GREEN  JOBS

An estimate of the direct employment potential of a greening South African economy

IDC
Industrial Development Corporation

DBSA
Development Bank of Southern Africa

TIPS
TRADE & INDUSTRIAL POLICY STRATEGIES

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ACRONYMS, ABBREVIATIONS AND INITIALISMS

AMD	Acid mine drainage
APC	Air pollution control
APDP	Automotive Production Development Programme
ARD	Acid rock drainage
ASD	Adjustable speed drives
B2B	Bottle to bottle
BEV	Battery electric vehicle
BRT	Bus rapid transit
BUSA	Business Unity South Africa
CCS	Carbon capture and storage
CEF	Central Energy Fund
CFL	Compact fluorescent lamp
CHP	Combined heat and power cogeneration
CO_2	Carbon dioxide
CRP	Conservation Reserve Programme
CSIR	Council for Scientific and Industrial Research
CSP	Concentrated solar power
DBSA	Development Bank of Southern Africa
DEA	Department of Environmental Affairs
DNI	Direct normal irradiation
DOE	Department of Energy
DRC	Democratic Republic of the Congo
DSM	Demand-side management
DTI	Department of Trade and Industry
DWA	Department of Water Affairs
EDD	Economic Development Department
EE	Energy efficiency
EIA	Environmental impact assessment
EMEC	European Marine Energy Centre
EOR	Enhanced oil recovery
ES	Ecosystem services
ESP	Electrostatic precipitator
EU	European Union
EWASA	e-Waste Association of South Africa
EWR	Emalehleni water reclamation
FGD	Flue-gas desulphurisation
FRIDGE	Fund for Research into Industrial Development, Growth and Equity
GDP	Gross domestic product
GHG	Greenhouse gas
GW	Gigawatt
GWh	Gigawatt hour
GW_{th}	Gigawatt thermal
ha	Hectare
HIT	High insulation technologies
HRSG	Heat recovery steam generator
HVAC	Heating ventilation and air conditioning
IAP	Invasive alien plant
IAS	Invasive alien species
IDC	Industrial Development Corporation
IDZ	Industrial development zone
IEA	International Energy Agency
ILO	International Labour Organization
IPAP	Industrial Policy Action Plan
IPP	Independent power producer
IRP 2010-2030	Integrated resource plan 2010-2030
IRPTN	Integrated rapid public transport network

ITDP	Institute for Transportation and Development Policy
kg	Kilogram
km/h	Kilometre per hour
kW	Kilowatt
kW/km^2	Kilowatt per square kilometre
kW/m	Kilowatt per metre
kWh	Kilowatt hour
LCD	Liquid crystal display
LED	Light emitting diode
LFG	Landfill gas
LIMPET	Land installed marine power energy transmitter
m/s	Metre per second
m^2	Square metre
m^3	Cubic metre
MFMA	Municipal Finance Management Act
mJ/m^2	Million Joule per square metre
mm	Millimetre
MSW	Municipal solid waste
MTPPP	Medium term power purchase programme
MW	Megawatt
NaREC	New and Renewable Energy Centre
NERSA	National Energy Regulator of South Africa
NGO	Non-governmental organisation
NO_x	Nitrogen oxides
NT	National Treasury
O&M	Operations and maintenance services
OEM	Original equipment manufacturer
OPT	Ocean power technologies
PES	Payment for ecosystem services
PET	Polyethylene terephthalate
PPA	Power purchase agreement
PROBEC	Programme for Biomass Energy Conservation
PV	Photovoltaic
R	South African rand
R&D	Research and development
RDP	Reconstruction and Development Programme
RE	Renewable energy
ReFIT	Renewable energy feed-in tariff
REPP	Renewable Energy Procurement Programme
RoA	Rest of Africa
RWH	Rainwater harvesting
SA	Republic of South Africa
SABREGEN	South African Bulk Renewable Energy Generation Project
SABS	South African Bureau of Standards
SADC	Southern African Development Community
SANERI	South African National Energy Research Institute
SARED	South African Resource Database
SARi	SA Renewables Initiative
SAWEA	South African Wind Energy Association
SO_2	Sulphur dioxide
StatsSA	Statistics South Africa
SWH	Solar water heater
TIPS	Trade and Industrial Policy Strategies
UCT	University of Cape Town
UK	United Kingdom
UNEP	United Nations Environment Programme
USA/US	United States of America
USD	United States dollar

GREEN JOBS:
AN ESTIMATE OF THE DIRECT EMPLOYMENT POTENTIAL OF A GREENING SOUTH AFRICAN ECONOMY

Contents

OVERVIEW[1]

Powerful forces are driving a green economic revolution worldwide, providing in the process a strong lever for broad-based economic development in many parts of the globe, and often re-orienting national development trajectories.

South Africa, having one of the most carbon-intensive economies in the world, is no exception. Its national government is strongly committed to unleashing the potential of the green economy. This is clearly spelt out in the 'New Growth Path'[2] strategy document, which classifies the green economy as one of the ten 'jobs drivers'. The 'Industrial Policy Action Plan'[3] in turn, encompasses strategic initiatives to develop green industries and to improve energy efficiencies. More recently, the 'National Climate Change Response Strategy' white paper highlighted a set of near term flagship programmes that underline the progressive transition towards a greener economy[4]. Importantly, the window of opportunity is quite limited and the international environment is increasingly competitive. This indicates a degree of urgency if South Africa is to succeed in the localisation drive.

For instance, globally the country has one of the best solar resources, complemented by significant wind energy potential in certain areas, providing a strong basis for the roll-out of these relatively mature technologies. Furthermore, other forms of energy generation are also proving quite attractive, with the biofuels and biogas industries fast evolving to supplement the supply mix. South Africa is also facing serious challenges with respect to the conservation of its scarce water and soil resources, the proper management of which will provide opportunities for development and employment creation.

A greening economy should result in expansions of productive capacity and service delivery across a wide spectrum of economic sectors, although contractions may be experienced in others. This should be progressively supported by investment activity and result in meaningful employment creation. A growing green economy should also translate into opportunities for the localisation of production, either through the utilisation of existing production capabilities, or the establishment of new capacity.

As businesses, households and state agencies progressively adopt cleaner and more sustainable operating models due to public pressure, cost considerations and evident opportunities, the sustainability of a greener growth and development path should be increasingly safeguarded.

PURPOSE OF THE REPORT

The green economy has been attracting enormous interest worldwide. As businesses, households and the public sector gradually choose to embrace green technologies and practices, the potential exists to create a substantial number of new job opportunities and to facilitate reskilling. In considering the green economy concept, the definition utilised is the United Nations Environment Programme's (UNEP) "… a green economy (is) one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities."[5]

In light of the adverse implications of the global economic crisis on employment levels, valuable research regarding the potential role of the green economy at national level is being gradually released in countries such as the United States of America (USA), United Kingdom (UK), South Korea and China. Multilateral institutions, national development agencies, government departments, academic institutions and private sector research units, among others, are increasingly partaking in research projects in this area. However, research that focuses on the employment potential of specific green industries or activities is far less prevalent at this point in time and, where available, is difficult to access. Furthermore, it is typically of a 'top-down' nature and rarely country-specific.

The primary purpose of this report is to provide a segmented view of the **net direct job creation** anticipated to emerge in the **formal economy** across a wide range of technologies/activities that may be classified as green or contributing to the greening of the economy. Supplemented by related information, both international and domestic, it is hoped that it will also assist a broad spectrum of stakeholders in embracing a green economic revolution, contribute to the prioritisation debate and to the respective strategic planning.

Furthermore, by highlighting implementation challenges that are deemed key to unlock the green economy's potential, the report also brings to the fore the importance of stakeholder interventions across the board. The success of such interventions would determine South Africa's ability to capture an earlier stage within a limited window of opportunity and develop competitive advantage in specific green areas.

However, the research team is conscious of the fact that the prioritisation of focus areas would have been strengthened by the inclusion of investment costs, including the relative costs of various technologies. Moreover, considering the segmented approach followed, this report does not attempt to provide a general equilibrium analysis that would take into account cross-sectoral trade-offs. It also does not cover the issue of structural changes that would necessarily accompany a transition to the decoupling of economic growth from resource use[6], such as changes in the carbon intensity of the economy and the consumption of natural resources. These aspects should be the subject of future research.

Nevertheless, it is believed that the research and analysis contained herein does provide a basis from which to better ascertain the employment creation potential associated with greening the South African economy across various segments, thus contributing to current debates on its merits, and policy-making.

APPROACH FOLLOWED

The research team was encouraged to envision or think of the desired, yet pragmatic end-state for the selected segments of South Africa's greener economy in 2025, or alternatively the gradual contribution that each could make over different timeframes. The approach was largely 'bottom-up', strongly quantitative and produced an interesting set of findings, although the coverage is not exhaustive.

After deliberation, it was decided to focus on the following broad types of activity:

- **Energy generation**, which pertains to the generation of energy from sustainable, renewable and/or alternative sources with low or no carbon emissions;

- **Energy and resource efficiency**, which captures, among others, initiatives aimed at reducing energy consumption through green buildings, solar water heaters, industrial equipment and public transportation;
- **Emission and pollution mitigation**, relating to the utilisation of technologies aimed at reducing the harmful emissions associated with highly polluting industries, including air pollution control, electric vehicles, cleaner stoves, recycling, carbon capture and storage and water treatment; and
- **Natural resource management**, which covers the sustainable management and restoration of natural resources, specifically water, soil and land, as well as the conservation and restoration of ecosystems.

The employment potential for the individual green areas/technologies within each of these broad types of activity was estimated for three consecutive timeframes: the **short term** (2011 – 12); the **medium term** (2013 – 17); and the **long term** (2018 – 25). The analysis attempts to estimate the employment potential associated with: **building, construction and installation** activities; **operations and maintenance** services; as well as the possible localisation spin-offs for the **manufacturing** sector as the domestic production of equipment, parts and components benefits from preferential local procurement.

Only **direct jobs in the formal economy** are estimated – that is, **multiplier effects are not taken into account** in this work – without specifying the skills requirements. Consequently, the analysis only captures a portion of the potential employment impact of a greening economy. Evidence of considerable backward and forward linkages through various value chains of production, as well as of indirect and induced employment effects is reflected in a number of international studies[7]. Furthermore, recognising the eventuality of considerable job destruction, **a net approach was adopted per segment** of the green economy covered. Lastly, the sectoral coverage is not exhaustive.

A standard layout was adopted for the broad sections and their respective subsections, with the exception of the natural resource management section, due to its specific characteristics. For each of the 26 green areas/technologies covered, a brief description of the broad technology and its variations is provided in the respective subsection. This is followed by a brief overview of the historical development and maturity stage, a listing of main advantages and disadvantages, and an assessment of its introduction potential in South Africa and in the rest of the African continent. A snapshot of the global usage and key players ensues, thus providing an indication of its international acceptance, the degree of competition and potential partners. An analysis of the potential job creation follows, including an outline of the assumptions made. Each subsection concludes with an identification of key challenges and implications for policy-makers and other key stakeholders.

The research and analysis process involved a review of numerous domestic and international publications, research papers, strategy documents and industry-specific information. Interaction with experts, industry players, government officials and state-owned enterprises also provided valuable guidance as to the strategic direction.

EMPLOYMENT CREATION POTENTIAL

South Africa is facing an enormous challenge in the form of an excessively high rate of unemployment at 25%, or 4.4 million people without work in the third quarter of 2011, which is largely of a structural nature, as well as a declining trend in labour intensity. Efforts are under way to increase the labour absorption of the various economic sectors (refer to Annexure I for employment statistics at sectoral level), with the green economy receiving particular attention.

The green economy is complex, extremely diverse, relatively new and fast evolving in many of its segments, particularly in an economy such as South Africa's. The country will essentially be dealing with the progressive and simultaneous introduction of technologies that are either being improved, developed or commercialised. The economic merit of many of these technologies may only be fully established in years to come, opening up opportunities for the establishment of infant industries over time.

The analysis reveals the potential of an unfolding green economy to lead to the creation of approximately 98 000 new direct jobs, on average, in the short term, almost 255 000 in the medium term and around 462 000 employment opportunities in the formal economy in the long term.

Analysing this potential for each of the four broad types of activity (see figure 0.1), it is clear that the jobs associated with **natural resource management** (ie activities pertaining to biodiversity conservation and ecosystem restoration, as well as soil and land management) predominate over the three consecutive timeframes due to South Africa's exceptional endowments of natural capital. The share of such activities in the estimated total employment potential rises from around 45% in the short term to almost 50% in the long term.

However, the contribution made by a progressively expanding green **energy generation** segment increases from 14% of the total in the short term, or just over 13 500 jobs, to more than 28% in the long term, by which time some 130 000 employment opportunities are, on average, expected to be associated with this type of activity.

New direct employment opportunities in **energy and resource efficiency** activities are expected to rise, on average, from around 31 500 (32% of the total) in the short term, to almost 68 000 or just under 15% of the total in the long term.

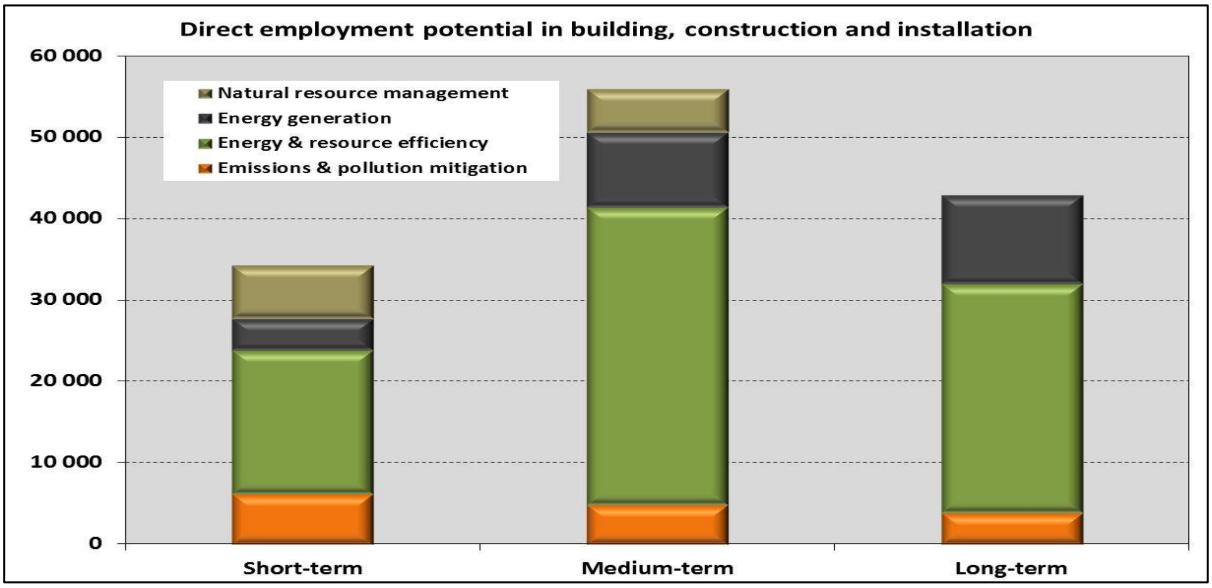
Activities associated with **emissions and pollution mitigation**, in turn, are anticipated to result in approximately 8 400 new direct jobs, on average, in the short term, with this number expanding to just under 32 000 in the long term.

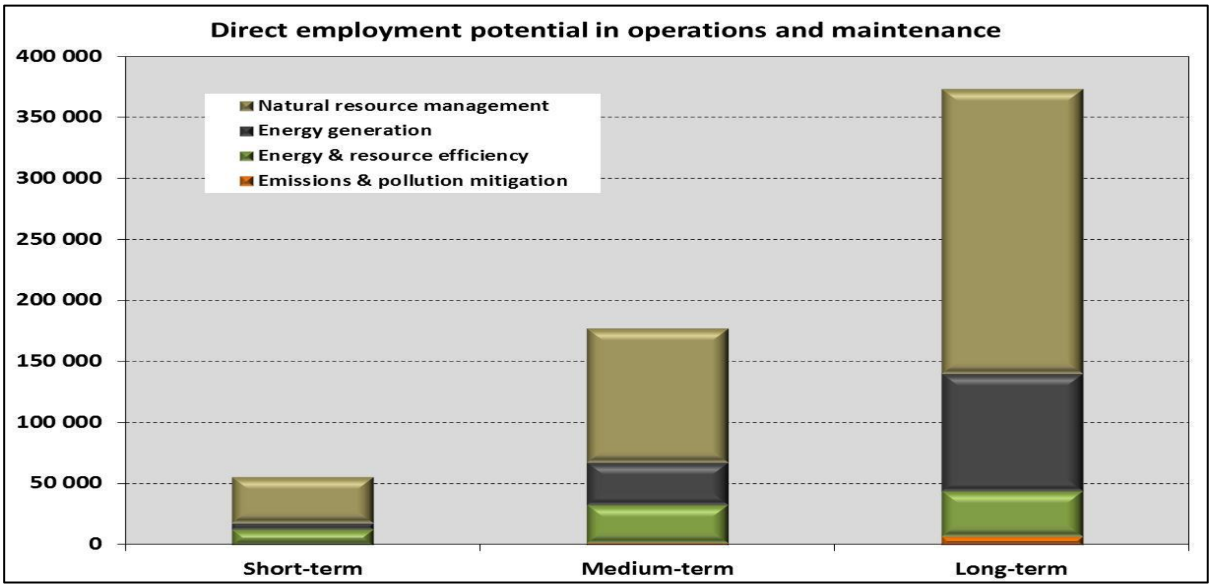
Figures 0.2 to 0.4 provide an overview of the employment potential associated with the respective building, construction and installation activities, operations and maintenance services (O&M), as well as manufacturing operations benefiting directly from the anticipated localisation benefits.

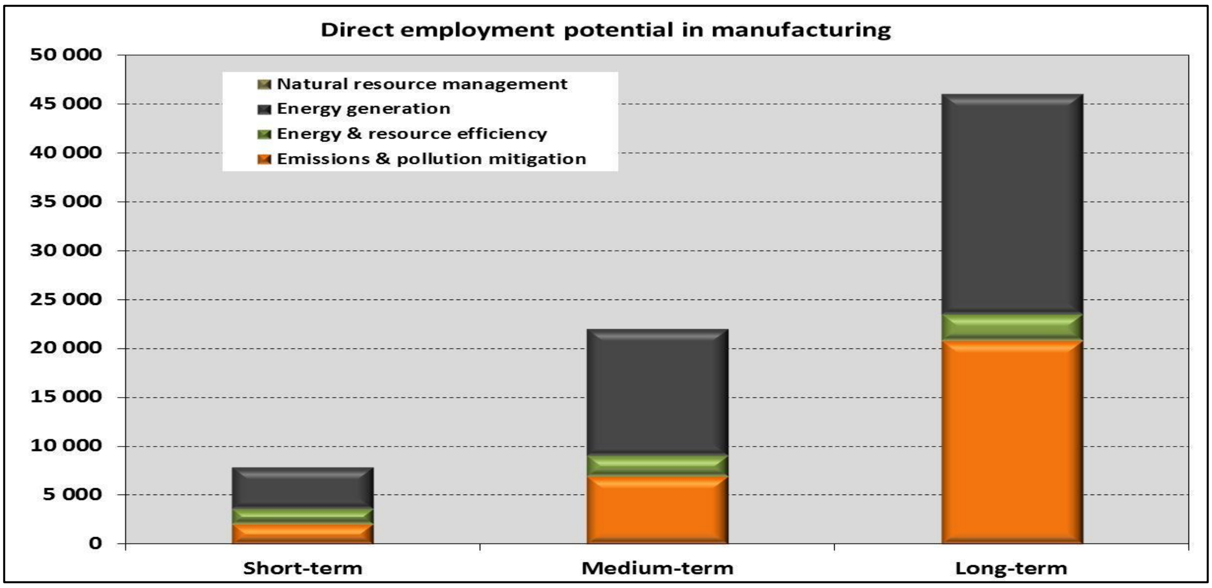
Figure 0.1: Net direct employment potential per broad type of activity over consecutive timeframes

Source: Authors

Figures 0.2 – 0.4: Net direct employment potential per type of employment activity over consecutive timeframes







Source: Authors

Table 0.1 on the next page provides a summary of the average employment potential in the long term (note that the jobs estimates were purposely not rounded throughout the analysis) for each of the four broad types of activity and respective segments. The direct localisation benefits for manufacturing employment are also listed. Both in terms of overall employment and manufacturing employment prospects, an indication is provided in the last two columns of the table of the extent of job creation potential (ie from 'negligible' through to 'very high' as per the intervals listed in the notes below the table) over the three consecutive timeframes.

Energy generation is expected to become an increasingly important contributor to green job creation over time, as projects are constructed or commissioned in: the biofuels industry, with the estimated employment gains manifesting themselves over time, and without compromising food security; the waste-to-energy segment, particularly cogeneration in the short term, biomass combustion in the medium and long term, as well as pyrolysis/gasification in the long term; solar power, particularly photovoltaic power, although the employment gains associated with concentrated solar power become evident in the long term; and wind power, with the momentum setting-in in the medium term and intensifying thereafter.

Although, in the long term, **energy and resource efficiency** initiatives are expected to deliver relatively lower contributions to employment creation than natural resource management and energy generation, these are extremely important from a sustainability standpoint. Furthermore, their anticipated employment contributions start earlier, particularly through very high job creation, in relative terms, associated with the roll-out of bus rapid transport (BRT) systems in several urban areas of the country. Employment gains are also expected to emanate from the roll-out of solar water heaters, especially in the medium and long term, with other green building activities likely to result in significant job creation in the long term.

Overall, the employment outcomes associated with **emissions and pollution mitigation** are expected to be relatively lower than for the other three types of activity, but this green area is absolutely critical from the environmental and societal perspectives. Considerable contributions are, nevertheless, expected to be made by recycling activities, particularly in the medium and long term, as well as by the electric vehicles and lithium-ion battery industries in the longer run.

As previously mentioned, the largest contributions to job creation are likely to be associated with **natural resource management** due to the very rich endowment of natural capital in South Africa and the need for its preservation. The level and pace of natural resource degradation require strong intervention to restore and/or safeguard ecosystems. The expansion and improvement of the 'Working for' programmes would make further valuable contributions to natural resource conservation and more comprehensive ecosystem restoration in South Africa, while yielding potential dividends in the form of inputs for downstream economic activities. In the long term, most of the jobs would be comparable to those created at present under the ongoing 'Working for' programmes, specifically maintenance jobs, mainly located in rural and relatively poor areas. While public works programmes and fiscal support have played the dominant role in their management, as well as in the restoration of ecosystem services, realising the associated employment potential would require substantial funding through innovative mechanisms in conjunction with the private sector. Examples include the establishment of payments for ecosystem services (PES) and the development of downstream activities (eg using the biomass collected through the clearing of invasives for the generation of energy), among others.

Table 0.1: Net direct employment potential estimated for the four broad types of activity and their respective segments in the long term, and an indication of the roll-out over the three timeframes

Broad green economy category		Segment	Technology/product	Total net direct employment potential in the long-term	Net direct manufacturing employment potential in the long-term	Total net direct employment potential (ST, MT, LT)	Net direct manufacturing employment potential (ST, MT, LT)
ENERGY GENERATION	Renewable (non-fuel) electricity	Wind power	Onshore wind power	5 156	2 105	VL, L, M	L, M, H
			Offshore wind power				
		Solar power	Concentrated solar power	3 014	608	N, VL, M	N, VL, M
			Photovoltaic power	13 541	8 463	M, H, H	H, VH, VH
		Marine power	Marine power	197	0	N, N, VL	N, N, N
		Hydro power	Large hydro power	272	111	VL, VL, VL	VL, M, VL
			Micro-/small-hydro power	100	0	VL, VL, VL	N, N, N
	Fuel-based renewable electricity	Waste-to-energy	Landfills	1 178	180	VL, VL, L	VL, VL, L
			Biomass combustion	37 270	154	VL, H, VH	VL, VL, L
			Anaerobic digestion	1 429	591	VL, VL, L	VL, L, M
			Pyrolysis/Gasification	4 348	2 663	VL, L, M	VL, H, H
			Co-generation	10 789	1 050	L, M, H	M, H, H
	Liquid fuel	Bio-fuels	Bio-ethanol	52 729	6 641	M, H, VH	L, H, VH
			Bio-diesel				
ENERGY GENERATION SUB-TOTAL				**130 023**	**22 566**		
ENERGY & RESOURCE EFFICIENCY		Green buildings	Insulation, lighting, windows	7 340	838	L, M, M	L, M, M
			Solar water heaters	17 621	1 225	L, H, H	L, M, H
			Rain water harvesting	1 275	181	VL, VL, L	VL, VL, L
		Transportation	Bus Rapid Transport	41 641	350	VH, VH, VH	H, M, L
		Industrial	Energy efficient motors	-566	4	VL, VL, VL	VL, VL, VL
			Mechanical insulation	666	89	VL, VL, VL	VL, VL, VL
ENERGY & RESOURCE EFFICIENCY SUB-TOTAL				**67 977**	**2 686**		
EMMISIONS AND POLLUTION MITIGATION		Pollution control	Air pollution control	900	166	N, VL, VL	N, L, L
			Electrical vehicles	11 428	10 642	VL, L, H	N, H, VH
			Clean stoves	2 783	973	VL, VL, L	VL, L, M
			Acid mine water treatment	361	0	VL, VL, VL	N, N, N
		Carbon Capture and Storage		251	0	N, VL, VL	N, N, N
		Recycling		15 918	9 016	M, H, H	H, VH, VH
EMMISIONS AND POLLUTION MITIGATION SUB-TOTAL				**31 641**	**20 797**		
NATURAL RESOURCE MANAGEMENT		Biodiversity conservation & eco-system restoration		121 553	0	H, VH, VH	N, N, N
		Soil & land management		111 373	0	VH, VH, VH	N, N, N
NATURAL RESOURCE MANAGEMENT SUB-TOTAL				**232 926**	**0**		
TOTAL				**462 567**	**46 049**		

Notes:

VH = very high (total employment potential > 20 000 direct jobs; manufacturing employment potential > 3 000 direct jobs)
H = high (total employment potential > 8 000 but < 20 000; manufacturing employment potential > 1 000 but < 3 000)
M = medium (total employment potential > 3 000 but < 8 000; manufacturing employment potential > 500 but < 1 000)
L = low (total employment potential > 1 000 but < 3 000; manufacturing employment potential > 150 but < 500)
VL = very low (total employment potential > 0 but < 1 000; manufacturing employment potential > 0 but < 150)
N = negligible/none (total employment potential = 0; manufacturing employment potential = 0)

Source: Authors

In summary, although employment related to natural resource management is likely to predominate over the three consecutive timeframes, energy and resource efficiency types of activity are expected to make considerable contributions in the short term, although these will be eventually overshadowed by the expanding energy generation segment as numerous projects are implemented.

The largest gains are likely to be associated with **operations and maintenance** (O&M) activities, particularly those involved in the various natural resource management initiatives. In the longer term, operations and maintenance employment linked to renewable energy generation plants will also be substantial. The employment growth momentum related to **building, construction and installation** activities peaks in the medium term, largely propelled by mass transportation infrastructure, stabilising thereafter as green building methods become progressively entrenched.

As the projects related to a greening economy are progressively commissioned, the potential for localisation of **manufacturing** also becomes increasingly viable. Manufacturing operations supplying equipment, parts and components to a greening economy, whether these are brownfield expansions or greenfield/infant industries, could record competitiveness gains over time. This will be largely due to economies of large scale production targeting both the domestic and export markets (principally elsewhere in Africa), but also due to technological improvements, knowledge acquisition and productivity gains. Employment gains in manufacturing are also expected to be relatively more stable than construction activities, since the sector should continue exhibiting growth potential as new and replacement components are produced, as additional markets are penetrated and as new green technologies are introduced.

The manufacturing segments that are expected to witness considerable employment gains (indicated as 'VH' in the table above), in relative terms, in the long term are those involved in the production of: electrical vehicles and related batteries; recycled materials; solar PV components; and biofuels. The recycling and solar PV segments are expected to develop the employment potential in the medium term, while the electrical vehicles and biofuels segments may take longer to generate the respective gains. Manufacturing segments with high employment potential (indicated as 'H' in the table above) in the long term would include suppliers of: pyrolysis/gasification plants; components for wind farms; insulation materials, lighting and windows; and solar water heaters. In most instances, the employment gains would be realised gradually over the three consecutive timeframes.

It should be emphasised that the employment projections are highly dependent upon a concerted and coordinated effort by all roleplayers. A conducive, cross-cutting and supportive policy and regulatory environment is essential for the implementation and/or development of the various technologies associated with a greening of the economy.

KEY IMPLEMENTATION CHALLENGES

The successful transition to a greener economy and the realisation of the associated employment potential will depend on numerous factors. A strong commitment by both the public and private sectors is essential to address implementation challenges such as the development of conducive and pragmatic policy and regulatory frameworks, institutional capabilities and skills, funding availability, technology acquisition and research and development, among others. The individual sections of this report highlight some of the respective implementation challenges and implications, many of which would need further investigation.

For this to materialise, the extraordinary and collaborative effort required will have to be focused, well integrated and coordinated, within and across sectors, targeting both the demand and supply sides of a greening economy within realistic, yet ambitious timeframes. There will always be difficulties along a transition path, thus warranting a degree of sensitivity across a range of stakeholders, taking into account the various inter-linkages and trade-offs in order to minimise the adverse consequences and enhance the benefits. To achieve the desired outcomes, signals may have to be sent by the public sector such as incentives, facilitating mechanisms, etc.

The country’s commitment to a greener growth path must be supported by realistic short, medium and long term milestones incorporating the roll-out of infrastructural and other investments. Suitable financing mechanisms could also reduce the risks for investors, with the development finance institutions playing a catalytic role in this regard.

Regulatory environment

The slow pace in the revision, amendment and development of certain regulatory frameworks, accompanied by coordination and communication challenges such as clarity regarding the allocation of responsibilities within the public sector, transparency on process status and dissemination of relevant information, have often caused unnecessary uncertainty, held back investment activity in green technology applications and, as a result, have constrained their roll-out. However, a transition to a greener economy should not necessarily result in an increased regulatory burden, thus requiring simplification and streamlining where possible. Efficiencies should be pursued in order to fast-track the required approval processes for green investments (eg environmental impact assessments (EIA), water permits). Local government is expected to play a major role in the implementation of green projects and, therefore, coordination and support to ensure the necessary capacities are vital.

Commitment/readiness to ensure growing green demand

In addition to regulatory aspects, the importance of the public sector playing an exemplary, leading and facilitating role in the greening of the economy cannot be overstated (eg demand stimulation through public sector procurement).

The level of commitment, awareness and readiness of the private sector and household sectors must also be enhanced (eg behavioural changes ranging from property developers buying into the concept of green buildings, to households and enterprises opting for energy efficient and water saving technologies).

Localisation

Sufficient local demand will have to be developed on a sustained basis, at times complemented by export market penetration, particularly within the African continent, for localisation programmes to succeed. Most machinery and equipment, as well as components associated with green technologies will be subject to serious foreign competition. The competitiveness of various segments of South Africa’s manufacturing base has been eroding over time for a variety of reasons, resulting in increased import penetration. Local players will have to offer competitive prices, quality products at various levels of sophistication, and efficient service delivery to withstand import competition.

The availability of competitively priced inputs (eg steel) and services to support domestic manufacturing will be essential, as will be the establishment of strong relationships with global technology partners in the case of advanced equipment, with the intention of gaining access to intellectual property rights.

Addressing the above should form part of clear long term national industrialisation strategies aiming to maximise the localisation benefits of a growing green economy. These should be developed in partnership with the relevant roleplayers, well communicated and effectively implemented so as to remove uncertainty. Temporary governmental support for the development of infant industries may be required in certain instances, preferably on a performance basis. Yet, this must be approached with pragmatism, as South Africa will not be alone in the localisation drive.

Furthermore, in order to succeed, the strategies will have to be built on a strong industrial foundation from which to develop several of the manufacturing opportunities identified in this report. Substantial investment activity in green industries will be the natural reaction of the business sector to a more conducive regulatory environment, changing behavioural patterns and consequently increased demand.

Research and development (R&D) will be crucial in securing and maintaining competitiveness. This could be accompanied by the establishment of bi- or multilateral global cooperation to encourage technology transfer. Relative competitiveness and the success of the market acceptance or penetration efforts, whether locally or abroad, will also increasingly depend on the perceptions of existing and future customer bases regarding the impact of business models on society at large and the natural environment.

Skills shortages

Although substantial human resource capacity is available locally, a shortage of skills in certain areas is likely to constrain the development of segments of a greening economy. Hence, a coherent strategy is needed to address skill constraints that may prevent the expansion of the pertinent sectors or the introduction of new activities. This would include worker reskilling programmes towards greener disciplines and activities.

Resource availability

A range of different resources are essential factors in the green economy, particularly where energy generation and water supply are concerned. The main concerns in this regard pertain to resource availability, accessibility, quality, sustainability and price. These factors are, individually or collectively, often key to the long term viability of certain types of green economy projects. This has been evidenced by a number of projects implemented to date (eg biomass). Hence, security of supply of resource inputs at the appropriate price is crucial for the sustainability of new ventures. In certain instances, current and future initiatives (eg the ‘Working for Water’ programme) may mitigate this risk to a considerable extent, but this could be supplemented by accessing resources in the broader southern African region.

Taking the lead

A gradual but effective transformation of behavioural patterns, particularly with respect to resource utilisation and protection, is deemed critical for the evolution of a green economy. It is not simply about responding to an adequate level of incentivisation or to the imposition of regulations and penalties, it is also about choices. By seeking greater consumption and production efficiencies and by making choices that are conducive to the proliferation of green industries, products and services, as well as the protection of resources, South African households, businesses and government agencies will establish momentum and progressively reinforce the greening of the economy.

1 INTRODUCTION[8]

In its recent green economy study, UNEP[9] concluded that environmental sustainability and economic progress are not opposing forces and that significant benefits will flow from the greening of the world's economies. Greening generates increases in wealth, measured in classical terms of higher growth in gross domestic product (GDP) – even in poorer or developing countries – as well as in the form of ecological gains due to positive impacts on the natural capital of ecosystems and biodiversity. An important synergy exists between poverty eradication (ensuring food supply, water, energy and health, as well as support to subsistence farmers) and enhanced conservation of natural capital.

The green economy could be an extremely important trigger and lever for enhancing a country's growth potential and redirecting its development trajectory in the 21st century. A burgeoning green economy will reflect a clear expansion of productive capacity and service delivery across many existing areas of economic activity, and the introduction of numerous new activities in the primary, secondary and tertiary sectors.

This should be evidenced by substantial investment activity in conventional and non-traditional activities, meaningful employment creation, sustaining competitiveness in a world that is increasingly determined to address adverse climate change trends, and by opportunities for export trade, among others.

The imperative of stabilising greenhouse gas (GHG) concentrations in the atmosphere within particular boundaries, so as to contain atmospheric warming trends and other associated forms of climate change, is leading to discernible behavioural change in societies around the world, and to the consideration of (or a commitment to) specific national targets.

On top of this, there is a "growing threat of increasing 'eco-protectionism' from advanced industrial countries in the form of tariff and non-tariff measures such as carbon taxes and restrictive standards"[10]. Such trends are proving to be a powerful force for the evolution of a green economy to protect biodiversity, address adverse climate change trends, pollution and unsustainable resource use.

Table 1.1: Top five countries/regions (plus South Africa, Brazil) ranked in terms of total emissions and listing emissions per capita*

Rank	Country	Total emissions (million t)	Emissions (t/capita)	Emissions (kg/USD GDP)
1	China	6 877.2	5.14	0.55
2	United States	5 195.0	16.90	0.46
3	European Union – 27	3 576.8	7.15	0.30
4	India	1 585.8	1.37	0.35
5	Russia	1 532.6	10.80	1.00
…				
14	**South Africa**	**369.4**	**7.49**	**0.70**
15	Brazil	337.8	1.74	0.20

Note: * Excluding emissions from deforestation and fossil fuel exports.

Source: Authors, compiled from International Energy Agency (2011) data.

The importance of the green economy is certainly not confined to climate change considerations. The anticipation regarding its economic potential underpins the green initiatives of many governments throughout the globe, particularly as they attempt to stimulate an economic recovery and seek various means of elevating and sustaining growth and employment creation.

Several countries embraced the green economy model much earlier and at varying speeds, with the likes of Denmark, Switzerland and Germany being among the countries at the forefront. Emerging economies such as China are making huge commitments to green energy production and clearly intend to play a dominant role in several of the associated industries (eg wind power equipment such as turbines).

South Africa has one of the most carbon-intensive economies in the world, thus making the greening of the electricity mix a national imperative. For instance, with one of the best solar resources globally and available land, there are opportunities for the successful roll-out of concentrated solar power (CSP) and photovoltaic (PV) solar power projects. Complementing this is the country's wind energy potential. The attractiveness of wind and solar technologies is not only supported by conducive natural conditions nationally, but also by the relatively mature stage of their technological development. However, other forms of energy generation, such as cogeneration and other waste-to-energy options are also proving quite attractive. With respect to liquid fuels, the fast evolving biofuels and biogas industries will supplement the supply mix.

South Africa is also facing serious challenges with respect to its natural resources, particularly water and soil, as well as in managing its waste adequately. The proper management of its scarce water resources is urgently required if the country is to avert a massive future crisis with unimaginable economic, social and even political repercussions. Similarly, soil conservation is extremely important for the welfare of communities and the sustainability of farming, forestry, tourism and several other types of economic activity.

South Africa has committed to investing in a green economy, being cognisant of the potential economic and social returns. The green economy *per se* is one of the ten so-called 'job drivers' identified by the 'New Growth Path' and a key focus area of the Department of Trade and Industry's 'Industrial Policy Action Plan' (IPAP2). The recently released 'National Climate Change Response Strategy' white paper further highlights some of the priority sectors. As the economy progressively adopts cleaner, more environmentally-friendly and/or energy efficient technologies and processes, the sustainability of its growth and development path will be increasingly safeguarded, due to improved natural eco-system and social protection.

Looking ahead, South African businesses, households and public sector agencies will have to improve their energy efficiency, as cost considerations and the evolving regulatory landscape gradually force them to alter their energy consumption behaviour. Related opportunities range from the roll-out of solar water heaters to efficient lighting, insulation, electric vehicles, mechanical insulation and metering equipment, to mention but a few. Substantial investment activity in green industries will be the natural, yet gradual reaction of the business sector to such signals and to changing behavioural patterns over time.

The solid growth potential of renewable energy (RE) and resource efficient technologies in years to come, both nationally and elsewhere in Africa, will also translate into numerous opportunities for the localisation of production, as a critical mass of demand for numerous parts and components gradually develops.

Various South African manufacturing firms may already be in a position to accommodate some of the procurement needs, possibly with certain operational adjustments, but their production capacity may have to expand in response to rising demand. Furthermore, many new industries can be established afresh, as the localisation process intensifies.

The positive ramifications in South Africa could be enormous for rural and urban areas alike. Rural development outcomes, for instance, are likely to be substantial, since most natural resources are found in such areas, with net gains in the form of improved access to energy, water and sanitation, as well as enhanced food security, to mention but a few.

2 METHODOLOGY

During the research and analysis process, the team consulted numerous publications, research papers, strategy documents and industry-specific information, both of a South African and international origin. There was substantial interaction with local and foreign experts, as well as industry players involved in the specific activities, or currently utilising/developing the various existing/potential technologies. Significant engagement with government officials and state-owned enterprises also provided valuable guidance as to the strategic direction.

Existing studies and models pertaining to estimations of the job creation potential through a greening economy, have been primarily compiled for developed nations in North America or in Europe[11]. These studies and models are based largely on highly disaggregated sectoral data that is then used in an input-output model to simulate different scenarios and their impact on job creation. Since data at such a disaggregated level is not available in South Africa, the research team had to develop a methodology to estimate the employment creation potential of a progressively greening economy.

The literature review and consultation with numerous roleplayers enabled the researchers to derive demand estimates and to obtain data for the employment calculations under each of the segments covered, while informing the appropriate approach to be followed in each instance. The final report benefited, during the drafting stages, from inputs and comments provided by numerous experts, locally and internationally.

2.1 Green segment/technology coverage

The initial step involved a scoping exercise that attempted to identify the green technology universe. The segments/technologies within this universe that were deemed to be of significant interest from a South African perspective were subsequently selected. Certain important segments/technologies may have been excluded due to an inability to access the necessary information for purposes of the report. Their stage of development and anticipated potential application locally were further determinants in selecting the segments/technologies that would be investigated further.

The coverage was eventually narrowed down to 26 green segments/technologies that could result in employment opportunities as the greening of the South African economy unfolds. These were grouped under the following four distinct broad types of activity: energy generation; energy and resource efficiency; emissions and pollution mitigation; and natural resource management.

2.2 Employment focus and categorisation of activities

Only **direct jobs in the formal economy** were estimated (ie multiplier effects are **not** taken into account in this work), and these were calculated on a **net basis** to take into account anticipated job losses at a segmented level.

The employment potential was categorised according to the following types of activity:

- **Building, construction and installation –** This pertains to any type of infrastructure, plant or factory that would have to be built, or the installation of equipment (eg solar water heaters) in order to introduce and/or expand a specific green segment/technology in South Africa and/or in the rest of Africa (RoA). Jobs related to construction are by definition temporary jobs and, therefore, were captured over the relevant timeframe.

- **Operations and maintenance –** This refers to the employment involved in operating or maintaining the new infrastructure (eg a wind farm) but excluding manufacturing plants, the jobs created in the operation and maintenance of new equipment (eg air pollution control equipment), farming employment (eg production of farm inputs for biofuel plants), as well as the bulk of employment generated by natural resource management activities. Such employment may be of a permanent or temporary nature. Employment opportunities related to operations and maintenance activities elsewhere on the African continent are also taken into account.
- **Manufacturing –** This refers to the job creation potential associated with new manufacturing activities (eg electrical vehicle manufacturing, biofuel and recycling plants), including the production of materials, components, equipment and other direct inputs in support of the respective green segment/technology (eg solar PV panels). This employment is deemed to be of a more permanent nature. Furthermore, export market penetration (largely in southern Africa, but also in the rest of the continent) is often required in order to secure the long term sustainability of manufacturing operations.

2.3 Timeframes, employment potential calculation

The time horizon spans 15 years, grouped as follows: the short term (ie the years 2011 and 2012); the medium term (ie the subsequent five-year period up to and including the year 2017); and the long term (ie the subsequent eight-year period up to and including the year 2025). It should be noted that the employment analysis was undertaken in 2010 and early in 2011, albeit with later revisions.

The estimation of the employment potential was based on the anticipated number of jobs per year, on a non-cumulative basis. Thus, for a construction job to be sustained from one year to the next, the construction activity would need to be maintained, while an increase in employment would have to be associated with a higher level of construction activity. It follows, therefore, that a slowing in construction activity, possibly due to the saturation of the market, would result in a decline in employment opportunities over time. A similar rationale applies to manufacturing activities. Nevertheless, external opportunities, whether in the rest of Africa or elsewhere, could sustain employment levels in whatever activity, partially or fully, on a more permanent basis. The lifespan of the facilities/equipment was, where necessary, taken into account in the employment calculations as it has replacement implications.

Employment estimates for operations and maintenance activities, in turn, capture the number of people needed to operate the plants already constructed and commissioned, implying that the workers employed in year one would still be employed in year two and so on. Thus, as the number of plants increases, so does the quantum of employment associated with operations and maintenance requirements.

The jobs are also calculated on a full-time equivalent basis. For instance, if a crew of ten people is able to build a plant in three months, it would have to build four plants per year in order to be considered fully employed. However, should the crew build only one plant, the employment creation would be reflected as 2.5 jobs.

The employment potential was determined for each year by creating an assumed build programme for each green segment/technology, where possible, and then averaged for each time frame, as highlighted in the following table (for further detail on the calculation method for the CSP build programme depicted in the table, refer to the notes below it). The principal reason for utilising an average for each time period (ie short, medium or long term) was that some of the green segments/technologies exhibited significant annual fluctuations in employment, especially regarding construction activities and manufacturing potential. Consequently, undue focus on the employment levels attained in any specific year could result in a distorted or inaccurate perception of the sustainable potential.

Table 2.1: Assumed build programme and direct employment calculations for concentrated solar power (CSP)

	CSP plants completed: SA	CSP plants completed: RoA	Construction: SA	Construction: RoA	O&M: SA	O&M: RoA	Manufacturing: SA	Manufacturing: RoA
Number of MW per year			18.75	18.75			18.75	18.75
Number of workers per MW			21.6	2.16	0.54	0.05	14.4	14.4
Construction period years			2	2			2	2
Year	No. of MW	No. of MW	No. of jobs	No. of jobs	No. of jobs	No. of jobs	No. of jobs	No. of jobs
2011	0		0	0	0	0	0	0
2012	0		0	0	0	0	0	0
Average short term			**0**	**0**	**0**	**0**	**0**	**0**
2013	0		58	0	0	0	38	0
2014	100		132	0	54	0	88	0
2015	130		173	1	124	0	115	10
2016	170	25	225	4	216	1	150	29
2017	220	50	294	6	335	3	196	38
Average medium term			**176**	**2**	**146**	**1**	**117**	**15**
2018	290	50	386	7	492	3	257	48
2019	380	75	501	10	697	4	334	67
2020	490	100	651	13	962	5	434	86
2021	640	125	829	16	1308	7	553	106
2022	800	150	922	17	1740	8	614	115
2023	800	150	922	18	2172	8	614	119
2024	800	160	922	21	2604	9	614	138
2025	800	200	922	23	3036	11	614	154
2026	800	200						
Average long term			**757**	**16**	**1626**	**7**	**504**	**104**

Notes: (i) Using the example of the CSP build programme depicted in the above table: The construction and manufacturing calculations utilise the number of megawatts that will be completed in a specific year as well as the following one, divided by the number of megawatts that can be built within a year, multiplied by the number of people required per MW and then divided by the number of years that it takes to build the plant. In numerical terms for construction in 2016, as follows: = ((170+220)/18.75) x 21.6) / 2

(ii) When calculating the number of O&M jobs, the number of megawatts completed in the specific year is multiplied by the ratio of workers per MW, plus the number of workers employed in O&M in the previous year. In numerical terms for 2016 = (170 x 0.54) + 124

Source: Authors

A modelling exercise undertaken by UNEP[12] has indicated that a greening of the economy could, during the transition period, bring about job losses in the brown economy, especially in the absence of additional support measures. According to the respective report[13], the creation of new jobs in the greener economy should nevertheless exceed these losses over time, provided that the necessary reskilling and re-educating of the workforce has taken place.

Accordingly, throughout the analysis and estimation process, due consideration has been given to the possibility of job destruction. Hence, the employment potential estimates reflect net job creation at a segmented level. For example, clear instances of existing jobs potentially being lost as a direct result of the roll-out of a green segment/technology are anticipated in the energy efficient industrial motors section, as well as in the bus rapid transport section.

Although all the estimates are based on the methodology described above, the various segments/technologies exhibited differing degrees and quality of information available, whether locally or internationally. For certain technologies, it was possible to construct annual tables indicating the roll-out over time, while in other cases it was only possible to estimate averages for the period. Some technologies, such as solar PV and CSP, are also characterised by significant variations in the application and design of plants, in which case the employment potential associated with such variations was averaged out, and it was assumed that the various types of technology would be rolled out in an equal manner.

Ratios were utilised with respect to specific green segments/technologies, with such ratios being either financial- or output related. For example, ratios of employment per megawatt (MW) installed were used in the case of solar PV, while a ratio reflecting the number of workers per rand spent was utilised for air pollution control equipment. Accordingly, the profile of megawatts installed or the amounts spent formed the bases for the employment calculations, respectively.

Other technologies used the estimated number of workers that would be required per fixed activity (eg the number of people per plant was utilised in order to determine the employment potential in the biomass combustion subsection of waste-to-energy). In turn, the calculation of the employment potential in the bus rapid transit (BRT) subsection of transport efficiency involved using employment numbers observed in the actual roll-out of Johannesburg's BRT system.

2.4 Other assumptions

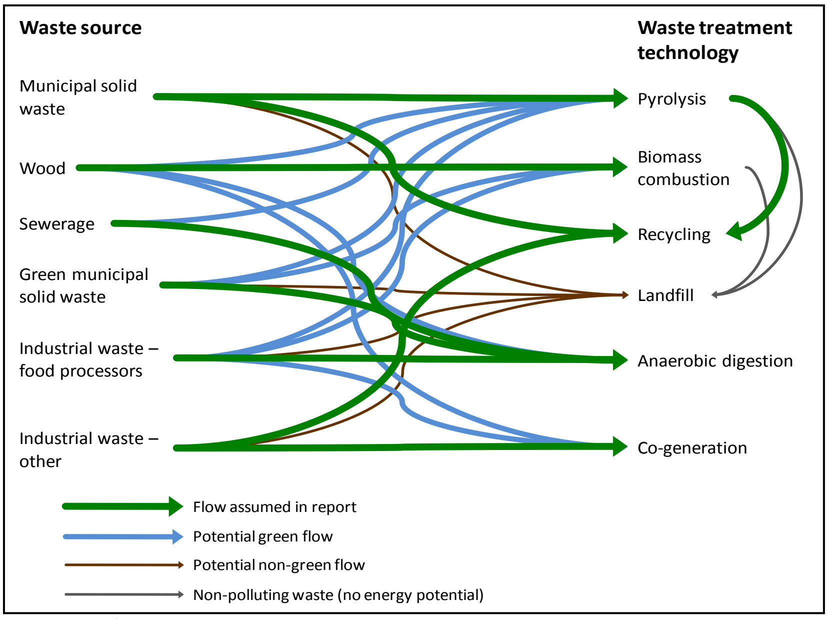
Multiple/competing demands for inputs

Certain segments may share the same inputs to a greater degree than others. For example, there is no limitation on the solar availability for two competing technologies, such as PV and CSP, although the land and water resources do play a limiting role. Hence, the solar resource was assigned to both segments without limitations, except for the realism of the roll-out.

In other instances, such as waste-to-energy, certain fundamental assumptions had to be made regarding the exclusive allocation of inputs to specific technologies. To illustrate, waste-to-energy technologies can use various sources of waste to produce energy (eg green municipal waste can be used in landfills, anaerobic digestion, biomass combustion as well as in pyrolysis/gasification). To ensure that the potential is not overstated, the potential of the individual technologies was constrained by the type of waste allocated for their operations.

Biomass combustion, for example, only uses wood waste generated in the forestry sector or obtained through the 'Working for Energy' programme. Green municipal waste, sewerage and waste from food processing plants, in turn, were allocated to anaerobic digestion, with the remaining municipal solid waste (MSW) being allocated to pyrolysis/gasification. Landfills, however, are assumed to be closed for general waste, accepting only inert waste that was treated previously. As such, this technology is deemed not to accept any new waste that could be used to generate energy. The following figure illustrates the channelling of waste sources to the various waste treatment and energy generation technologies, and/or to recycling activities.

Figure 2.1: Illustration of resource allocation to various technologies



Source: Authors

Sustainability of production through internationalisation

The size of the South African market, on its own, may be insufficient to maintain domestic manufacturing capability serving several green technologies. In this regard each technology was assessed to determine the potential for the exportation of components, or even complete systems, in order to enhance the sustainability of potential domestic manufacturing operations. Basically without exception, the target market for these exports is the rest of the African continent.

For example, the proximity of certain solar-rich regions (eg most of Namibia and Botswana) does provide a transportation cost advantage which is likely to be exploited by the South African solar equipment/component manufacturers. However, projects benefiting from the optimal solar intensity in the northern parts of the continent (eg the Saharan region) may prove far more difficult to capture and, therefore, were not included in the estimations. With respect to locally manufactured anaerobic digesters and pyrolysis/gasification plants, on the other hand, there may be significant potential for exports to the rest of the continent, since the existing technical know-how, local knowledge and plant design adaptation to operate under African conditions provide significant competitive advantages.

Feasibility and relative implementation costs

The analysis does not attempt to determine the actual feasibility of implementing each of the green segments/technologies covered, nor the relative ease of implementation. Furthermore, it is important to note that the relative cost of the various technologies has not been assessed nor taken into consideration. This critical factor would obviously determine the feasibility of implementation, and could be the subject matter of a supplementary research project. When considering the possible roll-out of the various technologies, the technical potential of each respective technology has, however, been taken into consideration.

Policy and regulatory support

Most importantly, it is assumed throughout the analysis that the introduction and/or expansion of each green segment/technology are accompanied by a reasonable degree of policy and regulatory support. The importance of adopting appropriate policies and regulations that will create an environment where the green segment/technology is rolled out in an effective, cost-efficient and sustainable manner cannot be over-emphasised. Without this, the employment potential outlined in this report would be highly compromised. Accordingly, some of the existing bottlenecks and other impediments are highlighted in the individual sections.

2.5 Section layout

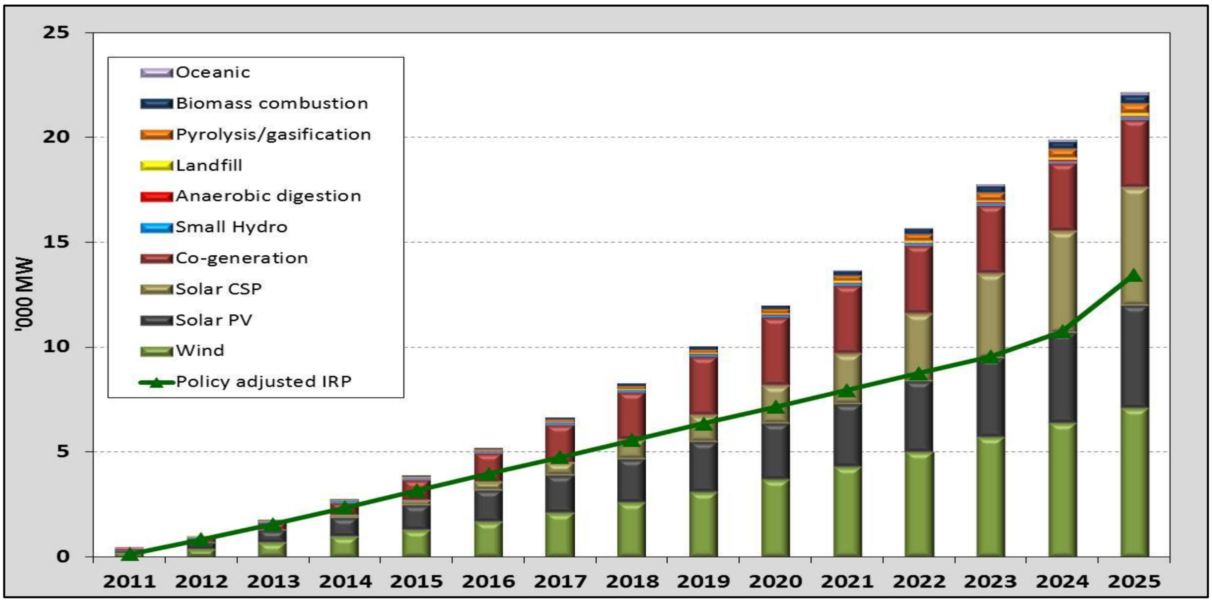
A standard layout was adopted for the broad sections and their respective subsections, with the exception being the natural resource management section due to its inherent nature and specific characteristics.

A brief description of each broad technology is provided in each subsection, including certain technological variations where applicable, followed by an outline of its historical development and maturity stage. The main advantages and disadvantages are highlighted, while the deemed introduction potential in South Africa and in the rest of the African continent is also assessed. A brief overview of the global use of each technology provides an indication of its international acceptance. Select global players are also identified in order to expose the extent of the possible competitive environment for South African counterparts, as well as the potential for future partnerships in rolling-out the technology in South Africa. The analysis of the potential job creation ensues, starting with an overview of the assumptions made. Lastly, key challenges and implications for policy-makers and other key stakeholders are highlighted.

3 ENERGY GENERATION

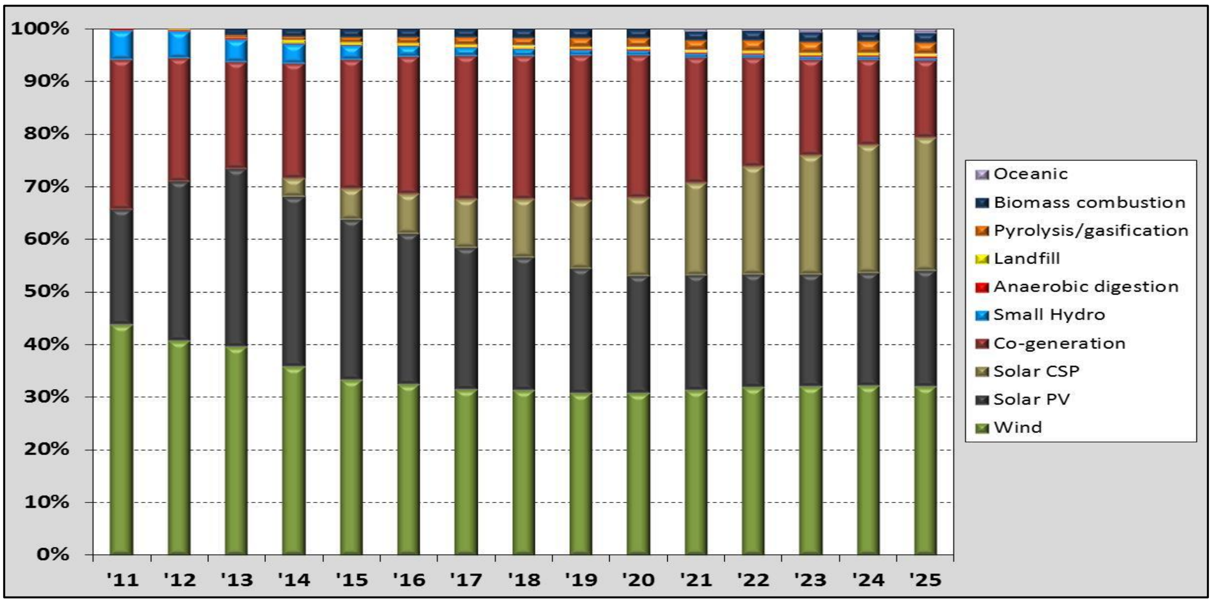
The assumptions made in the following subsections result in a specific renewable energy generation path, which is illustrated in figure 3.1 below (ie reflected by the stack bars) and compared with the respective combined projections of the Integrated Resource Plan for Electricity 2010 – 2030 (IRP 2010 – 2030) (ie the solid line in the graph). In this regard, this report covers a wider range of technologies than those included in the IRP 2010 – 2030 (eg pyrolysis/gasification), it anticipates a greater potential for capacity development in certain technologies (eg CSP) and, unlike the IRP 2010 – 2030, it includes cogeneration on the production side instead of demand side management. Figure 3.2, in turn, illustrates the changing composition of the renewable energy industry over time.

Figure 3.1: Electricity generation: Capacity growth based on report assumptions compared to the projections made in the IRP 2010 – 2030



Source: Authors and IRP 2010 – 2030.

Figure 3.2: Evolution of the relative shares of the various technologies covered in this report within the combined energy generation



Source: Authors

3.1 WIND POWER

Wind as a source of energy for power generation has gained much ground the world over in recent years. Wind power is generated by converting wind energy into a useful form of energy, such as electricity, through the use of a turbine mounted on a tower. Wind turbines are often built in clusters referred to as wind farms.

Technologies are continuously being developed and improved, while thousands of turbines, rotor blades and other parts or components are being produced, contributing to the vast increase in the reliability of the technology experienced over recent years. The largest wind farms currently in operation have capacities of around 1 000 MW generated by hundreds of turbines, with larger farms being planned. The wind power industry employed almost half a million workers worldwide in 2009 – a figure that is expected to grow to over a million in five years from now, according to forecasts by the Global Wind Energy Council[14].

Historical progress/maturity

The use of wind as a source of power has become established in the mainstream energy market worldwide. Global wind power generation capacity has risen almost exponentially and is in use in close to 80 developed as well as developing countries. The technology applied in wind power generation is mainly mature. Nevertheless, the size of wind farms and the capacity of turbines are continuously important factors, with a shift towards offshore wind farms also being evident in Europe.

A wind turbine is currently built from over 8 000 different components, commonly grouped in three major sections: nacelles, containing most of the machinery parts such as the gearbox, generator, transformer and brake system; the blades; and the tower. Components are produced by either original equipment manufacturers (OEMs) or outsourced to specialised suppliers of components or subsystems.

Investment in offshore wind power plants, especially in Europe, has increased significantly in recent years. The cost of establishing an offshore wind farm is currently almost double that of an onshore equivalent, but is expected to come down significantly in relative terms[15]. The higher average capacity factors at sea plants, however, contribute to their viability, while job creation is also higher than in onshore operations due to the greater employment requirements associated with the installation, operations and maintenance of offshore plants.

All countries with significant wind power industries have been supporting the development of the industry through the introduction of feed-in tariffs, subsidies, tax breaks and other incentives, thereby being highly successful in stimulating investment. Wind energy has, nevertheless, continued moving closer to achieving economic competitiveness relative to conventional energy sources, largely due to ongoing improvements in technologies and efficiencies, as well as rising economies of scale.

Although wind power technology has been operating on a commercial basis for many years, the strong growth in demand experienced over the last decade or so has resulted in supply chains becoming stretched. Simultaneously, a higher than expected component failure rate has been recorded, having a significant increasing effect on costs[16].

Advantages/disadvantages

Wind power is a source of renewable energy with a large 'technical' generation potential. The growth in wind power generating capacity has been driven mainly by factors such as environmental concerns, the need for sustainable energy supply and a stable (zero) fuel price. Wind energy does not emit carbon dioxide (CO_2) in generating electricity and is associated with exceptionally low lifecycle emissions. The construction period for a wind farm is much shorter than that of conventional power stations, while an income stream may in certain instances be provided to local communities through employment and land rental.

The fact that wind power projects emit no greenhouse gases (GHG) (those caused during the construction phase are offset within a very short period of time compared with the project's lifespan), coupled with the relatively short period of time needed for plant completion and the possibility of generating power from individually completed units as they become connected, make wind power an ideal means for reaching emission reduction targets in a relatively easy manner.

A number of other environment related forces support wind as energy source – it is not dependent on water (as compared to the massive water requirements of conventional power stations); it has no degrading effect on the land (as is the case with fossil fuel exploitation); there are no pollution risks (as opposed to the risk of oil spills when transporting fossil fuels); and there are no health risks (such as those associated with the O&M activities of nuclear plants).

The case for wind power can be boosted by its positive effect on rural or regional development. Many remote areas where there is significant wind stand a good chance of hosting a power generating plant, whereby a region's economy would benefit to some extent from the provision of jobs and the generation of tax revenue. This process directly opposes the draining of income from such areas through rural-urban migration or high rates of urbanisation. In Denmark, one of the world's most advanced countries with respect to wind power generation, a significant portion of wind turbines are owned by local communities.

A major drawback for wind energy is that, due to the natural variation in wind power on a daily and/or seasonal basis, back-up base-load generation capacity is imperative to provide stability to the energy supply. Furthermore, as with other renewable energy sources, wind power has relied on incentive measures throughout the world for its development, although its relative competitiveness has been improving continuously.

Brief overview of global usage

The world's cumulative wind power generation capacity grew by 28% per annum over the first decade of the 21st century, with the additional capacity installed on an annual basis increasing to 38 200 MW by 2009[17]. The new capacity added in 2010 should also be around the mid-30 000 MW. The overall market amounted to USD72 billion in new generating equipment in 2009. Due to the strong demand, supply channels were being stretched, although a slowdown in investment due to the global economic crisis provided some breathing space from the latter part of 2008 onward.

To illustrate the impact of the economic recession and fiscal austerity measures on the industry, according to a recent Citigroup analysis, growth in new wind energy installations in Europe has been projected to contract from 14% in 2010 to a mere 1% in 2011[18]. This dramatic slowdown has underpinned to a significant extent the massive job-shedding by a leading market player such as Vestas (the company decided to reduce its workforce by 3 000, or 13% of the total, as it closed four production facilities in high-cost countries – specifically Denmark and Sweden) and its search for cheaper manufacturing locations (eg China and Spain).

Where the industrial countries are concerned, Europe added more new wind generating capacity over the last two to three years than any other type of power generating plant. Altogether 36 of the states in the US already have utility-scale wind farms. Germany, in turn, sources 7% of its total electricity from wind, with some of its regions recording figures of over 40%. Some of the other European countries obtain between 7% and 20% of their total power from wind. Smaller industrial economies such as those of New Zealand and Australia are also growing fast in wind-driven electricity generating capacity.

Amongst the developing countries, China and India have been by far the largest contributors to new wind generation capacity in recent years. According to Citigroup, China's wind power capacity expanded from 6 050 MW in 2007 to an estimated 43 853 MW in 2010 and is projected to more than double by 2013[19]. China adopted aggressive policies in support of the diversification of energy generation, domestic industry growth and transmission enhancement investment. Installed capacity in India stood at just below 11 000 MW at the end of 2009 and is also expected to more than double over the next five years and to subsequently continue its steep uptrend in capacity creation. Brazil had 935 MW and Mexico 202 MW capacity at the end of 2009, planning sharp increases together with a number of other Latin American countries. At the end of 2009, 96% of Africa's wind power capacity was situated in Egypt (430 MW), Morocco (253 MW) and Tunisia (54 MW). Recent developments in Africa also include advanced projects in Kenya, Ethiopia and Tanzania[20].

According to a 'moderate' projection scenario covering the next two decades, wind power could contribute between 8.9% and 9.5% to world electricity consumption by 2020 and up to 15% in 2030[21]. The current share of wind power in Europe's electricity demand is between 4.5% and 5%. The annual increase in offshore wind power capacity is expected to eventually equal that of onshore capacity, although it is currently less than 10% thereof[22].

Major players globally and/or domestically

Several wind farm operators and owners have evolved over time from being relatively small project developers to large power producers. Global corporations such as General Electric, Siemens, Mitsubishi and the multinational oil companies are also becoming dominant players in the industry, investing large amounts in wind energy. Manufacturers worldwide have often opted for vertical integration, and many mergers and acquisitions have taken place to enhance the security of supply of key components. However, the splitting up of power companies in their power transmission and generation activities is promoted to eliminate over-concentration.

Table 3.1: Some of the major global turbine manufacturers

Manufacturer	Origin	Market share estimate	Website
Vestas	Denmark	13.5%	www.vestas.com
General Electric Energy	USA	13.5%	www.ge-energy.com
Sinovel	China	9.6%	www.sinovel.com
Enercon	Germany	8.9%	www.enercon.de
Goldwind	China	7.7%	www.goldwindglobal.com
Gamesa	Spain	7.2%	www.gamesacorp.com
Suzlon	India	6.9%	www.suzlon.com
Siemens	Germany	6.4%	www.siemens.com
Dongfang	China	5.8%	www.dongfang.com.chn
Nordex	Germany	3.0%	www.nordex-online.com
REpower	Germany	3.0%	www.repower.de
Others		14.5%	

Source: Authors and the South African Wind Energy Association (2010).

The operations of these companies are spread over approximately a dozen countries in Europe and North America, as well as in China, India and Brazil. Most of these countries already have significant wind power generating capacity, with only three having had less than 1 000 MW capacity in 2009.

The production of wind turbines and components in South Africa is still in its infancy. The few producers that are currently active in the industry are largely confined to experimental products and exhibit minimal production runs. However, the potential exists for increased production of wind energy components by a number of established factories and for the entry of new players. For example, existing foundries and steel manufacturers can, with some adjustments, produce rotors and other casting and steel towers.

Table 3.2: Some of the major South African turbine/components manufacturers

Manufacturers	Website address
African Wind Power	www.africanwindpower.com
Dorbyl	www.palmtreepower.com
General Electric	www.grinaker-lta.com
Green Power & Composites	www.gpcomposites.co.za
Grinaker LTA	www.johnthompson.co.za
Isivunguvungu Wind Energy Converter (I-WEC)	www.i-wec.com
Iskhus Power	www.iskhus.co.za
John Thomas Boilers	www.dcd-dorbyl.com
Kestrel	www.kestrelwind.co.za
Palmtree Power	www.palmtreepower.com
Siemens	www.siemens.co.za

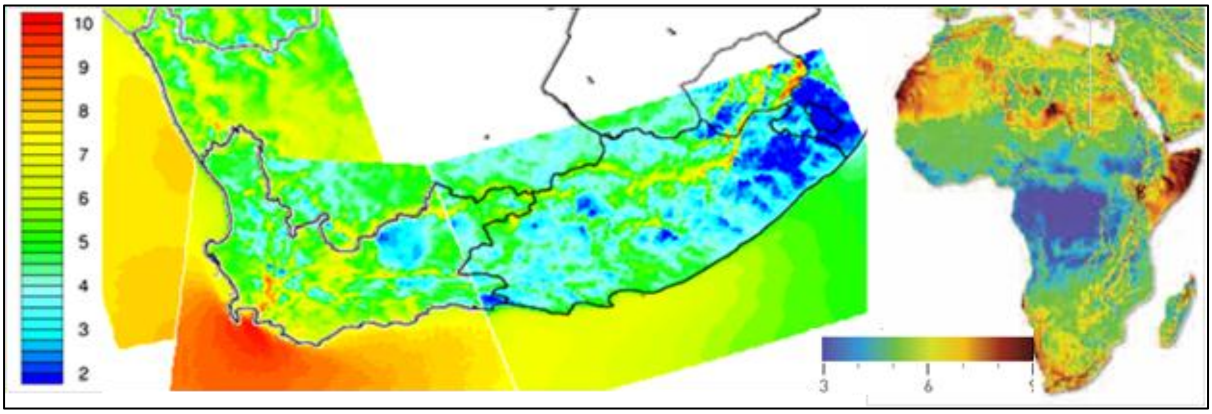
Source: Authors

Institutions that have shown strong interest in wind farm development in South Africa and that are involved in potential projects include: Eskom, IDC, DBSA, African Clean Energy Development, Macquarie, Genesis Eco-Energy, Mainstream, Electrawinds Belgium, The Oelsner Group, Umoya Energy, Safic/Accentuate, Suez, Investec and Inspired Evolution Investment Management.

Applicability to South Africa and/or the rest of Africa

According to the *Wind Atlas of South Africa 1995*[23], on which most estimates of wind power generation potential have been based, the recorded potential of wind power in South Africa is only moderate at best, thus limiting the expected future contribution to power generation. However, significant shortcomings have been ascribed to the available data[24] and an improved wind atlas was released by SABREGEN and CSIR in 2001.

Figure 3.3: Wind atlas of Africa and preliminary exposition for South Africa (wind speed m/s)



Source: Risø DTU and UCT (2010) (left-hand side), Global Wind Energy Council (2010 a) (right-hand side).

Wide-ranging estimates of the country's aggregate wind power generation potential have subsequently been put forward, with the results of more recent research having been much more promising. The wind power potential in some parts of eastern and northern Africa is, nevertheless, higher than in South Africa, although the surrounding grid and other support infrastructure are generally poorer in such areas.

The 5.2 MW Darling Wind Farm is South Africa's first commercial-scale, grid-connected wind generation project, consisting of four turbines with a 1.3 MW capacity each. Furthermore, Eskom runs an experimental 3.2 MW farm, generating around 5 GWh annually from three different units located at Klipheuwel in the Western Cape. Furthermore, a 1.8 MW wind turbine installed by Electrawinds at Coega started producing electricity in 2010. A number of wind power projects, adding up to between 5 000 MW and 10 000 MW depending on the stage of development, are in the pipeline for South Africa, with the earliest ones expected to start production in the next year or two.

Analysis of potential job creation

<u>Adaptation of generic methodology to the specific industry</u>
The estimation of the job creation potential in a future wind power generation industry was undertaken along the lines of the generic methodology. Whether employment opportunities would be created in the construction of the plants, in their O&M, or in the manufacturing of parts and components, the calculations are first and foremost based on the assumption that the number of jobs will be proportional to the capacity of the electricity generating plants involved. Thus, the envisaged capacity in terms of the size and number of turbines, determines the extent of construction activity and the quantum of component parts needed for the plant, as well as the number of maintenance staff eventually employed.

It was, furthermore, assumed that all jobs needed for the construction of plants in South Africa, as well as in their operation and maintenance, would be mostly supplied by the local labour market. On the other hand, it is assumed that half of the jobs created in the construction of some of the plants in other African countries will come from South Africa.

The capacity of wind farms would generally be between 50 MW and 100 MW, and O&M jobs are added from the second year after the commencement of construction, which would take around 18 months.

In analysing the potential of establishing a components manufacturing industry, it is necessary to take cognisance of the importance of a substantial and stable yearly demand for wind turbines in a country, as this is key in the decision-making by manufacturers to locate their plants in a specific country. A specific study[25] has estimated a prerequisite minimum of 150 MW to 200 MW in steady annual demand for at least three years in order to create a domestic wind technology manufacturing industry.

In the manufacturing of equipment, the share of local jobs in the total employment created is assumed to be determined by the capacity of the relevant local industries to supply parts and components. A wind turbine was, for this purpose, segmented into five major groupings of parts, each of which allocated a 'local capacity factor': one-third, two-thirds and 100%, respectively; referring to low-, medium- or high shares of supply (refer to table 3.4). The respective shares of the product groupings in the overall cost of a wind turbine, coupled with their local capacity factors, determined the number of jobs that could potentially be created domestically.

Lastly, employment numbers in domestic manufacturing are phased-in, assuming an increasing contribution of 40%, 60% and 80% by local industries in the short, medium and long term, respectively. An increasing contribution by South African manufacturing in the supply of wind turbine components to plants in the rest of the African continent is also built into the equation (ie 0%, 40% and 60% over the short, medium and long term, respectively).

Published data on employment figures and aggregate capacity in the USA, Europe and other countries with well-developed wind power industries, as well as average global figures, indicate that the average number of jobs per MW of power generation capacity ranges from 4 to 12. According to certain comparable international studies, as well as local estimates of employment potential[26], the average number of jobs per peak MW capacity derived by the CSIR[27] lies within the range of 3 to 11 for the manufacturing of plant and equipment, together with construction and installation activities, and between 0.2 and 0.4 for operations and maintenance.

Various studies concur with the dominant contribution made by manufacturing, indicating that around two-thirds of the number of jobs created in a wind power value chain is associated with such activities.

These figures have been accepted as a basis for estimating the employment potential, although they have been adjusted upwardly to some extent due to the following factors:

- Lower labour productivity in South Africa relative to the respective industrialised countries;
- Grid development will, to a certain extent, have to form an integral part of new generating capacity development and will contribute to job creation. An upgraded and expanded grid network, which will assist in enhancing competitiveness and energy security, is deemed essential;

- Apart from the grid, a whole new power sub-industry will have to be developed from scratch in South Africa. The assumption is made that it will be more labour-intensive initially (ie during the creation of largely new capacity) than in established wind farms in the long term;
- A significant number of jobs will be created by the demand for development, consultancy and engineering services, as well as in financial services and research and development activities that are largely included under the construction and O&M segments of the model; and
- Provision was also made for some jobs in the construction of community facilities that are essential for the operation of any wind farm.

The following ratios have therefore been utilised in estimating the employment creation potential associated with wind power: for construction employment, 1.5 jobs/MW capacity; for operations and maintenance, 0.5 jobs/MW capacity; and for manufacturing employment, 4.5 jobs/MW capacity. These add up to a combined total of 6.5 jobs per MW capacity.

Much higher job creation ratios have been estimated elsewhere, as high as 15 jobs per MW capacity installed[28]. However, these included manufacturing jobs created indirectly, while others make use of the average output capacity in MW, assumed to be around 35% of peak capacity, and thus leading to a significantly higher ratio of jobs per MW.

The South African Wind Energy Association (SAWEA) estimates the potential wind power capacity nationally to be as high as 30 000 MW in the long term, displacing 6 000 MW of coal-based electricity[29]. However, according to the IRP 2010 – 2030, which formed the basis for the employment potential calculations in this section of the report, the total contribution from wind power in South Africa is projected to reach 7 100 MW by 2025. This aggregate capacity was assumed to be generated by around 15 wind farms, with no distinction made between on- and offshore plants, although the possibility of some being offshore is not excluded.

Furthermore, the remainder of the African continent could offer opportunities for South African firms, firstly in activities related to construction and installation, but progressively those involved in the supply of components and parts.

<u>Results</u>

Table 3.3: Summary of net direct employment potential associated with wind energy

Activity	Short term			Medium term			Long term		
	Domestic	Export related	Total	Domestic	Export related	Total	Domestic	Export related	Total
Construction	251	0	**251**	490	53	**543**	919	75	**994**
O&M	50	0	**50**	510	0	**510**	2 056	0	**2 056**
Manufacturing	290	0	**290**	741	174	**915**	1 815	290	**2 105**
Totals	591	0	**591**	1 741	227	**1 968**	4 791	365	**5 156**

Source: Authors

The assumed supply potential (high, medium or low) of local industries and services is outlined below, also indicating the components and services to be supplied. It should be noted that many services not explicitly listed in the table below may also be involved in the development and operation of a wind farm.

Table 3.4: Potential contribution capacity of local industries

Industry	Product/services	Share in turbine cost[30]	Local capacity
Manufacturing:	**Production of:**		
Structural steel, cast iron, metal and cement products	Towers, frames, hubs	34%	High
Boat-, airplane-, glass fibre composites	Rotor blades, nacelle, other plastic and fibre glass products	26%	High
High-technology parts and machinery	Gearbox parts, shafts, bearings	18%	Low
Electrical and electronic equipment	Generators, transformers and other electrical components	15%	Medium
Metal products	Pitch, yaw and break systems, and other parts	7%	Medium
Construction and civil engineering	**Foundation laying, tower erection, housing**	-	High
Electricity distribution	**Grid connection**	-	High
Electricity generation	**Operations and maintenance**	-	High
Logistics	**Transportation of very large components**	-	Medium

Source: Authors

Ease of introduction of technology into South Africa

Implementation challenges

Material challenges could continue to slow down or constrain the development of a substantial wind power industry in South Africa, but many positive factors are contributing to balancing the process. As such, it is assumed that the first wind-generated electricity associated with the roll-out envisaged in this report will be supplied in 2012.

The viability of a wind farm depends on a reliable and sufficient income stream, which is directly influenced by the frequency and quality of the wind power available. Traditional estimates of the wind power potential in South Africa, which were based on suboptimal measurement conditions, indicated only a moderate potential, while more recent analyses point to significantly higher potential. The release of a revised and improved wind atlas, which is currently being developed[31], is expected within the next three years. Notwithstanding the uncertainty around the wind power potential and thus its competitiveness, studies have found that prices would compare favourably with, or be below those of coal-fired energy within the next decade[32].

A shortage of skills in certain professional fields pertinent to wind power generation presents a challenge that must be overcome.

The feeding of power into the grid and its transmission pose potential problems, depending on the geography, as the windiest sites are often located far from user markets. This includes the efficient integration of wind power into the system, which should allow for flexibility on the demand as well as the supply side. South Africa's existing infrastructure would need to be adapted for wind power variability, although it should initially be able to absorb a significant volume of additional electricity from wind farms[33].

The logistics involved in transporting the very sizeable parts, especially the rotor blades and tower, could also prove challenging, particularly if construction needs to be undertaken on rough terrain.

South Africa is in a position to leverage upon some of its existing manufacturing capacities in order to produce components and parts for various sections of wind turbines, especially its industries involved in the production of steel and metal products, as well as the boat building and electrical industries. Local manufacturing capacity can be promoted through engagement with established global manufacturers. However, critical mass would have to be developed in order to obtain economies of scale.

Considering the small size of the local market, tapping market penetration opportunities in other African countries with higher wind power potential could make an essential contribution to improving economies of scale and enhance the local industry’s chances to succeed. Participation in construction activities, in power transmission/distribution activities and in developing further the generation capacity, would be obvious areas for South African involvement in the rest of the continent.

A common observation from global experience is that investments in wind farm development and related manufacturing capacities gain momentum through the application of long term, proactive and stable policies. Conversely, policy uncertainty and lack of financial support generally have an adverse impact on potential industry development.

For instance, the following incentive measures have been instrumental in many countries:

- A ReFIT by means of which all wind power is bought at a price fixed by the government for a long period of time, say 20 years;
- An upfront investment tax credit on a wind project’s capital cost, or an energy production tax credit on the amount of renewable energy generated;
- A cash grant option to support development;
- The stipulation of a mandatory market share of electricity from certain renewable sources;
- The fixing of installed capacity targets for identified resource rich regions, giving grid connection priority to renewable energy sources and thereby addressing the transmission challenges; and
- A mandate to source a determined share of the wind turbines’ content locally.

South Africa has made significantly progress on the road to establishing a wind power industry. Government has clearly stated its commitment, mainly by establishing the necessary institutions and progressing with the implementation of the REPP. Future electricity price increases would also contribute to the viability of wind power. Consequently, a number of renewable energy companies are investing in the development of a dozen or more local wind power projects.

Key policy implications

For the successful development of a wind power industry and related manufacturing in South Africa, certain crucial measures are needed to create an environment that is conducive to rising investment in generation capacity, to the development of economies of scale and declining costs. However, the development of the regulatory framework that will put in place the necessary renewable energy procurement mechanisms, as well as provide an adequate regulatory environment and support to ensure sufficient progress in the development of a wind power industry in South Africa, has been experiencing bottlenecks.

Potential remaining stumbling blocks would have to be ironed out, for example:

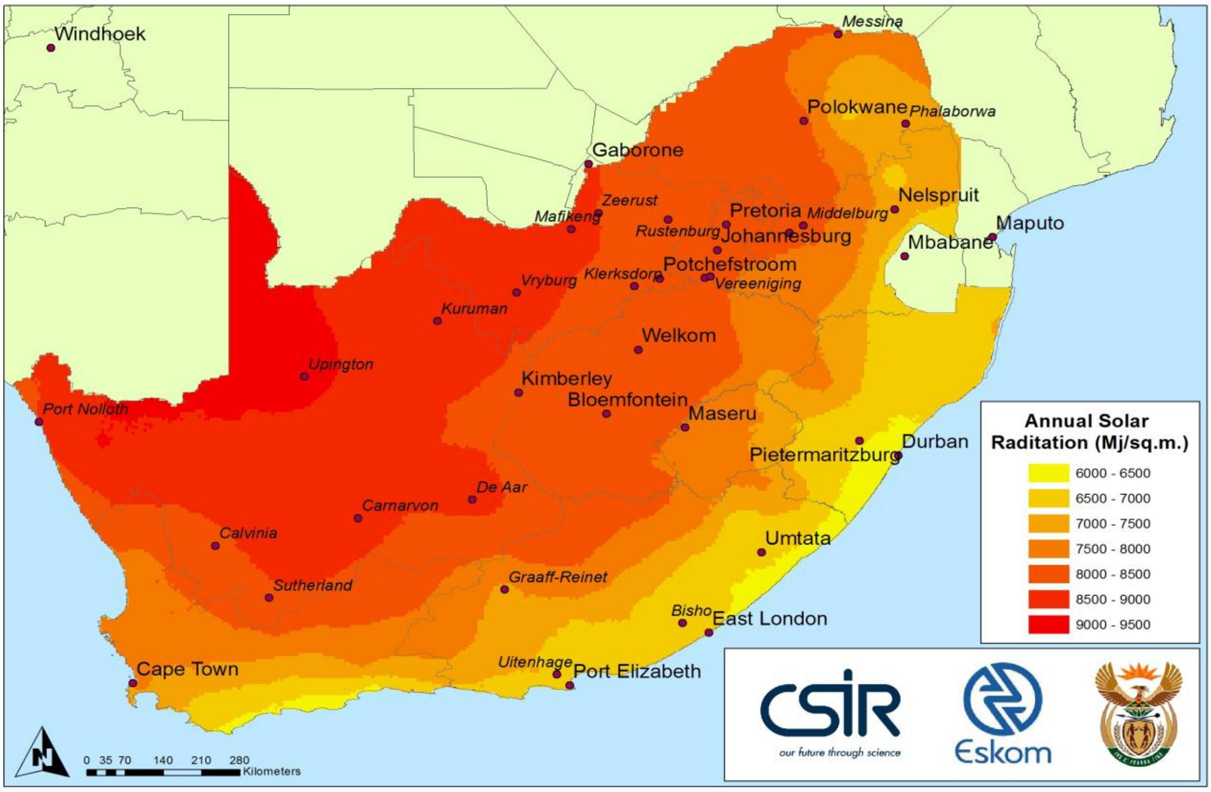
- Current high steel prices are increasing the cost of the construction of wind turbines, as well as the manufacturing of its components;
- Ensure that land approvals do not delay the development process; and
- Expedition of EIAs and water use permits by the respective authorities.

Government's commitment to renewable energy, and wind power in particular, has to be followed up by reasonable short, medium and long term milestones incorporating infrastructure plans and other appropriate measures such as financing mechanisms to meet the investment requirements and reduce the risks for developers. Due to the small size of the local market, the strategy should be regionally focused, aiming to explore markets in other African countries with significant wind potential.

3.2 SOLAR POWER

Solar power is forecast to be the dominant form of renewable energy by 2030. There are three types of technologies employed in the solar energy industry vying for dominance, namely concentrated solar power, silicon wafer based photovoltaics and thin film photovoltaics. Technological leadership is determined by the efficiency of the system.

Figure 3.4: South African Renewable Energy Resource Database – annual solar radiation



Source: South African Renewable Energy Resource Database (SARERD)

Regardless of the unit of measurement, South Africa has one of the best solar resources globally. According to Greenpeace[34], "[t]*he best solar resource in the world is in the deserts of South Africa and Chile where direct sunlight provides almost 3 000 kW/km^2 a year*." The Department of Minerals and Energy[35], in turn, places South Africa's annual direct normal irradiation (DNI) between 2 500kWh/m^2 and 2 900kWh/m^2, again amongst the very highest in the world. The accompanying map illustrates the country's annual solar radiation, which is substantially higher in most of the Northern Cape province and large parts of the North West province.

3.2.1 Concentrated solar power

Historical progress/maturity

Concentrated solar power (CSP), also referred to as solar thermal power, is a considerable source of renewable energy. CSP plants produce energy by concentrating the sun's rays into the plant. The steam is used to rotate a turbine that is connected to a generator, producing electricity to run through a traditional electricity grid[36]. CSP plants are suitable for peak-, mid-merit-, as well as base-loads, depending on their ability to store thermal energy or co-fire with fuels. They range from 50 to 280 MW in size. Although larger ones can be constructed[37], beyond the 280 MW mark the economic merits apparently become marginal.

There are four types of CSP technologies, namely parabolic troughs, central receivers/towers, concentrating dish/Stirling engine systems and linear Fresnel reflectors[38]:

- The first CSP plant to be developed involved the parabolic trough system and, therefore, this is the most advanced and most commonly found type of technology. Parabolic troughs make use of linear parabolas, which are mirrors that reflect the sun's rays and direct them towards a tube that is situated at the centre of the trough's arc. The tube gets heated up by the reflected sunlight, which then heats up the fluid inside the tube to temperatures of approximately 400°C. A collection unit inside the trough collects the hot fluid from the tube. In a heat exchanger the fluid passes the heat over to water to generate steam that powers the turbines[39]. Troughs are usually arranged along the north-south axis to enable them to follow the sun from sunrise to sunset. The nine CSP power plants built between 1984 and 1990 in California, with more than 350 MW installed capacity, are still in commercial operation.

- Central receivers/towers systems use flat mirrors instead of parabolic mirrors to direct the sun's rays onto the central tower. The fluid inside the central tower is then heated up to a temperature of up to 650^{o}C. The fluid again passes a heat exchanger, causing the water to generate steam and powering the turbine and to create power[40]. The first central receiver plant, with a 0.5 MW capacity, was constructed in Spain in 1981. This was followed by several others built in France, Italy, Japan, Russia and in the USA[41]. The first commercial plant, with an 11 MW capacity, was also built in Spain by Abengoa and was commissioned in March 2007. Abengoa has subsequently built a 22 MW plant and is planning to build four units for a total of 600 MW in the near future.

- Concentrating dish/Stirling engine systems make use of parabolic mirrors, shaped in satellite-dish form, to focus the sun's rays on a single area. At this focal point, temperatures as high as

750°C heat up the air or thermal fluid inside the Stirling engine, causing it to rotate and to produce power[42].

- A linear Fresnel reflector system works in a similar manner to parabolic troughs, except that this system uses flat mirrors that rotate to direct the sun's rays towards a collector in the system. The collectors are filled with water that, when heated up, generates steam to produce power. Linear Fresnel reflectors are more cost effective because flat mirrors are cheaper than parabolic mirrors[43]. However, the concentrating efficiency is not as high because of the reduced focus capabilities of flat mirrors.

Because CSP is basically a method of heat generation, it can also be used in a hybrid configuration with gas or steam based power systems, including oil or natural gas fired power stations and industrial heat applications, which enables them to operate even when there is no sunlight.

Advantages/disadvantages

The advantages of CSP include:

- CSP plants are almost fixed cost power generation resources;
- The technology is, for the most part, quite familiar. It uses a conventional steam cycle similar to that utilised in coal power stations;
- A CSP plant can be rolled out in less than two years;
- CSP is the only large-scale renewable technology with integrated energy storage, depending on the thermal liquid used (ie central tower receivers);
- The economies of scale associated with CSP plants;
- There is significant potential for localisation, particularly of the collector field, which makes up 40% of the plant in value terms; and
- Can be hybridised with existing or new fossil fuel plants (gas, as in the case of various existing plants, or more experimentally, coal), resulting in cost savings and improved availability.

The disadvantages of CSP include: high initial capital costs; and substantial water requirements for large scale installation, unless the plant is dry-cooled or, as in the case of concentrating dish/Stirling engine systems, water is not used.

The following technology trade-offs are involved:

- Two-axis tracking systems like those used for central receiver technology are more efficient, but cost more (in terms of m^2 of collector surface) than single-axis tracking, as used in parabolic troughs and in linear Fresnel technologies;
- Thermal storage adds an additional capital cost, but reduces the levelised energy cost by significantly improving the capacity factor of a plant; and
- Dry cooling saves a significant amount of water, but at the cost of some of the plant's energy efficiency.

Brief overview of global usage

In the past five years, the industry has grown rapidly from a novel technology to one that is becoming a most important energy generation solution. According to the Renewable Natural Resource Foundation[44], approximately 436 MW of the world's electricity generation was sourced from CSP in 2008, with this quantum expected to rise to at least 1 000 MW by 2011, when projects under construction, mostly in Spain, come on line.

The Emerging Energy Research Report states that new projects of over 7 010 MW are in the pipeline and will be commissioned by 2012, mostly in Spain (41%) and the USA (44%)[45], while only 10% will be in the Middle East, 3% in Africa, and 2% in the Asia-Pacific region.

Two plants in North Africa (ie in Morocco and Algeria) use 20 MW solar components in a hybrid configuration with an integrated combined-cycle gas-fired plant, but solar thermal could also be used in conjunction with pulverised or gasified coal in a combined cycle, in each case providing steam preheating.

Major players globally and/or domestically

Table 3.5: Some of the major international companies

Developers, suppliers & producers	Origin	Website Address
Abengoa	Spain	www.abengoasolar.com
Acciona	Spain	www.acciona.com
Areva	France	www.areva.com
Ausra	United States	www.ausra.com
BrightSource Energy	United States	www.brightsourceenergy.com
Concentrix Solar	Germany	www.concentrix-solar.de
eSolar	United States	www.esolar.com
Siemens	Germany	www.siemens.com
SkyFuel	Unites States	www.skyfuel.com
Solar Millennium	Germany	www.solarmillennium.de
SolarReserve	United States	www.solar-reserve.com
SolarTron Energy System	Canada	www.solartronenergy.com
Stirling Energy Systems	United States	www.stirlingenergy.com
Wizard Power	Australia	www.wizardpower.com.au

Source: Authors

Eskom is currently the main industry player in South Africa, but the country has also seen interest from major global players including Siemens and Areva, who have both diversified into CSP through acquisitions.

Applicability to South Africa and/or to the rest of Africa

CSP is a proven technology which is suited to South African conditions and has the potential for development on a large scale. Electricity generation based on the abundant solar resources in the country, in conjunction with the development of appropriate skills and manufacturing capacity, could enable the development of a competitive advantage for the country in the CSP market[46].

To date, only one CSP plant has been installed in South Africa, specifically the 25 kW solar dish with a Stirling engine located at the premises of the DBSA in Midrand, which was decommissioned in 2008.

Besides Eskom's pursuit in developing a 100 MW central receiver design CSP plant[47], there are numerous other initiatives in this arena, including:

- The Clinton Climate Initiative is partnering with the Department of Energy to set up a solar park in the Northern Cape, which could add up to 5 GW to South Africa's electricity generation capacity[48];
- Siemens is conducting a feasibility study on a potential 120 MW CSP plant in the Northern Cape, which could be commissioned by 2015; and
- The IDC is a developer in four CSP plants with the intent to take equity.

Additional likely participants in the local market include Exxaro, Group 5 and Shanduka Energy.

Analysis of potential job creation

Adaptation of generic methodology to the specific industry

The potential roll-out of CSP in South Africa was firstly determined, since the employment outcomes would be calculated in relation to the installed generation capacity. Three studies have estimated the potential overall generation capacity of CSP in South Africa, specifically: Eskom estimated that the country has a potential generation capacity of 58 000 MW (58 GW); Thomas Fluri from the University of Stellenbosch estimated a potential generation capacity of 547 600 MW (547.6 GW) [49]; while the University of Cape Town's Energy Research Centre estimated 133 000 MW (133 GW) of power. However, over the timeframe under consideration, South Africa will not reach the lowest estimated potential.

The second step involved determining the number of plants that could be built in South Africa in the short, medium and long term. While the IRP 2010 – 2030 only makes provision for 1 200 MW of CSP to be built by 2025, the IDC is already involved in projects amounting to more than 200 MW, while the Solar Parks initiative initially targets 1 000 MW, with a final target of 5 000 MW from various solar technologies, of which CSP will be a significant portion. This report therefore assumes a constant growth in new capacity of 30% per year, from a base of 100 MW (the annual allocation in the IRP 2010 – 2030) in 2014 to 640 MW by 2021. From 2022 onward, the annual installation capacity is capped at 800 MW, taking the long term total to 5 620 MW by 2025.

From an export perspective, the CSP capacity that could be built in the rest of Africa was ascertained, specifically in Namibia and Botswana due to abundance of sunshine and the potential roll-out of CSP plants in the near future in these two neighbouring countries. It was assumed that such a roll-out would begin in 2016 with 50 MW, progressing towards a combined annual installation total of 400 MW in 2025. However, only half of this capacity would be built by South African firms, which were assumed to win 50% of the contracts due to proximity and other competitive advantages.

According to IDC analyses, the minimum sizes for economically viable plants are 25 MW for tower systems and 50 MW for trough systems. These take about 2 and 2.5 years to build, respectively. It should be noted that no differentiation is made between the various potential CSP technologies in the employment potential calculations.

The number of jobs expected to be created through the roll-out of CSP in country was calculated using jobs/MW ratios derived from projects bidding for a REPP allocation where construction and O&M are concerned, and informed by the Greenpeace report[50], which is in line with the ratios for projects in which the IDC is involved, in the case of manufacturing activities:

- Construction – 21.6 jobs/MW;
- O&M – 0.54 jobs/MW; and
- Manufacturing – 14.4 jobs/MW.

Considering the time taken to build plants with the two technologies (ie 25 MW tower and 50 MW trough systems), as estimated by IDC project analysts, 18.75 MW could be built, on average, within a year.

The employment potential in manufacturing would include the production of some of the following components: mirrors, absorber tubes, steel structures, frames and pylons, control systems, turbines, generators, cooling systems, pipes, fire systems, heaters, pumps, storage tanks, water pipelines, and transmission lines/cabling.

Results

Table 3.6: Summary of net direct employment potential associated with concentrated solar power

Activity	Short term			Medium term			Long term		
	Domestic	Export-related	Total	Domestic	Export-related	Total	Domestic	Export-related	Total
Construction	0	0	**0**	176	2	**178**	757	16	**773**
O&M	0	0	**0**	146	1	**147**	1 626	7	**1 633**
Manufacturing	0	0	**0**	117	15	**132**	504	104	**608**
Totals	0	0	**0**	439	18	**457**	2 887	127	**3 014**

Source: Authors

The job creation potential is relatively low in the medium term, largely because the technology is still being introduced, whilst specific manufacturing capabilities are progressively developed. However, the employment potential increases in the long term due to economies of scale driven by the larger number of CSP plants under construction. O&M activities exhibit the largest potential for job creation in the long run.

Ease of introduction of the technology into South Africa

Implementation challenges

- The introduction of CSP technologies will require specific skills sets, which will have to be sourced externally in the initial stage and gradually developed locally.
- Depending on the technology utilised, the large scale roll-out of CSP may require substantial amounts of water for plants that are wet-cooled, a resource that is in relatively limited supply in South Africa. Dry cooling technologies significantly reduce the demand for water, but reduce plant efficiency.
- Considering the likely locations of CSP plants, grid connectivity will have to be addressed and transmission capacity strengthened.

Key policy implications

- A way of supporting the roll-out of this technology is through the establishment of solar parks, where grid connections and the issuing of permits are done on a collective basis to achieve lower development costs.

- Pursuit of technological cooperation initiatives at the bilateral and multilateral levels in order to facilitate the roll-out of technologies in South Africa and increase its localisation.
- Research and development support in order to maximise the potential for technology improvements, specifically with respect to energy storage, dry cooling and cost reduction.

3.2.2 Photovoltaic power

Historical progress/maturity

Silicon wafer based photovoltaics are the predominant technology based on current installed solar capacity. A solar cell (also referred to as a photovoltaic (PV) cell) is a semi-conductor device made out of polysilicon that consists of two layers of semi-conductors: one that is negatively charged; and the other being positively charged. When light is shone on the semi-conductors, the electric field across the line where the two layers meet triggers the flow of electricity in the shape of direct current. The intensity of light determines the rate of electricity flow. The cells in a PV system constitute the core and are combined to form a module. Inverters are used to transform the electricity from direct current to alternating current.

There are two major types of PV cells, namely crystalline silicon and thin film. The most widely used cells are the crystalline silicon cells made from ingots, sliced silicon or from grown ribbons. They have a high efficiency (ie the amount of radiation that is converted into electricity), with some silicon cells recording in excess of 20% efficiency.

Indications are that thin film technology will assume greater importance in the solar PV market in the medium to long term, with this potential associated with low material usage, low weights and a smooth appearance. Thin film modules are made by depositing thin layers of photosensitive materials on inexpensive base materials like glass, plastic or steel. This makes thin film cheaper and more amenable to automation in the manufacturing process. However, the cheapness of thin film solar cells is offset by the lower efficiency of the technology and the larger space requirements relative to crystalline modules for the same power generation. The efficiency of thin film modules ranges from 5% to 11%, while that of wafer-based crystalline modules varies between 12% and 19%.

Nevertheless, new research on thin film technologies is apparently yielding products with higher efficiencies. This applies to the thin film solar panels developed at the University of Johannesburg, whose pilot module has a 10% to 12% efficiency range and is targeting further improvements. However, the product is yet to be produced in commercial quantities and achieve market penetration.

Concentrator cells are a key efficiency improving technology for both thin film and crystalline silicon PV solar products. These cells operate by focusing light onto a small area utilising a concentrator such as a lens. The latter can have a concentration ratio of up to 1 000 times. These cells have higher efficiency ratios, ranging from 30% to 40%, but tend to fail to operate if the sunlight is diffused and must face the sun directly through a tracking system.

Advantages/disadvantages

South Africa in its entirety has almost 300 days of sunshine per year, making it an ideal location for solar PV plants. Moreover, a PV system can operate on cloudy days, albeit on a reduced power output, since it does not require direct light to function. The usefulness of solar PV also lies in the fact that it generates electricity during daytime, which is typically a period of high demand, if not peak demand.

Other advantages of solar PV systems include:

- Plants are almost fixed cost power generation resources;
- Relatively swift roll-out;
- Economies of scale can be achieved;
- There is significant potential for localisation;
- Minimal use of water (which is important for a water-stressed country);
- Low maintenance; and
- Absence of harmful gases in energy generation, as well as noise pollution.

However, a few disadvantages are associated with the use of solar PV for electricity generation, including:

- Efficiency declines markedly on cloudy days;
- Plants have significant upfront costs, although operating costs are lower;
- The inclusion of potentially toxic chemicals like mercury, lead and cadmium in the manufacture of certain thin film modules; and
- In order to generate high levels of energy, solar PV requires large tracts of land on which to lay the panels.

Brief overview of global usage

The solar PV industry recorded very rapid growth rates globally between 2004 and 2009, and is expected to play a key role in the world's energy supply over the next two decades or so. Furthermore, while worldwide investment in renewable energy as a whole fell by 6.5% in 2009, grid-connected solar PV registered more connections than in 2008. This was a direct result of the precipitous fall in the costs of solar PV panels (ie a 50% reduction in 2009, compared to 2008)[51].

Germany, Spain, Japan and California in the USA have installed the highest number of grid-connected solar PV. Collectively, they had 11 000 MW in solar PV capacity (or 85% of the global capacity) in 2008, adding 4 490 MW (equivalent to 83% of new global capacity added) in the same year alone. The solar PV industry employed almost 119 000 people across the globe, with employment figures estimated at around 220 000 in early 2010[52].

By 2010, more than 40 countries had a feed-in tariff policy designed to promote renewable energy. A number of countries, among them Japan and France, have set high targets for solar PV by 2020 or 2030[53].

Major players globally and/or domestically

Table 3.7: Some of the major players globally and in South Africa

Manufacturers	Origin	Website
First Solar	USA	www.firstsolar.com
Kyocera	Japan	www.kyocerasolar.com
Motech	Taiwan	www.motechsolar.com
Q-Cells	Germany	www.q-cells.com
REC Solar	USA	www.recsoalr.com
Sanyo	Japan	www.Sanyo.com/solar
Sharp Solar	Japan	www.Sharpsolar.com
SolarWorld	Germany	www.solarworld.de
Suntech	China	www.suntech-power.com
Yingli Solar	China	www.yinglisolar.com

Source: Authors

A joint venture involving Sasol, the Central Energy Fund (CEF) and the University of Johannesburg, among others, is investigating the feasibility of producing thin film solar PV panels in Paarl, Western Cape province, during the course of 2012.

Table 3.8: Some of the major players in South Africa

Manufacturer	Website
Kabi Energy	www.kabienergy.com
Solairedirect	www.solairedirect.co.za
Solairedirect	www.solairedirect.co.za
SolarTotal	www.solartotal.co.za
SolarWorld Africa	www.solarworld-africa.co.za
Tenesol	www.tenesol.co.za

Source: Authors

Applicability to South Africa and/or the rest of Africa

Certain parts of South Africa, particularly in the Northern Cape and North West provinces, offer the twin advantages of land availability and amongst the world's best solar radiation levels, making them ideal locations for solar PV power generation. However, the potential is not limited to these areas as the country in general provides very good solar conditions. In areas where land is scarce, rooftop applications should be considered as an alternative for the installation of solar PV panels.

Considering the relatively low cost of energy domestically and an abundance of minerals, South Africa could be an ideal location for the production of solar PV components, even at the upstream stages of the value chain. Photovoltaic grade silicon is used to manufacture solar cells that form the largest proportion of the solar module cost. The potential for local beneficiation of silicon is certainly worth investigating. Importantly, the domestic solar industry needs to expand in order to obtain the economies of scale required for a fully integrated production facility.

Analysis of potential job creation

Adaptation of generic methodology to the specific industry

It is assumed here that employment shares in South Africa will reflect the global ratios. SEREF[54] estimates seven direct full-time equivalent jobs per MW in the construction of a solar PV commercial/utility plant, while the manufacturing jobs figure, in turn, equates to 16.8 direct full-time equivalent jobs per MW. The ratio utilised for O&M employment is 0.7 jobs per MW[55]. Rooftop solar panels are not included in this analysis due to their individual small scale and unpredictable roll-out at this point in time. In line with the IRP 2010 – 2030, the assumed roll-out of solar PV capacity is 300 MW in the short term, 1 500 MW in the medium term and 3 100 MW in the long term, taking it to a total of 4 900 MW installed by 2025.

The construction of solar PV plants elsewhere in Africa is expected to provide market opportunities for a growing local industry and to support employment creation. In this regard, it is assumed that the participation by South African firms would be equivalent to 10% of the MW installed in South Africa per se in the short term, 20% in the medium term and 30% in the long term. This would probably be concentrated in Namibia and Botswana. On the construction front, it is assumed that 10% of the jobs associated with the solar PV roll-out in the rest of Africa would be filled by South Africans and the remainder by local workers. In manufacturing the employment outcomes would fully benefit the South African component supplier industry, whilst in operations and maintenance only 5% of the total O&M jobs will be filled by South Africans, largely in the higher skills categories.

Results

Table 3.9: Summary of net direct employment potential associated with solar PV

Activity	Short term			Medium term			Long term		
	Domestic	Export-related	Total	Domestic	Export-related	Total	Domestic	Export-related	Total
Construction	1 050	7	**1 057**	2 100	42	**2 142**	2 713	81	**2 794**
O&M	70	1	**71**	770	7	**777**	2 258	26	**2 284**
Manufacturing	2 520	168	**2 688**	5 040	1 008	**6 048**	6 510	1 953	**8 463**
Totals	3 640	176	**3 816**	7 910	1 057	**8 967**	11 481	2 060	**13 541**

Source: Authors

In terms of overall job creation, the solar PV industry is expected to be among the top generators of new direct employment within the emerging renewable energy industry. Manufacturing presents the greatest potential for employment gains in the solar PV industry, particularly in the medium to long term. Employment is likely to be concentrated in the production of modules, which entails combining solar cells to form modules that are then assembled into larger units called arrays. It is at this stage that various PV systems are assembled, with different applications and power output. Automation is still at an early stage, but as the industry grows it is expected that the employment intensity of manufacturing will decline. Although future automation could have a significant impact on the employment figures the extent is currently unknown.

Ease of introduction of the technology into South Africa

Implementation challenges

- EIAs, while necessary, tend to delay larger projects due to bureaucratic bottlenecks and carry the potential to derail some projects.
- The success of localisation will rely on the availability of the relevant skills.
- Grid connectivity will have to be addressed and transmission capacity may have to be strengthened in certain locations.

Key policy implications

- Access to the grid requires urgent attention. In similar vein to solar CSP, the establishment of solar parks could facilitate the roll-out by easing connectivity and lower development costs through collective processes such as the issuing of permits.
- Pursuit of technological cooperation initiatives at the bilateral and multilateral levels in order to facilitate the roll-out of technologies in South Africa and increase its localisation.
- As evidenced by ongoing research projects locally, R&D support may lead to technology improvements that will raise efficiencies and lower costs.

3.3 WASTE-TO-ENERGY

Considering the large amount of waste being placed into landfills in South Africa each year[56], the adverse environmental implications are substantial. Furthermore, the land area required for landfill purposes is significant and the availability of appropriate sites is becoming progressively limited.

A small number of municipalities are also facing a situation in which their landfill space will be filled in the short term, although most do appear to have sufficient space from a medium term perspective. With continued opposition to the establishment of new landfills, municipalities are increasingly under pressure to reduce the amount of waste that needs to be landfilled.

The waste currently being dumped in landfills has the potential to be converted into energy in the form of gas or electricity. The usage of waste for the production of energy will contribute towards addressing, simultaneously, three challenges facing South Africa at present, specifically the limited availability of landfill space, the country's energy supply constraints and its future requirements, and the detrimental impact of waste deposits on the environment.

There are various methods of extracting energy from waste, depending on the type of waste under consideration and its specific location. The methods analysed in this section of the report are:

- The extraction of landfill gas from existing landfills;
- Biomass combustion using mainly waste wood;
- Anaerobic digestion using farm, industrial, sewerage and municipal organic waste;
- Pyrolysis/gasification using almost all other solid waste; and
- Cogeneration, which uses the waste gases from industry.

3.3.1 Landfill gas

In simple terms, a landfill is a large hole made in the ground for the purpose of storing solid and/or liquid waste produced mostly by households, as well as the business segment and the public sector at large. The various types of landfills include: municipal solid waste (MSW) landfills; open dumps; construction and demolition waste landfills; hazardous waste landfills; vegetation waste disposal areas; and animal waste landfills.

Landfill gas (LFG), which is also referred to as landfill methane, is the gas released from landfills due to the natural decomposition of waste. LFG contains between 40% and 60% of methane (CH_4) and the balance is largely CO_2. The methane emitted from landfills presents a valuable energy resource that can be recovered and utilised in various ways. Furthermore, important benefits of an environmental, economic and safety-related nature are also associated with the reduction of methane emissions.

Historical progress/maturity

The use of landfill gas began in the 1970s, when oil shortages led to a search for alternative sources of energy. However, it was not until the 1980s and 1990s that LFG projects mushroomed.

The industry has matured significantly, with three technologies being widely used to produce landfill gas, specifically:

- Bacterial decomposition: this occurs when organic waste is broken down by bacteria naturally present in the waste and in the soil used to cover the landfill;
- Volatilisation: the gases are created when certain wastes, particularly organic compounds, change from a liquid or a solid form into a vapour; and
- Chemical reactions: these entail reactions of certain chemicals present in waste.

The system of extracting LFG involves a series of wells and pumps that channel the collected gas towards a particular point for processing purposes. The gas can subsequently be flared, utilised for the generation of electricity, improved to natural gas form or used as an alternative fuel for vehicles.

Flaring is the most widely used method for the mitigation of LFG emissions. It involves either open flame flares, which is the simplest technology, or the more complex and expensive enclosed flares technology.

Efficiency in landfill gas collection is a critical aspect of landfill design and operation. The percentage of LFG generation that is collected is referred to as collection efficiency, and varies between 40% and 70% depending on the design and operation of the disposal site. In order to maximise the LFG collection efficiency, it is crucial that the design of the landfill site take into consideration the following factors:

- Control of off-site migration of methane through surrounding soils;
- Odour control;
- Energy recovery; and, among others,
- Control of greenhouse gas emissions.

For the active gas collection to be effective, it must incorporate the following design elements:

- Gas-moving equipment that is capable of handling the maximum landfill gas-generation rate;
- Collection wells that are placed to capture gas from all areas of the landfills. However, the number and spacing between each extraction well depends on the type of waste, its depth and compaction; and
- The ability to monitor and adjust the flow from individual extraction wells. This requires the inclusion of a valve, pressure gauge, condenser and sampling port at each collection well, which allows a landfill operator to monitor and adjust pressure and to measure gas generation and content.

Advantages/disadvantages

The extraction of methane gas from landfills involves capturing an extremely harmful gas and using it to generate electricity or propel vehicles, with a significant reduction in the harmful gases that are released into the air. The capturing of landfill gas can be done on existing landfills or incorporated into new landfills. There is no need for any additional actions to achieve the production of methane, thus making it easier to operate.

Complex and expensive gas scrubbing equipment is required to remove contaminants that are damaging to engines and turbines used in power generation equipment. This equipment, while essential in gas utilisation, increases significantly the capital investment requirements and may, in many instances, render projects financially unattractive.

A concern related to landfill gas extraction is that it does not extend the life or capacity of a landfill. Thus, the life of the plant is limited to the period during which the material is being decomposed. Landfills do not encourage recycling and toxic materials can still be found therein, making it hazardous for pickers who make a living from waste collection.

Brief overview of global usage

The USA, China, Russia, Canada and the south-east Asia region are currently the main contributors of methane emission from MSW. However, it is projected that methane emissions from landfills elsewhere in Asia, as well as in eastern Europe, will increase steadily in light of growing populations, although there are shifts towards the efficient management of landfills. The efficient management of landfills involves, among others, the extraction and flaring of landfill gas to produce heat and electricity.

The majority of developed countries have legislation to control landfill emissions and combat LFG. Some of the landfill gas reduction efforts include the provision of financial incentives to promote the usage of electricity derived from LFG, to have standardised and streamlined interconnection policies, as well as to improve waste management regulation.

Major players globally and/or domestically

Table 3.10: Some of the major players globally

Global player	Origin	Website address
Beacon Landfill Gas	United States	www.beaconlfg.com
Biogas UK	United Kingdom	www.biogas.co.uk
HAASE Energietechnik AG	Germany	www.haase-energietechnik.de
Hofstetter AG	Switzerland	www.hofstetter.ch
GE Energy	United States	www.gepower.com
Wardell Armstrong LLP	United Kingdom	www.wardell-armstrong.com
WSN Environmental Solut	Australia	www.wsn.com.au

Source: Authors

In South Africa, Envitech Solutions has been awarded two separate contracts for the design, installation and commissioning of landfill gas extraction and flaring systems, as well as electricity generation plants, at the Marianhill and La Mercy landfill sites, respectively. An additional local player is Contra Odour, a sister company of Agaricus Trading and affiliated to GE Jenbacher gas engine technology.

Applicability to South Africa and/or the rest of Africa

The progress of landfill operations in South Africa has generally been significant since 1994, involving the use of engineered lining systems, advanced pollution detection methods, leachate treatment plants, odour management systems, landfill gas to electricity generation and advanced rehabilitation methods. In certain cases, national conservation site registration has been achieved.

Despite the progress made in the domestic landfill industry, the potential of waste utilisation and conversion to energy is far from having been tapped. However, there is a gradual paradigm shift towards the use of landfill gas for energy production, since it is increasingly seen as an important alternative energy source for South Africa.

The country has now established several plants utilising waste to produce energy. An example is that of the Marianhill Landfill site, which is located in KwaZulu-Natal province and processes between 550 and 700 tonnes of waste daily. This waste is collected from nearby areas such as Pinetown, Westville, Queensburg and Kloof. The unit produces one megawatt of electricity, which is enough to supply more than 500 houses. The landfill is registered to trade carbon credits on world markets and has the potential to save R50 million over a ten-year period from the sale of such credits.

The EnviroServ Chloorkop GLB landfill site, situated in Kempton Park (Gauteng province), is yet another potential location for the production of landfill gas. The site is used for the disposal of approximately 1 500 tonnes of domestic waste by the Ekurhuleni Metropolitan Municipality, Pikitup and other parties on a daily basis. The site is expected to reduce gas emissions through the destruction of LFG by means of gas combustion. Methane, with a global warming potential of 21 times that of CO_2, will be transformed into CO_2, thus reducing the impact on the environment.

Analysis of potential job creation

<u>Adaptation of generic methodology to the specific industry</u>

Prospects for LFG-to-electricity generation in South Africa are relatively positive, considering that there are 57 potential landfill sites available for waste-to-energy generation. These landfills range from micro-sized (ie 660 kW capacity) to large-sized (ie 4 000 kW capacity) and are estimated to be capable of producing a total of 43 million m^3 of methane yearly, as well as delivering 83 GWh of electricity per annum.

The following analysis of potential job creation in the industry is based on the information derived from the Marianhill Landfill plant and pertains to existing landfills (ie the establishment of new landfill sites for MSW is not being proposed):

- Construction – The number of jobs created during the construction phase is based on an assumption that a landfill that receives between 550 and 700 tonnes of waste on a daily basis is likely to employ 12 people per MW.
- Operations and maintenance – Based on the Marianhill Landfill case study, a 1 MW plant is likely to create 36 job opportunities for the operation and maintenance of the landfill gas plant, while a 4 MW plant could create 51 jobs and an 8 MW plant some 66 employment opportunities. This includes the pickers who operate on a landfill site, sorting waste and extracting recyclable materials.

- Manufacturing – A typical 1 MW plant requires the following key components for its construction: extraction wells used to extract landfill gas; gas collection pipes; leachate pumps; flare units; landfill gas generators; switchgears, transformers and cabling. The manufacture of the components for a 1 MW plant would employ about 40 people, while a 4 MW plant would require 50 workers and an 8 MW plant around 60 people. The employment numbers are not directly linked to the total capacity of the plant being built. Considering the number of possible landfill gas plant sites in the long term, the country has the potential to manufacture the above mentioned components, including proven gas engines. Furthermore, local production is likely to be stimulated by expanding demand for components such as pumps, pipes, transformers and cables.

The construction times for the various plant sizes vary from one year for a 1 MW plant, to two years for a 4 MW plant and three years for an 8 MW plant.

The capture of LFG is assumed to be implemented at a relatively slow pace over the short to medium term, with one 1 MW plant installed in the short term, complemented over the medium term by the installation of a further three 1 MW plants, two 4 MW plants and two 8 MW plants. Up to the year 2025 (ie the long term), the pace of new plants is assumed to increase as the benefits and knowledge of the technology become clear, with the installation of nineteen 1 MW plants, four 4 MW plants and two 8 MW plants. The number of plants that can be built is limited by the assumption that no new landfills will be constructed in South Africa in future, and also by the fact that a certain size of landfill is required to make a project viable.

The potential for exports is limited, but there is some potential for the procurement of components from South African manufacturers. The size of the South African market is limited and, therefore, provides limited localisation potential in terms of access to international intellectual property rights, thereby constraining export competitiveness.

Results

Table 3.11: Summary of net direct employment potential associated with landfill gas

Activity	Short term			Medium term			Long term		
	Domestic	Export related	Total	Domestic	Export related	Total	Domestic	Export related	Total
Construction	22	0	**22**	63	0	**63**	85	0	**85**
O&M	18	0	**18**	214	0	**214**	913	0	**913**
Manufacturing	30	0	**30**	69	8	**77**	140	40	**180**
Totals	70	0	**70**	346	8	**354**	1 138	40	**1 178**

Source: Authors

Ease of introduction of the technology into South Africa

Implementation challenges

It is important to note that the use LFG technology is not without its challenges, with the main barriers including:

- Economic and technical obstacles in connecting LFG power projects to the grid;

- A significant number of landfill sites do not have permits, making it difficult to regulate the management of landfills;
- Insufficient awareness of the existence of LFG emissions and of the value of lost fuel;
- The use of landfill gas to generate energy and reduce GHG emissions is viable in South Africa, but only when carbon funding is sourced;
- Most waste-to-energy facilities have high capital costs and require technical expertise for maintenance purposes, requiring long contract periods to recover initial investment costs; and
- The establishment of a landfill gas project requires an onerous process of registering the project for carbon financing, lengthy EIAs and local government approval processes[57].

Key policy implications

The backlog in the issuing of permits for existing landfill sites, as well as other waste handling facilities, must be addressed in order to enable the proper development and regulation of landfills, with the aim of capturing most of the LFG. Considering the significant contribution of LFG to the greenhouse effect, policies should be implemented to promote the capture of such gases for conversion to electricity or, ideally, for use as fuel by vehicles.

3.3.2 Biomass combustion

Historical progress/maturity

Energy generation through biomass combustion takes place by means of the direct burning of material originally sourced from living matter such as plants, crops, trees, grass and even animals, as well as any related waste products from biological sources. Commonly used primary biomass includes sawdust or wood chips from trees, bagasse from sugar, rice husks, and waste from other agricultural crops.

The energy produced can be heat as such, or heat for the production of steam, which can be utilised in the generation of electricity, or in other energy consuming operations.

Biomass combustion processes are commonly used in industrial operations for various purposes such as drying, blowing, spinning or cutting, with heat, steam or electricity as the end-energy. Often used technologies include fixed-bed, fluid-bed and dust combustion, the application of which will depend on factors such as the types of biomass available, the size of the project and the investment per se. Furthermore, combustion fuel can be biomass alone, combined coal- and biomass-fired technology, or switching from coal-fired to coal and biomass-fired combustion. The biomass 'end-fuel' can vary greatly, from least-processed material such as dried wood or agricultural matter, to wood chips or dust, to pellets or briquettes.

Advantages/disadvantages

The comparable advantages of biomass as an energy source over other renewable energy sources lie in its significant base-load capacity potential and the fact that the energy source is despatchable. Its major disadvantages include: low energy density/conversion efficiency; a number of fuel supply risks; and competition from other biomass and land using industries. Transportation costs are critical for the competitiveness of biomass relative to other energy sources and, therefore, the most economical approach should be sought (where possible, utilising biomass on-site).

Biomass in the form of pellets has strong benefits over 'less processed' biomass, such as a lower moisture and thus higher energy content, while its higher density and uniform shape imply easier handling, less storage space and more effective feeding systems. Biomass briquettes or charcoal also offer these benefits, albeit to a lesser extent.

Brief overview of global usage

Heat and electricity generation from biomass combustion is a well-established and reasonably economically viable process. Nevertheless, incentives such as feed-in tariffs are commonly used in support of biomass operations around the world, especially small-scale projects. The usage of biomass as fuel is very popular in Europe, particularly in pellet form, while its application is picking up in the USA and other industrialised countries. In both cases, as well as in other parts of the world, good growth is forecast in the application of biomass energy over the next decade and longer.

Major players globally and/or domestically

Many international consultants and carbon funds are involved in the implementation of biomass projects in southern Africa, including ECON South Africa, EcoSecurities (Netherlands), GF Energy BV (Netherlands) and Highland Energy Inc (Canada).

South African firms include BioTherm Energy, NuPlanet Clean Energy, Cape Advanced Engineering (CAE), PACE Centre, Sustainable Energy Africa and The SouthSouthNorth Project. Apart from the South African government, Eskom, the Central Energy Fund (CEF) and the South African National Energy Research Institute (SANERI) have significant influence in the industry.

Potential players on the demand side could include most industrial concerns that are currently consuming fossil fuels for the generation of energy, although the largest concentration of such industries lies in the production of basic metals, paper, cement, bricks, glass and synthetic fuels.

Three prominent projects recently developed involve the generation of thermal energy for steam production by co-firing waste biomass with coal by Sappi as well as Mondi, and power generation by burning wood residues mainly from the 'Working for Water' initiative (ie the Southern Cape Cleaner Energy Project).

Applicability to South Africa and/or the rest of Africa

The increased application of biomass combustion technology for energy generation in South Africa or other parts of the subcontinent is indicative of its significant potential. Generation of heat for various purposes is taking place in many established manufacturing industries that have traditionally depended strongly on coal or gas as fuel, which can be replaced or supplemented by biomass. Such fuel switching or co-firing actions normally do not involve extensive plant rebuilding.

Additionally, a potentially huge market lies in the switch of Eskom's coal-fired power stations to making use of burning biomass pellets to satisfy at least part of its fuel needs. A major benefit from such projects, apart from the generic green technology facets, will be to provide a local market for South Africa's young biomass pellet producing industry.

The 'Working for Land' and 'Working for Energy' programmes could also supply feedstock, through the removed invasive alien plants, for the production of biomass electricity. It is assumed that 15%

of the biomass cleared in these programmes can be used for electricity generation, although transport cost considerations are also critical to the successful uptake.

Analysis of potential job creation

Adaptation of generic methodology to the specific industry

Employment numbers are estimated by project, with IDC experience having shown that around 30 construction jobs may be created per project[58]. Growth in project size should occur over time since this is a relatively new ‘industry’. It is thus assumed that the initial number of construction jobs per project can potentially increase by one-third in both the medium and long term. All the jobs needed for the construction of South African plants, as well as for their O&M, will be supplied by the local labour market. Half of the job creation associated with construction and manufacturing opportunities emanating from the projects considered for other African countries is assumed to benefit South Africans.

The jobs associated with ongoing O&M are expected to firstly involve the collection and supply of raw material (ie ten jobs per project), and secondly the handling and feeding activities at the plant itself (ie five jobs per project). The numbers are also largely based on IDC experience in projects of this nature.

The relatively minor modifications involved in these general fuel-switching or co-firing projects should only merit limited components manufacturing activity, which are assumed to be supplied by the local industry. It mainly involves changes to the material handling and feeding sections of the boilers. Accordingly, it is expected that only a small number of additional manufacturing jobs will be created (ie estimated at five jobs initially for relatively small projects), although rising as per the above-mentioned increments for larger projects over the medium and long term.

Furthermore, job numbers pertaining to local manufacturing are ‘phased-in’ in order to provide for an increasing contribution by South African manufacturing in the supply of components to plants in the rest of Africa (ie 0%, 40% and 60% penetration over the short, medium and long term, respectively).

The use of biomass from the ’Working for Land’ and ‘Working for Energy’ programmes will require dedicated plants to be built, with the assumption made that each will have a 5 MW capacity. The IDC’s experience in biomass combustion plants formed the basis of the estimates for construction and manufacturing related employment creation.

Indications are that the potential of fuel switching projects is considerably higher than that of co-firing (ie biomass/coal or biomass/gas) projects. The two types of adaptations have, nevertheless, been assumed to have equal additional employment requirements.

After consultation with project managers at IDC on the future potential for fuel-switch or co-firing projects, and with an external expert[59] on the roll-out of the ‘Working for’ programmes, the following project numbers were utilised:

- Short term – One co-firing and three fuel-switch projects in South Africa; none in other countries. No plants directly linked to the ‘Working for’ programmes are expected to be set up.

- Medium term – Two co-firing and ten fuel-switch projects in South Africa; plus one co-firing and two fuel-switch projects in the rest of Africa. A total of 20 plants directly linked to the 'Working for' programmes are expected to be set up.
- Long term – Five co-firing and 20 fuel-switch projects in South Africa; plus one co-firing and one fuel-switch projects elsewhere in the continent. A total of 60 plants directly linked to the 'Working for' programmes are expected to be set up.

Results

Table 3.12: Summary of net direct employment potential associated with biomass combustion

Activity	Short term			Medium term			Long term		
	Domestic	Export related	Total	Domestic	Export related	Total	Domestic	Export related	Total
Construction	60	0	**60**	416	12	**428**	757	13	**770**
O&M	45	0	**45**	14 005	0	**14 005**	36 346	0	**36 346**
Manufacturing	10	0	**10**	69	2	**71**	151	3	**154**
Totals	115	0	**115**	14 490	14	**14 504**	37 254	16	**37 270**

Source: Authors

It should be pointed out that the potential of Eskom introducing biomass co-firing at existing or new coal- or gas-fired power stations in the future has not been taken into account.

Ease of introduction of the technology into South Africa

Implementation challenges

- The co-firing of biomass and coal is difficult to achieve due to the varying calorific values of the materials, handling requirements as well as their dust content.
- The replacement of, for example, coal with pellets or other forms of biomass in industrial applications is probably a less complicated process than generally expected. Functional components differ to a little extent, with only relatively few and small changes required for the implementation of the technology.
- The supply of biomass raw material, both in terms of the form and the location where it is needed, presents challenges in the transportation and storage of the product.
- Such supply chains have not yet been developed, as for instance is the case in coal sourcing. Any supply uncertainty will make long term investments by utilities or other energy users very difficult to decide upon.

Key policy implications

To accommodate the further development of a biomass-based energy industry in South Africa, increased demand will have to be met through the development of the necessary volumes and a variety of wood and agricultural biomass sources, as competition for the material would increase. Initiatives such as 'Working for Water' could play a positive role in raw material supply in the short to medium term. Regional differences regarding local availability will determine raw material types.

3.3.3 Anaerobic digestion

Anaerobic digestion is the process of decomposition of organic material in the absence of air, usually at temperatures of between 30°C and 50°C. Methane gas is produced during the process of decomposition, comprising roughly 60% of the total volume of the gas, which is highly flammable. Through this process, the amount of methane released can also be controlled. There are two types of anaerobic digesters:

- Liquid digesters are usually less controlled and are able to accept any organic feedstock, liquid or solid. Liquid digesters can be of a lagoon type, which is cheaper, or of an industrial type, which requires less space; and
- Solid digesters normally have more control over the process, but can only accept solid waste such as garden, kitchen or agricultural waste. Solid digesters involve mostly dry-digestion and normally utilise an industrial type digester.

Historical progress/maturity

The first digestion plant built to capture the gas that is produced was put up in India in 1859. Thereafter it was adopted in the UK, where the gas was collected from sewerage treatment facilities to provide fuel for streetlamps. Since the 19th century, the knowledge base on this process has improved, with the technology being well developed at present.

Anaerobic digesters are used fairly widely in the rural and under-developed areas of the world, especially in China and rural Europe. Most digesters involve low technology and tend to be designed so as to capture gas from natural processes, while the more technologically advanced plants increased the control over the process and the production of methane gas.

Advantages/disadvantages

A key advantage of anaerobic digesters is that very few mechanical parts are involved, and that they rely on a natural occurring decomposition process, which can be controlled to some extent. The inputs for a digester are wide ranging, with any organic waste being suitable, although the inclusion of non-organic waste would not necessarily have an adverse impact on the operation of the digester, but will increase the maintenance requirements of liquid digesters.

The type of waste being utilised determines the process that will be followed, as well as the final product that remains after the gas has been extracted. The availability of skills will also determine the type of digester that will be used. The process of anaerobic digestion produces high quality biogas, which can be cleaned for usage in gas vehicles, or for the production of electricity by means of a gas engine, as well as for organic compost.

Some of the disadvantages of anaerobic digester plants are that the decomposing organic material produces a potent smell before going into the plant, limiting the potential locations that are deemed suitable for such plants in urban areas. Some digester designs, usually the more complex ones, also require that the feedstock be devoid of any inorganic materials, as the inorganic waste is usually larger in size than the organic waste, which could damage or clog the moving parts of the digester.

Brief overview of global usage

The use of anaerobic digesters is spread worldwide, from developed countries such as Germany and Switzerland to developing countries such as Kenya and China. The latter is estimated to have around eight million digesters that are being utilised to generate small scale electricity. The type of digester being utilised to capture the gas varies from the small, simple type, to large, more complex plants.

Major players globally and/or domestically

Table 3.13: Some of the major global suppliers/operators

Company name	Country	Website
ArrowBio	United Kingdom	www.arrowbio.com
Biogen	United Kingdom	www.biogen.co.uk
Bioplex	United Kingdom	www.bioplex.co.uk
BTA	Germany	www.bta-technologie.de
CAMBI	Norway	www.cambi.no
Dranco	Belgium	www.ows.be
Entec Biogas GMBH	Austria	www.entec-biogas.com
Farmatic AG	Germany	www.farmatic.com
Haase	Germany	www.haase-energietechnik.de
HiRAD	United Kingdom	www.hiradbioenergy.com
Kompogas	Switzerland	www.kompogas.ch
Kruger AS	Denmark	www.kruger.dk
Monsal	United Kingdom	www.monsal.com
Paques	Netherland	www.paques.nl
Passavant Roediger	Germany	www.passavant-roediger-anlagenbau.de
Preseco Oy	Finland	www.preseco.eu
RosRoca	Spain	www.rosroca.com
Schmack Biogas AG	Germany	www.schmack-biogas.com
UTS Biogas	United Kingdom	www.uts-biogas.co.uk
Valorga	France	www.valorgainternational.fr
Wehrle	United Kingdom	www.wehrle-env.co.uk
Xergi	Denmark	www.xergi.com

Source: Authors

Table 3.14: Some of the major South African suppliers/operators

Company	Website
Bio2watt	www.bio2watt.com
Cape Advanced Engineering	www.cae.co.za
Talbot & Talbot	www.talbot.co.za

Source: Authors

Applicability to South Africa and/or the rest of Africa

Anaerobic digesters are already in use in South Africa, for instance SABMiller recently installed an anaerobic digester to treat their waste water at the Alrode brewery. Some of the country's older waste water treatment plants are designed to capture the gas that is released through the normal anaerobic process of sewerage treatment, but this gas is currently not being captured nor used. There is currently an investigation at the Barberton Municipality to determine the viability of capturing the gas from their sewerage treatment plant for the production of electricity. This could make the treatment plant energy-independent, with a small potential to provide electricity to the city.

The use of anaerobic digesters on farms could have a significant impact on the rural landscape. The capture of gas and its use for electricity production can increase the yield of organic agriculture. The heat that is produced from the internal combustion engine that generates the electricity can be used to regulate the temperature in the greenhouse. The CO_2 produced by the engine will also be utilised by the greenhouse to boost the growth rate of the plants. In this configuration, the compost that is produced by the digester will have to be converted to aerobic compost, before it can be worked into the greenhouse, as well as any other field that the farming community has, since the compost that is produced usually exceeds the amount that a farm can absorb.

The electricity generated from the digester gas is normally more than what the farm can utilise. Thus, there is the opportunity of providing electricity to neighbouring farms, or to utilise less gas in the production of electricity and instead piping the gas to nearby rural settlements for use in cooking or in economic activities. The latter could improve living standards among communities and lead to higher levels of economic activity. The potential employment creation from these actions could be significant, while the electricity production alone should be sufficient to offset the costs of the plant.

Analysis of potential job creation

<u>Adaptation of generic methodology to the specific industry</u>
The construction of anaerobic digesters can be either very simplistic or complex, but, judging from interviews conducted with players in this field, the number of employment opportunities tends to be fairly consistent, regardless of size. Although the use of anaerobic digesters is fairly widespread elsewhere in the world, South Africa is lagging behind in this regard.

A typical commercially viable, farm-sized digester is capable of producing around 250 kW, depending on the quantity of feedstock available. The types of farms suitable for anaerobic digesters are livestock farms, where the collection of manure is not too difficult.

The size of industrial anaerobic digesters, in turn, would tend to depend on the quantity of waste that is produced, but would typically produce between 250 kW and 500 kW.

Larger digesters can produce significantly larger amounts of electricity, with the electricity generation potential ranging from 1 MW to 10 MW. These large-scale digesters will require multiple sources of feedstock, such as greens[60] from a combination of municipal waste, sewerage sludge, manure and waste from food processing plants.

The employment potential associated with anaerobic digestion was calculated using the following assumptions:

- Construction – The construction of an anaerobic digester requires around 60 people for a period of around six months. Since not all workers are required on site for the full duration of construction, it is estimated that 60 people can build four anaerobic plants per year.
- Operations and maintenance – Farm-sized anaerobic digesters are designed to operate with more workers in order to keep the capital cost lower, as well as due to the increased material handling required. The increased handling is due to the relationship between the freshness of the manure and the amount of gas it can produce. The assumption is made that, on average, four workers are required. Industrial anaerobic digesters are usually fairly well integrated into

the production process of the plant, thus requiring far less employment, with a skilled technician/engineer and an assistant required. Large anaerobic digesters have significant raw material handling requirements that raise the number of workers to around six, depending on the design of the plant.

- Manufacturing – The manufacturing of the plants draws from the current manufacturing, civil engineering, electrical and metal fabrication skills available in South Africa. Farm- and industrial-scale plants require about 30 people to manufacture and install the components on the plant and, as is the case with construction workers, are able to manufacture and install the components of four plants per year. Large-scale plants create employment opportunities for around 100 people, which can manufacture and install four plants per annum.

The current regulatory environment, in conjunction with lack of skills in grid facilitation at municipal level, will limit the adoption of anaerobic digesters to supply electricity for wider distribution, especially industrial digesters. It is assumed that some farm-sized plants will be built for the generation of electricity for own use, while some large plants can be built on areas that are already appropriately zoned.

Thus, in the short term it is assumed that three farm-scale plants and two large-scale plants can be constructed, with a further two plants located in the rest of Africa. With respect to plants constructed elsewhere in the African continent, it is assumed that 20% of the construction team will be skilled South Africans, and the manufacturing of these plants will be undertaken in South Africa. In the medium term, the following are assumed: 16 farm-scale plants, 13 industrial plants and seven large scale plants in South Africa, while nine plants are assumed to be built in the rest of Africa.

The pace of construction in South Africa can increase up to the point where around 25 farm-scale plants are built per year, with a total of 116 plants assumed to be constructed in the long term. The number of industrial plants is limited by the suitability of the associated industrial process, with a further 32 plants being built over the same period. Since the size of large digesters requires significant feedstock, the total number of plants are limited, with a further 33 plants assumed to be built. As the technology becomes better understood, with close cooperation between universities and private companies, the up-take in the rest of Africa should increase, with a further 60 farm-scale plants of South African origin assumed to be erected elsewhere on the continent.

Results

Table 3.15: Summary of net direct employment potential associated with anaerobic digestion

Activity	Short term			Medium term			Long term		
	Domestic	Export related	Total	Domestic	Export related	Total	Domestic	Export related	Total
Construction	38	3	**41**	108	5	**113**	339	23	**362**
O&M	17	0	**17**	94	0	**94**	476	0	**476**
Manufacturing	54	19	**73**	144	34	**178**	450	141	**591**
Totals	109	22	**131**	346	39	**385**	1 265	164	**1 429**

Source: Authors

Ease of introduction of the technology into South Africa

Implementation challenges

- The current cost of electricity is still limiting the wide use of anaerobic digesters, while the poor state of South Africa's sewerage treatment plants is constraining the ability to extract gas from these plants.
- The Municipal Finance Management Act (MFMA) is currently an obstacle for companies that approach municipalities to implement projects, since the interpretation of the act varies from municipality to municipality.
- The EIA process is time consuming and can result in significant delays in project implementation. There have been allegations that the EIA process varies from region to region, limiting the countrywide roll-out of projects.
- Some projects experience difficulties in securing the transmission of the electricity produced on the Eskom as well as on municipal electricity networks.
- The limited use of gas-powered vehicles requires that the gas be used for electricity generation, which is less efficient than its use in gas vehicles.

Key policy implications

- The proper functioning of sewerage works in South Africa must be ensured, so that the plants that are designed to capture the gas produced can indeed do so.
- The MFMA should be reviewed in order to eliminate the confusion regarding the implementation of this type of projects, enabling municipalities to sign the appropriate off-take agreements.
- The EIA process should be standardised across South Africa, as well as re-examined in order to determine whether it can be speeded up.
- The introduction of gas-powered municipal vehicles will create a market for gas production, with consequential reductions in fuel costs for municipalities.
- Access to transmission networks should be simplified so as to enable various electricity producers to sell their electricity to Eskom, municipalities and end-users.

3.3.4 Pyrolysis/gasification

Organic material may be decomposed through a pyrolysis/gasification process. The pyrolysis process operates at temperatures in excess of 430°C and significant pressure, producing gases, tar (liquids) and char (solid residue). This may be followed by gasification at a temperature of around 1 000°C, which then breaks down the tar and char into gas. In reality, the removal of all oxygen from the process is not achievable, resulting in some oxidation occurring during the process[61].

This report focuses on the technologies that convert the biomass into gas and inert ash, with all the energy potential of the biomass thus captured in the gas.

Historical progress/maturity

The development of gasifiers has been around since the industrial revolution, but was phased out with the cheap availability of natural gas. The use of gasifiers has been used for the production of synthetic gas since the 1920s, when coal was converted into gas. As demand for renewable energy generation increased in recent years, the viability of pyrolysis/gasification was investigated for large-scale commercial use.

The process of pyrolysis/gasification is well understood, although the ability to convert this knowledge into large-scale, commercial-size plants has been limited. Most pyrolysis/gasification plants are small in scale, typically under 1 MW, therefore limiting the application of this technology to electricity generation for grid distribution. Most plants are also used as cogeneration plants, thereby limiting the cost of transporting the inputs for the plants. The scale of pyrolysis/gasification plants is also limited by the availability of the feedstock, since the cost of transporting the fuel has a significant impact on their financial viability.

Advantages/disadvantages

The process of pyrolysis/gasification speeds up the normal decomposition of organic materials into gas, and can extract all the energy potential stored. The breakdown of organic material into basic components enables this process to accept any organic material as feedstock, even hazardous material such as sewerage, medical waste, used oil or contaminated soil, to name only some of the potential inputs.

Some processes of pyrolysis/gasification have been developed to produce a gas that has a sufficiently high calorific value[62] so that the gas could be used as a fuel source for vehicles, such as buses. This dramatically changes the feasibility of such projects, since they could be competing with high value fuels such as petrol and diesel, instead of low cost coal-fired electricity. However, the challenge of biogas storage on a vehicle remains.

The ability to recycle various materials will be increased through the use of pyrolysis/gasification, as the materials will be sterile and stripped of any contamination or hazardous materials. The only recyclable materials that need to be removed prior to the process are paper, board and plastics with recyclable value. The process of pyrolysis/gasification reduces the original volume of waste to around 10%, which needs to be landfilled, as well as 1% inert ash that can be used in the cement and road construction industries, or used for capping on existing landfills.

Some uncertainty prevails regarding the commercial viability of pyrolysis/gasification plants, although the latest technological developments appear to have overcome this problem. The plants are complex, requiring some skilled operators as well as unskilled labour, while their reliability and efficiency has yet to be proven over an extended time period in large-scale commercial operations. The gas that is produced still needs further refinement before it can be used. The level of refinement depends on the final use for the gas, which has cost implications for the overall project plan and its viability.

The initial capital cost of pyrolysis/gasification plants is significant, although the payback period could be as low as four to six years, depending on the country and financial incentives in place.

Brief overview of global usage

According to the International Energy Agency (IEA) there are a limited number of commercial plants in operation, since operational and cost issues are major obstacles to widespread implementation[63]. Most plants are designed to be small-scale operations and are currently being custom-built for the feedstock that is being used. The City of Tokyo has a pyrolysis plant using industrial waste as an input. The Municipality of Hessequa, located close to Mossel Bay, in the Western Cape province of South Africa, has announced the start of construction of a plant that will handle all of the town's MSW.

There are projects based on the Biomass Integrated Gasification Combined Cycle concept where electricity is generated through a combined steam and gas engine for 9 MW plants. Although the feasibility of technology is still uncertain, a plant based on wood and straw feedstock has been running successfully in Sweden since 1995, while a similar plant in the UK failed due to a lack of support to resolve issues surrounding the operation and integration of the combined plant. Most operating commercial plants seem to be concentrated in Europe, including the UK.

Small pyrolysis plants are used intermittently in both India and China for electricity generation in rural areas. There are, however, concerns over the reliability of the plants and, hence, their ability to become large-scale continuous operations.

Major players globally and/or domestically

Table 3.16: Some of the major global suppliers/operators

Company	Country	Website
Advanced Biorefinery, Inc.	Canada	www.aee-austria.at
AE&E	Austria	www.waste2energy.com
Aruna Electrical works	India	www.advbiorefineryinc.ca
Balboa Pacific Corporation	United States	www.ensyn.com
BTG Bioliquids Enschede	The Netherlands	www.btgworld.com
Dynamotive Technologies	Canada	www.balboa-pacific.com
Ensysn	Canada	www.arunaelectricalworks.com
Waste2Energy	United Kingdom	www.dynamotive.com

Source: Authors

Table 3.17: Some of the major South African suppliers/operators

Company	Website
African Power Technologies	www.africanpowertechnologies.com
Cape Advanced Energy	www.cae.co.za
Eecofuels	www.eecofuels.com
Prestige Thermal	www.prestigethermal.com

Source: Authors

Applicability to South Africa and/or the rest of Africa

The usual designs of the plants are such that a small number of personnel is required to operate them, although the skills levels required may prove to be a constraint, depending on the plant design. The required skills are available in South Africa, although the cost of employing skilled engineers might impact on the viability of the operations. Companies with the required technology are already present in South Africa, but are struggling to get projects off the ground due to difficulties in obtaining approval for EIAs and in securing waste streams due to varying interpretations of the MFMA.

The components used in these plants are already available in South Africa, although gas and steam turbines would have to be imported. The use of pyrolysis plants could be expanded into the rest of the African continent and even the rest of the world for the treatment of carbon-based waste.

Analysis of potential job creation

Adaptation of generic methodology to the specific industry

The feasible number of pyrolysis/gasification plants is limited to the amount of MSW available. Thus, plants can only be constructed in municipalities that have sufficient waste, with the smallest plants requiring around 60 000 tonnes of waste per year.

The sizes of pyrolysis/gasification plants considered for purposes of determining the employment potential are 3 MW and 9 MW. It is assumed that the waste will be sorted into: greens for use in anaerobic digesters; and other waste, from which the recyclable paper, board and plastic are removed. Typically, MSW consists of one-third greens and two-thirds other waste, of which a small proportion is removed for recycling.

Based on these assumptions, there is a potential to construct sixty-six 9 MW plants and seventy 3 MW plants in South Africa.

- Construction – The 3 MW municipal solid waste plants require around 60 workers for project construction over the course of a year, while the 9 MW plants require around 180 construction workers over a three-year period.
- Operations and maintenance – Due to the economies of scale achieved in plant O&M, a 3 MW plant will employ about ten people, while a 9 MW plant will typically employ 15 people, assuming that the plant is set-up for maximum employment, which will keep the capital cost of the plant low.
- Manufacturing – The number of manufacturing jobs involved is in the region of 100 for a 3 MW plant and 300 for a 9 MW plant. The manufacturing time for a 3 MW plant is one year, while a 9 MW plant is generally constructed and assembled in three years.

The existing constraints, as well as the time required to obtain approval for an EIA, are assumed to result in no pyrolysis plants being completed in the country in the short term, although it is assumed that construction activity and related manufacturing can start during this period.

In the medium term, assuming the successful removal of existing regulatory obstacles and the securing of waste streams, it is projected that nine 9 MW pyrolysis/gasification plants will be built, most likely in one or two municipalities. Towards the latter half of the medium term period, smaller municipalities could also build 3 MW plants, with four such plants deemed possible.

The roll-out momentum of pyrolysis/gasification plants is expected to accelerate in the long term, as the benefits and business case become clear. It is assumed that thirty-two 9 MW plants will be built in all the large metropolitan areas in the long term, while thirty-six 3 MW plants will be built in secondary cities with smaller waste streams.

The introduction of pyrolysis/gasification plants in the rest of Africa is expected to start early in the medium term and to continue in the long term with the assumption that at least one 3 MW plant would be built per year, while exports to the rest of the world would be two 9 MW and two 3 MW plants.

Results

Table 3.18: Summary of net direct employment potential associated with pyrolysis/gasification

Activity	Short term			Medium term			Long term		
	Domestic	Export related	Total	Domestic	Export related	Total	Domestic	Export related	Total
Construction	90	0	**90**	444	24	**468**	1 058	30	**1 088**
O&M	0	0	**0**	80	0	**80**	597	0	**597**
Manufacturing	150	0	**150**	740	400	**1 140**	1 763	900	**2 663**
Totals	240	0	**240**	1 264	424	**1 688**	3 418	930	**4 348**

Source: Authors

Ease of introduction of the technology into South Africa

Implementation challenges

- A major challenge currently standing in the way of the development of pyrolysis/gasification plants in South Africa is the exclusion of this technology from the REPP.
- A lack of understanding of the underlying technology is limiting the availability of funding for pyrolysis/gasification projects.
- The long period of time involved in obtaining EIA approvals is also discouraging companies from investing in the development of pyrolysis/gasification plants, with the maze of regulatory red tape proving to be very difficult to navigate through in South Africa, despite the green nature of the associated technology.
- Lastly, the plants are reliant on the use of MSW and thus face constraints due to differing interpretations of the MFMA in the various municipalities.

Key policy implications

- The time taken for environmental regulatory approval would need to be curtailed substantially, and the variability reduced across regions, in order to encourage investment in this waste-to-energy segment.
- Electricity generated through the conversion of waste-to-energy should be included in the next round of the IRP and REPP.

3.3.5 Cogeneration

Cogeneration, at times also referred to as combined heat and power (CHP), utilises waste heat from electricity generation or from other industrial production processes, for the production of electricity and thermal power. CHP systems have efficiency ratios of between 75% and 90%, which are far higher than that of a typical coal-fired power plant (33%) or even natural gas-fired plants (around 60%).

There are various types of cogeneration plants, including: gas turbine CHP plants; steam turbine CHP plants; combined cycle power plants; and gas/biofuel engine plants.

Historical progress/maturity

According to the International Energy Agency (IEA), "CHP prime movers are mature, reliable and proven technologies. […] In all cases, fuel combustion creates mechanical energy directly, or first produces steam, which is subsequently converted to mechanical energy. The mechanical energy is used to spin a generator producing electricity."[64] In 2008, the Worldwatch Institute reported that "one-twelfth of global electricity comes from combined heat and power systems", with the global installed electricity capacity of cogeneration plants being approximately 325 000 MW[65].

According to the IEA, "CHP has a long history within the industrial sector, which has large concurrent heat and power demands."[66] Around 80% of the world's installed CHP capacity is concentrated in the following industries: paper and printing; steel; oil refining; as well as food processing[67].

Advantages/disadvantages

The advantages of combined heat and power cogeneration include:

- The process produces energy where it is needed, avoiding the wastage of heat;
- At higher efficiencies, CHP can assist countries in reducing their fuel demand;
- The technology provides the most efficient use of biomass resources, increasing thermal efficiencies from 40% to 85%;
- Greenhouse gas emissions (GHG) are reduced by up to 50%; and
- Investment requirements for transmission systems are lowered, while reducing transmission and distribution losses.

However, combined heat and power cogeneration also has certain disadvantages, particularly the fact that a cogeneration plant must be built close to where the power will be used. Depending on its application, this may not be feasible as power plants are generally located away from population centres and, therefore, transmission and delivery may become problematic. In many industries, however, building cogeneration facilities close to a plant is not necessarily an issue, as long as there is land available for their installation.

Brief overview of global usage

CHP systems are utilised across the globe, with the total generating capacity estimated at 329 GW. The four countries with the largest installed capacities are the US (85 GW), Russia (65 GW), China (28 GW) and Germany (20 GW)[68].

Major players globally and/or domestically

Cogeneration technology is still in its infancy in South Africa, with the major local players with cogeneration facilities currently including ArcelorMittal, Sappi and Mondi. Sasol and Ipsa are amongst the entities that have entered into PPAs with Eskom.

ArcelorMittal has built cogeneration facilities at its Vanderbijlpark and Newcastle sites, with a total installed capacity of 80 MW[69]. More recently the company has been planning to build a cogeneration plant at its new works in Bellary, India[70].

Sappi is generating more than 800 MW of cogeneration power worldwide[71], with a number of cogeneration facilities present in southern Africa. Domestically, Sappi's cogeneration operations generate 226 MW, with one such facility being the Saiccor plant in Umkomaas, south of Durban. This plant has a 46 MW back pressure turbine installed as part of the Amakhulu expansion project, which was designed to raise paper production by 225 000 tonnes per year[72]. A further opportunity to generate up to 40 MW of renewable power at Saiccor is being considered. Sappi Tugela currently generates approximately 8 MW of cogeneration power, but is considering a project which could raise this to 47 MW. A smaller project that would generate 8 MW from wood and forest waste in Barberton near the Lomati saw mill is under development.

The total cogeneration capacity at Mondi South Africa (excluding Mondi Packaging South Africa) is approximately 195 MW. Its larger plant has a cogeneration capacity of 135 MW, while the smaller one has a 60 MW capacity. More than 90% of the electricity consumed on-site by the operations of the Mondi Group is presently generated using cogeneration technology[73], with its cogeneration plants employing approximately 130 workers[74].

Petrochemicals group Sasol is one of the six independent power producers that have signed off-take agreements under Eskom's MTPPP while being granted generation licences by the National Energy Regulator of South Africa (NERSA)[75]. Sasol's project has a cogeneration capacity of 280 MW. Ipsa, in turn, has entered into a further PPA with Eskom, after its initial short term contract expired. The new agreement stretches to 31 March 2015 and is based on 13 MW cogeneration capacity[76].

Applicability to South Africa and/or the rest of Africa

Cogeneration is likely to be one of the critical solutions to South Africa's electricity capacity challenges, alleviating much of the pressure on the supply side as cogeneration plants are progressively installed across a number of industrial sectors. This technology is ideally suited to generate energy, especially in basic industries, with South Africa having the potential to develop cogeneration on a massive scale, provided the necessary policy measures, regulatory environment and incentives are put in place by the respective authorities.

Through the use of this technology, several basic industries will be able to meet a substantial portion, if not all of their own power requirements, and will release the excess into the national grid, alleviating demand pressures on Eskom's currently limited capacity while simultaneously augmenting it. In the process, electricity supply will be increasingly made available to other users, both existing and potential, that are unable to generate their own power.

Analysis of potential job creation

<u>Adaptation of generic methodology to the specific industry</u>

The building of cogeneration plants is becoming increasingly attractive to large industrial players that have the required capacity. Cogeneration can, and is expected to be rolled-out over a relatively short period of time, resulting in significant quantities of power coming on line over the short to medium term. This is a result of the potential associated with the existing industrial base that has yet to embrace this power technology. Once most of the 'current' potential has been exhausted, it is reasonable to assume that further expansion will be limited to the expansion of industrial sector investment. IDC experts estimate the overall cogeneration potential to be of the order of 3 000 MW, taking into consideration the levels of interest and awareness created by the Cogeneration World Africa Conference and the MTPPP.

Many individual projects of various sizes will be established over time, making it extremely difficult to base the employment potential on the number of plants. It is assumed that 230 MW of cogeneration capacity will be installed during the short term, and a further 1 580 MW over the medium term. The potential in the long term is deemed to be somewhat limited at an additional 1 440 MW, taking the overall cogeneration installed capacity to 3 250 MW in order to accommodate an expansion of the respective industrial base.

- Construction – Based on ArcelorMittal's 80 MW cogeneration facility in Vanderbijlpark, 230 workers were required during its construction phase, for a ratio of 2.9 jobs/MW. Moreover, IDC experts estimate that a 10 MW thermal plant would create 200 construction jobs over a 24-month period, translating into 20 jobs/MW. An average of 11.5 jobs/MW is, therefore, utilised in this report for construction activities.
- Operations and maintenance – According to a World Wide Fund for Nature report[77], the O&M of a 10 MW plant require around 25 workers, equating to 2.5 jobs per MW.
- Manufacturing – South Africa has the capacity to manufacture portions of, and components for cogeneration plants locally, including: boilers, heat exchangers, electric reticulations etc. The calculation of the potential employment creation in the manufacturing of components for cogeneration plants is based on the assumption made in the pyrolysis/gasification section of this report, but with specific adaptations to cogeneration plants. This is due to the similarity between the gas-capture, treatment and electricity generation sections of pyrolysis/gasification plants and those of cogeneration plants. It is assumed that 15 workers are required to manufacture components for the above mentioned sections of cogeneration plants, specifically for the equivalent of 3 MW generating capacity, on an annual basis.

Results

Table 3.19: Summary of net direct employment potential associated with cogeneration

Activity	Short term			Medium term			Long term		
	Domestic	Export related	Total	Domestic	Export related	Total	Domestic	Export related	Total
Construction	1 323	0	**1 323**	3 634	0	**3 634**	2 070	0	**2 070**
O & M	450	0	**450**	2 550	0	**2 550**	7 669	0	**7 669**
Manufacturing	575	0	**575**	1 580	120	**1 700**	900	150	**1 050**
Totals	2 348	0	**2 348**	7 764	120	**7 884**	10 639	150	**10 789**

Source: Authors

Ease of introduction of the technology into South Africa

Implementation challenges

Possible constraints in the roll-out of cogeneration capacity in South Africa include:

- The installation of a cogeneration facility is subject to the successful completion of an EIA and its approval by the authorities, a process that is excessively time consuming at present;
- The lack of appropriate policy instruments, including incentivisation, has constrained the growth of cogeneration capacity in South Africa; and
- Large budgets are generally required for capital expenditure in cogeneration projects.

Key policy implications

There is a need for long term national policy measures, including incentives and other support instruments that:

- Will entice energy-intensive industrial users to build integrated and optimal cogeneration systems; and
- Provide clear strategies to procure power from cogenerators, including the regulatory and institutional framework for the effective and mutually beneficial sale of power onto the national grid.

Various options to structure and finance cogeneration projects are required to fulfil the needs of principal users and developers.

3.4 HYDROPOWER

Hydropower is commonly defined as the electricity generated from moving water. Water may be stored in a reservoir or dam upstream and electrical power is generated through turbines driving generators, propelled by the gravitational force of falling or flowing water. Similarly, run-of-river canals or pipes may be utilised to generate hydroelectric power.

Hydropower is among the alternative energy sources that deliver relatively environmentally sound energy at low cost, considering that it eliminates the cost of using fuel required in other forms of electrical power generation. Hydropower produces virtually no CO_2 or other harmful emissions during the generation of electricity, and is therefore not a significant contributor to global warming.

3.4.1 Large hydropower

Although no official definition exists for the capacity range of large hydropower plants, those with an installed capacity exceeding 1 000 MW are generally considered to be large in size.

Hydropower plants installed in large rivers can be used to provide base load power. However, hydropower also lends itself to peak load applications as the generation can be regulated easily. As such it may also provide a high-capacity, low-cost means of energy storage, referred to as pumped storage. Large hydro dams interrupt the flow of a river in order to fill the dam for power generation, while a pumped storage scheme utilises two dams at significantly different heights. During periods of low electricity demand, the excess capacity of base load power stations is used to pump water from the lower of the two dams to the one positioned at a higher level, with the process reversed during peak demand periods.

It should, however, be noted that “pumped storage technology is actually a net consumer of energy as it returns approximately 3 kWh of energy for each 4 kWh required for pumping.”[78] Furthermore, pumped storage facilities in South Africa currently utilise energy produced from coal to drive the turbines or hydraulics, although the source could be shifted in future towards energy generated by renewables, such as solar or wind power.

Advantages/disadvantages

The advantages of hydropower plants include:

- Operating costs are relatively low;
- The plants are often used as tourist attractions (eg the Lesotho Highlands Water Project); and
- Pumped storage dams can be used to store excess electricity from variable energy sources, such as wind or solar plants.

Nevertheless, such plants also have a number of disadvantages, including:

- High investment costs;
- Fish populations may be seriously impacted upon should the dams prevent the fish from migrating upstream, or downstream to the ocean;
- Hydropower plants affect negatively the quality of water resources;
- The construction of hydropower plants can impact negatively on the local environment and communities, particularly when forced to vacate their homes;
- Large hydropower plants have very specific natural topographic requirements that limit their positioning, especially in South Africa;
- Large hydro plants that are not pumped storage facilities require significant and consistent water flow in order to be viable, with its variability possibly being altered by climate change; and
- Some rivers cross several countries, a factor that could complicate the development of hydroelectric power plants.

Brief overview of global usage

Hydropower (excluding pumped storage facilities) is estimated to supply around 860 GW of power worldwide[79]. There are at present three very large facilities in excess of 10 GW operating globally, namely the Three Gorges Dam (22.5 GW) in China, the Itaipu Dam (14 GW) in Brazil, and the Guri Dam (10.2 GW) in Venezuela. It has been estimated by the International Hydropower Association[80] that the pumped storage capacity installed globally is in the region of 120 to 150 GW.

Major players globally and/or domestically

Table 3.20: Some of the major global industry players

Company name	Origin	Website
China Three Gorges Project Corporation	China	www.ctgpc.com/en/
Copel	Brazil	www.copel.com
Itaipu Binacional	Brazil	www.itaipu.gov.br
Monitoba Hydro	Canada	www.hydro.mb.ca
National Hydroelectric Power Corporation Limited	India	www.nhpcindia
SN Power	Brazil	www.snpower.com
Statkraft AS	Norway	www.statkraft.com

Source: Authors

Eskom is currently the main developer of pumped storage schemes in South Africa. The installation of large hydropower plants and pumped storage schemes is mostly undertaken by international companies, with a small number involved in the sector.

Applicability to South Africa and/or the rest of Africa

According to the University of Stellenbosch, South Africa's average annual rainfall of 500 mm is considered low in global terms. Hence, the country has a modest potential for hydropower, which is largely concentrated in portions of the eastern escarpment. "Studies have shown that unconventional hydropower development can take place in both rural and urban areas of South Africa by means of tapping hydropower from irrigation canals, bulk water supply pipelines and deep mining undertakings for either electrical or mechanical energy conversion."[81]

There is thus no potential as such for large hydropower generation, except in the form of pumped storage schemes, with the 1 000 MW Drakensberg Pumped Storage Facility being the largest in South Africa. According to the University of Cape Town, only 2.3% of South Africa's electricity is produced from hydroelectric and pumped storage schemes. There are no feasibility studies proposing the construction of another large pumped storage scheme.

Nevertheless, several countries in southern Africa, such as the Democratic Republic of Congo (DRC), Mozambique, Zambia and Angola exhibit potential for large hydropower generation, thus presenting opportunities for the export of materials and services.

Analysis of potential job creation

<u>Adaptation of generic methodology to the specific industry</u>

The employment creation potential is calculated using pumped storage systems as a proxy for large hydropower generation in South Africa, whilst considering certain large hydroelectric dams planned elsewhere in the SADC region for the employment associated with export opportunities, particularly South African produced concrete and steel.

Eskom is currently commissioning and assisting in the construction of the Ingula Pumped Storage Scheme, which is located in KwaZulu-Natal with a capacity of 1 332 MW. For the purposes of this report, the Ingula Pumped Storage Scheme is therefore used as a proxy. The main components of the scheme include:

- Upper and lower reservoirs;
- An underground power house, access tunnels and waterways linking the two reservoirs;
- Four pump-turbines connected to generator-motors;
- Ancillary works that include building works, roads, transmission lines and both temporary and permanent infrastructure.

The pipeline in the rest of the African continent includes (the size and expected year of completion are depicted in brackets):

- Boroma, Mozambique (160 MW, 2016);
- Cahora Bassa North Bank, Mozambique (1 250 MW, 2017);
- Mpanda Nkuwa, Mozambique (1 500 MW, 2017);
- Kariba North Bank Extension, Zambia (360 MW, 2013);
- Itezhi Tezhi, Zambia (120 MW, 2015); and
- Kafue Gorge Lower, Zambia (600 MW, 2017).

From the above list, the focus will be on the following four projects only (based on the assumption that South African suppliers may not be awarded contracts for all the projects): Cahora Bassa North Bank, Mpanda Nkuwa, Kariba North Bank Extension and Kafue Gorge Lower. Furthermore, due to the extension of the Inga Project in the DRC, it is assumed that the region's resources will be more channelled towards the larger projects as opposed to the smaller ones such as Boroma (160 MW) and Itezhi Tezhi (120 MW).

With the exception of export-related potential, the employment projections are based on estimates provided by an expert from Eskom[82] who is involved in the construction of the Ingula Pumped Storage Scheme.

It takes between eight and nine years to build a pumped storage scheme, provided the feasibility and design phases are finalised timeously. Ingula has been under construction since 2006 and is expected to be completed in 2014. The employment potential for this report is deemed to pertain solely to operations and maintenance activities, since no new jobs are likely to be created in the construction phase or in manufacturing activities supplying the Ingula project.

There is potential for additional pumped storage plants in South Africa, most likely using seawater, in the longer term. However, this type of plant would require special types of technology, as the sea would be used as the 'lower reservoir', with water pumped up to the upper (man-made) reservoir, while issues (eg corrosion) pertaining to the salinity of the seawater would have to be resolved through technological solutions. Although there are currently discussions around potential projects of this nature, their conceptual stage has not been finalised. Furthermore, there is no information about the size of the plants or the potential generation capacity under such technologies.

- Construction – It is assumed that the local construction industry may benefit from the roll-out of hydropower projects elsewhere in the continent, creating 100 jobs per project.
- Operations and maintenance – Considering the expected completion date of 2014 for Ingula, employment opportunities are only expected to materialise in the medium term at 40 workers, rising to 50 workers in the long term. O&M employment opportunities associated with African hydropower projects in the pipeline outside of South Africa's borders are assumed to benefit the workforce of the respective countries.
- Manufacturing – About one million cubic metres of concrete (ie approximately 2.4 million tonnes) and 70 000 tonnes of steel were required in the construction of Ingula, translating into a concrete-to-steel ratio of 34.29. This ratio was used as a proxy for the concrete and steel requirements of the southern African projects identified above, which are assumed to be procured from South Africa.

  The concrete volumes were converted into tonnages in order to determine the employment potential using the input-output tables for South Africa (ie 800 jobs estimated to be associated with the production of one million cubic metres).

  With respect to steel, the capacity of local steel manufacturers was taken into consideration. According to ArcelorMittal, Cisco had an annual capacity of around 220 000 tonnes and 405 employees, but ceased operations in December 2010, while Newcastle Works has an annual capacity of 1 600 000 tonnes and employs 1 860 workers. Taking an average for the two plants, a ratio of 702 tonnes of steel per worker per year was calculated.

Using the 1 500 MW Mpanda Nkuwa pipeline project in Mozambique as an example, the concrete requirements are estimated at 1.37 million cubic metres or 3.3 million tonnes. Using Ingula's concrete-to-steel utilisation ratio, this translates into 96 168 tonnes of steel. These figures, in turn, translate into 2 200 tonnes of concrete per MW and 64 tonnes of steel per MW. This implies a ratio of 0.73 jobs per MW with respect to concrete and 0.09 jobs per MW with regard to steel requirements. These ratios were utilised in calculating the employment creation potentially associated with the above listed pipeline projects planned for other countries in southern Africa.

Furthermore, it is assumed that the external demand for steel and concrete will start in 2012, with the selected southern African projects expected to be built over the short to medium term. Construction activity (and by implication materials requirements) equivalent to a capacity of 360 MW, as per the employment calculation methodology that has been adopted, is projected to be installed in the short term, followed by 690 MW in the medium term and 1 080 MW in the long term.

Results

Table 3.21: Summary of net direct employment potential associated with large hydropower

Activity	Short term			Medium term			Long term		
	Domestic	Export related	Total	Domestic	Export related	Total	Domestic	Export related	Total
Construction	0	70	**70**	0	194	**194**	0	111	**111**
O&M	0	0	**0**	32	0	**32**	50	0	**50**
Manufacturing	0	148	**148**	0	566	**566**	0	111	**111**
Totals	0	218	**218**	32	760	**792**	50	222	**272**

Source: Authors

Ease of introduction of the technology into South Africa

Implementation challenges

- Scarcity and variability of water resources which may be further altered by climate change;
- Suitable locations for pumped storage facilities;
- Access to the appropriate technologies, which are mostly of foreign origin; and
- Industrial capabilities, including an appropriate skills base, for the manufacturing, installation and operation of turbines.

3.4.2 Small hydropower

Small hydropower normally refers to a generating capacity of up to 10 MW[83], although the threshold does vary across countries. Small hydropower generation can be further subdivided into:

- Mini hydro, which is normally defined as a plant with a capacity of under 1 MW;
- Micro hydro, referring to a generating capacity of less than 100 kW; and

- Pico hydro, which is a term used for power generation below 5 kW.

Small hydro plants can be connected to the national grid or built in isolation, depending on market conditions, cost implications or investor preferences. The potential for both on- or off-grid small hydroelectric power plants is explored, with most sites identified in the South African provinces of KwaZulu-Natal, the Eastern Cape, the Western Cape and Mpumalanga.

Historical progress/maturity

The first commercial hydropower plant was constructed in 1882 on the Fox River in Appleton, Wisconsin (US), with a capacity of 12.5 kW to electrify two paper mills and one home[84]. Its successful implementation resulted in this power generation technology being subsequently in high demand not only in the US, but the world over.

Rapid growth in demand for energy, particularly in developing countries as populations expand and the industrialisation momentum accelerates, has forced authorities to explore renewable energy sources, often due to their greater availability relative to conventional sources, but increasingly due to environmental concerns as well. For this reason, small hydropower has been identified as one of the appropriate sources of power generation and also as a suitable solution for securing a reliable and affordable energy supply in the long run.

A few types of hydraulic turbines are utilised in hydropower plants in South Africa, namely, the Pelton Wheel, Cross-flow, Turgo, Francis and Kaplan, with the first three being commonly used in small hydropower plants and the latter two found mainly in larger plants.

Advantages/disadvantages

Small hydropower has the following advantages:

- It is a relatively low cost renewable energy source;
- It is suitable for rural electrification, especially in areas where there is no distribution network;
- Easy assembly and maintenance, permitting repair work to be carried out by local mechanics;
- Plants can be installed in conjunction with larger renewable energy projects;
- Plants can be integrated with the provision of potable water – that is, small sand dams can be built in South Africa’s remote areas upstream, generating electricity as the water flows down towards a village or town; and
- Small hydro does not result in water wastage and, if it is operating at full capacity, it can generate power 24 hours a day.

Nevertheless, small hydropower presents certain disadvantages, including:

- South Africa’s relatively low average annual rainfall of about 500 mm, coupled with occasional droughts or floods and seasonal river flows (normally dry in winter), constrain the potential for hydropower in the country, small hydro included, and the variability may be further altered by climate change;
- Prefeasibility and feasibility studies are essential prior to the implementation of a small hydropower plant. Since the sunk costs of a project are not necessarily dependent on its size, small projects tend to have fairly higher sunk costs relative to the overall investment cost; and
- The issuing of licenses for non-consumptive use by the Department of Water Affairs is a time-consuming process.

Brief overview of global usage

Most countries use small hydro plants to supply electricity, particularly to their rural communities, which are often without a distribution network. In Norway, for example, there are about 800 small hydropower plants in operation[85], with more than 700 being studied[86]. These developments follow the implementation of the Norwegian government's five-year plan of 2002, which supported small hydro development.

According to turbine manufacturer MAVEL Americas Inc.[87], Europe has built at least 17% of its economically viable small hydro projects to date, whereas the US has developed 14%. In numerical terms, Europe has 17 571 small hydro plants, while the US has only 2 346. Other leading small hydroelectric generating countries include Brazil and China, with the latter having developed a large number of small hydropower plants that are electrifying mainly the rural areas[88].

In South Africa, small hydropower is mainly utilised to complement the electricity that local authorities (municipalities) buy from Eskom. For instance, Bethlehem Hydro (an IPP) competes on commercial terms with Eskom on electricity that it sells to Dihlabeng Municipality, with which it has a power purchasing agreement.

Major players globally and/or domestically

Most of the technologies utilised in small hydro plants are produced in China, due largely to relatively lower labour costs.

Table 3.22: Some of the global and domestic players in small hydropower

Company name	Origin	Website address
Alstom Power (technology developer)	Switzerland	www.alstom.com
Andritz Hydro (technology developer)	Austria	www.andritz.com
China Hydroelectric Corporation (owner, operator, developer)	China	www.chinahydroelectric.com
Emeishan Chicheng Machinery Co. Limited	China	www.chinacsky.com/co/76320
Eskom (project developer)	South Africa	www.eskom.co.za
Haeny (technology developer)	Switzerland	www.haeny.com
Hunan Turbopower Ltd (technology developer)	China	www.longshuang1207.en.ec21.com
Marelli Electrical Machines South Africa (technology developer)	South Africa	www.marellimotori.com
Nuplanet (project developer)	South Africa	www.nuplanet.co.za
Voith GmbH/Voith Hydro (technology developer)	Germany	www.voith.com

Source: Authors

Applicability to South Africa and/or the rest of Africa

South Africa's relatively low rainwater levels and occasional droughts have significantly curtailed the potential for small hydropower generation. However, previous studies have indicated that the potential for small hydropower in the country lies in the region of at least 100 MW, which could be realised through the implementation of about 40 projects with an average capacity of 2.5 MW each.

Analysis of potential job creation

Adaptation of generic methodology to the specific industry

- Construction – The 40 small hydropower projects are expected to be completed within five to eight years. Ten projects are assumed to be developed per year over the period 2011 – 2014, each project employing 30 people. These would include the building of small reservoirs (or rehabilitating existing ones in the case of upgrading abandoned hydro plants) and civil construction work, which will take one year to complete.
- Operations and maintenance – O&M activities would require 2.5 workers per project.
- Manufacturing – Equipment and machinery currently utilised in small hydropower plants are imported at present. Given the relatively limited potential of small hydropower in South Africa, it is likely that such import dependency will continue in future, as manufacturers may not find it feasible to establish a local plant producing small hydroelectric power technology for a very small market. Components could be manufactured in future, but existing local capacity should easily accommodate such demand, thus effectively not creating any new jobs according to industry experts.

Results

Table 3.23: Summary of net direct employment potential associated with small hydropower

Activity	Short term			Medium term			Long term		
	Domestic	Export-related	Total	Domestic	Export-related	Total	Domestic	Export-related	Total
Construction	300	0	**300**	120	0	**120**	0	0	**0**
O&M	38	0	**38**	95	0	**95**	100	0	**100**
Manufacturing	0	0	**0**	0	0	**0**	0	0	**0**
Totals	338	0	**338**	215	0	**215**	100	0	**100**

Source: Authors

Ease of introduction of the technology into South Africa

Implementation challenges

A key challenge is the industry’s domestic potential, which is fairly small in light of the country’s limited water resources, and therefore not necessarily attractive to suppliers of small hydroelectric power technologies.

Multinational companies selling hydraulic turbines and related equipment have set up branches and subsidiaries in South Africa, making it easier for the suppliers to channel their technologies into South Africa whenever the need arises. Furthermore, most suppliers sell directly to end-users, implying few, if any implementation challenges.

Key policy implications

To prevent the inadequate functioning or even the abandonment of small hydroelectric power plants, effective forms of state support may be required, such as regular monitoring and/or assessment of their performance and the adoption of corrective measures where appropriate (eg to ensure proper maintenance of plant and equipment).

3.5 MARINE POWER

Marine power refers to energy generated from ocean waves and tides. As oceanic water moves, it creates an enormous store of kinetic energy, normally referred to as 'energy in motion'. This energy may be harnessed to generate electricity that can be used to provide electricity to industries, homes and even transport. Marine power is normally classified as wave and tidal energy, however, offshore wind energy also forms part of this power category. Nevertheless, the focus in this section will be solely on wave and tidal energy, since wind energy was previously discussed.

Backed by strong research and development capabilities as well as testing stations, the UK is leading the development of renewable energy from marine sources. Prior experience acquired through working in the oil and gas industries has given UK experts enormous exposure to the development potential of marine and offshore areas.

Wave power refers to the transportation of energy generated from ocean surface waves. However, the technologies to harness such power are not yet widely utilised on a commercial basis. A number of UK companies have either tested or are currently deploying wave power devices in suitable sites in order to establish the appropriate technologies to harness marine generated power.

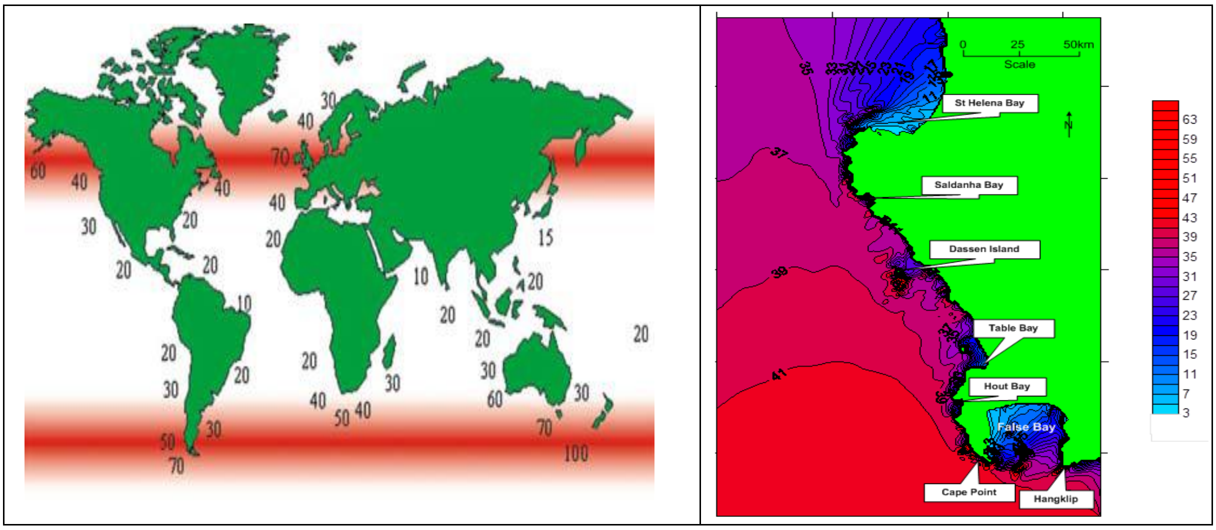
In South Africa, for instance, this technology is still being explored and, hence, its utilisation will most likely only materialise in the long run. However, previous studies have shown that the country has the potential to generate between 8 000 and 10 000 MW of wave power considering its tidal strength, particularly between Port Elizabeth and East London (at 20-35 kWh over this territory)[89].

An illustration of the world's wave power resources is provided on the next page, indicating that the best sites for capturing wave power lie along specific 'belts' in both the northern and southern hemispheres, with winds blowing at their strongest in the winter season. Furthermore, vast energy levels are far offshore, with the energy dissipating as waves approach the shore. In South Africa, the strongest wave power yield is in the range of 35 to 45 kW/m, mainly between Port Elizabeth and the Cape Peninsula.

A tidal strength of 15 kWh is considered acceptable, or strong enough for wave generated power by international standards. However, South Africa's tidal strength surpasses this benchmark to a substantial extent.

For this reason, Eskom had planned to install five acoustic doppler current profilers (ADCPs). These are sonar-based devices that deliver a wide range of water measurements (current, waves, water level, etc). If and when deployed, these ADCPs are expected to assist Eskom in establishing which technology would work best in the identified areas. The University of Cape Town (UCT), in collaboration with Eskom, is currently modelling marine current turbine generators. This exercise is expected to complement the outcome of the ADCPs in informing potential investors in wave generated power on which technologies are deemed appropriate for use in South African waters.

Figure 3.6: Wave power (kW/m) globally (LHS) and along South Africa's west coast (RHS)



Source: LHS: Rodrigues L.; RHS: Joubert J. (2008).

Wave power: Historical progress/maturity

Wave power technology is largely at the experimental stage. A wide range of technologies and schemes are being tested at present, indicating that the potential adoption of these technologies in South Africa will most likely only be in years to come. The sizes of the technologies range from small- to large-scale projects that may generate sufficient quantities of energy to be fed into a grid. Although it is difficult to establish how many jobs could be created from this energy source at this point in time, the experiences of countries such as the UK, Portugal, Canada and others suggest that wave generated power is highly capital-intensive, with minimal job creation potential.

Wave power: Advantages/disadvantages

The advantages of wave power generation include:

- The source (sea water) used to generate power is abundant;
- The energy capturing and conversion mechanism from waves (or tides) may protect the shoreline; and
- The environmental impact of energy generation through marine resources is very limited.

However, there are several disadvantages such as:

- The technology is not fully developed;
- It is relatively costly to produce wave power;
- The structure supporting energy converters must be strong enough to withstand very rough weather conditions;
- The systems must be salt resistant and the component parts may require regular maintenance;
- The converter frames and related devices may disturb the movement of large marine animals and the ships travelling through the channels in which the barrages are built;
- The energy generated from waves and tides can only be effective at specific locations with adequate tidal strength;
- Although capital support is crucial for the industry, most device developers are small- or medium-sized enterprises that do not have the necessary financial backing. Therefore, the initial risk exposure is too high for utilities to commit investment capital, or for manufacturers to commit to producing the devices; and

- Specialised skills and sufficient resources are essential for this industry to graduate from early stage technology development to the ultimate deployment of fully developed and tested devices.

Tidal power: Historical progress/maturity

Changing levels of the ocean at specific points, due to the gravitational effects of the moon and sun, result in the potential to convert this tidal movement into electricity. Due to the fact that the power is generated from gravitational forces, it is inexhaustible and predictable. In 1966, the first large-scale tidal power plant became operational.

To harness the power of tides, the flow of water in an estuary is blocked by a barge. When the tide changes, with the resultant drop in water levels on one side, power is generated in a similar manner to conventional hydropower. The barges can be designed so as to generate electricity on the ebb or flood sides, or both, although at least seven metres of tidal range are required for project viability.

Tidal power: Advantages/disadvantages

The following are some of the advantages of tidal power generation:

- Tides are usually predictable and, therefore, the electricity supply is almost certain and efficient;
- The long lifespan of tidal plants (ie from 75 to 100 years);
- In some instances, tidal power plants may provide a degree of coastline protection in the face of storm tides; and
- Tidal power plants may provide ready-made road bridges.

However, this energy source also poses disadvantages, such as:

- Potential interference with shipping activities;
- The inward and outward flow of saltwater in estuaries may be affected, leading to hydrological and salinity changes that, in turn, may impact on the ecosystems in such areas;
- It is expensive to construct barrages across estuaries, while also requiring salt-resistant parts and considerable maintenance;
- Suitable sites for the construction of tidal barrages are very difficult to find from a worldwide perspective;
- A limited amount of power is produced (ie only about 10 hours per day, as the tide moves inward or outward);
- Since the water that is used is not replenished, pollutants tend to be retained for longer periods;
- A relatively large coastal line is required for the plant to be cost effective;
- Remote control over operations is required, whilst maintenance challenges may also be present; and
- Tide levels may be affected by the dams used in generating tidal power.

Brief overview of global usage

The global marine power industry developed rapidly in recent years, witnessing the development and testing of full-scale prototypes, as well as the installation of deep water wave energy devices connected to the grid, and tidal stream devices. At the same time, research and development on innovative technologies has been ongoing, with certain devices maturing into pre-commercial stage.

In the UK, for instance, there were 0.85 MW of wave energy capacity and 1.55 MW of tidal stream capacity installed early in 2010, and commercial-scale projects totalling 77.5 MW are under development. Other countries that are rolling out tidal power generation include Argentina, Canada, France, China, South Korea and the USA, whilst Australia, Brazil, Germany, India, New Zealand and Spain are considering the possibility.

Major players globally and/or domestically

Table 3.24: Some of the major global and domestic players in marine renewable energy

Company name	Origin	Website address
Aquamarine Power (technology developer)	UK	www.aquamarinepower.com
Atlantis (technology developer)	UK	www.atlantisresourcescorporation.com
Eskom (project developer)	SA	www.eskom.co.za
European Marine Energy Centre (technology developer)	UK	www.emec.org.uk
Hammerfest Strøm AS (project and technology developer)	Norway	www.hammerfeststrom.com
Marine Current Turbines (technology developer, test centre)	UK	www.marineturbines.com
Minesto (technology developer)	UK	www.minesto.com
Ocean Power Technologies (technology developer)	UK	www.oceanpowertechnologies.com
Pelamis Wave Power (technology developer)	UK	www.pelamiswave.com
RenewableUK (association for wind, marine energy projects)	UK	www.renewable-uk.com
Sea Generation Limited (technology developer)	UK	www.seageneration.co.uk
Voith Hydro Wavegen Limited (technology developer)	UK	www.wavegen.co.uk

Source: Authors

Applicability to South Africa and/or the rest of Africa

In South Africa, Port Elizabeth and the Cape Peninsula exhibit above average potential for wave generated power, whilst in the rest of the African continent, countries such as Morocco and Madagascar also hold considerable potential.

South Africa and its neighbouring countries do not have significant tidal power potential due to their proximity to the equator, whereas tidal energy is stronger in countries nearer the poles. According to experts[90]:

- The tidal differences in South Africa vary between 1 and 1.5 metres, as compared to up to 9 metres in Europe. The effectiveness of the installation to produce significant levels of electricity depends entirely on the range of the tide and the volume of water. In order to make the process worthwhile the tidal range must be at least seven metres; and
- Moreover, the only two estuaries in South Africa, namely Knysna and Langebaan, are too environmentally sensitive to obtain permission to deploy tidal turbines.

Consequently, tidal power is not considered for purposes of estimating the employment potential associated with marine renewable energy.

Analysis of potential job creation

<u>Adaptation of the generic methodology to the specific industry</u>

Marine power generation utilises high-tech equipment and the structures on which power generating devices are to be placed require technical skills and experience. It is thus envisaged that very few jobs could be created in the short to medium term, and these would mainly be in R&D activities in order to learn more about the applicability of marine energy technologies.

Over time, as appropriate skills become available locally, some jobs will be generated, although this is a highly capital-intensive form of renewable energy generation, with minimal job creating opportunities. To illustrate, Islay's LIMPET wave energy project in the west coast of Scotland, which is managed by Wavegen Ireland Limited, is remotely operated on a day-to-day basis with a local engineer doing visual inspection on request.

Evidence from other countries shows that during the early stage of technology development, a tendency to rely on foreign technologies exists. In like manner, South Africa will also rely on 'tried and tested' foreign technologies for its marine generated power, specifically wave derived. However, in the long run, South Africa could start manufacturing at least some components of the relevant technologies (if necessary or economically viable) utilised to generate marine power, while employing local labour to construct and maintain marine plants.

- Construction – Since wave generated power is still in its early stages in South Africa, there will be no construction jobs in the short to medium term. However, small wave power plants may be constructed in the long term, with the assumption made that at least three plants of 50 MW each will be built in the long term, each requiring 125 workers per year over a three-year period. No exportation of service-related jobs to the rest of the African continent is anticipated at this stage.
- Operations and maintenance – Each plant would require 50 workers to operate and maintain the plant.
- Manufacturing – The technology utilised in wave power generation will most likely be imported and, therefore, no manufacturing jobs are expected to be created locally within the time horizon covered in this report.

<u>Results</u>

Table 3.25: Summary of net direct employment potential associated with marine power

Activity	Short term			Medium term			Long term		
	Domestic	Export related	Total	Domestic	Export related	Total	Domestic	Export related	Total
Construction	0	0	**0**	0	0	**0**	141	0	**141**
O&M	0	0	**0**	0	0	**0**	56	0	**56**
Manufacturing	0	0	**0**	0	0	**0**	0	0	**0**
Totals	0	0	**0**	0	0	**0**	197	0	**197**

Source: Authors

Ease of introduction of the technology into South Africa

<u>Implementation challenges</u>

The South African authorities require that two permits (ie an electricity generation permit by NERSA and a land use permit) be obtained and that an EIA be undertaken before any tidal or wave installation can be approved.

A challenge currently facing the budding marine power industry in South Africa is that it will take time for industry players to identify the appropriate technologies, as well as to gain the adequate experience to operate the marine devices and other multi-device projects in the marine

3.5.1 environment. This would be essential to prove to interested investors, both public and private, that the technology works and that there is potential for this industry to thrive in future.

From the demand perspective, unless government provides incentives/subsidies for the use of this form of energy, its cost structure will be high relative to conventional or other renewable sources. Without such support, demand for marine generated power could be minimal, thus acting as a deterrent to potential investors.

Key policy implications

Financial support could be provided either through tax incentives or other forms of subsidisation for the manufacturing of marine power machinery and equipment, as well as relevant components, in order to encourage local investors to partake in the realisation of the industry's growth potential.

3.6 BIOFUELS

Biofuels are liquid fuels derived from plant materials and recycled elements of the food chain and are basically split into bioethanol and biodiesel. Cereals, grains, sugar crops and other starches can be fermented to produce ethanol. Cellulosic materials from grass, sugar or sorghum bagasse, straw, bran, or wood waste – so-called second generation materials – can also be changed into alcohol and subsequently to fuel. The largest share of global bioethanol production comes from maize and sugar cane. Oil seed crops such as soy, canola and sunflower, as well as waste oil, can be converted into biodiesel, while biomass such as algae is seen as the next generation source thereof.

3.6.1 Bioethanol/biodiesel

Historical progress/maturity

The concept of biofuels is not a new one, particularly their use in the transportation sector. Over the last three decades, biofuels have gained credibility worldwide as a supplement to petroleum fuels.

Most biofuels were introduced in the late 1970s, following the fuel crisis. As oil prices rose, biofuels became more appealing as an alternative transport fuel. More recent and sustained increases in international oil prices, particularly in countries that import the bulk of their fossil fuel requirements, together with growing concerns over the environmental pollution caused by burning oil and other fossil fuels, have once again increased the attraction of alternative fuels.

Apart from the global warming and climate change forces, the recognition of the benefits of energy supply diversification, domestic air quality benefits and waste reduction, as well as enhanced rural economic development have also supported the expanding production and usage of biofuels. The use of biofuels for transport, nevertheless, remains relatively low in most countries - even where large volumes of biofuels are produced. However, legislative initiatives promoting the use of environmentally friendly fuel with lower emission levels are likely to further stimulate the production and utilisation of biofuels.

Advantages/disadvantages

The use of maize or sugar crops for bioethanol production can have a negative impact on the food security situation in a specific country and, if its share of global output is sizeable, the adversity can be aggravated in a more geographically widespread manner through rising food prices. Biodiesel is produced from vegetable oil sources and thus also has an influence on food markets.

Apart from the more generic benefits such as renewable energy goals, energy security and emissions reduction, biofuel production reduces the burden of importing petroleum fuels. It can also make a meaningful contribution to the development of rural areas, providing opportunities for both existing and emerging farmers and thereby augmenting job creation. Strong backward linkages to agriculture exist, while valuable by-products include some food products, animal feed components in various forms, and chemicals. An extended growing of food crops on currently under-utilised land would minimise the impact on food security, as well as have some positive impact thereon due to the increased availability of by-products used for animal feeds[91].

The production of ethanol from sugar crops, compared with maize for example, has the additional benefit of potentially generating its own energy from bagasse waste. Furthermore, the advantage of using waste from agricultural crops or wood, the so-called second generation feedstock, is that the effect on the food markets would be limited. Biodiesel projects also tend to require longer lead periods prior to production than is the case with bioethanol.

Brief overview of global usage

The technologies used in biofuels producing plants are well established worldwide. The production and use of biofuels has been gaining momentum in many industrialised as well as developing countries, a number of which are working towards the setting of targets for its usage.

Bioethanol accounted for around 84% of the world's biofuels production in 2007[92], although the share of biodiesel has been rising. World production of ethanol stood at about 52 billion litres, of which the USA contributed more than 50% and Brazil 36%. Europe supplied 60% of global biodiesel output, with Germany being the world's largest user. Future consumption is expected to continue rising at a rapid pace, with biofuels projected to contribute up to one-third of the world's transportation fuel within the next two decades.

Brazil's bioethanol industry has become the second largest of its kind in the world within a relatively short period of time. It was boosted by a dedicated development programme, which included incentivisation. This programme aimed to establish new sugar plantations, expand the number of distilleries, develop new fuel-distribution networks, encourage the production of a fleet of ethanol-fuelled vehicles, and stimulate demand. It also attempted to establish linkages between agricultural and industrial sector players.

Europe's world leadership in biodiesel production resulted from two major factors:

- Firstly, reform of the Common Agricultural Policy, whereby farmers receive some form of payment for removing a specified percentage of their farm area from production. Because non-food crops are permitted on set-aside land, this policy has encouraged oilseed production for biodiesel processing on such land; and

- Secondly, the exemption of biodiesel from the high European fuel excise tax provided a strong stimulant to its consumption. Coupled with these factors, quality control is of utmost importance in the EU, with this factor easing consumer concerns and raising acceptance and confidence levels by vehicle manufacturers as well.

Major players globally and/or domestically
A large number of producers are involved in the production of bioethanol and biodiesel around the world, mostly in North and South America (particularly the USA and Brazil), as well as in Europe.

In the South African market, a number of producers, including Illovo and NCP Alcohol based in Durban have been producing smaller volumes of potable alcohol for applications other than fuels. Five potential ethanol projects based on sugar cane or beet sugar have been identified by the IDC and the Central Energy Fund (CEF), at least two of which being at advanced stages of planning and expected to start production from the second quarter of 2014 onward. Stellenbosch Biomass Technologies is involved in the development of local technologies for the production of bioethanol from cellulosic materials.

Other than relatively small projects, biodiesel projects of greater importance in South Africa have not shown significant progress. A major project currently envisaged is the canola-based project in the Eastern Cape, where the DTI aims to enable the construction of a 400 000 tonnes refinery. The North West government, in conjunction with Mafikeng Bio-technologies, Clean Air Nurseries and the Mafikeng Industrial Development Zone, also initiated an oil seed growing and processing project.

A number of other companies have been involved in the planning of biodiesel plants, including Sasol, CEF, LG Biodiesel, SA Biodiesel and the National Biofuels Group. A different ‘technology’ for the production of biodiesel involves the refining of waste vegetable oil, with First In Spec intending to start production in the near future.

Applicability to South Africa and/or the rest of Africa
In recent years, a number of smaller biodiesel and bioethanol production facilities have been set up around the country, with the latter supplying inputs to the beverages and chemicals markets. As far as raw material supply is concerned, southern Africa has the potential to establish or expand the supply of a number of biofuel feedstock crops. These include maize, grain, sorghum, sugar cane, sugar beet and barley (as well as agricultural or wood waste as second-generation feedstock) for bioethanol production; and soya, sunflower, canola and groundnuts for biodiesel. There is limited potential for soya production in South Africa due to poor growing conditions with sub-economic returns.

Furthermore, of the country’s 16.7 million ha in potential arable land, 12.9 million ha are commercially utilised, leaving more than 3 million ha of currently under-utilised land[93]. The assumption in this report is that a total of 78 000 ha of previously under-utilised land will be earmarked for energy crop production. Thus, there is still a significant quantity of under-utilised land that could be used for future increase in food production. Other countries in the SADC region also have large portions of land available with even higher production potential. The supply of feedstock could be arranged through out-grower schemes, whereby local communities are involved.

As far back as the mid-1900s ethanol was being produced in South Africa, but production stalled due to low crude oil fuel prices. The bioethanol projects currently envisaged in South Africa largely aim to utilise grain, sorghum, sugar cane or beet sugar as feedstocks. The fact that maize is a staple food crop in South Africa limits its availability for fuel production. However, it can make a welcome contribution when grown on under-utilised land. The usage of second generation materials such as cellulose for ethanol production will also become increasingly important, not only because of the additional raw material source, which can be collected throughout southern Africa, but also due to the strength of the relevant local research capacity.

The fact that South Africa imports most of its vegetable oil places a damper on the immediate potential for using its local vegetable oil supply for biodiesel production. Consequently, biodiesel projects currently in the pipeline are heavily dependent on the successful development of the agricultural aspect of growing the relevant crop.

The South African government has committed to a 2% blend target for the national fuel supply by 2013, aiming to subsequently scale it up to 10%. This would amount to around 450 million litres per year in 2013.

Analysis of potential job creation

Adaptation of generic methodology to the specific industry

- Construction – Construction activities in this area will mainly entail the building of biofuel processing plants. The number of construction workers needed to build a plant has been estimated at 1 000 for an 80 million litre project, rising on a pro-rata basis for larger projects tackled in the medium and longer term[94]. Half of the employment opportunities associated with the construction of plants projected for other African countries are assumed to benefit South African workers, due to the level of skills required.
- Operations and maintenance – The largest contribution is expected to arise from the growing of crops for raw material supply. Some 3 100 permanent workers are estimated to be required on a farm of around 6 000 ha, rising over time along with project sizes[95].
- Manufacturing – The operations and maintenance of the biofuel plants are classified as manufacturing employment. It is estimated to amount to some 500 jobs in an 80 million litres plant[96], which includes the chemical process. With regard to the manufacturing of equipment, the share of local jobs in the total number of jobs created is assumed to be determined by the relevant local industries' capacity to supply parts and components. Depending on the assumed competitiveness and capability of a local industry to supply such parts, a 'capacity factor' of one-third, two-thirds and 100% was allocated, respectively, referring to low, medium or high supply shares (refer to the table below).

Table 3.26: Potential contribution capacity of local industries

Sector	Product/services	% share in total capital cost[97]	Local capacity
Manufacturing:	**Production/supply of:**		
High-tech plant and machinery	Plant for drying, stillage, distillation, etc	27.6	Low - medium
Metal products	Piping	6.5	High
High-quality parts and machinery	Instruments, valves and controls	3.6	High
Electrical and electronic equipment	Electrical installations	3.4	Medium
Metal products	Other installations and scaffolding	6.5	Medium
Construction and civil engineering	Civil engineering, building, structural work	11.6	High
Machinery / construction	Infrastructure	33.9	High
Services	EPCM services *	6.8	High

Note: * Engineering, Procurement, Construction Management
Source: Authors

A factor of 48% local supply, calculated from the shares in manufacturing capital cost and the competitiveness factors, is used in the jobs estimates. 50% of the infrastructure share is taken as manufactured products for the purpose of estimating the local manufacturing contribution.

Lastly, job numbers pertaining to local manufacturing are 'phased-in', assuming an increasing contribution of 40%, 60% and 80% by local industries in the short, medium and long term, respectively. An increasing contribution by South African manufacturing in the supply of materials and equipment to plants in the rest of Africa is also built into the equation (ie 0%, 40% and 60% over the short, medium and long term, respectively).

The capacity of the biofuel projects envisaged in the employment projections varies between 80 and 150 million litres of fuel per year, manufactured from crops grown on between 6 000 and 15 000 ha[98]. Taking into consideration the projects planned or envisaged by government, the IDC, CEF and private concerns, the following numbers of plants are forecast to be erected over the next 15 years:

Table 3.27: Number of biofuel plants

	Short term	Medium term	Long term
South Africa (ethanol)	1	3	4
South Africa (biodiesel)	1	2	2
Other countries in Africa (ethanol/biodiesel)	0	2	3

Source: Authors

According to the manufacturing potential highlighted above, the need would arise for at least 150 additional jobs for each 80 million litre plant, rising pro rata for larger plants. Furthermore, a small number of additional jobs are assumed to be potentially created by the demand for agricultural equipment on the biofuel crop farms. In calculating the employment potential, one artisan is also assumed to be involved in agricultural equipment manufacturing for every 164 farm workers[99].

Results

Table 3.28: Summary of net direct employment potential associated with biofuels

Activity	Short term			Medium term			Long term		
	Domestic	Export related	Total	Domestic	Export related	Total	Domestic	Export related	Total
Construction	750	0	**750**	1 125	200	**1 325**	1 391	328	**1 719**
O&M	4 650	0	**4 650**	16 430	0	**16 430**	44 369	0	**44 369**
Manufacturing	298	0	**298**	2 148	17	**2 165**	6 602	39	**6 641**
Totals	5 698	0	**5 698**	19 703	217	**19 920**	52 362	367	**52 729**

Source: Authors

Ease of introduction of the technology into South Africa

Implementation challenges

The supply of agricultural crops at an acceptable price and quality is the single most pressing challenge for a successful South African biofuels industry. The development and expansion of efficient agricultural supply capacity is thus at the centre of the emerging biofuels industry, with notable factors affecting it including climatic conditions, water and land availability, as well as support infrastructure.

Biodiesel can be more easily incorporated into the country's fuel system and used on its own, while bioethanol has to be blended with petrol. However, due to the lack of local vegetable oil supply (mostly imported), the envisaged biodiesel production plants are faced with higher priority demand from food markets, especially when targeting the export market.

The local Mafikeng Biodiesel project, aiming to produce biodiesel from Jatropha, Moringa and other oil-containing plants, has not come off the ground yet. Although Jatropha oil has been successfully used in projects around the world, it is still not permitted to be cultivated in South Africa due to its toxicity and environmental concerns. However, the possibility of its controlled development being permitted in future should not be ruled out.

The use of higher fuel blends could require widespread engine alterations. However, the decision-making process towards establishing the appropriate regulatory framework and operating environment, including financial and other forms of support for the development of the biofuels industry, has long experienced bottlenecks, retarding the progress of projects as a result.

Key policy implications

A variety of regulatory barriers still have to be crossed before the local biofuels industry can really take off. The success of developing a biofuels industry globally depends on governmental support such as mandatory legislation, policies and a range of incentives and subsidies, more so in the initial stages of development. In South Africa, draft regulations have already been gazetted for an initial upliftment to a 2% blend, to be followed by a scaling up to 5% and 10%.

Of significant importance is the inclusion of a mandatory blending target as part of the biofuels strategy. Such measures are even more important in South Africa, where the fossil fuel-based energy cost is relatively low and energy consumption markets are dominated by established industries.

Incentives in South Africa should include the continuation of the fuel levy exemptions on biodiesel and ethanol.

Feedstock availability is a major challenge and the development of currently under-utilised land for the supply of biofuel crops will have to be supported by government, especially if local communities and emerging farmers are targeted as growers. Support has to cover services such as crop selection, growing methods, logistics and infrastructure, and relationships with biofuel producers. Remaining technology challenges will also have to be addressed, together with sufficient funding supply for research and development and start-up cost support.

Biofuels developments in other SADC countries should be encouraged, as long as they do not compromise food security. After all, the agricultural potential in many of parts of the region is better than locally.

4 ENERGY AND RESOURCE EFFICIENCY

4.1 GREEN BUILDINGS

Green buildings encompass numerous dimensions (design principles, water use, lighting ventilation, shading, etc). Various studies have tried to tackle the relationship between job creation and green building development.

In the Intergovernmental Panel on Climate Change's Fourth Assessment Report (2007), it is mooted that the building sector has substantial potential for reducing GHG emissions. According to the Green Building Council of South Africa, independent studies confirm that certified green buildings can consume 70% to 85% less energy, 65% less potable water and send 69% less waste to landfills than non-certified buildings[100]. Furthermore, research published by the Green Building Council of Australia indicates that green buildings consume 26% less energy than the average commercial building, and generate 33% less GHG emissions[101].

The energy demand of buildings falls roughly into three categories:

- Lighting;
- Heating ventilation and air conditioning (HVAC); and
- "Small power", which consists of appliances within the building that use electricity (eg computers, copiers, printers and refrigerators).

Only building insulation, lighting efficiency and insulated windows are considered here as they were assessed to have job creation impacts. Other features of green buildings, like new construction materials or building design are not included as the impact on direct job creation is difficult to estimate. Heating ventilation and air conditioning are also not included since they are hardly green even if new heating and air conditioning technologies display higher efficiency rates[102].

4.1.1 Insulation, lighting and windows

Historical progress/maturity

The business case for green buildings is mostly based on anecdotal evidence, although some concrete evidence is coming to the fore as the sector progressively matures. By rethinking whole building design, the energy demand can be reduced to 5% of the norm, while the conditions in the building remain comfortable, as demonstrated by the 'Passivhaus'[103] in Germany. The key elements in this approach include:

- The envelope[104] – All components of the structure that encloses the internal space should be highly insulated;
- Air tightness – Stopping air leakages through unsealed joints;
- Ventilation – Using a mechanical system with heat recovery so that hot air leaving the building warms the cooler incoming air;
- Thermal 'bridges' – Eliminating heat loss from poorly insulated points in windows, doors and other parts of the envelope; and
- Windows – Minimising heat loss in winter and heat gain in summer.

In a case study on the refurbishment of a building in Melbourne, Australia [105], shading was used to reduce heat load with vents to exhaust hot air. Careful orientation, screening and shading reduced the heat load, while insulation and ventilation contributed to moderate temperatures. A study by the World Business Council for Sustainable Development[106] confirmed improved insulation products or practices to avoid loss of thermal insulation R-value[107], and that thermal bridging and air leakage are major factors that can result in a potential energy saving of 12%. However, the barriers to their broad implementation include a lack of consumer and builder education as well as of third-party oversight for retrofitting, while sufficient insulation could be expensive.

Insulation is often cited as 'low-hanging fruit', where the benefits exceed the cost, and it can generate large numbers of jobs. One example is the upgrading of buildings to reduce their emissions, as demonstrated in Germany[108]. This involved improving heating insulation in the roofs, windows and walls of 265 000 apartments, reducing heating operating costs and creating about 190 000 jobs in the process. Furthermore, it saved two million tonnes of CO_2 emissions as it incorporated triple glazed windows and controlled air ventilation systems with 85% heat recovery[109].

By adequately insulating the entire outer shell of a house, the demand for heat will be lower, thus requiring a smaller and cheaper heating system, and resulting in a two-thirds reduction in energy consumption. Such super-efficient houses have been built in Europe[110], but the region has different climatic conditions and heating requirements. Hence, the array of building and energy technologies used in other parts of the world are not necessarily readily applicable to South African climatic conditions.

According to the World Business Council for Sustainable Development[111], high performance windows have the potential to save 39% of heating and 32% of cooling energy for high insulation technologies (HIT). New window technologies include second generation low-emissivity (low-e) coatings, HIT with triple and quadruple panes, vacuum spaces and aero-gels. In the USA, low-e coatings and double pane windows are standard[112], but HIT windows account for less than 1% due to the cost being much higher than standard windows.

As far as lighting is concerned, incandescent lights produce light as a by-product of the heat generated. Consequently, the light efficiency of the technology is very low and new technologies have been developed. Compact fluorescent lamps (CFLs) were introduced in the 1990s. These consume two to five times less power than incandescent bulbs, and last about eight to ten times longer. Light emitting diodes (LEDs) are a more recent technology that is not yet fully mature. LEDs consume two to three times less power than CFLs, and last about nine to ten times longer[113].

Advantages/disadvantages

The advantages of utilising energy-efficient technologies in buildings include:

- Energy saving following building insulation or efficient lighting is potentially high, which impacts on the energy demand and on the energy/electricity bill of consumers at the local level;
- Insulation technologies are mature and materials are readily available;
- Lighting demand coincides with peak load hours, but the extensive use of energy efficient bulbs contributes to reducing peak power demand; and

- Off-grid lighting solutions are viable due to very low electricity consumption of the CFLs and LEDs.

However, there are also a number of disadvantages, such as:

- The upfront cost for insulation is relatively high, while energy savings are lower than in Europe because of different weather /climatic conditions;
- RDP houses are lacking in energy efficiency technologies, raising the cost of energy for the poor;
- CFLs contain a small amount of mercury, which requires CFLs to be recycled to prevent any potential damage to health or the environment; and
- LEDs are still in the early stages of development and remain quite expensive.

Brief overview of global usage

Energy efficient technologies for buildings and housing are not widely used around the world. Nevertheless, most of the developed countries have norms and standards related to housing and building construction and the trend is definitely toward their strengthening. However, the impacts of such measures are limited and countries are still far from the zero net energy mark for buildings. The potential for improvement is massive though, as buildings are responsible for more than 40% of the energy used and 29% of GHG emissions[114].

Major players globally and/or domestically

- Building insulation and windows – There are many players in the market supplying various types of insulation, while the global market caters predominantly for glass fibre and mineral wool for their climatic control characteristics. The major players for windows are not identified separately
- Lighting – China produced 3 billion CFLs in 2007, ie about 80% of the world CFL market[115]. Philips Lighting opened a CFL factory in Lesotho in March 2009 to supply the southern African market, and signed an agreement with Eskom for its CFL exchange programme[116]. LED producers are numerous around the world.

Applicability to South Africa and/or the rest of Africa

In South Africa, the government's focus is on solar radiation for heating, natural space heating and cooling, and on energy-efficient lighting. The main heating load of a residential house during the day is from solar radiation. This heat would be stored as thermal energy in the structure and would be released during the night to assist in heating the interior when the ambient environment is cold. The use of thermal mass is quite effective in local climates that have large daily temperature variations.

Most thermal energy in South African houses escapes through the roof and, therefore, the single most effective intervention in the building shell is roof insulation. Office buildings are normally operated during daylight hours and, depending on their design, are also heated by the sun. Natural ventilation systems offer large energy-savings, with the basic concepts being quite simple. However, the optimisation of such systems requires experience in the particular field, which currently does not exist in much depth in South Africa. Significant capital expenditure may, however, be required initially, depending on the design.

Insulation is imperative in houses that are built to be more energy efficient. Insulation is easy and cost-effective to implement, but is often neglected in order to save on capital expense. An insulated house does not often rank highly in what the average consumer wants in a house. With a massive housing backlog, the problem is exacerbated by RDP houses that lack energy efficiency[117].

Improved insulation products or practices to avoid loss of thermal insulation R-value have the potential of saving 12 % in energy, but the CSIR does not foresee new job opportunities[118], except in those jobs that are directly linked to higher levels of insulation manufacture and installation.

South Africa currently imports some green materials and new technologies. Evidence has affirmed the notion that green building is costly[119] and experience dictates that, in the local context, the initial capital investment is high due to the lack of competition in the green building materials sector, among other factors. Adding insulation during new building is more cost effective, as retrofitting insulation is harder and more costly.

In South Africa, 12% of the electricity used by the residential and commercial sectors corresponds to lighting. Eskom launched a CFL exchange programme in 2004. Since then, 34 million of CFLs were exchanged for incandescent bulbs[120]. This programme, which ended in August 2010, resulted in the saving of 1 759 MW[121]. Since the light bulb market in South Africa is estimated at 200 million, more can be done to improve the use of more efficient light bulbs. The potential for job creation in the lighting sector is practically non-existent, except for the retrofitting of street lights with LEDs.

Building codes are being updated to include energy-efficient measures. The aim is to include the standard ‘Energy usage in buildings’ SANS 10400-XA as part of the National Building Regulations, whilst SANS 204 ‘Energy efficiency in buildings’ is a voluntary standard. Legislation will only apply to new buildings. South African buildings are generally not centrally heated, and seldom artificially cooled. Opportunities in the residential building sector are found in energy efficient windows, roof insulation, lighting, the use of solar water heaters (SWHs), heat pumps and energy-efficient appliances.

Most retrofitting by the Department of Public Works entailed replacing old lighting with energy-efficient light fittings. The City of Cape Town, Ekurhuleni Metropolitan Municipality, eThekwini Municipality[122] and the City of Johannesburg all embarked on implementing energy-efficiency measures, such as retrofitting council buildings, installing energy monitoring and control systems, as well as retrofitting street lights. The energy-efficient retrofitting of 20 000 houses in Alexandra and Cosmo City was also achieved. In the Kuyasa Energy-Efficiency Project[123], existing low-income houses were retrofitted with SWHs, insulated ceilings and two CFLs each. The City of Cape Town has also developed ‘Green Building Guidelines’[124] for better energy efficiency during construction and for the operation of buildings[125].

Where solar radiation serves to heat a building, static shading structures can be applied to the windows. The windows could alternatively be recessed into the building structure, which would have the same effect. This intervention is simple and easy, with some implementation already evident in South Africa. However, according to the CSIR, such an intervention would not create any new jobs[126].

Analysis of potential job creation

Adaptation of generic methodology to the specific industry

One of the most comprehensive studies for South Africa remains the CSIR/ILO report[127]. This study found a very limited number of green jobs created in the building industry using macro-economic estimates (at best 13 833 jobs from 2008 to 2020, translating to 1 153 jobs per year). In this report, a different estimating approach was adopted, as described below.

New jobs can be largely created in the construction sector through the insulation of buildings (roofs, walls and floors). The roll-out of insulated windows and more efficient lighting is only expected to create a very limited number jobs, mainly in the construction sector via the replacement of old windows, and therefore has been excluded from the estimates.

It is not possible, using existing data according to the CSIR, to directly estimate the impact of green buildings on employment[128]. The data that could be used for the purposes of estimation was limited, with the type of data available being inconsistent across the public and private sectors. One of the underlying reasons is that historically the market for insulation was small in South Africa. The data that was available for the private sector was the area (square metres) of building plans approved and buildings completed, split by residential and non-residential as well as alterations and additions[129]. For the public sector, data was available for RDP housing delivery[130], and on expenditure on new construction works and major renovations and alterations[131]. Data pertaining to the insulation industry was obtained through interviews with various stakeholders in the industry[132].

Where possible, the estimates were based on the area of buildings completed. However, assumptions had to be made to ensure data consistency, such as converting public expenditure to square metres. Taking into account past trends and the economic slowdown, growth rates for the residential, non-residential and public sectors have been estimated to be respectively 2%, 5% and 10% per year on average until 2025. The SANS 10400XA will play a key role in catalysing the industry. From 2012 onwards, once its implementation is effective, we assume that new buildings will have both roof and insulated walls to comply with the energy efficient requirements, excluding RDP houses.

The following detail the methodology used to estimate the employment potential in insulation installation, O&M and in associated manufacturing activities:

- Building, construction and installation – The proxy for installation is based on the estimated building area completed each year, with the data for the private sector in 2009[133] and the public sector expenditure[134] drawn from StatsSA. The number of jobs required is then calculated based on the ratio of area in square metres per person and the number of working days in a year. The number of people required to install insulation is relatively low at three people per 150 m^2 per day. The installation was categorised into new buildings and retrofitting of existing buildings, and further differentiated by private and public, as well as residential and non-residential buildings. Energy auditors have been included in the installation estimates, based on the number of new buildings built, with each auditor auditing an average of 150 building a year.

  On the lighting side, only street light retrofitting is assumed to create new jobs, at a rate of one job year per 500 streetlights retrofitted.

- Operations and maintenance – Insulation installed in new or existing buildings is designed to last over the lifetime of the building and, therefore, the operations and maintenance jobs are deemed to be negligible.
- Manufacturing – The number of additional jobs is determined by the additional demand for insulation in the short, medium and long term. This demand is determined by the additional building area expected in the private and public sectors. By determining the area with the same methodology as described in the 'installation' section above, the ratio of square metres of insulation per manufacturing job could then be applied to estimate the employment numbers. For lighting, due to the CFL factory in Lesotho supplying the southern African market, there is no manufacturing opportunity in South Africa. There could be an opportunity to provide insulation to the rest of Africa, particular the SADC region. There are no trade-offs or job shedding implications, since South Africa has historically had low penetration rates for insulation.

<u>Results</u>

Table 4.1: Summary of net direct employment potential associated with insulation, lighting and windows

Activity	Short term			Medium term			Long term		
	Domestic	Export related	Total	Domestic	Export related	Total	Domestic	Export related	Total
Construction	1 559	0	**1 559**	3 856	0	**3 856**	6 502	0	**6 502**
O&M	0	0	**0**	0	0	**0**	0	0	**0**
Manufacturing	302	0	**302**	588	0	**588**	838	0	**838**
Totals	1 861	0	**1 861**	4 444	0	**4 444**	7 340	0	**7 340**

Source: Authors

The estimated employment potential identified above is significantly higher than that found in the ILO/CSIR study, although the differences in methodology should be borne in mind. However, it must be noted that the 7 340 new jobs represent an increase of less than 1% on the number of jobs recorded in South Africa's construction sector in the third quarter of 2011 (ie approximately one million as indicated in Appendix I).

The largest potential for job creation is found in building, construction and installation. According to a CSIR built environment expert, the installation of insulation can be undertaken by construction workers that would normally build the wall and install the ceiling. Therefore, there is little job creation potential, except in additional demand for insulation installations.

Ease of introduction of the technology into South Africa

<u>Implementation challenges</u>

- Further appropriate legislation, regulation and implementable programmes could trigger major energy-efficiency improvements in buildings, with the associated employment gains. However, our analysis is based on the currently proposed minimum standards (SANS 10400 XA).
- Good practice in voluntary building efficiency improvements (eg Green Star SA) could be an important stimulus, but would require commensurate consumer education.

Key policy implications

- Development of new regulatory instruments (eg building codes) that are effective and implementable.
- Progress with policy instruments has been limited due to capacity constraints, as well as the time scales required for implementation and to give effect to the respective policies.
- Policy instruments that are internationally known to be effective within the building sector have been identified, but have yet to be developed or implemented. These include mandatory audit requirements, as well as labelling and certification programmes, among others[135].
- Government should implement the necessary legislation and regulations, including low-income or RDP houses in the process since energy savings would benefit the poor and the potential for jobs creation is important (ie a double dividend). For instance, the SANS 10400 XA should also apply to RDP houses for insulation as the long term benefits in terms of job creation and energy expenditure by low income households would probably outpace the short term saving on spending.
- Raising awareness about the potential savings related to green standards for building and housing.

4.1.2 Solar water heaters

The abundant solar resources in South Africa make the applicability of solar water heating (SWH) particularly relevant, especially as a measure to reduce energy consumption and improve living standards of the poor. To heat water using solar energy, three main technologies exist, all using sun rays to heat water either directly or indirectly:

- Glazed flat-plate collectors can be open or closed loop, depending on whether the region is subjected to sub-zero temperatures. Closed loop systems, also called indirect systems, prevent the build up of calcium in the collector in areas where water contains a lot of calcium. These are mainly used for heating domestically used water;
- Unglazed flat plate collectors are used for swimming pools[136]; and
- Evacuated tube collectors involve the circulation of water through evacuated tubes coated with a solar radiation absorber. This technology can be used in all types of weather, since the outside temperature of the tube is not related to heat production, thus increasing energy efficiency (ie it can produce higher temperatures than flat-plate collectors when radiation is low)[137]. However, in a country like South Africa with high solar radiation, the risks of overheating domestic water are real, thus requiring the setting of special norms to avoid scalding.

Hybrid PV/thermal water heating systems might well be the technology of the future. However, despite being already commercially viable, such systems are not yet widely used. This technology combines PV cells, which convert radiation into electricity and solar thermal collectors, used to capture the heat coming from radiation that is not converted into electricity[138]. This has mainly been due to the cooling requirements of PV cells.

Historical progress/maturity

The invention of solar energy for heating water, involving a simple tank painted in black, dates back to the end of the 18th century, when the first patents were registered in the USA. In the 1920s, the first thermosyphon system (ie a tank on the roof, with a water collector below) was patented in

California. But the discovery of natural gas and its cheap costs of production stopped this technology from spreading. Every energy crisis that followed created renewed interest in solar water heating, but subsequent drops in energy prices always prevented any massive take-off[139].

Solar technologies for domestic hot water heating are now mature enough to be used in any kind of climatic environment[140]. Over the past five years, solar water heating capacity globally is estimated to have grown by 19% annually, with more than 70 million households presently using solar water heating, mostly in China[141]. In 2009, the total investment in hot water systems amounted to USD 13 billion [142].

Advantages/disadvantages

In 2008, the 150 Giga Watt Thermal (GW_{th})[143] capacity of solar thermal systems installed worldwide had led to an emission reduction of 39.4 million tonnes of CO_2, of which more than 22 million tonnes were recorded in China[144]. Furthermore, the solar heating and cooling sector employs between 200 000 and 300 000 people worldwide, depending on the estimates[145].

In South Africa, households could see their energy costs reduced by 30% to 50%, and their emissions lowered by 3 tonnes per year through the use of this technology. Moreover, the one million SWH target set by government should reduce peak demand on the grid by 630 MW, or 1.6%[146].

The high upfront costs of solar thermal systems can deter their development when users are looking for short payback times, while the low relative price of alternative energies, at times resulting from subsidies, creates a disincentive.

Brief overview of global usage

The solar thermal market has picked up over the past decade. In 2008, 217 million square metres of collector area were operating in 53 countries, representing an estimated 80% to 90% of the world market. In that year, the installed capacity of water collectors globally amounted to 150 GW_{th}, shared as follows: China (87 GW_{th} or 58%); Europe (28 GW_{th} or 19%); USA and Canada (15 GW_{th} or 10%)[147]. By 2009, it was estimated that this capacity had risen to 180 GW_{th}, with China providing 22 GW_{th} of the additional 30 GW_{th} in newly installed capacity[148].

While in the USA and Canada solar thermal systems are mainly used for the heating of swimming pools, in the rest of the world they are mostly utilised for heating water for domestic use as well as space heating.

Major players globally and/or domestically

China is the absolute world leader in evacuated tube collector production and installation, while flat-plate collectors predominate in Europe and North America. However, evacuated tube collectors are gaining market share, representing close to half of the installed capacity in South Africa [149].

In 2009, China produced 77% of the world solar water heating collectors, with more than 5 000 producers and distributors. China started exporting low-cost SWHs to Africa in the same year[150]. The manufacturing sector is very fragmented, with many firms in each country. While Chinese SWHs are very competitive in terms of price, their quality is at times questionable.

In South Africa, many small producers are trying to establish themselves, but the size of the market is still too small for the consolidation momentum to develop, or for major investments in a mechanised factory to materialise[151].

Table 4.2: Some of the major players in South Africa

Company	Feature	Website
Ikhwezi Solar	Local manufacturer – Flat plate collector	www.salorec.co.za
Solar Beam	Local manufacturer – Flat plate collector	www.solarbeamsa.co.za
Solar Heat Exchangers	Importer (France) and OEM geyser produced by Kwikot (geyser local/collector from France) – Flat plate collector	www.solarheat.co.za
Solar Tech	OEM geyser manufactured and imported by Kwikot (geyser local/collector imported from China) – Flat plate collector and evacuated tube collector	www.setsa.co.za
Solarhart	Importer (Australia) – Flat plate collector	www.solahart.co.za
Tasol Solar	Importer (China) – Evacuated tube collector	www.tasolsolar.co.za

Source: Authors

Applicability to South Africa and/or the rest of Africa

In South Africa, daily solar radiation ranges from 4.5 KWh/m^2 to 6.5 KWh/m^2, making solar systems very relevant[152]. Electricity savings can be generated through the expansion of solar water heater installation, since 17% of electricity is consumed by the residential sector, of which 40% to 50% is taken up by electrical geysers[153].

Given the high probability of water freezing in winter, as well as the high water calcium content, 85% of the SWHs installed in South Africa will be in the form of indirect systems[154], with this technology being also widely applicable to the rest of Africa. However, the shortage of installation skills could slow down the roll-out of SWHs in South Africa and in the rest of the region.

Analysis of potential job creation

<u>Adaptation of generic methodology to the specific industry</u>

To simulate the employment creation potential, the current income structures of households in the country were utilised. Different penetration rates were then assumed over time, depending on the income level of households:

- Mainly high income households are assumed to install solar water heating at least in the short-run, since the main objective is to save electricity from the grid, with support from the Eskom rebate programme;
- Because middle income households cannot easily afford it, they are assumed to benefit from this technology solely in the medium term, due to cost reductions;
- Poor households would only benefit in the short term because of the Eskom rebate scheme. Once revised to target households connected to the grid, poor households would be excluded. However, in the long term, following decreasing costs due to economies of scale and changes in technology, and appropriate public support, poor households would benefit again.

The following are also assumed:

- The obligation of every new residential building, excluding RDP, to be equipped with a SWH or heat pump, although assuming that SWH would be favoured;

- The limited use of SWHs in new public and commercial buildings, as heat pumps might be more appropriate;
- As far as retrofitting of residential building is concerned, while the penetration rate might be low in the first few years, it is assumed that the increase in the cost of electricity together with the deployment of the technology would lead to the progressive roll-out of SWHs.

After interviewing various SWH providers, it was identified that labour requirements for installations vary for the different types of households, while the maintenance is usually done by the households themselves, specifically:

- For high and medium income households, installation consists mainly of retrofitting existing installations, leading to more labour-intensive installation;
- Installation in new high and medium income houses is half as labour-intensive as retrofitting;
- Installation in public and commercial buildings is one-third as labour-intensive as housing retrofitting;
- Installation in low income and RDP housing is the least labour-intensive activity.

Economies of scale in the manufacturing of SWHs are assumed to be developed over time, leading to a shift from labour- to capital-intensive production. As economies of scale are developed, the competitiveness of the industry will improve, leading to:

- A shift from a 50% import penetration in SWHs[155] to a more dominant local production;
- The progressive development of export potential[156].

According to these assumptions, 200 000 SWHs would be installed by 2012, 3 million by 2018 and full residential coverage by 2020 due to both a decline in the costs of SWHs as well as increasing electricity prices.

Results

The potential for job creation is likely to be found mainly in installation activities. This is due to the higher labour-intensity of retrofitting hot water systems in high income housing. Despite progressive market growth, the number of jobs in the manufacturing of solar panels is expected to remain relatively low due to the economies of large scale production needed to attain a high degree of competitiveness and sustain manufacturing viability through export market penetration. No job losses are expected to be recorded since electrical geyser producers would shift to SWH tank production as the market expands (employment levels in solar water heating tank production are similar to those in traditional geyser manufacturing).

Table 4.3: Summary of net direct employment potential associated with solar water heaters

Activity	Short term			Medium term			Long term		
	Domestic	Export related	Total	Domestic	Export related	Total	Domestic	Export related	Total
Installation	1 345	0	**1 345**	8 932	0	**8 932**	16 278	0	**16 278**
Distribution	6	0	**6**	20	0	**20**	119	0	**119**
Manufacturing	157	1	**158**	451	104	**555**	912	313	**1 225**
Totals	1 508	1	**1 509**	9 403	104	**9 507**	17 309	313	**17 622**

Source: Authors

Ease of introduction of the technology into South Africa

Implementation challenges

The first set of impediments relates to the design of Eskom's current roll-out programme, which has not led to the anticipated spread of the technology. Government should put in place the appropriate regulations to meet the targets.

A second set of impediments to the realisation of the employment potential is technical. The shortage of qualified plumbers able to correctly install solar water heating devices might slow down the roll-out programme. The quality, and therefore the lifetime, of a solar water heater is a prerequisite for the development of the market. Too short a lifespan might prove highly detrimental to the sector and compromise its development for many years: the lifetime of the device must be thus long enough to permit a satisfactory payback over the long term. Should consumers opt for SWHs but subsequently have to change them before they pay back, they might switch back to normal geysers. At present, low price, low quality SWHs are available on the South African market.

Key policy implications

The main uncertainty arises from the design of the roll-out programme, specifically: whether the Eskom scheme will remain in place, be reformed or scratched outright; or whether it will be supplemented or substituted by an alternative programme. Depending on the targeted households, the potential for job creation might be very different under each pathway.

- The efficiency of the roll-out programme is critical, at least in the short run to medium term, to take the South African market to its maturity. Long term signals must also be given to potential manufacturers for these to invest in local production capacity.
- Quality assurance is crucial for both manufacturing and installation, with standards set by SABS for long-lasting, efficient and weather-proof SWHs. This must be accompanied by either a manufacturer warranty (along with a certification of the installation quality and the implementation of a maintenance plan) or an insurance mechanism (perhaps included in homeowner's insurance schemes, as is currently the case with electrical geysers). Assuring consumers that they will not have to bear the risks related to the quality of SWHs will raise their acceptance in the household sector and avoid a retreat back to electrical geysers.
- Plumbers must be trained to properly install SWH to cope with the increasing demand, and meet installation requirements for a potential warranty-insurance scheme to be implemented. A certification process is necessary to ensure the quality of the installation. A limited amount of training with adequate supervision of the installation might prove to be a suitable short term solution.
- The SAN 10400 XA is a first move, although not to the level required, to facilitate the roll-out of energy efficient water heating system (SWH and heat pump). Only new buildings are included in this regulation and additional legislation might be required for existing buildings (retrofitting).

4.1.3 Rainwater harvesting

"Freshwater is a precious but limited resource ... and the competition for those drops [of water] is increasing exponentially."[157] South Africa is considered a water-scarce country. Water scarcity is seen as the next big crisis following that of energy, as there is no substitute for water when the taps run dry.

Rainwater harvesting (RWH) is generally defined as the "practice of deliberate collection of rainwater and storing it for subsequent use."[158] Rainwater can be harvested from the roofs of buildings, and it may be collected as storm-water runoff. Commonly used systems are made up of three principal components, namely: the catchment area (roof and other surfaces); the conveyance system (gutters and drainpipes); and the collection/storage device. RWH takes various forms depending on the intended use, but this section focuses on the role of RWH mainly for household use.

Historical progress/maturity

According to UNEP[159], this technology has been used for thousands of years to make up for the temporal and spatial variability of rainfall, being one of the oldest means of collecting water for domestic use. In urban areas, RWH technology was replaced by the use of central pressurised water supply systems, with tap water being the accepted norm. However, RWH is still an important source of water in other areas (particularly rural areas) that do not have any kind of conventional, centralised supply system, but do experience significant rainfall.

There has been growing interest in RWH in recent decades, with this method of water supply gaining importance and relevance particularly in arid and semi-arid regions. RWH is also considered an environmentally sound technology that can be used to augment freshwater supplies, especially in urban areas. The high economic and environmental costs of centrally supplied water have heightened interest in more sustainable methods of water supply. Added to this is the availability of modern products and system design techniques that result in improved water quality relative to traditional gutter-to-barrel systems.

Advantages/disadvantages

The advantages of RWH include:

- It is considered an environmentally sound solution;
- The technology is simple, cost-effective and easy to install, providing water at, or close to the point where it is needed or used;
- It can potentially reduce pressure on municipal water by reducing demand, thus mitigating water shortages;
- Water is secured for emergency situations;
- It can potentially reduce storm drainage load and flooding;
- Results in savings on water bills for the consumer;
- Reduces environmental costs; and
- Defers capital outlays to augment water supplies.

Nevertheless, certain limitations[160] are associated with RWH, specifically:

- Rain is an unpredictable and irregular source of water;

- Large storage tanks may be required in areas where dry seasons are long-lasting;
- Inflexible guttering systems for certain roof structures (such as thatched or circular);
- The extensive development of RWH systems in certain areas may reduce the revenue streams of public utilities;
- The cost of the RWH system is high compared to the relatively low cost of water and household incomes. A small scale domestic RWH system can have a long payback period. Experiences from other countries show that low water tariffs for piped water make it uneconomical to install RWH mechanisms.
- The quality and health aspects of rainwater may be compromised by atmospheric pollution or acid rain[161]; and
- General lack of clear guidelines for developers and users to follow, especially in urban areas.

Brief overview of global usage

The technology of RWH is widely used the world over, including in developed countries. Increased demand for water and the impact of climate change (eg long drought spells) around the globe are pushing more countries to adopt RWH technologies. Rooftop RWH systems are becoming, or are already mandatory for new buildings in certain countries (eg Australia, India, China, etc).

Various cities in Australia, for instance, have developed water target guidelines for new and existing buildings, whereas a city like New Delhi (India) requires that government buildings have RWH systems[162]. Similarly, in Japan there are strict regulations for buildings with an area of over 300 000 m^2 requiring the installation of RWH systems[163]. Germany, in turn, is estimated to have nearly half a million RWH systems. The uptake of RWH systems has, to some extent, been boosted by the provision of subsidies from certain local governments or some other form of financial support from government.

The uptake has been comparatively slow in many African countries due to a number of limitations, including the relatively high cost of such installations in relation to household incomes.

Major players globally and/or domestically

There are many suppliers of water tanks in South Africa, particularly at the retail level. Jojo Tanks is a leading local manufacturer of polyethylene plastic storage tanks using various distributors nationwide. In terms of RWH systems, companies such as Water Rhapsody, which also has a franchise network in most provinces, as well as others such as Rain Harvesting Systems (Pty) Limited, offer various rain harvesting solutions. These range from relatively small scale residential rainwater systems to large scale commercial stormwater management and harvesting systems.

Applicability to South Africa and/or the rest of Africa

RWH is extensively used in South Africa, particularly in areas where there is no piped water and the groundwater is poor. However, the technology utilised varies from rudimentary to sophisticated systems. The general use of non-potable water for the respective water requirements is still very limited in the country, notwithstanding the predictions that South Africa may be moving towards absolute water scarcity[164].

Government, through the Department of Water Affairs (DWA), is engaged in RWH programmes aimed at facilitating "family food production and other household productive use, including temporary access to potable water for rural communities"[165]. The government's programme is expected to install thousands of water tanks across the country each year, but this is on a relatively small-scale. The DWA's 2009 'Water for Growth and Development Framework' envisages the use of RWH as a short term intervention to address the problem of service delivery, focusing more on remote and/or rural areas.

Various countries in Africa have successfully established and implemented RWH systems to complement their conventional water supplies. A report by Partnership in Development, asserts that South Africa is in fact lagging behind other African countries due to factors such as political pressure for reticulated water schemes, insufficient advocacy for RWH and the lack of design guidelines.

Analysis of potential job creation

Adaptation of generic methodology to the specific industry

Various products are used in the installation of a RWH system, including gutters, pipes, pumps etc. The biggest item is the storage component, in this case the water tank.

According to Water Rhapsody[166], about 140 000 water tanks are made each year in South Africa. An annual increase in production capacity (this would take into account the implementation of the DWA's RWH programme targeting the installation of 5 000 to 7 500 water tanks each year) would have a positive impact on job creation, particularly on the manufacturing front. Industry sources estimate that this would create between 75 and 120 additional jobs a year.

Maintenance of the system is generally limited to regular inspection of some of the components (including the gutters, downpipes etc), making the O&M of RWH systems at household level relatively easy. Employment creation is likely to be very limited should the use of ground or rock catchment areas be employed. In the case of installation (or construction), a limited number of jobs is also likely to be the outcome. Depending on the complexity of the RWH system being installed, about four people could be employed, with the installation taking between one and four days.

Few installations of full RWH systems are taking place at present, with estimates varying from 200 nationally to between 100 and 120 in Gauteng only. It has been estimated that installations of about 10 000 could and should be done. For the calculation of jobs in this category, the assumptions made in this study are based on the number of installations of RWH systems, starting with a base of 500 per year and increasing by 20% per annum in the short term, 25% in the medium term and 50% in the long term. However, the rate of penetration in terms of installation is still deemed to be on the conservative side due to some of the implementation challenges outlined in the respective section below.

The employment estimates associated with each type of activity were calculated as follows:

- Construction – One installation is estimated to involve four workers over four days;
- Operations and maintenance – It is assumed that most of this type of activity will be undertaken at the household level. The job creation opportunities are related to the servicing of the more complex components, with one technician servicing 1 000 systems in a year; and
- Manufacturing – The estimation is based on the number of water tanks manufactured annually. For every 7 000 increase in the main components used (in this case a water tank), an additional 75 jobs are expected to be created.

Results

Table 4.4: Summary of net direct employment potential associated with rainwater harvesting

Activity	Short term			Medium term			Long term		
	Domestic	Export related	Total	Domestic	Export related	Total	Domestic	Export related	Total
Construction	34	0	**34**	76	0	**76**	1 041	0	**1 041**
O&M	1	0	**1**	4	0	**4**	53	0	**53**
Manufacturing	6	0	**6**	13	0	**13**	181	0	**181**
Totals	41	0	**41**	93	0	**93**	1 275	0	**1 275**

Source: Authors

Ease of introduction of the technology into South Africa

Implementation challenges

While RWH technology is considered to be relatively simple and easy to operate and maintain, thereby permitting its implementation on a much larger scale than at present, this is likely to be constrained by a number of factors, including:

- The argument that water can rather be conserved by reducing water consumption within a household (eg low flow taps, aerated showers and low flush toilets) as these are seen to offer relatively shorter payback periods than RWH systems;
- A general lack of public awareness (or advocacy) about the concept of sustainability and conservation of water resources, as well as over the increasing potential of water shortages and restrictions in the country, except for those areas that have been severely affected by droughts;
- Concerns over the quality of rainwater, with perceptions that it may pose some health hazards;
- No regulatory framework and guidelines to implement RWH technology as an alternative to conventional water supply sources;
- Lack of incentives to include RWH in building designs, as well as mandatory regulations to enforce RWH systems; and
- Despite its relative simplicity, a RWH system is not considered a ’fit and forget’ technology, thus bringing along the ‘hassle’ of maintaining and repairing the system, compounded by the associated cost of new parts.

Key policy implications

- For the successful roll-out of RWH, government would need to develop approved regulations for the different types of systems, whether it is for potable or for non-potable applications (this would facilitate the use of rainwater sources);
- Air quality control standards (for dealing with acid rain) and the quality of materials used (particularly roofing materials, storage tanks and reservoirs) should be carefully considered;
- Specific guidelines relating to RWH, particularly for urban areas, including the integration of the current conventional water supply systems with RWH systems.

4.2 TRANSPORT

A transport system can reduce its environmental impact by increasing vehicle efficiency (eg hybrid-, electric-, gas- or fuel cell-vehicles) or through shifts in the modes of transport (eg public transport, cycling ways). Bus rapid transport is one of the priorities to improve transport services to communities, while reducing emissions. Shifting from road to rail is expected to have a significant impact on both the lowering of emissions as well as creating employment opportunities, but is not dealt with in this report due to a lack of adequate information.

4.2.1 Bus rapid transport

According to the World Health Organization, road transport is the "main contributor to emissions of nitrogen dioxide and benzene in cities" and traffic is a major contributor to "gaseous air pollutants and to suspended particulate matter"[167]. This necessitates a focus on public transport improvement to tackle increasing congestion in cities and encourage car users to opt for public transport modes.

A bus rapid transit system (BRT) is one of the technologies that form part of the solution to improve public transport. "[It] is an innovative, high capacity, lower cost public transit solution that can significantly improve urban mobility. This permanent, integrated system uses buses or specialised vehicles on roadways or dedicated lanes to quickly and efficiently transport passengers to their destinations, while offering the flexibility to meet transit demand. BRT systems can easily be customised to community needs and incorporate state-of-the-art, low-cost technologies that result in more passengers and less congestion."[168] For instance, buses could run on biogas that can be generated from anaerobic digesters, or possibly from pyrolysis plants. The option of installing overhead electric lines in conjunction with electric buses could also be a possibility, but only if the generation of the electricity is not based on fossil fuels.

Historical progress/maturity

As early as 1937, efforts had been made to improve the public transport experience. However, it was the 'surface metro' launched in 1974[169] in Curitiba (Brazil) that realised the full promise of BRT. Curitiba's move to improve public transport was a response to rapid population growth and the lack of comfort, convenience and safety that was provided to commuters by private sector operators, largely due to a lack of regulation and control[170]. The initial idea for Curitiba was that of a rail-based metro system, but due to insufficient funds the city was forced to rethink creatively, resulting in the development of bus-way corridors.

Spurred on by the oil crisis in the 1970s, bus-ways were recognised as having the potential to encourage public transport usage in the USA and France[171]. Other Brazilian cities followed Curitiba in implementing basic systems. Once the "crisis receded though, governmental interest with public transport waned"[172]. It was not until Bogotá (Colombia) implemented their highly successful BRT in 2000 that the system was taken seriously as a mass rapid transit solution. Today, BRT systems have been implemented the world over, both in developed and developing countries, with many planning future roll-outs[173].

Since the advent of climate change and the global focus on greening economies, improving public transport networks is seen as an important factor in support of this movement. It can help cities tackle the problems of congestion, pollution and GHG emissions associated with transportation.

Advantages/disadvantages

A study of the Rea Vaya (Johannesburg) Phase 1A implementation showed savings of 382 940 tonnes of CO_2 equivalent emissions, and it is expected that 1.6 million tonnes of CO_2 will be saved by 2020[174]. In Lagos (Nigeria), the Mile 12 to CMS corridor is reported to have reduced CO_2 and other greenhouse gas emissions by 13% and 20%, respectively[175]. The Bogotá BRT implementation has reduced emissions by 250 000 tonnes of CO_2 equivalent per year[176]. However, it should be borne in mind that a successful BRT network must offer customers a convenient, efficient and safe service to increase its usage and make the system a preferred mode over cars.

In comparison to rail modes of transport, BRT systems offer a more affordable way of obtaining adequate network coverage across cities. A case from Bangkok (Thailand) shows that, for the same cost, the BRT network can cover a distance of 426 kilometres, whereas light rail would cover only 40 kilometres[177]. This gives it a major advantage over other public transport options, since capital and operating costs are lower, allowing a shorter payback period for investors. Construction of the network is also straightforward, using a modular design and construction method. In addition, because BRT is capable of delivering a wider transport network, more people will have access to public transport. This means that BRT will indirectly have a positive impact on the economy, as improved mobility allows more people to make a greater contribution to value add.

A disadvantage is that the BRT system makes use of dedicated lanes on existing roads, effectively removing a lane for other transport modes and inevitably creating resistance from the affected road users. Such opposition could cause delays in the project, in turn delaying the benefits to commuters and fuelling negative perceptions. In addition, "the public may view buses as slow, noisy, and polluting"[178], preventing them from using the system. As mentioned previously, the use of cleaner bus fuels (eg biogas, electricity) could address some of these criticisms. The maintenance costs associated with a BRT system have also raised some concerns, since these do not always include road maintenance costs.

Brief overview of global usage

Amongst the numerous countries with successful BRT systems in operation are: developed countries such as Japan, Taiwan, France, The Netherlands, UK, Germany, Canada, Australia and the USA; and developing/emerging countries like China, India, Indonesia, South Korea, Brazil, Chile, Colombia, Ecuador, Guatemala and Mexico. More recently, there have been developments in South Africa, Venezuela and some Latin American and Caribbean countries. BRT is especially relevant for developing countries due to its relatively low capital requirements.

Major players globally and/or domestically

Global players that supply buses to the South African market include Volvo, Mercedes-Benz, Scania, MarcoPolo and MAN.

Volvo manufactures buses and bus chassis with production activities in Europe, North and South America, Asia and Africa[179]. Mercedes-Benz produces a range of complete buses and chassis in the premium and business segment[180]. Scania supplies engines that meet 'euro emissions standards' as well as chassis. The company operates globally, with production sites in Europe and Latin America, and assembly plants in Africa, Asia and Europe[181]. MarcoPolo is a supplier of bus bodies with manufacturing plants in Latin and Central America, Africa and Asia[182]. MAN is headquartered in Germany, with production sites in Germany, Austria, Poland, Turkey, Mexico, Brazil, South Africa, India and China[183].

Applicability to South Africa and/or the rest of Africa

As with any public transport system, the makeup of the city in which it is applied is deemed key. South African cities have been shaped by historical forces that have left them largely dispersed, not ideal for public transport systems. However, according to the 'National Household Travel Survey' undertaken in 2003, 38 million people lived in households that did not have access to a car, and approximately 14 million people travelled by one or other form of public transport in a week[184]. The survey also showed that more than 50% of bus, taxi and train users were unhappy with facilities at stops, ranks and stations[185]. Therefore, the need exists to improve the public transport systems in South Africa.

Many African cities face similar challenges and, therefore, BRT offers a feasible and affordable solution. In 2007, Ghana, Senegal and Nigeria already had BRT systems in the planning process[186]. Additional benefits are that BRT systems can help stimulate the economy while also contributing to the mitigation of adverse trends leading to climate change.

The most successful implementation of a full BRT system is in Bogotá (Colombia), from which many lessons can be drawn by countries planning to implement their own BRT networks. In addition, the Institute for Transportation & Development Policy (ITDP) has published a BRT Planning Guide[187] detailing the steps within the major planning areas for delivering a successful BRT implementation. The ITDP has also been involved in the implementation of BRT in South Africa.

The South African National Transport Strategy and Action Plan[188] published in 2007 set the framework for the development of Integrated Rapid Public Transport Networks (IRPTNs). It states that "Integrated Rapid Public Transport Networks focuses on the 4-20 year period and aims to implement high quality networks of car competitive public transport services that are fully integrated, have dedicated right of way and are managed and regulated by a capable municipal transport department. In this regard, the aim for major cities is to upgrade both commuter rail services and bus and minibus services to a Rapid Rail and a BRT level of quality, respectively. Ultimately these services will be fully integrated to form a single system regardless of mode."[189]

Analysis of potential job creation

<u>Adaptation of generic methodology to the specific industry</u>

Data gathered from the Rea Vaya operations in Johannesburg formed the basis for estimating the employment creation potential associated with implementing future BRT systems planned for other South African metropolitan areas and cities.

The following were considered for the short and medium term scenarios: Tshwane, Ekurhuleni, Cape Town, eThekwini and Nelson Mandela Bay. For the long term scenario, the municipalities of Buffalo City, Mbombela, Mangaung, Polokwane, Rustenburg and Msunduzi were considered, following the

National Public Transport Action Plan[190]. It is important to recall that indirect employment effects are not considered in this study.

The following generic assumptions were made:

- The five metropolitan cities of Tshwane, Ekurhuleni, Cape Town, eThekwini and Nelson Mandela Bay will complete their BRT implementations by 2020;
- The municipalities of Buffalo City, Mbombela, Mangaung, Polokwane, Rustenburg and Msunduzi will start construction in 2020, with its completion expected by 2028;
- Construction on non-trunk routes is negligible, therefore only the kilometres of trunk routes are included in the estimates;
- The distance between stations from start-to-start is the same for all implementations at 900m;
- Ratios calculated from the Rea Vaya implementation are applicable to all implementations;
- The percentage of total minibuses and buses operating that would be displaced (refer to table 4.5 below); and
- A 5% annual increase in travel demand per year was assumed for the next 2 years of BRT operations, thereafter rising to 10% per year. For the municipalities that would start construction in 2020, the increase in travel demand was assumed to be 5%.

The employment potential associated with BRT was calculated using the following more specific assumptions:

- Construction – The assumption was made that construction jobs would be created by building the trunk corridor and accompanying stations. Construction related to feeder routes would be negligible, since these routes would consist of only bus stops and not full BRT stations. Rea Vaya data was used as a benchmark for BRT expansions. In terms of BRT lane construction, the approach was to quantify the maximum number of kilometres achievable within the various timeframes.
- Operations and maintenance – O&M staff were considered to fall under three areas: central operations; station management; and bus operating company/ies. The staff functions were categorised by those not dependent on the number of stations and buses, and those that are. Management and support staff were grouped together, and typically include managers of internal departments and their support staff (eg director of operations, bus scheduling officer). The functions dependent on station numbers and bus numbers were listed individually to ensure that the ratios calculated were not skewed (ie number of security staff per station or number of bus drivers per bus). Road maintenance activities were not included.

  In addition, the implementation of a BRT network would displace existing modes of public transport, specifically minibus taxis and buses that are operating on the same routes. Some jobs would, however, be absorbed by those created by the BRT implementation. Therefore, the net effect on jobs is calculated in this instance. Refer to the table below for the assumed displacement percentages of minibuses and buses in the cities affected.

Table 4.5: Displacement of minibuses and buses as percentage of total in the cities/ municipalities affected

Transport mode	2012	2017	2025
Minibuses	10%	30%	30%*
Buses	0%	80%	80%*

Note: *Each implementation is considered separately – therefore, the percentage in 2028 is the same as in 2020, assuming that the implementation of BRT systems would displace 30% of minibuses and 80% of buses upon completion.

Source: Authors

- Manufacturing – This relates to the manufacturing of buses, with the number of vehicles calculated based on the estimated travel demand in each area. The travel demand by province was determined using the National Household Travel Survey of 2003[191], with the average population growth rate from 2003 to 2009[192] having been utilised to estimate travel demand for 2010 and future years. The travel demand for the cities under consideration was then calculated according to the proportion of the city to the province's population.

  Peak travel was assumed to be 60% of total demand and the use of BRT was estimated at 30%. These assumptions were based on current peak to off-peak travel demand and the percentage of bus use given by the survey. The ratio of articulated to complementary buses (ie 40%[193]) was then assumed to be the same across all implementations, with the capacity of an articulated bus being 112 passengers and that of a complementary bus being 81. The number of buses per total implementation was subsequently calculated by apportioning the passengers according to the capacity per bus type and the proportion of bus type.

$$\#\ \text{buses} = \text{travel demand} \times \left(\frac{\text{proportion articulated}}{\text{articulated capacity}} + \frac{\text{proportion complementary}}{\text{complementary capacity}}\right)$$

The three main manufacturing parts for a bus are: engine, chassis and the bus body. The technology required to manufacture engines is highly sophisticated and, therefore, very expensive. The current demand for buses in South Africa does not support manufacturing of engines in the country in the medium or long term[194]. Should the decision be made to switch to gas engines, there might be a possibility of establishing manufacturing capacity in South Africa (eg reopening the Atlantis plant). According to the model, the estimated number of additional buses resulting from BRT implementations is small in comparison to what is needed to justify building engines in South Africa.

The opportunities for South Africa lie in manufacturing some of the chassis parts (eg fuel tank), bus bodies, as well as in the assembling of buses. In addition to the direct jobs created by bus body manufacturing, the number of indirect jobs created would rise proportionally. Examples of industries in which these indirect jobs would be created include: steel and aluminium; glass for windows and windscreens; fibreglass; wood flooring; electrical harnesses; electronic equipment; passenger seats; automotive accessories for bus interiors[195].

Results

Table 4.6: Summary of net direct employment potential associated with bus rapid transit systems

Activity	Short term			Medium term			Long term		
	Domestic	Export related	Total	Domestic	Export related	Total	Domestic	Export related	Total
Construction	14 618	0	**14 618**	23 388	0	**23 388**	3 824	0	**3 824**
O&M	12 424	0	**12 424**	31 609	0	**31 609**	37 468	0	**37 468**
Manufacturing	1 038	0	**1 038**	898	0	**898**	350	0	**350**
Totals	28 080	0	**28 080**	55 896	0	**55 896**	41 642	0	**41 642**

Source: Authors

The bulk of permanent jobs are expected to be created in O&M activities, particularly in the long term. Although there would be substantial job destruction due to the loss of jobs in the minibus and existing bus industries, the net effect is overtly positive. Construction also offers a source for jobs, mostly in the short and medium term. It must be noted that these jobs are temporary. Overall the job creation potential is substantially positive for the industry.

Ease of introduction of the technology into South Africa

Implementation challenges

- Inclusion of existing public transport stakeholders, particularly taxi associations and public bus companies.
- Changes in the behaviour of car users.
- Lack of BRT planning and implementation skills in the initial phases, thus requiring a good plan for knowledge and skills transfer.
- Access to land / expropriation (Land Use Management Bill[196]).
- Low densification of certain areas could reduce operating margins.
- Ability to link with other modes of transport (ie rail, taxi etc).
- Adequate management of supply challenges (ie placing orders timeously).
- Asset ownership and funding by the transport authorities[197].

Key policy implications

- Local government would generally need to be strengthened in order for the National Land Transport Act to be implemented.
- Development of relevant information for transport planning.
- Development/mobilisation of capacity for public transport planning (incl. all transport modes).

4.3 INDUSTRIAL EFFICIENCIES

4.3.1 Industrial motors

Increasing energy prices, the high cost of new power generation capacity and global concerns over climate change have increased the urgency for more energy efficient industrial operations. In Europe, industrial motors can consume as much as 69% of the total industrial electricity[198]. In this regard, energy efficient motors have been globally recognised as a quick-win solution in the drive for more industrial energy efficiency and GHG mitigation.

Over the past thirty years, there has been a noticeable shift in industrialised countries away from conventional over-designed industrial motors towards more energy efficient ones. Consequently, more advanced- and some of the semi-industrialised countries now offer support programmes in the form of rebates and subsidies in order to stimulate the use of more energy efficient industrial motors. Accordingly, the global market for energy efficient industrial motors is gathering momentum, as the fiscal support measures of industrial countries drive the market forward.

Historical progress/maturity

Michael Faraday (1791-1867) is credited with having invented the electric motor, an electromechanical device that converts electrical energy into mechanical energy. Industrial electric motors are commonly used to drive mechanical devices such as pumps, fans, blowers, compressors, lifts, cranes, conveyors and so on. Conventional electric motors commonly operate at constant speeds, whilst the mechanical devices they drive may function at less than optimal speeds.

Newer energy efficient electric motors use variable speed drives, also called adjustable speed drives (ASD), thereby ensuring an optimal speed for mechanical equipment that carry varying loads, which in turn reduces energy consumption. These energy efficient motor systems have the potential to significantly reduce electricity consumption by industries. For example, the EU has estimated potential savings of 200 GWh of electricity per year if its industries switch to more energy efficient motor driven systems[199].

In South Africa, switching to energy efficient motors could result into savings of up to 2 500 MW per annum by 2012[200], not to mention the positive impact on the environment as less coal is burnt annually for electricity generation. This electricity saving would be associated with the replacement of about 5 000 motors and is equivalent to around half of the size of Eskom's forthcoming Medupi power station.

Advantages/disadvantages

Energy efficient motors exhibit the following advantages:

- Contribute significantly to energy savings from industrial processes, which lessen harmful GHG emissions;
- Improve the competitiveness of energy-intensive enterprises by lowering operating costs;
- Require less frequent downtime for maintenance operations;
- Could lead to higher indirect employment as more operating capital is freed up for alternative uses; and

- The resultant energy saving could delay the need for additional generation capacity.

Nonetheless, a couple of disadvantages are also associated with energy efficient motors, specifically:

- Their wide scale adoption could lead to direct job losses in motor repairs and maintenance; and
- Switching to energy efficient motors could be costly for small to medium enterprises considering the high upfront capital costs (ie about 20% higher than conventional motors) relative to overall operating costs.

Brief overview of global usage

Technological improvements in the design of industrial motors over the last 30 years have caused a steady shift away from the conventional energy-intensive over-designed motors to more energy-efficient fit-for-purpose motors.

Manufacturers of industrial motors have introduced vastly improved motors into the market that are not only energy efficient but also run on longer operation cycles, which reduce operating costs to industries. The benefits of switching to energy efficient motors are twofold: firstly, less energy consumption lowers GHG emissions; secondly, the need for costly investments in new electricity generation and distribution capacity can be significantly reduced, or the replacement of existing generation capacity delayed until the end of plant life or beyond[201].

Consequently, most major industrial economies provide some kind of support to industries, such as rebates and subsidies, to improve the energy consumption of manufacturing processes using more energy efficient motors. For example, US utility companies already offered a rebate to manufacturers to switch to more efficient industrial motors as far back as the 1980s[202].

The UK offers support for research and design of energy efficient motors, while France introduced legislation in 1977 requiring mandatory inspections of energy usage in industries. In addition, following the example of the US, the European Commission has implemented the European Motor Challenge Programme. Other EU countries that implemented energy efficiency programmes for industrial motors include Denmark, Germany, Italy, Poland and Belgium[203].

Semi-industrialised developing countries are also supporting the switch to more energy efficient motors. The move by major industrial motor manufacturers (eg Siemens and ABB) of their operations to low cost countries (eg China) have led to an increasing awareness of, and new markets for energy efficient motors. China currently offers subsidies to both domestic and foreign operations for the use of energy efficient motors. In addition, since June 2011 the sale of certain categories of less energy efficient motors has been outlawed in China[204].

South Africa also provides subsidies to industries through the country's Demand Side Management (DSM) programme, which is managed by Eskom (discussed in more detail below).

The global market for electric motors has been estimated at USD10 billion in 2010[205]. The market is expected to reach USD39 billion by 2015, as greater numbers of industrial operations convert to energy efficient motors[206]. The key drivers of the energy efficient electric motor market include energy efficiency legislation and policies driven by increasing energy prices and the need for GHG emissions mitigation, greenfield projects in renewable energy, oil and gas, as well as mining, and large scale industrialisation in rapidly growing emerging economies. An equally important and underlying driving force of electric motor usage is the increase in automation across industries.

Major players globally and/or domestically

Some of the leading players in the global market for energy efficient electric motors include ABB, Mitsubishi Electric Corporation, Rockwell Automation Inc. and Siemens Aktiengesellschaft. In addition, numerous smaller players enhance the competitive rivalry in the global market for energy efficient electric motors, especially those from emerging, low-cost Asian markets that are threatening the dominance of Western and Japanese manufacturers.

The following domestic suppliers are registered with Eskom on the demand-side management (DSM) programme: CMG Motors; BMG; ABB South Africa; Indusquip Marketing; and Zest Electric Motors.

Applicability to South Africa and/or the rest of Africa

Between 60 000 and 100 000 industrial motors, representing about 10 GW of installed electricity capacity, keep South Africa's industrial sector functioning. Only a small percentage of industrial motors used in South Africa are of the energy efficient type.

Recognising the energy savings that energy efficient electric motors offer, Eskom has included a rebate scheme (related to the size of the motor) in its national DSM programme, in order to stimulate the use of energy efficient electric motors by industries. However, for industrial users the payback lies in the real cost saving on energy bills that energy efficient motors offer. Payback periods range from 6 months to 3 years, making the switch to energy efficient motors attractive for industrial users over the short term.

Analysis of potential job creation

<u>Adaptation of generic methodology to the specific industry</u>

It is assumed that the DSM programme for energy efficient motors will be the key driver of the switch to more energy efficient motors. Incremental success scenarios are considered, in which a percentage of motors are replaced within the various timeframes, specifically 3% in the short term, 15% in the medium term and 32% in the long term, implying a cumulative replacement of 50% over the period.

In addition, industry sources estimate that there are approximately 560 firms operating in the electric motor repairs and maintenance sector, each employing between 10 and 50 people. Total employment is conservatively estimated at 6 000, with about 3 500 people doing repair and maintenance work, 1 500 involved in installation, 100 in manufacturing and about 900 in various managerial, sales and administrative positions.

It is assumed that, as the DSM subsidy programme gains traction within industries, its intensity will escalate over the medium and long term, provided the programme is successfully implemented. The replacement rate is expected to reach 2% per annum by 2012, to increase to 4% by 2016 and to remain at this level until 2025.

To calculate the employment potential, the number of jobs in each of the three types of employment activity, as well as the value of the industrial motor market, were determined. The jobs-per-rand ratio was then calculated. The following are the specific assumptions with regard to:

- Installation – The installation of new industrial motors is expected to create 15 jobs per 1% increase in the replacement rate.
- Operations and maintenance – Due to the increased efficiency and reliability of the new industrial motors it is expected that 17.5 jobs are lost in the maintenance of the motors for every 1% replacement rate.
- Manufacturing – South Africa's relatively small manufacturing base in this regard is expected to create one job per 1% replacement rate.

Results

Table 4.7: Summary of net direct employment potential associated with efficient industrial motors

Activity	Short term			Medium term			Long term		
	Domestic	Export related	Total	Domestic	Export related	Total	Domestic	Export related	Total
Construction	23	0	**23**	45	0	**45**	60	0	**60**
O&M	-35	0	**-35**	-189	0	**-189**	-630	0	**-630**
Manufacturing	2	0	**2**	3	0	**3**	4	0	**4**
Totals	-10	0	**-10**	-141	0	**-141**	-566	0	**-566**

Source: Authors

The substantial job losses in the O&M category occur because replacement would lessen the need for maintenance and repair since these motors typically run on longer operating cycles. It is expected that jobs will be created in the installation sector as the uptake of new motors gains momentum, but will not be enough to offset the job losses under maintenance. In addition, it is a stated requirement of the DSM subsidy programme that the old motors be scrapped and not be allowed to re-enter the market, which will in all likelihood lead to the closure of some maintenance and repair operations.

Despite the significant net loss in employment, the energy saving generated from the switch to energy efficient electric motors brings forth additional economic benefits in the form of improved industrial competitiveness through lower energy costs at industrial operations.

The country's small electrical motor manufacturing base is expected to show limited increases given the modest size of the domestic market.

Ease of introduction of the technology into South Africa

Implementation challenges

- Motors are typically considered small cost items, thus attracting limited attention by firms as an area for meaningful cost savings. There appears to be inadequate understanding at industry level of the impact of electricity consumption by motor systems on the bottom line.
- Reluctance on the part of industries to disrupt operations in order to switch to energy efficient motors, and limited knowledge of how energy efficiency measures ought to be approached and handled within firms. This includes a lack of operational expertise and systems approach in integrating energy efficient processes within production systems.
- Limited awareness of Eskom's DSM programme for energy efficient motors.
- The industry is highly import dependent, with a small local manufacturing base.

- Procurement processes may not consider the electricity consumption aspects of the lifecycle costs of equipment.
- Current electricity price levels are not sufficient to make the payback period attractive.

Key policy implications

- A concerted effort by government to promote the localisation of manufacturing operations through the implementation and upscaling of IPAP2, could significantly increase the base of existing manufacturers.
- Government could consider introducing a suitably crafted industrial motor industry development programme, with attendant subsidies and tax allowances for the manufacture of energy efficient industrial motors.
- A phased approach towards localisation could be adopted, whereby the first phase would involve the local assembly of imported motors moving towards complete manufacturing over time. The skills base for such ventures already exists, and increasing localisation could lessen the negative employment impact in operations and maintenance.
- There is a need to address the shortage of capital for undertaking investments in energy efficient motors, especially for small- and medium-sized enterprises.
- Greater clarity is required with regard to the regulatory environment.
- The efficiency of the processes for claiming back subsidies/rebates needs to be improved.

4.3.2 Mechanical insulation

Industrial thermal insulation, also called mechanical insulation, has been used for over 100 years in large industrial plants to prevent heat loss from components, and to protect plant workers against the high operating temperatures of equipment. With rising costs of electricity, and an increasing awareness of the need for carbon emission mitigation, mechanical insulation is being increasingly seen as a cost effective way to improve energy efficiencies in large industrial plants.

Historical progress/maturity

Historically, asbestos was the preferred mechanical insulation material. However, the serious health risk posed by this material to plant workers has resulted in a virtually worldwide ban on asbestos insulation. Presently, mechanical insulation is manufactured from glass wool, mineral fibre, vermiculite and fibre glass, which is wrapped around plant components such as piping, valves, boilers and vessels.

According to the US-based National Insulation Association, mechanical insulation is a forgotten technology in the global drive for more energy efficient industrial operations[207]. Mechanical insulation offers almost immediate returns in terms of energy savings for plant operators. However, the thickness of mechanical insulation, which improves its effectiveness, has not changed much in the last 20 years.

Advantages/disadvantages

Mechanical insulation provides numerous advantages, such as:

- Increasing energy efficiency and, in the process, reducing CO_2 and other pollutants (eg SO_2 and NO_X emissions);

- Improving plant work environment by protecting personnel from potential burns due to components that operate at high temperatures;
- Reducing noise pollution associated with the operation of plant equipment;
- Improving process control of plant systems; and
- Reducing the lifecycle costs of plants.

However, there are a number of disadvantages, including:
- Mechanical insulation material can be hazardous to plant personnel;
- Mechanical insulation requires regular maintenance;
- Its efficacy is drastically reduced when contaminated by water; and
- Poor insulation could lead to corrosion under insulation, which might remain undetected.

Brief overview of global usage

Mechanical insulation is widely used globally in large industrial plants such as power stations, smelters, petrochemical plants, cement plants, paper and pulp plants, sugar mills, and other industrial operations where components operate at high temperatures.

Major players globally and/or domestically

The global mechanical insulation market is exceedingly fragmented, with many players focusing mainly on their domestic markets. The key players in South Africa, in turn, may be categorised as follows:
- Contractors – Insul-coustic Contracting, Iseco, SGB Cape, Kaefer Thermal Contracting, TSI Projects, Vedder and Moffat, Eco-Insulation, Nova Plant Services.
- Manufacturers – Lafarge Gypsum, Sagex, BPB Gypsum, Capco, Isover.
- Distributors – Africa Thermal Insulations, Alucushion Thermal Insulation, D&D Roof Insulation, Global Innovative Building Systems, Global Specialised Systems, Insulation Converters & Distributors, Insulation Warehouse, Fangriaan Energy Spectrum, Insulpro.

Applicability to South Africa and/or the rest of Africa

Mechanical insulation is extensively used in all sizes of industrial plants in South Africa and elsewhere on the African continent. South Africa has approximately 50 very large industrial plants in power generation, chemicals, steel and smelting, pulp, paper and cement industries, and small- to medium-sized processing plants such as foundries, secondary smelters, bottling plants, dairies, pharmaceutical plants and glass works. The current value of total installed mechanical insulation is conservatively estimated to be in the region of R20 billion[208].

Analysis of potential job creation

<u>Adaptation of generic methodology to the specific industry</u>

Currently no energy efficiency policy or strategy in South Africa mentions specifically the importance of mechanical insulation as a lever in the drive for higher energy efficiency from industrial processes. Even Eskom in its DSM strategies does not specifically mention mechanical insulation. Only the Department of Minerals and Energy referred to mechanical insulation in a 2005 document dealing with capacity building in energy efficiency and renewable energy. Hence, the job creation potential under the projected scenario depends heavily on expanding the scope of the DSM programme to include the regular monitoring and replacement of damaged mechanical insulation.

Large industrial plants typically undergo mandatory periodic maintenance, normally every ten years, or after a defined number of hours in operation. The same frequency applies to the replacement of mechanical insulation as a result of mandatory maintenance schedules of plant components. Consequently, the domestic market for mechanical insulation is estimated at R2 billion per annum (ie 10% of the total installed mechanical insulation). Accordingly, the key driver of mechanical insulation is largely the maintenance and replacement market.

It is noted that between 10% and 30% of all the mechanical insulation in most operating plants is damaged within one to three years of installation[209]. Should a similar ratio apply to domestic plants, this would imply that the potential boost to the replacement market would be of the order of R2 billion to R6 billion – effectively a doubling or tripling of the estimated market size, which is the focus of this section.

In addition, the building of new large plants, such as Medupi and Kusile power stations, will increase the domestic demand for mechanical insulation in future. It is estimated that the insulation costs associated with these two power stations is in the region of R2 billion. If proposed investments in additional steel, petrochemicals and generation capacity are added, new replacement demand could increase to R7 billion by 2020 (or R500 million per annum)[210], after which it is assumed to remain constant.

Industry sources have estimated total employment in the mechanical insulation industry to be in the region of 3 000, comprising about 400 manufacturing jobs, 600 O&M workers and 2 000 contract personnel for installation activities.

The number of jobs has been conservatively estimated to coincide with predicted increases in the mechanical insulation replacement market, over and above the normal replacement cycle. This is expected to rise to 3% (R90 million) in the short term, increasing to 6% (R330 million) in the medium term and rising to 7% (R490 million) in the long term. The increases in the replacement levels over the different periods are based on the inclusion of mechanical insulation under the DSM subsidy programme, and on its successful roll-out.

The following assumptions pertain to the three types of employment activities:

- Installation – It is assumed that, under a DSM subsidy programme, most of the jobs will be created in installation activities. These are mostly contract-based jobs, although higher levels of replacement of mechanical insulation across the country's industrial plants would result in these jobs being permanent in nature, as personnel is moved from one project to another. For every R10 million increase in the replacement market, ten jobs would be created.
- Operations and maintenance – It is assumed that increases in O&M jobs will be modest, since only skeleton staff is found at a plant site to take care of daily operations and maintenance requirements. Therefore, it is expected that three jobs would be created for every R10 million increase in the replacement market.
- Manufacturing – The expansion in replacement activity of mechanical insulation across the country's industrial plants is expected to result in very modest increases in manufacturing employment due to the capital-intensive nature of manufacturing operations. A R10 million increase in demand would translate into two manufacturing jobs being created.

It is unclear what the export potential associated with mechanical thermal insulation would be over the periods under consideration, and as such were excluded for the analysis.

Results

Table 4.8: Summary of net direct employment potential associated with mechanical insulation

Activity	Short term			Medium term			Long term		
	Domestic	Export related	Total	Domestic	Export related	Total	Domestic	Export related	Total
Construction	58	0	**58**	263	0	**263**	444	0	**444**
O&M	18	0	**18**	79	0	**79**	133	0	**133**
Manufacturing	12	0	**12**	53	0	**53**	89	0	**89**
Totals	88	0	**88**	395	0	**395**	666	0	**666**

Source: Authors

Ease of introduction of the technology into South Africa

Implementation challenges

- Current energy efficiency strategies appear to overlook the advantages of mechanical insulation as a means of promoting energy saving.
- The availability of competitively priced inputs to support domestic manufacturing of mechanical insulation products.

Key policy implications

- Energy efficiency policies and strategies should include mechanical insulation as a focus area due to the immediate gains achievable in energy efficiency and industrial competitiveness, with meaningful energy savings both at the micro- and macro levels.
- Government support is needed for the transition to energy efficient industrial operations. This may be indirectly addressed under IPAP 2, but would need to be focused and up-scaled in order to support domestic manufacture.
- Improved monitoring of mandatory periodic maintenance in order to induce industrial energy efficiency and, by implication, reduce GHG emissions due to energy-savings.

5 EMISSIONS AND POLLUTION MITIGATION

5.1 POLLUTION CONTROL

5.1.1 Air pollution control equipment

The introduction of progressively more stringent air pollution control (APC) regulations in developed countries, and increasingly in developing countries, has been a key driver of the evolution of more efficient APC systems to filter out progressively smaller and harmful particles emitted by heavy industrial plants.

The key technologies in use are fabric filters, electrostatic precipitators (ESPs) and flue-gas desulphurisation (FGD) systems. Although some of these technologies have been in existence since the 1950s, their usage is on the increase, particularly in countries where there is strict enforcement of APC regulations.

Historical progress/maturity
ESPs were introduced in the 1950s as state-of-the-art emission control systems for power plants and other large industrial plants. ESPs remain the predominant form of air pollution control equipment in heavy industries around the world. Modern ESPs have proved very effective in removing fine and toxic particulates, with efficiencies of up to 99%.

Fabric filters were introduced in the mid-1990s as a more efficient method of removing harmful sulphur and nitrogen particles from the flue gas streams of large industrial plants. Fabric filters, commonly known as bag filters, are increasingly used in coal-fired power stations and cement plants to remove harmful dust particles from the flue gas stream by introducing a filtration layer. Suitably designed fabric filter systems can remove up to 99.9% of particulate emissions.

Wet scrubbers are the most commonly used FGD technology. It has been used widely over the last 40 years to control the emission of SO_2 from power stations and large industrial plants. A sorbent, usually lime or limestone, which reacts with the SO_2, is injected into to the flue gas stream. In certain scrubber types, this reaction produces a saleable by-product, gypsum, used in the manufacturing of ceiling boards and other building materials. Other FGD technologies include dry and semi-dry scrubber systems.

Advantages/disadvantages
Depending on the type of industrial plant and its operating conditions, each of the abovementioned technologies has its strengths and drawbacks, as indicated in the table below.

Table 5.1: Advantages and disadvantages of the various air pollution control technologies

Advantages	Disadvantages
Fabric filters	
• Fabric filters are particularly suited to the high ash content of coals burned in South Africa's coal fired power stations. • Fabric filters are better able to assist in reaching lower emission targets than other technologies (ie they are able to remove up to 99.9% of particulates from the flue gas stream). • Fabric filters can be used across a range of industrial plants, including power stations, steel plants, cement plants, petrochemical plants etc. • Traditional electrostatic precipitators can easily be converted to bag filtration systems.	• Fabric filters require regular replacement (ie every three to four years) depending on the operating conditions. • Fabric filter systems are not suitable for reducing CO_2 emissions. • Fabric filter operations are expensive to install.
Electrostatic precipitators (ESP)	
• ESPs have improved much since the 1950s and are able to take out up to 99% of harmful particulates. • Widely installed in heavy industrial plants across the world. • Able to handle large volumes of flue-gas and can be easily modified into a bag filter system.	• High capital costs. • Do not reduce CO_2 emissions.
Flue-gas desulphurisation (FGD)	
• Very efficient in the removal of SO_2. • Able to handle volatile and explosive particles • Some systems have saleable by-products such as gypsum.	• Harmful effluent could create water pollution. • Treatment of waste sludge disposal can be expensive.

Source: Authors

Brief overview of global usage

As noted, the key driver of APC equipment is the introduction of more stringent measures and their enforcement in both developed and developing countries. The global market is estimated at approximately USD42 billion[211].

The majority of heavy industrial plants are fitted with electrostatic precipitators. Only 20% of global industrial plants presently use bag filtration systems to capture harmful particles from waste gas streams. Expensive FGD systems are mostly installed in developed countries where APC enforcement is stricter.

Major players globally and/or domestically

Table5.2: Some of the global air pollution control companies, and their presence in South Africa

Firm name	Country of origin	Presence in South Africa	Website
Alstom	France South Africa	Alstom Power Service SA ACTOM John Thompson	www.alstom.co.za
Bateman	Netherlands	Bateman Projects Limited Bateman Engineered Technologies	www.bateman.co.za
GEECOM	South Africa		www.geecom.co.za/
Howden Power	UK	Howden Power Africa	www.howden.com/en/Businesses/HowdenAfrica
Siemens	Germany	Siemens South Africa	www.siemens.com/entry/za/en/
SPX Corporation	US	DB Thermal	www.spx.com

Source: Authors

Applicability to South Africa and/or the rest of Africa

The introduction of the South Africa Air Quality Act of 2004 puts in place very strict APC regulations on companies, with hefty fines for non-compliance. These regulations are comparable to the regulation regimes in developed countries. However, enforcement of APC regulations remains a problem in South Africa. Nevertheless, the government agency responsible for air pollution control, the Environmental Management Inspectorate (also known as the 'Green Scorpions'), recently acted against a number of non-compliant industries such as ferro-alloy smelters, steel plants, petrochemical plants and foundries.

In addition, South African firms face increasing international pressure to comply with globally accepted environmental standards, usually established in developed countries. This could see an increase in the installation of APC equipment at South Africa's major polluting industrial plants, which have large foreign shareholdings. For example, none of Eskom's coal fired power stations are currently fitted with FGD systems, as the utility deems it too expensive to install them given the current regulatory environment. However, should the environmental regulations become increasingly stringent as the utility itself expects, Eskom will be forced to retrofit FGD systems on all its plants.

APC technologies are applicable to heavy industrial plants elsewhere on the continent, whose operations are increasingly under international scrutiny for violations of labour and environmental standards.

Analysis of potential job creation

<u>Adaptation of generic methodology to the specific industry</u>

APC represents both capital and, to a lesser extent, operational costs that firms would prefer to externalise (ie they would prefer it if someone else would pay for pollution control). With mounting global awareness that firms in polluting industries may not be paying for the full cost of their operations, policy-makers and concerned stakeholders are increasing pressure upon them, through regulations and awareness campaigns, to pay for the clean-up of their operations.

As stated in a previous section of the report, there are approximately 50 very large industrial processing plants across South Africa, comprising power generation, chemicals, steel, smelting, pulp, paper and cement. Conservatively, this makes the potential market for APC equipment in the region of approximately R50 billion, calculated at roughly R1 billion per plant. This of course, excludes small- to medium-sized enterprises, which also operate polluting industrial processes. However, given the problem of the externalisation of pollution costs by firms and whilst regulators are catching up with enforcement efforts, the actual market for APC equipment is currently only a fraction of the potential market.

In order to estimate the realistic employment potential of the APC industry, reasonable assumptions regarding the changing regulatory environment and its impact on APC equipment spending must be made. Consequently, it was conservatively assumed that under the current enforcement regime the actual market is only about R5 billion[212], or 10% of the potential market of R50 billion.

Total employment in the industry, which comprises manufacturing, construction, as well as O&M activities, is considered to be in the region of 5 000 full-time people. About 3 500 people are involved in manufacturing and 1 500 in operations and maintenance. In addition, industry sources estimate about 2 000 construction staff in the employment of on-site engineering firms.

For the purpose of this exercise, it is assumed that the increase in enforcement levels is 0% over the short term, rising to 22% over the medium term and to 60% over the long term.

The following specific assumptions were made for the three types of employment activity:

- Installation – Every 1% increase in the enforcement level is expected to create 20 jobs through the installation of APC equipment.
- Operations and maintenance – The O&M staff required for the APC equipment is estimated to be 15 people per 1% increase in the enforcement level.
- Manufacturing – The manufacturing of the equipment required is expected to create 35 jobs per 1% increase in the enforcement level.

The level of exports associated with an expansion in the domestic air pollution industry remains unclear, primarily because demand is strongly associated with prevailing regulatory regimes either domestic or foreign. An increase in the construction of large-scale industrial plants across the SADC region, especially associated with resource-based activities, could potentially stimulate manufactured exports, provided air pollution control enforcement regimes also increase. However, this is potentially a medium to long term matter, which would probably not lead to any additional jobs in domestic manufacturing. It would certainly stimulate construction, O&M jobs in the countries concerned.

Results

Table 5.3: Summary of net direct employment potential associated with air pollution control

Activity	Short term			Medium term			Long term		
	Domestic	Export related	Total	Domestic	Export related	Total	Domestic	Export related	Total
Construction	0	0	**0**	88	0	**88**	95	0	**95**
O&M	0	0	**0**	192	0	**192**	639	0	**639**
Manufacturing	0	0	**0**	154	0	**154**	166	0	**166**
Totals	0	0	**0**	434	0	**434**	900	0	**900**

Source: Authors

A higher enforcement regime is not likely to have any negative employment impacts on large industrial plants. As noted before, whilst the capital expenditure can be substantial (eg R5 billion for an FGD plant in a coal-fired power station), the operational costs relative to other input costs such as raw materials and energy costs, are marginal. However, the upfront capital expenditure for a small to medium sized polluting plant, such as a foundry or a secondary smelter, could be very large relative to the plant's total costs. Therefore, stricter enforcement could result in plant shutdowns and, therefore, job losses in small to medium sized polluting industries, in the absence of more cost-effective pollution control solutions.

Ease of introduction of the technology into South Africa

Implementation challenges

- Existing skills shortages in technical, engineering and project management.

- The availability of competitively priced inputs to support domestic manufacturing.
- The enforcement of clean air legislation and regulations.
- Capital is needed for investments in APC equipment.

Key policy implications

- Support for these industries is addressed in IPAP2, but needs to be scaled up in order to stimulate domestic manufacturing.
- A coherent strategy is needed to address skills constraints that prevent further expansion of the industrial sectors.
- Government support is needed for the transition to cleaner industrial operations.
- Improved policing of energy efficiency and GHG emissions will stimulate pollution control and energy efficiency industries.

5.1.2 Electric vehicles and lithium-ion batteries

Transportation is the second largest emitter of greenhouse gases after power generation. The sector accounts for 25% of all GHG emissions due to its dependence on liquid hydrocarbons. Over 95% of the transportation sector's energy needs are satisfied by crude oil and three-quarters of the greenhouse gases emitted by this sector originate from road transport. This makes the automotive industry a key focus area of government policies on environmental regulations.

A number of battery electric vehicles are currently on the road in several countries around the world. Several of the new developments in battery electric vehicles have occurred outside of the major Original Equipment Manufacturers (OEMs), including South Africa's 'Joule', developed by Optimal Energy.

Historical progress/maturity

The electric car predates diesel and petrol-powered motor vehicles. Its evolution came to a halt in the 1910s as a result of the inexpensive Model T Ford and the invention and ubiquitous adoption of the electric starter. Electric vehicles themselves lacked speed and range. By the early 1960s, electric vehicle production basically collapsed, notwithstanding higher speeds of up to 100 km/h. Their production became largely confined to golf carts and similar vehicles, with full-scale models remaining experimental products exhibited at motor shows.

However, over the last decade or so, renewed interest in electric vehicles has manifested itself in the growing quantum of both traditional and new motor vehicle manufacturers. Albeit from a low base, an expanding number of consumers in certain advanced economies are opting for battery electric vehicles. Increasingly, environmentally aware consumers tend to prefer vehicles that have a minimal adverse impact on the environment.

Advantages/disadvantages

Electric vehicles emit no greenhouse emissions directly and are more energy efficient than those powered by internal combustion engines. According to the US Energy Department, only 15% to 20% of the chemical energy contained in the fuel is used to propel the vehicle[213]. This is due to the fact that large amounts of energy are lost as heat is transferred to the exhaust and for cooling water.

Electrical powertrains have been proven to be three to four times more efficient than petrol-powered engines. Per kilometre travelled, the energy costs of electric vehicles are only about 10% (or less) of those associated with petrol- or diesel-powered vehicles. They also contribute to the reduction of vehicle related noise pollution as electric engines emit minimal noise.

Brief overview of global usage

In an environment characterised by stubbornly high fuel prices and mounting concerns over climate change, demand for battery electric vehicles is on the rise in several countries. In 2008, battery electric vehicles accounted for about 7% of all alternative-fuelled vehicles (excluding hybrids) in the US market[214]. Around the world, electric vehicles have captured a negligible, yet growing, share of the market.

Major players globally and/or domestically

Most major OEMs are involved in alternative-fuelled vehicles, including battery electric vehicles, to varying degrees. Ford was involved in the Th!nk City, but soon abandoned it to other investors. In 2006, the GiWiz was the highest selling electric vehicle. The Tesla Roadster has the power and performance of a conventional internal combustion engine car.

The Nissan Leaf may become a considerable player in South Africa, as an early entrant. Optimal Energy, which is sponsored by the IDC and the Department of Science and Technology's Technology Innovation Agency, is a key local player in battery electric vehicle development.

Applicability to South Africa and/or the rest of Africa

On the demand side, electric vehicle technology is applicable virtually anywhere where conventional cars operate, as long as there is electricity for recharging. Nevertheless, the penetration rate of electric vehicles in South Africa is expected to be low in the foreseeable future, with only a small proportion of the total car parc being electric by 2025. This will, therefore, have a limited impact on overall emissions by vehicles in South Africa.

With regard to production, the automotive industry is one of the largest in South Africa's manufacturing sector. The industry is dominated by several OEMs that are subsidiaries of overseas-based multinational companies[215], and over two hundred automotive component manufacturers. The manufacture of an electric vehicle is similar to that of an internal combustion engine motor vehicle, except that the mechanical assembly of an electric vehicle involves fewer parts. The mechanical assembly stage is where the key difference between conventional vehicles and electric vehicles assembly is stark – as opposed to the engine, oil filters and the like being fitted, in an electric vehicle the battery and the motor are fitted in their stead.

Analysis of potential job creation

<u>Adaptation of generic methodology to the specific industry</u>

South Africa has the potential to host an electric vehicle plant alongside a lithium-ion battery manufacturing factory. The analysis of potential job creation summarised below is predicated upon information drawn from various sources.

The construction of an electric vehicle plant is expected to take about three years to complete, after which production should commence. Production would be under 3 500 units in the first year, but may be ramped up rapidly in the second year and continue growing strongly in subsequent years. Over time, much of the output is assumed to target foreign markets, with exports of both electric vehicles and lithium-ion batteries expected to exceed sales in the domestic market.

In the long term, over three million batteries are projected to be exported. The manufacturing of components is expected to grow as local content rises from about 40% to 70%, adding to the respective industries' employment creation potential. However, the servicing of electric vehicles creates fewer jobs relative to conventional motor vehicles. This is due to long service intervals, the absence of oil filters and the like.

The following assumptions are made:

- Construction – In the construction phase, it is assumed that one job will be created per 46 m^2 of plant area. The plant size constructed over the short to medium term is assumed to be about 86 000 square metres.
- Operations and maintenance – In this instance, estimates are based on employment in the motor trade, excluding sales of motorcycles, and on the number of motor vehicles currently in operation in South Africa, with the ratio being 38 vehicles per employee. Since electric vehicles require less servicing than conventional vehicles due to their longer service intervals, it is assumed that 76 electric vehicles in the market will create one job.
- Manufacturing – In this instance, the employment potential calculations are based on sales projections, with every 49.5 vehicles produced creating one job in the electric vehicles industry. With respect to the manufacturing of lithium-ion batteries, it must be pointed out that battery manufacturing pertains mainly to cell production, which is highly automated and thus generates limited jobs. However, the subsequent assembly process is more labour-intensive. The employment ratio utilised was that of 750 jobs (ie 250 for the cell manufacturing segment plus 500 for the battery management integration or assembly) per 55 000 batteries manufactured. It is assumed that two batteries will be manufactured for each electric vehicle produced. It is further assumed that four batteries will be exported for every electric car that is exported (ie two batteries exported for each locally produced electric vehicle sold abroad and a further two batteries exported to other manufacturers of electric vehicles worldwide).

Results

Table 5.4: Summary of net direct employment potential associated with electric vehicle/lithium-ion industries

Activity	Short term			Medium term			Long term		
	Domestic	Export related	Total	Domestic	Export related	Total	Domestic	Export related	Total
Construction	475	0	**475**	190	0	**190**	0	0	**0**
O&M	0	0	**0**	59	0	**59**	786	0	**786**
Manufacturing	0	0	**0**	248	1 306	**1 554**	1 691	8 951	**10 642**
Totals	475	0	**475**	497	1 306	**1 803**	2 477	8 951	**11 428**

Source: Authors

In the short term, most of the job creation will be in the construction of the plant, with no expectations of manufacturing or O&M employment being created at this stage. The plant equipment will be sourced from overseas, where much of the expertise in the provision of such turnkey projects already exists. As a result, local job creation will be limited. Construction activities are expected to cease in the long term.

The electric vehicle requires minimal maintenance as the absence of many serviceable parts results in longer service intervals. Consequently, job creation on the servicing front will remain minimal. However, employment in service areas such as the replacement of brake pads and tyres, wheel alignment, as well as panel beating, will be similar to that of conventional motor vehicles.

As previously stated, the battery cell manufacturing process is less labour-intensive than the assembly segment. Approximately 58% of the manufacturing jobs depicted in the above table for the long term are expected to be associated with a future lithium-ion battery industry, with the remainder linked to the manufacturing of the vehicles and other components.

Ease of introduction of the technology into South Africa

<u>Implementation challenges</u>

Regardless of the battery and related infrastructure (eg recharging stations or points), as well as market development per se, the technology should be introduced with minimal problems. Should the vehicles concerned meet the regulatory requirements with respect to matters such as safety, few (if any) hurdles will need to be overcome.

Setting up the infrastructure across the country for battery swaps and recharging stations will require massive investments. The growth of the market for electric vehicles could be undermined by the small size of the domestic automotive market and especially if export markets fail to meet expected demand. The automotive industry requires economies of scale for plants to reap maximum benefits.

<u>Key policy implications</u>

Carbon taxes will provide some price competitive advantage to electric vehicles as they do not emit carbon dioxide. In certain cities around the world, electric vehicles are given parking preference in the inner areas. South Africa could also consider introducing subsidised recharge stations in the inner cities in order to boost the demand for electric vehicles while reducing pollution.

The Department of Trade and Industry could consider relaxing the Automotive Production Development Programme (APDP) qualification requirements of 50 000 units per annum in the case of electric vehicle manufacturing. In the early stages, a local plant could find it difficult to reach the projected targets for various reasons.

5.1.3 Clean stoves

An estimated 2.4 billion people around the world still use wood as fuel for heat generation, whether as a sole source of energy or on a part-time basis. Statistics show that the number of people in Africa without electricity has increased rather than declined over the past decade, due to high population growth, insufficient infrastructure development and a lack of maintenance of power supplies. Furthermore, the anticipated large-scale transition from biomass as the major source of energy to electricity in Sub-Saharan Africa is unlikely to materialise in the short to medium term.

Although wood as a source of energy has been seen as a lower level fuel, while its burning for cooking purposes is contributing to deforestation, it must be pointed out that its use as the major source of biomass, if sustainably harvested, is increasingly counted as one of the best carbon neutral cooking methods. Recognising the considerable potential, global businesses are showing rising interest in supplying innovative, well packaged and affordable products to the enormous 'bottom of the pyramid' market.

Historical progress/maturity

Over the centuries, households have been burning collected wood biomass in cooking stoves. Various stove improvement programmes have been launched since the middle of the previous century, initially aiming at social and environmental justice, and subsequently also seeking to improve health environments (eg programmes initiated by the World Health Organisation[216]).

The most common principle in improved stove designs has been to consume less wood, although more advanced and expensive models also focus on further reducing carbon emissions. Many affordable biomass cooking stove designs made of mud, metal, fired clay, or combinations thereof, already exist. Common elements are a combustion chamber (eg made of light, insulating ceramic), a stove body (of steel sheet), a top (cast iron), handles and a refractory cement floor. Larger cast iron stoves are more efficient and have a much longer lifetime. However, they are too expensive for low-income households. The more affordable biomass stoves are typically designed to last between three and five years.

According to experience gained in the roll-out of stove improvement programmes, the success of distributing improved stoves to households does not depend on their availability per se, but rather on ensuring acceptance through the appropriate marketing and information actions.

Advantages/disadvantages

The major advantages of cleaner stoves include:

- A reduction in the emission of unwanted gases, serving the twin target of a cleaner environment in general, as well as healthier and safer living conditions in homes[217];
- Cost savings if firewood is purchased;
- Time saving when firewood is collected, as well as due to the higher efficiency of stoves and, thus, faster cooking;
- Possibly the development of the local industry, depending on the strategies followed;
- Increased household cleanliness and convenience; and
- Contribution to the preservation of wood resources.

With respect to disadvantages, wood or charcoal cooking stoves are at times seen as a threat to the environment due to potential deforestation caused by their use of available wood resources. However, an improved efficiency of stoves would reduce wood consumption per household, while the use of sustainable harvested woods as fuel or for charcoal production could offer an environmentally friendly cooking method. The common disadvantages of woodstoves, such as smokiness and dirtiness, can all be addressed by improved stoves.

Brief overview of global usage

This section of the report focuses on the market for the traditional charcoal/wood fuelled cooking stoves (ie the type prevailing in many developing countries). The global biomass stove market does include a higher-end, pellet-fuelled, heat stove market in Europe, for example, but is assumed not to have significant potential in southern Africa in the foreseeable future.

A number of developing countries have already made a strong shift towards higher cooking stove efficiency. During the 1990s, efficiency-improved stoves were already being commercialised in countries such as Kenya and Sri Lanka. In more recent years, stove improvement programmes in India have been leading the way, largely involving social investors and institutions dedicated to the implementation of improved cooking stove programmes. Potential consumers for stove dissemination have largely been households or institutions such as schools, while other applications include farming (eg heating chicken or pig sheds during winter).

Major players globally and/or domestically

Global players that have been active in cleaner stove projects include Katene Kadji, Anagi Stoves, Ugastoves, Toyola Energy Limited, Envirofit, Prakti Design and Shengzhou. In South Africa, the Programme for Biomass Energy Conservation (PROBEC), GTZ Hera and StoveTec have been involved in research on, or in the planning of, cleaner stove projects.

Applicability to South Africa and/or the rest of Africa

The current use of cooking stoves in South Africa is prone to the inefficient use of (wood) biomass and the emission of significant volumes of CO_2. The upgrading of their fuel to, for example, charcoal, or the supply and replacement of more efficient stoves, offers significant opportunities for development within a southern African context. Improved woodstoves, or charcoal stoves, can be distributed locally or in other African countries, primarily for cooking, but also for space heating or (water) heating of a central heating system.

A longer term opportunity could be the introduction of pellet stoves in higher-end household heating and even cooking requirements, although these are significantly more advanced and expensive while serving a different market.

Analysis of potential job creation

<u>Adaptation of generic methodology to the specific industry</u>

In a number of African countries, job creation through the introduction of charcoal stoves has provided a significant source of income. Employment opportunities exist in the manufacturing, distribution, retailing and possibly the maintenance of stoves, while charcoal manufacturing has also provided employment in some countries. Depending on the stove design, artisans in clay or ceramic work and metal cladding will be needed. Certain parts tend to wear-out faster and need to be replaced during maintenance, although the demand for this purpose could be negligible if the stoves are of relatively low value. Production of charcoal by means of a traditional, low-technology process can provide satisfactory yields[218], with the additional benefit of being labour-intensive.

South Africa's demand for fuelwood was estimated at 11.2 million tonnes or 13 million m^3 per year (roughly R3 billion) in the 1990s[219]. More than half of the country's rural households (with some estimates being as high as 80%[220]) use wood fuel to provide energy to a greater or lesser degree, as do large numbers of urban households. However, this could range from a few times per month to daily usage and differ from low numbers in the Gauteng and Western Cape provinces, to a much higher prevalence in the Limpopo province[221].

Estimates of local household consumption range from 0.6 tonnes to over 7.5 tonnes of fuelwood per year, with a mode of between 3 tonnes and 4 tonnes[222]. International experience has indicated that households using charcoal would burn about one-third of the weight of wood as fuel. Although national demand for biomass fuel is not likely to grow, the number of households (2.3 to 2.8 million[223]) relying on fuelwood is also not expected to decrease significantly below the current number. The usage in the whole southern African region is expected to increase by half over the next 20 years[224].

In many African countries, charcoal used as fuel for cooking stoves has been replacing wood, especially in urban areas. Estimates of the (rising) share of charcoal as fuel in biomass cooking stoves vary from as low as 5% in some countries to as high as 50% in the cities of other countries[225]. In South Africa, charcoal should also increase its share as fuel in biomass cooking stoves over time. Subsequently, the opportunity for small-scale charcoal producers, such as to the north in Africa, will exist. However, due to the country's relative shortage of wood resources, such penetration will probably be slow and limited.

Cooking stove replacement programmes in countries such as India, Sri Lanka and Kenya distributed between 35 000 and 80 000 stoves per year[226] (note that Kenya's population is somewhat smaller than that of South Africa, whilst Sri Lanka's is less than half). For the purpose of estimating the net direct employment potential, it was assumed that, out of South Africa's 2.5 million households (using one wood-fuelled cooking stove each), between 750 000 and 800 000 households (ie 30%) would eventually replace it with an improved model.

This would amount to around 50 000 per year, on average, and the distribution is projected at the following rate:

- Short term – 0.5% or 12 500 households;
- Medium term – 5% or 125 000 households;
- Long term – 24.6% or 615 000 households; and
- Each stove will be replaced after five years.

Furthermore, of more than 20 million households in other African countries, a stove distribution target of 600 000 (ie 3% of the market) is projected, at the following rates, amounting to just under 40 000 stoves per year, on average:

- Short term – No sales;
- Medium term – 1% or 190 000 households;

- Long term – 2% or 400 000 households; and
- Replacement of old stoves will also take place after a five-year period of use.

Taking into account some cleaner stove projects around the world as examples[227], stove production capacity can be expected to be developed by local manufacturers, with an average production capacity of 25 000 stoves per year. Artisanal jobs for the production of the stoves will be created at these factories and, in addition, jobs in charcoal production will also be created in South Africa.

Furthermore, no construction jobs are involved in the roll-out of a cleaner stove project, while distribution and retail activities are included under O&M, being in fact the only activities in this category. Projects in other parts of Africa, as mentioned above, have indicated the following numbers:

- In distribution and retail, some 400 jobs will be created for every 25 000 stoves sold annually;
- In manufacturing activities, 110 jobs will be created for every 25 000 stoves manufactured; and
- No additional raw material collector jobs are taken into account, as these would more than likely already exist. Furthermore, no stove maintenance jobs are added, assuming that the stoves, which would typically be sold at a low price of around R200, would rather be replaced than serviced.

Provision is made that 10% of the households buying improved cooking stoves will change their fuel from wood to charcoal, buying a conservative 1.5 kg of charcoal per day from a small charcoal producer. Such a producer is assumed to employ three people and supply around 500 households.

<u>Results</u>

Table 5.5: Summary of net direct employment potential associated with clean stoves

Activity	Short term			Medium term			Long term		
	Domestic	Export related	Total	Domestic	Export related	Total	Domestic	Export related	Total
Construction	0	0	**0**	0	0	**0**	0	0	**0**
O&M	100	0	**100**	440	0	**440**	1 810	0	**1 810**
Manufacturing	32	0	**32**	138	167	**305**	566	407	**973**
Totals	132	0	**132**	578	167	**745**	2 376	407	**2 783**

Source: Authors

Ease of introduction of the technology into South Africa

<u>Implementation challenges</u>

Barriers to the dissemination of cleaner stoves are considerable, including the potential cost to the consumer, as well as cultural, technological and regulatory factors. However, indications are that an efficient stove distribution project would stand a good chance of being generally accepted by consumers[228]. However, the design of the stoves would have to be adapted to southern African needs. The majority of stove users in South Africa make use of wood as fuel, thus creating the need for marketing and education on the use of charcoal, if and where that should prove to be the preferred fuel.

Import competition is a major problem that will have to be addressed if the development of a local stove manufacturing industry is envisaged. Stoves from China and other countries are already being distributed in many developing countries with significant usage of biomass-burning stoves.

Key policy implications

Innovative and focused marketing and planning will be needed in order to address the abovementioned challenges. The launching of a successful cleaner stove project will demand a well-planned effort, especially from a policy perspective. The major problem area will be the introduction of such a project to the broad user market. An effective marketing campaign, or 'selling' the product as such, should be catalysed by government/s and related agencies.

Where raw materials are concerned, sustainable production of fuelwood can meet the demand at an aggregate scale. Due to the distribution of the resources, however, much of which is on state-owned or private land, its accessibility by consumers is a challenge. Apart from fuelwood, a micro-business charcoal manufacturing industry will have to be promoted if that is found to be viable.

5.1.4 Water treatment with special reference to acid mine drainage

Indications are that South Africa is gravitating towards a chronic water scarcity, with the country fast approaching the limits of its available water supply. Deterioration in water quality through various economic and human activities, including industrial and mining activities, is "arguably the most serious threat to the country's water resources"[229], according to the Department of Water Affairs (DWA). Acid mine drainage is one of the biggest pollution challenges for water resource resources in the country and, hence, its treatment and perhaps the use of treated water could potentially offer the opportunity of solving pollution and simultaneously augment water supplies.

Historical progress/maturity

Acid mine drainage (AMD), also known as acid rock drainage (ARD), is a worldwide phenomenon and a serious environmental legacy of the mining industry. Simply put, it is defined as the "outflow of acidic water from (usually abandoned) metal and coal mines"[230]. This can be from underground or surface mines.

The mining process of accessing and removing the mineral-bearing ore could include the excavation of rock and eventually the exposure of the previously buried rock to air. This exposes a mineral-containing iron sulphate (found in many types of rocks) called pyrite that oxidises (or reacts) when exposed to the atmosphere[231]. When this oxidised component comes into contact with water, sulphuric acid is formed. This mine water is typically extremely acidic, with high concentrations of sulphate and dissolved metals and iron. Acidic conditions eventually result in heavy metals becoming soluble, with damaging effects for the environment and to humans.

In terms of treatment, there are various technologies used, largely determined by the type of mine water to be treated and the extent of the required treatment. These technologies are broadly categorised as active, passive and in situ methods and sometimes combine a hybrid technology of active/passive treatment.

Active treatment technology is mainly characterised by ongoing human operations, maintenance and monitoring based on external sources of energy (such as electrical power) using infrastructure and engineered systems, while the passive treatment technology uses less human intervention, requires less O&M and makes use of natural materials such as soils, clays, manure etc. This would include systems such as aerobic and anaerobic wetlands. In-situ treatment, in turn, can take various forms, but it typically involves the "introduction of alkaline material into the mine water body"[232] and is considered to be effective in the case of open cast mines.

According to the International Network for Acid Prevention[233], most of these technologies have been developed, proven and applied to various applications.

Advantages/disadvantages

Various benefits[234] can be derived from the treatment of AMD, depending on the objectives of a particular treatment plant. But overall, improved water quality is the main benefit. Other benefits would include:

- Environmental protection by reducing and even eliminating the contamination of surface and ground water environments;
- Protection of human health from direct or indirect contact with acidic mine water;
- Treated mine water could satisfy various water needs, including industrial usage and even potable needs (eg the Emalahleni project serving the communities around its treatment plant with water treated to potable use);
- In some cases, there could be useful and potential 'saleable' by-products recovered from mine drainage (eg gypsum, which is used in the building and construction industry, as well as sulphur and magnesium); and
- In the case of South Africa (areas such as Johannesburg), there is an urgent need to avoid damage to the underground urban infrastructures and reduce the potential increase in seismic activity from water ingress and decanting. The treatment of AMD would prevent potential loss of property and infrastructure to the populated areas.

With respect to the disadvantages, all the technologies applied to mine water treatment produce some residues and emissions, according to INAP. These are in the form of sludge, brine and even gases, with potential adverse environmental impacts and disposal challenges. For instance, brines contain high concentrations of soluble salts, while sludge contains small solid particles (precipitates) of diverse compositions.

Brief overview of global usage

AMD is a widespread problem from a global perspective[235], with countries such as Australia, Canada, United States and even Germany having programmes in place to deal with the treatment of mine water. As previously mentioned, different technologies are utilised for various types of mine water. In the case of the USA, for instance, most of the acid mine drainage results from coal mines, while in Germany it mainly emanates from the mining of uranium in the former East German states of Saxony and Thuringia.

Major players globally and/or domestically

The treatment of AMD requires a range of stakeholders with different roles, with the principal ones including government or state entities such as regulatory agencies, the mining industry and technology partners. Universities, NGOs and communities also play an important role, including applied research, provision of advocacy, communication of risks, etc.

Applicability to South Africa and/or the rest of Africa

One of the potential environmental disasters facing the country pertains to the pollution of its water resources by industrial and mining activities, amongst others. More specifically, AMD is increasingly recognised as a very serious issue, with some areas of the Witwatersrand basin reportedly already showing signs of decanting as a result of poorly managed, century-old mining practices.

Expectations are that there will be an increase in water treatment plants for mining, particularly the gold mining industry, in the Witwatersrand and coal mining in the Witbank area.

According to an unpublished paper prepared for FRIDGE[236], effluent reuse is already practised by most major industries, including mining, in South Africa. These industries use desalination as one of the treatment technologies for effluent water. To deal with the problem of AMD, various mining operations are using the reverse osmosis method (or technology). Other available technology options are at various stages of development by different universities, research and development organisations such as the CSIR, Mintek and others.

The following mining areas have been identified as having known AMD sources: Western Basin, Central Basin, Eastern Basin, Free State Gold Fields, KOSH Gold Fields, Far Western Basin, Evander Gold Fields, South Rand Gold Fields, Mpumalanga Coal Fields, KwaZulu-Natal Coal Fields and O'Kiep Copper District. However, the Western, Central and Eastern Basins have been categorised as 'highest priority areas', while the others are considered to be 'vulnerable areas', with some of them tilting towards being 'low priority areas'.

Analysis of potential job creation

<u>Adaptation of generic methodology to the specific industry</u>

In terms of desalination for effluent reuse, estimates were based on the expected water treatment plants that are likely to be built for the mining industry. The Emalahleni water reclamation project was used as the basis for the calculation of job potential and the number of plants that can be built over time. However, it is critical to note that the number of jobs created will vary depending on the choice of technology used to treat AMD.

The Emalahleni Water Reclamation project (EWR) desalinates rising underground water for potable use from four mines owned by Anglo Coal and BHP Billiton Energy Coal. The plant produces about 23 million litres a day, with about 18 million litres pumped into the local municipality's reservoirs.

Based on the EWR project, which took about two years to complete, the following assumptions were made:

- Two water treatment plants (desalinating mine water) could be built in the short term to deal with the imminent problem of the defunct mines in the Western and Central Basins; and
- A further two plants can be added in the medium term and another two plants in the long term.

Potential employment estimates are based on the figures for the EWR project. An estimate of 40 jobs for operations and maintenance is made, while approximately 700 jobs are created during the construction phase. However, in the case of construction related employment, the assumption was made that, at any particular point, only 350 persons would be on site. Accordingly, the jobs were split equally over a two-year period.

As far as manufacturing is concerned, most of the components and products required are already manufactured for the water and wastewater treatment industry, and no study was found to determine the number of jobs as manufacturing capacity increases. Some of the components used include industrial pumps, pressure vessels, filters/strainers, compressors and vacuum pumps, water hydraulics, etc.

Results

Table 5.6: Summary of net direct employment potential associated with water treatment of AMD

Activity	Short term			Medium term			Long term		
	Domestic	Export related	Total	Domestic	Export related	Total	Domestic	Export related	Total
Construction	700	0	**700**	350	0	**350**	131	0	**131**
O&M	40	0	**40**	128	0	**128**	230	0	**230**
Manufacturing	0	0	**0**	0	0	**0**	0	0	**0**
Totals	740	0	**740**	478	0	**478**	361	0	**361**

Source: Authors

The construction category has a relatively large potential for jobs and local labour is usually targeted. However, construction jobs tend to be short term, lasting for the duration of the construction phase. Permanent jobs are only anticipated in the O&M category.

Ease of introduction of the technology into South Africa

Implementation challenges

There have been delays in dealing with the problem of AMD. Given that some mines have long been shut down in certain areas affected by AMD, concerns have been raised over who should bear the treatment costs. A recently released government report on mine water management, with special emphasis on AMD, explores the possibility of involving the private sector, but clearly points out that private initiatives "are unlikely to be economically sustainable without major financial subsidies."[237] Hence, funding or budgetary allocations for such treatment plants is likely to be a major constraint, particularly in the very short term.

Cost recovery is an important issue, with estimates of running costs and potential income from some of the technologies available in South Africa showing a wide divergence. The running cost estimates for the different technologies range from R2.22/m^3 to about R12.95/m^3, with income varying from R0/m^3 to R10.70/m^3. The only full-scale operating plant is the Emalahleni treatment plant, which is estimated to have a running cost of R11/m^3, while its treated water is sold to the local municipality for R3/m^3. The shortfall is borne by the mining companies involved.

Another challenge would most likely arise from 'proving and enforcing liability' if the 'polluter pays' principle is adopted. This could be time consuming, particularly for the high priority areas such as the Western and Central Basins.

Key policy implications

Treatment of mining and industrial effluents for reuse has already been identified as a potential source to augment the country's dwindling water supplies. With regard to the treatment of polluted water, government and various stakeholders, such as mining companies, are in the process of developing a holistic and integrated plan on how to deal with AMD.

Unfortunately, the problem of AMD is not dissipating, given that the country has a developed mining industry and is actively mining. Government needs to find ways of managing this process extensively, including ongoing monitoring and consistently engaging with the relevant industries. One of the recommendations is an investigation of the viability of an environmental levy on all operating mines to fund the current challenges and the management of AMD in future. In the interim, there may be a need to subsidise the treatment of AMD.

5.2 CARBON CAPTURE AND STORAGE

Carbon capture storage (CCS) technology can capture up to 90% of the CO_2 produced from burning fossil fuels. It is, therefore, a technology that can mitigate GHG emissions from major fossil fuel usage.

CCS consists of three stages. The first is the capture process, which can take place via a number of chemical reactions, either in pre-combustion, combustion or post-combustion[238]. The next two stages involve the transportation and storage of CO_2. This gas can be transported either by pipeline or ship for storage at a suitable site[239]. It can be stored underground, either inshore or offshore. It can also be injected into declining oil fields, increasing the amount of oil recovered – a process known as enhanced oil recovery (EOR). Storage sites are typically several kilometres under the earth's surface[240].

Historical progress/maturity

CCS technologies have the potential to not only decrease the present value of the cost of mitigation over time, but also capture significant quantities of CO_2 without exceeding most current storage capacity estimates[241].

Importantly, however, these technologies are not yet fully matured and investigation is still required to test their reliability and sustainability. For instance, there is still uncertainty about how much CO_2 the identified reservoirs can hold, for how long the injected CO_2 would remain trapped and whether it would escape from storage reservoirs to other formations[242].

At the present time, prospects for carbon capture are promising for electric power generation and some industrial sources, with storage in geologic formations, such as depleted oil and gas reservoirs and deep aquifers. However, further efforts are needed in demonstrating the economic and technical feasibility of large-scale CCS, exploring options for lowering the cost of CCS technologies, researching technical aspects and environmental impacts of various storage options and considering the constraints and opportunities provided by legislation, regulation and public opinion on the widespread application of CCS[243].

Advantages/disadvantages

The following are the principal advantages of CSS:

- It permits the continued use of existing fossil energy sources despite their GHG emissions;
- It has the potential for combining geological sequestration with enhanced resource recovery via EOR;
- Storage locations already exist and infrastructure such as gas pipelines can be used to pipe CO_2 to storage locations; and
- At below 3 000m, the CO_2 becomes heavier than the seawater, thus sinking to the bottom of the ocean. The oceans are, therefore, the largest potential storage locations for CO_2.

The disadvantages[244] of CSS include:

- Cost of existing technologies;
- Concerns over the possibility of the CO_2 somehow converting back to gas and floating to the top of the ocean;
- Not enough is known about the effects of CO_2 on the rock formation in saline aquifers; and
- CO_2 reacts with water in the long term to produce carbolic acid. This could corrode cement caps used to seal old reservoir wells, in time allowing the CO_2 to escape to the atmosphere.

Brief overview of global usage

A pilot site for commercial scale CCS in a saline aquifer is being developed in Canada. In Italy, a coal-fired energy plant of more than 2 500 MW is planned, with a CCS unit for abating CO_2 emissions.

The USA is embarking on perhaps the world's first CCS power plant, with integrated CCS, of at least 250 MW. A demonstration project for CCS is out on tender by the UK government and should be operational by 2014. A power plant in China is capturing and reselling a fraction of its CO_2 emissions. Germany has the world's first CCS coal plant.

Major CCS projects in operation around the world include the Sleipner and Snøhvit (Norway) and Salah (Algeria). These projects employ CCS where the CO_2 content of extracted natural gas is too high, removing and storing the CO_2 in underground geological formations[245]. The Rangely project in North America also uses CO_2 from natural gas processing at a plant in Wyoming, using the CO_2 for enhanced oil recovery. The Weyburn-Midale project, also in North America, transports CO_2 derived from a coal-based plant in North Dakota via pipeline to an oil field in Canada, where it is used for EOR as well as storage purposes[246].

Major players globally and/or domestically

Table 5.7: Major players in carbon storage and capture

Company name	Origin	Website
Dakota Gasification Company	United States	www.dakotagas.com
Statoil	Norway	www.statoil.com

Source: Authors

Applicability to South Africa and/or the rest of Africa

South Africa has already undertaken an investigation to establish whether there were sources and possible sinks for CCS. The investigation indicated potential carbon sources and storage sites[247].

A comprehensive study to identify and assess potential CO_2 storage sites has also been embarked upon in the form of the Carbon Geological Storage Atlas. The findings of the Atlas are that South Africa has about 15 Giga tonnes of storage capacity at the theoretical level, of which most of the storage is offshore[248]. About 98% of the storage potential is located in the Mezoic basins along the coast of the country, with less than 2% of the storage capacity occurring onshore, while some storage is available in coal seams that are not mineable[249]. The study showed that the high logistics costs associated with offshore storage locations, due to the depth, lack of detailed information and distance to major CO_2 sources, need to be evaluated when determining the feasibility[250].

Analysis of potential job creation

<u>Adaptation of generic methodology to the specific industry</u>

CCS is a capital-intensive technology. It is, therefore, unlikely that it could become a significant source of employment.

- Construction – The South African Centre for Carbon Capture and Storage has announced its intention to demonstrate CSS technology in the country by means of a CSS demonstration plant by 2020. Therefore, there is a very low potential for job creation within the time horizon covered by this report. Using an international ratio of 550 workers over three years for the construction of a 60 MW to 80 MW CSS demonstration plant in Australia as a yardstick, the construction of a similar CSS plant in South Africa would require 550 construction jobs.
- Operations and maintenance – Using the same plant as a benchmark, 150 operating jobs are expected to be created.
- Manufacturing – No manufacturing opportunities have been identified.

<u>Results</u>

Table 5.8: Summary of net direct employment potential associated with carbon capture and storage

Activity	Short term			Medium term			Long term		
	Domestic	Export related	Total	Domestic	Export related	Total	Domestic	Export related	Total
Construction	0	0	**0**	110	0	**110**	138	0	**138**
O&M	0	0	**0**	0	0	**0**	113	0	**113**
Manufacturing	0	0	**0**	0	0	**0**	0	0	**0**
Totals	0	0	**0**	110	0	**110**	251	0	**251**

Source: Authors

The job creation potential is only likely to be realised in the medium and long term, because a South African CSS plant would only be expected to be operational by 2020.

Ease of introduction of the technology into South Africa

<u>Implementation challenges</u>

- The IRP 2010 – 2030 makes reference to the fact that CCS technologies, as well as other related technologies, are not sufficiently developed to be included therein.
- The characteristics of sources need to be assessed before a new plant is brought into operation.
- Detailed characteristics of the potential geological storage sites have not yet been investigated.

- The extra cost for offshore storage, plus the distance between CO_2 production sites and storage sites.

Key policy implications
- Developing the necessary research to identify the full potential for CSS in the country.
- Establishing bi/multilateral cooperation to properly manage technology diffusion.
- Developing human capacity to manage the technology.

5.3 RECYCLING

Recycling involves the processing of used materials (waste) into new products. South Africa's solid waste is increasing at a rapid pace, particularly in urban areas. In the context of the enormous environmental impact, decreasing landfill space availability and rising waste management costs, this highlights the imperative of waste minimisation, waste diversion and reuse.

Various materials can be recycled, with this report focusing on glass, paper, metal cans, scrap metal, plastics and e-waste. In recent years, the inadequate levels of recycling have become a growing concern, with serious implications, including opportunity costs, for the economy at large. In cases where the primary commodities from which waste products are made are in fact non-renewable, such as metal products, recycling is critical for resource security and long term sustainability. Hence, recycling is both an environmental and an economic development tool. Accompanied by reduced consumption pressures, recycling is among the most cost-effective means of alleviating the human impact on the environment.

Historical progress/maturity

The recycling industry is a very old and mature industry, except for the usage, more recently, of recyclable inputs such as electronic materials. An early major experience dates back to 1865 with the creation of the Salvation Army, which employed the unskilled poor to collect, sort and recycle unwanted goods.

Technologies are well-established for most products, particularly paper, glass, metals etc. While the recycling of paper and glass is centuries old (eg around 1060 in the case of paper in Japan), the recycling process of certain other materials is much more recent (eg 1964 for aluminium cans, 1977 for PET bottles). The development of large scale recycling occurred during the Second World War, but the modern take-off started in earnest in the 1970s in developed countries, spurred by rising oil prices, and accelerated in the 1990s.

In South Africa, the recycling industry is relatively young, with a major expansion having been witnessed after 2000. For instance, the first glass recycling plant was established in 1987 by Consol, while the first polyethylene terephthalate (PET) recycling plant was only introduced in 2005. However, the industry has developed at impressive rates. Technological progresses are still expected and new processes are being progressively introduced, such as the bottle-to-bottle (B2B) recycling of PET, with the first plant established in 2008 by Extru-Pet.

Advantages/disadvantages

Recycling prevents the wastage of potentially useful materials, reduces consumption pressure on fresh raw materials and reduces air pollution (from incineration) as well as water pollution (from traditional incineration and landfills), compared to other waste management techniques. In addition, recycling is less energy-intensive and, therefore, less carbon-intensive than the production of the initial material. Furthermore, discarded materials are a local resource that can contribute to revenue generation, job creation and value added benefits through recycling and reuse.

For instance, each tonne of paper recycled reportedly results in 17 less trees being used and $3m^3$ of landfill space spared, while the reduction in coal-based emissions has been estimated at 1 tonne of CO_2 and for electricity-based emissions some 1.8 tonnes of CO_2. The energy consumed in the production of paper from recycled paper is said to be 40% lower than that required for virgin paper. In addition, recycled fibre reduces emissions in paper-making by approximately 70%.

Brief overview of global usage

Individuals and businesses the world over are increasingly realising the unsustainability of excessive consumption, the extent of resource depletion and the harmful footprint they are leaving on earth. Recycling, along with reducing consumption, is the best means of countering the damage.

Recycling is indeed a global phenomenon that increasingly encompasses international trade in recycled materials. For example, China imported almost 5.6 million tonnes of scrap copper in 2007 – an increase of 13% year-on-year – while its scrap aluminium imports rose by more than 18% from the previous year to 2.1 million tonnes.

Several facts reported by the Institute for Local Self-Reliance reveal the enormous economic benefits of recycling in various states of the USA. For instance, not only did recycling industries employ over 8 700 people in North Carolina, but the job gains in such activities far outnumbered the jobs lost in other industries. Moreover, a survey undertaken in ten north-eastern states found that 103 413 people were employed in recycling. In Massachusetts, more than 9 000 people were employed in over 200 recycling enterprises, with approximately half of these jobs pertaining to recycling-based manufacturing and more than half a billion dollars in value added to the state's economy. In the case of California, meeting the state's 50% recycling goal is expected to create about 45 000 recycling jobs, over 20 000 of which in the manufacturing sector.

Applicability to South Africa and/or the rest of Africa

According to a FRIDGE report on the Environmental Goods and Services sector, waste management (including recycling) was by far its biggest subsector[251]. A study commissioned by the Department of Trade and Industry on the potential of recycling in South Africa estimated that between 36 960 and 131 130 persons were employed directly in the recycling industry in 2007[252].

Based on production levels in that year and certain population and economic growth projections until 2015, this study indicated that the recycling industry could, at full capacity, sustain 190 000 job opportunities, some 90% of which would be unskilled employment (ie largely in the collecting segment)[253].

Approximately 52% of recyclable paper and board are currently recycled – that is, 943 000 tonnes out of a total of 1.8 million tonnes that can be recycled annually. Paper and board recycling is well established in the country and is dominated by three major paper-making companies, namely Sappi, Mondi and Nampak. The recycling of paper and board is an important element of the domestic paper-making industry, as it is less expensive than processing virgin tree fibre. Recycling figures for paper specifically indicate that there is room for improvement, since only 44% of recyclable paper is allegedly being recycled at present.

Around 26% of all non-returnable glass containers produced annually are retrieved through recycling in South Africa, equalling around 296 000 tonnes out of a total of 1.1 million tonnes of manufactured glass. Consol and Nampak Wiegand are the major glass recyclers in South Africa. Since 2006, approximately 312 entrepreneurs, purchasing waste glass from collectors, were established, and 2 180 glass banks were created.

Approximately 1.25 million tonnes of plastics are converted into products annually, of which 500 000 tonnes are converted into packaging products[254]. Currently, 228 000 of the 1.25 million tonnes of plastics manufactured are recycled, constituting a ratio of 18.2%. However, it must be kept in mind that not all plastic can be recycled[255]. The recycled plastics chain in South Africa employs over 40 000 people.

The local plastics recycling industry is quite fragmented, consisting of 224 individual recyclers[256]. The Plastic Federation lists more than 260 recyclers, although around 100 are apparently collectors[257]. Petco has identified only seven PET recyclers. Six types of packaging plastics can be recycled[258], the most common one being PET, which is used to make soft drink and water bottles, salad domes, biscuit trays, etc[259].

In southern Africa, over two billion metal beverage cans (ie cans previously containing beer, soft drinks, cider, fruit juices and others) are estimated to be used every year. Like glass bottles, metal cans are 100% recyclable. There are five metal can recycling plants established in South Africa by Collect-a-Can. According to a BKS study, these plants process around 50 000 tonnes, out of a total of around 70 000 tonnes, per year[260]. This translates into a recycling rate of around 70% in South Africa, which is amongst the highest recycling rates in the world.

The Metal Recyclers Association estimates that there are 10 000 direct jobs created by the scrap recycling industry in South Africa, including collectors.

An estimated 90 000 tonnes of e-waste is processed yearly in South Africa (ie around 8% of the total of 1.1 million tonnes of e-waste being disposed annually). Different recyclers receive and process various types of e-waste, such as personal computers, fax machines, photocopiers, scanners, monitors (including LCD panels), mobile phones and other communication equipment. The non-recyclable portion of e-waste includes batteries and cathode ray tubes, which are deemed problematic as they contain hazardous materials. According to the E-Waste Association of South Africa, there are about six e-waste recycling companies in South Africa.

Major players in recycling

Table 5.9: Some of the major players in the South African recycling industry

Recycling segment	Company	Website address
Plastic	Atlantic Plastic Recycling	www.plasticrecycling.co.za
	PET Recycling Company	www.petco.co.za
Glass	Consol Glass	www.consol.co.za
	Nampak Wiegand	www.npwg.co.za
Paper and board	Kimberly Clark SA	www.kimberly-clark.co.za
	Mondi Recycling	www.mondigroup.com
	Nampak Recycling	www.nampak.com
Metal cans	Collect-a-can	www.collectacan.co.za
Scrap	Metalco Recycling	www.metalco.edx.co.za
	UCG Recycling	www.ucg.co.za
E-waste	Desco Electronic Recyclers	www.desco.co.za
	Universal Recycling Company	www.urc.co.za

Source: Authors

Analysis of potential job creation

Adaptation of generic methodology to the recycling industry

Information gathered by means of interviews with companies and associations in specific recycling industry segments formed the basis for estimating the net direct job creation potential in the formal segment of the economy. This section of the report covers the following segments of the recycling industry: plastic, paper and board, glass, metal cans, e-waste and scrap metals.

The following assumptions were made:

- Construction – The number of recycling plants expected to be built based on the volume of recyclable material, together with the average number of construction workers involved in some of the existing recycling companies in each segment, were used as the basis for estimating the employment potential over time.
- Operations and maintenance – Employment in recycling is generally classified as manufacturing related. As such it is captured in the respective type of activity. However, a portion of recycling employment associated with pyrolysis/gasification plants pertains to O&M activities, specifically the work undertaken by pickers who collect recyclable materials prior to and after the waste-to - energy conversion processes. Collection jobs were not counted due to their informal nature, as well as to prevent double counting across recycling segments.
- Manufacturing – Activities in each recycling segment at present, coupled with the expected growth of the individual recycling segments over time, formed the basis for calculating the employment creation potential in the various timeframes. Where the manufacturing of recycling equipment is concerned, the employment potential is likely to be limited, as a substantial portion of such equipment is imported. Growing local manufacturing capacity in this area would require steady growth in demand for locally made equipment, backed by increased recovery rates and, where possible, utilising the leverage of government (municipal) procurement.

There is significant potential to include the sorting of waste at waste-to-energy operations, especially pyrolysis/gasification plants. This would involve removing paper and plastic products before the waste enters these plants, as they would be decomposed in the process. After the pyrolysis/gasification process, the remaining recyclable materials (eg glass, metals) can be easily and safely extracted, as they are sterile and stripped to virgin form. This will not impact on other efforts, as it is preferable to separate the materials before they are mixed with general waste, but it would increase the recovery rates of the different materials, supplementing efforts elsewhere.

The average annual rate of increase in plastic recycling is assumed to be 25% in the first three years. A 10% annual growth rate is assumed in the subsequent three years, after which the rate slows to 5% per annum, in line with the rate of increase in total plastic waste. A typical plant has a capacity of 18 000 tonnes per annum and employs 120 workers.

Improving the rate of recycling closer to 70% will require that glass recycling volumes grow by 25% per annum over the first five years, after which a long term growth rate of 5% is assumed. A typical glass recycling plant has a capacity of 100 000 tonnes per year and employs 20 workers.

The Paper Recycling Association of South Africa has set a target to recycle 63% of paper and board by 2015, up from 52% at present. The growth in paper recycling volumes is assumed to be 7.5% per annum over a four-year period to reach this set target, whereafter a long term average annual growth rate of 5% is assumed. A typical paper recycling plant has an annual capacity of 42 000 tonnes, with an employment complement of 85 workers.

The recycling rate for cans is already at 70%. Therefore, strong growth is not expected in can recycling volumes, with a long term annual growth rate of 5% assumed over the entire period under analysis. Can recycling plants, with an annual capacity of 10 000 tonnes, typically employ 20 workers.

Increasing scrap metal recycling is aimed at reducing South African exports thereof. Hence, the recycling rate is based on exports. Currently South Africa recycles 250 000 tonnes of scrap metal annually, while 1.4 million tonnes are being exported (ie a ratio of 16.9%). It is assumed that the local use of scrap metal will increase by 25% per annum for the first five years, whereafter it will follow the long term growth of 5% per year. The average scrap metal plant has a capacity of 90 000 tonnes per annum and employs 261 workers.

It is assumed that e-waste recycling volumes will expand by 20% per annum over the first four years, and by 10% per annum in the subsequent three years. Thereafter, the average annual rate of growth is assumed to slow to 5%. A typical e-waste recycling plant has a capacity of 1 100 tonnes per annum and employs 34 workers.

<u>Results</u>

Table 5.10: Summary of combined net direct employment potential associated with recycling

Activity	Short term			Medium term			Long term		
	Domestic	Export related	Total	Domestic	Export related	Total	Domestic	Export related	Total
Construction	5 023	0	**5 023**	4 226	0	**4 226**	3 651	0	**3 651**
O&M	0	0	**0**	459	0	**459**	3 251	0	**3 251**
Manufacturing	2 064	0	**2 064**	4 934	0	**4 934**	9 016	0	**9 016**
Totals	7 087	0	**7 087**	9 619	0	**9 619**	15 918	0	**15 918**

Source: Authors

- Construction: – Based on the above assumptions regarding the rates of increase in recycling, the industry will require 15 plants to be built in the short term, 35 in the medium term and a further 42 in the long term. Employment creation in construction-related activities is likely to be dominated by the following segments: plastic, paper and board, glass and scrap metal recycling. In the short term, the construction of plastic recycling plants is expected to be the largest employment contributor, followed by paper and board, glass and scrap metals recycling plant construction. In the medium and long term, the plastic recycling segment provides the most job creation, followed by paper and board recycling plant construction.
- Operations and maintenance – O&M employment pertains to pickers at pyrolysis/gasification plants, with strong job creation in the long term.
- Manufacturing – Although most of the equipment utilised in recycling plants is imported, there should be employment opportunities in the manufacture of structural steel products, wiring etc. Based on the assumption that each recycling plant that is constructed will result in 50 manufacturing jobs being created annually, the plastic recycling segment is, once again, the leading contributor over the three consecutive timeframes, followed by glass and scrap metals recycling.

Ease of introduction of the technology into South Africa

Implementation challenges

- Recycling machinery is imported mostly from different countries. In general, the likelihood of developing this type of productive capacity in South Africa is relatively low due to the infancy of the local industry and market size limitations, especially when compared with supplying countries such as the USA. Nevertheless, many types of machinery and equipment are used in the recycling industry and, therefore, certain niches may exhibit greater promise, especially when the domestic market is complemented by export potential.
- Inadequate public awareness of the advantages and techniques associated with waste recycling.
- Insufficient waste recovered for reuse as raw material for other segments of this industry, coupled with unreliable and poor quality recyclable materials from the waste stream at source.
- Lack of financial support for recycling activities from lending institutions due to the perceived risks of the business.
- Inadequate commitment by the household sector and industry at large to augment recycling practices.
- Lack of industry transparency, as revealed by an almost absence of indicators, statistics, exacerbated by market fragmentation.

Key policy implications

The Waste Act No 59 of 2008 acknowledges that sustainable development requires that the generation of waste should be avoided, or where it cannot be avoided, that it be minimised, reused, recycled or recovered, and treated and safely disposed of only as a last resort. This is known as the 'waste management hierarchy', a concept established in the White Paper on Environmental Management.

In order to increase participation levels and recycling rates in the recycling industry, the following should be considered:

- The departments of Environmental Affairs and Trade and Industry establish a bilateral committee, required by the Act, to co-ordinate initiatives impacting on product design and minimum recyclable content for products in order to increase the percentage of recyclable material;
- Early separation of different recyclables, especially at a household level, as this is important for the economic viability of the industry;
- The role of municipalities, as the primary waste collectors, is crucial for 'separation-at-source' projects to be successful;
- Provision of incentives to encourage community recycling programmes;
- Provision of incentives in support of green technologies at the recycling plants to reduce the environmental costs;
- Introduction of measures to ensure that important recyclable materials, such as scrap metal, are not exported, but instead beneficiated locally; and
- Determine precise recycling targets and timeframes for the different materials.

6 NATURAL RESOURCE MANAGEMENT

This section of the report covers biodiversity conservation and ecosystem restoration, as well as soil and land management separately. It relies on externally sourced estimates[261] of the direct formal sector employment potential associated with various natural resource management programmes in South Africa, specifically: 'Working for Water'; 'Working for Wetlands'; 'Working for Land'; and 'Working on Fire'. However, it should be noted that there may be significant employment potential in other programmes not covered in this report.

These programmes are among the more established ones and, thus, contain historical data upon which to base the analysis. Furthermore, the analysis of the net direct employment potential associated with soil and land management also encompasses organic farming and sustainable agriculture.

6.1 BIODIVERSITY CONSERVATION AND ECOSYSTEM RESTORATION

Biodiversity (or biological diversity in full) is defined as the "variability among living organisms from all sources including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part, and also includes diversity within species, between species and of ecosystems."[262] Alternatively, it is simply defined as 'the diversity of life on earth'.

According to the Millennium Ecosystem Assessment[263] report, nearly all of the earth's ecosystems have been considerably altered through human driven habits or actions, resulting in the world's biodiversity and the ecosystems that it supports being threatened. This threat comes from various activities including, but not limited to, invasive alien species, environmental pollution, over-exploitation of natural resources, deforestation and climate change.

Over the past decades, humans have converted more land to cropland, built more dams and have been transforming the natural flow of water through the rivers, and destroyed or degraded some ecosystems, such as coral reefs, mangroves, tropical forests etc, than in any other period.

While in certain instances there may have been some economic 'gains' associated with the 'loss of biodiversity', such as growth in the agriculture, fisheries and forestry sectors, on balance, the loss of biodiversity has come at a massive cost, given the 'often undervalued' benefits that are derived from these ecosystems. There are now calls from all fronts to enhance the conservation of biodiversity and for the sustainable use of ecosystems, reflecting the acknowledgement of the long term economic and social implications of its degradation.

Historical progress/maturity

While numerous conservation and restoration programmes have been developed around the world, including many developing countries, it must be acknowledged that restoration is a much more recent phenomenon than conservation. Indeed, the link between ecological and economic systems is very recent – the term 'ecosystem services' was introduced in the early 1980s and it took nearly 15 years for economists to fully recognise the importance of ecosystems[264].

According to the 2005 National Spatial Biodiversity Assessment draft report[265], South Africa is regarded as one of the most biologically diverse countries in the world and is home to a number of species of plants, reptiles, mammals and birds. However, like many other countries, this rich diversity, which is sometimes called the 'natural capital asset of a country', is being seriously threatened and/or critically endangered.

Conservation of biodiversity is pursued for a number of benefits at different scales, not only as a critical source of 'particular biological resources'[266], but also for:

- The functioning of ecosystems that provide ecosystem services such as fresh water, food, fibre and soil formation;
- Maintaining the resilience of ecosystems (eg coastal ecosystems that protect humans from the violent force of onshore waves and storms); and
- More fundamentally, to provide options for the future (eg rainforests as a source not only of food, water, fibre, tourism, hunting, spiritual healing, climate regulation and other long term/future benefits, but also potential for new sources of medicinal plants or drugs, for food options or other functional benefits like insect repellents).

According to the Secretariat of the Convention on Biological Diversity (2010), national societies rely on a wide range of ecosystem services that are underpinned by biodiversity and, hence, when certain elements are lost, ecosystems become less resilient and their services threatened, rendering them more vulnerable to other forces of nature.

Both conservation and ecosystem restoration are well-established in South Africa, with the 'Working for Water' programme considered an example of international best practice in the conservation and rehabilitation of ecosystems and their biodiversity. South Africa has developed various programmes aimed at the restoration of ecosystems, with the 'Working for's'[267] as the flagship programmes.

Advantages/disadvantages

According to UNEP (2010)[268], the goods and services offered by ecosystems and biodiversity are estimated at between USD21 trillion and USD72 trillion a year. These services range from "food security to keeping our waters clean, buffering against extreme weather, providing medicines to recreation and adding to the foundation of human culture."[269] Indeed, according to UNEP, the role played by forested wetlands is much greater and more cost-effective than that of traditional sand filtration found in waste treatment plants.

Costanza (1997)[270] asserted that the total economic value of ecosystem services is infinite and that without them economies will not function. Different ecosystems provide varied services and goods that are essential and beneficial to human kind.

Flood control, regulation of water flows, pollination, decontamination, carbon sequestration, erosion control and sediment retention, waste water treatment, provision of water, food and medicines, raw materials (eg timber, reeds) and nursery areas, are just some of the benefits derived from biodiversity and ecosystems[271].

Terrestrial (eg forests) and oceanic (mangroves, seagrass) ecosystems are natural 'carbon sinks' that cause societies to adapt to climate change. Degradation or the loss of these ecosystems represents a higher cost to present and future generations.

Therefore, the various benefits arising from the conservation and restoration of ecosystems could be summarised as follows[272]:

- Long term conservation of natural resources, be they biodiversity, land, water, etc;
- Maximisation of the delivery of ecosystem goods and services; and
- Opportunities for job creation and improved livelihoods. Measures to ensure greater security of income from ecosystem restoration projects may include a system of payment for ecosystem services (PES), or by adding value to the by-products emanating from different conservation and restoration programmes.

Sustainable use of biodiversity and its ecosystems is at the centre of conservation. However, many communities around the globe derive their livelihoods from exploiting some of the natural resources. Naturally, there are likely to be trade-offs between economic development initiatives or maintaining livelihoods and loss of biodiversity and ecosystems. The expansion of sectors such as agriculture, forestry and fisheries at times occurs at the expense of biodiversity (eg habitat change or land use change), or the construction of reservoirs (eg dams) aimed at providing water to a larger population, could have a detrimental impact on freshwater ecosystems.

There is no disadvantage in conservation and restoration, as long as the true value of ecosystems is revealed. However, certain difficulties are encountered:

- Uncertainties around restoration programmes (eg long processes, hard to fast track, substantial adaptation required for local efficiency)[273];
- High costs associated with restoration, despite evidence that acting now is always much more cost effective than acting later; and
- In certain cases, like land and biodiversity, conservation might compete with other economic uses of the resources. Hence, placing economic value on ecosystem goods and services and combating 'short termism' are critical to sustain conservation[274].

Brief overview of global usage

Conservation and ecosystem restoration is a global issue that is governed, in part, by multilateral environmental agreements. According to the World Resources Institute[275], many countries around the world have projects related to ecosystem restoration and these encompass all types of ecosystems. Ecosystem restoration is becoming increasingly critical, with wetlands, forests, grasslands, estuaries, coral reefs, mangroves and many others being restored.

In the case of South Africa, the 'Working for Water' programme is a flagship programme that has combined awareness about environmental degradation and its restoration, as well as emphasising other key government priority areas, particularly job creation for the poor and water scarcity.

Applicability to South Africa

In South Africa, concerns over the conservation and restoration of natural resources, such as water and land, have led to concrete measures being taken as early as 1936, initially in the Western Cape, with experiments on the consequences of commercial afforestation with alien trees on catchment water yields.

Invasive alien plant clearing programmes were launched in the 1970s by the government, but were later abandoned because of a lack of funding. In 1995, following studies showing the cost effectiveness of 'acting now' against invasive alien species, the then Minister of Water Affair, Kader Asmal, launched the 'Working for Water' programme[276]. Several other programmes have been developed since then, such as the 'Working for Wetlands', 'Working on Fire', 'Working for Land' and, more recently, 'Working for Energy'.

The 'Working for Water' programme is a multi-departmental initiative currently administered by the Department of Environmental Affairs (DEA). It is one of the most successful programmes internationally aimed at tackling the problem of invasive alien species (IAS), with special focus on invasive alien plants (IAPs), while also providing work for tens of thousands of previously unemployed people. The programme has a two-pronged approach aimed at controlling IAS, while simultaneously creating employment opportunities. It is estimated that over two million ha of land have been cleared since the programme's inception in 1995.

The rapid spread of invasive alien plant species has put the country's water resources under pressure. The challenge is that IAPs have a tendency to reduce the mean annual water runoff and, hence, water quantity. According to DWA reports, the IAPs currently utilise approximately 7% of water resources, which is significantly more than what would have been used by the displaced indigenous vegetation. Left alone, the rapid spread and growth of invasive species could mean that over 20% of mean annual water runoff – and perhaps as much as 25%, with climate change impacts on the spread and growth of the plants – could be lost to IAPs. These IAPs significantly restrict and decrease the country's agricultural capacity, intensify flooding and fires, cause erosion, siltation of dams and estuaries, as well as result (ultimately) in poor water quality. Furthermore, IAPs are the single largest threat to South Africa's biodiversity.

There is a potential to enhance the programme through the extension of the value chain to include the manufacturing of sustainable biomass fuel. The relatively new 'Working for Energy' programme can be seen as an 'offshoot' of the 'Working for Water' counterpart, with one of the main focus areas being the provision of renewable energy, in this case biomass, from invasive alien plants and bush encroachment.

Another well-known programme is the 'Working for Wetlands', which was launched with the primary objective of rehabilitating wetlands that have been degraded or lost. At the same time, it focuses on maximising job creation, creating and supporting small businesses, while restoring the wetlands and the services that are provided by these wetlands. According to the South African National Biodiversity Institute[277], just over 1 500 people were employed during 2009 to rehabilitate 95 wetlands around the country. The importance of wetlands has already been touched upon in a previous section of this report.

While these programmes are relatively large, there are other smaller projects across the country that have gained international prominence, including the restoration of degraded grasslands and lands around the Drakensberg's river systems. The Maloti Drakensberg Transfrontier Project has created about 300 permanent, natural resource management jobs and is estimated to "bring back winter river flows to vulnerable communities amounting to about 4 million cubic metres, cut sediment losses and help store carbon"[278].

The challenge of environmental degradation, coupled with imminent water scarcity, among other impacts, may help support the case for more increased use of such programmes in restoring degraded ecosystems. It is also a means of creating employment opportunities for poor and unemployed people, with marginalised groups, especially in rural areas, being targeted (ie women, disabled persons and the youth).

Analysis of potential job creation

<u>Adaptation of generic methodology to the specific industry</u>
Quantifying the potential of job creation in natural resource conservation and restoration is often complicated by the fact that most of the projects or programmes associated with this sector are often triggered by the initiatives of various stakeholders.

These stakeholders – public, private or at times non-governmental organisations (NGOs) – would normally provide funding for a particular project (in many instances, a pilot project), which would run for a limited period. Direct jobs tend to be limited. Nonetheless, this sector also tends to generate 'indirect jobs' by creating employment opportunities in other related sectors such as in eco-tourism, sustainable fishing, agriculture (eg organic farming) and forestry. However, UNEP (2009) makes a reference to programmes such as 'Working for Water' as having a great potential to create green jobs. All the more so when these programmes are managed as public works projects.

This has been the case in South Africa, with 'Working for Water' being part of the expanded public works programme. In this section of the report, the potential for job creation is, therefore, based upon estimates for the 'Working for Water' and 'Working for Wetlands' programmes.

These two programmes have been chosen for the following reasons:

- Their role in maximising environmental and employment benefits;
- They are relatively large and have been running for a longer period;
- They are internationally recognised amongst the successful programmes from which lessons could be drawn; and
- The needs are so important in South Africa that they have to be extended.

Given the nature of these programmes, direct jobs would fall under O&M, with manufacturing or construction jobs resulting only from the development of downstream activities or industries. However, indirect employment falls outside the scope of this report. The 'Working for Energy' programme, which uses invasive species for biomass combustion (energy) is integrated in the biomass section of this report, while others such as 'Working for Land' are discussed under the soil and land management section.

Data collected by the DWA and DEA since the launch of the 'Working for Water' programme in 1995 has been used to calculate a baseline on which estimates are extrapolated. The data includes the number of person-days and the area cleared (both initial clearing and follow-up clearings when necessary). All the estimates (number of person-days) have been calculated by province before being totalled up and translated into full-time annual job equivalent.

The main assumption is related to the areas which could be cleared overtime: It is assumed that an average of 200 000 ha per year are cleared in the short term (compared to 150 000 ha in 2010), 560 000ha in the medium term and 1 450 000 ha in the long term. These figures are based on the current area invaded (ie more than 20 million ha in 2010), the rate of invasion (ie 2% a year, which is a conservative estimate), and the number of person-days required to clear an invaded area (including follow-up clearing), which itself depends on the degree of infestation.

The 'Working for Wetlands' is more recent, since it was launched in 2003/2004 after being split from 'Working for Water'. Data subsequently collected is used as a baseline, although this base is very low, ie 500 ha rehabilitated thus far, versus the estimated 1.6 million ha degraded. It is assumed that this programme will grow by 20% per year in the short term, by 30% a year in the medium term and by 5% per annum in the long term. Also included in these estimates are jobs related to the rehabilitation of the wetlands, as well as those dealing with the prevention of wetland degradation.

Results

Table 6.1: Summary of net direct employment potential associated with biodiversity conservation/ecosystem

Activity	Short term			Medium term			Long term		
	Domestic	Export related	Total	Domestic	Export related	Total	Domestic	Export related	Total
Construction	0	0	**0**	0	0	**0**	0	0	**0**
O&M	17 191	0	**17 190**	50 029	0	**50 029**	121 553	0	**121 553**
Working for Water	*15 416*	*0*	***15 416***	*42 979*	*0*	***42 979***	*111 632*	*0*	***111 632***
Working for Wetlands	*1 775*	*0*	***1 775***	*7 050*	*0*	***7 050***	*9 921*	*0*	***9 921***
Manufacturing	0	0	**0**	0	0	**0**	0	0	**0**
Totals	17 191	0	**17 190**	50 029	0	**50 029**	121 553	0	**121 553**

Source: Authors

New direct jobs in the formal sector are only anticipated in O&M activities, with indirect manufacturing employment potential (eg upstream manufacturing of tools and equipment, or the downstream processing of plant material for the furniture industry) falling outside the scope of the analysis.

Ease of introduction of the technology into South Africa

Implementation challenges

The country has some of the most progressive policies and legislation to ensure that various ecosystems are well protected. However, enforcement of and compliance with the respective legislation remain the main challenges. Key impediments to the implementation of policies include:

- The competing needs and mandates of various institutions, or a lack of clear responsibility and accountability at the three levels of government with respect to these programmes;

- Lack of understanding of and the tendency to underestimate the many benefits that can be derived from well protected ecosystems;
- Lack of management capacity required for the effective programme implementation; and
- Inadequate regulation of land owner responsibilities.

However, the most important constraint relates to the budget required for running these programmes. Meeting this job potential will require a shift in the way these programmes are funded. Public funding, which is currently the main source of financing, has to be accompanied by other sources, including the private sector (eg payment for ecosystem services, carbon finance) and, to some extent, donors to make the programmes more sustainable.

Key policy implications

- An adapted legal framework, with incentive and disincentive mechanisms aimed at the rehabilitation of ecosystems.
- An effective institutional framework and public investment strategy aimed at attracting private investors.

6.2 SOIL AND LAND MANAGEMENT

Land degradation and soil erosion is a global challenge that does not spare South Africa. According to the State of Environment Report, "[al]though the true costs of land degradation are poorly understood, it has considerable effects on the economy. In South Africa, about 35% of the country's net agricultural income is overstated because the environmental costs are not currently included in the accounts.

Soil degradation alone, for example, costs South Africa an average of nearly R2 billion annually in dam sedimentation and increased water treatment costs. The costs associated with neutralising the effects of acid rain (caused by energy generation) on soils in Mpumalanga are estimated at R25 million per year, while the loss of soil nutrients through degradation costs R1.5 billion per year."[279]

Historical progress/maturity

More sustainable farming practices, including conservation agriculture, low-input agriculture and organic farming, are based on improved land and soil management.

These practices are generally low-tech and, in many cases, a local adaptation of more traditional techniques of agriculture. Some target directly soil erosion (use of contour ploughing and wind breaks; leaving unploughed grass strips between ploughed land; ensuring continuous plant growth and that the soil is rich in humus, etc). Others are related to soil management (crop rotation, conservation tillage, residue retention, incorporation of grass and legumes in the rotation cycle, manuring, afforestation, etc). Finally, land conservation through land stewardship also offers some opportunities.

The main issue related to land and soil degradation stems from the fact the ecosystem services are mostly unaccounted for in market prices, leading to a classic market failure due to the existence of externalities. Several options exist to provide ecosystem services, which could be grouped into two broad categories: a command and control mechanism; and an incentive-based mechanism.

As mentioned by Jack et al. [280], PES has emerged as a policy solution for realigning the private and social benefits that result from decisions related to the environment. The PES approach is based on a theoretically straightforward proposition – pay individuals or communities to undertake actions that increase levels of desired ecosystem services."

Hence, payments for ecosystem services have been identified as a promising element for conservation, with a potential for job creation depending on how the PES programme is designed. "A PES is a voluntary transaction where a well-defined ecosystem service (or land-use likely to secure that service) is being 'bought' by a (minimum one) ecosystem service buyer if and only if the ecosystem provider secures ecosystem provision (conditionality)."[281] A PES programme can be financed either by the final user to whom the service is provided, or by public funding (including international funding).

According to the Millennium Ecosystem Assessment Report, ecosystem services (ES) are "the benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as regulation of floods, drought, land degradation, and disease; supporting services such as soil formation and nutrient cycling; and cultural services such as recreational, spiritual, religious and other nonmaterial benefits."[282]

The abovementioned report then identifies the different categories of ES as follows:

- "Provisioning services are the products people obtain from ecosystems, such as food, fuel, fibre, fresh water and genetic resources.
- Regulating services are the benefits people obtain from the regulation of ecosystem processes, including air quality maintenance, climate regulation, erosion control, regulation of human diseases, and water purification.
- Cultural services are the nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences.
- Supporting services are those that are necessary for the production of all other ecosystem services, such as primary production, production of oxygen, and soil formation."[283]

Consequently the provision of ecosystem services is a major challenge. In 1997, Costanza estimated the value of ecosystem services provided by the planet and biodiversity, rather than human activity, at USD33 trillion, or nearly double the global GDP at the time. According to the same report 'soil formation' was by far the most valuable of all ecosystem services at a value of USD17.1 trillion, nearly the same as the world GDP of USD18 trillion in 1997[284].

A study undertaken for the Presidency on the possible role of PES in poverty alleviation estimated the potential for trading with the output emanating from five PES activities to be between R15 billion and R23 billion, and the potential for job creation to be as high as 367 000 person-years[285]. This includes the clearing of invasive species, water catchment management, energy from biomass, as well as carbon sequestration. Most of these activities are covered in other sections of this report. However, carbon sequestration, which may result in substantial job creation (ie 240 000 jobs for management alone), is not covered. This is due to the fact that the development of a carbon trading system at local level still needs to be built and, consequently, no past records were available for estimate calculations. Therefore, the figures are not comparable, with this section of the report concentrating mainly on the expansion of existing programmes (ie 'Working on Fire' and 'Working for Land').

Advantages/disadvantages

Sustainable farming offers numerous advantages, including: increased productivity (through improved soil, physical and biological health); higher carbon sequestration; better water retention; reduction in inputs, etc[286].

Sustainable farming has the advantage of cost savings in fertilisers and pesticides, but suffers on the growth front due to higher risks associated with difficulties in controlling pests and weeds. As a compromise, agricultural produce buyers, such as Woolworths and Pick 'n Pay, are pursuing a standards and certification scheme for low-input, near-organic cultivation of products. Based on continuous monitoring of soil health, the farmer only applies fertiliser as and when required, thus avoiding 'dead' soil devoid of organic matter and unable to self-regulate. Such practices should be encouraged.

The impact on employment depends on the type of practices used. According to Pimentel et al[287], on average, organic systems require about 15% more labour, but the increase in labour input may range from 7% to a high of 75%. Britain's Soil Association found that organic farming provides 32% more jobs per farm than equivalent non-organic farms[288]. However, the impact on employment for other sustainable farming practices is unclear – some practices can raise on-farm demand for labour, while others might reduce it[289].

Since most of the sustainable farming practices have to be locally adapted and transmitted to farmers, agricultural extension services are perhaps the one area where more jobs could best catalyse greater adoption of erosion control and soil management practices.

Land stewardship does, however, have an opportunity cost in terms of deferred agriculture, which is potentially offset by eco-tourism.

Because sustainable farming might lead to an increase in production costs and a loss of revenue, PES programmes can create the right incentives to support land and soil management. In general, PES yields a triple-dividend: economic gain; social benefit; and environmental protection.

Brief overview of global usage and major players globally and/or domestically

Soil and land management is generally a non-commercial exercise, implemented by farmers or rural communities. However, it can involve multiple stakeholders, including public and private sector players, and can involve very large sums of money.

PES programmes are widely developed around the world, some dating back to the 1990s, both in developed (eg USA, UK, Australia, New Zealand) and developing countries (eg Costa Rica, Ecuador, Bolivia, China, South Africa and Zimbabwe), for natural resource conservation, be it related to water, land, forest etc[290].

One of the oldest PES programme is the USA's Conservation Reserve Programme (CRP) established in 1985, which promotes land retirement for preserving soil productivity. However, this programme has existed in other forms since 1936. At the end of 2005, 14.5 million ha were enrolled under the CRP, with farmers receiving USD1.8 billion a year[291]. The Catskill Mountains provide drinkable water to the city of New York following a USD1.3 billion investment in natural capital in 1995. This aimed to protect the water catchment from sewage, fertilisers and pesticides that were compromising the natural ecosystem purification process. This investment compared favourably to the capital costs of USD8 billion for building a filtration plant and the operation costs of such plants estimated at USD300 million a year[292].

In 1999, the Chinese government launched the largest land retirement/reforestation programme in the developing world – the sloping land conservation programme. It aimed to convert more than 14 million ha of land into forest by 2010, with a total budget of USD40 billion[293]. By the end of 2006, the programme had subsidised 32.5 million rural households[294].

Applicability to South Africa and/or the rest of Africa

Africa is possibly the world's only remaining continent that is a net bio-capacity creditor (WWF Living Planet Report) – providing more bio-resources than it consumes. Yet, various land use impacts are contributing to a steady depletion of this capacity[295].

Land degradation is most prevalent in communal and rural districts, which means that the poor are not only the worst affected, but are also in a position to address the situation through PES mechanisms.

Given the prevalence of poverty in South Africa's rural areas, PES has been identified by the Second Economy Strategy Framework as having the potential to generate lifeline incomes through subsidies which pay for themselves through deferred environmental costs.

According to Cape Nature, at least 80% of the natural vegetation in South Africa, including much of its most scarce and threatened habitats, is on privately owned land. As such, it is clearly insufficient to entrust conservation entirely to the authorities in the form of proclaimed reserves and national parks.

While land stewardship may have an opportunity cost in terms of deferred agricultural production, it may well produce alternative income through eco-tourism. The jobs impact of stewardship is, therefore, not readily apparent. However, land stewardship projects can have a significant impact for communities who are the beneficiaries of land reform, but who are not in a position to pursue agriculture.

IPAP2 identifies organic agriculture as an industry with the potential to create 20 000 jobs over a ten-year period. It also contains plans for growing organic cotton as a market differentiator in export markets, to stem the decline of the local industry. It further targets the retention of 5 000 jobs in the Rooibos and Honeybush industries through improved marketing.

Several other programmes, initially inherent in the 'Working for Water' programme, have been launched more recently as stand-alone programmes. The 'Working for Wetlands' programme was developed in the year 2000 and the 'Working on Fire' programme was launched in 2008. In 2010, 14% of the burnt areas had been covered by the programme. In 2010, the Department of Water Affairs launched a 'Working for Land' programme in the Eastern Cape aimed at rehabilitating land through the planting of indigenous spekboom. As a result, 1 700 ha have been restored. This programme should be extended in coming years to restore progressively the 5.6 million ha of degraded land.

Analysis of potential job creation

Adaptation of generic methodology to the specific industry

The estimates of job creation potential in agriculture are based on the projections made using the 2002 and 2007 commercial farm censuses and a linear trend as the base scenario [296]. However, to take into account the fact that South Africa has suffered from a premature de-agriculturalisation[297], the decline in the number of projected jobs in the 'business as usual' scenario has been limited to 540 000.

In 2007, the number of commercial farming units amounted 39 982, employing 431 664 full-time workers and 365 142 part-time workers.

- Construction – Soil and land management creates hardly any jobs in construction, except for certain practices such as the construction of terraces, grassed waterways and other soil conservation structures. It is assumed that in the short and medium term a 0.1% increase of the agricultural workforce could be needed to complete the required construction. In the long term, the construction will be completed and only maintenance will be required.
- Operations and maintenance – Organic farming is significantly more labour-intensive than conventional farming. It is assumed that 5% of the farms will be organic in the short term, 10% in the medium term and 20% in the long term. For each organic farm, a 30% increase in the labour force is used, an upper limit according to international experiences emanating mainly from developed countries. This assumption is deemed to be quite realistic because labour is, and will probably remain, relatively cheap in South Africa over the next 15 years, allowing the substitution of labour to capital. The development of sustainable agriculture might lead to some increases in employment, but to a much lesser extent than organic farming, as shown earlier in this section. It is assumed that a 5% increase in labour is possible due to relatively low labour costs in South Africa and that 10% of the farms will be managed sustainably in the short term, 40% in the medium term and 80% in the long term. Furthermore, extension services are needed to make these changes. The assumption is made that each farm shifting from conventional to organic or sustainable farming will be visited twice a year either by a public or private advisor. Finally, PES in the form of "Working for Land" and "Working on Fire" programmes are included. The targets for restoration of currently degraded land are set to be respectively 0.5%, 10% and 30% in the short, medium and long term. The 'Working on Fire' programme is assumed to grow and progressively reach full coverage of the average burnt area every year by 2017.
- Manufacturing – Soil and land management is not expected to result in any significant direct job creation in manufacturing, while there is, in fact, the potential for job losses as the use of inputs is reduced (eg chemical fertilisers and pesticides). Nevertheless, it is assumed that the decrease in input utilisation per ha is offset by the expansion in land usage following rehabilitation.

Results

Table 6.2: Summary of the net direct employment potential associated with soil and land management

Activity	Short term			Medium term			Long term		
	Domestic	Export related	Total	Domestic	Export related	Total	Domestic	Export related	Total
Construction	6 528	0	**6 528**	5 348	0	**5 348**	0	0	**0**
O&M	20 794	0	**20 794**	59 465	0	**59 465**	111 373	0	**111 373**
Working for Land	*3 485*	*0*	***3 485***	*23 941*	*0*	***23 941***	*63 749*	*0*	***63 749***
Working on Fire	*5 000*	*0*	***5 000***	*14 085*	*0*	***14 085***	*14 085*	*0*	***14 085***
Manufacturing	0	0	**0**	0	0	**0**	0	0	**0**
Totals	27 322	0	**27 322**	64 813	0	**64 813**	111 373	0	**111 373**

Source: Authors

New direct jobs in the formal sector are mainly anticipated in O&M activities, while construction employment is not sustainable in the long term.

Ease of introduction of the technology into South Africa

Implementation challenges

South Africa already has a successful public works land-based ecosystem services programme (ie the ‘Working for’s’), which is planned to be extended to cover land management. The country has also adopted tax incentives for land stewardship. Low input and organic agriculture is currently largely supported through the private sector.

Key policy implications

The value of healthy soil should be acknowledged and protected through policy in agriculture, spatial planning and environmental impact assessment.

The development and implementation of a comprehensive agricultural policy supporting sustainable farming is required. More especially, service extension provision and R&D for new farming method development and adaptation to local contexts are crucial.

APPENDIX I:
SECTORAL EMPLOYMENT IN THE SOUTH AFRICAN ECONOMY

Industry	Quarter 3, 2011 (thousands)
Agriculture	624
Mining	324
Manufacturing	1 737
Utilities	73
Construction	1 086
Trade	3 012
Transport	756
Finance and other business services	1 768
Community and social services	2 836
Private households	1 098
Total	**13 318**

Source: Statistic South Africa

ENDNOTES

[1] This section draws extensively from Maia (2010).

[2] Economic Development Department (2010).

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[4] Government of the Republic of South Africa (2011).

[5] United Nations Environment Programme (2011a).

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[22] The European Wind Energy Association (2009a): "Wind at Work: Wind Energy and Job Creation in the EU", pp. 9, 23.

[23] Diab, R. (1995).

[24] A major weakness of the existing wind atlas is the fact that its data represent wind measurements relating to 10-metre heights, while most wind turbines are constructed at 60-metre heights and over.

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[51] World Economic Forum, Green investing 2010.

[52] Greenpeace (2010) and Greenpeace (2011).

[53] Greenpeace (2011).

[54] SEREF (2008) Economic Impacts of Extending Federal Solar Tax Credits, Solar Energy Research and Education Foundation.

[55] Greenpeace (2010).

[56] it has been estimated by the Department of Environmental Affairs that some 24 million tonnes of general waste were produced in the 2006/07 financial year, almost all of which was landfilled.

[57] The major challenge encountered in the establishment of the eThekwini landfill gas project, for instance, was the length of time involved in reaching implementation stage.

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[59] Professor James Blignaut from the University of Pretoria.

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