Renewable Energy Briefing Paper

Potential of Renewable Energy to contribute to National Electricity Emergency Response and Sustainable Development

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This work is dedicated to the memory of our colleague Douglas Banks
March 2008

Executive summary

This paper provides an overview of the potential contribution of renewable energies to rapidly and cost-effectively address South Africa's current power crisis, foster a ground swell of local industries with sustainable work opportunities and contribute to meeting our international commitment to climate change mitigation. Sustainable development demands truly sustainable energies. While South Africa has abundant renewable resources, it is still reliant on finite and polluting local coal and imported oil. The case for a concerted move to sustainable development through renewable energies is compelling. Prior energy modelling underestimated and neglected renewable energies, in part because of the short planning horizons. More balanced long-term scenarios were developed by civil society, showing 50% renewable energy power by 2050 to be realistic and in line with international imperatives and current EU actions.

Renewable energy already plays a small but significant role in meeting energy service needs, through biomass burned for cooking and space heating, reducing electricity demand through solar water heaters and solar passive building design, grid-connected applications like hydropower (642MW), biomass (20MW) and wind. Renewables are already the most cost-effective strategy for most decentralised rural energisation. Currently the residential sector alone is responsible for 35% of our peak demand crisis, and its share is growing.

A conservative study shows that solar water heating can displace between 7 900 GWh/a of grid energy, while another puts this more realistically at 43 000 GWh/a by 2021. If only 5% of on-grid households installed a 2kW PV system, this can contribute 800MW, generating 1 300GWh/a. Both technologies are applicable at point of use, with considerable savings in distribution infrastructure. Given the right incentives, PV on consumers' premises allows for a very wide base of installers, financiers and project implementers to make a large-scale cumulative contribution. Plans are going ahead for North Africa to produce massive scale concentrating solar power for the EU market. South Africa has similar and better resource levels.

Abundant renewable energy resources and technologies are available in South Africa. A primary objection to the widespread use of renewables is given as their intermittency; the assertion that they are not "despatchable". Some renewable energy technologies are constant (hydro, wave, current, bioenergy), while others can be combined for predictable supply through geographic and technological mixes (hybrid systems, Green Tower, wind). Some are coincident with demand (solar cooling, solar water pumping, some wind resources) and some have their own integral energy storage systems (solar water heating, solar passive building design, biogas). The remainder can be covered by energy storage systems (pumped storage, compression, molten salts, hydrogen, and kinetic energy). A high proportion of renewable energy in the mix does present challenges, but **intermittency (despatchability) is not a disqualifying issue for renewables in South Africa.**

The **energy market is distorted in South Africa,** by the omission of externalities, a protected monopoly and subsidies. Renewable energy prices are declining while finite fossil fuel prices are rising (oil, coal, uranium). Some renewables (solar water heating, solar passive buildings, hydro, landfill gas) are already cheaper than building new generating capacity, others (wind, CSP) will be cheaper long before the end of life of fossil power stations currently being built. **The economic, social and environmental cost of delaying massive deployment of renewables is higher than the current capital cost differential.**

The unique characteristics of renewable energy technologies are that they use, by definition, sustainable energies, can be implemented relatively quickly, come in modular units, support distributed generation, offer more work opportunities and have a much lower environmental impact than stock energy options, including achieving the lowest CO_2 emissions. Most are suited for co-generation, are geographically dispersed, and have a modest footprint, while some can be placed on the roofs of existing and new buildings.

Section 4 provides international and local **cost details** for a range of renewable options, including projected unit costs, per kWh, to 2030, showing some reductions as a result of technology learning. Consistent trends in electricity generation costs over the last 15 years are:

- increasing costs of stock energy options and
- decreasing costs of renewable options.

At present, there are some areas where renewables are financially cheaper or very close to the cost of fossil counterparts. When environmental, job creation and other factors are taken into account renewable energy options are economic (least cost) in a wider range of scenarios. However, even from a purely financial perspective, if one makes conservative assumptions about fossil fuel price increases and renewable energy technology price reductions, aggressive renewable energy scenarios for electricity generation result in lower costs in the medium term.

The main **constraints** are neither resource availability nor techno-economics but a limiting **mindset** focussed on the supply-side, partial energy costing, low (indirectly subsidised) energy prices and short-term thinking favouring low initial costs. Dominance of the state-controlled power monopoly and the influence of vested interests (particularly of the minerals sector) on key stakeholders are exacerbated by a lack of awareness and informed leadership as well as a real shortage of person power. It is concluded that **the most important constraint is not money, men, machines, materials or management, but the motivation, the inspired political will.**

An **effective action framework** requires a long-term commitment, challenging targets and consistent and predictable market conditions. It has long been internationally recognised that addressing skewed markets and subsidies requires measures that are long, loud and legal. Good intentions are not enough. The internationally proven Feed-in-Tariff stands out as a key mechanism, but a suite of interventions would be required. Twenty-one cardinal action items with responsible entities and expected impacts.

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ABBREVIATIONS

CaBEERE	Capacity Building in Energy Efficiency & Renewable Energy, A Danida funded programme implemented by the DME
CF	Capacity Factor
CHP	Combined Heat & Power
CSH	Concentrated Solar Heat
CSIR	Council for Scientific & Industrial Research
CT	Cape Town
DACST	Department of Arts, Culture, Science and Technology
DBSA	Development Bank of Southern Africa
DEADP	Department of Environmental Affairs and Development Planning
DME	Department of Minerals and Energy
DTI	Department Trade & Industry
FIT	Feed-In Tariff
GHG	Greenhouse Gas
GT	GreenTower
IEP	Integrated Energy Plan
ISEP	Integrated Strategic Electricity Plan (has gone under several different names over the years)
LCC	Life Cycle Costing: counting all costs of a facility (capital, running & demolishment) in terms of net present value
LEAP	Least cost based modelling tool
LIRP	Local Integrated Resource Planning
LTMS	Long Term Mitigation Study (a major consultative research programme that is ongoing, primarily funded by
MW	Megawatt – power rating
MWe	Megawatt capacity – indicates theoretical or nominal, rather than actual capacity
MWh	Megawatt hour (1000 kWh – the most common metering unit)
NERSA	National Energy Regulator of South Africa
OCGT	Open Cycle Gas Turbine
PPP	Public Private Partnership
PV	Photovoltaic
R&D&D	Research, Development & Demonstration
RE	Renewable Energy
REC	Renewable Energy Certificate
RED	Regional Electricity Distributor
REMT	Renewable Energy Market Transformation
RET	Renewable Energy Technology
SA	South Africa
SADC	Southern African Development Community
SANS	South African National Standards
SD	Sustainable Development: fulfilling the needs of the present needs (socially, environmentally, economically & institutionally) without impairing the options of future generations
SECCP	Sustainable Energy & Climate Change Partnership
SHS	Solar Home photovoltaic System
SWH	Solar Water Heater
TREC	Tradable Renewable Energy Certificate
UPS	Uninterrupted Power Supply
WC	Western Cape

1. Introduction

This paper was commissioned by the Trade and Industry Policy Studies (TIPS) initiative, with the aim of providing an overview for decision-makers of how renewable energies (REs) can contribute to a rapid alleviation of our current power crisis and the move to diversity of supply, while fostering the growth of local industries with many sustainable work opportunities. Sustainable development, including climate change response, requires a shift to renewable energies, which are sustainable because, unlike stock energy – fossil fuels and uranium - they are continuously replenished.

In the past, renewable energies have been treated in South African energy planning as expensive, intermittent, unreliable and an only-good-for-the-environment, or 'niche application' energy source. The prevailing conditions for such a perception are changing. Growing appreciation of energy security, social and climate protection benefits of renewable energy are encouraging a move away from the short-term thinking and planning that marginalises renewable energy. The massive expansion of open-cycle gas turbine deployment clearly indicates a willingness to pay, with costs comparable to and exceeding many options for generation harnessing renewable energy. Not only is there growing recognition of the long-run marginal costs of generation, but also of the full range of externalised costs, and of the risks associated with long-lived infrastructure premised on stock energy supplies in an increasingly volatile and constrained global market. It is time for a fresh look at the potential of renewable energy.

South Africa is officially committed to renewable energy targets and Sustainable Development through its White Paper on renewable energy (November 2003). However, the renewable energy White Paper and its target require an urgent review, consistent with commitments made by the DME, since the context has completely changed and its short-term planning horizon underestimated the potential of renewable energies, The excess electricity generation capacity the South African economy used to enjoy is now a thing of the past and the cost of building new capacity is escalating globally. The price of primary energy, including coal, has skyrocketed since the publication of the White Paper while renewable energies prices are generally dropping internationally.

The electricity price in South Africa is climbing steeply; the debate is only over how rapidly the escalation takes place. Renewable energy can also play a significant role in strengthening security of energy supply in sectors other than electricity. With appropriate conditions in place, renewable energy technologies can be implemented with far shorter lead times than the 5-8 years of conventional options, thus ameliorating the current crisis. This also presents an opportunity to develop our local renewable energy technology industries for the socio-economic benefits of job creation and international competitiveness. This requires stimulating the local renewable energy industry through priority actions

While South Africa has very little oil, it has abundant renewable energy resources, which could make it a leader in renewable energy technologies, given the right conditions. The bulk of transport fuels and the new gas turbines (to be run on diesel, at least in the short term) are exposed to the vagaries of the rising oil price (SANEA 2007). Oil, gas and coal are internationally traded commodities and fairly interchangeable: coal can be converted to oil, or sometimes substituted for oil. The growing linkage (which is strengthened as the price of oil exceeds the cost to produce and convert coal to liquid fuels) is a major factor in South African coal prices moving $50/ton in 2007 to $100 in 2008[1].

This paper provides an overview of the current status of RE implementation and planning in South Africa, reviews the resource base and discusses key issues related to implementation, including pricing, employment opportunities and the main constraints. It briefly considers the consequences of South Africa being one of the world's major CO_2 emitters, within a region most vulnerable to climate change impacts, which, if unchecked, will give rise to a massive influx of environmental refugees. After a brief discussion of the key stakeholders, the paper concludes with priority actions that would address the constraints, identified in terms of: legislation and regulation; financial interventions; governance; stakeholder involvement; information management and awareness creation.

[1] Rostoll, L. 2008. More coal price increases on the way, says senior analyst. *Mining Weekly.*

2. Current status of renewable energy implementation and planning

The South African renewable energy resource base is greater than energy demand. Indications are that costs of electricity converted from renewable energy resources will compete favourably with their stock resource counterparts in the supply mix (coal, gas, nuclear, oil) in the short to medium term (10 years) on a pure least-cost financial basis. With full economic costs included, a renewable energy based electricity supply system is not only sustainable but represents the economically optimal option.

2.1. Prior work on the potential and integration of renewable energy

The **DANIDA funded renewable energy baseline and financial calculation** studies (CaBEERE, 2003) assessed the current installed capacities in wind, biomass, hydro and solar resources and began some collation of minimal resource material readily available at the time. The stand-alone baseline studies did not consider supply scenarios in detail.

A National Integrated Energy Plan (IEP) published by the DME in 2001, modelled national energy supply options up to 2014. Two major shortfalls of the study were the short planning horizon and the marginalisation of renewable energy contributions due to considering financial rather than full economic costs. The second IEP began in November 2005 but was put "in abeyance" a year later to focus on short-term security of supply of liquid fuels and electricity. It was to consider a 25-year planning horizon and include externality costs.

The National Integrated Resource Plan (NIRP) - prepared by the NER (now NERSA) (NER, 2004b, p. 28) includes, as an option to the preferred plan to 2021, the installation of 300 MW of solar thermal electrical power plant and 20 MW of wind turbines, to produce about 2 TWh per year from 2008 onwards - about 1 percent of current grid consumption. NERSA is currently working on a new NIRP, but the results are not yet available. Of concern is regulatory 'capture' by Eskom, with the regulator unable to prescribe options to the utility.

Eskom produces an internal **Integrated Strategic Electricity Plan (ISEP)** from time to time. As of last year, larger scale wind and solar thermal electricity (in the order of 100MW) have started to enter the early stages of the Eskom investment option pipeline.

Provincial initiatives: "A Proposed Renewable Energy Plan of Action for the Western Cape, Resource Assessment, Scenarios, Proposed Objectives and Actions" (D:EA&DP, 2007) demonstrates that the WC could realistically achieve just under 14% renewable energy contribution to the gird supply by 2014, and 30% by 2030. The province issued a 12-point action plan to help move towards a more sustainable energy future. KwaZulu Natal has recently released a report considering renewable energy options for the province. Gauteng has initiated a project to examine the introduction of alternative, cleaner sources of energy as part of the R3 billion *20 Prioritised Townships Programme*. Key strategies are expected soon.

The potential of renewable energy in South Africa, was the title of a report commissioned by civil society (Banks and Schäffler, 2006), which investigated the national resource base and developed scenarios to 2050. This shows that more than 50% of electricity could be generated from renewable resources by 2050, with surprisingly little cost penalty. Indeed, a 'progressive renewable scenario' had lower long-term costs than conventional options, even though the analysis preceded the recent significant coal and oil price increases.

Resource maps are available. Estimates of total realisable national potential are ultimately based on these resource maps.

The **Renewable Energy White Paper (DME, 2003)** set a target of an equivalent of 10 000 GWh (or 10 TWh) to be produced by renewable energy (excluding large-scale hydro, including biofuels and SWH) by 2013. The economic modelling undertaken for setting the target and the due diligence for the World Bank's South African Renewable Energy Market Transformation programme design considered least cost options excluding externalities, job creation and climate mitigation to reach the renewable energy target (CaBEERE, 2003). Recent conventional energy cost escalations have overtaken the White Paper and its assumptions.

The **CSIR** in partnership with **Shell** published three **scenarios** in November 2003, assuming a long-term oil price of US$20/barrel, when the current price was US$29.

Summary of major initiatives approved and proposed investments, indicating recent progress towards initiating a transition to a sustainable energy economy:

- Eskom incentive scheme aimed at the uptake of approximately one million middle to high income residential solar water heaters. The initiative would cost in the order of R 4 billion over a 5 year period

- Several wind farms in the 100MW class are being considered within the private sector. A 100MW wind farm draws a capital investment in the order of R1Billion. Eskom has issued two tenders: for 100MW of turbine supply and 100MW to 200MW wind farm ranches.
- A call for proposals to provide up to 3 GW of generation with a short lead-time (commissioned before 2012) provides an option for a range of renewable energy generation technologies to demonstrate financial competitiveness.
- Plans for large solar thermal electricity generation (and heat supply) facilities, again in the 100MW class, are being driven by both the national utility and private sector players
- The Department of Minerals and Energy led a study into the feasibility of Tradable Renewable Energy Certification and hosts a secretariat of the South African National TREC Team, under the authority of the minister, to establish the system. About 30GWh of green electricity - specifically the beneficial attributes, other than climate change mitigation, of utilising renewable energy sources - has been traded via the existing system. The EU compliance of this system potentially allows for international trade of these attributes.
- The South African Wind Energy Programme, funded by UNDP/GEF, has been resumed and has targets of 50.2 MW by 2013 (including Darling) and 150 MW by 2020. The outputs include an "Implementation strategy… of the White Paper on Renewable Energy" and "Financial instruments… such as feed-in tariffs".
- NERSA is investigating the Feed-in Tariff that that is successfully being used by 50 developing and developed nations.
- Issues deserving high level national coordination and/or intervention include:
  - The longstanding off-grid rural electrification programme: a public private partnership (PPP) with state (or donor) capital subsidies financing Solar Home System implementation (now in holding mode pending award of new contracts);
  - A national biofuels strategy struggling to stimulate investment;
  - Lack of public access to information from publicly funded initiatives e.g. the national renewable energy resource database and National Integrated Resource Planning exercise;
  - The Renewable Energy Subsidy Office in the DME, which has been inadequately resourced and is unable to effectively disburse what funding does exist;
  - The Renewable Energy Market Transformation Programme funded by the World Bank needs to be monitored to ensure that full advantage is taken of its potential.

While the above initiatives are significant, they fall far short of the level of effort and focus required to realise the very significant short, medium and long-term potential of renewable energy to contribute to the sustainable development of South Africa and ameliorate the current energy crisis.

2.2. Existing renewable energy contributions in South Africa

Renewable energy already plays a significant role in South African energy supply:

- Biomass – burned directly for cooking and space heating in homes
- As a generation source for provision of electricity to the national grid (together with above, contributing 9 -14% to total primary energy supply according to DME figures)
- As a decentralized method of energy service delivery such as water pumping, lighting, telecommunications etc (incl.: PV and wind pumps)
- Passive solar design and solar water heating reduce electricity demand.

Although there are significant uncertainties in South African assessments, Table 1 provides an indication of the electricity equivalent of the contribution.

Table 1: Current renewable energy contributions (total grid electricity data is provided for comparison only) (Updated from Banks & Schäffler, 2006)

	Existing mixed-Grid production	**Hydro-power**	**SWH (2005)**	**PV (2002)**	**Wind**	**Biomass**	**Biomass for power generation**
Capacity (MW)	39 493	661	652	12.1	29 (including 23 MW at boreholes)	Not applicable	200
Annual production (GWh)	207 000	1057	1377	21	60	106 000[2]	700
Reference	NER 2002	Barta 2002 DME energy balance, 2001	Holm, 2005. p 30	Cawood & Morris, 2002, p. 27	Tripod & Oelsner, 2003 in World Bank 2004	WEC, 2003, p. 39. .	Schäffler 2008 correspondence and CaBEERE 2004.

This is a very small base from which to grow the renewable energy contribution, posing a challenge on a par with meeting escalation of peak electricity demand of 4.8%[3] or 1706 MW per year[4]. It also demonstrates the desperate need for energy efficiency.

[2] Note: expression of biomass in GWh does not imply 100% conversion to useful energy, it shows the inherent energy of fuel used
[3] DME, 2008, National Response to South Africa's Electricity Crisis
[4] DME, 2008, National Response to South Africa's Electricity Crisis

3. Renewable energy technologies and the South African resource base

3.1. Hydro power

Potential: Hydropower plants range from 50 W pico hydro systems to the multi-Gigawatt installations. Several previous hydropower potential estimates were concisely collated in the 'Baseline Study: Hydropower in South Africa' (Barta, 2002). The study concluded that large (>10 MW) hydro generation systems have a potential of 5 091 MW. Systems smaller than 10 MW, have a potential of 69 MW. Barta also identified resources that could be developed in the longer term, providing an additional 1 994 MW of hydropower. A significantly lower estimate of only 300 MWe is provided in the National Integrated Energy Plan (DME, 2003, p. 21). There is also considerable potential, in the longer term, for South Africa to draw on regional hydro resources, with Grand Inga in the DRC said to have a potential of 40 GW.

Challenges: As large dams have significant social and environmental impacts (including greenhouse gases) and are subject to siltation, which can disable generation facilities, they are not universally regarded as renewable. There are significant political risks related to reliance on long distance/multi country hydropower resource development and transmission line construction and operation. Large dams have long lead times of up to ten years.

Hydropower costs are highly variable, and depend on the specific civil engineering work required to build the necessary dams or water off-takes, as well as the transmission distances. For limited applications, the estimated costs are of the order of 47 c/kWh, but are expected to be higher if non-optimal sites need to be developed.

3.2. Biomass

Potential: Biomass contributes in the region of 10% of total energy – estimates are extrapolated from limited surveys – and not all of this is sustainably harvested. There are currently 4 300 km^2 ha of sugar cane plantation and 13 000 km^2 of forestry plantation in South Africa (SMRI 2004). The SMRI study indicates a total potential of 12.7 TWh per year from the existing sugar cane, forestry, sawmill, pulp and paper industries. If an additional land area equal to the current sugar crop were to be used for energy crops, then, with an average yield of 106 GJ/ha (3 GWh/km^2), it would be possible to produce a further 3.7 TWh of electricity as outlined in Banks & Schäffler 2006. However, Lynd et. al. (2003) estimate that the gross (prior to conversion) annual biomass energy production potential for South Africa is about 135 PJ per percent of South Africa's available non-crop, non-forest, non-wilderness area, if used to produce energy crops. Their base case entails using of 10% of such land giving an estimated production potential of 1350 PJ. Assuming a conversion efficiency of 25 percent for electricity, this could deliver almost 100TWh (just under half the current electricity demand in South Africa). If it were converted to liquid fuels at a conversion efficiency of 50 percent it would provide 675 PJ of liquid fuels equivalent (more than current transport fuel requirements).

Challenges: Biomass is a renewable resource only if production is sustainable. Production of biofuels requires significant land, fertiliser and water resources and has a potential impact on food prices, food security, water availability as well as bio-diversity. On the other hand, bioenergy crops require significant agricultural activity, with good potential for job-creation, particularly when other inputs such as mechanisation are low. Great care has to be taken when developing bioenergy projects that use purpose-grown feedstock.

Costs of bioenergy are variable, depending on whether the biomass feedstock is a by-product or 'waste' (in which case costs already compete with retail tariffs), and whether or not one can use combined heat and power cycles to derive useful thermal energy (process heat) from the process. If done on large scale, biomass power generation will need dedicated energy crops, in which case the prices are expected to climb significantly, to R1/kWh or more.

3.3. Landfill gas and sewerage

Potential: Lombard de Mattos and Associates (2004) established that 453 landfill sites were operational or in the process of being permitted. Fifty-three of these sites were analysed to determine the potential energy that could be extracted from the methane gas that results from anaerobic decomposition of organic component of municipal waste. They estimated that South Africa has the potential for an installed capacity of 105 MWe of landfill gas-based electricity generation facilities, which would produce an estimated 850 GWh of electricity annually at a load factor of 90 percent. In addition, the net realisable electricity available from sewage-derived methane in South Africa would be in the order of 800 GWh per annum, giving a total of 1 650 GWh. If waste resource streams are separated, there can be improved energy return accompanying improved waste management. Assuming a 1 percent growth rate in this resource over 40 years, the final potential would be 2.45 TWh by 2045.

Biogas digesters, which produce methane from sewerage, animal waste and organic material, present a significant opportunity to produce gas for domestic cooking or other thermal applications, as well as for electricity generation. A recent study has investigated the potential to establish a national biogas programme – and indicates potential for 300 000 digesters in rural areas[5].

Challenges: The extraction of landfill gas has been used to justify extending the life of landfills that have an adverse impact on local communities.

3.4. Wind energy

Potential: Prior work by Banks and Schäffler (D:EA&DP 2007, p 30) found that, with publicly available information of only moderate quality, it is difficult to derive an accurate estimate of the wind resource potential. Nevertheless, a mapping exercise overlaying wind resources, powerlines, roads and taking into account recommendations of a provincial report on land use requirements, estimated that there is sufficient available land in areas with medium to high wind resource potential to conservatively justify installation of 3 100 MW in on-shore locations in the Western Cape[6]. Furthermore, the study estimates more than 1 500 MW potential for offshore development in the longer term. There are also significant wind resources in the Northern Cape, Eastern Cape and parts of Kwazulu Natal. One national study assumed that 1 percent of the land area in the highest five wind class zones could be allocated to wind farms, giving a land area of up to 4 100 km^2 and a resource potential of about 50 GW, yielding 106 TWh at capacity factors between 24 and 37 percent. Note that farming activities can continue on land utilized for wind turbines.

Challenges: One of the primary negative factors levelled against wind-based electricity generation systems is intermittency - 'what happens when the wind does not blow?' International experiences indicate that a contribution of up to 20 percent of total electricity supply can be added to electrical grids such as that in South Africa, without significant changes being required to system operating procedures or distribution and transmission networks. As weather systems move considerably slower than wind gusts at a single location, the larger the area over which turbines are distributed, the smaller the average fluctuation in energy generated will be. Some people consider large turbines unsightly and resulting opposition has resulted in the protraction of project lead times.

Wind Energy costs are of the order of 5 to 8 USc/kWh and the first Wind IPP in South Africa has negotiated a power purchase tariff that is at the lower end of this scale. Following interviews with wind farm developers and financiers in 2006/7, Banks and Schäffler (D:EA&DP 2007, p 30) estimated wind power costs of the order of ZAR 0.45 to 0.54/kWh. Others have put the price necessary to secure private sector investment in IPP's at around ZAR 0.60 to 0.70/kWh with the range of reported sales prices required ranging to the order of ZAR 1.10/kWh. The rapid growth in the global industry, as well as increases in steel prices have unfortunately placed upward pressure on wind farm costs, but these dynamics are not peculiar to wind turbines only and there is still room for further real cost reductions as the industry grows and technological improvements continue.

3.5. Solar energy

South Africa is blessed with excellent solar energy resources, and there is a range of technologies, which can be harnessed to either generate or help save electricity, as the sun can help meet important thermal (e.g. hot water) or lighting needs directly.

3.5.1. Solar technologies that generate electricity

Concentrated solar heat (CSH) is used in the largest existing centralized systems with parabolic troughs that focus sunlight onto evacuated glass tubes that carry the heat to conventional steam turbines via heat exchangers. They produce cheaper centralised power than PV. Other variants directly generate steam in the focal pipes, or use flat mirrors in a Fresnel arrangement, focussing sunlight on passive absorber units. Yet another has static primary troughs with mobile secondary reflectors achieving very high solar concentration

[5] AGAMA, 2007. Integrated Biomass Systems
[6] The assessment assumed only 1 MW per km^2 of land used for wind farms. In some installations up to 4 MW/km^2 have been installed.

ratios. All these systems are imminently suitable for combined heat and power generation (CHP) and take advantage of the established mass market of the conventional steam cycle. Supplementary power can be provided by gas or, preferably, by any suitable renewable energy (e.g. biomass).

Parabolic dishes track the sun and focus the radiation on, say, a Stirling engine that drives a pump or generator. Most current units are stand-alone systems of 5 to 25kW nominal capacity. This capacity represents a useful size for remote rural applications and farms, although the devices can also be used in larger clusters to create multi-megawatt power stations. The technology is not fully commercialized but does show good medium term promise.

Solar power towers are surrounded by extensive fields of movable mirrors (heliostats) that concentrate solar radiation onto a central receiver situated on top of a tower. There the heat exchange medium (air, water or salt) is heated to 500 – 1 000°C, driving a gas turbine or combined cycle plant. Systems incorporating molten salt can use the salt to store heat energy, allow the system to continue generating power through cloudy patches or into the evening. Typical grid-connected units would be $200MW_e$. Eskom is planning a 200 MW_e unit at Upington.

Solar chimneys/Green Towers combine agricultural greenhouses and thermal storage with updraught chimneys to produce uninterrupted power. Although these have lower efficiency than the above technologies (3.5 to 5%), they do have potential to continue providing significant night time power. There has been extensive feasibility study work done on solar chimneys in South Africa.

Photovoltaic (PV) cells convert sunlight into direct current electricity without any moving parts. The semiconductor materials are encapsulated and sealed hermetically. A long service life of more than 20 years and unusually long warranty periods make this modern technology increasingly attractive. With suitable electronics, PV systems can be grid-connected or stand-alone, where they can also be used for lighting, information technology power supply, water pumping or other mechanical work. A storage battery is normally optional for grid-connected systems, but is a necessity for stand-alone systems that need to provide electricity at night or during cloudy weather. No battery is required for water pumping and other daytime work.

PV arrays do not emit vibrations, noises and pollutants during their operation, and they can be deployed at both small and large scale. This means they can be integrated into buildings, shading systems, noise barriers or other components of both city and rural infrastructure. It is relatively easy to add PV units to an existing system as demand grows (high modularity).

In South Africa, PV has primarily been used for off-grid (rural) applications, where the costs of grid extension are high, thus helping to justify the relatively high costs of batteries and PV modules. Typical applications include schools, health centres, and rural household lighting, cell phone and TV/radio power supply. This market is also well developed internationally with around 2.5 million household lighting systems installed – key markets being Bangladesh, China, Sri-Lanka and Kenya. However, globally PV is primarily used in grid-connected applications (with an estimated 7.8 GW installed by 2007), where it feeds power into national grids and buildings during the day, helping to offset daytime peak load. Average growth rates for grid-connect PV were 60% from 2002 to 2006[7]. Where prolonged grid interruptions occur, PV assisted battery, based uninterrupted power supply systems also have significant potential.

3.5.2. Solar technologies that do not produce electricity can save electricity

Electrical storage heaters in SA have high annual energy standing losses in excess of 26% (Lane & Holm, 2000). Instantaneous ("push through") water heaters are more efficient, but add considerable peak loads to the municipal distribution system. **Solar Water Heaters (SWHs)** range from unglazed collectors, e.g. black plastic, water filled absorbers, typically used for low temperature applications such as swimming pools, to glazed or evacuated tube collectors that achieve much higher temperatures and could be cost effectively applied to meet most water heating needs in South Africa. SWH can contribute enormously to space heating, as well as to space cooling, although the latter technology is still underdeveloped. There are also significant industrial pre-heating applications. Standards are reasonably well established, and the industry is currently growing fast, although not nearly at the rate required to have a major impact.

3.5.2.1. Potential

The solar resource is very abundant in SA, which enjoys 24% of the world's best winter sunshine area, and is well distributed. If solar electricity generation facilities, such as photovoltaic (PV) panels or concentrating solar thermal plant (CSP) are established on virgin land, then Banks & Schäffler (2005) estimate that an area of only

[7] Renewables 2007, Global Status Report, p 10

730 km^2 is required to meet the entire current electricity needs of South Africa, at a 13% conversion efficiency.[8] The potential scale of application of the various conversion technologies is thus not limited by the resource, but more by costs, industry growth rates and by the fact that electricity cannot easily be stored. To give some idea of the potential scale of application in South Africa – consider the following:

- There are approximately 3.4 million households that still do not have access to electricity. Perhaps 2 million of these are in rural areas, where the cost of gaining access to the grid is high. Even if only 1 million of these were provided with Solar PV systems, this would allow significant improvement in quality of life, and avoid the addition of approximately 500 MW to the national demand[9].
- DME (2004a, p. 88 and p. 94) indicates a potential for SWH to displace between 4 900 and 5 900 TWh of electricity in residential applications, and 2 000 TWh in commercial applications (a total of possibly 7 900 GWh). A World Bank study (World Bank, 2004, p. 61) indicates far more significant potential, with up to 43 000 GWh/year being produced in a scenario for market transformation by the year 2021. According to one assessment "Solar geyser deployment in low-mid to high income households has the potential of removing 4 747 MW from our winter peak load" and 1 014 from the summer standard load, to deliver a total annual saving of 12 125 (M Willemse, 2007. ii)
- If only 5% of South African households that have a grid supply were to install a 2 kW grid connected PV system, this would contribute about 800 MW, and would generate of the order of 1 300 GWh per annum..
- Grid-connected PV is a technology that allows consumers and companies to implement renewable electricity generation on their own premises. This allows the country to draw on a very wide base of installers, financiers and small project implementers to have a cumulative large-scale contribution (provided that the financial incentives are there, see below).
- Internationally, scenarios have been developed which consider the potential for the solar resource-rich regions of North Africa to generate electricity using concentrating solar technologies, and export this on a massive scale to Europe. South Africa has similar and better resource levels in the Karoo and Northern Cape.

The primary impediment to large-scale application of solar for electricity is the fact that the sun does not always shine. However:

- For off-grid applications, solutions already exist and have been implemented on a medium scale in South Africa.
- For grid systems,
    - a significant portion of peak electricity demand occurs during the day,
    - several of the solar CSP based electricity generation technologies can have thermal energy storage (in molten salt) integrated to allow generation well into the night
    - hybridisation of CSP plant with either fossil or biomass based heating is possible
    - energy storage options need not be at the same location as the generation site (e.g. pumped storage systems)
- solar water heaters inherently solve the storage problem (the energy stored in the hot water)
- the solar resource is generally predictable, and in some regions of the country highly predictable – making it easier to plan and manage the energy flows

Energy storage is discussed in more detail in section 5.3

Costs of energy from solar technologies in South Africa should typically be significantly lower than for international applications, because our solar resource is excellent. Bekker (in press) has calculated the cost of energy from PV for a range of locations in South Africa, and comes up with prices of R1.66 to R1.72 for De Aar, and R1.77 and R1.93 for Cape Town (using a maximum power point tracking inverter – MPPT). Others have prices more in the R2 to R3.00 range.

3.6. Ocean Energy

3.6.1. Wave energy

Potential: The Centre for Renewable and Sustainable Energy Studies at the University of Stellenbosch told media in March 2007, following its first ocean energy workshop, that South Africa's coast has the potential to generate between 8 000 MW and 10 000 MW of wave power.

[8] 720 km^2 is a relatively small surface area, for example, a strip 500 metres wide along the length of the N1 between Gauteng and Cape Town.

[9] If one assumes an after diversity maximum demand for grid connected rural households of 0.5 kVA, then 1 million households have a design demand of the order of 500 MW. Wealthier households have a demand higher than this, so the savings could be even higher.

Although Eskom and other parties are undertaking detailed resource assessments, we are not aware of published results. However, Banks & Schäffler (2007, p 35), drawing on the available literature, provide the following summary table for the Western Cape.[10]

Table 2 Initial estimate of the potential wave energy resource in the Western Cape – theoretical potential in MW

Region	**Length of coast (km)**	**Energy kW/m (Ave)**	**Theoretical Potential**
Hoekbaai to Cape Columbine	280	30	8398
Cape Columbine to Marcus Islan	54	45	2420
Marcus Island to Mouille Point	252	40	10071
Moiuille Point to Cape Point	85	40	3389
Cape Point to Kaap Hangklip	128	40	5100
Kaap Hangklip to Danger Point	110	25	2756
Danger Point to Northumberland	110	20	2204
Northumberland Point to Bloukr	525	13	6820
Total			**41158**
Assume that practical limitations limit access to 10% of this			**4116**

From the above it seems quite feasible to consider that more than a 1000 MW of wave power plant could be installed in the Western Cape. There is also significant potential along the other parts of the South African coastline. Note that there are already concept plans for up to 600 MW of wave power plant in the project listing given in D:EA&DP (2007).

Preliminary information on wave plant feasibility in the Western Cape (Ocean Power Delivery, Genesis Eco Energy, personal communication) indicated (Banks and Schäffler 2007) costs of the order of R18 000/kW installed. Given that wave power plants would have high costs for connection to the grid, they used a slightly more conservative base cost of R25 000/kW for wave power plant (2007 figures). Cost per kWh depends on the resource utilization factors etc. As discussed in D:EA&DP (2007), anticipated costs are of the order of ZAR 0.71/kWh.

3.6.2. Ocean current

South Africa has two strong ocean currents, which flow past, the Benguela on the West, and the Agulhas on the Southern/Eastern coast. Eskom is currently investigating the potential of the ocean current resource. See Nel 2007, which indicates that the Agulhas current reaches speeds up to 2.7 m/s. This is well within the range being considered for ocean current turbines. In an ocean current moving at this velocity, the power density would be above four kW/m^2 ([11]) (Mueller, quoting Fraenkel, 2007). It has not been possible to obtain an assessment of the potential energy that could be extracted from the Agulhas (or the Benguela) currents. Banks and Schäffler deduce an order of magnitude estimate of perhaps 1000 MW per 10 km^2.

Challenges: Technologies are still relatively immature and ocean conditions very challenging, so there is not widespread agreement on how to construct the plant necessary to extract the energy. A particular advantage of ocean energy is that it would effectively operate as base load plant.

3.7. Geothermal

Potential: South Africa is not particularly well endowed with easily accessed geothermal activity. However, the Southern Cape Fold Mountains hold subterranean reservoirs of superheated water that some argue could be a source of cheap 'green' and continuous energy (Engineering News, 2003c). Geothermal resources have not been reviewed in the recent DME strategy development processes, or in the series of Danida funded CaBEERE resource assessments. Little is thus known of the true potential. According to estimates quoted by the German Advisory Council on Global Change (WBGU, 2003, p. 72), economic reserves of geothermal energy in 10 to 20 years time could be equivalent to current global primary energy use.

[10] A recent presentation by J Joubert based on detailed wave modelling research indicates an average power of 35 to 41 kW/m for the South West coastal region.
[11] For comparative purposes, solar radiation has a power density of about 1 kW/m^2

3.8. New and emerging technologies

- Hybrid technologies combine conventional fossil generation with renewable energy. Conventional power stations in Australia use supply air heated by solar means, increasing electricity output per unit of fuel consumed.
- Fuel cell vehicles could run entirely on Hydrogen produced by renewables, however the current production of hydrogen is energy intensive.
- Electricity from renewables can replace liquid fuels for transport, most efficiently through increased use of rail, particularly for freight – this is not achievable in the short term, but should inform the level of ambition for growing local industries.
- International studies show that oil and uranium importing countries like Japan can cost-effectively run on entirely RE with state-of-the-art integration technology See footnote references in Section 5.3.

3.9. Conclusion: Availability of RE resources not a constraint

Wind, solar, biomass, ocean and hydro resources could all make substantial contributions to the energy mix in the near term and as shown in the scenarios developed by B&S 2006 (which took into account the resource limitations listed above), it is quite possible to imagine renewable energy contributing more than 50% to the electricity mix by 2050.

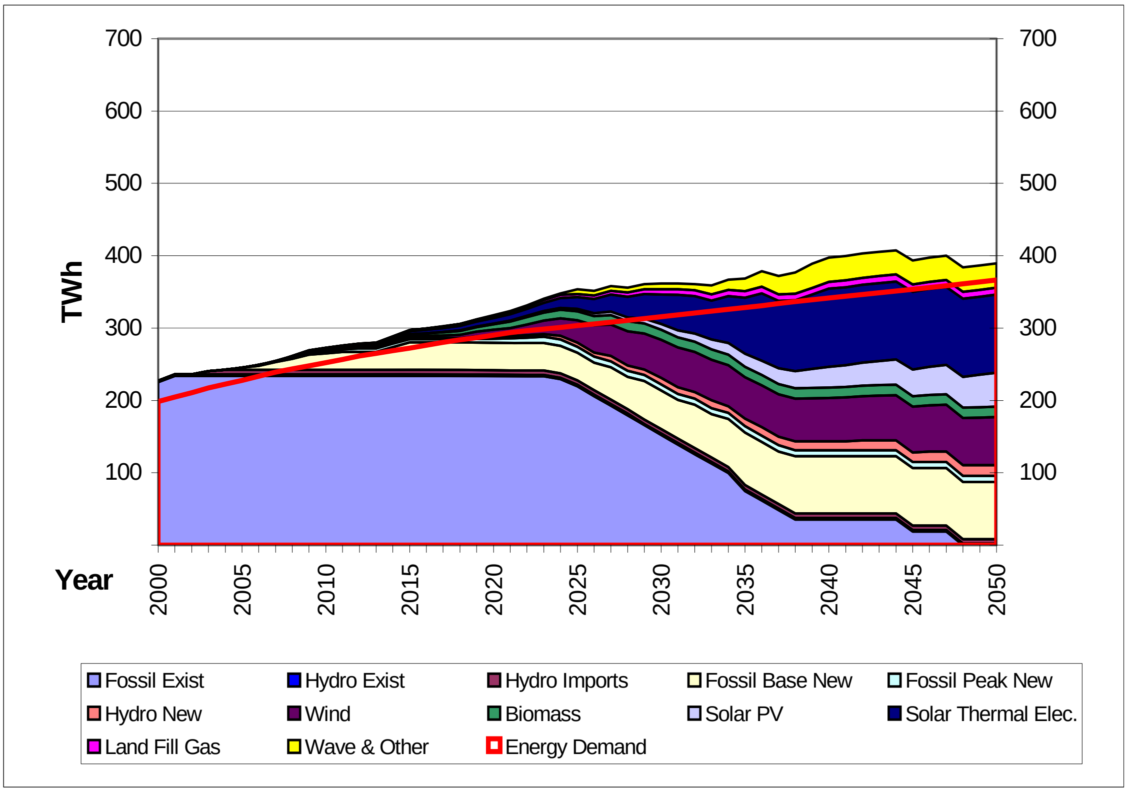

Figure 1 Progressive renewable scenario from Banks and Schäffler 2006, illustrating how a mix of renewable energy resources could contribute more than 50% to the electricity supply mix by 2050.

4. Costs

Table 3 Status of Renewable Technologies (from Ren 21, 2007)

Table 1. Status of Renewables Technologies—Characteristics and Cost

Technology	Typical Characteristics	Typical Energy Costs (U.S. cents/kilowatt-hour)
Power Generation		
Large hydro	*Plant size:* 10 megawatts (MW)–18,000 MW	3–4
Small hydro	*Plant size:* 1–10 MW	4–7
On-shore wind	*Turbine size:* 1–3 MW *Blade diameter:* 60–100 meters	5–8
Off-shore wind	*Turbine size:* 1.5–5 MW *Blade diameter:* 70–125 meters	8–12
Biomass power	*Plant size:* 1–20 MW	5–12
Geothermal power	*Plant size:* 1–100 MW *Type:* binary, single- and double-flash, natural steam	4–7
Solar PV (module)	*Cell type and efficiency:* single-crystal 17%; polycrystalline 15%; amorphous silicon 10%; thin film 9-12%	—
Rooftop solar PV	*Peak capacity:* 2–5 kilowatts-peak	20–80*
Concentrating solar thermal power (CSP)	*Plant size:* 50–500 MW (trough), 10-20 MW (tower); *Types:* trough, tower, dish	12–18†
Hot Water/Heating		
Biomass heat	*Plant size:* 1–20 MW	1–6
Solar hot water/heating	*Size:* 2–5 m^2 (household); 20–200 m^2 (medium/multi-family); 0.5–2 MWth (large/district heating); *Types:* evacuated tube, flat-plate	2–20 (household) 1–15 (medium) 1–8 (large)
Geothermal heating/cooling	*Plant capacity:* 1–10 MW; *Types:* heat pumps, direct use, chillers	0.5–2
Biofuels		
Ethanol	*Feedstocks:* sugar cane, sugar beets, corn, cassava, sorghum, wheat (and cellulose in the future)	25–30 cents/liter (sugar) 40–50 cents/liter (corn) (gasoline equivalent)
Biodiesel	*Feedstocks:* soy, rapeseed, mustard seed, palm, jatropha, or waste vegetable oils	40–80 cents/liter (diesel equivalent)
Rural (off-grid) Energy		
Mini-hydro	*Plant capacity:* 100–1,000 kilowatts (kW)	5–10
Micro-hydro	*Plant capacity:* 1–100 kW	7–20
Pico-hydro	*Plant capacity:* 0.1–1 kW	20–40
Biogas digester	*Digester size:* 6–8 cubic meters	n/a
Biomass gasifier	*Size:* 20–5,000 kW	8–12
Small wind turbine	*Turbine size:* 3–100 kW	15–25
Household wind turbine	*Turbine size:* 0.1–3 kW	15–35
Village-scale mini-grid	*System size:* 10–1,000 kW	25–100
Solar home system	*System size:* 20–100 watts	40–60

Note: Costs are economic costs, exclusive of subsidies or policy incentives. Typical energy costs are under best conditions, including system design, siting, and resource availability. Optimal conditions can yield lower costs, and less favorable conditions can yield substantially higher costs. Costs of off-grid hybrid power systems employing renewables depend strongly on system size, location, and associated items like diesel backup and battery storage. (*) Typical costs of 20–40 cents/kWh for low-latitudes with solar insolation of 2,500 kWh/m^2/year, 30–50 cents/kWh for 1,500 kWh/m^2/year (typical of Southern Europe), and 50–80 cents for 1,000 kWh/m^2/year (higher latitudes). (†) Costs for trough plants; costs decrease as plant size increases. *Source:* See Endnote 18.

This section focuses primarily on costs of electricity generation, as this is the area of most immediate concern in South Africa and of greatest market opportunities for renewable energy. The primary application that can displace electricity demand – solar water heating – is currently subject to a high degree of price volatility; the price is strongly demand driven and securing least cost prices will largely be determined by bulk contracting and/or by regulations associated with incentive schemes (including resulting impetus for dramatically expanding local manufacture). Other applications for renewable resources are significant, particularly in terms of extending access to energy services – "energisation" - in areas remote from the grid, but costs are more dependent on particular local circumstances.

Table 4 below provides an overview of international typical energy costs for renewable energy. South African cost estimates have been summarized in Banks and Schäffler (2007):

Table 4 Summary of South African costs

Name	Short Description	Capital cost /kW (R2005)	Fixed OM, (R/kWh)	Variable OM, (R/kWh)	Plant life (years)	Cap. Factor (%)	CoE (R2005)	CoE (R2015)	CoE (R2030)
Biomass cogeneration	Electricity production from forest waste or similar	23 000	154	22.9	30	68	0.39	0.37	0.32
Hydro	Small hydro opportunities	10 938	202	0	25	30	0.47	0.47	0.47
Municipal Waste	Landfill and waste gasification	4 287	156	135.6	25	89	0.21	0.20	0.20
Pumped storage		4 822	49	9	40	20	0.27	0.27	0.27
Solar PV off-grid	Stand alone or isolated grid PV	60 000	2000	0	15	23	4.47	3.68	2.64
Solar PV grid-connected	Small or large scale PV power generation	40 000	69	0	30	23	1.80	1.40	0.87
Solar thermal electric - no storage		21 900	178	0.1	30	34	0.71	0.59	0.42
Solar thermal electric - storage		32 850	178	0.1	30	54	0.65	0.54	0.38
Ocean Energy	Wave, possibly ocean current	25 000	251	0	20	45	0.71	0.59	0.41
Wind High CF	High capacity factor	10 000	167	0	20	30	0.45	0.39	0.32
Wind Medium CF	Medium capacity factor	10 000	167	0	20	25	0.54	0.47	0.39
Imported Renewable Energy		10 000	167	0	20	30	0.45	0.39	0.32
New nuclear conventional		25 920	507	25	40	86	0.38	0.38	0.38
New fossil mid merit/peak	A catch all for non-base general plant	3 949	110	247	25	10	0.79	0.86	0.98
New fossil base	A catch all for national fossil generation plant	17 500	227	47.3	35	86	0.28	0.30	0.34
Existing mid-merit/peak	Represents national mix	0	0	550	25	10	0.55	0.61	0.74
Existing Base	Represents national mix	0	0	120	35	86	0.12	0.13	0.16

The price of energy delivered by different technologies and resources changes over time. Factors, which influence this downwards, include:

- Technical developments – gradual improvements in technology that allow for gradual cost reductions.
- Significant technical innovations - from time to time there are significant technical innovations resulting in large cost reductions (the recent South African breakthrough in new thin film PV technology being a potential case in point).
- Global economies of scale - as the industry and installed capacity grows a range of design, manufacturing, financial and distribution efficiency improvements bring down costs.
- Local economies of scale – particularly relevant if the technology or large portions thereof can be manufactured in South Africa.
- Government subsidies, R&D funding and insurance backing equal to those given to conventional energies will reduce the price of renewables significantly.

On the other hand, some aspects of energy technology costs are likely to increase. Steel and some other relevant commodities have recently shown dramatic cost increases in real terms, impacting on almost all generation options. PV modules increased in price from 2004 to early 2007, primarily because the growth in demand was so rapid that it outstripped certain key production facility capacity (solar grade silicon). PV costs are now dropping again. Off-grid energy service delivery has also been negatively affected by recent climbs in the cost of lead for batteries.

Consistent trends in electricity generation costs over the last 15 years are increasing costs of stock energy options and decreasing costs of renewable options. Efficiency gains in stock energy technologies are offset by increased plant costs to achieve these gains (e.g. to withstand higher temperature and pressure) and to comply with increasing environmental and safety constraints. The cost and construction time estimated of the latest Finnish nuclear plant seem to be running out of control. Renewable options, having benefited from well below 10% of energy investment to date even in the past decade, will continue to benefit from technology learning and growing economies of scale at least into the medium term, notwithstanding some short-term disruption in this trend due to very strong global demand. This is borne out by the LTMS and mainstream international literature.

Some costs change after plant construction, particularly fuel costs. Even with long-term supply contracts, penalties for non-delivery of energy resources may become preferable to meeting existing contractual obligations. In the case of dedicated fuel supply, a source may not yield as anticipated, as in the case of the coalmine at Majuba, imposing unanticipated costs (including massive road damage and increased accidental deaths from coal transport in Mpumalanga). Given that renewable technologies have very low or no fuel costs, with the exception of biomass from dedicated crops, the running costs of a renewable energy plant are largely fixed at the time of construction. Renewable energy thus provides a very significant risk mitigation option for electricity generation. This predictability has monetary value.

At present, there are some areas where renewables are *financially* cheaper or very close to the cost of fossil counterparts (e.g. SHW, Solar passive building design in most parts of the country). When environmental, job creation and other factors are taken into account, full cost economic accounting would show that renewable energy options are economic (least cost) in a wider range of scenarios. However, even from a purely financial perspective, if one makes conservative assumptions about fossil fuel price *increases* and renewable energy technology price *reductions*, aggressive renewable energy scenarios for electricity generation result in lower costs in the medium to long term. The following is an example from a set of scenarios produced for the Western Cape:

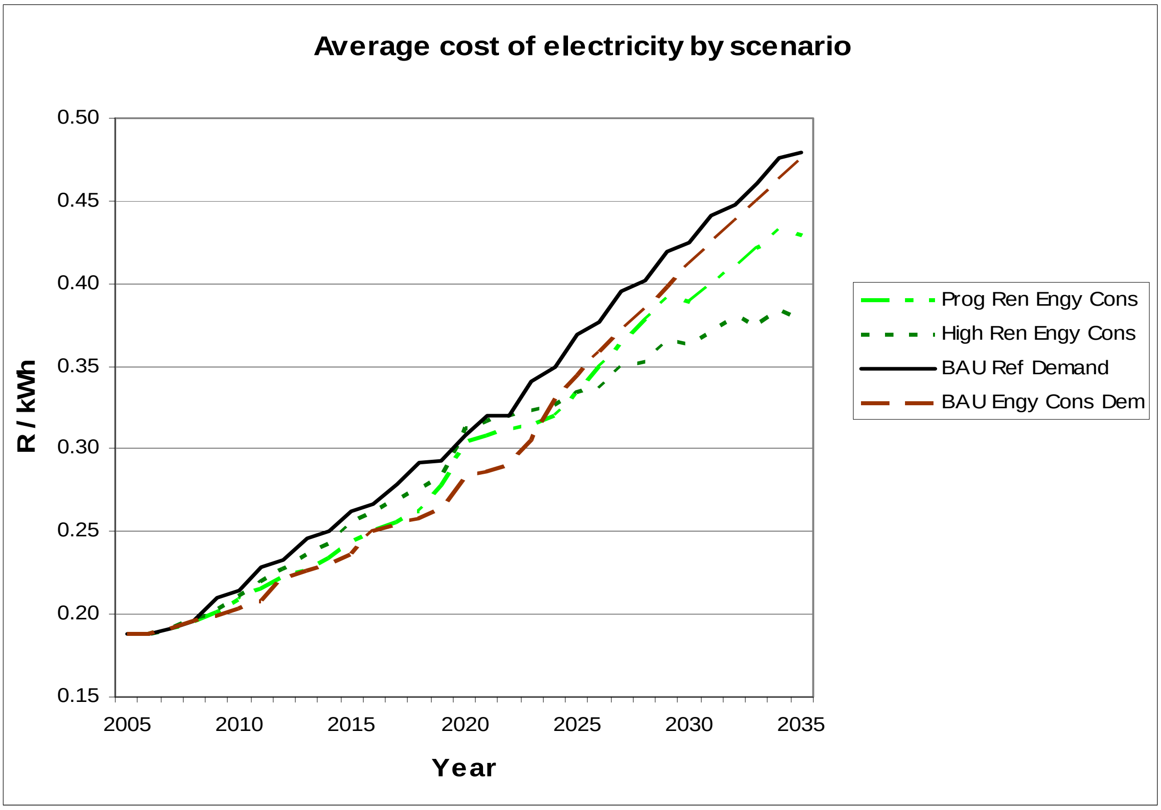

Figure 2 Cost of energy supplied for different electricity supply scenarios (adapted from DEA&DP, 2007).

Figure 2 above depicts the average cost of energy supplied to the Western Cape grid for different electricity supply scenarios (adapted from D: EA&DP, 2007). In three cases energy efficiency (Energy Cons curves) also helps to keep costs down – including keeping BAU (business as usual scenario) below the RE average until about 2024. Thereafter, the scenarios with significant renewable energy components have lower average costs to generate electricity than the BAU (fossil fuelled) scenarios, with lowest costs for the higher RE contribution, without accounting for full economic / any currently externalised costs.

The full sets of assumptions are provided in the referenced publication. Scenarios with a significant renewable component have marginally higher initial costs as, in the early years, some expensive plant needs to be installed to gain the experience and benefit from learning/technology/capacity development, to achieve lower costs in the long term.

Banks & Schäffler (2006) shows similar trends when looking at the country as a whole. The kinds of assumptions these studies make are analysed in more detail in the LTMS Technical Report as "…learning ratios, measuring the reduction of cost per unit of installed capacity for each doubling of cumulative capacity.[12]" The learning rate chosen for South African modelling indicates the anticipated decline in cost for each doubling of global capacity:

Table 5 Learning rates for electricity generating technologies (Winkler, H (Ed) 2007)

Energy technology	*Range of learning rates in the literature *(%)*	*Maximum level this technology can reach globally (GW)*	*Learning rate, this study*
Wind	5 - 40%	2,000	19%
Solar photovoltaic	17 – 68%	500	25%
			35%
Solar thermal, parabolic trough	5 – 32%	500	15%
Solar thermal, power tower	5 – 20%	500	20%
Geothermal			
Small hydro	5%		5%
Tidal	5%		5%
Supercritical coal	3 – 7%	3,072	4%
Integrated gasification combined cycle			
Fluidised bed combustion			
Natural gas combined cycle	4 – 7%	3,773	5%
Advanced water reactors, nuclear			
* The full range (from the minimum to maximum value we found in the literature) is reported in the second column. See Appendix 1 of the SBT3 document for all the values.			

Learning is expected to stop when a certain global maximum level is achieved. Doubling times are impossible to predict, but will be shorter while growing from a small base and would likely increase as the capacity to be doubled becomes greater each time. Studies considered by the LTMS[13] indicated a doubling time for wind and solar photovoltaic of 3 years, with 14 for concentrating solar thermal. Doubling time for the latter will certainly become shorter given the massive global interest in this technology (as a less mature technology, there is far greater learning potential than for e.g. wind). A key question will be the extent to which South Africa participates directly in such rapid learning. Early adopters not only take the major market share but also register the patents.

Another significant variable having a profound impact on the relative costs of competing options is the cost of capital, or chosen discount rate. Higher discount rates, typical and generally considered appropriate for developing countries, favour options with lower up-front or capital costs, reducing the benefits of avoided fuel costs, which materialize later when a higher return on capital is required. One way to give recognition to the avoided national resource depletion of utilizing renewable energy would be to apply a minimal discount rate to public spending to this end (whereby the unit cost of electricity from an RE plant would become competitive with conventional plant a lot earlier in the plant lifetime). Accelerated depreciation would have a similar, though less pronounced, effect for private investments.

A further consideration is the premium that can be derived from options with negligible greenhouse gas emissions and the cost of future climate change mitigation measures. The Clean Development Mechanism provides a supplementary revenue stream for renewable energy utilisation that, while currently insufficient to

[12] Emperical data on learning for energy technologies has been gathered (IEA & OECD 2000; World Bank 1999; Laitner 2002; NREL 1999; Papineau 2006; Nemet 2006; Junginger *et al.* 2004)
[13] Sources: (UNDP et al. 2000; Laitner 2002; NREL 1999)

make projects bankable, is likely to increase in value as the multilateral response gains momentum. With a price for Certified Emissions Reduction of US$10 per ton CO_2[14], about $0.01 would be earned for avoiding the approximately 1kg[15] that is emitted to generate 1 kWh from coal, though there are significant transaction costs that need to be covered from the revenue. The costs of removing a ton of emissions from a coal-fired plant are far higher and the potential to store (or sequester) CO_2 in South Africa is still unknown. Carbon Capture and Storage (CCS) technologies exist, but require geological formations that can absorb the CO_2 within reasonable proximity to the source. CCS also reduces the overall efficiency of the system due to energy requirements. It still has to be established whether the compressed CO_2 reacts with underground reagents, forming methane, a GHG 20 times as potent as CO_2 it originally was supposed to address.
Under favourable conditions (including assuming the existence of appropriate geological formations), costs have been conservatively estimated by the DME to be in the region $50 – 100 per ton, thus adding up to $0.10 /kWh to the cost of future of coal-fired electricity, quite conceivably within ten to twelve years[16].

In off-grid applications, a direct cent per kWh comparison is not the most useful approach, as one needs to look at the full costs of delivering specific energy services (lighting, refrigeration, cooking, communications power) to communities in specific locations. The avoided costs of extending a grid system, for example by delivering a combination of solar PV for lights, TV and cell phone charging plus LPG and biomass for cooking, justify far higher unit costs. Where households, schools or health centres are remote from the grid, or are widely scattered, PV technology is already the most cost effective way to deliver the necessary electricity component for meeting energy service needs (See Banks 2007 for a recent review of rural electrification using different technologies in South Africa).

Avoided distribution costs, “non-technical losses” and line losses are relevant to many grid-connected decentralized generation options to which renewables are well suited. When PV is applied in a distributed fashion through multiple smaller grid-connect installations, it achieves significant distributed generation benefits and is expected to be financially competitive with point of consumption grid costs during the next 5 to 10 years.

The most recent and comprehensive assessment of the costs of electricity generation options for South Africa was undertaken as part of the Long Term Mitigation Scenarios (LTMS) process[17] which involved peer review by the multi-stakeholder Scenarios Building Team.

[14] Prices are set by the market and vary by project; $10/ton is above the current average, but has been achieved.

[15] Recent Eskom Annual Reports indicate an average slightly less than 1kg/kWh, but CDM methodologies have advocated for a baseline of somewhat over 1 kg/kWh

[16] In this regard, electricity generation will be competing with for space with coal-to-liquids fuel plants, which produce a highly concentrated CO_2 emissions stream offering lower overall CCS costs.

[17] While the LTMS documentation has not been published as of March 2008, permission was granted by DEAT to use material from the final Technical Report, as reproduced here.

5. Key issues related to Renewable Energy Technology implementation

5.1. Characteristics of Renewable Energy Technologies (RETs)

The following are general characteristics. Renewable energies, other than geothermal and tidal, are derived from the sun, either directly (solar heating/cooling, drying, daylighting etc) or indirectly (wind, hydro, ocean current, biomass, biofuels etc). They are replenished by nature, and not finite like the stock fossils or uranium-based energies.

- **RETs use sustainable energies,** and are thus a precondition for Sustainable Development, with great potential to facilitate development in rural areas with infrastructure constraints.
- **RETs can be implemented rapidly:** Passive Solar Buildings require no additional erection time. A domestic SWH is installed within hours, a residential building-integrated Photovoltaic (PV) system within half a day, a biogas system within a week. A wind farm with 5MW turbine requires 2 years; 350-400MW Green Tower 3 to 4 years each. Generally, the lead times are shorter than for conventional power stations.
- **RETs come in modular units,** which means one does not have to tie up massive public investments in fruitless overcapacity as South Africa did with the mothballed coal fired plants. Modules can be added closely leading the demand curve. It also means that RETs can be implemented simultaneously by many entrepreneurs in many localities. Many hands make light work.
- **RETs support distributed generation** (DG), whereby electricity is fed into the grid in many places instead of a centralised system with high transmission losses (average 10% in SA) and additional distribution losses. Generation at point of use can also yield savings in energy distribution infrastructure.
- **Small RETs can be placed on the roofs of existing and new buildings,** avoiding the long-winded and costly EIA process, while the risk of vandalism is reduced.
- **The footprint area of RETs is less** than for conventional power stations, with their concomitant storage/dumping sites. Wind turbines require a minimum footprint and are being used on commercial farms, where they contribute to rural development.
- **RETs are suited for co-generation that** is using both the electricity generated as well as the waste heat. This increases efficiency from 34% to more than 80%.
- **Many RETS (wind, PV) are intermittent,** while others (hydro, sea) are continuous (see 4.3).
- **RE resources are geographically dispersed,** which reduces the demands on the network. Some areas are more suitable for wind power, others for (micro) hydro or solar/solar thermal. There is no single winner-takes-all RET, in spite of what contenders may say.
- **RETs have a much lower environmental impact** than fossils. Studies show that motorcars, domestic cats and power lines kill many times more birds than wind turbines. Their noise and visual pollution is less than traffic and pylons respectively. The carbon footprint is dramatically less.
- **RETs offer more work opportunities** (see 5.4.).

5.2. CO_2 reductions

Climate change is acknowledged as the leading threat to sustainable development and objectives such as the Millennium Development Goals. As the richest and by far the most polluting country in one of the world’s most vulnerable regions, South Africa faces the prospect of particularly severe impacts from accelerating climate change. These range from direct domestic impacts on poor communities and subsistence lifestyles, vulnerable infrastructure, biodiversity and tourism and the effects of diminishing water availability (expanding fossil fuel industries are already starting to compete with agriculture), to displaced regional impacts, primarily in the form of large-scale migrations, with South Africa the logical destination for climate refugees.

South Africa has committed internationally to mitigation actions that are measurable, reportable and verifiable. The Stern Review of the Economics of Climate Change has clearly established the economic case for ambitious and urgent mitigation efforts, not just globally, but for all major emitters/polluters. South Africa is justified in seeking financial and other assistance from richer, highly industrialised countries to support our mitigation efforts. However, neglecting ready opportunities to reduce our emissions growth for want of improved support is contrary to the national interest in purely economic terms.

There are numerous estimations of the ‘cost of carbon’, yielding a wide range of values, from current prices for tradable ‘carbon credits’ at the low end, to approaches that seek to account for future costs of adaptation, which are generally at least an order of magnitude higher. Clearly current prices offered for certified emissions reduction credits under the Clean Development Mechanism (CDM), based on lowest-cost opportunities, fall far short of the true value of mitigation. Linking South Africa's ambitions for renewable energy to potential CDM revenue (as encouraged by World Bank consultants for the formulation of the Renewable Energy White Paper target) has to date served as a deterrent to realising the national potential for renewable energy. The results demonstrated that this strategy does not work.

The Technical Report of the Long Term Mitigation Scenarios (LTMS) process mandated by Cabinet has yet to be published, but was approved in November 2007 by the multi-stakeholder Scenarios Building Team. The technical work confirms the trend of decreasing costs of renewable energy technologies, particularly with significant deployment, while the economy-wide analysis confirms a net increase in employment as a result of increasing the share of renewable energy in the national energy mix. The LTMS macro-economic research thus contradicts the contention, still peddled by some high profile 'independent analysts', that large-scale deployment of renewable energy technologies would result in a lower net national rate of job creation due to their higher up-front costs. Provided that South Africa's new commitment to scaling up renewables starts to approach the level of ambition required to mitigate climate change[18], a high level of local content will be driven by cost optimisation, while economies of scale will reduce up-front costs.

As we improve our understanding of the synergies between climate change response, job creation, poverty reduction and economic competitiveness over the medium and long terms, so the *opportunity costs* of failing to exploit our abundant renewable resources become a lot more relevant than anticipated market prices for carbon credits, which are but one factor determining such costs.
As Stern and others have demonstrated in detail, deferring climate change response increases costs and negative impacts on GDP growth. At the risk of oversimplification, the key finding of the Stern Review indicates that investing 1 % of GDP in mitigation is likely to avoid a 5%, and possibly as much as 20% (in Sub-Saharan Africa) , downturn in GDP.

The agreement at the recent UNFCCC negotiations in Bali, including the USA, to negotiate a post-2012 climate change regime by the end of 2009, not only improves the prospects for a burgeoning carbon market, but increases the risk for carbon intensive economies and product. South Africa is amongst the most carbon-intensive economies in the world, by some analyses more vulnerable than the USA. Short of an economic collapse, energy efficiency, while the most obvious imperative, will not bring us close to the mitigation levels required, even under the most favourable scenarios. Renewable energy is the next most cost-effective mitigation option, while also reducing risks attached to stock energy price volatility and escalation. Furthermore, growing international political will to achieve the objective of the UNFCCC is essential for Southern Africa's development and can be significantly enhanced by a truly ambitious South African target for utilising renewable resources.

5.3. Load matching capability

A **primary objection** to the widespread use of renewables is claimed to be their **intermittency.** In reality, grid demand is not constant. Many renewable energy technologies (hydro, wave, current, bioenergy) are relatively constant, others have a predictable after-diversity supply[19] through geographic and technological mixes (hybrid systems, Green Tower, wind), some are coincident with demand (solar cooling, solar water pumping, some wind), and some have their own integral energy storage systems (solar water heating, solar passive building design, biogas). The remainder can be covered by energy storage systems (grid-feeding, pumped storage, compression, molten salts, hydrogen, and kinetic energy). **Intermittency (despatchability) is not a disqualifying issue with renewables in South Africa.**

Energy storage is an important element of energy supply planning, both for the electricity sector and for other energy options. The current electrical mix has required the building of storage capacity of approximately 1 500 MW or about 4% of maximum electrical system demand. The bulk of this has been through pumped storage of water in the world-class Drakensberg, Palmiet and Steenbras storage facilities. There is potential for 7 000 to 10 300 MW of new capacity. A key limiting factor for pumped storage technology is its environmental impact. Meanwhile, other technologies are being developed, including redox batteries, flywheels, super capacitors, super conductors, and compressed air options. Studies on the integration of renewable energy at high penetration levels elsewhere indicate that the perceived need for extensive additional storage capacity with increased renewable energy contributions are not well supported theoretically. As early as 1998 a Japanese study confirmed that renewable resources alone could meet the full electrical demand in Japan and similar approaches are underway elsewhere[20]

[18] The level of national ambition contemplated in the LTMS is based on our status as a developing country, taking account of differentiated responsibilities and our particular national circumstances.
[19] After-diversity supply refers to the average supply of which distributed generators in a network are capable as a collective, after diversification and decentralisation of supply.
[20] http://www.energyrichjapan.info/en/animation.html ; http://www.youtube.com/watch?v=tR8gEMpzos4

As the electricity supply sector evolves, there is likely to be greater use of distributed generation, to which many of the renewable energy technologies lend themselves particularly well. This can help to reduce transmission and substation investments and to some extent mitigate the requirement for storage. The predominant themes emerging amongst visionaries on the future of the energy industry are that energy will be used more efficiently and electrical generation facilities will be smaller and decentralised. The storage and electricity demand management potential through solar charged electrical vehicles has yet to be realized. The current capacity on the road exceeds our total electric capacity.

Distributed generation reduces reliance on large-scale transmission lines. If properly applied, it can reduce substation loading and transmission line upgrades. Smaller scale generation options also typically require shorter lead times for construction and development programmes can be adapted more easily to changes in demand. Large-scale centralised plant construction programmes carry significant economic risk, as a slower than anticipated growth in electricity demand can result in stranded assets. Several of the large-scale contributions included in renewable energy dominant scenarios would be made up of several hundred or thousand smaller distributed generators.
Through the Feed-in Tariff Germany has already over-achieved on her RE targets.

5.4. Job creation potential/social case for RE

Projections of job creation potential use technology uptake (or decline) rates coupled with labour intensity figures, usually based on project experience. While there are large variances in labour intensity, which tend to be higher in developing countries, renewable energy consistently exhibits superior long-term job creation potential (a characteristic that has elsewhere been portrayed as a negative attribute). It has been argued that the higher capital costs of renewable energy technologies divert money from other investments that could create more jobs, elsewhere in the economy. This is refuted by the economy-wide impacts analysis undertaken within the LTMS process, which confirms net employment gains from a higher share of renewables in electricity supply (mostly benefiting low and semi-skilled jobs).

A study undertaken by AGAMA Energy in 2003 found that if South Africa generates just 15% of total electricity use in 2020 using renewable energy, it will create 36 400 new direct jobs, without taking any jobs away from coal-based electricity. Direct job creation in solar water heating and biofuels have a far higher potential, each exceeding 100 000, given ambitious targets for 2020, with sustainable biomass production being particularly labour-intensive. The study calculated average labour intensity, using data from developing as well as OECD countries and applying these to South African conditions. For electricity generation, jobs are given per unit of installed capacity and unit of output:

Table 6 Jobs directly created from generating electricity

Conventional Energy Technology	Total	
	/MW	/GWh
Coal (current)	1.7	0.3
Coal (future)	3.0	0.7
Nuclear	0.5	0.1
Pebble Bed Modular Reactors	1.3	0.2
Gas	1.2	0.1

Renewable Energy Technology	Total	
	/MW	/GWh
Solar thermal	5.9	10.4
Solar Panels	35.4	62.0
Wind	4.8	12.6
Biomass	1.0	5.6
Landfills	6.0	23.0

Indirect job creation is consistently higher than direct job creation, but harder to differentiate between energy sources. Delivering energy services as part of rural development, where renewables have more inherent advantages, the services are of economic value well beyond that of the quantities of energy delivered, enabling a range of other productive activities. Furthermore, the predictable life cycle costs of renewable energy technologies and their utilisation of local resources reduces the vulnerability of poor communities, productive activities and livelihood strategies to volatile markets.

5.5. Status of the industry/growth rates

To gain some understanding of required growth rates, and the possibilities of achieving these, consider the following:

- The current installed based of PV modules in South Africa is of the order of 20 to 25 MWp. Estimates of the annual market are in the range of 2 - 3 MW/annum. However, for the past few years, a factory located in Cape Town has been annually producing 30 to 60 MWp of PV modules (primarily for the

export market). Plans are well underway to set up a new 20 MWp factory in Paarl, using South African developed technology.
- Our wind turbine installation base is currently a few megawatts. Global wind turbine manufacturers globally installed 20 GW (or 54.8 MW/day) in 2007. Wind park developers interviewed have indicated that the minimum size of facility to justify engagement is 100 MW.
- A recent review of renewable energy projects that were in the pre-feasibility or feasibility stage in the Western Cape identified 312.7 MW Wind, 12 MW biomass, 633 MW wave. These projects all had several of the required elements in place.
- Several of the renewable energy technologies (wind, wave, SWH) rely on fairly conventional engineering fabrication techniques (steel, civils, electro-mechanical). South Africa has good capacity in these areas (albeit that 2005 to 2007 growth rates have stressed the industries). Provided that intellectual property issues can be dealt with, it should be possible for existing skills and facilities to be rapidly re-deployed into renewable energy technology production.

5.6. Constraints

Mind-set. In South Africa, the dominant paradigm is inclined towards:
- a supply-side approach, rather than an Integrated Resource Planning paradigm that interrogates energy service needs and how they can most appropriately be met;
- preference for large centralised installations and systems (which the apartheid government considered to be easy to protect), rather than distributed generation, diversity of supply and using the network as an energy bank;
- reliance upon a state-controlled monopoly with no demonstrable interest in democratisating energy supply, including multi-stakeholder private initiatives and community participation;
- partial energy costing, with social and environmental costs externalised, opportunity costs ignored and low initial capital costs prioritised over low life cycle costs;
- an unsubstantiated assumption that low energy prices are *the* key to international competitiveness;
- a subservience of energy to minerals interests (arguably another legacy of apartheid, which required rapid - cheap-and-dirty - extraction of mineral wealth to finance the state machinery and produce uranium for the USA during the Cold War, with no regard for the impacts on the working class or future generations).

Shortage of qualified person power:
- There is a shortage of experienced energy engineers in the country and the public utility.
- Through the institutionalisation of short-term energy planning horizons there was little scope for building capacity and retaining long-term energy planning expertise.
- The culture of preventative maintenance has not been overstressed in the past, creating an impression of a policy of “sweating the assets”, which does reflect on the human resources.

Lack of energy awareness and information
- A sense of entitlement has been encouraged without accompanying understanding of energy services and the various options and full associated costs of providing them, e.g. the slogan of “Electricity for all” was developed by Eskom in 1988 in a period when electricity sales had slowed down dramatically (Conradie & Messerschmidt, 2000: 269)..
- South Africa has yet to undertake an inclusive analysis – embracing social, as well as economic and environmental factors – of the costs and benefits of our energy development options. The Integrated Energy Planning process and Externalities Study (very nearly commissioned in 2005 and again in 2006) remain “in abeyance”[21] since late in 2006.
- Physical planning of urban settlements and energy planning are disconnected. Architects and town planners are generally unaware of energy issues and renewable energy options. Uninformed town and regional planning impacts on transport energy and on building sites where solar design is impaired. Energy efficient buildings are cheaper and faster to construct than new power stations, and they last three times longer.

Lack of leadership, vision and public spending
- The renewable energy targets are opportunistic, undifferentiated and too small to inspire investor confidence. (Parliamentarians were persuaded to accept the Renewable Energy White Paper (2003) target, as it was presented as equivalent to 4% of electricity supply or the output of two 660MW coal-fired generation units, while officials intended that such a contribution would be delivered over 10 years and thus unlikely to contribute even 0.2% of primary energy in 2013.)

[21] Correspondence from Minister Bulelwa Sonjica / the Ministry of minerals and Energy

- Marginalisation of renewable energy in South Africa is epitomised by the CEO of the state utility in 2007 presenting a long-term electricity supply and investment plan that proposed no more than 1% of supply from renewables by 2025. This was apparently accepted by government as showing a significant commitment to growing the renewable energy industry.
- Despite various Cabinet and Presidential statements over the last two years that we need to do more to promote and develop renewable energy, the DME's Masterplan for electricity supply, published in January 2008 suggests that current initiatives on RE are adequate.
- Public authorities do not yet buy or demonstrate by renewable energy options (e.g. SWH).
- Stats SA does not carry renewable energy statistics, or provide any information of renewable energy progress.
- The policy commitment to "an equitable share of resources" to renewable energy has been ignored. (National revenue committed to nuclear R&D would suffice to buy and install two solar water heaters on every South African dwelling. The missed opportunities imply that South Africa will have to import know-how and pay for patents for the energies of the future.)

Insufficient renewable energy training and accreditation

Any new growth industry requires a dedicated training effort at all levels. As it is human nature to remain in one's comfort zone, incentives or regulations (e.g. for licensed plumbers) will be needed to stimulate relevant professionals to acquire relevant skills.

Vested interests

A wide range of individuals and commercial concerns derive a range of financial benefits from the externalisation of many of the economic costs of current energy supply and/or from the special status accorded to minerals, and are thus resistant to significant change.

6. Stakeholders

The actions of certain key institutions effectively constitute a barrier to renewable energy. Eskom's disdain is expressed in on-going assertions such as "renewable energy cannot provide baseload supply" and "you can't run a freight train on renewables" - both patently untrue – projecting the characteristics of an individual wind farm upon all renewable energy technologies. The proposal to increase the share of renewable input to its generation mix to at best 1% by 2025 also reflects antipathy on the part of the Department of Public Enterprises. The lack of commitment within the DME is evident in the limited human resources in the renewable energy sub-directorate (while India has a distinct and dedicated government department for renewable energy) and failure of the Renewable Energy Finance and Subsidy Office to disburse the merge funds it was allocated or to revise the onerous criteria to qualify for a subsidy.

The key constraint facing renewable energy and sustainable development stakeholders is the lack of space for their effective participation in decision making, which should contribute to the development of the renewable energy industry to the benefit of the country. The limited initiatives amongst government departments and agencies supporting renewable energy development lack the necessary coordination and efficient communication to achieve stakeholder participation and buy-in. Where stakeholder consultation does take place, it is often ineffective because it occurs towards the end of the policy or regulatory framework formulation processes, affording little opportunity to effect the outcomes. A typical example is the current project by the National Energy Regulator of South Africa (NERSA) to develop a regulatory framework for a Feed-in Tariffs system. While a draft of the framework has been completed, no wider stakeholder involvement has been allowed to date, e.g. in shaping the coverage of the tariffs being developed.

Another challenge is lack of information sharing on key developments in the renewable energy industry. Information on project requirements and support for renewable energy investment is scattered in small units in various government departments and agencies, which are not visible enough to attract serious investors. The relevant mandates of government departments and agencies are ineffective because they are usually loosely defined. A clear example is the 2004 Electricity Regulation Act that failed to provide an effective mandate for NERSA to confidently regulate renewable energy with appropriate support mechanisms. Sometimes the roles of agencies are conflicting or duplicating. For example, while the National Treasury is working on the allocation of funds to DME for promoting renewable energy, units within DTI use our cheap electricity tariffs to energy-intensive investments and penalise the imports of sustainable energy products with heavy taxation.

The end result is fragmentation of support for renewable energy development. Such failure manifests in the collapse of investor confidence, exclusion of private sector entrepreneurship, disinterest of financial institutions in renewable energy project finance, frustration of renewable energy project developers, lack of broader local government involvement (with some progressive exceptions), and continuing domination of the state-owned utility. A well-resourced government institution is needed to coordinate all government support for renewable energy, collate, and disseminate information from a central source. This has been done effectively in Germany through the German Energy Agency (DENA), which is the competence centre for both energy efficiency and renewable energies. The scope of the National Energy Efficiency Agency (NEEA) could be broadened to address these issues without creating a new institution. However, this would mean nothing if the current resource deprivation of NEEA is not urgently addressed.

The mandate of some government entities are not kept in the appropriate balance, to the detriment of renewable energy. For example, the mandate of the Department of Public Enterprises (DPE) is to ensure alignment of the Eskom business strategies with Sector department policies and regulatory authorities, whilst ensuring that Eskom is a sustainable business that provides economic benefit to the country. In fostering this objective, Eskom has managed to undertake substantial renewable energy research, feasibility and demonstration projects financed by electricity customers (through tariff approvals by NERSA) without similar opportunities being offered to other project developers. The information gathered from such experience is guarded as Eskom's private property. Unlike the conventional coal-powered generation, the renewable energy industry is an emerging market with Eskom having no special competency or distinguished track record to justify such favouritism. DPE and Eskom officials have recently been motivating a significant portion (at least half) of the renewable energy target to be allocated to Eskom e.g. at recent Forum for Energy Executives. This would mean that electricity customers would again finance the projects, however uncompetitive they are. This approach is extending the entrenchment of the monopoly of the state-owned utility to the new market of renewable energy and excluding other project developers and investors. Such an approach deprives the country of a wider scope of innovation and job creation opportunities. Appropriate project finance and renewable energy resource information should be accessible to all role players.

The National Treasury is the department that has shown the most resolve for levelling the playing field for renewable energy, with the introduction of a tax on non-renewable electricity generation. Perhaps NERSA, mandated to function as an independent authority, should be made accountable to Treasury, rather than the DME. The Department of the Presidency has shown an active interest in the potential of renewables. This could be extended to an oversight role over the NEEA, including ensuring that funds from electricity tariffs that finance the Demand Side Management Programme are not held or controlled by Eskom. The practice of Eskom staff being seconded to authorities to whom they are accountable is far from ideal. Finally, implementation of a Feed-in Tariff must not be held hostage to rollout of Regional Energy Distributors or providing a role for EDI Holdings.

7. Conclusion

Internationally, renewable energy industries are great growth industries comparable to the IT industries. Huge investments are being made in R&D and in implementation as the world is moving from finite energies to renewables, and governments provide the enabling environment and financial incentives Nevertheless, the Renewables2004 Conference in Bonn, in which SA participated, resolved that “Renewable energy related RD&D should be increased by one order of magnitude”.

The technologies of hydropower, sugar cane ethylene, landfill gas, passive solar building design, solar water heating, wood pellets and wind energy have been demonstrated to be cost competitive, even with the current skewed market. Concentrating solar power, tidal wave and ocean power, green tower, biodiesel and innovative renewable energy driven vehicles are in intermediate development stages. The renewable energy based hydrogen technology is still under development. Photovoltaics are cost competitive in rural areas, but the largest penetration and growth is in urban grid-connected applications.

In South Africa, the picture is different: While renewable energy resources are abundant, renewable energy technologies play a Cinderella role. The SWH industry – left to run almost entirely on its own steam - survived and is currently expanding in leaps and bounds. Critically, this expansion is largely decoupled from the recent subsidy scheme. The SWH component alone is expected to cover the entire national SA renewable energy target in 2013. Given appropriate enabling government regulatory frameworks, there is no reason why SA cannot achieve similar growth rates in all renewable energy technologies. It should be understood that the *private sector and state investments in R&D, manufacturing, training and marketing need to be quite unprecedented.* 1000 to 2000 MW of Renewables will require a major and sustained effort. However, Investors do have a choice where they can place their resources. Their perception of long-term stability is crucial. This is where internationally proven FIT is required. We should strongly resist the temptation of producing a less attractive and less transparent local version.

Intermittency applies to some renewables, but is a challenging rather than a debilitating issue. Renewable energies provide significantly more work opportunities than finite conventional energies and these jobs are sustainable. The current electricity situation mandates that the perceived and real constraints or barriers to the rapid and orderly introduction of renewable energy should be addressed as a matter of national urgency. These constraints are not unique to South Africa and have been overcome successfully elsewhere. The most important constraint is not money, men, machines, materials or management, but the motivation, the inspired political will.

ACTION PRIORITIES

A substantial body of knowledge has been accumulated by the world leaders in renewable energies. South Africa can profit from that experience. **Long-term commitment, targets and consistency** are essential to deliver predictable, reliable market conditions: There are several case studies in the developed and developing world illustrating the harmful effect of on-again-off-again renewable energy policies: Potential investors tend to shun such uncertainties (Gipe, 2008). Consistent policies foster domestic industries and job growth. The Renewable Energy Feed-in system, employed in over 40 countries in the developed and developing world, has been shown to be most successful to date, achieving the greatest market penetration of renewable energy, producing cost-effective renewable energy, establishing local industries and building domestic markets by attracting small and large private investors as well as bankers. By contrast, quota systems have been more volatile and may allow foreign industries, backed by steady policies in their home countries, to have an edge over the locals. In contrast to theory, quota systems could not achieve cheaper energy prices. Feed-in systems are characterized by simple, transparent and cost-effective procedures, well suitable to developing countries, with no cost to government

Action items

Short-term actions towards realising the public benefits of renewable energy are listed under five categories:

1. Legislation and regulation
2. Financial interventions and incentives
3. Governance
4. Stakeholder involvement and public ownership/buy-in
5. Awareness, information, education, training

No	Action	Responsibility	Begin	Anticipate impact
		Legislation & regulation		
A1	Introduce national RE feed-in tariff, as part of a suite of supporting measures, through legally mandated regulation	NERSA / DME	2008	Stimulate investment in and operation of renewable energy technologies and related capacity; investor confidence
A2	Ensure equitable access for IPPs to transmission and distribution networks, including development of standard grid connection contract and two-way metering for households;	NERSA / DME (REDS) Municipalities	2008/ 9	Open market access to all providers and stimulate investment in and operation of renewable energy technologies, including at household level
A3	Make SWH mandatory for all water heating applications other than low-income households and SMMEs; phased in starting with new build[22].	DME; DoH; SABS; SALGA	2008 for rich	Reduce electricity demand, particularly peak demand and ensure rapid growth of local production capacity
A4	Review the Renewable Energy White Paper and set ambitious new targets, including for the medium and long term; differentiated by energy carriers; including 15% electricity by 2020; binding on all licensed distributors. Targets to be effectively monitored, e.g. through renewable energy certification	DME; NERSA and all stakeholders incl. civil society	2008	Sends clear policy signal; & enables enhanced energy security; reduced risk of price volatility; stimulates development of local renewable energy technology industries; Supports international competitiveness
A5	Introduce regulation for new buildings/developments over a minimum size to generate an amount of their energy requirement by on-site RE	DME SABS (SANS204) DoH	2009	Direct & significant impact on national energy mix; development of local renewable energy technology industries; Awareness

[22] Regulatory measures should ensure that the affluent carry most of the cost for SWH so that DSM and other finance is available to subsidise SWH for low-income households

No	Action	Responsibility	Begin	Anticipate impact
A6	Ensure that necessary standards and guidelines are adopted for small and medium scale embedded generation integration (currently being written)	NERSA; EDI / SALGA		Empowers a range of citizens and business to implement renewable energy and directly contribute to electricity generation
NOTE	Strict sustainability criteria need to be developed and applied for biomass production	DEAT; SABS	2008	Avoid perverse incentives to unsustainable and input-intense land use
Financial interventions & incentives				
A7	Step up environmental tax on non-renewable energy & 'soft ring-fence' a percentage (no less than half) for renewable energy fund	Treasury	2009	Creates predictable revenue stream for fund that enables implementation of renewable energy feed-in tariff and R&D & demonstration of renewable energy
A8	Finance renewable energy R&D including feasibility studies (following the precedent of PBMR for each of CSP, PV, wind and wave) and carefully targeted financial incentives for renewable energy pre-feasibility studies	DTI; DST SANERI [CEF?; DBSA]	2009	stimulates development of local renewable energy technology industries; builds skills / local capacity and attracts foreign direct investment
A9	Reduce import tax on renewable energy sales & accelerate write-offs / depreciation of renewable energy installations	Dept Finance Treasury DTI	2009	Incentive to local industry growth & job creation. International competitiveness
A10	Apply a lower discount rate to renewable energy projects in energy planning	DME; NERSA	2008	Recognise public benefits of Renewable energy.
Governance				
A11	Facilitate 'streamlined' process for EIAs, incl. undertaking and publishing generic assessments of technology impacts, mitigation options and sensitivities within high-resource areas (e.g. major bird migration routes and special scenic value)	DME tenders; DEAT	2008	Reduced lead time for renewable energy projects
A12	Re-invigorate PPP initiative in rural concession areas & encourage PPP involvement in rural grid and mini-grid electrification; encourage integrated range of technical and delivery options for electricity (beyond SHS) and thermal service delivery	DME private sector, municipalities, NERSA, EDI	2008	Rural development, job creation, poverty alleviation; Enhanced service delivery with private investment. Achievement of Millennium Goals.
A13	Review Integrated Energy Centres initiative, include renewable energy options and provide direct support for outreach - providing information on energy service options	DME and private sector partners & cooperatives	2008	Public awareness and participation in service delivery and 'buy-in' to PPPs
A14	Resume Integrated Energy planning incl. the study of externalised costs	DME & all stakeholders	2008	Cost-reflective pricing and optimising use of public resources
A15	Resource a full directorate exclusively for renewable energy and steadily build capacity; incl. dedicated sub-directorate to facilitate large scale SWH roll-out (e.g. through a utility approach)	DME & local authorities (utility approach to SWH); REDS	2008	Facilitate other actions, as well as project development and local production capacity;
Stakeholder involvement & public ownership/buy-in				

No	Action	Responsibility	Begin	Anticipate impact
A16	Introduce fast track training programme for SWH and SHS/off-grid system installation and maintenance	SETA; Dept Labour, Dept Education, DTI	2008	Reduce implementation bottlenecks. Create localised business opportunities and reduce O&M costs
A17	Include civil society, incl. advocacy and consumer organisations, in the work of the National Emergency Response Team components on renewable energy	Cabinet; stakeholders	2008	Informed decision making, feedback, stakeholder buy-in. Local and regional development
Awareness; Information; Education; Training				
A18	Establish national mechanism for renewable energy monitoring & reporting (accounting system) – building on the TRECs initiative - and to monitor progress on meeting targets; including publishing resource maps.	SANERI; published by Stats SA; Expanded NEEA	2008	Necessary input to market creation, measuring progress, & attracting national & international Investors participation. Foster business confidence in South Africa.
A19	Ensure that National Energy Efficiency Agency staff (which should have dozens of people employed for outreach as soon as possible) are also knowledgeable on renewable energy options; (also applicable to Energy Service Companies supported through Eskom).	National Energy Efficiency Agency (NEEA)	2008	Public participation in renewable energy deployment, particularly in residential and commercial sectors; Renewable energy awareness, fast implementation. International competitiveness. Security of supply
A20	Make it mandatory to publicise proposed grid extension areas and timetables	Eskom	2009	Assists rural development; enables renewable energy; provides certainty for non-grid investment
A21	Prominently profile Solar Water Heating in national energy and efficiency awareness campaigns,	DME, NERSA	2008	Buy-in of key stakeholders.

8. List of references

AGAMA Energy. 2003. Employment Potential of Renewable Energy in South Africa published by Earthlife Africa Johannesburg.

Banks D.I. & Schäffler, J.L. 2007. A Proposed Renewable Energy Plan of Action for the Western Cape: Resource Assessment, Scenarios, proposed Objectives and Actions, Prepared for the Department of Environmental Affairs and Development Planning, Western Cape, 2007.

Banks, D.I. & Schäffler, J.L. 2006. The potential contribution of renewable energy in South Africa, 2nd Ed, Prepared for Sustainable Energy & Climate Change Project, Earthlife Africa Johannesburg, February 2006.

Barta, B. 2002. Baseline study: Hydropower in South Africa. CaBEERE Project report, Department of Minerals and Energy, Pretoria. Bouille & McDade, 2002 in Christensen 2004. Background Papers to Renewables 2004. Bonn: BMU.

Conradie, S.R. & Messerschmidt, L.J.M. 2000. A Symphony of Power - the Eskom Story. CvR Publ: Melville.

Cawood, W. & Morris, G. 2002. Baseline study: Solar energy in South Africa. CaBEERE Project report, Department of Minerals and Energy, Pretoria.

CSIR & Shell International. 2003. CSIR Energy Scenarios for Africa. Pretoria.

Department of Environmental Affairs and Development Planning. 2007. Western Cape provincial sustainable energy strategy. DEADP, Cape Town.

Department of Minerals and Energy. 2002. South Africa national energy balance, 2000. Department of Minerals and Energy, Pretoria.

Department of Minerals and Energy. 2003a. Integrated energy plan for the Republic of South Africa. Department of Minerals and Energy.

Department of Minerals and Energy. 2003b. Business opportunities in South Africa for renewable energy Independent Power Producers, Pretoria.

Department of Minerals and Energy. 2004a. Economic and financial calculations and modelling for the renewable energy strategy formulation. Prepared for DME by Conningarth Economists for CaBEERE project, Pretoria.

Department of Minerals and Energy. 2004b. White paper on renewable energy policy of the Republic of South Africa. Government Gazette, 14 May 2004.

Department of Minerals and Energy. 2004c. National Energy Balance, 2001.

Gipe, P.2008. Keynote Speech, World Wind Energy Conference, Kingston, Canada.

Holm, D. 2005. Market Survey of Solar Water Heating in South Africa. EDC of CEF: Johannesburg.

Lane, I. E. & Holm, D.2000. Hartbeespoort Local Integrated Resource Plan. UP: Pretoria.

National Electricity Regulator. 2002. Electricity supply statistics for South Africa 2000. Pretoria.

National Electricity Regulator. 2004a. National integrated resource plan, 2003/4: Reference case. Compiled by ISEP Eskom (Resources and Strategy), Energy Research Institute (University of Cape Town), National Electricity Regulator.

National Electricity Regulator. 2004b. National integrated resource plan, 2003/4: Stage two: Risk and sensitivity analysis. Compiled by ISEP Eskom (Resources and Strategy), Energy Research Institute (University of Cape Town), National Electricity Regulator.

Tripod & Oelsner, H. 2003. Wind Energy. Cape Town.

Winkler, H. (Ed) 2007 Long Term Mitigation Scenarios: Technical Report, Prepared by the Energy Research Centre for Department of Environment Affairs and Tourism, Pretoria, October 2007.

World Energy Council. 2003. South African energy profile. WEC and South African National Energy Association, Johannesburg.

World Bank, 2004. South Africa: Renewable energy market transformation (REMT) project: Economic and financial analysis due diligence. Prepared by Conningarth Economists. Pretoria.