**Renewable Energy Technology (RET) Working Group**
**Global Network on Energy for Sustainable Development (GNESD)**

# Renewable energy technologies for poverty alleviation
# Initial assessment report: South Africa

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# EXECUTIVE SUMMARY

## 1. Background

South African energy policy priorities have always been closely linked to the prevailing political situation. Pre-democratic energy policy and planning were characterized by energy security priorities, excessive secrecy and racially skewed provision of energy services.

Post-apartheid South Africa witnessed substantial revision and a strong focus on energy for development. In accordance with the Constitution (Act No. 108 of 1996) an inclusive Energy White Paper (1998) was developed.

Major objectives of government's Energy White Paper are (DME, 1998):

- Increasing access to affordable energy services;
- Stimulating economic development – encouragement of competition within energy markets;
- Managing energy-related environmental and health effects;
- Securing supply through diversity – increased opportunities for energy trade and diversity in both supply sources and primary energy carriers.

Renewable energy becomes one of the areas that the government would want to consider pursuing in managing energy-related environmental impacts and diversifying energy supplies from a coal-dominated system.

In May 2004, the Department of Minerals and Energy (DME) published the White Paper on Renewable Energy Policy. This targets the provision of 10 000 GWh (accumulative over a period of 10 years) of electricity from RE resources (mainly biomass, wind, solar and small-scale hydro projects) by 2013. This is approximately 4 % of the country's estimated electricity demand or equivalent to replacing two 660 MW units of Eskom's combined coal-fired power stations. At present less than 1% of the 200 000 GWh of electricity generated annually in South Africa originates from RE sources (DME, 2004).

This study outlines the current use of RE, its potential, and discusses barriers and opportunities in alleviating poverty. Furthermore, it examines policy options for promoting access to RE as an affordable, reliable and socially acceptable alternative to grid electricity.

## 2. Rationale and motivation

South Africa's fast-dwindling peak electricity generation capacity is expected to run out by 2007 and given the time needed to build new or refurbish mothballed power stations, the harnessing of abundant renewable sources has become more urgent.

The government is committed to the diversification of the electricity supply industry, and in doing so will create an enabling environment to facilitate the introduction of independent power producers to generate electricity from renewables.

A major challenge facing the government is the provision of energy to remote rural areas where grid electricity is not likely to reach in the foreseeable future. This, coupled with global concerns around carbon dioxide emissions, has triggered renewed interest in developing RE technologies.

Achieving the 10 000 GWh for 2013 is based on an evaluation of the macroeconomic impacts on GDP, improvement in low-income households' income, capacity for employment creation and the impact on black economic empowerment (BEE). Pursuing this target (10 000 GWh) more than 35 000 jobs would be created, more than R5 billion would be added to GDP, and R687 million would be added to the incomes of low-income households.

# 3. Initial Assessment

## 3.1 Characterisation of population and zones

South Africa has a population of approximately 44 million people and the majority of its citizens live in urban areas (57.9 %). The country is divided into 9 provinces and has a total area of 1 223 201 square kilometers. By the end of 2002, almost 70 % of households had access to grid electricity.

## 3.2 Needs and energy requirements:

Table 1 lists the different energy requirements for each of the following sectors: transport, residential, commercial and industrial. A list of potential RE technologies available to satisfy the various energy needs is provided.

**Table 1: RE requirements and technologies**
***Source: DME (2004)***

| Sector/subsector | Requirements | Technology |
|---|---|---|
| Transport | Fuels for vehicles | ethanol, biodiesel |
| Residential | Fuels for lighting<br>Fuels for cooking<br>Fuels for space heating<br>Fuels for water heating<br>Fuels for refrigeration<br>Fuels for cooling | PV solar, wind<br>solar cookers, wind, small hydro, gel fuel, fuel wood & other biomass<br>wind, small hydro, biomass, solar water heaters<br>wind, small hydro, PV solar, biomass<br>wind, small hydro, PV solar, biomass<br>passive night cooling |
| Commercial | Fuels for lighting<br>Fuels for commercial activities<br>Fuels for water heating | wind, small hydro, hybrid, PV solar<br>wind, small hydro, solar<br>wind, small hydro, biomass, solar water heaters |
| Industrial | Fuels for lighting<br>Fuels for industrial activities<br>Fuels for water heating | wind, small hydro<br>wind, small hydro, cogeneration, biomass<br>wind, small hydro, biomass, solar water heaters |

## 3.3 Technologies

Table 5 (see main report) presents the annual GWh production output of each of the 39 RE resource categories modeled. South Africa has a potential GWh output of 86 843. Although wind has the highest GWh output, the cost associated with wind generation is generally higher than most of the other RE resource categories. Sugar bagasse is the most economically viable RE resource with the highest GWh output (see Table 7).

## 3.4 Renewable energy resources

South Africa's technically feasible RE production of approximately 87 000 GWh corresponds to about 49 % of the electricity consumption in 2001 (DME, 2004). In 1999 RE accounted for approximately 9 % of the total energy consumption (Energy Futures, 2000). Most of the energy is generated from fuelwood and dung and not from modern RE technologies.

*Hydro:* Currently there are 8 licensed small hydro facilities less than 50 MW, with a combined capacity of 68 MW. The power generation potential of small hydro schemes amounts to 9 900 GWh per year (Mlambo- Ngcuka, 2003).

*Solar:* Photovoltaic (PV) systems are used in telecommunications networks, small-scale remote stand alone power supplies for domestic use, game farms and household and community water pumping schemes. The installed PV capacity is estimated at 12 MW.

The DME has established a concessioning process (fee-for-service) for off-grid rural electrification. Currently 20 399 solar home systems have been installed in 4 concession areas.

Solar water heating is currently about 1.3 % of the solar energy market in terms of GWh.

*Wind*: Wind power potential is fairly good along most coastal and escarpment areas with mean annual speeds above 6 meters per second. It is estimated that wind power could supply at least 1 % (198 000 GWh) of South Africa's projected electricity requirements (DME, 2002a). Eskom is currently generating electricity from the Klipheuwel Wind Farm about 40 km north of Cape Town. The 3 wind turbines have a combined generation capacity of 3.16 MW.

Phase 1 of the Darling wind farm, a 5 MW power project is to start in 2005. The Oelsner-Group from Darling will be the first independent power producer.

*Biomass*: The main sources of biomass are fuelwood used in the rural domestic sector, bagasse in the sugar industry and pulp and paper waste in commercial forestry industry for in-house heat and electricity generation. Biomass in the form of fuelwood, wood waste, dung, charcoal and bagasse accounts for close to 10 % of net energy use at a national level.

The viability of wood as an energy source suitable for electricity generation lies within the wood, pulp and paper industries. Table 2 below gives the result of the Renewable Resource Database (RRDB) modeling of the wood and pulp industries energy potential based on availability and energy content of fuels.

**Table 2: Annual fuelwood and pulp energy potential (DME, Eskom, CSIR, 2001)**

| Type | Tonnage (T/Year) | Energy potential (GWh/year) |
|---|---|---|
| Sawmills | 1.57 | 7 639 |
| Pulp mills | 1 million | 4 528 |

*Wave energy*: The potential wave energy along the Cape coastline is estimated as significant. The average harvestable potential power along the entire coast is estimated to be 56 800 MW (DME, 2004).

## 3.5 Case studies

Three case studies on biodiesel, solar water heaters (SWH) and fuelwood, have been selected on the basis of contributing to poverty alleviation and their feasibility and government policy priority.

*Biodiesel*: The major contribution to poverty alleviation of a biodiesel programme would be job creation and economic development in disadvantaged rural areas. Further it would contribute to energy security and reduce greenhouse gas emissions.

Biodiesel is produced by the process of transesterification. The by-products are a protein-rich oil cake and glycerol. Four oil crops – sunflower, soy, cotton and groundnuts - are grown for human consumption and are suited to soil and climatic conditions. These crops are often rotated with the staple food maize.

*SWH:* Manufacturing and installing SWHs would create jobs and if suitably subsidised, by including the subsidy in the existing housing grant for the poor, SWH would increase the welfare of the poor. SWHs can reduce the peak load of grid electricity and they are GHG emission neutral i.e. less electricity generated from coal.

*Fuelwood* is the most commonly used energy source of the rural poor. Even after electrification many poor households in South Africa still use fuelwood for cooking because they cannot afford the appliances and the monthly electricity bill. Fuelwood is a valuable national resource and overall the fuelwood resources in South Africa are adequate but there are shortfalls in several areas and many woodlands are not sustainably managed. The fuelwood case study has been included because it is the most important energy source of the poor in Southern Africa and Africa for the next 40 years; the deficits in other African countries are apparently huge; and no clear policy has yet emerged to address the situation successfully.

**Table 3: Summary of case studies**

| Potential case studies criteria | Case study 1: Biodiesel | Case study 2: Solar water heaters | Case study3: Fuelwood |
|---|---|---|---|
| Representativeness<br>Replicability | Oil crops can be grown in 6 out of 9 provinces | Can be fitted on many buildings; suitable for all parts of the country | Affects all poor households, particularly poor rural households |
| Potential population benefited | 200 000-300 000 | 15 million | 20% of population |
| Complexity | Highly complex | Not complex | Complex |

## 3.6 Assessment of capacity

Capacities for the three cases vary greatly. Fuelwood is the oldest energy source used by humans. SWH are known and the technology is used by some while biodiesel is relatively new and it is not well known.

*Biodiesel:* At present there are no fuel crops grown specifically for biodiesel production but oil crops such as soya and sunflower are grown for human and animal consumption. For example sunflower is quite widely grown and soya beans are also grown in some areas. There would be some existing capacity to grow some of the crops but the amount grown would have to be scaled up. There is no biodiesel being processed, blended and marketed and considerable new capacity would have to be built. Assisting small-scale producers and cooperatives in disadvantaged areas would be most effective for poverty alleviation.

*Solar Water Heaters:* The most urgent capacity is required in developing attractive financing schemes for prospective customers. SWH companies have to upscale their capacities to manufacture, install and maintain SWH. This will create additional jobs.

*Fuelwood:* National fuelwood resources exist and capacity is required to put the provision of fuelwood on the agenda of government and follow up on the implementation. A dedicated subsector within DWAF should be created. The fuelwood resources exist but they are spatially variable and there are local shortfalls of supply; sustainable management is required to supply fuelwood where it is needed. Capacities have to be built in different departments of government and in local communities to sustainably manage wood resources providing affordable fuelwood for the poor and creating jobs at the same time. Capacity to manage fuelwood markets has to be created. The inclusion of fuelwood into the integrated development plans needs attention by the Department of Provincial and Local Government.

## 3.7 Renewable energy niches

The dissemination likelihood for various renewable energy fuels and technologies depends to a large degree on policy and strategy support, on the willingness of government to subsidise technologies that cannot yet compete with existing alternative technologies, on interested private producers who are willing to invest, on customer or user acceptance of the new product or service and the ability of the technology to be self-sustaining financially in future. Table 4 gives an estimate of some of these factors for biodiesel, SWH and fuelwood.

**Table 4: Support for technology**

| | *Biodiesel* | *SWH* | *Fuelwood* |
|---|---|---|---|
| Specific policy/strategy support | High | Low at the moment | Moderate |
| Energy Ministry support | High | High | Moderate |
| Other ministries' support | High | Moderate | Moderate |
| Government's willingness to subsidise | High | Not yet decided | Moderate |
| Private producers interested | High | Very high | Low |
| User/customer acceptance | Moderate | Low | High |

*Niches for biodiesel:* There are three major market niches for biodiesel. Blending biodiesel with petroleum diesel for the transport sector is the most common market outlet for biodiesel in other countries and is estimated to absorb the largest amount of biodiesel in the future. Other niches are cooperatives with surrounding producers and customers. This model has been successful in some European countries. The third niche is using biodiesel as an energy source for energising villages in remote rural areas which have no access to other modern energy. All niches create employment and the second and third niches have great potential for development of disadvantaged areas and poverty alleviation.

*Niches for solar water heaters:* The market provides three niches for the dissemination of SWH. Better information and access to affordable financing is important for all three niches. The middle-to-high-income customers are one niche. The recipients of RDP houses for the poor make up the potential second niche. In this case the SWH could be a part of the existing or an additional grant. Poor people without piped water could be excluded from this benefit unless alternative systems are provided. However, poor households might prefer any additional subsidies to be used to increase the size of the house.The third niche would be in the commercial and institutional sectors, such as in hotels, offices, hospitals and prisons.

*Niches for fuelwood:* In the context of energy poverty alleviation two niches for fuelwood have been identified; the rural and the peri-urban market. Since the poorest people live in rural areas with few job opportunities they will have to rely on fuelwood for a very long time to come. The peri-urban market depends on the macroeconomic situation of the country. This market may shrink and eventually disappear with rising incomes and more employment opportunities, while increasing unemployment would fuel the peri-urban market.

## 3.8 Assessment of other experiences

The solar electrification by the concession approach is assessed in the report in order to highlight the problems, and opportunities associated with the provision of electricity for all.

South Africa is committed to provide universal access to electricity by 2012 (Mlambo-Ngcuka 2004). Grid electricity is the general approach and 70 percent of households are connected to the grid. For the remaining households the Energy White Paper indicates that Government will determine an appropriate mix between grid and non-grid technologies (DME 1998) and 'in remote rural areas where the lowest capacity grid system cannot be supplied within the capital expenditure limit, this system will provide a natural opportunity for Remote Area Power Supply (RAPS) systems to be supplied' (DME 1998). The South African off-grid electrification programme grants private companies the rights to establish off-grid energy utilities. This utility service provision is a fee-for-service model including the maintenance of the system by the utility. The utilities have exclusive rights to government subsidies to cover most of capital costs for five years. The fee-for-service agreement will last for 20 years (Afrane-Okese & Thom 2001).

Four companies are currently operating on a fee-for-service model in four concession areas and they have installed about 20 399 SHSs. Assuming an average household size of 4.5, approximately 90 000 people have benefited so far.

**Table 4: Concessionaires, concession areas and total number of installations, June 2004**
***Source: Willemse (2004); Ranninger (2004)***

| Concessionaire | Concession Area | Total number of installations |
|---|---|---|
| Nuon-Raps (NuRa) | Northern Kwa-Zulu Natal | 6541 |
| Solar Vision | Northern Limpopo | 4758 |
| Shell-Eskom | Nortern parts of the Eastern Cape and Southern Kwa-Zulu Natal | 5800 |
| EDF-Total (KES) | Interior Kwa-Zulu Natal | 3300 |
| Renewable Energy Africa (REA) | Central Eastern Cape | 0 |
| Total | | 20 399 |

It was clear from the beginning that poor rural households for which the systems were intended would not be able to afford the initial capital cost and a government subsidy of R3500 for each installed system was included in the programme for the first five years.

In 2001 the government announced a subsidy for free basic electricity for grid-connected households, equivalent to 50 kWh per month. SHS users in the concession areas were also intended to receive a monthly subsidy of R40, reducing the service fee charged by the service providers to R18 per month.

It is still doubtful if the very poor rural people can afford even this highly subsidised service of PV just for lighting and media use. There is also a question whether and for how long the government can afford the high capital subsidy for each system.

## 3.9 Analysis of barriers and problems

The following general barriers to the further implementation of renewable energy have been identified (DME 2004):

- Many renewable energy technologies remain expensive, on account of higher capital costs, compared to conventional energy supplies for bulk energy supply to urban areas or major industries.
- Implementation of renewable energy technologies needs significant initial investment and may need support for relatively long periods before reaching profitability.
- There is a lack of consumer awareness on benefits and opportunities of renewable energy.
- The economic and social system of energy services is based on centralized development around conventional sources of energy, specifically electricity generation, gas supplies, and to some extent, liquid fuel provision.
- Financial, legal, regulatory and organisational barriers need to be overcome in order to implement renewable energy technologies and develop markets.
- There is a lack of non-discriminatory open access to key energy infrastructure such as the national electricity grid, certain liquid fuels and gas infrastructure.
- Market power of utilities.

Most of these barriers affect the implementation of biodiesel and SWH. Fuelwood being an energy source of the poor does not compete, to the same extent, with modern fuels and faces different problems such as sustainability and access for the poor.

*Barriers for implementing biodiesel:* The technology producing biodiesel is relatively simple but implementing a biodiesel programme is complex because many ministries have to work together to make it work. The Department of Agriculture has to provide advice through its extension services, and this should be particularly addressed to small and subsistence farmers to increase productivity in disadvantaged areas. The Department of Science and Technology should assist with extracting and processing technology and transfer of such technologies to disadvantaged areas. The Department of Minerals and Energy would be concerned with policy, strategy, distribution and regulation. Infrastructural services will have to be improved in disadvantaged areas and the programme will have to be included in the current integrated regional and local development plans (Department of Provincial and Local Government). Taxes or their exemption and subsidies will have to be determined and approved by the Treasury. The oil companies will have to blend the biodiesel with petroleum diesel and have to agree to transport the biodiesel in their pipelines and wheeling charges will have to be negotiated. The motor car industry will have to approve the biodiesel blends as suitable for their makes of vehicles and extend the engine guarantee to customers under the conditions that a certain percentage of the diesel mix is biodiesel. The Bureau of Standards will have to determine fuel specifications and standards. The list of stakeholders may even be longer.

Biodiesel needs substantial initial capital and support for at least ten years before reaching profitability. At present the projected cost of biodiesel cannot compete with petroleum diesel at the pump.

There is a lack of information and awareness on the benefits of biodiesel.

Being a new fuel, biodiesel's entry into the market faces legal and regulatory problems, which have to be solved. There are also no standards for biodiesel and these have to be agreed upon by all stakeholders. Also the access to pipelines will have to be negotiated and regulated.

The oil refineries in South Africa produce more diesel than the country needs and have to export some of it. Biodiesel will therefore not replace oil imports but increases the diesel export. Markets will have to be found.

Sunflowers are the most common oil crops but the sunflower seed cake has relatively low nutritional value and does not substantially contribute to the value of the crop. Further research is required on how to increase the nutritional value of sunflower cake.

There is potential conflict with food crops over land and water resources; national food security and the limited water resources have to be carefully assessed before large-scale oil crop plantations are started. If poverty alleviation is to be achieved emergent farmers and farmers in disadvantaged areas have to be included in the programme as a priority and the lack of infrastructure in disadvantaged areas has to be addressed.

Starting capital is needed to assist small-scale and community producers to set up biodiesel plants. SASOL the world's largest producer of coal-to-oil, has indicated plans to produce biodiesel from soy beans. There are not enough soy beans grown in South Africa to support the large-scale production and soy beans would have to be imported at least initially. Poor subsistence and emergent farmers should be trained to grow soy beans locally for SASOL's biodiesel plant.

*Barriers for implementing solar water heaters:* There is not enough information and awareness about SWH so that the benefits are not appreciated. The initial installation cost of SWH is high and affordable financing schemes are not offered; electricity tariffs are low so that people perceive the installation of SWH as not worth the initial expenditure. Potential customers are also not sure about quality assurance of SWH.

Most poor people live in areas without piped water and therefore cannot benefit from SWH even if their installation is subsidised.

The potential and the mechanism of accessing CDM credits for financing, is complicated and not widely known.

Summarising the biggest barriers to installing SWH are attractive financing, information availability, marketing and the perception of being inefficient and unreliable. Affordable financial and service loans are widely available for buying a car and similar arrangements could be developed for buying a SWH. Accreditation of manufacturers and installers to a professional association is the obvious solution for quality assurance. This must be backed up by standards approved by the South African Bureau of Standards.

*Barriers for implementing sustainable fuelwood use:* One of the greatest barriers of sustainable fuelwood supply for the poor is the incorrect understanding of the problem. The fuelwood crisis was originally thought to be a resource problem; the demand for fuelwood exceeding sustainable yield resulting in deforestation and land degradation. Woodlots were supposed to solve the supply problem and efficient stoves, kerosene subsidy and similar measures were the technology remedies (Gandar 1994). It has now been understood that agricultural practices and land clearing and not fuelwood collection are the major causes of deforestation. Also the regenerative capacity of woodland had been underestimated and the coping strategies of rural people had not been considered

The role of trees in the rural economy and environment is not fully understood and insufficient recognition of the value of woodland and woodland product to rural communities is given. Building on indigenous knowledge systems in sustainable woodland management may be one of the useful strategies. Woodland management is not included into the local integrated development plans.

The emphasis on industrial forestry, which creates large-scale employment and export earnings marginalized the role of community forestry.

There is no clear strategy to address the fuelwood problem.

There is no institutional framework for fuelwood management and it is not integrated into development plans at national, regional and local level. Government, communities and NGOs are not closely interacting to address the problem.

# 4. Objectives and policy outlines

## 4.1 Problems and objectives

The problems and objectives for each case study are outlined.

### *4.1.1 Biodiesel*

Two different strategies may be pursued in implementing biodiesel, industrial-scale biodiesel production and small-scale decentralised production.

*Industrial scale biodiesel*

Sasol Oil is taking up the production of biodiesel at a centralised location and providing the oil market. Recognising the importance to its long-term sustainability Sasol is considering building a 400 000 t/y soybean-to-diesel plant. Soy appears the most appropriate oil crop because not only can the pressed oil be used, but the residue oil cake is also a very desirable by-product, either for animal feed or for human consumption alleviating protein deficiency. In the initial phases production is limited and biodiesel is being blended with petroleum diesel ranging from 1% to 5% biodiesel and 95% to 99% percent petroleum diesel. No engine modification is required at such low percentages of biodiesel.

*Small-scale production of biodiesel*

The objective is to encourage the small-scale production of biodiesel for decentralised consumption. Small towns and remote rural areas are being energised leading to local development.

**Table 5: Identification of problems, opportunities, objectives and policy outlines for biodiesel**

| *Problem and Opportunities* | *Objective* | *Policy outline* |
|---|---|---|
| 1. Implementing a biodiesel | All concerned ministries | Facilitating the |

| | | |
|---|---|---|
| programme is complex because many ministries must work together to make it succeed | cooperate to support the implementation of biodiesel | cooperation between ministries to implement biodiesel |
| 2. Global political developments threaten the continuous supply of oil and, in the long term, reserves of oil and gas will be exhausted. | Sustainable production of biodiesel has been achieved and has become competitive with petroleum diesel, which is gradually being replaced. Greater security of supply has been achieved. | Producing biodiesel in SA and increasing security of supply |
| 3. Developing new technologies and products is a long and capital intensive process. Who will advance or fund the development until the new products can compete in the market? | Expertise in growing and processing crops for biodiesel is developed and the technology has matured and is adapted to small-, medium- and industrial scale production. Biodiesel is competing with petroleum diesel in the market without being supported by incentives. | Facilitating the attraction of capital for biodiesel dvelopment.<br>Providing agricultural extension services to farmers growing oil crops.<br>Supporting oil plant research.<br>Transferring technologies and research results. |
| 4. Very high unemployment rates undermine the government's policies aiming at greater equality, poverty reduction and development of disadvantaged rural areas. | Biodiesel plants have been built in central locations as well as in rural areas and the extracted and processed oil and the residue of protein cake are fuelling and feeding secondary developments. Many jobs are created. The biodiesel plants in rural areas have become development hubs, black economic empowerment is achieved. | Training farmers and other rural people to grow and process oil plants.<br>Encouraging the establishment of feedlots for cattle raising<br>Promoting black economic empowerment |
| 5. South Africa has one of the highest per capita GHG emission rates worldwide. | Petroleum diesel is gradually and sustainably replaced by biodiesel and consequently GHG emissions are reduced. | Reducing GHG emissions by replacing petroleum diesel with biodiesel.<br>Complying with future obligations of the Kyoto Protocol. |

In conclusion, the cooperation of different ministries to implement biodiesel is essential. Strategies to raise the initial capital for biodiesel production and making the cost of biodiesel competitive with petroleum diesel have to be addressed. Expertise in growing and processing oil resources has to be created. Development of biodiesel production in remote rural areas should be given priority because it leads to poverty alleviation by creating jobs, better livelihoods and rural development.

Replacing petroleum diesel with biodiesel reduces GHG emissions.

#### *4.1.2 Solar water heaters*

Seven problems perceived to be most important have been identified. The objectives outline the way to address the problems.

**Table 6: Identification of problems, opportunities, objectives and policy outlines for SWH**

| *Problems and opportunities* | *Objective* | *Policy outline* |
|---|---|---|
| 1. High upfront capital cost and the absence of affordable financing schemes discourage the installation of SWH | SWH companies offer attractive financing schemes and many households and the commercial sector are installing SWH | Facilitating attractive financing schemes.<br>Expanding markets for SWH. |
| 2. Many people don't know about or have a negative perception of SWH | Information, education and quality assurance have convinced people of the benefits of SWH | Supporting information programmes.<br>Encouraging research on evaluating the benefits and limitations of SWH<br>Implementing quality assurance. |
| 3. High unemployment rates limit socio-economic development | Employment is created in manufacturing, installing and servicing SWH | Encouraging and supporting manufacturing SWH for employment generation.<br>Training in SWH manufacturing, installation and maintenance. |
| 4. Electricity peak load demand will be greater than generation capacity by the year 2007 | Installed SWH have reduced peak load | Reducing peak electricity demand by expanding SWH market. |
| 5. The poor live in shacks and houses with insufficient service provision. Even if they have an electricity connection they cannot afford to use it for water heating | SWH are installed in all housing projects for the poor | Subsidising capital expenditure on SWH for the poor.<br>Improving quality of live by facilitating SWH for people in social housing. |
| 6. Black economic empowerment is still lacking in the country | A high percentage of SWH companies are owned and managed by black entrepreneurs | Facilitating the training of black entrepreneurs in the SWH sector.<br>Supporting access to finances for black entrepreneurs. |
| 7. South Africa has one of the highest GHG emission rates because electricity is generated from coal-fired power stations | Solar water heaters replace electric geysers and water heating on stoves reducing GHG emissions | Facilitating the replacement of electric geysers by SWH and supporting the installation of new SWH.<br>Reducing GHG emissions for water heating |

*Objective 1:* SWH companies develop attractive financing schemes together with service contracts targeting different market niches. It is expected that high income groups are the first to take up the offers and monthly electricity expenditure will be much reduced when SWH are installed. Particular schemes are developed for institutions such as clinics, hospitals, prisons, schools and boarding houses, adjusting their repayment schemes to the saved electricity expenditure. The barriers of initial up-front costs are lowered and many SWH are installed.

*Objective 2:* An information and education campaign is carried out by government in cooperation with SWH companies. Information on SWH, their benefits and limitations is widely disseminated in different media. Easily accessible demonstration sites are set up. The association of SWH companies, Solarsure, assures quality and dissatisfied customers can complain when they are not satisfied with the installed product.

*Objective 3:* Affordable financing schemes and government assistance have facilitated an active SWH market and have created sustainable employment in manufacturing, installing and servicing SWH.

*Objective 4:* Private house and flat owners have replaced their electric geysers with SWH and people who heated water on electric stoves have switched to SWH. Institutions have installed SWH and it is estimated that about 2300 GWh (DME 2003) of grid electricity is replaced by SWH thus reducing the peak load.

*Objective 5:* Government is implementing housing plans to provide basic housing to improve the livelihoods of the poor. In addition to the basic housing grant of about R23 000 they receive an additional amount to install SWH. Part of this amount is to be included as an addition in the housing grant and the other part to be paid by the customer in affordable instalments. The precise proportions and the repayment schedule is to be worked out by government, SWH companies and the customer. SWH are made affordable for the poor and are installed in new RDP houses and retrofitted in old ones.

*Objective 6:* Intensive training conducted by the Energy SETA (Sectoral Education and Training Authority) and other organisations, together with financial incentives for BEE companies, have encouraged black technicians and entrepreneurs to set up SWH companies. After initial support the BEE companies have gained technical and managerial experience and successfully compete in the market without further incentives.

*Objective 7:* The measures under Objectives 1 to 6 have led to the dissemination of many SWH replacing water heating that previously used grid electricity from coal-fired power stations. GHG emission rates have been reduced.

In conclusion, the major objectives are developing proper access to attractive financing, implementing of technical standards, wider information programmes and increasing the capacity of the industry to implement together with support for BEE companies. Additional benefits are lowering of peak loads and the reduction of GHG.

#### *4.1.3 Fuelwood*

Five major objectives have been identified. Four are in the fuelwood sector and the fifth emphasises the importance of disseminating efficient fuelwood stoves. The major objectives are developing proper access to attractive financing, implementing of technical standards, wider information programmes and increasing the capacity of the industry to implement SWH together with support for BEE companies. Additional benefits are lowering of peak loads and the reduction of GHG.

**Table 7: Identification of problems, opportunities, objectives and policy outlines for fuelwood**

| *Problem and opportunities* | *Objective* | *Policy outline* |
|---|---|---|
| 1. Fuelwood is becoming scarce and poor women and children have to walk longer and longer distances to gather fuelwood for their cooking and heating needs. | A fuelwood strategy is in place and the poor have easy access to affordable fuelwood. | Developing a fuelwood strategy.<br>Providing affordable access to fuelwood for the poor |
| 2. The value of woodlands for the poor is not fully recognised. Fuelwood production is not economically viable. | Fuelwood is recognised as a major national resource and marketed together with other wood products such as bark and poles and communities are involved in the harvesting and marketing and jobs are created. | Recognising fuelwood as a major national resource.<br>Facilitating the marketing of fuelwood together with other wood products.<br>Involving and supporting communities in the harvesting and marketing of fuelwood. |
| 3. Unsustainable harvesting of wood from communal forests and woodlands and inadequate resource management has negative environmental impact. | Communal woodlands and forests are managed by the community and generate a sustainable supply of fuelwood. Community members and outsiders respect rules governing access and harvesting of fuelwood. Employment is created. | Facilitating community management of fuelwood resources.<br>Generating a sustainable supply of fuelwood.<br>Creating employment in the fuelwood sector. |
| 4. Women and children are exposed to indoor air pollution when cooking. Smoke from wood fires is particularly bad and leads to a number of diseases. | Efficient cooking stoves that are smokeless and burn efficiently using less wood are disseminated, accepted and used. | Recognising indoor air pollution as a major health problem.<br>Promoting the dissemination of efficient and smokeless stoves. |
| 5. The poor do not have access to 87% of land, which is owned privately or by the state. | Strategies have been implemented to give the poor access to state-owned land for fuelwood collection. | Facilitating access to state-owned land for fuelwood collection.<br>Developing strategies and rules for access to state-owned land for fuelwood collection |

*Objective 1:* A fuelwood strategy is in place. Communities are sustainably managing forests and woodlands and fuelwood is harvested at a reasonable distance from homesteads.

The objective is to provide easy access to affordable fuelwood for the poor. These issues are under discussion.

*Objective 2:* The value of woodlands as a national resource is recognised. Its particular importance as a fuelwood resource for the poor is appreciated. Fuelwood marketing is facilitated.

*Objective 3:* Rules have been drafted regulating the harvesting of fuelwood covering such issues as right of access, season and time of access, species to be harvested, dead or live wood and thickness of stem to be harvested for which purpose. The rules are known, respected and enforced. It is clear who has the power to enforce the rules effectively and what the penalties are if they are transgressed. Fuelwood and other marketable wood products are included in the integrated local development plans and they do not remain the sole responsibility of DWAF. Local communities, entrepreneurs and local government develop plans for marketing wood products. When trees are harvested for commercial use such as bark, poles and paper the small branches of waste wood are used for fuelwood. Waste wood sources are integrated in the fuelwood management and transport of fuelwood is minimised.

*Objective 4:* Efficient and smokeless wood burning stoves have been developed and some new models such as Vesta stoves are locally manufactured. Micro-lending schemes permit poor households to buy the improved stoves. Fuelwood is saved and indoor air pollution is reduced.

NGOs and energy centres are promoting and disseminating the improved stoves. Solar cookers, which are not yet very popular, are also promoted by NGOs and energy centres in order to reduce indoor air pollution and dependence on wood and other sources of energy.

*Objective 5:* Strategies have been developed to give the poor greater access to state-owned forests and woodlands to collect fuelwood resources. Access is well managed and controlled.

In conclusion, woodlands are recognised as a major national fuelwood resource for the poor. Policies and strategies have been put in place to facilitate affordable access to fuelwood for the poor. Community woodlands are well managed and women and children walk shorter distances and spend less time to gather fuelwood for their household needs.

Efficient and smokeless stoves have been introduced and indoor air pollution has been substantially reduced

In conclusion, woodlands are recognised as a major national fuelwood resource for the poor. Policies and strategies have been put in place to facilitate affordable access to fuelwood for the poor. Community woodlands are well managed and women and children walk shorter distances and spend less time to gather fuelwood for their household needs.

Efficient and smokeless stoves have been introduced and indoor air pollution has been substantially reduced.

## 4.2 Stakeholder reactions

Two meetings with stakeholders were held, one in Pretoria the capital and one in Cape Town, the seat of parliament. In Pretoria representatives from the Treasury, the Department of Water Affairs and Forestry and policy analysts attended the discussion. In Cape Town we addressed the entire Parliamentary Portfolio Committee on Energy, a representative of the Department of Minerals and Energy and policy analysts; the presentation was followed by a question-and-answer session.

The Minister of DWAF has requested to draft a policy on fuelwood in order to alleviate the worst effects of poverty. . A preparatory meeting gathering background information on problems and objectives was attended in Pretoria on 26 October 2004. The Energy Sector Education and Training Authority invited us to a meeting discussing training programmes for artisans for the installation of SWH.

The stakeholder reactions were enriching and in some areas broadened the discussion.

The stakeholder reactions were enriching and in some areas broadened the discussion. Discussing with stakeholders from the treasury was very useful and contributed to our understanding of the limitations and opportunities of incentives.

#### *4.2.1 Stakeholders' reaction: Biodiesel*

1 In order to facilitate the implementation of biodiesel the DST convened a joint implementation committee of stakeholders in biodiesel. This is strategic support for the development of biodiesel.

The Treasury's 30% exemption from fuel level is a government incentive for biodiesel. Depreciation on capital investment for biodiesel plants is suggested.The depreciation on capital investment for technology projects is normally 4 to 5 years and reducing this period to 3 years will be a further incentive to make the biodiesel production cost competitive with petroleum diesel.

The effects of new crops on stream flow reduction would have to be monitored and assessed according to the Water Act of 1998. It might restrict the land on which oil crops are grown.

2 The availability of oil seeds limits the amount of biodiesel in the market. Oil crops for biodiesel are not yet widely grown and may even have to be imported until such a time that they are grown locally. For this reason the initial percentage of biodiesel in the petroleum diesel blend will be 1% rising to 5% in 2010.

3 A recent SADC strategic planning meeting on 'Farming for Energy for Better Livelihoods in Southern Africa' recommends biodiesel, which can be produced in decentralised locations as an appropriate crop to overcome farmers' lack of access to markets.

4 The SADC meeting found decentralised small- to medium-scale developments very suitable for Southern Africa. Definite strategies have to be developed and the capital for the processing plants has to be raised. It was suggested that a pilot plant be set up as a demonstration project. It is expected that after an initial period of learning and support the processing plants be privatised.

***4.2.2 Stakeholders' reaction: SWH***

1 The poorest people in urban and rural areas live in housing without piped water and therefore cannot benefit from SWH that are connected to the piped water system.

2 Some of the stakeholders are aware that the high initial cost is the biggest constraints and strategies have to be put in place to facilitate financing programmes.

3 Installing SWH increases the value of the building and this may increase the municipal tax on the property.

4 In the winter rainfall region there is not enough sunshine during the coldest months and a backup system is required.

5 Hot water is important for hygienic purposes.

***4.2.3 Stakeholders' reaction: Fuelwood***

The Department of Water Affairs and Forestry convened an expert workshop on 26 October 2004 to discuss the opportunities and constraints for intervening in the fuelwood sector to help poverty alleviation. Stakeholders from different sectors were represented. The workshop proposed the following strategies for immediate , medium term and the long term intervention (Shackleton et al 2004):

Immediate:

- Creating a sub-directorate in DWAF (Department of Water Affairs and Forestry) regarding fuelwood initiatives
- Prioritization of local-level hotspots for intervention
- Subsidize fuelwood marketing
- Better cooperation with Working for Water to supply wood
- Advocate for state lands for sustainable harvesting of fuelwood
- Identify and address information gaps
- Examine and treat the issue in a holistic manner
- Differentiate rural requirements from peri-urban/urban ones

Medium term:

- Develop and implement a national biomass conservation stove programme
- Subsidise small-scale industries to manufacture biomass stoves

- Develop and implement a national tree planting incentive programme
- Provide incentives to private land owners to maintain pockets of natural woody vegetation on their land
- Promote closer cooperation between DWAF and the National Dept. of Agriculture in terms of maintaining trees in the environment
- Liaise with the Dept. of Housing around fuelwood needs for peri-urban and local-cost housing programmes
- Amend legislation to facilitate greater ease in establishment of woodlots of fast-growing alien species
- Increase the capacity of local government

Long term:

- Develop long-term plans for use of fuelwood as a national resource
- Develop an effective woodlands extension service
- Promotion of rehabilitation forestry

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# Acronyms and abbreviations

| | |
|---|---|
| **ANC** | African National Congress |
| **BEE** | Black economic empowerment |
| **CaBEERE** | Capacity Building Project in Energy Efficiency and Renewable Energy |
| **CD** | Capacity Development |
| **CSIR** | Centre for Scientific and Industrial Research |
| **DANCED** | Danish Co-operation for Environment and Development |
| **DANIDA** | Danish International Development Agency |
| **DEAT** | Department of Environmental Affairs and Tourism |
| **DFA** | Department of Foreign Affairs |
| **DME** | Department of Minerals and Energy |
| **DPLG** | Department of Provincial and Local Government |
| **DST** | Department of Science and Technology |
| **DTI** | Department of Trade and Industry |
| **DWAF** | Department of Water Affairs and Forestry |
| **EPWP** | Expanded Public Works Programme |
| **ERC** | Energy Research Centre |
| **GHG** | Greenhouse gas |
| **IDP** | Integrated Development Plan |
| **IKS** | Indigenous knowledge systems |
| **NER** | National Electricity Regulator |
| **RAPS** | Rural area power supply |
| **RDP** | Reconstruction and Development Programme |
| **R&D** | Research and Development |
| **SADC** | Southern African Development Community |
| **SAPP** | Southern African Power Pool |
| **SELF** | Solar Electric Light Fund |
| **SESSA** | Sustainable Energy Society of Southern Africa |
| **SETA** | Sector Education and Training Authority |
| **SF** | Social forestry |
| **SHS** | Solar home system |
| **SME** | Small and medium enterprises |
| **SWH** | Solar water heating/heaters |

# 1. Background

South Africa is a developing country with a population of 44 million people. The 2003 annual GDP amounted to R1 234 billion (National Treasury, 2003). A first world and a third world economy exist side by side reflected in a highly unequal income distribution. Income inequality is similar to Brazil – one of the highest in the world as measured by the Gini coefficient. After democratic elections in 1994 social spending increased considerably and income inequality was reduced, which resulted in a pre-tax Gini of 0.57 and – taking taxes and social transfer into account – a post-transfer Gini of 0.35 in 2000 (Netshitenzhe, 2003).

An integrated political and socio-economic policy framework determining policy priorities was published as the Reconstruction and Development Programme (RDP) in 1994, to meet the objectives of freedom and an improved standard of living and quality of life for all South Africans within a peaceful and stable society. The key programmes of the RDP are

- meeting basic needs;
- developing the human resources;
- building the economy;
- democratising the state and society;
- implementing the RDP.

Poverty is the single greatest burden, shaped by the apartheid system and the unequal business and industrial development which accompanied it. The first priority was to meet basic needs of people and these include jobs, land, housing, electricity, telecommunication, transport, a clean and healthy environment, nutrition, health care and social welfare. Electrifying 2.5 million homes was included under meeting basic needs.

Detailed sectoral policies and legislative programmes including capacity building took direction from the RDP.

During the political campaigning for the April 2004 general elections, many political leaders realised that the livelihoods of the poor had hardly improved in the last ten years. This led the new government to put poverty reduction at the top of their agenda with clearly defined timeframes for delivery in all sectors. President Mbeki in his State of the Nation address on the 21 May 2004 stated that: "At the core of our response to all these challenges is the struggle against poverty and underdevelopment."

A massive Expanded Public Works Programme will be launched in September 2004 with the objectives of developing the social and economic infrastructure, human resource development, enterprise development, and poverty alleviation (DFA, 2004).

South African energy policy priorities have always been closely linked to the prevailing political situation. Pre-democratic South African energy policy and planning were characterized by energy security priorities, excessive secrecy and racially skewed provision of energy services. Access to electricity and other forms of commercial energy for black and poor households was very limited, in particular in rural areas and townships. Investment, research and development focused mainly on energy supply and the energy demands of the white minority.

Subsequently, energy policy has undergone substantial revision and now has a strong focus on energy for development. 1994 saw a shift in energy policy priorities and the inclusive development of an Energy White Paper (1998). The Constitution (Act No. 108 of 1996) requires that government establish a national energy policy to ensure that national energy resources are adequately tapped and delivered to cater for the needs of the nation; further, the production and distribution of energy should be sustainable and lead to an improvement in the standard of living of citizens (DME, 1998). One of the government's most ambitious RDP programmes since 1994 has been the launch of the national electrification programme which saw the electrification of an additional 2.5 million households by 2000 – thereby increasing access from about 36% (1994) to about 70% (NER, 2001).

Major objectives of government policy for the energy sector are spelled out in the 1998 Energy White Paper as (DME, 1998):

i) Increasing access to affordable energy services.

ii) Improving energy governance – clarification of the relative roles and functions of various energy institutions within the context of accountability, transparency and inclusive membership, particularly participation by the previously disadvantaged.

iii) Stimulating economic development – encouragement of competition within energy markets.

iv) Managing energy-related environmental and health effects – promotion of access to basic energy services for poor households while reducing negative health impacts arising from energy activities.

v) Securing supply through diversity – increased opportunities for energy trade, particularly within the Southern African region, and diversity of both supply sources and primary energy carriers.

Imperatively, renewable energy becomes one of the areas that the government would want to consider pursuing in managing energy-related environmental impacts and diversifying energy supplies from a coal-dominated system. Government's overall vision for the role of renewable energy in its energy economy is an "energy economy in which modern renewable energy increases its share of energy consumed and provides affordable access to energy throughout South Africa, thus contributing to sustainable development and environmental conservation (DME, 2004)."

In May 2004, the DME published the White Paper on Renewable Energy Policy. This targets the provision of 10 000 GWh of electricity from renewable resources (mainly biomass, wind, solar and small-scale hydro projects) by 2013. This is approximately 4% of the country's estimated electricity demand or equivalent to replacing 660 MW units of Eskom's combined coal-fired power stations. At present less than 1% of the 200 000 GWh of electricity generated annually in South Africa originates from renewable sources (DME, 2004).

This study outlines the current use of renewable energy, its potential, and discusses barriers and opportunities in alleviating poverty. Furthermore, it examines policy options for promoting access to renewable energy as an affordable, reliable and socially acceptable alternative to grid electrification.

# 2. Rationale and motivation

The South African economy is largely based on mineral extraction and processing, which is by its nature very energy-intensive. It is heavily dependent on coal for power generation (coal provides 75% of the country's primary energy). The country has developed an efficient coal-based power generation system that provides low-cost electricity and coal is likely to remain a financially attractive source of energy in the long term. About 40% of the country's liquid fuels requirement is supplied by Sasol and Mossgas synthetic fuel plants producing liquid fuel from coal and gas. As a result South Africa ranks amongst one of the highest with regard to carbon dioxide emissions on a per capita basis.

South Africa's fast-dwindling peak electricity generation capacity is expected to run out by 2007 and given the time needed to build new or refurbish mothballed power stations, the harnessing of abundant (especially solar) renewable sources has become more urgent. The government is committed to the introduction of greater levels of competition in electricity markets which would contribute to the diversification of electricity supply and energy security, and in doing so will create an enabling environment to facilitate the introduction of independent power producers to generate electricity from renewable resources.

A major challenge facing the government is to supply energy to remote and rural areas where grid electricity is not likely to reach in the foreseeable future. This, coupled with global concerns around carbon dioxide emissions, has triggered renewed interest in developing renewable energy technologies.

The White Paper on Renewable Energy was developed in the context of national and international driving forces. International developments around the United Nations Framework Convention on Climate Change, South Africa's integration into the global economy, the Johannesburg World Summit on Sustainable Development and government's White Paper on Energy Policy (1998).

Achieving the 10 000 GWh target from renewables for 2013 is based on an evaluation of the macroeconomic impacts on GDP, improvement in low-income household incomes, capacity for employment creation and the impact on black economic empowerment (BEE) (Table 1). Wind as a resource category is excluded because of costs.

**Table 1: Macroeconomic- impact on GDP, income of low-income households and employment.**
*Source: DME (2004)*

| *Resource categories* | *GWh* | *GDP R millions* | *Low-income households income R millions* | *Labour requirements Numbers* |
|---|---|---|---|---|
| Hydro: Large-refurbishment | 273 | 123 | 16 | 430 |
| Hydro: Large-inter-basin transfer | 526 | 305 | 38 | 1 407 |
| Hydro: Large-ROR-LH | 310 | 180 | 23 | 961 |
| Biomass Pulp and paper: Mill 1 | 65 | 28 | 4 | 76 |
| Biomass Pulp and paper: Mill 2 | 39 | 20 | 3 | 80 |
| Landfill gas: Micro | 191 | 96 | 12 | 443 |
| Landfill gas: Small | 160 | 67 | 9 | 237 |
| Landfill gas: Medium | 215 | 89 | 12 | 306 |
| Landfill gas: Large | 32 | 13 | 2 | 43 |
| Sugar bagasse: Reduced process steam | 570 | 301 | 39 | 1 209 |
| Sugar bagasse: Including high pressure boilers | 1 483 | 897 | 113 | 3 894 |
| Sugar bagasse: Including tops & trash | 3 795 | 1 840 | 240 | 20 214 |
| SWH Residential – High income households | 930 | 578 | 73 | 2 589 |
| SWH Commercial – Office & banking space | 224 | 119 | 15 | 449 |
| SWH Commercial – Hospitals | 267 | 154 | 20 | 646 |
| SWH Commercial – Hostels – Education | 581 | 336 | 43 | 1 405 |
| SWH Commercial – Security services | 339 | 196 | 25 | 820 |
| **Total** | **10 000** | **5 342** | **687** | **35 209** |

Pursuing this target (10 000 GWh) more than 35 000 jobs would be created, more than R5 billion would be added to GDP and R687 million would be added to the incomes of low-income households. More job opportunities will be created as a result of RE technologies than in coal-fired power stations. Especially in the case of bagasse (including tops and trash) a significant number of unskilled labourers will be employed, mostly black farm workers employed on the sugar farms. Table 2 provides a qualitative evaluation of BEE opportunities that exist within individual technologies.

**Table 2: An evaluation of BEE opportunities for renewable energy resources**
*Source: DME (2004)*

| *Opportunity Resource category* | *Entrepreneurial potential* | | | *Employment opportunity* | | |
|---|---|---|---|---|---|---|
| | *Good* | *Fair* | *Small* | *Good* | *Fair* | *Small* |
| Biomass pulp and paper | | | x | | x | |
| Sugar bagasse | | | x | x | | |
| Landfill gas | | x | | | x | |
| Hydro | x | | | x | | |
| SWH - residential | | x | | | x | |
| SWH - commercial & industrial | | x | | | x | |
| Wind | | x | | | x | |

As part of the presidential lead programmes promoting integrated sustainable rural development, renewable energy is seen as having the potential to assume a significant role in supporting economic development. The government is also introducing decentralised mini-grids and hybrid systems in rural areas in order to promote the development of small medium and micro enterprises (Shabangu, 2003).

# 3. Initial assessment

## 3.1 Characterisation of population and zones

South Africa is divided into nine provinces and has a total area of 1 223 201 square kilometers. The majority of its citizens live in urban areas (57.9%). Provinces with the highest poverty rate (% of persons in poverty) are: Eastern Cape (63.3 %), Limpopo (64.2 %), KwaZulu-Natal (53.1 %) and for South Africa (47.3%). Table 3 shows the status of electrification at the end of 2002.

**Table 3: Status of electrification at the end of 2002**
*Source: NER (2002)*

| *Province* | *Type of area* | *Households electrified* | *Households not electrified* | *Percentage electrified* | *Percentage not electrified* |
|---|---|---|---|---|---|
| Eastern Cape | Rural | 351 856 | 568 889 | 38.2 | 61.8 |
| | Urban | 553 293 | 27 885 | 95.2 | 4.8 |
| Free State | Rural | 122 231 | 118 756 | 50.7 | 49.3 |
| | Urban | 436 796 | 87 771 | 83.3 | 16.7 |
| Gauteng | Rural | 38 466 | 95 576 | 28.7 | 71.3 |
| | Urban | 1 649 705 | 605 813 | 73.1 | 26.9 |
| KwaZulu Natal | Rural | 365 252 | 575 061 | 38.8 | 61.2 |
| | Urban | 816 084 | 371 168 | 68.7 | 31.3 |
| Limpopo | Rural | 610 581 | 385 803 | 61.3 | 38.7 |
| | Urban | 157 970 | 3 290 | 98.0 | 2.0 |
| Mpumalanga | Rural | 294 937 | 144 166 | 67.2 | 32.8 |
| | Urban | 261 161 | 52 450 | 83.3 | 16.7 |
| Northern Cape | Rural | 57 448 | 31 990 | 64.2 | 35.8 |
| | Urban | 121 417 | 30 276 | 80.0 | 20.0 |
| North West | Rural | 305 669 | 239 015 | 56.1 | 43.9 |
| | Urban | 358 464 | 37 | 100.0 | 0.0 |
| Western Cape | Rural | 85 484 | 45 425 | 65.3 | 34.7 |
| | Urban | 870 173 | 143 292 | 85.9 | 14.1 |
| Total | Rural | 2 231 924 | 2 204 680 | 50.3 | 49.7 |
| | Urban | 5 225 063 | 1 321 982 | 79.8 | 20.2 |
| | Total | 7 456 987 | 3 526 663 | 67.9 | 32.1 |

The National Electrification Programme (NEP) Phase 1 (1994-1999) provided 2.5 million grid electricity connections at a total cost of about R7 billion. Phase 2 of the National Electrification Programme was started in 2000 and the target to provide 300 000 additional households with electricity every year has to date been achieved (Prasad, 2003).

## 3.2 Needs and energy requirements

Table 4 lists the different energy requirements for each of the following sectors: transport, residential, commercial and industrial. A list of potential RE technologies available to satisfy the various energy needs is provided.

**Table 4: RE requirements and technologies**
*Source: DME (2004)*

| *Sector/subsector* | *Requirements* | *Technology* |
|---|---|---|
| Transport | Fuels for vehicles | Ethanol, biodiesel |
| Residential | Fuels for lighting<br>Fuels for cooking<br>Fuels for space heating<br>Fuels for water heating<br>Fuels for refrigeration<br>Fuels for cooling | PV solar, wind<br>Solar cookers, wind, small hydro, gel fuel, fuel wood & other biomass<br>wind, small hydro, biomass, solar water heaters<br>wind, small hydro, PV solar, biomass<br>wind, small hydro, PV solar, biomass<br>passive night cooling |
| Commercial | Fuels for lighting<br>Fuels for commercial activities<br>Fuels for water heating | wind, small hydro, hybrid, PV solar<br>wind, small hydro, solar<br>wind, small hydro, biomass, solar water heaters |
| Industrial | Fuels for lighting<br>Fuels industrial activities<br>Fuels for water heating | wind, small hydro<br>wind, small hydro, cogeneration, biomass<br>wind, small hydro, biomass, solar water heaters |

## 3.3 Technologies

There are a large number of technologies available to harness renewable energy for different purposes. Table 5 presents the annual GWh production output of each of the 39 resource categories modeled. It also reflects the different costs-per-kWh statistics for the static and dynamic supply curves broken down into financial, economic and socio-economic costs (DME, 2004). Although wind has potentially the highest GWh output the cost associated with wind generation is generally higher than most of the other RE resource categories. See table 5A below for explanation of terms.

**Table 5: Potential of RE technologies and associated costs**

| | ***RE Resource Categories*** | ***GWh output*** | ***Static financial cost[1] R/kWh*** | ***Static economic cost R/kWh*** | ***Static socio-economic cost R/kWh*** | ***Dynamic financial cost R/kWh*** | ***Dynamic economic cost R/kWh*** | ***Dynamic socio-econ cost R/kWh*** |
|---|---|---|---|---|---|---|---|---|
| 1 | Hydro: Small: Refurbishment | 19 | 0.58 | 0.46 | 0.45 | 0.57 | 0.45 | 0.43 |
| 2 | Hydro: Small: Inter-basin Transfer | 95 | 0.47 | 0.37 | 0.36 | 0.46 | 0.36 | 0.35 |
| 3 | Hydro: Small: ROR – HH | 77 | 0.48 | 0.38 | 0.36 | 0.47 | 0.37 | 0.36 |
| 4 | Hydro: Small: ROR-LH | 108 | 0.56 | 0.46 | 0.44 | 0.55 | 0.45 | 0.43 |
| 5 | Hydro: Small Unconventional | 205 | 0.34 | 0.25 | 0.25 | 0.33 | 0.25 | 0.24 |
| 6 | Hydro: Large: Refurbishment | 273 | 0.11 | 0.07 | 0.07 | 0.07 | 0.11 | 0.06 |
| 7 | Hydro: Large: Inter-basin Transfer | 526 | 0.30 | 0.26 | 0.25 | 0.30 | 0.25 | 0.25 |
| 8 | Hydro: ROR-LH | 820 | 0.34 | 0.29 | 0.28 | 0.33 | 0.28 | 0.28 |
| 9 | Hydro: Diversion | 6 964 | 0.43 | 0.39 | 0.37 | 0.42 | 0.38 | 0.37 |
| 10 | Hydro: Storage | 158 | 0.51 | 0.48 | 0.46 | 0.49 | 0.46 | 0.45 |
| SUB TOTAL HYDRO | | **9 245** | | | | | | |
| 11 | Biomass Pulp & Paper: Mill 1 | 65 | 0.10 | 0.06 | 0.06 | 0.10 | 0.06 | 0.06 |
| 12 | Biomass Pulp & Paper: Mill 2 | 39 | 0.23 | 0.19 | 0.19 | 0.22 | 0.18 | 0.18 |
| 13 | Biomass Pulp & Paper: Mill 3 | 5 | 0.98 | 0.92 | 0.88 | 0.94 | 0.89 | 0.85 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| SUB TOTAL PULP & PAPER | | **110** | | | | | | |
| 14 | Landfill Gas: Micro | 191 | 0.30 | 0.10 | 0.10 | 0.29 | 0.09 | 0.09 |
| 15 | Landfill Gas: Small | 160 | 0.19 | 0.05 | 0.05 | 0.19 | 0.05 | 0.05 |
| 16 | Landfill Gas: Medium | 215 | 0.18 | 0.04 | 0.04 | 0.18 | 0.04 | 0.04 |
| 17 | Landfill Gas: Large | 32 | 0.17 | 0.03 | 0.03 | 0.17 | 0.03 | 0.03 |
| SUB TOTAL LANDFILL GAS | | **598** | | | | | | |
| 18 | Sugar Bagasse: Reduced Process Steam | 570 | 0.24 | 0.19 | 0.19 | 0.23 | 0.19 | 0.18 |
| 19 | Sugar Bagasse: High Pressure Boilers | 1 483 | 0.29 | 0.25 | 0.24 | 0.27 | 0.23 | 0.23 |
| 20 | Sugar Bagasse: Include Tops & Trash | 3 795 | 0.22 | 0.18 | 0.18 | 0.22 | 0.17 | 0.17 |
| SUB TOTAL SUGAR BAGASSE | | **5 848** | | | | | | |
| 21 | Wind generation: Class 1[2] | 63 | 0.38 | 0.33 | 0.32 | 0.33 | 0.28 | 0.27 |
| 22 | Wind generation: Class 2 | 78 | 0.40 | 0.35 | 0.34 | 0.35 | 0.30 | 0.29 |
| 23 | Wind generation: Class 3 | 167 | 0.45 | 0.40 | 0.39 | 0.39 | 0.34 | 0.33 |
| 24 | Wind generation: Class 4 | 5 109 | 0.51 | 0.47 | 0.45 | 0.45 | 0.40 | 0.38 |
| 25 | Wind generation: Class 5 | 24 841 | 0.58 | 0.53 | 0.51 | 0.51 | 0.45 | 0.43 |
| 26 | Wind generation: Class 6 | 31 139 | 0.70 | 0.64 | 0.62 | 0.61 | 0.55 | 0.53 |
| 27 | Wind generation: Class 7 | 2 705 | 0.82 | 0.76 | 0.73 | 0.72 | 0.65 | 0.62 |
| SUB TOTAL WIND | | **64 102** | | | | | | |
| 28 | Solar Water Heating Residential Housing: Low-income houses | 2 232 | 0.50 | 0.46 | 0.45 | 0.46 | 0.42 | 0.41 |
| 29 | Solar Water Heating Residential Housing: Medium-income houses | 1 339 | 0.42 | 0.38 | 0.37 | 0.38 | 0.34 | 0.33 |
| 30 | Solar Water Heating Residential Housing: High-income houses | 930 | 0.35 | 0.31 | 0.30 | 0.32 | 0.28 | 0.27 |
| 31 | Solar Water Heating Residential Housing: Cluster Housing | 254 | 0.42 | 0.38 | 0.37 | 0.38 | 0.34 | 0.33 |
| 32 | Solar Water Heating Residential Housing: Traditional Houses | 159 | 0.42 | 0.38 | 0.37 | 0.38 | 0.34 | 0.33 |
| SUB TOTAL RESIDENTIAL SOLAR WATER HEATING | | **4 914** | | | | | | |
| 33 | Solar Water Heating Commercial and Industrial Buildings: Office & Banking Space | 224 | 0.23 | 0.19 | 0.19 | 0.22 | 0.17 | 0.17 |
| 34 | Solar Water Heating Commercial and Industrial Buildings: Shopping Space | 121 | 0.45 | 0.41 | 0.40 | 0.42 | 0.38 | 0.36 |
| 35 | Solar Water Heating Commercial and Industrial Buildings: Industrial & Warehouse Space | 210 | 0.54 | 0.49 | 0.48 | 0.49 | 0.45 | 0.43 |
| 36 | Solar Water Heating Commercial and Industrial Buildings: Hospitals | 267 | 0.30 | 0.25 | 0.25 | 0.27 | 0.23 | 0.23 |
| 37 | Solar Water Heating Commercial and Industrial Buildings: Hostels: Education | 581 | 0.30 | 0.25 | 0.25 | 0.27 | 0.23 | 0.23 |
| 38 | Solar Water Heating Commercial and Industrial Buildings: Security Services | 339 | 0.30 | 0.25 | 0.25 | 0.27 | 0.23 | 0.23 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 39 | Solar Water Heating Commercial and Industrial Buildings: Hotels | 284 | 0.49 | 0.45 | 0.44 | 0.45 | 0.41 | 0.40 |
| SUB TOTAL COMMERCIAL SOLAR WATER HEATING | | **2 026** | | | | | | |
| GRAND TOTAL | | **86 843** | | | | | | |

[2] See Table 5b in Appendix A for wind class descriptions

**Table 5a: Explanation of cost terms**

*Static financial cost* (R/kWh) – All costs (capital, operating and maintenance) costs priced at 2003 market prices. Capital costs are annualised, using a formula that incorporates the lifespan of the capital equipment, and a discount rate of 10%.

*Static economic cost* (R/kWh) – Based on the data used in deriving financial curves. Adjustments are made in 2 categories of inputs: input data for fuels, labour and the exchange rate are shadow priced to reflect the opportunity cost to the economy rather than the market price and carbon dioxide emission offset data is included, valued with certified emission credits of the Clean Development Mechanism (CDM).

*Static socio economic cost* (R/kWh) – Apart from direct labour, additional indirect and induced employment effects are also accounted for.

*Dynamic financial cost* (R/kWh) – Takes into consideration the likely impact that 'technology improvements' and 'economies of scale' will have on individual Re technology production outputs, and the costs associated with constructing, operating and maintaining them in 2013.

*Dynamic economic cost* (R/kWh) – Future RE technology development will make improvements in effectiveness and efficiency of electricity generation. For technologies undergoing rapid change, capital costs are likely to decrease.

*Dynamic socio- economic cost* (R/kWh) – As a result of the achievement of economies of scale, discounts are included in the dynamic socio economic costs.

The table below presents the financial and socio-economic costs per kWh for each of the nineteen RE technologies, using a least-cost basis for ranking the RE technologies. The financial cost per kWh indicates the subsidies that would be required to make each qualifying RE technology financially viable, whilst the socio-economic cost per kWh indicates the macroeconomic impact these subsidies would have on the South African economy. Solar PV is excluded, as it would not be economically feasible (Table 6).

**Table 6: Economically viable RE technologies**
*Source: DME (2004)*

| *Resource categories* | *GWh output* | *Cumulative GWh output* | *Dynamic financial cost* R/kWh | *Dynamic socio-economic cost* R/kWh |
|---|---|---|---|---|
| Landfill gas: large | 32 | 32 | 0.17 | 0.03 |
| Landfill gas: medium | 215 | 247 | 0.18 | 0.04 |
| Landfill gas: small | 160 | 407 | 0.19 | 0.05 |
| Biomass pulp & paper: mill 1 | 65 | 472 | 0.10 | 0.06 |
| Hydro: large: refurbishment | 273 | 746 | 0.11 | 0.07 |
| Landfill gas: micro | 191 | 936 | 0.30 | 0.09 |
| SWH commercial: office & banking space | 224 | 1 160 | 0.23 | 0.17 |
| Sugar bagasse: include high pressure boilers | 3 795 | 4 955 | 0.22 | 0.17 |
| Biomass pulp & paper: mill 2 | 39 | 4 995 | 0.23 | 0.18 |
| Sugar bagasse: reduced process steam | 570 | 5 565 | 0.24 | 0.18 |
| SWH commercial: hostels-education | 581 | 61 468 | 0.30 | 0.23 |
| SWH commercial: hospitals | 267 | 6 413 | 0.30 | 0.23 |

| | | | | |
|---|---|---|---|---|
| SWH commercial: Hostels-security services | 339 | 6 753 | 0.30 | 0.23 |
| Sugar bagasse: including high tops & trash | 1 483 | 8 236 | 0.29 | 0.23 |
| Hydro: small-unconventional | 205 | 8 441 | 0.34 | 0.24 |
| Hydro: large-inter-basin transfer | 526 | 8 966 | 0.30 | 0.25 |
| Wind energy: class 1 | 63 | 9 029 | 0.38 | 0.27 |
| Solar residential: low income households | 930 | 9 959 | 0.35 | 0.27 |
| Hydro: large-ROR-LH (Run of River-Low Head) | 41 | 10 000 | 0.34 | 0.28 |

A study (DST 2003) was recently conducted to give a preliminary estimate of what the financial costs of meeting various RE targets for the electricity sector would be. It was done by comparing the costs of a non-renewable reference scenario with the costs of scenarios with renewable targets, using the Long Range Energy Alternatives Planning (LEAP) model.

Figure 1 shows the difference in electricity generation by technology between the non-renewable reference case and the different RE scenarios. Positive values indicate additional generation while negative values indicate less generation. It is clear that RE technologies can reduce the load factor of existing coal fired power stations, thus delaying the construction of new coal fired fluidised bed combustion stations and will consequently lead to substantial reductions in green house gas emissions (Alfstadt, 2004).

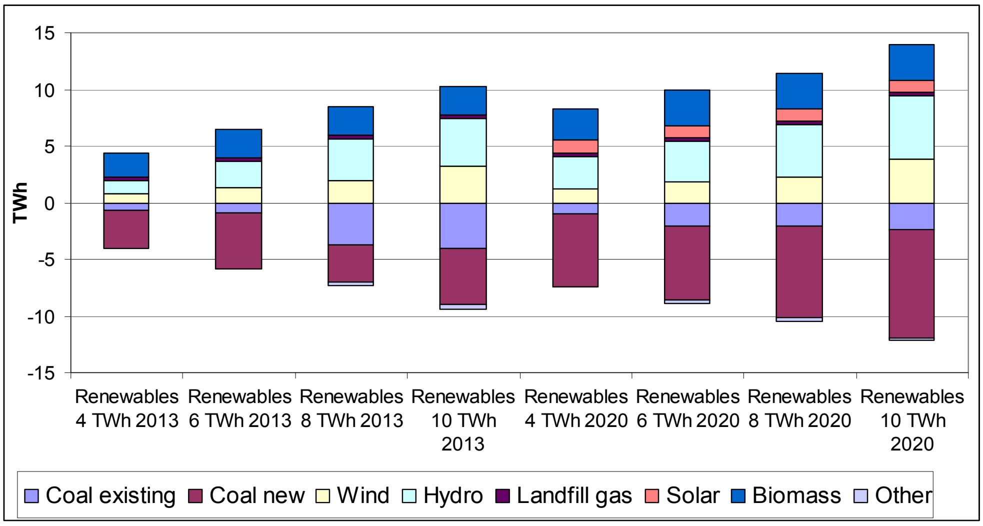


**Figure 1: Difference in electricity generation by technology**

***Source: Alfstadt (2004)***

## 3.4 Renewable energy resources

South Africa has a technically feasible renewable energy production of almost 87 000 GWh, corresponding to about 49% of the electricity consumption in 2001 (DME, 2004). Table 7 reflects the contribution that each of the RE technologies makes to this technically feasible production of 86 843 GWh.

In South Africa renewable energy accounts for approximately 9% (1999) of the total energy consumption (Energy Futures, 2000). Most of this energy is generated from fuelwood and dung and not from modern renewable energy technologies. Less than 1% of the total electrical energy used in South Africa originates from renewable energy sources. The White Paper on Renewable Energy Policies (DME, 2004) targets the provision of 10 000 GWh of electricity from renewable resources (mainly biomass, wind, solar and small-scale hydro projects) by 2013. This is approximately 4% of the country's estimated electricity demand or equivalent to replacing two 660 MW units of Eskom's coal-fired power stations.

Table 7 outlines estimates of the theoretical potential for RE sources from 3 different sources.

**Table 7: Estimates of theoretical potential for renewable energy sources in South Africa**
*Source: DME (2003a)*

| | *DANCED / DME* | *Howells* | *RE White Paper* |
|---|---|---|---|
| *Resource* | *PJ / year* | | |
| Wind | 6 | 50 | 21 |
| Bagasse | 47 | 49 | 18 |
| Wood | 44 | 220 | |
| Hydro | 40 | 20 | 36 |
| Solar | | 8 500 000 | |
| Agricultural waste | | 20 | |
| Wood waste | | | 9 |

### 3.4.1 Hydro

Currently there are 8 licensed small hydro facilities smaller than 50 MW, which have a combined capacity of 68 MW. In South Africa small-hydro is regarded as RE and ranges from 1 MW to 50 MW. The power generation potential of small hydro schemes amounts to 9 900GWh per year (DME 2003b). However, there are an estimated 3 500 to 5 000 potential sites for mini-hydro along the eastern escarpment, and currently six small-hydro schemes, taking 10 MW as the cut-off. Eskom (the national power utility) runs two of these (First Falls, 6 MW licensed capacity; Ncora 2 MW), municipal generators three (Lydenburg 2 MW, Ceres 1 MW and Piet Retief 1 MW) and one privately-owned facility (Friedenheim 3 MW). Eskom also runs Second Falls with 11 MW and Collywobbles at 42 MW (ERC, 2004).

There exists a significant potential for development of all categories of hydropower in the short and medium terms in specific areas of the country (Figure A1). For example, the Eastern Cape and KwaZulu Natal provinces are endowed with the best potential for the development of small, i.e. less than 10 MW, hydropower plants. The advantages and attractiveness of these small hydropower plants are that they can either be stand-alone or in a hybrid combination with other renewable energy sources. Further, advantages can be derived from association with other uses of water (e.g. water supply, irrigation, flood control, etc.), which are critical for the future economic and socio-economic development of South Africa (DME, 2004).

**Table 8: Total capacity and potential for all hydropower types in South Africa**
*Source: DME (2002)*

| *Hydropower category and size (MW, kW)* | *Hydropower type* | *Installed capacity* | *Potential for development* | |
|---|---|---|---|---|
| | | | *Firmly established MW)* | *Additional long-term (MW)* |
| Pico – up to 20kW | Conventional | 0.02 | 0.1 | 0.2 |
| | Unconventional | - | - | 60.0 |
| Micro- 20 to 100kW | Conventional | 0.1 | 0.4 | 0.5 |
| | Unconventional | - | - | 3.3 |
| Mini – 100 to 1MW | Conventional | 8.1 | 5.5 | 3.0 |
| | Unconventional | - | - | 2.0 |
| Small – 1MW to 10MW | Conventional | 25.7 | 27.0 | 20.0 |
| | Transfers | - | 25.0 | 5.0 |
| | Refurbishment | - | 11.0 | - |
| Subtotal for small/mini/micro and pico hydropower | | **33.92** | **69.0** | **94.0** |

| | | | | |
|---|---|---|---|---|
| Conventional macro hydropower (> 10MW) | Diversion fed | - | 3 700 | 1 500 |
| | Storage regulated head | 653 | 1 271 | 250 |
| | Run-of-river | - | 120 | 150 |
| **Subtotal for renewable hydropower in SA** | | **687** | **5 160** | **1 994** |
| Macro (large) (> 10 MW)-Pumped storage | | 1 580 | 7 000 | 3 200 |
| Total for macro and small hydropower in SA | | 2 267 | 12 160 | 5 194 |
| Macro (large) (> 10 MW) – Imported hydro | | 800 | 1 400 | 35 000 |
| **Grand total for all hydropower** | | **3 067** | **13 560** | **-** |

Some 5 160 MW of additional renewable hydropower can potentially be exploited from rural and urban hydropower resources, for either electrical or mechanical energy conversion (Table 8).

The Southern African Power Pool (SAPP) allows the free trading of electricity between SADC member countries, providing South Africa with access to the vast hydropower potential of the Inga Falls in the Democratic Republic of the Congo, and the Lesotho Highlands Water Scheme has the capacity to contribute some 72 MW of hydroelectric power to the system in the short term.

### 3.4.2 Solar

South Africa has one of the highest levels of solar radiation in the world (Figure A2). The average daily solar radiation varies between 4.5 and 6.5 kWh/ $m^2$ compared to about 3.6 kWh/ $m^2$ for parts of the United States and about 2.5 kWh/ $m^2$ for Europe and the United Kingdom (DME, 2004).

***Photovoltaics (PV)***

Photovoltaic (PV) systems are used for powering telecommunications networks, applied in small-scale remote stand-alone power supplies for domestic use, game farms and household and community water pumping schemes. The installed PV capacity is estimated at 12 MW (DME, 2003). Off-grid systems include a wide range of applications and sizes. The majority of off-grid systems are small (<50 Wp) solar home systems.

*Folovhodwe solar village project*

A village electrification project of 580 SHS systems was completed in the village of Folovhodwe, Limpopo Province. This project was undertaken through the Department of Minerals and Energy in 1997/8. It was not successful: a case of technology dumping.

*Maphephetheni solar village project*

The Maphephetheni solar village project is a small project initiated by the Solar Electric Light Fund and Solar Engineering Services in KwaZulu/Natal over the period 1996 – 2001. Overall, 52 households and a school – with 27 computers – have been equipped with PV systems. However, some of the households have since defaulted on payments or decided to opt out of the project and consequently 33 of the households are still equipped with SHS systems and are servicing their loans. In addition, the Embuyeni Clinic is supplied with key electricity services by three 75 $W_p$ modules.

*Off-grid concessions*

The DME has established a concessioning process (fee-for-service) for off-grid rural electrification. Six concession areas have been identified and concessionaires have been awarded concessions in five of these. Installations of SHS have so far taken place in only 4 concession areas. The sixth concession was planned to be awarded in September 2004 (see case study below).

**Table 9: Concessionaires, concession areas and total number of installations, June 2004**
*Source: Willemse (2004); ERC (2004)*

| *Concessionaire* | *Concession Area* | *Total number of installations* |
|---|---|---|
| Nuon-Raps (NuRa) | Northern Kwa-Zulu Natal | 6541 |
| Solar Vision | Northern Limpopo | 4758 |
| Shell-Eskom | Northern parts of the Eastern Cape and Southern Kwa-Zulu Natal | 5800 |
| EDF-Total (KES) | Interior Kwa-Zulu Natal | 3300 |
| Renewable Energy Africa (REA) | Central Eastern Cape | 0 |
| Total | | 20 399 |

The overall rate of installation was initially promising (in 1998/9) but has since slowed down considerably principally because of government subsidy uncertainties. The concession process is intended to deliver roughly 50 000 systems per concession area over the next 10 years. This represents a sizeable market, although there are uncertainties as to whether the customer base really exists, and whether the installation rate can be adequately accelerated.

*Other solar systems include:*

- Solar lanterns
- Larger household (or small business) systems > 50 $W_{peak}$
- Game lodge / guest house systems
- Water pumping systems
- Telecommunication systems
- School systems
- Clinic systems
- Other (navigational aids, garden lights; electric fencing; gate openers; etc.)

Grid connected PV (seven BP filling stations, Moshoeshoe Eco-Village, the Novalis Institute and the Green Building in Cape Town) capacity amounts to about 150kW and the new BP head office has installed about 40 kW.

**Table 10: Installed capacity and energy production of off-grid PV systems**
*Source: DME (2002)*

| *System description* | *Installed capacity (kWp)* | *Energy production (MWh/year)* |
|---|---|---|
| Pre-1992 SHS | 1 125 | 1 971 |
| Off-grid concession SHS | 350 | 613 |
| Maphephethe SHS | 5 | 9 |
| Free State farmworkers SHS | 40 | 70 |
| Folovhodwe solar village | 29 | 51 |
| Hluleka mini-grid | 50 | 88 |
| Solar schools | 1 460 | 2 558 |
| Solar clinics | 100 | 175 |
| Telecommunications | 7 000 | 12 264 |
| PV pumping | 1 000 | 1 752 |
| Game lodges | 500 | 876 |
| **Total** | **11 759** | **20 602** |

*Solar water heating*

Domestic solar water heating (SWH) is currently about 1.3% of the solar energy market in terms of numbers. SWH can reduce domestic electricity consumption by approximately 30% (DME, 2002). Due to the high initial capital cost, virtually no solar water heaters are found in low-cost housing areas. As such, until very recently, increased access to affordable energy services for disadvantaged household has not been provided by solar water heaters. Nevertheless, SWH could make a major contribution in respect of reducing household expenditure and increasing job creation through the manufacture, sale, installation and maintenance of SWH especially in disadvantaged communities.

### 3.4.3 Wind

Wind power potential is fairly good along most coastal and escarpment areas with mean annual windspeeds above 4 m/s (see Figure A3 in the appendices). The upper limit of wind energy available to be captured in South Africa is estimated at 3 GW. It is estimated that wind power could supply at least 1% (198 000 GWh) of South Africa's projected electricity requirements (DME, 2002).

**Table 12: A projection of the available wind energy capacity in South Africa, along with its estimated annual energy production (DME, 2002a).**

| *Type* | *Capacity (KW)* | *Estimated annual production (MWh)* |
|---|---|---|
| National grid | 3 160 | 5 000 |
| Rural mini-grid | 45 | 111 |
| Off-grid | 510 | 1 117 |
| Bore-hole windmills | 12 000 | 26 000 |
| Exploited wind energy | 16 000 | 32 000 |

The South African government has recognised the importance of wind energy in a future energy mix and has declared the Darling wind farm project a national demonstration project. According to Haskins and Oelsner, 2004 the Darling wind farm to be established in the Western Cape is an example of a potential independent power producer. The proposed 10 MW facility will be sited at the Slangkop farm, north of Cape Town. It will be built over 2 phases: phase 1 will comprise five 1 MW turbines. The City of Cape Town will purchase electricity from the Darling wind farm at a cost higher than the average price of Eskom-supplied power in the area. City of Cape Town will sell this as green electricity. City of Cape Town has thus far spent about R2 million on a green electricity market survey. Work on phase 1 is scheduled to start in November 2004. A R35-million demonstration and training facility is also being planned (Haskins & Oelsner, 2004).

The Darling wind farm will be used to identify, develop and update the necessary strategies and regulations on how to deal with independent power producer issues. It will also serve as a case study to formulate future wind energy policy.

Eskom has started to generate electricity from three wind turbines at the Klipheuwel wind farm, about 40 km north of Cape Town. The wind farm consists of Danish Vestas V47 660 kW and V66 1,75 MW wind turbines and a French Jeumont J48 750 kW wind turbine. Implementation of this research and demonstration project started in 2002/2003 with a view to investigate the potential of large-scale wind energy for bulk electricity generation in South Africa.

### 3.4.4 Biomass

The main sources of biomass energy are fuel wood in the rural domestic sector, bagasse in the sugar industry, and pulp and paper waste in the commercial forestry industry for in-house heat and electricity generation. The total biomass potential is given in Figure A4. Fuel wood is the main source of energy for most rural households. The Renewable Resource Database identified the following woody biomass resources:

- commercial plantations;
- indigenous woodlands;
- alien vegetation;

- deciduous fruit tree off cuts from pruning;
- sawmills – mostly woodchips, sawdust and bark;
- pulp mills: boiler ash, sludge, sawdust and black liquor.

The viability of wood as an energy source suitable for electricity generation lies within the wood, pulp and paper industries. The table below gives the result of the Renewable Resource Database modeling of the wood and pulp industries' energy potential based on availability and energy content of fuels. The electricity generation capacity for sawmills is estimated at 7 600 GWh per year, and for pulp mills at 4 500 GWh per year.

**Table 13: Annual fuelwood and pulp energy potential from specific sources in terms of electricity generation**
*Source: DME; Eskom; CSIR (2001)*

| *Type* | *Tonnage (t/Year)* | *Energy potential (GWh/year)* |
|---|---|---|
| Sawmills | 1.57 million | 7 639 |
| Pulp mills | 1 million | 4 528 |

Biomass in the form of firewood, wood waste, dung, charcoal and bagasse accounts for close to 10% of net energy use at a national level.

***Bagasse***
Bagasse currently produces 210 GWh a year in terms of electricity generation. Potential bagasse generation capacity is approximately 1 400 GWh per year.

***Manure and litter***
The potential exists to utilise the manure and litter from livestock to generate methane gas through anaerobic fermentation in biogas plants. The potential energy from livestock manure and litter is approximately 5 600 GWh per year (Stassen, 1996).

**Table 14: Potential energy from livestock manure and litter**
*Source: Stassen (1996)*

| *Type* | *Energy production (GWh/year)* |
|---|---|
| Cattle | 3 889 |
| Pigs | 306 |
| Poultry | 1 417 |

***Biodiesel***
South Africa could produce 1.4 billion litres of biodiesel per annum without impacting negatively on the production of food (DST 2003). This amounts to 20% of the country's diesel consumption. The study also shows that, for the best-case scenario (i.e. where sunflowers and soybeans are produced on a rotational basis), biodiesel can be produced with borrowed capital at a break-even factory price of R3.06 per litre. When return on investment of R0.40 per litre is added to this figure, it means that the factory gate price of biodiesel is R3.46 per litre. If taxes and levies of R0,79 per litre plus the existing fuel companies' wholesale margin is added, the biodiesel wholesale price is R4.54. This means that a corresponding subsidy would be required, and to ensure fiscal neutrality, this would require a premium of between R0.01 and R0.03 per litre on petrol.

A number of positive impacts have been identified. Biodiesel would have a positive impact on job creation and would lead to development in disadvantaged rural areas.

***Energy from waste***
South Africa disposes most of its refuse to landfill sites. The net realisable energy available from sewage-derived methane is in the order of 36 MWh (1.13 PJ) per annum for electricity generation

and 96 MWh (3.0 PJ) for heating purposes (DME, DANCED, 2001). Options for energy production from municipal waste are being examined including biogas digestion as well as methane gas from landfills (DME, 2004).

### 3.4.5 Wave energy

Wave potential along the Cape coastline is estimated as significant. The Cape Peninsula has an offshore mean annual power level of approximately 40 kW/m wave crest. The average harvestable potential power along the entire coast is estimated to be 56 800 MW (DME, 2004). However the economic and engineering feasibility of harvesting this resource has not yet been demonstrated in South Africa.

## 3.5 Case studies

Three case studies have been selected on the basis of contributing to poverty alleviation and poverty reduction, their feasibility, and government policy priorities. The case studies are on biodiesel, solar water heaters, and fuelwood. They address different requirements and contributions to poverty alleviation. The major contribution to poverty alleviation of a biodiesel programme would be job creation and economic development in disadvantaged rural areas. Biodiesel could energise remote communities and raise productivity. Further it would contribute to energy security and reduce greenhouse gas emissions. SWH are an obvious way of reducing fossil-fuel emissions associated with water heating aand the high-end market can be expanded at a relatively low intervention cost. Manufacturing and installing SWH on a large scale would create jobs and if suitably subsidised, possibly by including them into the existing housing grant for the poor, SWH would increase the welfare of the poor but the question remains if SWH are the most urgent need of the poor. Fuelwood is the most commonly used energy source of the rural poor. Even after electrification many poor households in South Africa still have to rely on fuelwood for cooking because they cannot afford to pay the monthly electricity bill. Overall the fuelwood potential in South Africa seems to be adequate although there are shortfalls in several areas and women and children have to walk longer and longer distances to gather fuelwood for cooking. Fuelwood has been included as a case study because it is going to be the staple energy source of the poor in Southern Africa and Africa for the next 40 years. Forests and woodlands around population centres are degrading fast and fuelwood deficits are getting larger and no clear policy has yet emerged to address the situation successfully. The South African case study may be useful for other African countries.

**Table 15: Summary of case studies**

| *Potential case studies criteria* | *Case study 1: Biodiesel* | *Case study 2: Solar water heaters* | *Case study3: Fuelwood* |
|---|---|---|---|
| Representativeness<br>Replicability | Oil crops can be grown in 6 out of 9 provinces | Can be fitted on many buildings; suitable for all parts of the country | Affects very many poor households, particularly poor rural households |
| Potential population benefited | 200 000-300 000 | 15 million | 20% of population |
| Complexity | Highly complex | Not complex | Complex |

### 3.5.1 Case study: Biodiesel

The most common liquid and gaseous biofuels are biodiesel, ethanol and biogas. Biodiesel is the fuel that has grown most rapidly from almost zero in 1995 to 1.5 billion litres per annum worldwide in 2004 (IEA). The use of biofuels is expected to grow rapidly in the future because they address key fuel and policy needs of economic development, energy security and environment. New conversion technologies will make woody biomass and dried leaves and stems of other crops such as maize important resources for biofuels in the future. Such feedstocks will expand the growing of suitable biomass to a wide range of climatic conditions and will help reduce the potential for food/fuel conflict (IEA 2004). Biodiesel is a fuel oil made by a transesterification process from oil plants such as sunflower, soy, rape and cotton seed or from waste cooking oil. It may be used in any diesel motor vehicle and mixed in any ratio with mineral diesel. Biodiesel costs two to three times as much to produce as it costs to produce petroleum diesel (IEA 2004) and appropriate economic, market and regulatory instruments are required to make biodiesel competitive.

In North America and Europe biodiesel is usually blended with petroleum diesel at concentrations of 5 to 25% (B5-B25). In Germany the use of 100% biodiesel (B100) is common. There are over 1800 biodiesel pumps at filling stations in Germany and Austria; it has a 100% tax exemption which allows the consumer to buy B100 at about the same price or slightly less than petroleum diesel.

In South Africa a number of positive impacts have been identified. Positive balance of payment impacts will be achieved through increased exports and reduced imports. At present South Africa is a net exporter of diesel. This means that any additional diesel produced would add to the amount to be exported. At R2.00 per litre, this would amount to R2.8 billion per annum. However considering present estimares the production cost would be higher. The better strategy would be to promote greater use of diesel within South Africa. In addition, imports of R1 billion per annum (in the form of oil cake, oil seeds, glycerol and seed cotton) will be saved as these are by-products of biodiesel production. The impact on job creation is also positive. For the best-case scenario, it is estimated that up to 300 000 jobs could be created, mainly in disadvantaged rural areas (CSIR, 2002).

***Policy issues***

At present the cost of biodiesel is greater than petroleum diesel and this means that policies and regulations are necessary for biodiesel to compete in the marketplace. Biofuel policies in other countries (covering both biodiesel and ethanol) are based on three approaches (IEA, 2004; Winkler, 2005): taxation-based policies, agriculture-based policies and fuel mandates.

**Taxation-based policies** typically reduce the fuel excise taxes. In 2002 the South African Minister of Finance reduced the fuel tax on biodiesel by 30% thus encouraging production of biodiesel. Tax reductions and exemption reduce government revenue.

**Agriculture-based policies** in some countries consist of farming credits for using biomass grown on set-aside lands that are unavailable for food production. This will lower the cost of the biomass feedstock and the biofuels. Such policies have been used in Europe for ethanol production. So far no agriculture-based policies or regulations have been developed in South Africa to facilitate the growing of oil crops for biodiesel. Agriculture-based policies like tax-based policies help to keep the biodiesel price down at the pump but reduce government revenue.

**Fuel mandates** determine a minimum percentage of biofuels that motor fuels must contain. Such a policy is helpful to achieve biofuel implementation. For example Brazil’s policy requires that all motor gasoline contains at least 22% ethanol. The European Union also has policies that stipulate minimum percentages of biofuels in the motor fuels mix and fuel mandates are considered in other parts of the world including North America. Fuel mandates are easy to implement. Motor fuel taxes levied by government are not affected, but consumers may pay higher prices at the pump to cover the higher cost of biofuels.

***Poverty alleviation***

One of the government’s priority policy goals is to facilitate employment creation and to reduce poverty. The biodiesel programme could contribute to the alleviation of poverty through agricultural activities in planting and processing oil crops. This requires that oil crops are not grown exclusively by commercial farmers but also by small-scale farmers in disadvantaged areas. Biodiesel can be produced on a small or large scale. In Austria and France agricultural cooperatives supply the feedstock and use scaled-down technology for biodiesel production. Their members are often the end-users of the fuel. A tax relief on biofuels produced by small pilot plants can be a powerful incentive to SMEs.

**Table 16: Estimation of biodiesel production potential per province with assumed rotation practices**

*Source: CSIR (2002)*

| *Province* | *Crop rotation* | *Estimated area for oil crop (ha)* | *Estimated biodiesel production (million litres)* |
|---|---|---|---|
| Eastern Cape | 50% maize<br>25% sunflower<br>25% soy | 450 000 | 270 |

| | | | |
|---|---|---|---|
| KwaZulu-Natal | 30% maize<br>30% sunflower<br>30% cotton | 526 000 | 260 |
| Limpopo Province | 50% sunflower<br>50% cotton | 800 000 | 480 |
| Traditional maize areas | maize<br>sunflower | 600 000 | 396 |
| Total potential | | 2 376 000 | 1 400 |

***Potential population benefited***

The number of people who could benefit from the implementation of a biodiesel programme is difficult to estimate. The programme may start with a pilot area in which oilcrops are grown on a limited scale and experience is gained. Once this stage is successfully completed oil crops can be extended to larger areas and more and more small-scale farmers can be involved. The limiting factors will be availability of land, water, soil and climatic conditions.

***Complexity***

Manufacturing biodiesel from oil crops is not technologically complex. The typical by-products of biodiesel are a protein-rich oil cake and glycerol. The value chain from the seed in the farmer's hand to diesel in the vehicle engine is long and this makes the implementation complex. A biodiesel project would involve many sectors such as agriculture, local government, energy, science and technology, treasury. This is one of the reasons why the initial production will have to be facilitated and supported, and assistance from different government departments is required.

Four oil crops – sunflower, soy, cotton and groundnut – are grown in South Africa and are suited to soil and climatic conditions. These crops are often rotated with the staple food maize. Different crop rotations are suitable in different geographic regions (see Table 16). Various by-products are associated with each oil crop and these can determine if a crop can be grown economically. Prices for each crop and by-products have to be set very carefully to satisfy the national demand for the various end products and to make sure that national food production is guaranteed when more land is cultivated for oilcrops. At least four ministries are involved here. The Department of Agriculture has to provide advice through its extension services, and this should be particularly addressed to small and subsistence farmers to increase productivity in disadvantaged areas. The Department of Science and Technology should assist with extracting and processing technology and transfer of such technologies to disadvantaged areas. The Department of Minerals and Energy would be concerned with policy, strategy, distribution and regulation. Infrastructural services will have to be improved in disadvantaged areas and the programme will have to be included in the current integrated regional and local development plans (Department of Provincial and Local Government). Taxes or their exemption and subsidies will have to be determined and approved by the Treasury. The oil companies will have to blend the biodiesel with petroleum diesel and have to agree to transport the biodiesel in their pipelines and wheeling charges will have to be negotiated. The motor car industry will have to approve the biodiesel blends as suitable for their makes of vehicles and extend the engine guarantee to customers under the conditions that a certain percentage of the diesel mix is biodiesel. The Bureau of Standards will have to determine fuel specifications and standards. The list of stakeholders may even be longer.

The biodiesel by-products may have other advantages, such as the following: If more cotton seed is grown for biodiesel it would increase the national cotton production and substitute cotton imports. Also the quality of cotton harvested by small-scale farmers is higher because it is hand picked and the net income per hectare is higher than for machine-harvested cotton. The by-product, oil cake reduces the shortage of plant protein as animal feed and also would substitute oil cake imports. Production levels in disadvantaged rural areas could be increased after studying the production limiting factors in these areas. Producing 1.4 billion litres of biodiesel per annum will have no negative impact on food production.

***Case study characteristics***

**Table 17: Involvement of other sectors**

| *Sectors/ subsectors* | *Requirement* | *Technology* | *% covered with RETs* | *Target population* | *Case study context* |
|---|---|---|---|---|---|
| Agriculture | Oil crops for biodiesel | Growing oil crops | 1.4 billion litres of biodiesel can be produced from 2.3 million ha | Large- and small-scale farmers | Need for extension services |
| Science and Technology | Developing and transferring technologies | Oil extracting and processing technologies, oil cake production | | Large and small-scale producers | Producers to be assisted with design of oil extraction equipment |
| Minerals and Energy | Policy and strategy formulation, regulation, pricing | Draft strategies and determine amount and types of subsidies | | | Policies and strategies |
| Provincial and Local Government | Development of infrastructure in areas where oil crops are grown, IDP | Roads, water, electricity | | Commercial, small-scale and subsistence farmers | Land ownership and land tenure, development in disadvantaged areas |
| Treasury | Taxes, their exemption and subsidies | Determine amount and types of subsidies and other incentives | | Producers and consumers | Prices, taxes, subsidies |
| Transport | Diesel for vehicles | Biodiesel | 1-10% of diesel blend in the next 10 years | Taxis, buses, heavy transport vehicles, government and corporate fleets, private cars | Encourage official fleets to use biodiesel |

The production of biodiesel has many potential benefits in terms of security of supply and particularly in the future when mineral oil and gas reserves will be declining. It has the potential to contribute to job creation and development in disadvantaged rural areas. However, the development is complex and needs the cooperation of different sectors. It is a new venture and few sectors have experience in it. A coordinated effort is required to develop biodiesel.

### 3.5.2 Case study: Solar water heaters

All regions of South Africa have an ideal climate for SWH, with high annual radiation levels averaging daily between 4.5 and 6.5 kWh/m$^2$ compared to about 2.5 kWh/m$^2$ for Europe. Most parts have clear skies during winter and only in the relatively small winter rainfall region of the Western Cape and some other areas which experience cold cloudy spells radiation levels in winter are reduced and SWH systems are usually backed up by grid electricity. About 18% of the urban residential electricity consumption could be replaced by SWH (CaBEERE 2004).

SWH are manufactured in South Africa and there is a well established SWH industry. The industry is presently forming an umbrella organisation called Solasure to assist quality assurance. In the 1970s and 1980s ten times more SWH were sold than now, then the industry collapsed and has never recovered. This had partly to do with the fact that the CSIR stopped a fairly active nationwide marketing programme and 'fly-by-night' companies, unsuitable design and disgruntled customers. To prevent this happening again the industry got together, planning to set manufacturing and installation standards. Accreditation will be another feature to assure homeowners and insurance companies. An ombudsman is also to be appointed. These measures are expected to change the way solar water heating is viewed and to raise the profile of the industry.

***Poverty alleviation***

The SWH industry has the potential of adding R1383 million to the GDP and R176 million to the income of low income households (Table 1). It is estimated that manufacturing, installing and servicing SWH will create 5909 jobs but since SWH will in some cases replace electric water heaters some jobs may be lost in the electric-water-heater industry.

SWH improve the welfare of the poor by having running hot water and spending less for it. Hot water improves hygiene and health.

***Potential population benefited***

There are different groups of people who will benefit from expanding the SWH industry. Newly created jobs will benefit about 6000 people. If all RDP houses are fitted with SWH 6.5 million people will enjoy the comfort of running hot water and will be spending less for it. The high income households are principally targeted for the installation of SWH because they are most likely to afford them. In the commercial and institutional sectors, offices, hotels, banks, hospitals, hostels (education) and prisons would derive long-term financial benefits.

***Complexity***

No aspect of SWH is very complex. The greatest barrier is their upfront cost. Affordable financing schemes have to be developed. If SWH companies offer flexible loans, guarantee the reliability of SWH and a nationwide marketing drive is maintained SWH will be widely disseminated in the domestic and commercial sectors. Electricity tariffs are expected to rise in the future and this will make SWH more attractive. In an expanding SWH market, larger sales volumes can be expected to lead to lower equipment prices.

### 3.5.3 Case study: Fuelwood

In the last ten years access to electricity has increased from 36% to 70%, bringing electricity to many disadvantaged communities. In the early years of the accelerated national electrification programme, it was thought that households would switch to electricity when they obtained a grid connection or that those not yet connected would use other modern fuels such as kerosene or LPGas. As a result of such views, the provision of fuelwood was no longer considered a priority. But many poor households cannot afford the electrical appliances and the monthly cost of electricity for cooking, in spite of the fact that South Africa has relatively low tariffs and the poor receive 50 kWh per month of free basic electricity. Many poor households still depend on fuelwood for their most energy-intensive activity: cooking. In 2001, 69% of households used electricity for lighting and only 51% used it for cooking (ERC 2004: 57), indicating that 18% of those households that were connected to the grid did not use it for cooking. Very poor households use fuelwood and kerosene because they perceive these fuels to be cheaper. Overall, 21% of South Africans use wood for cooking and 64% of these households are in the lowest income brackets (annual household incomes from R0 to R9600) (ERC 2004: 58). The use of fuelwood for cooking is clearly correlated to poverty. Many of the poorest people live in remote rural areas which have not yet been reached by the electricity grid, and therefore they miss out on electricity for lighting and also the free basic electricity subsidy. Fuelwood strategies could explore how poor people without access to electricity could benefit from free basic energy.

The national fuelwood stock is a very valuable resource and annual fuelwood demand is estimated to be worth R3 to 4 billion. Locally, the demand is very variable and appears to be higher where more wood is available (Shackleton et al 2004). Where fuelwood is the major energy source households consume about 1 to 4 tonnes per year.

Community forest and woodland resources are declining in some areas making it harder for poor women to satisfy their fuelwood needs. A case study in a poor rural area of the Eastern Cape where fuelwood sources were depleted showed that households which bought fuelwood spent as much as R69 on fuelwood per month (Prasad et al 2004).

Fuelwood is a renewable resource and if harvested sustainably it will meet the energy needs of the rural poor for many decades. Growing trees for sustainable fuelwood harvesting has environmental and socio-cultural value; the carbon sequestration potential and the international trading of carbon credits are also of potential benefit (Shackleton et al 2004). At the same time, it must be remembered that smoky use of fuelwood contributes to local air pollution and health risks, as well as other GHG emissions associated with incomplete combustion.

Wood and fuelwood are part of forestry and fall within the responsibilities of the Department of Water Affairs and Forestry. Forestry in South Africa has a long history and has developed in two sectors, industrial forestry and community forestry, along with the dual economy of the country. Industrial forestry is a profitable business providing raw materials for a substantial pulp and paper industry and also supplying timber to the mining and other industries.

Community forestry is expected to meet local social, household and environmental needs and to assist local development (DWAF 1996b). Communities are the major participants. It includes forestry programmes like farm forestry, agroforestry, community and village planting, woodlots and woodland management by rural people, as well as tree planting in urban and peri-urban areas (DWAF 1996b). Community forestry for fuelwood has been neglected in the past and community forestry among African people has had little success (DWAF 1996b). Some woodlots in the Eastern Cape established around indigenous forests helped to conserve the natural resource. Woodlots were more successful when they were integrated into the natural resource use system in which the needs of the community were given greater consideration.

Social forestry (SF) is the planting and/or management of trees by local individuals, communities or groups to meet local needs. It includes a number of options for tree planting and tree dissemination like agroforestry, homesite tree planting, tree delivery systems based on a network of village nurseries, school tree planting, using trees for soil rehabilitation. Some SF programmes have been very successful and their replication in different areas is very promising.

The Biomass Initiative (Gandar1994) has gathered a wealth of information and lessons learned which are very valuable for designing a fuelwood strategy

***Policy issues***

Fuelwood is a large national resource that if sustainably managed could contribute to improve the livelihoods of poor households.

Poor households in remote rural areas often lose out on free basic services such as free basic electricity because they don’t have access to these services. Such subsidy could be used to facilitate sustainable fuelwood management and marketing so that the poor have easy and affordable access to it.

The state owns considerable wooded land resources and access to state woodlands for fuelwood collection should be considered.

It is important to integrate fuelwood provision into local integrated development plans.

***Poverty alleviation***

The poorest of the poor use fuelwood because they cannot afford other energy sources and appliances. Poverty alleviation is a priority area for government and subsidies for free basic energy could include a fuelwood subsidy in poor areas without electricity where fuelwood is the primary source of energy. Subsidies and/or other support measures for healthier wood-burning techniques such as stoves and ventilation of smoke could reduce the health costs and hazards of smoky fuelwood use.

The national fuelwood resources are worth billions of Rands and if sustainably managed the planting, maintaining, harvesting and marketing of fuelwood can create many jobs.

***Potential population benefited***
At the national level, 20% of all households use fuelwood for cooking and space heating. At the local level the situation is very variable and in some areas more than 50% of households use fuelwood as their primary energy source.

## 3.6 Assessment of capacities

The assessment of capacity is done for the three case studies. Capacities for the three cases vary greatly. Fuelwood is the oldest energy source used by humans. SWH are known and the technology is used by some while biodiesel is relatively new and it is not well known. The capacity assessment of the three cases is given in the comparable following lists. See also tables A5, A6 and A7 in the Appendix.

### 3.6.1 Capacity assessment: Biodiesel

There are no fuel crops grown for biodiesel production but oil crops such as soya and sunflower are grown for human and animal consumption. For example sunflower is quite widely grown and soy beans are also grown in some areas. There would be some capacity to grow some of the crops but the amount grown would have to be scaled up. There is no biodiesel being processed, blended and marketed and considerable new capacity would have to be built.

***1. Legislative authorities, elected officials and 2. Government macroeconomic and development planners***
There are just a few pioneering farmers who have grown oil plants for biodiesel in the past and biodiesel is known to some in the agricultural sector but it is not so well known in other sectors and by elected officials its potential role in creating jobs and uplifting disadvantaged areas is not appreciated. Since biodiesel cannot yet compete with petroleum diesel, initial incentives – such as tax relief, subsidies, credits and fuel mandates – are necessary to get the industry started. When the production cost of biodiesel comes down and the price of fossil oil continues to rise, biodiesel incentives may be reduced.

***3. Government energy authority or ministry***
The role of biodiesel is appreciated in the energy and finance ministry and the minister of finance has recently announced a fuel levy rebate of 30% on biodiesel. This is an encouraging sign for industry because it would make the biodiesel manufacture more competitive with petroleum diesel.

***4. Energy regulatory bodies***
The minister of energy is the regulator for the liquid fuel industry including biodiesel. Having supported a 30% cut in government levy it is expected that the future biodiesel industry will be encouraged by the regulatory authority.

***5. Market coordination agency***
There is a need to identify potential market coordination agencies. The recently established South Africa Energy Management Association (website: www.sema.uct.ac.za) includes industry members, energy experts and public sector organisations. With government support such organisations could bridge the gap between policy goals and implementation by providing training, and assistance with technology development and implementation (EDRC 2003).

***6. Non-energy governmental authorities/ministries***
The production of biodiesel involves other ministries besides the Department of Minerals and Energy. The Department of Agriculture would be concerned with food security when food crops are displaced by oil crops for the transport sector. The technology innovations and the various aspects of technology transfer either from countries outside South Africa where a viable biodiesel industry has been established or within the country from technology centres to disadvantaged populations, would be of interest to the Department of Science and Technology. The DST has recognised the need for more information and capacity and has set up a joint implementation committee for biodiesel in which stakeholders are represented.

***7. Energy supply industry***

Sasol, the world's biggest producer of fuel from coal, is considering a soybean-to-diesel plant (Bridge, 2004). If approved, the plant would produce 91 million litres of biodiesel per annum. At present local farmers produce only 136 500 tons of soy beans and the company may have to import the shortfall until such a time that South African farmers switch to growing more soy.

***8. Entrepreneurs and productive industry***

Potential large producers like Sasol, which has declared an intention of starting biodiesel manufacture, have the in-house capacity to start a biodiesel industry. Any capacity they do not have they can hire or subcontract. Sasol would build capacity for its own production units but small rural producers need assistance and support from government..

***9. Energy equipment and end-use equipment manufacturers and 10. Energy equipment O&M services***

Some of the equipment will be imported at least initially. The country has a well-developed mining and manufacturing industry and if demand is sufficient all equipment could be manufactured in the country. O&M services can be trained locally and will contribute to employment creation.

***11. Credit institutions***

Credit is essential for manufacturers and farmers. Commercial farmers can obtain credit through the appropriate farming-related institutions. Large companies have well established relations with credit institutions and biodiesel would just be another product for which they would seek credit. The small-scale and community producers need assistance and possibly government support to access credit institutions. Credit institutions need to become familiar with oil crops as an economically viable crop.

***12. Civil society / NGOs***

Civil society and NGOs have important roles to support the implementation of biodiesel as consumers, advocating diesel cars and supporting community biodiesel producers. They need to be better informed of the potential benefits of biodiesel.

***13. Users***

Diesel vehicles are not yet common in South Africa. 99 percent of light passenger motor vehicles (less than 12 persons) are petrol powered (Table 19). A study on attitudes towards diesel and petrol-powered vehicles (CSIR 2001) found that petrol vehicles were preferred and gave the following reasons for their preference:

The respondents said that they don't know diesel, they are used to petrol, petrol is readily available, petrol cars are faster, they start first time and start better when it is cold, petrol engines are quieter, have good performance and are more powerful. The respondents gave the following reasons for preferring diesel vehicles: they are more economical, they last longer and are more fuel efficient; diesel vehicles are better for farm and poor roads, their maintenance costs are cheaper and they are easier to maintain/service (CSIR 2001, p 52).

**Table 19: Motor vehicle propulsion**

*Source: CSIR (2001)*

| *Vehicle type* | *Petrol/diesel-powered* |
|---|---|
| Light passenger motor vehicle (less than 12 persons) | 99% petrol<br>1% diesel |
| Light load vehicle (GVM 3 500 kg or less) | 85% petrol<br>15% diesel |
| Motor cycle | 100% petrol |
| Minibus | 85% petrol<br>15% diesel |
| Special vehicle | 90% diesel<br>10% petrol |
| Heavy passenger motor vehicle (12 or more persons) | 100% diesel |

| | |
|---|---|
| Heavy load vehicle (GVM>3 500 kg, not equipped to draw) | 100% diesel |
| Heavy load vehicle (GVM>3 500 kg, equipped to draw) | 100% diesel |

There is a taxi recapitalisation programme in place which involves replacing the estimated 120 000 petrol-powered taxis with larger diesel-powered midi-bus taxis expected to use 600 000 kl of diesel per annum (CSIR 2001). Users need to be better informed about the advantages and disadvantages of modern diesel engines.

***14. Energy specialists and consultant firms***
There are hardly any energy experts and consultancy firms specialising in biodiesel. These would have to be trained.

***15. Academia and research organisations***
There are no specific courses on biodiesel. Oil crops are well known and are grown in the country as vegetable oils for human consumption and their cultivation is taught in the agricultural faculties. Research and teaching in renewable energy resources, technologies, markets and policies has to be strengthened as a matter of priority at universities and technical training institutions.

***16. Media***
Media play an important role in shaping public opinion and attitudes. Media should be made aware of the advantages and disadvantages of diesel engines and explain these to the public.

Concluding the assessment of capacities it appears that a major capacity-building drive at all levels and in all relevant areas is required to implement a biodiesel programme. The major reason for this is that biodiesel is a relatively new fuel and has been known to only very few as a viable fuel for motor vehicles. The very first step is to start an information programme about the potential of biodiesel.

### 3.6.2 Capacity assessment: Solar water heaters (SWH)

SWH technology is known and a limited number of SWH companies exist. It is necessary to create greater demand and increase the capacity of SWH companies in South Africa. Reliable studies, analysis and demonstration are required to evaluate the benefits. Legislative authorities, elected officials

Wider dissemination of information on the benefits of SWH is required.

***2. Government macroeconomic and development planners***
The macroeconomic impact: according to the CaBEERE 2004 report SWH for commercial buildings and high-income households would create 5909 jobs (Table 1); the dynamic financial costs would be R0.27 per kWh as compared to the dynamic socioeconomic cost of R0.23 per kWh. They would contribute 2341 GWh to the targeted 10 000 GWh from RE.

***3. Government energy authority or ministry***
The DME with sponsorship from Danida/DANCED has been running a large capacity-building programme (CaBEERE) focusing on renewable energy and energy efficiency. The White Paper on Renewable Energy Policy was published in February 2004 and a Renewable Energy Strategy is being drafted.

***4. Energy regulatory bodies***
No particular regulation is required for SWH. Developing standards for the industry has been going on for at least 15 years. EDRC recommended standards revisions (EU-compatible) as early as 1990-91. A weak commercial market, and poor SABS performance in this area, led to stagnation in effective national standards implementation.

***5. Market coordination agency***

The market players in the SWH industry formed an association ‘Solasure’ under the auspices of the Sustainable Energy Society for Southern Africa (SESSA). Its major function is quality assurance. There is no market coordination agency.

***6. Non-energy governmental authorities and ministries***
The DST and the DTI are generally supportive of renewable energy programmes. DST has support programmes for new technologies and SWH could benefit from these.

***7. The energy supply industry***

The energy supply industry is not involved in SWH. However, it is important for Eskom (and any other electricity suppliers) to judge the role of SWH in reducing average and peak load demands. This can affect their generation investment decisions.

***8. Entrepreneurs and productive industry***
There is a good number of entrepreneurs in the SWH industry who are trying to increase the market share of SWH. Lack of awareness, high upfront costs and relatively low grid electricity prices are the major obstacles to the expansion of the industry.

***9. Energy equipment and end-use equipment manufacturers***
The Solar Water Heating Division of SESSA worked out priority areas for their new association called Solasure. These are generally accepted testing standards, testing equipment and quality assurance for all sections of the industry. Market transformation was to start at the high-to-middle-income sector of the market because that sector is open to innovation and can afford the new technologies.

***10. Energy equipment and O&M services***
There is a range of companies to supply equipment and provide O&M services. If the market expands it is expected that the companies will grow in number and size and new capacities will have to be built.

***11. Credit institutions and financial support***
The Development Bank of Southern Africa is supportive of developments in renewable energy and has financed the Lwandle SWH project near Cape Town. The Industrial Development Fund invests in renewable energy and the Central Energy Fund is a potential co-investor. The Department of Science and Technology supports technology transfer and innovation and also capacity building in these areas. It is also supporting energy technologies that are targeting the poor and have the potential to alleviate poverty. Capital and service subsidies for SHS paid by government facilitate private investment in PV concessions but there is no funding support for SWH. Credit institutions in cooperation with SWH companies need to develop affordable financing schemes.

The CDM may offer project opportunities to sell the carbon emission reduction. The buyers in the market are among others the World Bank's Prototype Carbon Fund. The DBSA is an intermediary to assist project developers to access these funds from the World Bank. The Kuyasa project in Cape Town has developed a methodology for receiving CDM credits from the installation of SWHs.

***12. Civil society and NGOs***
Civil society and many NGOs lack inform information on technology, cost and financing of SWH. Reliable information is required.

***13. Users***
The potential users of SWH generally lack information about the advantages and drawbacks of SWH. Electricity tariffs being low many users are not convinced that SWH are an economic investment. It is quite likely that some domestic customers and even some industrial and business customers would be prepared to pay a little more for installing green water heating. Exporting industries would be interested to affix the green label to their products

***14. Energy specialists and consultant firms***
There are specialist and well established consultancy companies. If there is a massive roll-out more capacity would have to be added to the existing pool.

***15. Academia and research organisations***
SWH is a specialised topic which is taught as part of renewables. A masters dissertation has recently been written on SWH at the Energy Research Centre.

***16. Media***

Media need to be better informed. Professional magazines carry articles on SWH occasionally.

### 3.6.3 Conclusion

Basic capacities on which to build exist. However if SWH are rolled out at a large scale, much more capacity has to be built at all levels and in all relevant areas. Financial schemes have to be developed as a matter of priority. The SETA on energy should facilitate the training and education activities.

### 3.6.4 Capacity assessment: fuelwood

The poorest of the poor depend on fuelwood for their energy needs because they cannot afford to buy commercial fuels. National fuelwood resources exist and the capacity for their sustainable management has to be created so as to meet the fuelwood needs of the poor. Strategies and programmes have to be developed at all relevant government levels and in communities to facilitate affordable access to fuelwood.

***1. Legislative authorities, elected officials***

The DME has transferred the responsibility for fuelwood to DWAF, which appears to have considered fuelwood more of a forestry/woodland problem than an acute energy problem of the poor. Very recently the plight of the poor has been recognised and DWAF is in the process of preparing a fuelwood strategy.

The framework conditions for wood products are laid down in the forestry policy. With respect to household energy, government's prioritisation of electrification has led to the continued fuelwood dependence of poor households being insufficiently appreciated.

2. ***Government macroeconomic and development planners***

The great value of the national fuelwood resources and its potential to contribute to better livelihoods and job creation are not fully recognised. A policy, strategy and programmes for providing sustainable fuelwood for poor households are required.

3. ***Government energy authority or ministry***

The Department of Minerals and Energy is concerned mainly with modern fuels and has transferred the responsibility for fuelwood to the Department of Water Affairs and Forestry (DWAF). As part of a government drive to implement poverty alleviation programmes DWAF has recently started the process of drafting a fuelwood strategy. Capacity has to be built for strategy development and implementation.

***4. Energy regulatory bodies***

DWAF is the regulatory body for fuelwood. As part of a drive to implement poverty alleviation programmes the DWAF has recognised the urgency to regulate the fuelwood sector and to facilitate access to this basic energy source for the rural poor. Local government and traditional authorities have to be involved in formulating local-level regulation.

***5. Market coordination agencies***

Fuelwood is obtained from three sources: state forests/woodlands, private forests/woodlands and community forests/woodlands. The fuelwood market is localised and not coordinated. Individual entrepreneurs transport and sell fuelwood. Their mode of operation is often not sustainable largely because of very low profit margins. Marketing bodies in which fuelwood-using communities participate should be established.

***6. Non-energy governmental authorities/ministries***

Coordination between DWAF, DME and the Department for Provincial and Local Government (DPLG) is required for strategies and programmes of sustainable fuelwood production. The role of DPLG is to include the provision of fuelwood into provincial and local integrated development plans.

7. ***Energy supply industry***

The state, private individuals and plantation owners are suppliers of fuelwood. In addition community members can collect fuelwood from communal woodland for no charge. Community leaders generally stipulate conditions, under which fuelwood can be collected. The authority of the leaders is frequently challenged and the conditions are often not enforced.

8. ***Entrepreneurs and productive industry***

In plantation forests fuelwood is a by-product and in community woodlands it is one of the resources community members gather free of charge. The right to free collection is often abused - sometimes by outside fuelwood sellers. The sustainable management of woodlands by communities is required and entrepreneurs in community forestry should be trained.

9. ***Energy equipment and end-use manufacturers***

There have been many attempts to disseminate different types of woodstoves which increase the wood-burning efficiency and reduce indoor air pollution but in most cases user acceptance has been slow. A more effective dissemination strategy has to be developed. Energy centres and rural energy stores should be encouraged to sell improved stoves.

***10. Energy equipment O&M services***

The poor for whom the improved stoves are intended have to be involved in designing, testing and producing the stoves. Skill training in rural areas for production and repair services is necessary. A umber of efficient and low-smoke stoves are available, eg, Vesta stoves.

***11. Credit institutions***

Access to credit specifically designed to help the poor is very limited. Microcredit for the poor should be widely introduced.

***12. Civil society/NGOs***

Some NGOs have been active in promoting improved stoves. Fuelwood is a by-product of the very successful public works programme Working for Water whose objective is to remove alien invasive species. In areas where alien vegetation is the major or only fuelwood source, such vegetation should not be removed indiscriminately, but instead (where possible) carefully managed to maintain a sustainable fuelwood source for the poor.

***13. Users***

The most important group of fuelwood users are the poorest of the poor. When the poor cannot afford commercial fuels they fall back on fuelwood particularly when it can be collected free of charge. In order to assist the poorest of the poor it is very important that access to free or affordable fuelwood remains an integral part of any energy and forestry policy and strategy.

***14. Energy specialists and consultant firms***

There are hardly any energy specialists working on fuelwood problems at the moment. There are a few experts in environmental science and forestry who have concerned themselves with the sustainability of woodlands where most of the poor live and from which much of the fuelwood is collected.

***15. Academia and research organisations***

Very little work on fuelwood has been done since 1995/6 when the Biomass Initiative was effectively put on hold, and responsibilities fell in the cracks between DME and DWAF.

Most attention was on the dissemination of modern fuels and how to phase out fuelwood to achieve the transition from traditional biomass fuels to electricity, gas or even paraffin.

***16. Media***

The media follow the general trend, reporting extensively on issues to do with modern fuels. In contrast, fuelwood as an energy source for the poor is hardly ever reported on and has been forgotten. Awareness has to be raised.

#### 3.6.5 Conclusion

Capacity is required to put the provision of fuelwood on the agenda of government and follow up on the implementation. A dedicated sub-sector within DWAF should be created. The fuelwood resources exist but they are spatially variable and there are local shortfalls of supply; sustainable management is required to supply fuelwood where it is needed. Capacities have to be built in different departments of government and in local communities in order to manage wood resources sustainably, providing affordable fuelwood for the poor and creating jobs at the same time.

## 3.7 Renewable energy niches

#### 3.7.1 The concept of niche in the context of this project

The niche concept (Nadal 2004) was introduced in this project to characterize those situations in which it would be feasible to extrapolate some components of case study to national or regional level and generate a significant positive impact for the population. It involves the selection of those renewable energy resources and technologies as well as those energy system sectors and uses where their penetration is more likely, and where the potential for poverty alleviation is high. A niche is defined by a combination of activities and requirements, energy resources and biogeographical characteristics. One could also go into more detail and include socio-cultural and capacity aspects. In relation to mature technologies and renewable resources, either good present availability or potential for their development in the short and medium term are required. A niche tends to be of more general applicability than a case study and therefore includes the potential for replication and viability and sustainability aspects in the analysis. A niche does not simply refer to market issues but also to other non-economic aspects (technical, cultural, resources, etc.).

The prospects for successful dissemination of renewable energy fuels and technologies depend to a large degree on policy and strategy support, on the willingness of government to subsidise technologies that cannot yet compete with existing alternative technologies, on interested private producers who are willing to invest, on customer or user acceptance of the new product or service, and the ability of the technology to be financially self-sustaining in future. Table 22 gives an estimate of some of these factors for biodiesel, SWH and fuelwood.

**Table 22: Support for technology**

| | *Biodiesel* | *SWH* | *Fuelwood* |
|---|---|---|---|
| Specific policy/strategy support | High | Low at the moment | Moderate |
| Energy Ministry support | High | High | Moderate |
| Other ministries' support | High | Moderate | Moderate |
| Government's willingness to subsidise | High | Not yet decided | Moderate |
| Private producers interested | High | Very high | Low |
| User/customer acceptance | Moderate | Low | High |

#### 3.7.2 Niches for biodiesel

There are three major niches for biodiesel. Blending biodiesel with petroleum diesel for the transport sector is the most common market outlet for biodiesel in other countries and is estimated to absorb the largest amount of biodiesel in the future. Jobs will be created in the new industries and as the overall demand for transport fuel rises no jobs will be lost in the petroleum diesel sector. Cooperatives are established in some European countries and together with niche 3 in Table 25 have great potential for development and poverty alleviation.

**Table 25: Potential niches**

| *Potential niches criteria* | *N 1 Blend for petroleum diesel at industrial scale* | *N 2 Cooperative with surrounding producers and customers* | *N 3 Energy fuel in remote rural area* |
|---|---|---|---|
| Representativeness | | | |
| Replicability | High | High | Very high |
| Potential population benefited | Biodiesel producers and the global environment | Difficult to estimate at this time | Difficult to estimate at this time |
| Complexity | High | High | High |
| Suitability/Viability/Sustainability | | | |
| Affordability | Medium | | |
| Effectiveness | High | | |
| Risk of obsolescence | Low | | |
| Flexibility | Medium | | |
| Technological capability | Low | | |
| Suitability and urgency | High | | |
| Resilience | High | | |
| Adaptability | High | | |
| Environmental impacts | Very positive | | |
| Social acceptance | High but need for information and education | | |
| CD requirements | High | | |
| Income generation | High | | |

***Assessment of niches***

*Affordability:* There are three aspects of this technology for poor rural people: growing the oil crop, manufacturing the diesel and buying the diesel fuel. Poor rural people in communal areas have some land under communal land tenure, which they could use for oil crops. The government is implementing a land reclamation and redistribution programme under which many communities and individuals have made successful claims. The biodiesel cannot yet be produced at prices which directly compete with fossil diesel. In the long term, prices of fossil fuels are bound to rise. In the shorter term, the volatility of oil prices can pose problems for the financial sustainability of competing products such as biofuels. There is also a question about the ability of smaller-scale producers of oil crops (such as poor rural communities) to compete with larger agro-business. In the meantime, the Government has announced a fuel levy exemption of 30% for biodiesel, but further measures would be required to make biodiesel competitive at current prices. Such measures might have to include stabilisation mechanisms, to offset the effects of volatile prices in the petroleum sector.

*Efficiency*: At present oil crops for biodiesel are not grown and biodiesel is not produced. Adequate extension services for growing the crop and technological and management support will be required to produce biodiesel efficiently.

*Risk of obsolence:* There is very little risk of being locked into an obsolete technology. Crops can be changed within less than a year, the manufacturing equipment could be adapted if more advanced technologies are developed. Potential producers will be aware that biodiesel is a new technological area in which adaptation and technological innovation is part of the on-going development.

*Flexibility* The technology can be upscaled or downscaled according to the capacity to grow and process oil seeds.

*Technological capability:* The technology is not overly complex but relatively new in South Africa. Big companies with wide international experience such as Sasol have the capacity to assess the technological components on the market, assess their value, select which specific technology is needed, use it, adapt it and improve it and finally develop technologies themselves. Poor rural communities will need assistance to develop technological capability.

*Suitability and urgency:* Growing oil crops creates jobs in agriculture. The processing plants create employment and business opportunities in rural areas where unemployment is a major problem. The government has made poverty alleviation and job creation one of its urgent priorities.

*Effectiveness and efficacy:* Biodiesel production meets the needs for rural employment and increased rural productivity. It can also provide decentralised power systems to energise rural areas.

*Resilience and adaptability:* Different oil plants have different degrees of resilience under varying soil and climatic conditions. As the oil plant stock will be improved over the next five to ten years and technological processes will become more efficient the production system will have to remain resilient. At the same time the system has to be able to change to fit the changed circumstances.

*Environmental impacts:* There might be competing land and water demands for growing food and oil crops in some areas. The water use of the new oil crops would have to be assessed. Proactive planning can avoid a potential conflicting situation.

In contrast to petroleum diesel, biodiesel is $CO_2$ emission-neutral if harvested plants are replaced by new crops.

*Social acceptance:* Maize and sunflower are very common crops, cotton is well known in some areas and soy is known in few areas. Crop rotation is a well known practice. A few farmers have grown crops for diesel before. General social acceptance is expected provided that effective and sensitive information and education programmes are conducted and previously disadvantaged people benefit.

*Capacity requirements:* Capacity building at all levels is required. Extensive education campaigns have to be developed and implemented. In poor rural areas biodiesel crops will be new and sensitive and intensive capacity building is necessary.

*Income generation:* Biodiesel production will create jobs at many different levels from labourers to entrepreneurs.

***Poverty alleviation***
Poverty alleviation potential for all three niches is high because of the number of created jobs in agriculture and the production process and increase in agricultural productivity particularly for subsistence farmers in disadvantaged areas. In addition new cooperatives centred around the biodiesel production units could be development hubs for other agricultural activities such as cattle feed lots.

***Chances of being implemented***
The chances of implementation are quite high because the minister of finance announced a 30% reduction in fuel levy for biodiesel and Sasol is considering production of biodiesel from soy beans. This would pave the way for many smaller producers who could be subcontracted by Sasol to grow the oil crops or start their own biodiesel and oil cake production and combine it with a feedlot. This combination is described in Appendix B.

### 3.7.3 Niches for solar water heaters

The market provides three niches for the dissemination of SWH. Better information and access to affordable financing is important for all three niches. The middle-to-high-income customers are one niche. The recipients of RDP houses for the poor make up the second niche. In this case the SWH could be a part of the existing or an additional grant. Poor people without piped water could be excluded from this benefit unless alternative systems are provided. However, poor households might prefer any additional subsidies to be used to increase the size of the house.The third niche would be in the commercial and institutional sectors such as in offices, hospitals and prisons.

**Table 26: Niches for solar water heaters**

| *Potential niches criteria* | *N1 Higher-income households* | *N2 Recipients of housing grants (lower-income households)* | *N3 Commercial and institutional sectors* |
|---|---|---|---|
| Representativeness | | | |
| Replicability | High | High | High |
| Potential population benefited | 7.5 million | 7.5 million | ? |
| Complexity | Low | Moderate | Moderate |
| Suitability/viability/sustainability | | | |
| Affordability | Moderate | Very low | Moderate |
| Effectiveness | High | High | High |
| Risk of obsolescence | Low | Low | Low |
| Flexibility | Low | Low | Low |
| Technological capability | High | Moderate | Moderate |
| Suitability and urgency | High | High | High |
| Resilience | High | High | High |
| Adaptability | High | High | High |
| Environmental impacts | Very low | Very low | Very low |
| Social acceptance | High | High | High |
| CD requirements | Moderate | Moderate | Moderate |
| Income generation | Low | Low | Low |

***Assessment of niches***

*Affordability:* The upfront cost of SWH is too high for most people. Middle to high income groups and institutions are the most likely groups to buy SWH if affordable financial schemes are offered. The poor will have to rely on government subsidy for installing SWH.

*Efficiency:* SWH are efficient in providing low-cost hot water in most parts of South Africa during most of the year. In the winter rainfall region and areas with cold cloudy spells in winter electricity grid backup is required in the cold season.for reliable hot water service. If SWHs are ineffective on the coldest days of the year, and require electrical back-up then, the overall effect could be to make the national electricity load profile more peaky over the course of a year, which is bad for electricity supply efficiencies.

*Risk of obsolescence:* Internationally, SWH manufacturers are improving designs, materials and manufacturing processes. However, the technology is considered relatively mature, and improvements are likely to be incremental.

*Flexibility:* The technology is adaptable to all climatic regions and (potentially) to small households with low incomes as well as large institutions.

*Technological capability:* Basic technological capability exists for assessing technological development, innovation and adaptation. Companies are manufacturing, installing, servicing and marketing a limited number of SWH. For medium to large scale roll-out, technological capability will have to be developed, in manufacturing, installation and service capacity, marketing and awareness campaigns, and quality assurance.

*Suitability and urgency:* SWH are very suitable to heat water. There is still some doubt if solar water heating is less expensive than electric water heating at the present relatively low electricity tariffs. The urgency is related to the possibility of reducing peak electricity demand levels although further information is need to assess this; SWH could contribute to poverty alleviation provided capital and maintenance expenses are covered by government in which case government needs to ask whether this is a more important subsidy area than others such as social grants.. Hot water is a basic requirement for households and poor people would greatly benefit having affordable running hot water. The technology is unsuitable in areas where there is no piped water and where most of the very poor live.

*Environmental impacts*: SWH don't emit any GHG and replace grid electricity which is generated from coal, reducing the overall country emissions.

*Social acceptance:* SWH projects in poor areas have a mixed record. Free or almost free installation and maintenance seem to guarantee user satisfaction. If free maintenance is not included in the project SWH are generally not repaired when faulty. When a project is successful home owners appreciate the service provided; it saves labour because they don't have to heat water on stoves and it saves money because they don't have to buy kerosene for water heating.

*Capacity development requirements:* capacity exists for limited sales but has to be stepped up for medium- and large-scale roll-out.

*Income generation:* When the SWH market is expanded new SWH have to be built. The manufacturing, installing and servicing SWH creates additional jobs. Having running hot water in the house increases the chances of income generation when poor women start home businesses such as a crèche.

***Poverty alleviation***
SWH can contribute to poverty alleviation in so far as jobs are created in manufacturing, installation and maintenance. SWH in poor households improve livelihoods, comfort levels and health but do not alleviate income poverty. Most of the poor live in areas without piped water and they would be excluded from the benefits of SWH.

***Chances of being implemented***
SWH replace electric geysers and thus save electricity produced from coal. Using SWH also reduces peak load and since new electricity capacity is required by 2007 any reduction peak electricity demand is desirable. It is believed that government has an interest to provide incentives for the installation of SWH.

Domestic electricity prices can be expected to rise in the future, due to industry restructuring, the need for investments in new generation capacity, and other factors. The poor may be shielded from such price rises to a greater extent than higher-income households. Higher-income households in South Africa mostly use electric geysers for water heating, and higher electricity prices would be an incentive for them to consider SWH options.

If proper access to attractive financing is developed, technical standards are implemented and the public is well-informed, the chances of wider-scale SWH implementation should be very high.

### 3.7.4 Niches for fuelwood

In the context of energy poverty alleviation two niches for fuelwood have been identified: the rural and the low-income peri-urban market. Since the poorest people live in rural areas with few job opportunities they will have to rely on fuelwood for a very long time to come. The peri-urban market depends on the macroeconomic situation of the country. It may shrink and eventually disappear with rising incomes and more employment opportunities, if these socio-economic targets are achieved. However, if high levels of unemployment and poverty continue, affecting both the economic situation of peri-urban settlements as well as in-migration in search of jobs, it is likely that the demand for fuelwood will remain significant in those peri-urban areas where fuelwood is locally accessible or cheaper than other available energy options.

**Table 27: Selection matrix for fuelwood niches**

| *Potential niches criteria* | *Niche 1 Rural market* | *Niche 2 Peri-urban market* |
|---|---|---|
| Representativeness | | |
| Replicability | High | Limited |
| Potential population benefited | About 20% of the population | Poor peri-urban fuelwood users |
| Complexity | High | High |
| Suitability/Viability/Sustainability | | |

| | | |
|---|---|---|
| Affordability | High | High |
| Effectiveness | High | High |
| Risk of obsolescence | Very low | Very low |
| Flexibility | High | Moderate |
| Technological capability | Moderate | Moderate |
| Suitability and urgency | High | High |
| Resilience | High | Moderate |
| Adaptability | High | Moderate |
| Environmental impacts | Moderate | Moderate |
| Social acceptance | High | High |
| CD requirements | Moderate | Moderate |
| Income generation | Moderate | Moderate |

***Assessment of niches***

*Affordability:* Woodlands and forests provide social, economic and environmental benefits for the poor. The sustainable management of woodland and forest resources as well as the marketing of fuelwood has to be supported by the government initially.

*Effectiveness:* As long as poor households have severe cash constraints and cannot afford modern fuels, fuelwood remains the most suitable thermal energy source for the poor, where available. However support measures are needed to assist sustainable resource management, and reduce health hazards associated with exposure to wood smoke.

*Risk of obsolescence:* Wood is used for many different purposes, increasing the incentives for sustainable resource management. As a fuel, the risk of becoming obsolete is very low in the short- to medium-term since fuelwood (together with some other biomass fuels, such as dung and crop residues) is the only energy source over which poor people have some control. Fuelwood as an energy source for the poor will become obsolete when income levels rise sufficiently to lift the poor out of poverty. Community management structures, which are set up for fuelwood management, can be used for other development activities if with rising incomes the need for fuelwood is no longer felt.

*Flexibility:* It is expected that fuelwood demand will go down when employment and income levels rise. Fuelwood planting and harvesting can easily be downscaled or upscaled as economic conditions of the community improve or deteriorate. However, it does take time for trees to grow.

*Technological capability:* Communities have limited capabilities to manage their wood resources. DWAF will also have to develop strategies and support structures to assist communities. As far as improved stoves are concerned NGOs and private producers have the technical capability to produce them. Marketing of improved stoves needs some assistance from NGOs, government and energy centres.

S*uitability and urgency:* In rural areas fuelwood is the most common energy source of the poor but it is not always easily available. The management of the fuelwood resource is very urgent in some areas where resources are declining due to over-harvesting and lack of replanting.

*Environmental impact:* Sustainable management of woodlands and tree planting will prevent biome degradation and will have a beneficial impact on the environment. Carbon sequestration is another environmental benefit when more trees are grown continuously. Local smoke pollution from wood burning can affect the health of fuelwood users, especially women and children exposed to unventilated smoke.

*Social acceptance:* The social acceptance of tree growing and fuelwood harvesting is high when adequate support structures such as extension services, seedling production and marketing of tree products are facilitated. Using fuelwood in the home is an age old tradition and women have always accepted it although they would prefer cooking with modern fuels such as electricity if they could afford it.

*Capacity development requirements:* Capacity development is required in DWAF for fuelwood strategies and programmes, in DPLG for including fuelwood into integrated development plans and in communities for forest and woodland management and fuelwood marketing. Fuelwood users may need assistance to choose ways of avoiding smoke health hazards.

*Income generation:* There is potential for income generation and job creation in the management of woodlands and the sale and transport of fuelwood. The marketing of fuelwood may have to be subsidised initially.

***Poverty alleviation***

A sustainable fuelwood programme would help to ensure that many poor households depending on this fuel will have access to fuelwood at no monetary cost, or where commercialised, at a more affordable financial cost. Women and children could save time and energy by collecting fuelwood closer to home. Improved stoves and ventilation practices can reduce indoor air pollution, with positive effects on health. Improved methods of using fuelwood can also reduce the quantities consumed, and/or increase the benefits from fuelwood use.

***Chances of being implemented***

The chances of providing better access to fuelwood are quite high. As poverty alleviation is one of the government's priority areas, and fuelwood is a primary energy source for the poor, a fuelwood strategy will be drafted in the very near future and the proposed programmes will probably be implemented. It is recognised that successful programme implementation in this area will be difficult and complex because of he spatial variation and spread of fuelwood-management problem. The past history of South Africa and some neighbouring countries have not been encouraging and it is not easy to find the 'breakthrough'. DWAF needs to draw on all available experience, vision, outreach, cabinet support etc to achieve a successful, comprehensive programme.

## 3.8 Assessment of other experiences

The solar electrification by the concession approach is included in the report in order to highlight the problems, and opportunities associated with the provision of electricity for all. The policy objective is the provision of electricity for lighting and media to people living in remote rural areas, who for economic reasons will not receive grid electricity in the near future. Some of the key findings were: the poorest of the poor could not afford the solar home system and the job opportunities were not so great.

### 3.8.1 Solar electrification by the concession approach

*Introduction*

South Africa is committed to provide universal access to electricity by 2012 (Mlambo-Ngcuka 2004). Grid electricity is the general approach and 70 percent of households are already connected to the grid. For the remaining households the Energy White Paper indicates that Government will determine an appropriate mix between grid and non-grid technologies (DME 1998) and 'in remote rural areas where the lowest capacity grid system cannot be supplied within the capital expenditure limit, this system will provide a natural opportunity for Remote Area Power Supply (RAPS) systems to be supplied' (DME 1998). In 1999, 51 percent of rural households were still without electricity and it became clear that the supply technology had to be re-evaluated. Photovoltaic solar home systems (SHS) were selected to provide a basic service to those households that cannot be grid-connected within acceptable cost parameters (Kotze 2000).

A pure commercial model and a utility model were considered for the SHS implementation and it was decided to select the utility model and to involve the private sector in the non-grid electrification programme (Kotze 1997; 1998).

The South African off-grid electrification programme grants private companies the rights to establish off-grid energy utilities. This utility service provision is a fee-for-service model including the maintenance of the off-grid energy systems by the utility. The utilities have exclusive rights to government subsidies to cover most of the capital costs for five years. The fee-for-service agreement will last for 20 years (Afrane-Okese & Thom 2001).

The rationale for the private utility model was (Kotze 2000):

- It would speed up universal access to electricity envisioned in the Energy White Paper since non-grid electricity service had become increasingly cost-effective in remote areas.
- It could attract larger, better organised private companies with their own sources of financing.
- It would facilitate and rationalise electrification planning, funding and subsidisation at national level, allowing regulation and financing mechanisms to maximise targets and optimise resource allocation.
- It had the potential to reduce equipment costs (through volume discounts), transaction costs, and operation and maintenance costs (through economies of scale).
- It ensures service to customer over a long period of time (e.g. 20 years).
- The utility would own the hardware as assets, which should facilitate the raising of capital on the money markets, while the strong financial and maintenance controls characteristic of the private sector should facilitate the channeling of international development funding.
- This should facilitate relocation of technologies that may arise over time as the grid reaches more remote areas.
- It was expected that the service providers would adopt a delivery model that promotes a range of fuels such as gas or kerosene, in addition to SHS or mini-grid systems. This energisation model has been motivated by the realisation that electricity often does not meet all the energy needs of rural people who, after electrification, tend to continue to rely on multiple fuels.
- Most rural dwellers that have access to grid electricity are usually not able to afford higher consumption of electricity and they tend to use it mainly for lighting, radio and B/W television, services that can be equally provided by SHS. The service level that is subsidised under the non-grid electrification programme was set at 50 Wp.

The main disadvantages of the utility route were considered to be that the systems were installed at the clients' premises under their control but not under their ownership of the utility and were therefore prone to vandalism, neglect and misuse.

*Limitations of the SHSs*
The SHSs can only be used for lighting and media. The systems do not provide for the greatest energy needs of the rural population which are cooking and space heating.

*Results obtained*
Four companies are operating on a fee-for-service model in four concession areas and they have installed about 20 000 SHSs. Regulatory, institutional and contractual arrangement for off-grid energy services have been worked out as the part of the programme. Among the achievements is the publication of a service standard for non-grid electricity customers. The standard outlines the service activities and the minimum standards for measuring the quality of service provided by the non-grid service providers. The standards give the National Regulator a basis for evaluating quality of service to non-grid customers.

*Population target*
The programme targets 300 000 households for SHSs, 50 000 for each of the six concessions. So far the roll-out has often been delayed by institutional and contractual disagreements among the various stakeholders and it is unlikely that the target will be achieved within the next years if installation rates are not increased.

*Population benefited*
Accurate installation figures are difficult to get. It is estimated that 20 000 SHSs had been installed under the concession programme by 2004. Assuming an average household size of 4.5, this would imply that about 90 000 people have benefited so far. In some areas, households did not continue with payments, and a proportion of the installed SHSs were repossessed by the company.

*Weak points*
The systems are expensive, requiring large subsidies in order to be affordable for the rural households and a reasonable commercial venture for the supply utilities. They are of very limited use

providing electricity only for lighting and media. Maintenance is problematic. The payment of regular monthly service fees is difficult for poor households, which are characterised by low and irregular income. In one of the concessions the utility provided SHS to only those households with proof of regular income, effectively excluding the poor.

*Capacity status assessment of the project*
Part of the programme was to build capacity and that is one of the reasons why the initial phase was very slow. Further capacity building is necessary to implement the project and provide 300 000 households with off-grid electricity by 2012.

*Stakeholders*
The major stakeholders directly involved in the programme are the off-grid customers, and the service providers. Eskom and municipalities are the licensed electricity providers and they have to demarcate areas in their license area in which the off-grid service providers can operate. The Department of Minerals and Energy is to facilitate the process, formulate policy and administer the capital subsidy for the installation of the systems. The Department of Provincial and Local Government is charged with providing services and channeling the free basic electricity subsidy to the service providers. The Electricity Regulator approves the installation of the systems according to the set standards. Service providers are paid the capital subsidy only after the installation has been approved by the Regulator. The commercial providers of PV systems sell and may manufacture components.

*Zones*
The concession areas were chosen in relation to the national grid. They are in the Eastern Cape, KwaZulu-Natal, Mpumalanga, Limpopo and the North-West Province in areas where it is unlikely that the grid will reach in the very near future. However some households which had opted for a SHS have recently been connected to the grid.

***Replicability***
SHSs, the concession approach and the fee-for-service model are replicable in any rural area without grid electricity supply. A basic maintenance service is required and the battery has to be replaced at least every 3 to 4 years.

Solar concessions are not financially viable without the capital subsidy for new installations and the operational subsidy. The government seems to be deciding the replicability question by limiting the funds available for capital-cost subsidy. The future payment of the monthly operational subsidy is also doubtful. Unless something changes, the whole programme may slowly come to an end.

***Complexity***
Although the SHS technology is easy to use the introduction of PV technology in remote rural areas has often been compared to providing space age technology to the least developed populations. In many cases the technology gap and the problems related to service delivery had not been identified as one of the potential major barriers to successful implementation. This knowledge gap extends into two directions. The service provider does not understand the needs and conditions of the customers and the customer does not understand the technology and the often complicated agreements that go with it. The methods for supplying the technology, negotiating government subsidies, etc., are not simple and have led to widespread confusion. The provision of SHSs has to be backed up by information and training, customer responsive service and maintenance long-term contractual subsidy agreements with government.

***Assessment of niche***

*Affordability*
It was clear from the beginning that poor rural households for which the systems were intended would not be able to afford the initial capital cost and a government subsidy of R3500 for each installed system was included in the programme for the first five years. The subsidy was paid directly to the service provider. The customer had to pay R110 as an installation fee and a cellular phone charger was offered for an additional R20.

In 2001 the government announced a subsidy for free basic electricity for grid-connected households, equivalent to 50 kWh per month. SHS users in the concession areas also received a monthly subsidy of R40 reducing the service fee charged by the service provider to R18 per month.

It is still doubtful if very poor rural people can afford even this highly subsidised service of PV just for lighting and media use. A comparison of mean monthly incomes of 348 households in the Eastern Cape Province indicates that the very poor households remained without electricity. SHS users earned the highest income (R2307/month) compared to R1860 for grid users and R819 for households without electricity (ERC 2004).

There is also a question whether and for how long the government can afford the high capital subsidy for each system.

*Effectiveness*
The programme has not been very effective in delivering electricity to the rural poor. However, considering that the technology, delivery mode, financial and institutional arrangements have been new and in many cases untested, all stakeholders have learned during the process and it is hoped that the next phase of implementation will be more effective.

*Risk of obsolescence*
The solar panel, the most expensive part of the system, has a lifetime of about 20 years. It is quite likely that cheaper and/or more efficient panels will be developed within that time period, locking the poor into a system of obsolete expensive technology.

If the programme fizzles out the question arises: how to make best use of the investments so far? They are substantial – maybe R100 million by government maybe R 40 million by the companies. These amounts are small compared with grid electrification budgets and subsidies (about R1 billion/year) but high compared with other RET investments in South Africa.

*Flexibility and technological capability*
SHS technology is not very flexible and is limited in its application. The major energy requirement of poor households is cooking and PV systems do not provide energy for cooking. The operation of higher-power media appliances such as colour televisions usually requires a larger PV system than the standard 50 Wp SHS. Similarly, power for refrigeration requires larger and more expensive systems.

*Suitability and urgency*
It is urgent to provide energy services to the poor, but PV systems are only suitable in very remote rural areas where the grid will not reach in the future.

*Adaptability*
Since South Africa has high solar radiation the technology can be used almost anywhere. PV technology is modular, allowing for upscaling or downscaling. PV systems of various sizes can meet a range of electricity needs but are not economic for thermal applications.

*Environmental impacts*
Concerns are raised about the disposal of disused batteries and solar panels. No clear disposal strategy has been developed. The electricity generation of SHS is emission neutral. However the manufacture of PV modules, and routine maintenance (by vehicle) in spread-out rural areas can be relatively energy-intensive.

*Social acceptance*
The reaction to SHS and the mode of delivery has been ambivalent. The customers are pleased to have lights, to watch TV and listen to the radio. They are disappointed that they cannot cook and they still have to pay more for other fuels like kerosene, wood and gas for their thermal needs. They also don't understand the fee-for-service model and are often ignorant of the government capital subsidy. In the Eastern Cape study only 57 % of SHS-users would recommend others to get a SHS while 96 % of grid-connected households would recommend grid electricity to others (ERC 2004).

*CD requirements*
There are high capacity development needs in the villages where SHS are installed. Local technicians should be trained to do simple O&M services. This would create some employment in disadvantaged rural areas and also would reduce the cost of the service.

*Income generation*
Hardly any income generation was created by acquiring SHSs. Although productive end uses for PV systems are known in other parts of South Africa, the concessions programme has failed to initiate income generation among its customers.

### 3.8.2 Conclusion

SHS owners are happy having electricity for lighting and media but they still have to use other sources such as fuelwood and paraffin for their greatest energy need, cooking. The monthly SHS service fee has been R58 per household, and for electric lighting and media only, this has been a high cost for very poor households. The poorest of the poor for whom the SHSs were intended can neither afford the initial installation fee nor the monthly service fee. In line with its policy of free basic services for the poor, government subsequently proposed a further monthly subsidy of R40/month for SHS users, reducing their monthly payments to R18/month. This makes SHS electricity more affordable to a wider range of poor rural households; but it is difficult to implement this subsidy, because it has to be administered at another government level, local government (in this case, impoverished rural district municipalities). Local government leaders may not endorse SHS subsidies if they have higher priority spending needs in their areas. As a result, the R40/month SHS operational subsidy proposed by national government has only reached a few of the concession areas. In one area, this subsidy was started, then stopped, causing quite serious problems for customers and the service provider.

In all cases, the installation of SHSs has been highly subsidised by the government (R3500 or more per household) and the subsidy may be better used extending the grid. The individual and collective benefits of grid electricity supply are greater than the benefits of SHS services. Nonetheless, SHSs have their niche in very remote rural areas which cannot be reached by grid electricity in the medium to distant future.

## 3.9 Analysis of barriers and problems

### 3.9.1 General

South Africa has taken major steps to promote renewable energy by publishing a White Paper on Renewable Energy. The stated target of supplying 10 000 GWh from renewables by the year 2013 sets a specific goal. One of the biggest challenges will be finding the finances for this implementation.

Identifying barriers to implementation is an important step to future progress. The following general barriers to the further implementation of renewable energy have been identified (DME 2004):

- Many renewable energy technologies remain expensive, on account of higher capital costs, compared to conventional energy supplies for bulk energy supply to urban areas or major industries.
- Implementation of renewable energy technologies needs significant initial investment and may need support for relatively long periods before reaching profitability.
- There is a lack of consumer awareness on benefits and opportunities of renewable energy.
- The economic and social system of energy services is based on centralised development around conventional sources of energy, specifically electricity generation, gas supplies, and to some extent, liquid fuel provision.
- Financial, legal, regulatory and organisational barriers need to be overcome in order to implement renewable energy technologies and develop markets.
- There is a lack of non-discriminatory open access to key energy infrastructure such as the national electricity grid, certain liquid fuels and gas infrastructure.

- Market power of utilities.

Most of these barriers affect the implementation of biodiesel and SWH. Fuelwood being an energy source of the poor does not compete, to the same extent, with modern fuels and faces different problems such as sustainability and access for the poor.

### 3.9.2 Problems and barriers: biodiesel

There are some national challenges such as unemployment and the historical income gap of rich and poor people which can be addressed, to some limited extent, by biodiesel production. Then there are the problems which are specific to biodiesel, the growing of oil plants and the production process.

Oil companies are facing the reality of finite petroleum resources.

Producing biodiesel is technically feasible. The biggest barrier is price competition with mineral diesel. However with increasing crude oil prices and reducing production cost biodiesel will be able to compete in the future.

Biodiesel needs substantial initial capital and support for at least ten years before reaching profitability. At present the projected cost of biodiesel cannot compete with petroleum diesel at the pump.

There is a lack of information and awareness on the benefits of biodiesel.

Being a new fuel biodiesel's entry into the market faces legal and regulatory problems which have to be solved. There are also no standards for biodiesel and these have to be agreed upon by all stakeholders. Also the access to pipelines will have to be negotiated and regulated.

The oil refineries in South Africa produce more diesel than the country needs and have to export some of it. Biodiesel will therefore not replace oil imports but increases the diesel export. Markets will have to be found.

Sunflowers are the most common oil crops but the sunflower seed cake has relatively low nutritional value and does not substantially contribute to the value of the crop. Further research is required on how to increase the nutritional value of sunflower cake.

There is potential conflict with food crops over land and water resources; national food security and the limited water resources have to be carefully assessed before large-scale oil crop plantations are started. If poverty alleviation is to be achieved emergent farmers and farmers in disadvantaged areas have to be included in the programme as a priority and the lack of infrastructure in disadvantaged areas has to be addressed.

Starting capital is needed to assist small-scale and community producers to set up biodiesel plants. SASOL the world's largest producer of coal-to-oil, has indicated plans to produce biodiesel from soy beans. There are not enough soy beans grown in South Africa to support the large-scale production and soy beans would have to be imported at least initially. If only commercial farmers will provide soy to SASOL poor subsistence and emergent farmers will not benefit.

### 3.9.3 Problems and barriers: Solar water heaters (SWH)

There is not enough information and awareness on SWH so that the benefits and limitations are not appreciated. The initial installation cost of SWH is high and affordable financing schemes are not offered; electricity tariffs are low so that people perceive the installation of SWH as not worth the initial expenditure. Potential customers are also not sure about quality assurance of SWH.

If SWH were rolled out at a large scale there is presently insufficient capacity.

Most poor people live in areas without piped water and therefore cannot benefit from normal SWH systems even if their installation is subsidised.

Since SWHs replace grid electricity there is a potential for CDM credits but the mechanism of accessing CDM credits is complicated and not widely known.

The government is attempting to redress the enormous housing backlog for the poor by providing housing grants to all poor people. If a small grant for SWH is added, the livelihoods of the poor would be much improved. However, low-income householders express other competing demands for the use of housing subsidy grants, such as trying to maximise the floor space of their dwellings.

To summarise, the main barriers to installing SWHs on a large scale are lack of attractive financing mechanisms, poor information availability, the need for effective marketing and overcoming perceptions that SHW is inefficient and unreliable. Affordable financial and service loans are widely available for buying a car and similar arrangements could be developed for buying a SWH. Accreditation of manufacturers and installers to a professional association is the obvious solution for quality assurance. This must be backed up by standards approved by the South African Bureau of Standards. The need for nationwide information programmes has been pointed out earlier.

### 3.9.4 Problems and barriers: fuelwood

One of the greatest barriers to sustainable fuelwood supply for the poor is an incorrect understanding of the problem. The fuelwood crisis was originally thought to be a resource problem; the demand for fuelwood exceeding sustainable yield resulting in deforestation and land degradation. Woodlots were supposed to solve the supply problem and efficient stoves, kerosene subsidies and similar measures were the technology remedies (Gandar 1994). It has now been understood that agricultural practices and land clearing and not fuelwood collection are the major causes of deforestation. Also the regenerative capacity of woodlands had been underestimated and the coping strategies of rural people had not been considered.

***Better understanding of the problem***

It is not widely recognized that fuelwood resources are a major national asset.

The role of trees in the rural economy and environment is not fully understood and insufficient recognition is given to the value of woodland and woodland products to rural communities. Building on indigenous knowledge systems in sustainable woodland management may be one of the useful strategies. Woodland management is generally not included in the local integrated development plans.

The emphasis on industrial forestry, which creates large-scale employment and export earnings marginalised the role of community forestry.

The management of natural woodlands is not built on existing practices in communal woodlands. There is usually inadequate regulation of harvestable areas, the time of fuelwood harvesting, the material harvested (live wood, allowable species) and who has access to the forest resources of the community.

***Capacity in communal and social forestry lacking***

Capacity in sustainable fuelwood management is lacking at all levels.

A community approach and social forestry (SF) has proved to be a successful strategy in rural communities. Facilities for training in SF need to be better developed. Constraints in the area of extension and fieldwork should be addressed.

***Fuelwood strategies***

There is no clear strategy to address the fuelwood problem. Alternative strategies are not widely considered. There are two strategies to address fuelwood demand: one is to increase the efficiency of wood usage, and the other is to shift the demand from wood to other forms of energy. Making LPG available and affordable would help to preserve the forest resources and ease the burden of wood collection of and exposure to indoor air pollution of women and children.

Woodstoves used by the poor are generally inefficient. They use more wood than improved stoves and emit large amounts of smoke affecting the health of women and children.

There is no institutional framework for fuelwood management and it is not integrated into development plans at national, regional and local level. Government, communities and NGOs are not closely interacting to address the problem.

# 4. Objectives and policy outlines

## 4.1 Problems, opportunities, objectives and policy outlines

The methodology of the multi-country RET study describes problems as a situation that is considered negative and objectives outline the desired and feasible situation at which the application of policy is aiming.

Problems, opportunities, objectives and policy outlines are given for the case studies in Tables 28, 29 and 30. Strategies for achieving the objectives are outlined for each case study.

### 4.1.1 Strategic objectives and policy outlines: Biodiesel

Two different strategies may be pursued in implementing biodiesel, industrial-scale biodiesel production and small-scale decentralised production.

*Industrial scale biodiesel*

Sasol Oil is considering to take up the production of biodiesel at a centralised location and providing the oil market. Recognising the importance to its long-term sustainability Sasol is intending to build a 400 000 t/y soybean-to-diesel plant. The USA already produces biodiesel from soy at a commercial scale. This production is subsidised and such agricultural subsidies may pose a problem when countries such as South Africa will be marketing biodiesel on the world market. Soy is regarded as the most appropriate oil crop since not only can the oil can be used but the residue oil cake is also a very desirable by-product either for animal feed or for human consumption, alleviating protein deficiency. Biodiesel is produced by a process of transesterification, involving the addition of methanol, resulting in biodiesel and the by-product glycerine. In the initial phases production is limited and biodiesel is being blended with petroleum diesel ranging from 2% to 10% biodiesel and 98% to 90% percent petroleum diesel. No engine modification is required at such low percentages of biodiesel.

*Small-scale production of biodiesel*

The objective is to encourage the small-scale production of biodiesel for decentralised consumption. Small towns and remote rural areas can be energised, leading to local development.

Problems, objectives and policy outlines for biodiesel are presented in Table 28. The Table is not intended to be an exhaustive list. It summarises some of the important problems and gives some of the policy outlines in order to reach the strategic objectives.

**Table 28: Identification of problems, opportunities, objectives and policy outlines for biodiesel**

| *Problems and Opportunities* | *Objective* | *Policy outline* |
|---|---|---|
| 1. Implementing a biodiesel programme is complex because many ministries must work together to make it succeed | All concerned ministries cooperate to support the implementation of biodiesel | Facilitating the cooperation between ministries to implement biodiesel |
| 2. Global political developments threaten the continuous supply of oil and, in the long term, reserves of oil and gas will be exhausted. | Sustainable production of biodiesel has been achieved and has become competitive with petroleum diesel, which is gradually being replaced. Greater security of supply has been achieved. | Producing biodiesel in SA<br>Increasing security of supply<br>Replacing petroleum diesel |
| 3. Developing new technologies and products is a long and capital-intensive process. Who | Capital investments have been made. Expertise in growing and processing crops for biodiesel is | Facilitating the attraction of capital for biodiesel development. |

| | | |
|---|---|---|
| will advance or fund the development until such a time when the new products can compete in the market? | developed and the technology has matured and is adapted to small-, medium- and industrial scale production. Biodiesel is competing with petroleum diesel in the market without being supported by incentives. | Providing agricultural extension services to farmers growing oil crops.<br>Supporting oil plant research.<br>Transferring technologies and research results. |
| 4. Very high unemployment rates undermine the government's policies aiming at greater equality, poverty reduction and development of disadvantaged rural areas. | Biodiesel plants have been built in central locations as well as in rural areas and the extracted and processed oil and the residue of protein cake are fuelling and feeding secondary developments. Many jobs are created. The biodiesel plants in rural areas have become development hubs, black economic empowerment is achieved. | Training farmers and other rural people to grow and process oil plants.<br>Encouraging the establishment of feedlots for cattle raising<br>Promoting black economic empowerment |
| 5. South Africa has one of the highest per capita GHG emission rates worldwide. | Petroleum diesel is gradually and sustainably replaced by biodiesel and consequently GHG emissions are reduced. | Reducing GHG emissions by replacing petroleum diesel with biodiesel.<br>Complying with future obligations of the Kyoto Protocol. |

*Objective 1:* All concerned ministries cooperate to support the implementation of biodiesel

Interministerial cooperation on new projects is complex and can take a long time. When several ministries are involved expected to complete interdependent tasks it is not always easy to make progress.

*Objective 2:* Sustainable production of biofuels has been achieved.

As petroleum resources decline over the next decades, biodiesel will gradually replace petroleum diesel. Initially production will be limited and biodiesel will be added to petroleum diesel at a low ratio of 2% to 10% (B2 to B10). This ratio will rise with time. Fuel mandates are used in other countries to achieve biofuel implementation. They stipulate minimum percentages of biofuel for all vehicle fuels. Fuel mandates are easy to implement. Government levies are not reduced and the higher prices to cover the higher cost of biofuels are paid by the consumers at the pump.

Educational programmes explaining the environmental and social benefits of biodiesel may be necessary to convince the motor vehicle users to buy biodiesel.

*Objective 3:* Oil companies are realising the long-term benefits of biodiesel and have made capital investments in biodiesel production. Government policy is supporting the development. Expertise in growing and processing crops for vehicle fuels is developed and the technology is matured and adapted to small-, medium- and industrial-scale production.

Various oil crops are cultivated in different climatic zones supported by agricultural extension services. Plant breeding programmes have developed varieties that optimise oil content and quality and high-value protein seed cake. Sunflower and cotton are widely produced and the poor quality of sunflower oil cake has been improved to compete with oil cakes from other crops. Agricultural extension services and research institutions work closely with farmers to support the transfer of new plant varieties and their farming systems. The marketing of improved by-products initially facilitated through extension programmes, are now competitive. High yields are achieved and oilseeds and their by-products are economic crops which do not require any further subsidy. Oil seeds are grown in many SADC countries, custom barriers have been removed and they are freely traded in a liberated regional market.

*Objective 4:* Biodiesel plants have been built in rural areas. The oil fuels secondary developments and the protein cake feeds cattle growing industries and jobs are created in disadvantaged areas.

Initially capital assistance is required to set up oil processing plants. Private investment, government investment or foreign aid are possible sources of funding. Incentives for private investment will be necessary.

In disadvantaged rural areas all technically qualified people continually migrate to the cities in search for jobs and therefore training will be needed at all levels. Once the plants are established and rural areas become development hubs, job seekers will be attracted to these centres and the migration to the cities will be slowed down.

Emergent farmers are successfully growing oil crops and black economic empowerment groups are managing the oil processing facilities. Cattle feedlots are added and initially aided by extension services. More emergent farmers are benefiting by raising and selling cattle. Once the system is in place the market will drive further developments and no further incentives are required.

*Objective 5:* Petroleum diesel is gradually replaced by biodiesel and GHG emissions from petroleum diesel are reduced. The use of fossil oil in engines is gradually phased out and it is used predominantly in manufacturing and other industries.

Using biodiesel is carbon neutral when crops are grown continuously. Growing plants such as oil crops absorb $CO_2$. The $CO_2$ is released back into the atmosphere when the fuel is burnt. Petroleum diesel only emits carbon dioxide without absorbing it. As less and less petroleum diesel is burnt less GHG is emitted.

As petroleum resources decline petroleum prices go up and fossil oil is phased out as a motor fuel and it is used predominantly in petroleum-based industries such as plastic, pharmaceutics and cosmetics.

The driving forces are emission reduction regulations such as the Kyoto protocol, economically viable biofuels and their by-products and declining petroleum resources.

### 4.1.2 Conclusion

The cooperation of different ministries to implement biodiesel is essential. Strategies to raise the initial capital for biodiesel production and making the cost of biodiesel competitive with petroleum diesel have to be addressed. Expertise in growing and processing oil resources has to be created. Development of biodiesel production in remote rural areas should be given priority because it leads to poverty alleviation by creating jobs, better livelihoods and rural development.

Replacing petroleum diesel with biodiesel reduces GHG emissions.

### 4.1.3 Strategy objectives and policy outlines: Solar Water Heaters

The seven most important problems have been identified. The objectives outline the way to address the problems.

**Table 29: Identification of problems, opportunities, objectives and policy outlines for SWH**

| *Problems and Opportunities* | *Objective* | *Policy outline* |
|---|---|---|
| 1. High upfront capital cost and the absence of affordable financing schemes discourage the installation of SWH | SWH companies offer attractive financing schemes and many households and the commercial sector are installing SWH | Facilitating attractive financing schemes.<br>Expanding markets for SWH. |
| 2. Many people don't know about or have a negative perception of SWH | Information, education and quality assurance have convinced people of the benefits of SWH | Supporting information programmes.<br>Encouraging research on |

| | | |
|---|---|---|
| | | evaluating the benefits and limitations of SWH<br>Implementing quality assurance. |
| 3. High unemployment rates limit socio-economic development | Employment is created in manufacturing, installing and servicing SWH | Encouraging and supporting manufacturing SWH for employment generation.<br>Training in SWH manufacturing, installation and maintenance. |
| 4. Electricity peak load demand will be greater than generation capacity by the year 2007 | Installed SWH have reduced peak load | Reducing peak electricity demand by expanding SWH market. |
| 5. The poor live in shacks and houses with insufficient service provision. Even if they have an electricity connection they cannot afford to use it for water heating | SWH are installed in all housing projects for the poor | Subsidising capital expenditure on SWH for the poor.<br>Improving quality of live by facilitating SWH for people in social housing. |
| 6. Black economic empowerment is still lacking in the country | A high percentage of SWH companies are owned and managed by black entrepreneurs | Facilitating the training of black entrepreneurs in the SWH sector.<br>Supporting access to finances for black entrepreneurs. |
| 7. South Africa has one of the highest GHG emission rates because electricity is generated from coal-fired power stations | Solar water heaters replace electric geysers and water heating on stoves reducing GHG emissions | Facilitating the replacement of electric geysers by SWH and supporting the installation of new SWH.<br>Reducing GHG emissions for water heating |

*Objective 1:* SWH companies develop attractive financing schemes together with service contracts targeting different market niches. It is expected that high income groups are the first to take up the offers and monthly electricity expenditure will be much reduced when SWH are installed. Particular schemes are developed for institutions such as clinics, hospitals, prisons, schools and boarding houses, adjusting their repayment schemes to the saved electricity expenditure. The barriers of initial up-front costs are lowered and many SWH are installed.

*Objective 2:* An information and education campaign is carried out by government in cooperation with SWH companies. Information on SWH, their benefits and limitations is widely disseminated in different media. Easily accessible demonstration sites are set up. The association of SWH companies, Solarsure, assures quality and dissatisfied customers can complain when they are not satisfied with the installed product.

*Objective 3:* Affordable financing schemes and government assistance have facilitated an active SWH market and have created sustainable employment in manufacturing, installing and servicing SWH.

*Objective 4:* Private house and flat owners have replaced their electric geysers with SWH and people who heated water on electric stoves have switched to SWH. Institutions have installed SWH and it is estimated that about 2300 GWh (DME 2003) of grid electricity is replaced by SWH thus reducing the peak load.

*Objective 5:* Government is implementing housing plans to provide basic housing to improve the livelihoods of the poor. In addition to the basic housing grant of about R23 000 they receive an additional amount to install SWH. Part of this amount is to be included as an addition in the housing grant and the other part to be paid by the customer in affordable instalments. The precise proportions and the repayment schedule is to be worked out by government, SWH companies and the customer. SWH are made affordable for the poor and are installed in new RDP houses and retrofitted in old ones.

*Objective 6:* Intensive training conducted by the Energy SETA (Sectoral Education and Training Authority) and other organisations, together with financial incentives for BEE companies, have encouraged black technicians and entrepreneurs to set up SWH companies. After initial support the BEE companies have gained technical and managerial experience and successfully compete in the market without further incentives.

*Objective 7:* The measures under Objectives 1 to 6 have led to the dissemination of many SWH replacing water heating that previously used grid electricity from coal-fired power stations. GHG emission rates have been reduced.

### 4.1.4 Conclusion

The major objectives are developing proper access to attractive financing, implementing of technical standards, wider information programmes and increasing the capacity of the industry to implement together with support for BEE companies. Additional benefits are lowering of peak loads and the reduction of GHG.

### 4.1.5 Strategy objectives for fuelwood

Five major objectives have been identified. Four are in the fuelwood sector and the fifth emphasises the importance of disseminating efficient fuelwood stoves.

**Table 30: Identification of problems, opportunities, objectives and policy outlines for fuelwood**

| *Problems and opportunities* | *Objective* | *Policy outline* |
|---|---|---|
| 1. Fuelwood is becoming scarce and poor women and children have to walk longer and longer distances to gather fuelwood for their cooking and heating needs. | A fuelwood strategy is in place and the poor have easy access to affordable fuelwood. | Developing a fuelwood strategy.<br>Providing affordable access to fuelwood for the poor |
| 2. The value of woodlands for the poor is not fully recognised. Fuelwood production is not economically viable. | Fuelwood is recognised as a major national resource and marketed together with other wood products such as bark and poles and communities are involved in the harvesting and marketing and jobs are created. | Recognising fuelwood as a major national resource.<br>Facilitating the marketing of fuelwood together with other wood products.<br>Involving and supporting communities in the harvesting and marketing of fuelwood. |
| 3. Unsustainable harvesting of wood from communal forests and woodlands and inadequate resource management has negative environmental impact. | Communal woodlands and forests are managed by the community and generate a sustainable supply of fuelwood. Community members and outsiders respect rules governing access and harvesting of fuelwood. Employment is created. | Facilitating community management of fuelwood resources.<br>Generating a sustainable supply of fuelwood.<br>Creating employment in the fuelwood sector. |
| 4. Women and children are exposed to indoor air pollution when cooking. Smoke from wood fires is particularly bad and leads to a number of diseases. | Efficient cooking stoves that are smokeless and burn efficiently using less wood are disseminated, accepted and used. | Recognising indoor air pollution as a major health problem.<br>Promoting the dissemination of efficient and smokeless stoves. |
| 5. The poor do not have access to 87% of land, which is owned privately or by the state. | Strategies have been implemented to give the poor access to state-owned land for fuelwood collection. | Facilitating access to state-owned land for fuelwood collection.<br>Developing strategies and rules for access to state-owned land for fuelwood collection |

*Objective 1:* A fuelwood strategy is in place. Communities are sustainably managing forests and woodlands and fuelwood is harvested at a reasonable distance from homesteads.

The objective is to provide easy access to affordable fuelwood for the poor. These issues are under discussion.

*Objective 2:* The value of woodlands as a national resource is recognised. Its particular importance as a fuelwood resource for the poor is appreciated. Fuelwood marketing is facilitated.

*Objective 3:* Rules have been drafted regulating the harvesting of fuelwood covering such issues as right of access, season and time of access, species to be harvested, dead or live wood and thickness of stem to be harvested for which purpose. The rules are known, respected and enforced. It is clear who has the power to enforce the rules effectively and what the penalties are if they are transgressed. Fuelwood and other marketable wood products are included in the integrated local development plans and they do not remain the sole responsibility of DWAF. Local communities, entrepreneurs and local government develop plans for marketing wood products. When trees are harvested for commercial use such as bark, poles and paper the small branches of waste wood are used for fuelwood. Waste wood sources are integrated in the fuelwood management and transport of fuelwood is minimised.

*Objective 4:* Efficient and smokeless wood burning stoves have been developed and some new models such as Vesta stoves are locally manufactured. Micro-lending schemes permit poor households to buy the improved stoves. Fuelwood is saved and indoor air pollution is reduced.

NGOs and energy centres are promoting and disseminating the improved stoves. Solar cookers, which are not yet very popular, are also promoted by NGOs and energy centres in order to reduce indoor air pollution and dependence on wood and other sources of energy.

*Objective 5:* Strategies have been developed to give the poor greater access to state-owned forests and woodlands to collect fuelwood resources. Access is well managed and controlled.

### 4.1.6 Conclusion

Woodlands are recognised as a major national fuelwood resource for the poor. Policies and strategies have been put in place to facilitate affordable access to fuelwood for the poor. Community woodlands are well managed and women and children walk shorter distances and spend less time to gather fuelwood for their household needs.

Efficient and smokeless stoves have been introduced and indoor air pollution has been substantially reduced.

## 4.2 Stakeholder reactions

Two meetings with stakeholders were held, one in Pretoria the capital and one in Cape Town, the seat of parliament. In Pretoria representatives from the Treasury, the Department of Water Affairs and Forestry and policy analysts attended the discussion. In Cape Town we addressed the entire Parliamentary Portfolio Committee on Energy, a representative of the Department of Minerals and Energy and policy analysts; the presentation was followed by a question-and-answer session.

The Minister of DWAF has requested to draft a policy on fuelwood in order to alleviate the worst effects of poverty. A preparatory meeting gathering background information on problems and objectives was attended in Pretoria on 26 October 2004 (See Shackleton et al, 2004). We also attended a meeting convened by the Energy Sector Education and Training Authority discussing training programmes for artisans for the installation of SWH.

The stakeholder reactions were enriching and in some areas broadened the discussion. Discussing with stakeholders from the treasury was very useful and contributed to our understanding of the limitations and opportunities of incentives.

### 4.2.1 Stakeholders' reaction: Biodiesel

1 In order to facilitate the implementation of biodiesel the DST convened a joint implementation committee of stakeholders in biodiesel. This is strategic support for the development of biodiesel.

The Treasury's 30% exemption from fuel level is a government incentive for biodiesel. Depreciation on capital investment for biodiesel plants is suggested.The depreciation on capital investment for technology projects is normally 4 to 5 years and reducing this period to 3 years will be a further incentive to make the biodiesel production cost competitive with petroleum diesel.

The effects of new crops on stream flow reduction would have to be monitored and assessed according to the Water Act of 1998. It might restrict the land on which oil crops are grown.

2 The availability of oil seeds limits the amount of biodiesel in the market. Oil crops for biodiesel are not yet widely grown and may even have to be imported until such a time that

they are grown locally. For this reason the initial percentage of biodiesel in the petroleum diesel blend will be 1% rising to 5% in 2010.

3 A recent SADC strategic planning meeting on 'Farming for Energy for Better Livelihoods in Southern Africa' recommends biodiesel, which can be produced in decentralised locations as an appropriate crop to overcome farmers' lack of access to markets.

4 The SADC meeting found decentralised small- to medium-scale developments very suitable for Southern Africa. Definite strategies have to be developed and the capital for the processing plants has to be raised. It was suggested that a pilot plant be set up as a demonstration project. It is expected that after an initial period of learning and support the processing plants be privatised.

### 4.2.2 Stakeholders' reaction: SWH

1 The poorest people in urban and rural areas live in housing without piped water and therefore cannot benefit from SWH that are connected to the piped water system.

2 Some of the stakeholders are aware that the high initial cost is the biggest constraints and strategies have to be put in place to facilitate financing programmes.

3 Installing SWH increases the value of the building and this may increase the municipal tax on the property.

4 In the winter rainfall region there is not enough sunshine during the coldest months and a backup system is required.

5 Hot water is important for hygienic purposes.

### 4.2.3 Stakeholders' reaction: Fuelwood

The Department of Water Affairs and Forestry convened an expert workshop on 26 October 2004 to discuss the opportunities and constraints for intervening in the fuelwood sector to help poverty alleviation. Stakeholders from different sectors were represented. The workshop proposed the following strategies for immediate, medium term and the long term intervention (Shackleton et al 2004):

Immediate action:

- Creating a sub-directorate in DWAF (Department of Water Affairs and Forestry) regarding fuelwood initiatives
- Prioritization of local-level hotspots for intervention
- Subsidize fuelwood marketing
- Better cooperation with Working for Water to supply wood
- Advocate for state lands for sustainable harvesting of fuelwood
- Identify and address information gaps
- Examine and treat the issue in a holistic manner
- Differentiate rural requirements from peri-urban/urban ones

Medium term strategy:

- Develop and implement a national biomass conservation stove programme
- Subsidise small-scale industries to manufacture biomass stoves
- Develop and implement a national tree planting incentive programme
- Provide incentives to private land owners to maintain pockets of natural woody vegetation on their land

- Promote closer cooperation between DWAF and the National Dept. of Agriculture in terms of maintaining trees in the environment
- Liaise with the Dept. of Housing around fuelwood needs for peri-urban and local-cost housing programmes
- Amend legislation to facilitate greater ease in establishment of woodlots of fast-growing alien species
- Increase the capacity of local government

Long term strategy:

- Develop long-term plans for use of fuelwood as a national resource
- Develop an effective woodlands extension service
- Promotion of rehabilitation forestry

# 5. Key findings and Recommendations

## 5.1 Key findings:

South Africa has an abundance of coal and the cost of electricity generated from coal is amongst the cheapest in the world. Approximately 40% of the country's petrol and diesel is manufactured from coal and gas. Large quantities of diesel are being exported. This poses a major challenge to the successful implementation of a RE strategy.

In 2004 the Renewable Energy Policy Strategy was published targeting a cumulative 10 000 GWh by 2013. The renewable energy strategy is seen as having the potential to assume a significant role in socio-economic development Pursuing the 10 000 GWh target more than 35 000 jobs will be created, more than R5 billion would be added to the GDP and R687 million would be added to the incomes of low-income households. More jobs opportunities will be created as a result of RE technologies than in coal-fired power stations.

The solar home systems currently being installed in South Africa can only be used for lighting and media. They do not provide energy for cooking and space heating – thus the rural poor stays dependent on fuelwood and kerosene (paraffin) for cooking and space heating.

Solar water heaters (SWH), biodiesel and fuelwood have the greatest potential to meet the government's 10 000 GWh RE target by 2013.

The country has high levels of solar radiation and an established manufacturing infrastructure for SWH. The high upfront capital cost and people's negative perceptions of SWH are some of the key barriers to the development of a SWH market in South Africa.

Biodiesel has the potential to create job opportunities especially amongst the poor. However, there will be competition with food crops if market prices of biofuels are higher than food crop prices

Nationally there are sufficient fuelwood resources and climate and soil conditions are suitable for forestry in many parts of the country. Many causes of deforestation/degradation are outside the household energy system (e.g. agriculture, overgrazing, forest fires, infrastructure) and some aspects of these must be addressed at the policy level.

## 5.2 Recommendations

In the light of the barriers identified to implement a RE strategy the following key recommendations are proposed:

- A reduction in the initial cost (or form of subsidy) of RE technologies is critical in order to make it more competitive to conventional technologies.

- The cost of conventional energy services should be more cost-reflective.
- Training and skills development for nationals in RE technologies should be promoted as a private-public initiative.
- R & D in RE technologies is to be promoted in order to develop the local industrial market.
- RE technology projects should have a pro-poor focus.
- Legal and regulatory framework to be in place that would give equal access to RE independent power producers.
- More needs to be done to promote communication and awareness of RE and RETs.
- Quality standards of RETs are to be developed and implemented.

# 6 Suggestions for future actions

South Africa has developed a renewable energy strategy setting a target of 10 000 GWh of RE (solar, small hydro, biomass and wind) to be achieved by 2013. Future activities should include an identification of instruments and actions that would best achieve the objectives of the policy oulines.

Meetings with stakeholders, in particular policymakers and government officials, illustrated a lack of awareness and knowledge of RE technologies. Future work should address the area of communication, awareness and education.

Future action should also look at opportunities for public and private partnerships to promote RETs.

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# APPENDICES

## APPENDIX A: Figures for Renewable Energy Resources

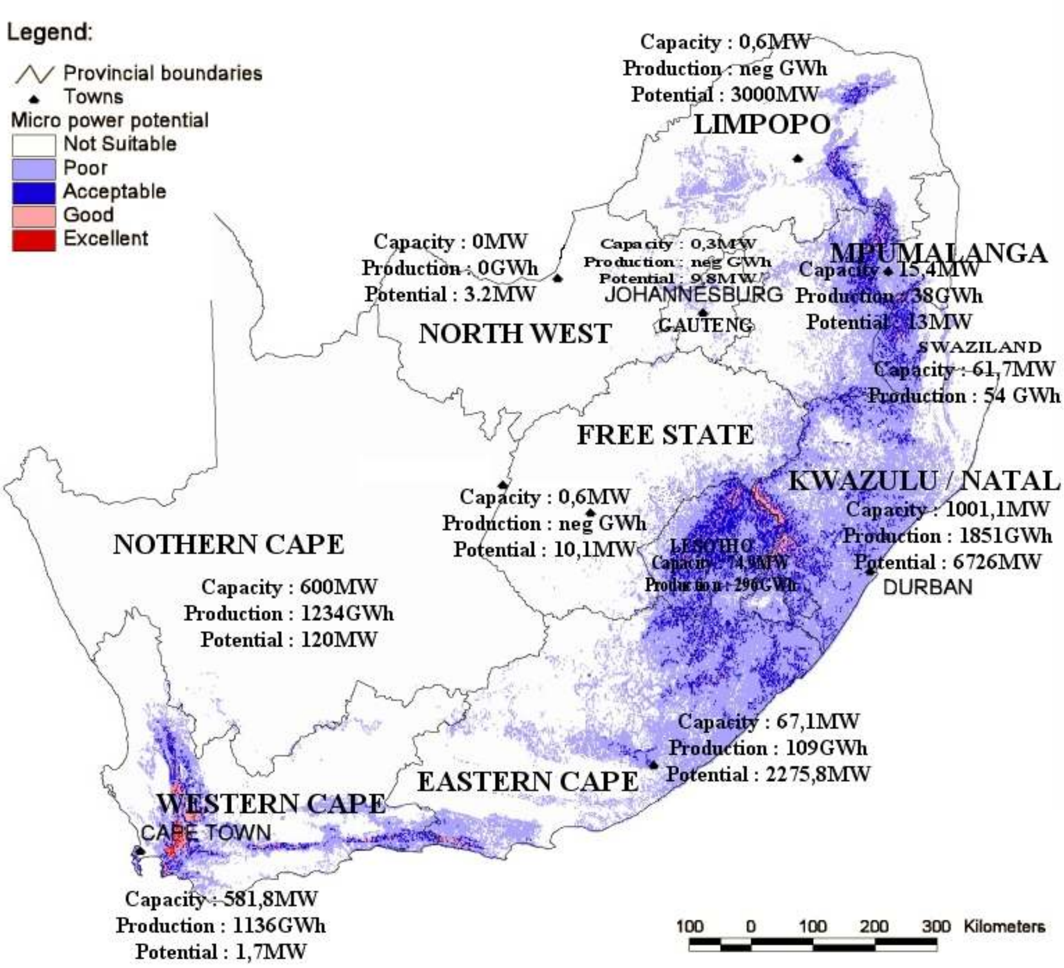


**Figure A1: Provincial representation of hydropower capacity, production and potential. This represents all categories of hydropower including pumping storage but excluding imported hydropower**
*(DME, 2002c)*

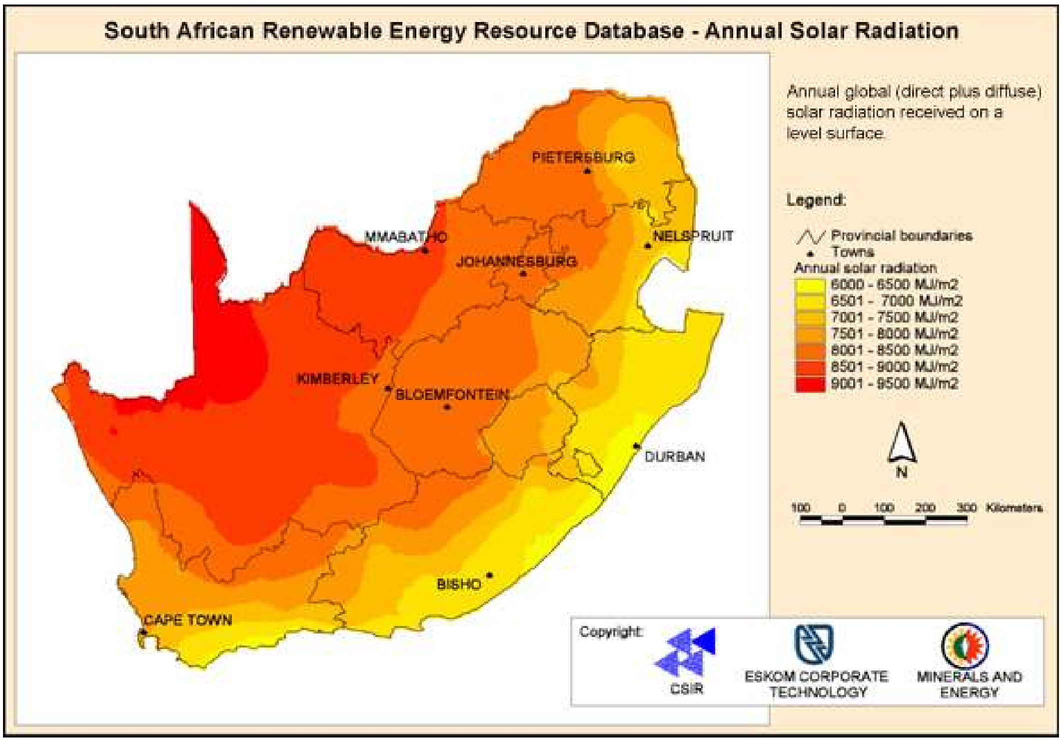


**Figure A2: Annual direct and diffuse solar radiation**
*(CSIR, 2002)*

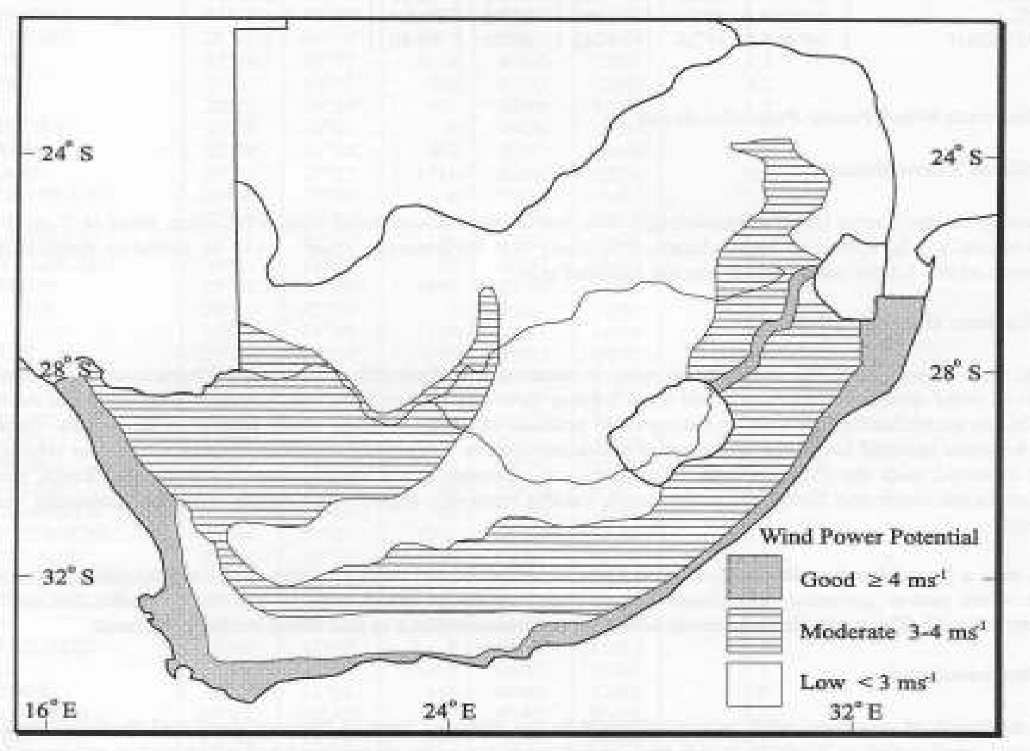


**Figure A3: Map of Wind Power Potential in South Africa**
**(DME, 2004)**

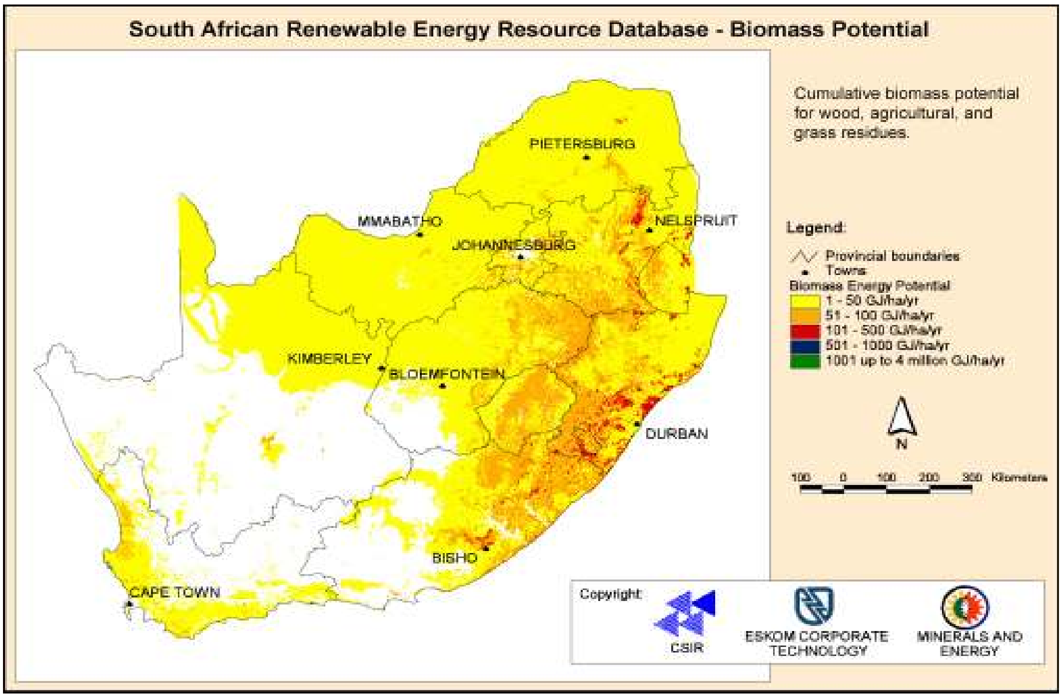


**Figure A4: Total biomass energy potential for South Africa**
*(CSIR, 2002)*

**Table 5b: Wind class description (DME, 2004)**

| ***Category number*** | ***Category name*** | ***Category description*** |
|---|---|---|
| 1 | Class 1 | Estimated mean annual wind speed at 60m in excess of 8.5 m per sec |
| 2 | Class 2 | Estimated mean annual wind speed at 60m in excess of 8.5 m per sec |
| 3 | Class 3 | Estimated mean annual wind speed at 60m in excess of 8.5 m per sec |
| 4 | Class 4 | Estimated mean annual wind speed at 60m in excess of 8.5 m per sec |
| 5 | Class 5 | Estimated mean annual wind speed at 60m in excess of 8.5 m per sec |
| 6 | Class 6 | Estimated mean annual wind speed at 60m in excess of 8.5 m per sec |
| 7 | Class 7 | Estimated mean annual wind speed at 60m in excess of 8.5 m per sec |

*Table A5: Capacity assessment for biodiesel*

| *Stakeholder* | *Function/activities* | *Capacity status / problems* | *Capacity development measures* | *Magnitude of CD needs / priority* |
|---|---|---|---|---|
| 1. Legislative authorities, elected officials | Set national priorities; social, economic and environmental goals; legal framework conditions | There is little awareness of biodiesel and its potential | Information and training on RE and more successful demonstration projects are | Very high |

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| | | | required; human capacity programmes to be strengthened<br>Lobby | |
| 2. Government macroeconomic and development planners | Define development goals and macro policy; general economic policy issues; subsidies and trade policy; sustainable development goals, and frameworks | Study on these completed by CSIR(DST 2003) | Capacity development in all areas required | Very high |
| 3. Government energy authority or ministry | Set sectoral goals; technology priorities; policymaking and standard-setting functions; legal and regulatory framework; incentive systems; national and local level jurisdiction. | Strategy and goals for RE not yet completed; standards for biodiesel have to be set; tax rebate have been announced; details to be worked out | Study similar projects in other countries | Very high |
| 4. Energy regulatory bodies | Have monitoring and oversight functions; implement the regulatory framework; administer fees and incentives. | Minister of Energy is the regulator for oil and oil products | Regulatory framework has to be drafted, detailed taxes to be worked out; incentives clearly allocated | High |
| 5. Market coordination agencies | Dispatch entities; have operational coordination functions; interface with industry investors; information brokers. | Biodiesel would either be exported or sold through existing oil companies | Build on existing capacity in the fossil fuel sector | Moderate |
| 6. Non-energy governmental authorities/ministries | Sector policies; cross-cutting issues; inter-relation with energy policies; public sector energy consumers; require energy inputs for social services provision. | DA, DWAF, DST, DME and DPLG have to coordinate activities | Strong coordination required | Very high |
| 7. Energy supply industry | Private companies and public utilities; manage energy supply, electricity generation; fuels management and transport; finance some R&D. | SASOL plan to produce biodiesel from soybeans | Private company takes over capacity development with assistance from government | |
| 8. Entrepreneurs and productive industry | Business development; economic value added; employment generation; private sector energy consumers. | Motor vehicle producers are aware and in the past extended engine guarantee to biodiesel use | Wider awareness required | High |
| 9. Energy equipment and end-use equipment manufacturers | Supply equipment for the energy industry and other industries, including vehicles and appliances; impact | Extracting biodiesel from the oil crop can be done by relatively simple equipment and this | Professional capacity has to be trained for this particular job. General capacity | Moderate |

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| | energy end-use efficiency; adapt/disseminate technology; finance some R&D. | can be manufactured in SA | available | |
| 10. Energy equipment O&M services | Provide O&M. Feedback on performance and feasibility | Can be trained locally | Special training required | Moderate |
| 11. Credit institutions | Financing options for large- and small-scale energy generation; capital provision for energy using enterprises; financing options for household energy consumers. | Financing options partularly for small-scale operators has to be created | This might require government assistance; eg, credit guarantees, subsidies | High |
| 12. Civil society / NGOs | Consumer participation and awareness; oversight and monitoring; environmental and social advocacy; equity considerations | Consumers are reluctant to buy diesel cars; 99% of light vehicles are petrol-powered | More information and education needed | Very high |
| 13. Users | Users of renewable energy systems. Providers of feedback and knowledge about resources, cultural traits, technology performance, friendliness and suitability. | Bioddiesel cars of all price categories have to be widely available and users have to be informed about the advantages/disadvantages of diesel engines | Taxi recapitalisation should be speeded up; market for small-range diesel cars should be facilitated and once established, such cars could then be manufactured in SA | High |
| 14. Energy specialists and consultant firms | Strategic advice, problem definition and analysis; systems development; specialist services delivery; options analysis; information sharing. | Very few specialists in the country | Provide training courses and on-the-job training | |
| 15. Academia and research organizations | R&D, knowledge generation, and sharing; formal and informal education; technical training; technology adaptation, application, and innovation. | CSIR is the only research organization carrying out detailed biodiesel studies at present | A brief overview of renewables is given in most undergraduate engineering courses ; ERC offers a PG course on new and renewable energy technologies | |
| 16. Media | Awareness raising, advocacy; information sharing; journalistic inquiry, watchdog functions; monitoring, | Very little information easily available on biodiesel | Invite media to seminars, conferences workshops on biodiesel | High |

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| | public transparency. | | | |

**Table A6: Capacity assessment for solar water heaters**

| *Stakeholder* | *Function/Activities* | *Capacity status / problems* | *Capacity development measures* | *Magnitude of CD needs / priority* |
|---|---|---|---|---|
| 1. Legislative authorities, elected officials | Set national political priorities; social, economic, and environmental goals; legal framework conditions. | Broad political goals are set; social, economic and environmental goals are defined in policies are being regularly reviewed | As under 3 | High |
| 2. Government macroeconomic and development planners | Define development goals and macro policy; general economic policies; cross-cutting issues; subsidies and trade policy; sustainable development goals, and frameworks. | Development and RE goals are defined in policies; some implementation scenarios are modeled.<br>Market has to be stimulated to make SWH cost effective (taxes, subsidies) | As under 3 | High |
| 3. Government energy authority or ministry | Set sectoral goals; technology priorities; policymaking and standard-setting functions; legal and regulatory framework;<br>incentive systems; federal, state, and local level jurisdiction. | Sectoral goals stated in the White papers an energy policy (1998) and renewable energy policy (2003); publication of strategy paper for RE is in preparation | Capacity is being developed under the CaBEERE project | High |
| 4. Energy regulatory bodies | Have monitoring and oversight functions; implement the regulatory framework; administer fees and incentives. | Standards are being developed by the industry | Capacity is being developed | High |
| 5. Market coordination agencies | Dispatch entities; have operational coordination functions;<br>interface with industry investors; information brokers. | The Solar Water Heating Division of SESSA worked out voluntary standards | Capacity development needed if large-scale roll out | Moderate |
| 6. Non-energy governmental authorities/ministries | Sector policies; cross-cutting issues; inter-relation with energy policies; public sector energy consumers; require energy inputs for social services provision. | SWH suggested for educational, health and correctional services | Capacity has to be developed | High |
| 7. Energy supply | Private companies and | Private companies | If demand increase | Moderate |

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| industry | public utilities; manage energy supply, electricity generation; fuels management and transport; finance some R&D. | are well established . | more capacity is neede | |
| 8. Entrepreneurs and productive industry | Business development; economic value added; employment generation; private sector energy consumers. | There are many SWH companies and a range of products are available on the market | Only required if market expands | |
| 9. Energy equipment and end-use equipment manufacturers | Supply equipment for the energy industry and other industries, including vehicles and appliances; impact energy end-use efficiency; adapt/disseminate technology; finance some R&D. | Imported and locally made equipment is available | Manufacturers dormed an association called Solasure | |
| 10. Energy equipment O&M services | Provide O&M. Feedback on performance and feasibility | O&M provided by private companies | | |
| 11. Credit institutions | Financing options for large- and small-scale energy generation; capital provision for energy using enterprises; financing options for household energy consumers. | DST supports innovation in S&T and particularly technology transfer for poverty reduction in the energy sector Other credit options need further development, general loans available for households | DTI financially contributes to capacity building in Industry/academia partnerships (Technology and Human Resources for Industry Programme programme) | High |
| 12. Civil society / NGOs | Consumer participation and awareness; oversight and monitoring; environmental and social advocacy; equity considerations | Awareness is limited, social and environmental advocacy required, subsidy for equitable implementation needed | | |
| 13. Users | Users of renewable energy systems. Providers of feedback and knowledge about resources, cultural traits, technology performance, friendliness and suitability. | Relatively few users therefore little feedback, technology performance good; different climatic conditions require different technology solutions | | |
| 14. Energy specialists and consultant firms | Strategic advice, problem definition and analysis; systems development; specialist services delivery; options analysis; information sharing. | Specialists and consultancy firms available | | |
| 15. Academia and research organizations | R&D, knowledge generation, and sharing; formal and informal education; technical | Limited amount of RE, SWH technology taught, formal | | |

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| | training; technology adaptation, application, and innovation. | courses or modules required | | |
| 16. Media | Awareness raising, advocacy; information sharing; journalistic inquiry, watchdog functions; monitoring, public transparency. | Media need to be better informed | | |

***suggest table to appendices (as before)

**Table A7: Capacity assessment for fuelwood**

| *Stakeholder* | *Function/activities* | *Capacity status / problems* | *Capacity development measures* | *Magnitude of CD needs / priority* |
|---|---|---|---|---|
| 1. Legislative authorities, elected officials | Set national political priorities; social, economic, and environmental goals; legal framework conditions. | Lack of knowledge about the role of fuel wood dependence in poor households | Presentation of solutions to the problem. Lobby | *Very high* |
| 2. Government macroeconomi c and development planners | Define development goals and macro policy; general economic policies; cross-cutting issues; subsidies and trade policy; sustainable development goals, and frameworks. | Effective policies on fuelwood are lacking, providing adequate fuelwood is part of the sustainable development goals; trade among the poor seems informal | Policy and strategy on sustainable fuelwood provision is required | Very high |
| 3. Government energy authority or ministry | Set sectoral goals; technology priorities; policymaking and standard-setting functions; legal and regulatory framework; incentive systems; federal, state, and local level jurisdiction. | Fuelwood problem is not taken seriously because more modern fuel sources and technologies are preferred | A champion for fuelwood is required | Very high |
| 4. Energy regulatory bodies | Have monitoring and oversight functions; implement the regulatory framework; administer fees and incentives. | Fuelwood is not overseen by the energy regulator | n/a | n/a |
| 5. Market coordination agencies | Dispatch entities; have operational coordination functions; interface with industry investors; information brokers. | There are no coordinating agencies in the fuelwood market of the poor | Marketing bodies should be established at the local level | High |
| 6. Non-energy governmental authorities/mini stries | Sector policies; cross-cutting issues; inter-relation with energy policies; public sector energy consumers; require energy inputs for social services provision. | Inadequate coordination between DWAF, DME and DPLG | Coordination body should be established | Very high |
| 7. Energy supply industry | Private companies and public utilities; manage energy supply, electricity generation; fuels management and | The community or individuals in the community are the suppliers | Communites and members in the community should be empowered to | Very high |

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| | transport; finance some R&D. | | manage the supply | |
| 8. Entrepeneurs and productive industry | Business development; economic value added; employment generation; private sector energy consumers. | Some fuelwood sellers; community members consumers of fuelwood | Entrepreneurs in community forestry management should be trained | Very high |
| 9. Energy equipment and end-use equipment manufacturers | Supply equipment for the energy industry and other industries, including vehicles and appliances; impact energy end-use efficiency; adapt/disseminate technology; finance some R&D. | Improved affordable stoves needed; marketing of improved stoves or alternatives is not effective | Improved stoves to be manufactured at community level | High |
| 10. Energy equipment O&M services | Provide O&M. Feedback on performance and feasibility | Consumers have to be involved in designing and testing of stoves | Skills training in rural areas very necessary | Very high |
| 11. Credit institutions | Financing options for large- and small-scale energy generation; capital provision for energy using enterprises; financing options for household energy consumers. | Credit options probably non-existing for poor households | Credit facilities for poor people in rural areas have to be introduced | Very High |
| 12. Civil society / NGOs | Consumer participation and awareness; oversight and monitoring; environmental and social advocacy; equity considerations | Consumer participation and advocacy urgently required | Training of consumers | High |
| 13. Users | Users of renewable energy systems. Providers of feedback and knowledge about resources, cultural traits, technology performance, friendliness and suitability. | Involvement of users most important to make programmes sustainable | Involve consumers | Very High |
| 14. Energy specialists and consultant firms | Strategic advice, problem definition and analysis; systems development; specialist services delivery; options analysis; information sharing. | Strategic advice to be integrated into sustainable development plans of the area | Strategic planning programmes to be introduced | Very high |
| 15. Academia and research organisations | R&D, knowledge generation, and sharing; formal and informal education; technical training; technology adaptation, application, and innovation. | Insufficient research funding and research interest | Make more research funding available | High |
| 16. Media | Awareness raising, advocacy; information sharing; journalistic inquiry, watchdog functions; monitoring, public transparency. | Media not aware of the problem | Make media aware of different aspects of fuelwood scarcity | High |

# APPENDIX B

## A potential rural biodiesel initiative and its impact on the community (from DST 2003)

A biodiesel factory could operate as a single business entity, but in rural areas there is also the opportunity to combine the biodiesel factory with a feedlot.

It is also possible to design a biodiesel factory operating in conjunction with an ethanol factory. Here a potential biodiesel/cattle feedlot is described

A fictional community living in an under-developed rural area is used to illustrate the concept. Such a community currently cultivates small pieces of land per family, mostly with maize, keeps a small herd of cattle and/or goats, lives in small houses scattered across a hilly landscape with access only to a rutted two-track dirt road. Income of the families is low and is augmented by pensions and salaries earned by family members working in Johannesburg.

For such a scenario, a biodiesel plant operating in conjunction with a cattle feedlot was conceptualised and its impact quantified. As an example, the biodiesel plant will produce 8 000 ℓ/day of biodiesel, utilising 16 tons of sunflower seed/day, or 4 800 t/annum. The 4800 t/annum of sunflower could be produced on 4 000 ha of land. Oil cake will be produced at a rate of 6.4 t/day.

In the feedlot, beef cattle consume about 10 kg of feed per day, which consists amongst other things of 0.5 kg of oil cake plus 4 kg of maize. If 35% of the 6.4 t/day of oil cake is used by the local cattle feedlot, 5 000 head of weaners could be fed. These weaners will require 20 tons of maize per day, or 7 300 tons per annum. At least 3 000 ha of maize production will be required.

For a project of this size, the following production outputs will be realised:

8 000 ℓ/day of biodiesel.

20 tons of maize per day produced on 3 000 ha.

6.4 t/day of oil cake produced from sunflowers on 4 000 ha, of which some are sold.

14 weaners/day sold to abattoirs.

The impact on the community will be as follows:

If it is assumed that the ratio of cultivated area to natural grazing is 10:1, then the total area affected will be around 70 000 ha. Physically this represents an area with a radius of about 30 km around the biodiesel factory and cattle feedlot. This brings the market within the reach of the small-scale farmers.

At least 14 000 head of cattle can be kept on 70 000 ha of natural grazing, producing around 5 000 weaners per annum. These weaners are fattened in the feedlot and sold to abattoirs. At 12 cattle per farmer, around 1 200 cattle farmers will benefit.

At 3 ha per maize/sunflower producer, 2 300 small-scale farmers will have a ready market for their crops, transforming them from subsistence to small-scale commercial farmers.

With a biodiesel factory and animal feedlot at the centre of such a production area, technical information transfer, training and input supply by the factory could be arranged to benefit the farmers.

The cash injection for the community will be around R500/t for maize and R750/t for sunflower for a total of R7,2 million/annum. On top that, the income from weaners will be around R1 000 a head, totalling R5 million. The biodiesel may realise a profit of R0.20/ℓ for a cash income of R580 000/annum.

The number of people who will become economically active instead of being subsistence farmers indicates the potential for job creation. For the project in the example, 2 300 small-scale crop producers alone will become economically active, which translates into 2 300 jobs created.