNEPP is utilising both consultative and participatory approaches and involving stakeholders and decision makers at various points in the policy formulation process while undertaking the project. Eight working groups have been formed, structured around a number of identified energy issues, and 'energy savings and energy efficiency' was one of these groups. Parallel to the eight established working groups, three technical background reports that included analyses and assessment were solicited, of which this report on energy efficiency is one. The others are on the use of indigenous resources for electricity and heat generation, and on energy use in non-grid-connected areas.

This report will, then, examine energy efficiency and savings in the Swaziland energy economy, while incorporating appropriate African and international experiences. In Section 1, a general discussion on energy efficiency provides background. Issues and barriers to energy efficiency are then briefly commented on, before energy efficiency in Africa is briefly looked at, along with some international experiences that could be useful to Swaziland. The second section presents various technology options, policy options and programmes which can be used to increase energy efficiency in the different economic sub-sectors of Swaziland. As a prelude to these options, the energy situation of Swaziland is discussed. Section 3 recommends a number of policy options for Swaziland to consider, including discussion on how these options can be implemented in a Swaziland context.

2. Energy efficiency

Generally, energy efficiency can be seen as technical efficiency (enthalpic efficiency relating to the first law of thermodynamics, or as entropic efficiency relating to the second law of thermodynamics), or as economic efficiency (Brookes 2000). Technical efficiency refers to the technical potential of an energy efficiency measure, while the economic efficiency refers to the economic potential or cost-effectiveness of the measure. In practice, any energy efficiency measure involves these two types of efficiencies, but depending on the energy efficiency measure one type may be more pronounced than the other. In general, improving the technical efficiency in energy conversion can be just as important as improving cost-effectiveness, especially when the measure involves behavioural changes. Because implementing an energy efficiency measure mostly involves costing, however, cost-effectiveness tends to be more important. Hence, energy efficiency in this report will be considered in terms of both technical and economic efficiency.

Undertaking an energy efficiency exercise involves finding ways to reduce the quantity of energy needed to produce a service or a unit economic output, or increasing the amount of service derived from a given energy input. Therefore energy efficiency can be introduced at any point in the energy chain, from extraction to end-use. In global terms, at present only 37% of the primary energy supplies ends up as useful energy (WEA 2000) – a clear indication of the significant inefficiencies and losses in the way energy is produced and used world-wide. Normally, inefficiencies and losses associated with energy extraction, conversion, transportation, and distribution of final energy are referred to as supply-side energy efficiency, while those relating to the conversion of the final energy to useful energy that leads to energy service are referred to as end-use energy efficiency. This chapter will limit itself to end-use energy efficiency, as supply-side efficiency will be treated in other working group reports

The oil price hikes in the 1970s triggered energy efficiency in most parts of the world because of the intense search for alternatives to crude oil and for ways to reduce energy demand. Due to the pervasiveness of the oil price impacts, significant gains were made worldwide, especially in the developed countries that were the major consumers of crude petroleum and its derivatives. A striking change that occurred as a result of energy efficiency improvements was a decline in energy intensity (energy use per unit economic output), which signalled the de-coupling of energy use and economic growth, especially in developed countries (Morovic 1987; IEA 1997). This was an important turning point in energy analysis because it was a departure from the established belief in a direct correlation between energy use and economic activity. By utilising energy intensities for different demand sectors, improvements in energy use without sacrificing economic productivity can be identified.

An interesting feature of improving energy efficiency was its implication for environmental concerns, especially the threat to climate stability caused by the increased concentration of greenhouse gases (IPCC 1995). This is directly linked to energy production and use, because this sector accounts for over 70% of carbon dioxide emissions – by far the major contributor of greenhouse gases – to the atmosphere. Furthermore, energy efficiency measures can result in the reduction of other greenhouse gases and pollutants such as SO_2, NO_x, and dust. In short, improving energy efficiency can lead to substantial environmental gains.

Caution is needed in dealing with energy efficiency gains, because the literature suggests that increase in energy efficiency tends to stimulate energy demand – generally referred to as the 'rebound effect' in energy efficiency. This effect can be weak if some of the energy gains are lost, or strong if all the efficiency gains are lost (Schipper & Grubb 2000). This explains why energy efficiency and energy savings must be closely monitored to ensure that expected gains are realised. Another caution is that where there are cases of significant unsaturated energy demand, as in many African countries, energy efficiency gains are treated as energy supply, because gains achieved are quickly consumed by the suppressed demand in those countries (Davidson & Sokona 2001).

2.1 Barriers to energy efficiency

Historically, it has been shown that most of the gains predicted in energy efficiency measures are not realised in practice, because of the activities of the various stakeholders involved – including customers, manufacturers, financiers, utilities, regulators and government agencies. This poses serious challenges, because strategies may be required to reduce or remove barriers that may prevent the full realisation of energy efficiency measures. These barriers can be grouped as information barriers, institutional barriers, social barriers, financial and market barriers, and technical barriers.

Information barriers

Most studies have shown that the greatest impediment to fully realising energy efficiency measures is lack of information on energy efficiency technologies or the possible gains from energy efficiency measures (Williams & Ross 1980; Carl Smith *et al* 1990). Usually this lapse is due to the different levels of knowledge between various actors, and is normally referred to as an 'information gap'. The gap occurs between the different stakeholders of energy efficiency, but more so between the buyer and seller of energy efficiency measures. Mostly, the buyers lack the appropriate knowledge to make the necessary decisions regarding selecting, operating and maintaining the devices involved in the proposed measure. Increasing the knowledge of users of an energy efficiency measure will promote the use of energy efficiency options.

Institutional barriers

A major institutional barrier is the lack of promotion of energy efficiency by national governments, which are expected to provide the lead to other stakeholders for full participation in promoting energy efficiency measures. One way of demonstrating commitment by governments is by establishing a national efficiency programme with clear objectives, so that other parties can be guided.

Most energy institutions existing before 1980 were not designed to cope with new issues such as energy efficiency, especially in developing countries. Therefore, activities that will assist the promotion of energy efficiency, such as information dissemination, monitoring, evaluation and verification of energy efficiency measures, are hardly carried out. Such exercises are crucial to achieve energy efficiency gains and to ensure effectiveness. Some developed countries have adequately equipped institutions, though in some of these the respective functions may be carried out in different government departments. Also, in a good number of countries, 'energy efficiency centres' are used, to stimulate and accelerate the adoption of energy efficiency measures, as well as to introduce new ones. This initiative may be considered for other countries.

Another institutional constraint is the lack of a suitable legal framework and accompanying regulations to promote energy efficiency. Without necessary regulations it is difficult to market efficiency measures. They are also necessary to develop and enforce the standards that will stimulate efficiency measures, as most earlier energy regulations did not take energy efficiency into account.

Social barriers

Unfortunately, the poor are the most likely to be involved with the devices and practices that are least energy-efficient, especially in the residential sector (Clinch & Healy 1999). The paradox is that the poor usually cannot afford proposed measures and so end up not adopting them. Unless special financial programmes are instituted for the poor, such as credit facilities, they will be unable to access these measures. The usually high discount rates and high risks associated with poor people do not help the situation either, because conventional banks cannot address their problems.

Financial and market barriers

The difference in perception between personal and societal benefits always tends to affect decisions by individuals, and this can prove to be an obstacle to adopting a particular energy efficiency measure, because benefits from such measures are not always personal. Hence, measures with more societal benefits than personal can be ignored.

Another obstacle to energy efficiency is high interest rates for loans, because energy efficiency measures that involve high capital expenditure will be affected, as most people need assistance for involvement. This is more relevant in developing countries, where incomes are generally low. The situation worsens if the expected gains from adopting the measure cannot be easily recognised. Apart from high interest rates, if the measure attracts high taxes then it becomes difficult to be adopted, as most people tend to run away from taxes.

The costs for learning about the measures to ensure proper selection, installation and use (normally known as transaction costs) can be high, depending on the national situation, and since this cost is not always included in the cost-benefit analysis that is used to determine payback periods, high cost can affect decisions regarding the use of energy-efficient technologies. In technology-deficient countries (as generally applies in Africa), these costs can be very high and can offset expected gains. A major problem is that such costs are not easy to evaluate and so cannot easily be integrated.

Energy pricing can also be an obstacle to the adoption of an energy efficiency measure. Low energy prices, which in some cases may not reflect real costs and externalities, and low tariffs for large users, can have a significant influence on a particular measure. In the case of electricity, a pricing system that severely penalises peak loading may lead to reducing peak loads rather than optimising consumption.

Technical barriers

Technical deficiency is more common in developing countries where there is lack of suitably trained specialists and other capacities for installing, operating and maintaining energy efficiency measures. This lapse can easily result in the particular measure malfunctioning. A lack of adequate spare parts can affect full implementation.

In addition, some countries (particularly developing ones) lack the R&D support system for energy efficiency measures and this creates an obstacle for the follow-up that may be required for gains to be fully realised. Creating useful linkages between institutions can overcome this obstacle significantly, by maximising the availability of skills.

2.2 Energy efficiency in Africa

Africa has abundant, diverse and unexploited renewable and non-renewable energy resources, but is the worlds lowest consumer of primary energy: 21GJ per capita in 1996, as compared to Latin America (50GJ) and (30GJ) (Davidson & Sokona 2001; WEA 2000). Some specific features characterise the African energy economy, such as the highest production to consumption ratio in the world (apart from the Middle East), and high dependence on fuelwood for cooking.

There are significant disparities in Africa's energy economies. On average, about 40% of total commercial energy is used in six countries in the northern sub-region, and a similar share in Southern Africa (80% of which by South Africa alone); the 40-odd remaining countries use 20%

(Davidson & Sokona 2001). This feature is more striking on a per capita basis. In 1996, per capita energy consumption in North Africa was 29.2GJ, and in Southern Africa 27.2 GJ, while in the rest of Africa it was 2.5GJ, as shown in Table 1 (WEA 2000). There is a heavy reliance on fuelwood, which is used at less than 15% efficiency. The use of commercial energy is also inefficient in comparison with other regions. Significant potential therefore exists for improving energy efficiency in the continent.

The trend in energy intensity of African countries has not been encouraging. In most developing regions, energy intensity is declining, but, as shown in Table 1, this has not been the case in Africa, where energy intensity is very low, and has remained constant or has increased. Substitution of commercial fuels for non-commercial fuels will play a part, but much energy use is not for production and so has a minimal impact on the economy.

Table 1: Ratios of primary energy to GDP in developing countries, 1975-95

Country or region	*Energy consumption per capita, 1996 (gigajoules)*	*Megajoules per unit of GDP (1990 purchasing power parity dollars)*				
		1975	*1980*	*1985*	*1990*	*1995*
China	36.3	23.4	22.6	17.3	15.0	10.9
India	14.6	7.5	7.8	8.3	8.7	9.2
Indonesia	18.4	3.3	4.2	4.6	5.4	5.4
Argentina	64.1	8.0	8.4	9.2	9.6	9.6
Brazil	61.0	4.6	4.6	5.0	5.4	5.9
Mexico	61.4	7.2	8.2	8.5	8.7	8.7
Venezuela	94.0	10.5	11.3	12.6	12.1	12.1
North Africa	29.2	5.4	6.3	7.9	8.8	9.4
Southern Africa	27.4	10.8	11.6	15.2	3.9	14.4
Rest of Africa	2.5	2.5	2.6	2.9	2.6	2.9
Middle East	80.4	8.4	10.9	17.6	20.9	22.6
Russia	170					36.8
USA	340					

Source: WEA: 2000

As mentioned, Africa has significant potential for energy efficiency improvements, in both the supply and demand sectors. Co-ordination of energy supply offers a major opportunity for efficiency of energy supply, as can be shown in the Southern African Power Pool and the West African Gas Pipeline projects. Improvements of energy use in existing power plants provide some opportunities – up to 10% gains can be achieved with little or no cost measures. Due to the high transmission and distribution losses recorded for most power utilities in the region, reducing such losses using well-known technical and other measures is possible (Davidson & Sokona 2001). The greatest potential among the demand sectors is in industry, households and transportation, which account for about 80% of total consumption (Adebulugbe 1993). Use of more modern demand-side management (DSM) practices can result in 10-30% savings on consumption. For example, 15% can be achieved through housekeeping measures and up to 40% with use of more modern equipment for cooling, etc, (Davidson & Sokona 2001).

Data are relatively scarce, but the recent World Energy Assessment estimated that savings between 15% and 32% can be achieved in 2020. A recent study in Mozambique shows a savings potential of 20% in industry. Improving the energy efficiency of cooking provides the greatest potential in the residential sector, because the use of firewood is very inefficient, with over 85% of the useful energy lost. The transport sector also provides opportunities, although most of the vehicles in a largely road-dominated continent are imported. The average fuel efficiencies are very low, mainly because of the age of the fleet and poor maintenance (Adebulugbe 1992). It is estimated that savings of up to 30% are achievable. Energy pricing rationalisation also provides opportunities for energy savings in both the electricity and the transport sectors, especially the former. A summary of potential energy savings in the continent is given in Table 2.

Table 2: Economic energy efficiency potentials in Africa, 2020

Sector and area	*Economic potentials (%)*	*Country*	*Energy price level assumed*	*Base year*	*Source*
Industry					
Total industry	15	Zimbabwe		1990	TAU, 1991
	about 30	Zambia		1995	SADC, 1996
	32	Ghana		1991	Davidson & Karekezi, 1991; Adegbugbe, 1992a
	25	Nigeria		1985	
	>20	Sierra Leone		1991	Davidson & Karekezi, 1991; SADC,1997
	20	Mozambique			Adegbulugbe,1993
Iron and steel	7.2	Kenya			Nyoike, 1993
Cement	11.3	Kenya		1998	Nyoike, 1993
Aluminium (sec.)	15.4	Ghana		1993	Opam, 1992
Refineries	9.8	Kenya		1988	Nyoike 1993
Inorganic chemicals	44.8	Kenya		1998	Nyoike, 1993
Consumer goods	6.3	Kenya			Nyoike, 1993
Food	19.0	Kenya			Nyoike, 1993
Co-generation	25	Kenya			Nyoike, 1993
	16-24	Mozambique			SADC
	1-30	Ghana			Opam
	600 MW	Egypt			Alnakeeb, 1998
Residential					
Electric appliances	20-25	Mozambique	1993	1991	SADC, 1997
	11	South Africa		1995	*Energy Efficiency News, 1996*
Commercial/public/agriculture					
Electricity	20-25	Mozambique	1993	1995	SADC,1997
Agriculture/forestry	up to 50	Egypt	1988	1998	Alnakeeb & others,1998
	12.5	Tanzania (bio-power)	1993	1993	
Transportation					
Cars, road system	30	Nigeria		1985	Adegbulugbe, 1992a
Total transport	30	Nigeria		1995	Mengistu, 1995

Source: WEA: 2000

3. Swaziland

Background

Swaziland, a land-locked country with a land area of 17 362 square kilometres, has an estimated population of just under one million (1995), and an estimated annual growth of 3.4% (Energy Bulletin 1997). The country is divided into four geographical regions: the western-most zone covers 29% of the land area, the main activity being the wood processing and pulp industries; the subtropical hilly region covers 26% and is the most densely populated area, with the main commercial and industrial centres; the dry lowveld contains the agro-based industries and coal deposits, covering 37% of the country; and, lastly, the Lubombo plateau near the Mozambique border.

GDP per capita in Swaziland was US$1100 in 1995 based on the exchange rate, but using purchasing power parity, the GDP per capita is given as US$3490. Within the African context, Swaziland can be considered as a middle-income country. Agriculture accounts for about 11% of the GDP, while manufacturing industry accounts for a third. The main industries are coal mining, asbestos and agro-based industries (wood pulp and sugar). Manufacturing is the main driver of the economy, while mining's share is declining. Agricultural activities are largely subsistence, and sugar remains the major revenue earner from this sector.

Being land-locked, Swaziland depends largely on South Africa, which accounts for 90% of its imports and over 50% of its exports. Dependence on South Africa includes trade, transport and communications, investments and energy, as well as employment. Remittances from Swazis working in South Africa account for about 20% of domestic income. Between 1968 and 1996, the economy grew by 6.5% annually; since 1986 growth has been mainly due to the manufacturing sector, which, by 1995, accounted for 36% of GDP – while previously dominant agriculture accounted for 10%. The manufacturing sector mainly comprises sugar processing, wood pulp production and fruit canning. The country is engaged in two formal economic relationships with South Africa: the Southern Africa Customs Union (SACU) and the Rand Monetary Area (RMA). This means that customs and excise revenues are pooled and distributed according to an agreed formula and the national currency, the lilangeni and the rand are at par and are both legal tender in Swaziland.

3.1 The energy sector of Swaziland

Swaziland largely depends on South Africa for energy imports, which include electricity, petroleum products and coal. This could create energy security problems but with the country now a member of the Southern African Power Pool (SAPP), the potential for such supply problems has lessened.

The country has large reserves of good quality semi-pure and pure anthracite coal, but at present all the coal used in the country is imported, because the equipment used in Swaziland works better with imported bituminous coal. This is an area for attention, because the country should use equipment that is more suited to locally available coal. Other indigenous energy resources in Swaziland include bagasse, forestry wood waste, and wastes from agriculture, industry and household sectors, hydropower, wind, solar and geothermal energy sources. Theoretically, these energy sources could make Swaziland self-sufficient in energy, but there are major economic and technical challenges to overcome.

The sugar industry, an agro-based industry and other manufacturing industries use 65% of coal produced, and the household sector uses 23%. Imported diesel and gasoline are mainly used in the transport sector. The other petroleum products used are paraffin, used for lighting in rural households and cooking in some urban and rural households; LPG, used mainly in both rural and urban households; jet fuel used in aviation; and heavy fuel oil used in industries.

Of the electricity consumed, 70% is supplied through the national grid, with the remainder self-generated by establishments in industry, agriculture and service sectors for their operational requirements. Total electricity consumed in 1995 was about 580GWh, of which 53% was consumed by industry, 21% by agriculture and 8% by commerce and services. Electricity production is generated from four hydropower plants (which are vulnerable to drought). Production by the hydro plants has varied considerably over the past years from a minimum of 77 207MWh in the drought year 1992, to 213 251MWh in 1989. However, the majority of the power requirement is imported from Eskom: 96MW. A 400kV line, established in 2000, will provide supply by Eskom to the MOZAL aluminium smelter plant in Mozambique, and also provide up to 250MW to Swaziland. Presently the Swaziland electricity supply industry is being restructured to allow private participation and third party access.

Biomass, comprising bagasse, woodfuel (firewood and wood waste from sawmills and plantations), and small amounts of agricultural waste and animal waste, accounts for more than 60% of final energy consumption. It is the major household fuel and also the major source of electricity self-generation in the sugar, pulp and saw mill industries. The use of biomass is strategic to the country and is an indigenous resource. The sugar and pulp timber industries produce large quantities of by-product during the processing of raw materials. In the sugar industry 12 500TJ of bagasse were produced in 1995, 10 670TJ of bagasse were used for industrial process heat and 1 800TJ were used to generate electricity. The pulp and timber industry used 740TJ of wood waste during the same period for electricity generation.

Some specific features of the energy sector of Swaziland in addition to those given above are that the coal produced is exported while the coal consumed is imported from South Africa. The problems in the sector include: high-energy dependency, high environmental impacts resulting from biomass use, poor access to electricity in rural areas, and poor planning and information systems.

Energy demand in Swaziland is set to grow as the country become more urbanised (only 25% now live in urban areas) and the desire for more urban lifestyle increases. This expected widening income disparities and health problems related to AIDS may moderate growth.

Swaziland energy balance

The following discussion concentrates on end-use energy efficiency, and the section considers the various energy efficiency potentials of the energy demand sectors as identified from the energy balance. The features of the energy balance that are of direct relevance are the following:

- Half of the total final energy consumption is used by industry (49.7%).
- The second largest consumption is by rural households (22.9%). The consumption of woodfuel in rural households is high (20.9% of the total energy consumption)
- Transport energy accounts for 16.7%.
- Urban households account for 7.7%.
- Agriculture, commerce and services, and mining are minor contributors to the total energy consumption accounting for only 1.8%, 0.7% and 0. 6% of the total respectively;

The dominance of the industrial sector is clear, and three sectors – namely industrial, households and transport – account for almost 78% of the total energy consumption in the country, a trend similar to that in many African countries, as discussed earlier. However, contributions from the commercial and public sector could be more than 0.7% but the discrepancy may be due to how electricity consumption is reported in these sector, especially the difference between commercial and industrial sectors not always well defined. Most of the discussion below will focus on these three major energy-consuming sectors, as it is them that will have the greatest impact on energy efficiency.

Table 3: Energy balance of Swaziland, 1995

Energy carrier (1)	*Coal*	*Gasoline (2)*	*Diesel*	*Kerosene (3)*	*LPG (4)*	*Jet fuel*	*HFO (5)*	*Electricity*	*Wood fuel (6)*	*Bagasse*	*Other (7)*	*Total*
Unit used	*TJ*	*TJ*	*TJ*	*TJ*	*TJ*	*TJ*	*TJ*	*TJ*	*TJ*	*TJ*	*TJ*	*TJ*
Total primary energy supply	5000	3240	3400	360	200	130	170	2580	9730	12530	440	37780
Production	5500							390	9730	12530	440	28590
Imports	5000	3240	3400	360	200	130	170	2190				14690
Exports	-5500											-5500
Total transformation	-1160	0	-10	0	0	0	0	310	-740	-1860	0	-3460
Transformation												
Public power plants		-10						0	-10			
Self generation	-1160							800	-740	-1860	-2960	
Distribution losses/self use								-490				-490
Total supply after transformation	3840	3240	3390	360	200	130	170	2890	8990	10670	440	34320
Total final energy consumption	3840	3240	3390	360	200	130	170	2890	8990	10670	440	34320
Agriculture		100	160				1	340				601
Mining			30					170				200
Industry (8)	3020	370	410	70	8		169	1530	800	10670		17047
Transport	40	2760	2790		2	130		20				5742
Commerce & services		10			10			210				230

Subtotal households	780		0	290	180	0		620	8190	0	440	10500
-Urban	780			130	130			570	1000		20	2630
-Rural				160	50			50	7190		420	7870

Notes:
1. Only presently relevant energy carriers considered; excluding molasses which is mainly being used for non-energetic purposes and export commodity
2. Gasoline (petrol) comprises petrol 93 and petrol 97
3. Kerosene comprises illuminating paraffin and power paraffin
4. LPG is the acronym for liquefied petroleum gas
5. HFO is the acronym for heavy fuel oil
6. Woodfuel comprises firewood (non-commercial, commercial) and industrial wood waste
7. Other comprises candles, agricultural wastes and animal wastes

Discussion of issues raised at SNEPP

In the Discussion Document No 1 (September 2000), SNEPP identified some areas for discussion, including energy savings and energy efficiency. It was envisaged that energy efficiency and energy management programmes could contribute to fulfil policy objectives in the SNEPP, because cost-effective reduction of energy consumption would have a number of national benefits, including improved balance of payments, environmental gains, job creation, improved security of energy supply, and overall positive contribution to the national economy. Two issues identified in the Document which are particularly relevant to the present report, are the promotion of energy efficiency and energy management, and the role of the government in energy efficiency. Based on these issues, the following policy options were identified in the Document:

- Develop knowledge and information on sectors and applications, where energy is used inefficiently, potentials for improvements and obstacles for the implementation of energy savings
- Support information, dissemination and education
- Establish energy awareness campaigns
- Establish support for energy audits
- Advise professionals and decision-makers in industry, commerce and the building sector
- Initiate demonstration projects
- Introduce financial schemes
- Establish minimum standards, codes of practice, norms and models of best practice

Issue no. 20 addresses energy conservation and energy efficiency in all demand sub-sectors, and poses the following questions:

- In which areas can the largest potentials for energy savings be identified?
- Which energy saving possibilities is the cheapest and as well as most cost-effective?
- How can cost-effective energy savings be promoted by the Government and implemented?

3.2 Possible energy efficiency options in the different sectors

3.2.1 Agriculture

Agriculture is not a major energy consumer, because of the relatively low level of mechanisation in agricultural practices, though the sector plays a critical role in the economy as a food provider and contributor to national exports. However, in Swaziland there are not large commercial farms as in South Africa, so energy efficiency potential in this sector is limited. Generally, energy needs in agriculture will depend on government policies in the sector. If agro-based industries are intensified, then practising energy self-sufficiency will be advisable. In that case, the use of ethanol as a direct transport fuel or as blend will be most appropriate. Replacing diesel with vegetable oils, or using them as additives, could be considered.

Planning agricultural systems better would provide opportunities for energy savings; for example, reducing bulk load travel by pre-processing of agricultural produce on site offers significant energy savings because of the inertia effect. Better routing can also contribute. However, these measures depend more on agricultural polices than on energy policies. Other policies and programmes that can assist in this sector include improved access to liquid fuels, acceleration of rural electrification, establishing rural service centres, and extending the availability of credit.

3.2.2 Commerce and services

This sector comprises a large range of activities such as offices of government and private, retail services, education, health-care, and catering. In Swaziland this sector is the lowest energy consumer, with only 0.7% of the total. Areas with saving potentials in this sector include heating, ventilation and air conditioning, building energy management systems, hot water generation, light and appliances. Possible technology options, policy options and programmes for this sector include the following:

Space conditioning in existing buildings:

Retrofit programmes for existing service sector buildings, such as introducing control systems and switches can help as much as suitable information in strategic places. Promotional programmes that aim at efficient energy systems will also be useful.

Space conditioning in new buildings

The government energy efficiency agency should introduce stringent energy efficiency standards for the new buildings. However, the necessary support systems, such as testing, monitoring and evaluating, should be done to ensure compliance. There are now far more efficient air conditioners, refrigerators and cooling systems. Overall building thermal integrity can be assured by using improved duct sealing, proper orientation, insulation and sealing, and energy-efficient windows.

Office equipment and appliances

Introduction and gradual tightening of efficiency standards for office equipment and other appliances is important. Use of more efficient computers and low-power mode for equipment are useful choices in selecting office equipment. Introduction of efficient escalators and lifts with the necessary control systems can lead to energy savings.

Lighting

Various measures exist to stimulate the use of efficient lighting systems, including compact fluorescent lamps, halogen IR lamps, efficient fluorescent lamps, and lighting control systems.

3.2.3 Households

Most rural households in Swaziland and a large fraction of public facilities do not have adequate (if any) access to reliable and affordable electricity. Access to grid electricity in rural areas was reported to be less than 5% in 1999. On the other hand, there is a shortage of fuelwood in some localised areas; and this is a major energy source in rural areas. Cooking and lighting dominate residential energy use in lower-income households. Possible technology options, policy options and programmes include those given below.

Information

The most important starting point is with various forms of awareness programmes, including exhibitions and demonstrations, mass media campaigns, brochures and leaflets, technical manuals, various types of training courses, and labelling of appliances.

Information programmes for the residential, commercial and institutional sectors are important, and considerable effort should be given to this instrument. If possible, information programmes could be combined with subsidy programmes. There is a large range of information, education and training programmes available. Government can try the use of multi-media as a new way to promote energy efficiency.

Financial incentives

A number of options, including national, multilateral or bilateral assistance, can support innovative schemes such as those tried out in Hungary, supported by Germany. Many studies show that it is not always a lack of finance that impedes practising certain measures – it can be a lack of confidence in the measure or a lack of information on the benefits available. Thus, programmes should target removing specific barriers.

Regulations
Regulations could be useful for appliance efficiency (including refrigerators, air-conditioners, lighting, etc), appliance labelling, and thermal efficiency standards. These regulations could be easily linked to voluntary agreements.

3.2.4 Industry and mining

The industrial sector is the major energy-consuming sector in Swaziland (49.7% in 1995, and, if the mining sector is added, accounting for 50.7% of the total energy consumed), thus providing the greatest opportunity for energy savings. Possible technology options, policy options and programmes for this sector include those given below.

Information
Lack of information tends to affect this sector most, so improving information is crucial in realising the opportunities available. Making technical manuals available and undertaking audit programmes are the most used strategies. Generally, audits can be undertaken within specific projects, rather than within long-term programmes. Audits are, however, seen as a form of enforcement of standards and norms. Training courses on auditing and good energy management systems are also useful.

Information programmes in the industrial sector are important. There is a growing interest in providing information related to best practice. There are also many programmes to disseminate information on new or emerging energy-efficient technologies; these programmes include technology competition, demonstration and exhibition, educational programmes, leaflets and newsletters and reports, and establishing collaborative networks.

New technologies and processes
As a result of continued progress in technology, several more energy-efficient technologies and processes now exist – improved lighting systems, more efficient motors and pumps, improved heat capture, better thermal cascading, etc. Use of combined heat and power in co-generation systems can lead to energy savings. Fuel switching also offers opportunity to achieve energy savings. Switching to natural gas, better use of biomass, and use of renewable energy are some options that can be tried. Material substitution can assist energy efficiency indirectly – such as replacing metals with plastic and concrete with wood. In general, lighter materials use less energy.

Financial incentives
Funding is an obstacle to the introduction of modern programmes to improve energy efficiency. The creation of revolving funds to provide the capital needed to upgrade plants could be the answer. The most effective strategy is programmes targeted to specific sectors or technologies.

Regulations
Energy managers could be employed and charged with the task with the task to develop plans to justify the need for a certain level of energy resources, and to allocate the resources received from a central body. Standards could be developed, with energy inspectors to enforce them. Penalties would be used to finance various funds.

Voluntary agreements
Voluntary agreements, which are normally agreements between governments and industries to achieve certain targets, can be important, because they provide industries with greater flexibility in achieving energy efficiency targets and help governments reach desired goals. Voluntary agreements could be linked with various financial incentives of the government for the industrial sector. Also, it provides government with the opportunity to undertake carefully planned audits to determine cost-effective targets that are achievable.

3.2.5 Transport

The transport sector is crucial to any developing country such as Swaziland, because at an early stage of social development most travel trips are work-related. Therefore the provision of adequate and affordable transport services is directly linked with developmental activities, especially moving freight around. Satisfying this demand in these countries has been a problem for a long time because of a lack of suitable public transportation for goods and passengers. A major difficulty in planning for all these lapses is correct and reliable data acquisition. A prevailing problem in the sub-Saharan region, for example, is the difficulty in differentiating between fuels used for passenger transportation and that used for freight (Davidson 1993). In general, transportation in Swaziland consists of several travel modes, but, as it is an inland country, road travel dominates, and the options that will be suggested take this factor into consideration. Possible technology options, policy options and programmes for this sector include:

Information

There is a need for general awareness programmes on good driving practices and on the benefits of public transport. Regular publicity campaigns encourage good driving practices and promote public transport. Many labelling programmes for new vehicles exist as well (see regulations below).

New technologies

Although Swaziland does not manufacture vehicles, standards can be instituted to ensure that vehicles imported are of acceptable efficiency. Some developments have been made in many countries to reduce energy intensity (energy consumed per transport activity) by changing vehicle engine design, reduce weight of vehicle and developing fuel alternatives, but as mentioned previously Swaziland can only benefit from such measures by controlling imports.

One option open to Swaziland in trying to improve efficiency is to restrict the imports of old inefficient vehicles and encourage the imports of vehicles with newer design. However, the monitoring of such a measure can be demanding.

Transport management practices can offer some efficiency improvements. A wide use of collective transport schemes in areas with large poor populations, and well-managed public transportation, can prove very important because the mobility of people can have development gains. Undertaking transport management programmes, such as route management, introduction of comfortable walkways, lane management, etc, can lead to substantial energy savings.

Fuel switching can assist greatly, because of the current high dependence on petroleum fuels – as in most countries worldwide. The use of sugar-based ethanol, either blended with petroleum fuels as in Zimbabwe or as a fuel on its own as in Brazil, could be attractive, because of the large sugar factory in Swaziland.

Financial incentives

There are few financial incentives that can lead to energy efficiency improvements such as expanding or improving public transport systems. There is an opportunity for public bus companies to operate as self-financed organisations and with appropriate pricing structures this could improve their financial performance.

Regulations

There are few regulations relating to energy efficiency in the transport sector. This could change with requirements for labelling new passenger cars, or by requiring driving tests to have an efficient driving component. Regulations in the transport sector could relate to energy efficiency standards for new vehicles and for energy consumption labelling on new vehicles. Efficiency standards vary significantly.

Voluntary agreements

These could be used mainly in the area of manufacturing new vehicles, but also in the area of freight transport and carriers, leading to improvements in the use of energy.

4. Desirable options for energy efficiency

Swaziland can benefit from several energy efficiency options available from Africa and the rest of the world. Some options are more expensive than others, but effectiveness depends on the situation. – for example, in a highly industrialised country major equipment investments in industry will have more impact than information dissemination, which may prove effective elsewhere. Some desirable options are suggested below, ranked according to priority and importance:

- Information collection, analysis and dissemination
- Labelling
- Regulation and standards
- Voluntary agreements
- Financing approaches
- Demand-side management
- Research, development and demonstration (RD&D)

4.1 Information collection, analysis and dissemination

Developing an active information system on energy efficiency is important and, if done properly, is less expensive than other options. Such a system should empower the different actors in the energy market and should be designed to be targeted, positive, and sustaining for long periods. The information should be prepared so as to ensure that the consumer can identify potential gains from any energy efficiency measure selected.

An information system on energy efficiency will depend on the accuracy and clarity of the information it contains. It should include general data (such as energy pricing, investment requirements, product performance and potential energy savings), as well as specific information that can provide capacity to evaluate possible savings. Reliable data often have to be collected by surveys and then organised for appropriate analysis. In some cases, independent and credible testing of equipment and appliances may be required. In designing information for industry and commercial agencies there is the need to ensure that the information motivates the user and also provide technical advice.

Several instruments can be used to deliver the information:

- Information campaigns through mass media or other channels, workshops and seminars, demonstration, etc.
- Relevant government institutions such as energy and information ministries can be very useful.
- The use of billboards for giving out general information and creating awareness is useful.
- Schools and other institutions can be used for more targeted audiences.
- Government can use professional and industry associations as channels for information delivery to their members. Industry associations can be used to provide technical advice and assistance on energy efficiency.

Development of technical information manuals and guidelines for professionals (while recognising the differences among institutions) through auditing or any other activity can provide good information for users, especially in industry. Depending on the situation, government can offer incentives through tax measures for industries and commercial agencies to provide information and undertake the required audits. Information dissemination and demonstration by government using public buildings and operations can prove useful, because it stimulates not only other government agencies but the private sector as well.

Energy efficiency measures can be demonstrated. These include awareness campaigns, energy management systems, and alternative systems and direct financial support systems. Demonstration by government clearly indicates government's leadership and commitment and provides a basis for energy efficiency service providers to expand into other areas of the economy.

4.2 Labelling

Labelling of products, equipment and other devices can be useful in promoting energy efficiency. The labels provide purchasers with information about the performance and energy consumption of the product, and give the option to select from different options. In general, labels inform the purchaser of the expected energy consumption, to enable a comparison between various models. If the difference in pricing is not significant, the purchaser may opt for a device that uses less energy – provided the purchaser can identify the impact on the savings on the energy bill; so labelling is more useful if the purchasers are also given relative operating costs. Labelling can also motivate manufacturers to produce more efficiency products and can assist government to choose which products to allow in the market. Energy consumption-related labels could also be applied to buildings, as in the Danish energy certification of buildings, and to automobiles.

Labelling requires, however, well trained specialists to evaluate and test the performance of the different devices. If this capacity is not available in the country, then it will have to depend on external sources for the required knowledge, which can prove to be an obstacle.

4.3 Regulations and standards

Standards and regulations for promoting energy efficiency are mainly applied to buildings, vehicles and household energy-use devices. Regulations provide a basis to establish label protocols. Standards can set a minimum efficiency value – keeping appliances which do not meet stipulated standards out of the market.

Regulations and standards can be applied to either old stock or new stock, though the former can be less effective because adoption and compliance depends upon on the rate of capital stock turnover by the user. Design of standards requires considerable technical knowledge. They need to be flexible to adapt to dynamic conditions such as technological advances. Governments can create incentives for industry to invest in the use and development of more energy efficient technologies.

Standards and regulations can provide opportunities for promoting energy efficiency; Swaziland being an inland country and importing most goods, the country can institute energy efficiency standards and regulations that control the import of inefficient goods. However, since this measure must be done with nearby countries as these goods mostly go through them, co-operation is important.

Whereas standards tend to be applied to appliances and equipment, regulations are employed more generally for offices, homes and other buildings. Regulations in the building sector tend to focus on the building shell, with codes for levels of insulation, thermal efficiency of windows and other building materials, or on overall thermal performance. These codes are developed and implemented at a local or regional level in much the same way as health and safety regulations.

Regulations are also commonly applied in the transport sector. Speed limits are primarily set for safety reasons and traffic control, but they also affect fuel consumption. Periodic inspection of the technical conditions is mandatory, as they can affect fuel efficiency, although focusing on safety and emissions,

4.4 Voluntary agreements

Voluntary agreements (VAs), which refer to agreements between government and industries for a wide range of actions to be taken by the industries, can also be used to stimulate energy efficiency. Actions by industries may include industrial covenants, negotiated agreements, self-regulation, codes of conduct, and eco-contracts. The driving force for the government to enter into VAs is usually gains in social outcome, and that for the participating industry is self-interest – to gain goodwill from customers. As *** encourage industry-led initiatives to set and meet energy and environmental goals. They tend to raise the profile of environmental issues in corporate decision-making and to give participating industries the flexibility to achieve these goals in a suitable manner, in line with their economic, social and political circumstances.

There are different types of VAs: *target-based VAs,* sometimes called negotiated agreements, include negotiated targets that are legally binding, which pre-empt future regulatory requirements, or are tied to a strong regulatory threat. *Performance-based VAs* are based on negotiated performance goals that are neither legally binding nor explicitly designed to pre-empt future regulatory requirements. *Co-operative R&D VAs* focus on spurring new technology developments that advance the best practice frontier, rather than improving existing best practice.

The effectiveness of the different types of VAs depends on the economic and international competitiveness of the industry and the potential, which exists. For example, performance-based VAs may bring about desired results when there are significant 'no-regrets' opportunities for energy efficiency and/or legally binding national emission limitation objectives. In the absence of such binding objectives, target-based VAs may be the more effective tool.

Monitoring and reporting of VAs is important to track progress, identify potential differences with the mutually agreed objectives and targets, adapt or modify the approach, or initiate appropriate additional measures or actions when necessary. Reporting requirements can be a burden to VA participants, but this burden is generally preferable to the more onerous requirements imposed by formal regulation.

4.5 Financing approaches

There are several financing approaches that can stimulate energy efficiency. These include leasing, performance contracts, third party financing, market transformation, and fiscal prices.

Leasing energy-efficiency equipment allows both the customer and owner to share the cost of the efficiency measure. The customer pays monthly amounts lower than the expected energy savings. In return, the provider is responsible for all aspects of the measure, including equipment installed and its operation, and retains ownership. If the system does not operate within the contract provisions, the customer can terminate the contract. Such an arrangement reduces the risk for the customer but the risk is reflected in the cost of the leasing arrangements. This type of arrangement is useful for countries with large manufacturing facilities.

In a performance contract arrangement, a contractor finances and installs the energy efficiency device or equipment on a consumer's premises and assumes all the risks. The contractor is paid out of the energy savings. The consumer pays a fixed rate to the contractor for all the energy needs covered by the contract.

Third-party financing involves a third-party investor financing the energy efficiency measure and taking responsibility for it. The investments of the measure are repaid on a pro rata basis from operational savings over a limited period. In this method, third-party financiers are compelled to limit the difference between estimated and actual energy savings because they assume the risk.

Setting up a pricing framework by governments that ensures that the full cost of supply, distribution and external costs are reflected in it will stimulate companies and industries to consider efficiency measures in their activities, especially for long-term perspectives. In Swaziland, as in most countries, targeted subsidies may be necessary – but it should be ensured that the subsidies do not promote inefficiencies. Some approaches to adequate price-setting include ensuring that subsidies are transparent and give a clear phase-out schedule, considering long-run marginal costs rather than just average historical costs as a basis for price calculations.

4.6 Demand-side management

Demand-side management is a concept that includes demand-side options to meet consumers' needs for energy services. It incorporates energy efficiency and load management programmes. DSM is generally used in a utility context – primarily for electricity savings. DSM internalises the choice of least-cost options for undertaking certain actions. It also opens up a broad long-term activity to meet concerns for the environment and sustainable development. In short, the main thrust is the necessity to get more energy efficiency and better value for money into the energy system.

DSM can be used to modify load profile and hence reduce electricity consumption. Planning, implementing and monitoring a wide range of conservation and energy efficiency programmes to influence energy consumption could achieve this. Also, load management can be used to shift demand from peak to off-peak periods or to create a more flexible load shape.

DSM has not been entirely successful, for many reasons, including customer education and finance. Some energy providers in competitive markets are, however, now offering energy efficiency measures as part of their service package. In addition, at the retail level, energy companies are finding it more cost-effective to undertake DSM than to invest in additional capacity. Capacity shortages, developments in capital markets, public opposition to new generation facilities, improved customer relations and marketing can motivate energy suppliers to pursue DSM efforts. Competitive markets can also pose new opportunities such as demand-side bidding into a wholesale power pool.

4.7 Research, development and demonstration

Government RD&D programmes can support energy efficiency through the development of new end-use technology, demonstration of its technical feasibility and behavioural studies related to energy demand and use. Most of these energy-efficiency research initiatives consist of applied research to improve the efficiency of existing equipment, materials or process design. Usually, their aim is to facilitate market entrance for new products through demonstration of a new technology.

4.8 Opportunities from the climate change debate

In the context of climate change concerns, improved energy efficiency is a critical feature. This holds for national governments, which have made commitments under the UN Framework Convention on Climate Change (UNFCCC), as well as for the numerous local industries, which have entered into voluntary agreements. Even for countries that have no binding UNFCCC obligations, energy efficiency has a strategic place in achieving energy and environment objectives. Two policy measures arising from this international agreement will affect energy efficiency activities.

Greenhouse gas emission trading

An emission trading is designed to achieve greenhouse gas emission reduction at minimum cost for all participants involved by using the principle that reductions should be undertaken where it is cheapest to do so. This could facilitate investment in energy efficiency. However, at present such transactions can only be done between developed countries, thus excluding Swaziland.

Activities Implemented Jointly (AIJ)

The aim of AIJ is to mitigate GHG emissions where it is most cost effective to do so through joint activities by Parties to the UNFCCC. AIJ is the pilot phase of Joint Implementation (JI), that was agreed in 1995 and should continue to 2000. It is presently being reviewed. However, JI as stated in the Kyoto Protocol is only for transactions between developed countries. The major disadvantage of AIJ is that it does not allow for greenhouse gas reduction credits to any of the involved Parties and hence dilutes incentives for project developers to be involved.

Clean Development Mechanism (CDM)

CDM is a mechanism agreed upon in the Kyoto Protocol of the UNFCCC and yet to be ratified. Through it, a developed country can invest in a developing country on projects that promote sustainable development in the developing country as well as reduce greenhouse gas emissions that the developed country can take as credits towards their commitments under the Kyoto Protocol. The modalities and governance of this mechanism are yet to be finalised. Swaziland, as a developing country, can attract energy efficiency investments that include capacity building and technology transfer benefits. However, the enabling environments for foreign investments, including the institutional demands for CDM, are crucial for attracting CDM investments.

Global Environment Facility (GEF)

GEF, a facility managed by the World Bank, UNDP and UNEP, is the funding mechanism for the UNFCC. The facility funds climate change projects that have the potential to reduce greenhouse gas emissions by financing the extra cost (incremental cost) required to transform a project from one which will not necessarily reduce greenhouse gas emissions to one with greenhouse gas reduction. GEF has funded several projects in many developing countries and continues to do so. Carefully designed and implemented GEF funded projects have potential benefits including technology transfer, additional investment, and local economic and environmental benefits. They can also help to address some barriers to financing energy efficiency, such as lack of managerial and technical capacity, and the scarcity and high costs of capital.

4.9 The role of different actors

Many actors influence the production and use of energy. Success in energy efficiency improvements depends on how well these actors are linked with each other, and on how well their actions are integrated. Since these actors tend to act independently in formulating their policies, they can either pull together or separately. Based on the literature and other observations, some roles and functions of the different actors that can be involved in promoting energy efficiency are given below:

Governments (national and local):

- establish legal and institutional frameworks and market parameters;
- establish symbiotic conditions for energy and environment policies in the institutional framework;
- act as an example by improving energy efficiency in their activities;
- develop organisational routines so that energy efficiency is on the agenda and integrated in decision-making in all sectors, such as transportation;
- establish methodologies to evaluate performance of energy services and products using least-cost principles;
- conduct and provide transparent evaluations to learn from and to guide;
- support effective agency and administration efforts to enhance energy efficiency.

Energy efficiency agencies:

- gather and disseminate information about activities (technology, programmes, operations etc);
- develop and implement energy efficiency programmes;
- evaluate activities and disseminate targeted information to support the learning process;
- co-operate with peers to establish common ground and common projects to ensure a larger market response;
- are active in guiding and transferring experiences, programmes and projects.

Business and municipal associations:

- support members in applying energy efficient technology and operations, particularly in changing routines and adapting activities to certification schemes;
- communicate the results;
- participate in agreements with branch, government or international concerns to achieve targeted results.

Utilities:

- improve the efficiency of energy supply, transmission and distribution;
- take part in dissemination of technology to improve energy services;
- provide information on energy services and on circumstances essential for the customer to exercise energy-efficient options;
- develop rate structures that encourage energy-efficient consumption patterns.

Equipment manufacturers:

- actively promote energy efficient technology by targeted marketing;
- make efforts to persuade consumers to consider life-cycle costs;
- act together with governments and large buyers to develop new, more efficient technologies.

Big buyers (public authorities, business chains, etc):

- identify opportunities for efficiency within their sphere of influence;
- examine purchasing routines and ensure that energy efficiency is adequately incorporated;
- consolidate purchasing power.

Non-governmental organisations

- publicise good examples;
- network to make use of the latest experiences in research in both technology and applications.

International organisations

- develop supporting instruments for monitoring and evaluation;

- support mutual interest by adapting routines and instruments;
- serve as a forum to disseminate results;
- act as a clearing-house to establish collaborative actions.

4.10 Conclusion

This brief report looked at the Swaziland energy economy and, based on African and international experience, has suggested specific energy options, which can assist the country to cope with the rapidly growing energy demand triggered by population growth and development demands. Also discussed were the possible generic barriers to the implementation of energy efficiency measures.

The report suggests a range of measures that have varying potential for energy savings in the energy economy in the main energy consuming sectors of the economy, industry, domestic and transportation. Some of these measures – such as information collection, analysis, and dissemination, and product labelling – are most attractive because they cost little or nothing. Measures such as regulations and voluntary agreements can also be pursued because they are low-cost measures. Financing approaches and funding of R&D programmes along with demonstration activities may require further analysis because they are comparatively more expensive. Improving linkages and interaction between the different stakeholders is being advocated for effective implementation of the measures suggested. Some opportunities arise from the climate change debate, such as involving the CDM and requesting funds from the GEF.

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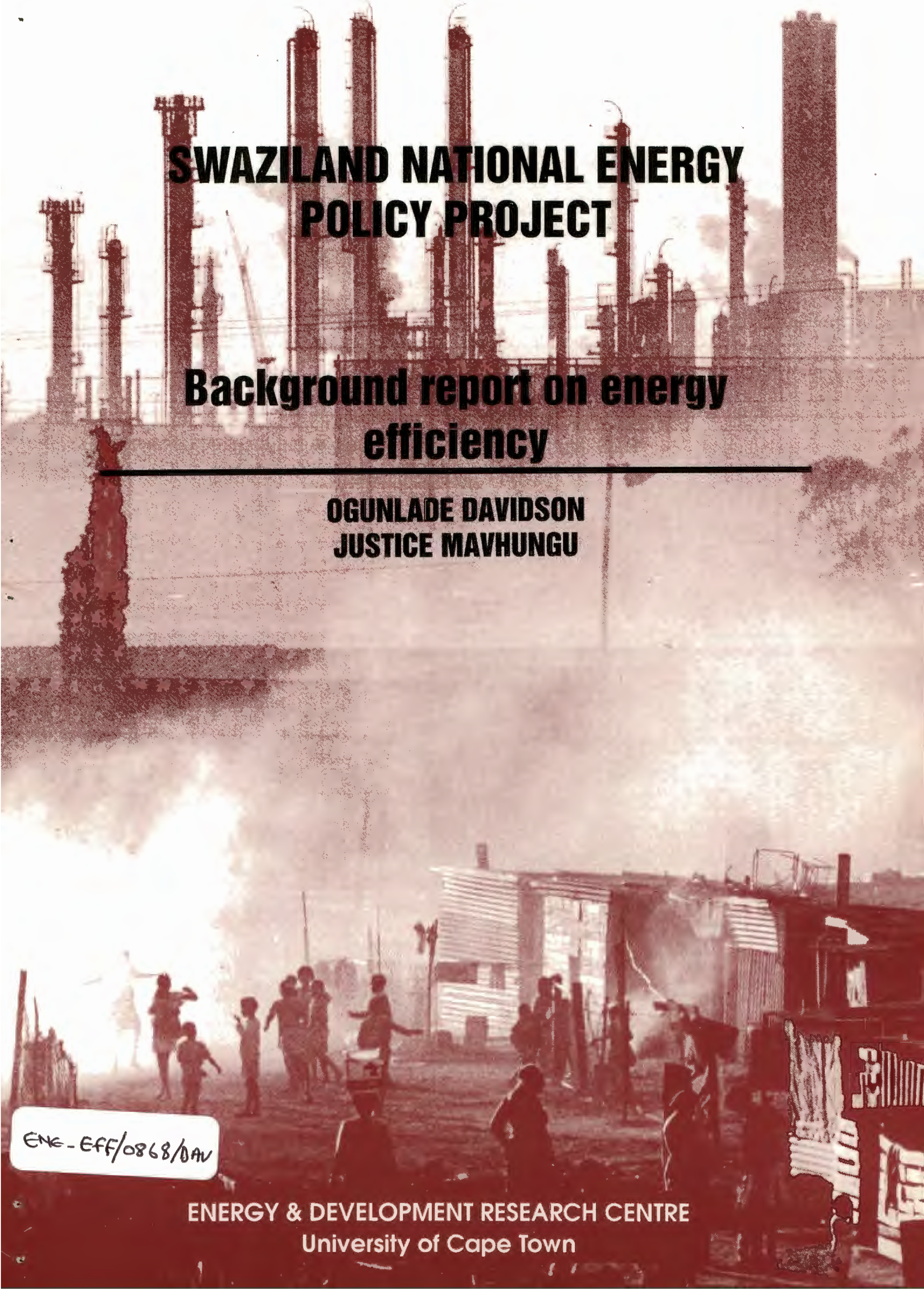

Background report on energy efficiency

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