South African Energy Sector Jobs to 2030

How the Energy [R]evolution will create sustainable green jobs

Independently reviewed by Thapelo Letete, Energy Research Centre, University of Cape Town

Author: Jay Rutovitz, Institute for Sustainable Futures, University of Technology, Sydney

Acknowledgements
We would like to thank Melita Steele (climate campaigner) and Greenpeace Africa, Sven Teske, Sophie Clausen, and Chris Dunstan for their assistance with this research, and Thapelo Letete of the Energy Research Centre at the University of Cape Town for reviewing the report.

Please cite this report as
Rutovitz, J. 2010. South African energy sector jobs to 2030. Prepared for Greenpeace Africa by the Institute for Sustainable Futures, University of Technology, Sydney, Australia.

Published by
Greenpeace Africa, 10A and 10B Clamart House, Clamart Road,
Richmond, Johannesburg, 2092, South Africa.

Photos
Cover: © Greenpeace / Nicolas Fojtu
Back cover: © Greenpeace / Ex-Press / Heike Grasser
Kumi Naidoo: © Greenpeace / Shayne Robinson
Michelle Ndiaye Ntab: © Greenpeace / Tracy Edser

Printed on 100% recycled post-consumer paper with vegetable based inks.

Foreword

South Africa like many other countries in the South faces two seemingly intractable problems: poverty and joblessness.

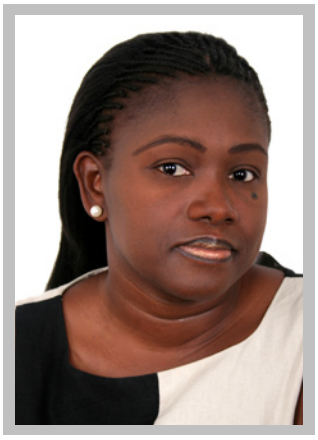
Any solution to one problem must address the other for the country to progress, but in this truth also lies the seed for a greener and more sustainable future for the country and its people.

Indeed, South Africa sits atop a treasure trove of renewable energy sources, from wind and marine energy to some of the best solar resources in the world. Greenpeace believes that harnessing these resources would not only make a massive contribution in the global fight against climate change, but would also create the much vaunted “better life for all South Africans” including a brand new industry with thousands of green, sustainable jobs. In essence, it is about investing in people and in our future.

The Greenpeace **South African Energy Sector Jobs to 2030** report is aimed at initiating dialogue around the twin issues of renewable energy and green jobs and presenting real, feasible solutions for a country in the throes of the problems created by a world transfixed by global warming. Chief among the opportunities offered by renewable energy is the creation of 78 000 direct jobs, and countless thousands of other indirect jobs in less than 20 years if the country finds the political will to read the writing on the wall and start overhauling its entire energy supply process.

The questions are stark. The answers are clear. The timing is right. It is the implementation that requires courage, determination - and vision.

Kumi Naidoo
International Executive Director, Greenpeace



Michelle Ndiaye Ntab
Executive Director, Greenpeace Africa

Contents

Appendices

© Greenpeace / Dean Sewell

Executive summary

The **Energy [R]evolution** scenario published by Greenpeace International and the European Renewable Energy Council sets out a vision for a low-carbon energy future for South Africa (RSA) and compares it to a scenario derived from the International Energy Agency (IEA) 2007 energy projection for Africa (IEA 2007) the **'IEA Reference case'**. The South African Government has also published a set of energy scenarios, including a '**Growth Without Constraints**' (GWC) scenario[1], which is commonly regarded as a reference case for the country. The GWC scenario was designed to reflect South Africa's energy future in the absence of climate change, with no oil constraints, and if no effort was made to internalise externalities (Scenario Building Team 2007).

This report presents an analysis of the energy sector job creation associated with the three scenarios to 2030: the Energy [R]evolution, the IEA Reference case, and the Growth Without Constraints scenario. Only direct employment is calculated, including jobs in fuel production, manufacturing, construction, and operations and maintenance. Energy efficiency jobs associated with reducing the need for electricity, and jobs associated with coal exports are also calculated.

It was found that **the Energy [R]evolution scenario could be a major employment creator in South Africa, with a net increase of 78,000 jobs by 2030.** This is slightly more than even the Growth Without Constraints scenario, which sees energy sector employment increase by 71,000, and considerably more than the IEA Reference case which has an estimated growth of 46,000.

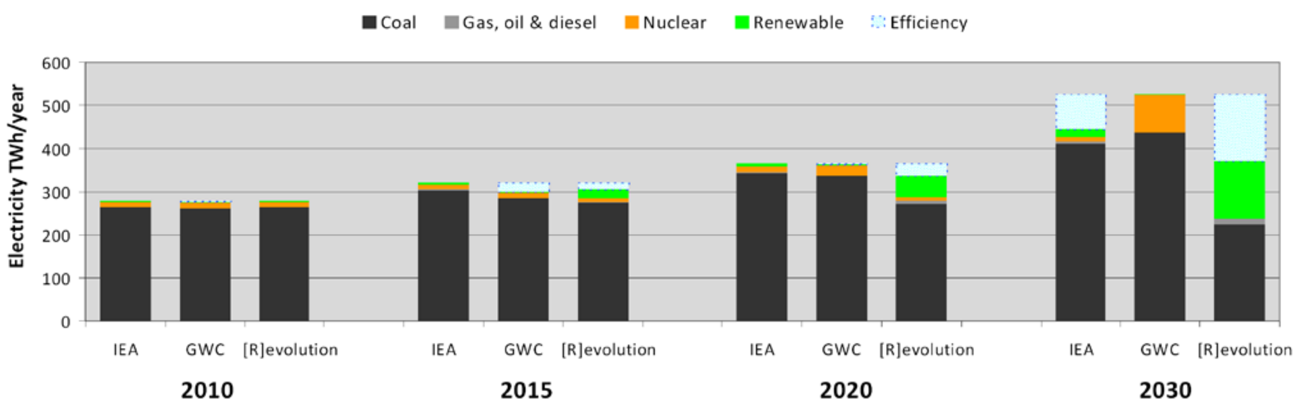
The Energy [R]evolution scenario

The Energy [R]evolution reduces South African emissions by 60% by 2050 (compared to the 2005 level). These reductions are achieved through existing technologies, such as energy efficiency, renewable energy and combined heat and power generation. Energy efficiency reduces the need for energy services by one third, with significant economic as well as environmental benefits. Nuclear power is gradually phased out, and reliance on coal is greatly reduced. By 2030, renewable energy supplies 36% of South Africa's electricity.

By comparison, under the IEA Reference case South Africa's emissions nearly double by 2050 relative to 2005, and under the Growth Without Constraints scenario emissions increase nearly fourfold.

The figure below shows annual generation under the three scenarios. At 2010 the scenarios are almost identical. By 2020, the [R]evolution scenario has started to reduce generation compared to both the reference cases, which is indicated by the energy efficiency shown on the graph. By 2030, electricity consumption in the [R]evolution scenario is 16% below the IEA Reference scenario, and 29% below the Growth Without Constraints scenario. Renewable generation is making a much greater contribution. In contrast, the Growth Without Constraints scenario has significantly higher electricity consumption than either the IEA reference case or the [R]evolution scenario by 2030, and has a much larger nuclear component.

Electricity generation under the three scenarios



[1] The GWC scenario has been modlified to bring forward construction of new supercritical coal capacity, to take account of the construction of Medupi and Kusile power stations.

Methodology

Employment is projected for the three scenarios at 2010, 2020 and 2030 by using a series of multipliers and the projected electricity consumption. An indicative result for energy efficiency jobs is calculated, although the associated uncertainty is even greater than for energy supply.

The inputs to the employment projections for energy are as follows:

- **Installed electrical capacity by technology.**
- **Employment factors**, which give the number of jobs per MW for each technology. These are the key inputs to the analysis. Local factors are used where possible, namely for some aspects of coal, nuclear, hydro, and Solar Water Heating. Where local factors are unavailable, Organisation for Economic Co-operation and Development (OECD) employment factors are increased by 2.15, to allow for the tendency for greater labour intensity in regions with lower Gross Domestic Product (GDP) per capita.
- **Decline factors**, or learning adjustment rates, for each technology, which reduce the employment factors by a given percentage per year.
- **Local manufacturing percentages for renewable energy.**
- **Energy efficiency employment** is calculated from the reduction in electricity generation in the [R]evolution compared to the two reference scenarios, multiplied by a derived factor for jobs per unit of energy saved.

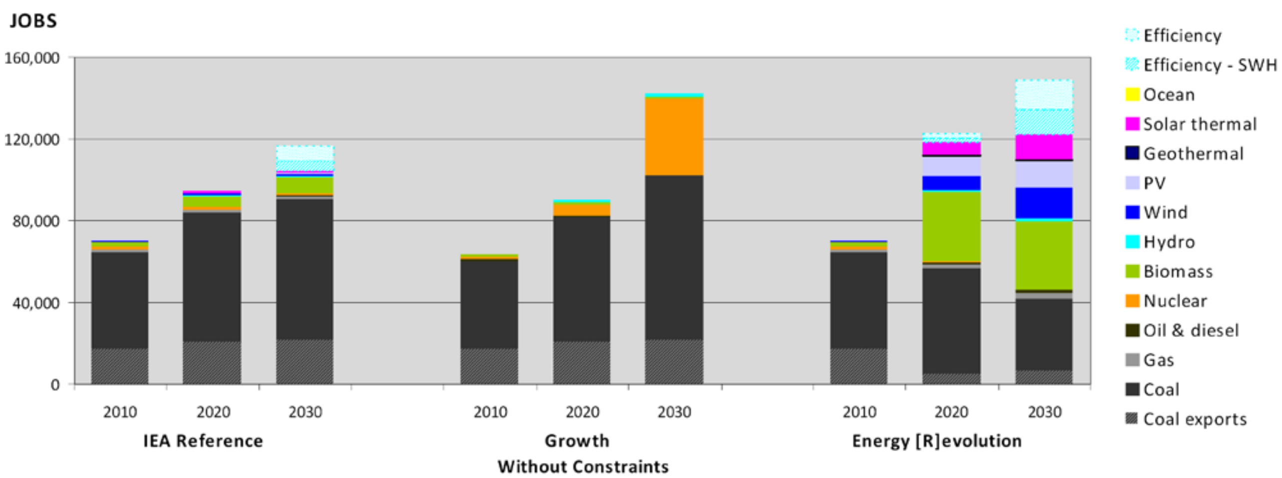
An enhanced manufacturing scenario is also modelled, in which 50% of renewable technology equipment is manufactured locally by 2030, and South Africa services 30% of the growth in renewable technologies in the rest of Africa.

Employment numbers are indicative only, as a large number of assumptions are required to make calculations. Quantitative data on present employment based on actual surveys is difficult to obtain, even in established industries such as coal and gas generation, so it is not possible to calibrate the methodology against time series data. However, within the limits of data availability, the figures presented are indicative of employment levels under the three scenarios.

Results

- In 2020 energy sector jobs (including coal exports) in the [R]evolution scenario are estimated to be 123,000, 30% (28,400 jobs) more than the IEA Reference scenario, and 37% (32,900) more than the Growth Without Constraints scenario.
- By 2030 energy sector jobs (including coal exports) in the [R]evolution scenario are estimated to be 149,000, 27% (31,900 jobs) more than the IEA Reference scenario, and 5% (6,700) more than the Growth Without Constraints scenario.
- In the [R]evolution scenario 72,400 new renewable energy jobs are created by 2030, compared to only 7,500 in the IEA reference scenario and only 2,000 in the Growth Without Constraints scenario. The

Jobs by technology and type in 2010, 2020 and 2030



Growth Without Constraints scenario creates 35,800 additional jobs in nuclear energy.

- An additional 33,700 jobs could be created by 2030 by pursuing policies to boost South African renewable manufacturing capability, taking the total new jobs in the [R]evolution scenario to 182,400, 56% more than in the IEA Reference scenario and 28% more than in the Growth Without Constraints scenario, even with coal export jobs included.

The number of jobs under the [R]evolution, the IEA Reference, and the Growth Without Constraints scenarios are shown below. Combined Heat and Power (CHP) generation is included under the fuel type, such as gas or biomass.

Conclusion

The Energy [R]evolution has the potential to create more employment in the energy sector than continuing with Business As Usual, whether this is defined as the IEA reference scenario or the Growth Without Constraints scenario. The benefit is substantial compared to the IEA reference scenario, with jobs 27% higher in the low carbon case. Employment in the [R]evolution scenario even slightly exceeds (by 5%) employment under Growth Without Constraints, demonstrating that **acting on climate change can significantly benefit the creation of sustainable jobs in South Africa**.

Even if South Africa did not take strong action to reduce greenhouse emissions, as would be the case in the Growth Without Constraints scenario, the rest of the world is likely to be operating under carbon constraints. This may make coal export jobs, which account for more than 15% of jobs in the two reference scenarios, very uncertain. If coal exports are not considered, the employment benefit of the [R]evolution compared to either scenario is significant: 49% (43,500 jobs) higher than the IEA reference case, and 18% (21,700) higher than Growth Without Constraints.

The employment analysis here shows that although South Africa will gain employment overall from a switch to a low carbon energy supply, it is likely to experience job losses in coal mining in a carbon constrained world. The enhanced manufacturing scenario demonstrates that employment in renewable technology manufacturing has the potential to exceed the jobs lost from declining coal exports.

Diversifying South Africa's energy supply by deploying renewable energy at a large scale, alongside active industry support and training for local renewable technology manufacturing and installation, has significant job creation potential. In the short term, this would occur alongside coal export jobs, as those are determined by the international market.

RSA has to decide now whether to be a technology importer or an exporter in the coming decades. Large scale development of renewable technologies combined with ambitious energy efficiency measures would reduce South African emissions, and make the South African economy much more resilient in a carbon constrained world.

Energy sector jobs at 2010, 2020 and 2030

JOBS	IEA REFERENCE			GROWTH WITHOUT CONSTRAINTS			ENERGY [R]EVOLUTION		
	2010	2020	2030	2010	2020	2030	2010	2020	2030
Coal	47 000	64 000	69 000	43 000	61 000	81 000	47 000	52 000	35 000
Gas, oil, diesel	1 100	1 200	1 900	1 100	400	200	1 100	2 500	4 300
Nuclear	1 200	1 200	1 200	1 200	5 700	37 000	1 200	900	-
Renewable	3 600	8 000	11 000	800	2 100	2 800	3 600	58 000	76 000
Electricity supply jobs	**53 000**	**74 000**	**83 000**	**46 000**	**70 000**	**121 000**	**53 000**	**113 000**	**116 000**
Energy efficiency jobs	-	-	12 000	-	-	-	-	4 500	27 000
Coal exports	17 000	20 000	22 000	17 300	20 000	22 000	17 000	5 200	6 500
TOTAL JOBS	**71 000**	**94 000**	**117 000**	**63 000**	**90 000**	**142 000**	**71 000**	**123 000**	**149 000**

Note: Energy efficiency jobs are only those over and above efficiency jobs in the highest consumption reference scenario.

List of Tables and Figures

Abbreviations

ACEEE	American Council for an Energy-Efficient Economy
bn	billion
CA-OE	Co-ordination Action on Ocean Energy
CHP	Combined Heat and Power
CMI	Construction, Manufacturing and Installation
CSP	Concentrating Solar Thermal Power
DME	Department of Minerals and Energy (South Africa)
DTI	Department of Trade and Industry (UK)
EIA	Energy Information Administration (USA)
EPIA	European Photovoltaic Industry Association
EPRI	Electric Power Research Institute
EREC	European Renewable Energy Council
ESTELA	European Solar Thermal Electricity Association
EWEA	European Wind Energy Association
FTE	Full time equivalent
GDP	Gross Domestic Product
GEA	Geothermal Energy Association
GPI	Greenpeace International
GW	Gigawatt
GWC	Growth Without Constraints
GWh	Gigawatt hour
IEA	International Energy Agency
ILO	International Labour Organisation
ISF	Institute for Sustainable Futures
KILM	Key Indicators of the Labour Market
kWh	Kilowatt hour
LTMS	Long Term Mitigation Scenarios
MW	Megawatt
MWh	Megawatt hour
MWp	Megawatt peak
NREL	National Renewable Energy Laboratories (USA)
O&M	Operations and Maintenance
OECD	Organisation for Economic Co-operation and Development
PV	Photovoltaic
REN21	Renewable Energy Policy Network for the 21st Century
RSA	Republic of South Africa
SERG	Sustainable Energy Research Group, School of Civil Engineering and the Environment, University of Southampton
SWH	Solar Water Heating
Th	Thousands
TWh	Terawatt hour
UK	United Kingdom
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
USA	United States of America

1. Introduction

1.1 Background

Greenpeace International (GPI) and the European Renewable Energy Council (EREC) have published a series of global and national Greenpeace energy scenario reports, called the **Energy [R]evolution**. These reports set out a blueprint for a low-carbon future, and compare it to a reference case derived from the International Energy Agency (IEA) projection for Africa as a whole (IEA 2007), which is referred to in this **South African Energy Sector Jobs to 2030** report as the '**IEA Reference scenario**'. The Energy [R]evolution report advocates a pathway for low carbon development up to 2050 which reduces global carbon emissions by more than half.

The South African Government has published a set of energy scenarios, the Long Term Mitigation Scenarios (LTMS), as a basis for development of RSA's climate and energy policy. This includes a '**Growth Without Constraints**' (GWC) scenario, which is commonly regarded as a reference case for the country. The GWC scenario was designed to reflect South Africa's energy development in the absence of climate change, with no oil constraints, and if no effort was made to internalise externalities. While this scenario continues current trends, it does not represent a likely development path. In the words of the authors: 'Growth Without Constraints is really only likely if the world fails in its efforts around climate change, if oil remains cheap, and if South Africa can survive isolated from a carbon conscious world' (Scenario Building Team 2007).

The Energy [R]evolution reduces carbon emissions in South Africa by 60% by 2050 (compared to 2005 levels). In the same period, emissions under the IEA Reference scenario increase by 80%, and under the Growth Without Constraints scenario increase by nearly 400%.

This report presents an analysis of the job creation potential associated with the three scenarios to 2030. It also examines the potential effects of enhanced manufacturing, where South Africa increases its manufacturing capacity in renewable technologies, and commences exporting to the rest of Africa.

The Institute for Sustainable Futures carried out an employment analysis of the Greenpeace and EREC global scenarios (Rutovitz and Atherton 2009), which included regional results for Africa as a whole. This work develops that methodology in order to take account of local South African information where it is available.

Only direct employment in the primary industry sector, consisting of jobs in fuel production, manufacturing, construction and operations and maintenance, is included in the study. Direct jobs are those in the primary industry sector and include jobs in fuel production, manufacturing, construction, and operations and maintenance. Indirect jobs generally include jobs in secondary industries which supply the primary industry sector. These may include catering and accommodation, or construction jobs to provide housing for construction workers, and are sometimes taken to include the effects from spending wages earned in the primary industries. Indirect jobs are usually calculated using a multiplier derived from input-output modelling, and have been completely excluded from this analysis owing to the considerable uncertainties involved.

This section of the report provides some background on the global renewable energy industry, with an overview of current employment. Section 2 summarises the Energy [R]evolution scenario on which the jobs analysis is based. Section 3 explains the methodology used to estimate jobs and Section 4 presents the results. Section 5 outlines the sensitivity analysis and Section 6 concludes that the analysis in this study shows that the diversification of RSA's energy supply through renewable energy has the potential for significant job creation.

© Greenpeace / Philip Reynaers

1.2 Global installed renewable energy capacity and employment

The information in this section is based on the 2009 Renewables Global Status Report (REN21 2009). Worldwide, renewable energy experienced strong growth during 2008. Highlights for the year include:

- Renewable energy capacity grew by 6%, about 70 GW.
- In the United States of America (USA) and Europe, more new capacity came from renewable energy than from fossil fuel power sources.
- Wind power grew by around 29% or 27 GW, constituting the largest addition to renewable energy capacity.

Table 1 and Table 2 show the total global capacity at the end of 2008, the new capacity added during 2008, and the leading countries in the major sectors.

Table 1 Renewable energy capacity – added and existing, 2008 (estimated)*

	Added during 2008 GW	Existing end of 2008 GW
Large hydropower	25-30	860
Wind power	27	121
Small hydropower	6-8	85
Biomass power	2	52
Solar PV, grid-connected	5.4	13
Geothermal power	0.4	10
Concentrating Solar Thermal Power (CSP)	0.06	0.5
Ocean (tidal) power	~0	0.3

* reproduced from REN21 2009, Table R1

Table 2 Renewable energy leaders – capacity in 2008*

TOP FIVE COUNTRIES Installed capacity as of end 2008	#1	#2	#3	#4	#5
Renewable capacity (electricity only, excludes large hydro)	China (76 GW)	United States (40 GW)	Germany (34 GW)	Spain (22 GW)	India (13 GW)
Small hydro	China	Japan	USA	Italy	Brazil
Wind power	United States (~25 GW)	Germany (~24 GW)	Spain (~17 GW)	China (~12 GW)	India (~10 GW)
Biomass power	United States	Brazil	Philippines	Germany Sweden Finland	
Geothermal power	United States	Philippines	Indonesia	Mexico	Italy
Solar PV (grid-connected)	Germany	Spain	Japan	USA	South Korea

* reproduced from REN21 2009, p.9

South Africa does not appear in this ranking as its current renewable capacity is very low, with approximately 160 MW biomass, 665 MW hydro, and no capacity in wind power, grid connected solar Photovoltaic (PV), Concentrating Solar Power (CSP), or geothermal power.

Data on employment in the electricity sector globally is patchy and disaggregated, even in established industries such as coal generation. Information is more readily available for some sectors, such as wind power, and for some Organisation for Economic Co-operation and Development (OECD) countries. For emerging technologies, such as ocean power, data on employment is hard to find.

Table 3 gives an indication of levels of renewable energy employment in selected countries, although it is not always clear whether data is for direct jobs only. There is no data available for China, which currently leads the world in installed capacity.

Current estimates for world employment in the renewable energy sector other than Solar Water Heating are 1.3 million (REN21 2008, p.7) to 1.7 million (United Nations Environment Programme (UNEP) 2008, p. 295), while employment in Solar Water Heating is estimated at 0.6 million in China alone (UNEP 2008, p. 99).

Table 3 Renewable electricity employment – selected countries and world

RENEWABLE ENERGY SOURCE	Selected countries	Employment estimates
Wind	United States	16,000 [a]
	Spain	32,906 [b]
	Denmark	21,612 [c]
	India	10,000 [d]
	World estimate	**300,000 [f]**
Solar PV	United States	6,800 [a]
	Spain	26,449 [b]
	World estimate	**170,000 [f]**
Solar Thermal electricity	United States	800 [a]
	Spain	968 [b]
Solar Water Heating	China	600,000 [g]
	Spain	8,000
	Germany	12,500 [h]
	South Africa	300 [i]
Biomass power	United States	66,000 [a]
	Spain	4,948 [b]
Hydropower	Europe	20,000
	United States	8,000 [a]
	Spain (small hydro)	6,661 [b]
Geothermal	United States	9,000 [a]
All sectors	**World estimate**	**1.3 [e] – 2.3 [f] million**

a 2006 data: Bedzek 2007

b 2007 data: Nieto Sáinz J 2007, in UNEP 2008 Table 11.1-4.

c 2006 data: Danish Wind Industry Association

d 2007 data: Suzlon 2007

e 2006 data: REN21 2008 p.7

f UNEP 2008 p.295.

g UNEP 2008: China p.99, Spain p.98,Germany p.97,

h BMU 2007, p.38

i AGAMA 2003

1.3 Renewable energy in South Africa in 2009

RSA is currently heavily dependent on coal, which supplies 94% of electricity, while only about 1% comes from renewable energy.

The following information is from Winkler (2007):

- **Hydro** is the largest contributor to renewable electricity, with 665 MW installed (excluding pumped storage).
- **Biomass** makes the biggest contribution to South Africa's renewable energy. Most of this is in the form of heating, lighting and cooking in low income households, but there is also a small but significant contribution to industrial energy. Approximately seven million tons of sugar cane waste is burnt for process heat and steam for electricity generation, and there is an estimated 170 MW capacity to burn black liquor at pulp and paper mills. At present these resources are used on site, rather than exporting electricity to the grid, but there is significant capacity to expand generation.
- There is no **wind** power currently exporting to the grid, but there is 10 MW planned at the Darling wind farm. There is, however, a long tradition of off grid wind power.
- **Solar PV** systems are widely used off grid at present, but there are little or no grid connected PV systems installed.
- A feasibility assessment is currently underway for a 300 MW **CSP** station near Upington in the Northern Cape.
- There is a **Solar Water Heating** industry, estimated to have employed 300 people in 2003, with annual installation (excluding pool heating) of 10 MW (AGAMA 2003).

Despite the very small base, the LTMS report prepared for the Department of Environmental Affairs and Tourism indicates that renewable energy could supply 30% of electricity by 2020 (Winkler 2007), which is a similar percentage to the Energy [R]evolution scenario.

2. Energy [R]evolution scenarios

The Energy [R]evolution scenario published by Greenpeace International and the European Renewable Energy Council would reduce South African emissions by 60% by 2050, compared to 2005 levels (GPI/EREC 2009). The Reference scenario is derived from the IEA's 'World Energy Outlook 2007' projection for Africa, and would see South Africa's emissions increase by 80% in 2050 compared to 2005 levels.

The Growth Without Constraints scenario, published by the Department of Environment Affairs and Tourism as part of the Long Term Mitigation Scenarios suite of scenarios, sees emissions increase nearly fourfold between 2005 and 2050.

Energy [R]evolution highlights

- Energy efficiency delivers the equivalent of one third of the total projected demand for energy services by 2050. This means primary energy demand can go down in the Energy [R]evolution scenario, compared to an increase of 1.6 times in the IEA Reference scenario. This has significant economic as well as environmental benefits.
- In the electricity sector alone, energy efficiency reduces demand by 23% compared to the IEA Reference scenario.
- In 2020, renewable sources supply 15% of electricity, with installed capacity of 16 GW. This rises to 36% by 2030, with installed capacity of 36 GW. By contrast, in the IEA Reference scenario renewable energy supplies only 2% of electricity in 2020, and only 4% in 2030.
- Nuclear power plants are phased out in the Energy [R]evolution scenario.

- Coal power capacity stays reasonably constant in the Energy [R]evolution up until 2020, and is reduced from then onwards, supplying 80% of electricity in 2020, and only 60% in 2030. Current construction of supercritical coal power stations at Medupi and Kusile are continued, allowing older stations to be progressively phased out (Teske 2010).
- Hydro power is kept constant throughout the [R]evolution scenario. There are currently two large hydro stations under consideration in the western Democratic Republic of Congo, which could potentially supply 39 GW to southern Africa. These are not included in the [R]evolution scenario as there is a great deal of uncertainty around the projects.

The [R]evolution scenario proposes significant shifts in electricity supply. By 2030, renewable energy supplies 36% of South Africa's electricity. This is only slightly above the renewable scenario presented as one of the mitigation options under the 'Required by Science' scenario in the LTMS (Winkler 2007, Table 22).

Two key underlying drivers of energy demand are population development and economic growth. The [R]evolution scenario uses the United Nations Development Programme (UNDP) 2007 projections (UNDP 2007), which see South Africa's population increase from 48 million people in 2005 to 56 million by 2050.

The Energy [R]evolution modelling uses the economic growth projections to 2030 from the International Energy Agency (IEA 2007), but uses their own best estimates to project these to 2050. South Africa's economy is projected to grow at an average of 3% per year between 2005 and 2050.

The third key driver of future energy demand is energy intensity i.e. how much energy is required to produce a unit of GDP. This is a key point of difference between the [R]evolution and the IEA Reference scenario. The [R]evolution scenario decouples energy consumption from economic growth through efficiency measures, so energy intensity under the [R]evolution scenario is significantly lower than in the IEA Reference scenario.

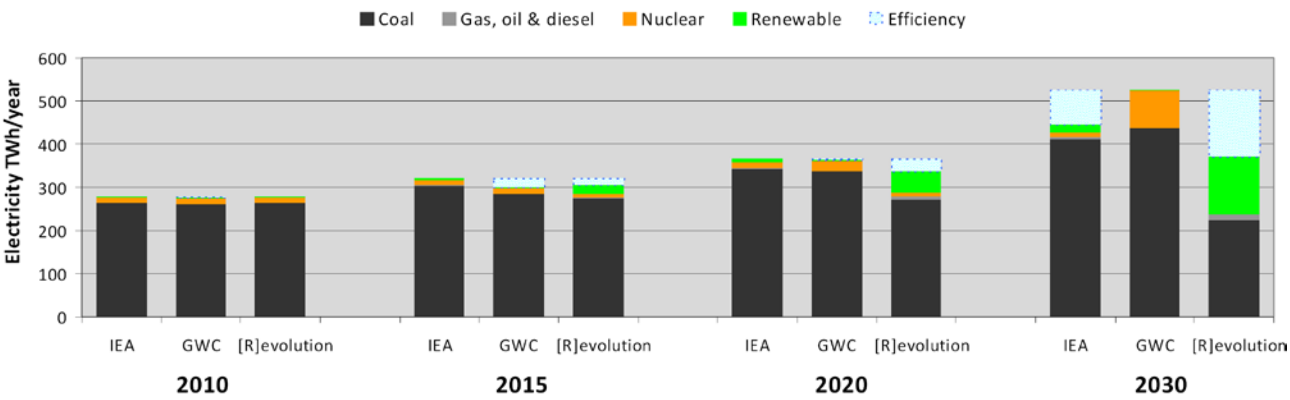
Figure 1 shows electricity supply, including the portion of consumption displaced by energy efficiency, for the three scenarios up until 2050.

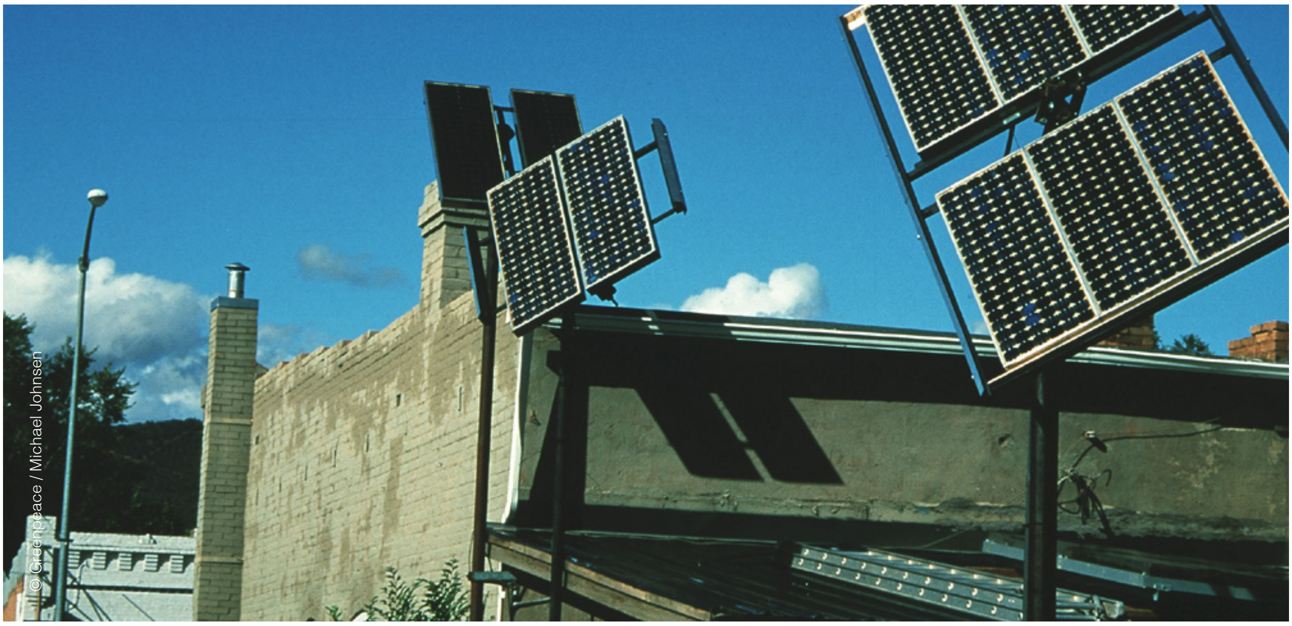
The Growth Without Constraints scenario has been modified slightly:

- Firstly, the Growth Without Constraints scenario presents electricity sent out from generators, rather than generated, while the Greenpeace Energy [R]evolution presents total generation including generators own consumption.
- Secondly, the construction of new coal fired capacity has been brought forward to reflect the construction of Medupi and Kusile power stations. This is quite significant, as under the original Growth Without Constraints only 5 GW of new coal power is online by 2020, and this only reaches 13 GW by 2040. Taking planned construction times for Kusile/Medupi into account, 7 GW of new capacity comes online by 2015, and 10 GW by 2020.
  The overall generation (allowing for own consumption, as described above) remains unaltered, with generation from existing power stations reduced to match the generation from the new supercritical stations.

Full details of the [R]evolution scenarios can be found in the Greenpeace/European Renewable Energy council report (GPI/EREC 2009), and details of the Growth Without Constraints scenario can be found in Hughes et al (2007).

Figure 1 Electricity generation in South Africa under the three scenarios





3. Methodology

3.1 Methodology overview

Employment in the electricity sector is projected for the three scenarios at 2010, 2020 and 2030 by using a series of employment multipliers and the projected electricity generation and installed capacity. Only direct employment is included, namely jobs in construction, manufacturing, operations and maintenance, and fuel supply associated with electricity generation.

An indicative result for energy efficiency jobs is calculated, although the associated uncertainty is even greater than for energy supply.

Employment is also projected for an 'enhanced manufacturing' scenario, in which local manufacturing for renewable technologies reaches 50% by 2030, and there is some export of technology to the rest of Africa.

The inputs to the employment projections are as follows:

- **Installed electrical capacity and generation by technology**, at 5 or 10 yearly intervals, from the two Greenpeace scenarios, the IEA Reference and the Energy [R]evolution, and the Growth Without Constraints scenario.
- **Employment factors** which give the number of jobs per MW for each technology in construction and manufacturing, operations and maintenance, and fuel supply. These are the key inputs to the analysis. Local factors are used where possible, but are only available for operations and maintenance employment in coal, nuclear, and hydro generation, for construction employment for coal, for coal mining, and for employment in all aspects of Solar Water Heating.
- **A regional multiplier** is used where local factors are not available. In this case, employment factors from OECD data are adjusted upwards using a multiplier to allow for the fact that economic activities in regions with lower GDP per capita are generally more labour intensive. In the global employment analysis (Rutovitz and Atherton 2009) the ratio of labour productivity (excluding agriculture) in the OECD compared to Africa's labour productivity is used as the multiplier. However, for the country analysis, the weighted average ratio of local to OECD factors is used.
- **Decline factors**, or learning adjustment rates, for each technology. These reduce the employment factors by a given percentage per year, to take account of the reduction in employment per MW as technologies mature.
- **Local manufacturing percentages** are used to determine the proportion of manufacturing jobs associated with each technology that occurs within South Africa.
- **Projected coal exports for RSA:** the Reference case for exports is derived from the IEA projection for South African coal exports in inter-regional trade and the current exports to the rest of Africa (IEA 2008a). Coal exports in the [R]evolution scenario are adjusted to follow the reduction in coal powered electricity in the rest of the world, with the consequent reduction in demand for coal.
- **Export percentages for renewable technologies:** the enhanced manufacturing scenario assumes the rest of Africa imports a proportion of the renewable technology needed for the growth in their renewable capacity from South Africa. The regional changes in capacity in wind, solar thermal, geothermal, and ocean powered electricity are inputs from the global [R]evolution scenario (GPI/EREC 2008).
- **Energy efficiency employment** is only calculated for the reduction in electricity generation in the [R]evolution compared to the Reference scenario. A percentage of this is assumed to be Solar Water Heating. Employment from SWH is calculated using local employment factors, while the remaining energy savings are multiplied by a derived factor for jobs per unit of energy saved. The factor is derived from OECD data and modified by the regional multiplier.

The calculation of energy supply jobs in each region is summarised in the four equations below:

Jobs = Manufacturing jobs + construction jobs + Operations and Maintenance (O&M) jobs + fuel supply jobs + coal export jobs

Where:

Manufacturing jobs (for domestic use)	=	MW installed per year	**x**	Manufacturing employment factor	**x**	% local manufacturing
Manufacturing jobs (for export, enhanced scenario only)	=	MW exported per year	**x**	Manufacturing employment factor	**x**	% local manufacturing
Construction jobs	=	MW installed per year	**x**	Construction employment factor		
O&M jobs	=	Cumulative capacity	**x**	O&M employment factor		
Fuel supply jobs	=	Electricity generation	**x**	Fuel employment factor		
Coal export jobs	=	Coal export tons	**x**	Fuel employment factor		

E2 Jobs in region at 2010 = jobs (as above)

E3 Jobs in region at 2020 = jobs (as above) x technology decline factor (years after start)

E4 Jobs in region at 2030 = jobs (as above) x technology decline factor (years after start)

3.2 Limitations

Employment numbers are indicative only, as a large number of assumptions are required to make calculations. Quantitative data on present employment based on actual surveys is extremely difficult to obtain, so it is not possible to calibrate the methodology against time series data, or even against the current situation.

However, within the limits of data availability, the figures presented are indicative of employment levels under the two scenarios. For a discussion of the uncertainty around the numbers, see the sensitivity analysis in Section 5.

3.3 Employment factors overview

Electricity sector employment is calculated by using employment factors, which give the jobs created per MW of capacity or per GWh of generation.

Only **direct** employment in development, construction, manufacturing, operations and maintenance, and fuel supply is included in this study.

Operations and Maintenance (O&M) and fuel supply employment factors are expressed in terms of jobs per MW and per GWh respectively, and are ongoing jobs which fluctuate with the capacity or the generation totals.

Construction, Manufacturing and Installation (CMI) and development employment factors are expressed in terms of job years per MW installed. Some studies (for example Kammen et al 2004) convert construction jobs to jobs per GWh over the lifetime of the facility, in order to compare the job creation potential of different technologies. While this is theoretically sound, it does not reflect physical reality, as construction employment occurs before the power station comes online, not during operation. For example, a coal plant with a forty year lifetime will create a large number of construction jobs for a ten year period before commencing generation, and a wind farm will create construction jobs for 1- 2 years prior to generation. In this study, construction and manufacturing employment is modelled by multiplying the average annual increase over the ten year period prior to generation by the job years of employment per MW. For 2010, the average is calculated over the five year period prior to generation.

The employment factors are the most important inputs to employment calculations. It is difficult to obtain accurate data as information is patchy, even for well established industries such as coal and gas generation.

This analysis uses local data where it is available, namely coal, hydro, and nuclear generation, coal mining, and Solar Water Heating. In other cases, the factors from the global employment analysis of the Energy [R]evolution are used (Rutovitz and Atherton 2009), adjusted for the fact that wage levels in South Africa are lower than in the OECD.

The derivation of local factors is detailed in Section 3.4, and the employment factors used in the global analysis are given in Appendix 1. Wherever possible, industry employment factors were used, or factors were calculated from employment and production data. The wide variation in employment factors for each technology is discussed in the global analysis of the Energy [R]evolution (Rutovitz and Atherton 2009).

The factors presented in Table 4 are those used in this study. Local factors are in bold type. The other factors are from the USA or Europe, and are adjusted by a factor of 1.8 as labour intensity tends to be higher when wage levels are lower (see Section 3.5).

These factors are further adjusted to:

- Take cognisance of the proportion of manufacturing which occurs locally by using local manufacturing percentages (see Section 3.8).
- Take account of the reduction in technology costs and the corresponding fall in employment per MW by using decline factors (see Section 3.7).


© Greenpeace / Dean Sewell

Table 4 Employment factors for use in South African analysis

	CMI JOBS		O&M AND FUEL		NOTE
	Construction/ installation	Manufacturing	Operations and Maintenance	Fuel	
	job years/MW		jobs/MW	jobs/GWh	
Coal (existing and refurbished)	**5.2 (local)**	1.5	**0.3 (local)**	**0.13 (local)**	Note 2
Supercritical coal	**10.4 (local)**	1.5	**0.294 (local)**	**0.11 (local)**	Note 2
Gas, oil and diesel	6.2	0.07	0.09	0.22	Note 3
Nuclear	10.8	1.2	**0.66 (local)**	0.002	Note 4
Biomass	6.9	0.8	5.51	0.40	Note 5
Hydro	19.4	0.9	**0.04 (local)**		Note 6
Wind	4.5	22.5	0.72		Note 7
PV	52.3	16.8	0.73		Note 8
Geothermal	5.6	5.9	1.33		Note 9
Solar thermal	10.8	7.2	0.54		Note 10
Ocean	16.2	1.8	0.58		Note 11
Solar Water Heating	**11.7(local)**	**10.7(local)**			Note 12
Energy efficiency	0.5 jobs per GWH				Note 13

Notes

1. **Where local factors are not available, OECD factors have been multiplied by 2.15.** Local factors are in bold and noted as local in brackets.
2. **Coal**

   Construction is a local factor, and has been calculated from the estimates for Medupi and Kusile power stations (ESKOM 2009b), assuming an average of 5000 people employed for ten years. O&M is a local factor, with a different figure for existing and new power stations. The O&M for existing power stations is calculated from employment and capacity in Eskom's generation division (ESKOM 2009a), and includes ancillary staff (finance, human resources, etc), which have been allocated to generation or distribution and transmission according to the percentage of staff in each division.

   For supercritical coal (new build) O&M is calculated from the projected figures for Medupi power station (ESKOM 2009b).Fuel is a local factor, and is calculated from coal production and use in electricity (IEA 2009), electricity production from coal for 2006 (ESKOM 2009), and employment in coal mining (DME 2008), assuming that employment per ton is constant irrespective of the usage of the coal.
3. **Gas generation**

   Gas generation uses factors from the USA, from the USA National Renewable Energy Laboratory (NREL) publicly available JEDI model (NREL JEDI), which was developed to allow calculation of local benefits from different electricity supply options. Default values from the model were used for all variables. These are multiplied by 2.15. Oil and diesel use the same factors as gas.
4. **Nuclear**

   O&M is a local factor, and is calculated from employees and capacity at South Africa's Koeburg nuclear station (ESKOM 2010a). Fuel and CMI employment is derived from USA and Australian industry data, and are multiplied by 2.15 for use in the South African context.
5. **Biomass**

   Only biomass for power generation is considered in this analysis (it does not include bio-fuels). Construction and manufacturing factors are from a USA study (EPRI 2001), and O&M and fuel factors are from a detailed UK analysis (DTI 2004). Both are multiplied by 2.15 for use in the South African context.
6. **Hydro**

   O&M is a local factor calculated from employment and capacity data for Gariep and Vanderkloof power stations (ESKOM 2010a).

   CMI is from a Canadian study (Pembina 2004), multiplied by 2.15 for use in the South African context.

7. **Wind**

All factors are from the European Wind Energy Association (EWEA 2009), and are multiplied by 2.15 for use in the South African context.

8. **Solar PV**

CMI factors are from the European Photovoltaic Industry Association (EPIA 2008A), and O&M factors are from Germany industry data (BMU 2008a). Factors are multiplied by 2.15.

9. **Geothermal**

All factors are from the USA Geothermal Energy Association (GEA 2005), and are multiplied by 2.15 for use in the South African context.

10. **Solar thermal electricity**

All factors are from the European Renewable Energy Council (EREC 2008), and are multiplied by 2.15.

11. **Ocean** (includes wave and tidal)

All factors use United Kingdom (UK) data, taken from two research studies (SERG 2007, CA-OE 2008), and are multiplied by 2.15 for use in the South African context.

12. **Solar Water Heating**

Energy efficiency is divided into Solar Water Heating (SWH) and other efficiency, as SWH is expected to contribute significant energy savings. This report does not calculate total employment in SWH in South Africa; instead 10% of the energy efficiency savings are assumed to come from SWH, and employment calculated for that portion of SWH. CMI employment is a local factor, taken from AGAMA 2003. In this study retailing and distribution have been included in installation.

13. **Energy efficiency**

Base case energy efficiency jobs are not calculated, so the energy efficiency jobs reported are only those additional to the reference scenarios, which contribute to reducing electricity consumption. The factor for energy efficiency other than Solar Water Heating is taken from a USA study (ACEEE 2008), and is multiplied by 2.15 for use in the South African context.

3.4 Local employment factors

Local employment factors are used where possible, which is for coal construction, coal, hydro, and nuclear operations and maintenance, coal mining and for Solar Water Heating. Further details of the derivation are given below.

3.4.1 Coal mining (fuel)

The current (2006) employment per ton of coal in South Africa is calculated from IEA data on coal production for 2006, and the Department of Minerals and Energy (DME) data on employment. These are combined with data for electricity from coal to derive an employment figure per ton of coal and per GWh of electricity.

In 2006, South Africa produced 245 million tons of coal (IEA 2009), and employed 57,700 people in coal mining (DME 2008). A total of 116 million tons of coal was used in electricity generation (IEA 2009), which produced approximately 216,201 GWh (calculated from ESKOM 2009a)[2]. Employment per GWh is calculated from the employment per ton, and the tons per GWh, as shown in the equation below.

This results in employment of 0.0002 per ton, and 0.13 per GWh. For supercritical coal[3], the employment per GWh is adjusted because of the higher efficiency of the technology (39% compared to 35%) to 0.11 jobs per GWh.

Employment per ton in coal mining has fallen sharply over the last twenty years in South Africa, with an average decline of 5% per year. This pattern is repeated worldwide, and is expected to continue during the next two decades, regardless of which energy path is followed.

$$\text{Employment per GWh} = \text{Employment per ton coal} \times \text{tons per GWh}$$

[2] Of the remaining 129 million tons of coal, 66 million tons were exported, 40 million tons used in industry for non-electricity uses (mainly liquefaction), and 2 million tons for petrochemical feedstocks (DME 2007).

[3] The two new coal fired power stations being constructed at Medupi and Kusile are supercritical, which means the boiler operates above the critical point for water (25 MPa pressure, 374ºC), with steam temperatures above 550ºC. Generation using supercritical technology is expected to achieve efficiencies of 41% (wet cooled) and 39% (dry cooled), compared to about 35% for subcritical generation (Connell Wagner 2007).

Table 5 Declining employment in South African coal mining 1986 - 2006

Year	Employees	Production tons	Employment per 1000 tons	Average annual change
1986	120,214	174 m	0.69	
1990	103,808	175 m	0.59	- 4%
1995	62,064	206 m	0.30	- 13%
2000	51,346	224 m	0.23	- 5%
2006	56,971	245 m	0.23	+ 1%
Whole period				**- 5%**

The 2006 figure is used for employment calculations in 2010. Thereafter, it is adjusted using the projected decline in cost for coal power of 0.9% per year (see Section 3.8).

Employment and production data was collected for most major coal producing countries for the global employment analysis, and is given in Appendix 2. Employment per GWh in South Africa is low compared to most developing countries, but is still between three and four times higher than Australia and the USA.

3.4.2 Coal, nuclear and hydro generation

Coal employment for O&M at existing power stations is derived from ESKOM data for employment and generation. Total employment by division is shown in Table 6. In this study, ancillary staff are allocated to generation, distribution, or transmission according to the size of the division. The generation total is then divided by the total capacity of 44,193 MW to obtain the O&M figure for existing coal generation, which is 0.29 including ancillary staff. Although this includes all ESKOM generation, coal power makes up 85% of capacity.

Employment figures for O&M at new coal power stations are taken from ESKOM's projections for Medupi and Kusile, of 750 staff per 4,800 MW (ESKOM 2009b). This results in employment per MW of 0.16. No decline factor is applied to this during 2010 – 2020.

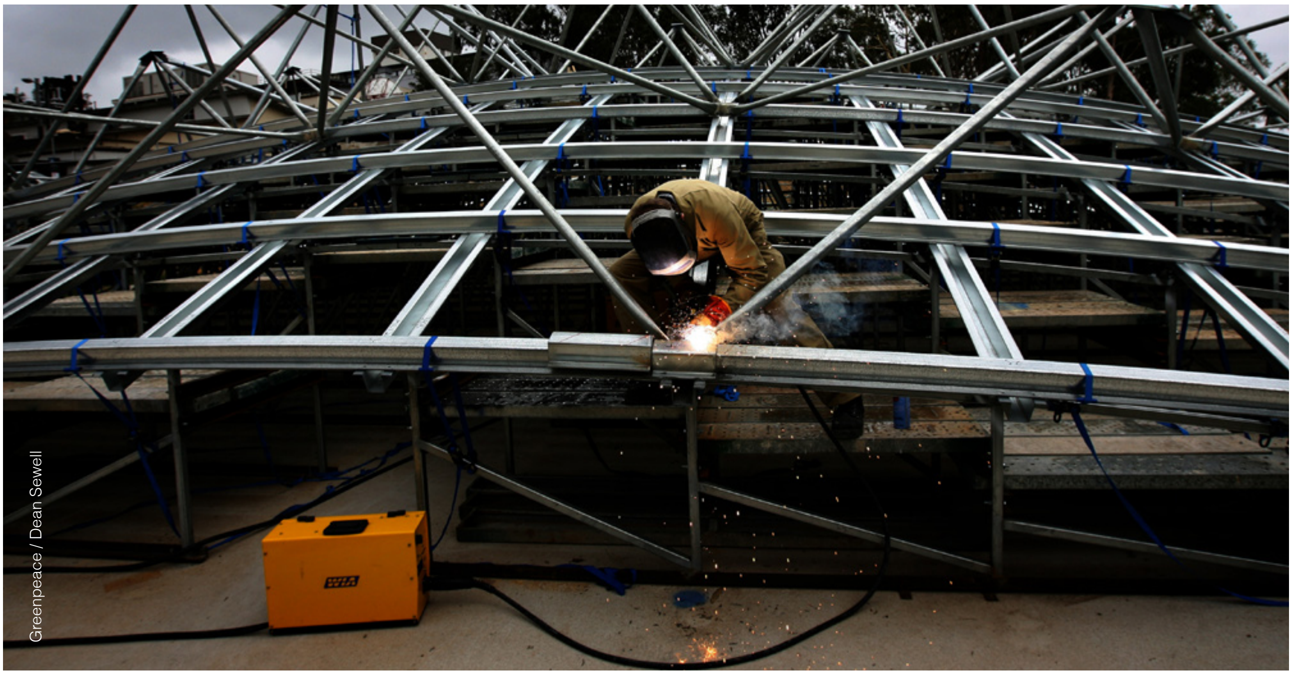

Greenpeace / Dean Sewell

Table 6 ESKOM employment

Division	Employment	Including proportional ancillary staff
Generation	10,833	12,983
Distribution	16,716	20,033
Transmission	1,819	2,180
System operations and planning	270	-
Enterprises	3,097	-
Corporate services	1,339	-
Human resources	422	-
Finance	649	-
Group communication	51	-
Total	**35,196**	**35,196**

From ESKOM 2009 annual report, p. 93

Nuclear employment for O&M is calculated from employees and capacity at South Africa's Koeberg nuclear power station, which are reported as 1,200 employees and 1,800 capacity (ESKOM 2010a).

Hydro employment for O&M is calculated from the combined employment and capacity at Gariep and Vanderkloof power stations, which total 25 employees and 600 MW (ESKOM 2010a).

3.4.3 Coal – construction

Construction data for coal fired power stations come from the projection for Medupi and Kusile.

ESKOM estimates that employment will peak on each project at 8,000, and current employment at Medupi is 2,000 (ESKOM 2009b). Construction time is projected to be 10 years. This study makes the assumption that employment will average 5,000 over the 10 year period, although this is somewhat uncertain. This results in a figure of 10.4 job years per MW, compared to a figure of 14.4 from the USA National Renewable Energy Laboratory model. However, that model was for a much smaller power station, so the large size of the Medupi power station may lead to economies of scale.

There is also a programme of refurbishment underway, for example, at Grootvlei and Komati power stations. There is no employment information available, so it has been assumed that refurbishment will employ half the number of people employed by construction. This may overestimate the numbers of jobs created in this area.

3.4.4 Solar Water Heating

SWH is expected to contribute significantly to energy efficiency savings in the residential sector. It is outside the scope of this report to calculate total SWH employment in South Africa, as this study is examining electricity generation rather than heat. However, some of the reduction in electricity generation in the [R]evolution compared to the Reference scenario will be because of SWH displacing electricity. It is assumed that 10% of the energy efficiency savings in the [R]evolution electricity supply are because of SWH, and employment is only calculated for that proportion. Total employment in SWH will be much higher.

The CMI employment is from AGAMA (2003). They report that there were 300 jobs in SWH in 2002 (excluding swimming pool heaters), and annual installation of 10 MWp[4]. They use the split between manufacturing, installation, and retailing and distribution from a USA report, and quote the employment in the USA in 2003 as 6.1 jobs per MWp (EIA 2002, quoted in AGAMA 2003). They also project the employment factor for 2012 and 2020, using a decline factor of 3.6% per year.

In this study retailing and distribution are included under installation, which gives a construction and installation employment of 15.7 per MW, and manufacturing employment of 14.3 per MW in 2002, declining to 11.7 per MW and 10.7 per MW by 2010.

[4] MWp means megawatt peak, i.e. the capacity when the heater is operating in full sunlight.

3.5 Regional adjustments

Most available employment factors are for OECD countries or regions, and need adjustment for differing stages of economic development. Broadly, the lower the cost of labour in a country, the greater the number of workers that will be employed to produce a unit of any particular output, be it manufacturing, construction or agriculture. Low average labour costs are closely associated with low Gross Domestic Product (GDP) per capita, a key indicator of economic development.

In the global analysis of the employment effects of the Energy [R]evolution (Rutovitz and Atherton 2009), it was important to derive regional job multipliers from a relatively complete data set with global coverage. Average labour productivity, measured as GDP (or value added) per worker, was selected, using the International Labour Organisation (ILO) Key Indicators of the Labour Market (KILM) database (ILO 2007 KILM). The job multipliers were adjusted over the study period 2010 to 2030, using the projected change in GDP per capita derived from IEA 2007. This gives projections for both GDP growth and population, as these are key inputs to the energy scenario.

South African average labour productivity is projected to remain at 22% of OECD labour productivity from 2010 to 2030, using economic data excluding agriculture (derived from ILO 2007 and IEA 2007). This would result in a job multiplier for South Africa of 4.6 for the entire period. This compares to the multiplier of 6 used for the whole of Africa in the global analysis.[5]

In order to see whether this is appropriate, the available local factors are compared to OECD employment factors in Table 7. Factors other than hydro power and coal construction vary from 1.6 times greater to 3.7 times greater than OECD factors. The weighted average ratio is used, with the weighting following the MW installed in 2020 in the Energy [R]evolution scenario. Solar Water Heating is not included in the calculation.

This results in a regional multiplier of 2.15, which is applied to OECD employment factors when South African local factors are not available.

The regional multiplier has a significant effect on job calculations in all three scenarios, but most notably in the [R]evolution scenario, as this scenario has high renewable energy penetration and the renewable technologies other than hydro and Solar Water Heating all use OECD factors. See Section 5 for an analysis of the effect of varying the regional multiplier between the lowest and highest ratios in the electricity sector (1.6 and 2.9).

Table 7 Local employment factors and OECD factors compared

	South Africa	OECD	Capacity in 2020	Ratio
	Jobs/MW	Jobs/MW	GW	
O&M coal (existing)	0.29	0.10	38.5	2.9
O&M coal (new)	0.16	0.10	9.6	1.6
O&M nuclear	0.66	0.3	1.3	2.1
O&M hydro	0.04	0.2	1.1	0.2
Construction coal (new)	10.4	6.5	38.5	1.6
CMI Solar Water Heating	22.4	6.1	-	3.7
Capacity weighted average ratio				**2.15**

[5] For a full discussion of the regional adjustment factors used in the global analysis, and the economic data used to derive them, see Rutovitz and Atherton, 2009.

3.6 Coal trade

Jobs in coal mining have been calculated after taking international trade into account. The projected growth in exports in the Reference scenario is derived from IEA (2008a and 2008b). In 2006 RSA exported 66.2 million tons of coal, with 78% exported to the European Union, 8% to the rest of Africa, and 14% to the rest of the world (IEA 2008a, Part IV page 44).

Total exports in the Reference scenario are assumed to grow in proportion to the IEA projected growth in inter-regional trade. This sees South Africa's coal exports growing by 48% between 2006 and 2015, and by 70% between 2006 and 2030 (IEA 2008b, Table 5.3, shown in Appendix 2). South African coal exports to Europe are assumed to change in proportion to projected European coal imports, while exports to the rest of Africa are assumed to stay at a constant proportion of total RSA coal exports.

The decline in coal exports in the [R]evolution scenario is calculated from the percentage change in coal consumption for electricity in Africa, OECD Europe, and the rest of the world. Exports to the rest of Africa are assumed to grow in proportion to the growth in African coal powered electricity in the [R]evolution scenario.

In the [R]evolution scenario inter-regional imports of coal decline by 90% in 2020 relative to the Reference scenario, and by 99% in 2030 relative to the Reference scenario.

South African exports to the rest of the world other than Africa fall to only 9 million tons in 2020 in the [R]evolution scenario, and to only 1 million tons by 2030. Exports to the rest of Africa actually increase over the period, as coal powered electricity in the rest of the continent continues to rise in the [R]evolution scenario. Projected exports are shown in Table 8.

Table 8 Projected South African coal exports, million tons

	IEA REFERENCE			ENERGY [R]EVOLUTION		
	2010	2020	2030	2010	2020	2030
Africa	6	7	8	6	16	34
OECD Europe	56	59	53	56	9	0
Rest of world	18	36	51	18	2	1
TOTAL	**80**	**103**	**112**	**80**	**27**	**34**

3.7 Adjustment for learning rates – decline factors

Employment factors are adjusted to take account of the reduction in employment per unit of electrical capacity as technologies and production techniques mature. The learning rates assumed have a significant effect on the outcome of the analysis.

Industry projections for employment decline values are only available in a small number of technologies, namely wind, solar, and ocean. For other technologies, the annual decline in cost for each technology is taken as a proxy value for the decline in employment. Cost declines will correspond to a reduction in employment, whether they result from greater efficiency in production processes, scaling up of technology, or as a direct result of more efficient working practices.

The decline factors derived from the GPI/EREC data are presented in Table 9, along with decline factors from industry sources. The industry factors have been used where they are available, as they are generally more conservative, predicting a steeper decline in employment factors. The decline factors from cost data for wind, PV, solar thermal, and ocean energy are shown for comparison but are not used in the analysis.

Table 9 Decline rates

	Annual decline in job factors Reference scenario		Annual decline in job factors [R]evolution scenario		Source
	2010-20	2020-30	2010-20	2020-30	
Coal	0.9%	0.3%	1.0%	0.3%	GPI & EREC 2008 (cost data)
Gas	0.4%	0.5%	0.4%	0.6%	GPI & EREC 2008 (cost data)
Oil	0.4%	0.4%	0.4%	0.4%	GPI & EREC 2008 (cost data)
Diesel	0.0%	0.0%	0.0%	0.0%	GPI & EREC 2008 (cost data)
Biomass power plant	1.0%	0.5%	1.0%	0.5%	GPI & EREC 2008 (cost data)
Hydro	-0.6%	-0.5%	-0.6%	-0.5%	GPI & EREC 2008 (cost data)
Wind	1.40%	1.40%	1.40%	1.40%	Derived from EWEA 200, footnotes 5 & 6 page 22.
Wind turbine *	1.1%	0.8%	1.2%	0.7%	GPI & EREC 2008 (cost data)
PV	6.88%	1.41%	7.72%	2.42%	EPIA 2008b
PV *	6.5%	5.7%	6.9%	5.2%	GPI & EREC 2008 (cost data)
Geothermal	2.3%	2.0%	2.5%	1.7%	GPI & EREC 2008 (cost data)
Solar thermal (electricity)	0%	2.2%	1.6%	0.5%	GPI/ ESTELA 2009, page 62
Solar thermal (electricity) *	2.0%	1.7%	2.0%	1.7%	GPI & EREC 2008 (cost data)
Ocean	7.80%	7.80%	7.80%	7.80%	SERG 2007
Ocean energy *	8.4%	3.8%	8.4%	3.8%	GPI & EREC 2008 (cost data)

* Factors not used in analysis, provided for comparison only.

3.8 Adjustment for manufacturing occurring out of the country

The proportion of manufacturing that occurs within RSA is estimated in order to calculate local jobs. It is assumed that only 20% of manufacturing occurs within the country for all technologies in all scenarios. The only exception is Solar Water Heating, where it is assumed that 50% of manufacturing occurs within the country.

3.9 Enhanced manufacturing and renewable export scenario

Job calculations were also performed for an enhanced manufacturing scenario. In this scenario the proportion of renewable technology equipment manufactured within the country reaches 50% by 2030 (70% for Solar Water Heating). This reflects the extremely high deployment of renewable technologies in the scenario, and assumes that there is active support for developing a domestic manufacturing industry as a result of a strategic policy on climate change.

In the enhanced manufacturing scenario, South Africa also becomes an exporter to the rest of Africa. It supplies 15% of the renewable market in Africa by 2020, and 30% by 2030. The manufacturing multiplier is still used, as only parts that are made in South Africa can be exported. Jobs for export are calculated using the following equation:

3.10 Energy efficiency

This analysis only considers additional energy efficiency employment over and above what would occur in the reference scenarios, it does not consider the existing jobs in energy efficiency, or those additional energy efficiency jobs which would be created in the IEA Reference scenario.

The amount of energy efficiency (in TWh) is calculated from the difference between the [R]evolution scenario and whichever of the two other scenarios (IEA Reference or Growth Without Constraints) has the higher electricity consumption in that year. Where the Growth Without Constraints has higher consumption than the IEA Reference case, energy efficiency jobs are calculated for the IEA Reference case.

Energy efficiency is assumed to persist for 15 years (the presumed lifetime of equipment), so in each year only the 'new' efficiency savings are counted for employment calculations. Investment is assumed to occur linearly.

$$\text{Jobs} = \text{\% of export to rest of Africa} \times \text{MW under construction} \times \text{\% local manufacturing} \times \text{employment factor}$$

This would mean that South Africa supplied 15% of the components associated with the renewable capacity expansion in the rest of Africa.

The difference between the scenario electricity consumption and the highest consumption in any of the three scenarios for a particular year is referred to as Efficiency-YEAR, and efficiency employment is calculated using the following equations:

$$\text{Jobs at 2020} = \frac{\text{Efficiency\_2020}}{10} \times \text{employment factor} \times \text{regional adjustment factor}$$

$$\text{Jobs at 2030} = \frac{\text{Efficiency\_2030} - \text{Efficiency\_2020} + \text{Efficiency\_2015}}{10} \times \text{employment factor} \times \text{regional adjustment factor}$$

The most comprehensive assessment of the energy efficiency industry is given in a 2008 study of the USA, The Size of the U.S. Energy Efficiency Market: Generating a More Complete Picture, by Ehrhardt-Martinez and Laitner (ACEEE 2008). This identifies the energy efficiency premium spending by sector in the USA in 2004, and gives both the energy savings and the job creation, shown in Table 10. This information has been used to derive a figure for energy efficiency jobs per GWh in South Africa, using an approximation of the mix of sectoral savings.

A weighted average of 0.47 jobs per GWh for energy efficiency jobs in the residential, commercial, industrial and utility sectors is calculated using the approximate distribution of electricity savings in the Energy [R]evolution scenario for South Africa, namely 50% industrial energy savings, and 50% 'other sectors'. The latter is assumed to be split 25% residential and 25% commercial. This is higher than the employment per GWh for the entire economy quoted in Table 10, as this analysis does not include energy efficiency in transport or utilities, which dominate the overall figures for the US.

The sensitivity of the overall jobs calculations to the sectoral split in energy efficiency is not significant, as discussed in Section 5.

Table 10 Employment from energy efficiency investment in the USA, 2004

	Residential	Commercial	Industrial	Appliances and electronics	Transport	Utilities	Entire economy
Efficiency premium employment	47,400	45,200	52,700	44,700	22,700	20,800	**233,500**
Jobs per million USA $ investment	8.1	5.9	4.6	4.2	4.7	8.8	**5.4**
Investment billion USA $	5.9 bn	7.7 bn	11 bn	10.6 bn			n/a
Energy savings GWh	96,713	73,268	193,427	43,961	407,369	718,024	**1,532,762**
Employment per GWh	**0.49**	**0.62**	**0.27**	**1.02**	**0.06**	**0.03**	**0.35**

From ACEEE 2008, Table 8 (employment and jobs per million), Figures 5 – 8 and p.24

Table 11 Energy efficiency employment factor for South Africa, derived from alternate sectoral splits of energy efficiency

	Residential	Commercial	Industrial	Employment per GWh
Sectoral split of energy efficiency from [R]evolution	50%	25%	25%	**0.47**
Alternative split 1	25%	50%	25%	**0.5**
Alternative split 2	25%	25%	50%	**0.41**

4 Employment in the electricity sector – Results

Highlights

- In 2020 energy sector jobs (including coal exports) in the [R]evolution scenario are estimated to be 123,000, 30% (28,400 jobs) more than the IEA Reference scenario, and 37% (32,900) more than the Growth Without Constraints scenario.
- By 2030 energy sector jobs (including coal exports) in the [R]evolution scenario are estimated to be 149,000, 27% (31,900 jobs) more than the IEA Reference scenario, and 5% (6,700) more than the Growth Without Constraints scenario.
- In the [R]evolution scenario 72,400 new renewable energy jobs are created by 2030, compared to only 7,500 in the IEA reference scenario and only 2,000 in the Growth Without Constraints scenario. The Growth Without Constraints scenario, by comparison, creates 35,800 additional jobs in nuclear energy.
- An additional 33,700 jobs could be created by 2030 by pursuing policies to boost South African renewable manufacturing capability, taking the total new jobs in the [R]evolution scenario to 182,400, 56% more than in the IEA Reference scenario and 28% more than in the Growth Without Constraints scenario.

Figure 2 shows the number of jobs under the three scenarios by technology in 2010, 2020 and 2030, and Figure 3 shows jobs by type: CMI, O&M, fuel supply, and energy efficiency. Combined heat and power generation is included under the fuel type, for example gas or biomass.

In the [R]evolution scenario jobs increase from 71,000 in 2010 to 123,000 in 2020, and reach 149,000 in 2030, despite the reduction in jobs related to coal exports.

Figure 2 Energy sector jobs by technology in 2010, 2020 and 2030 (including coal exports)

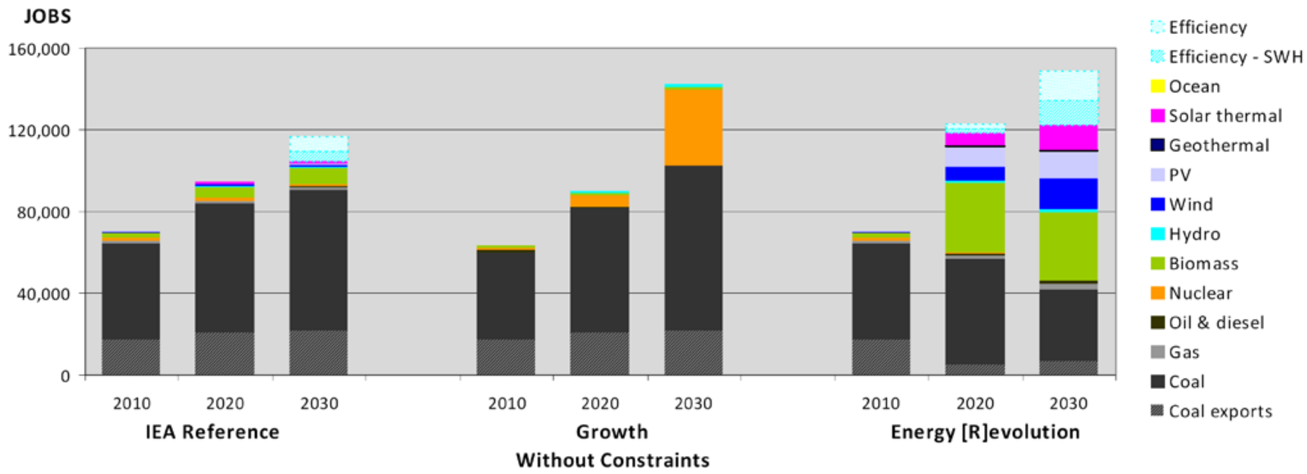
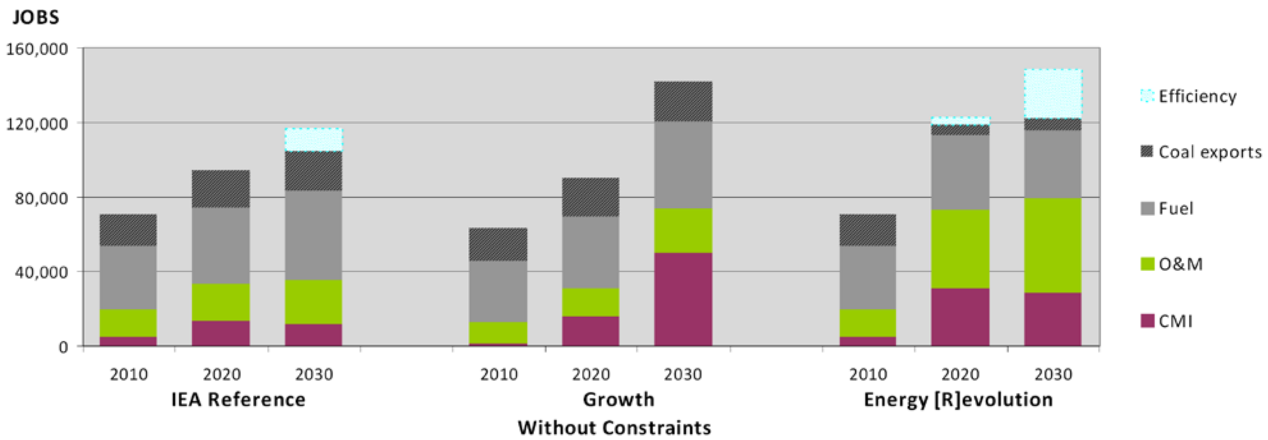


Figure 3 Energy sector jobs by type in 2010, 2020 and 2030 (including coal exports)



The employment advantage of the [R]evolution scenario is much greater if only electricity supply and efficiency jobs are considered. When coal exports are excluded, the Energy [R]evolution creates 46,900 (49%) more jobs than the IEA Reference case by 2030, and 21,700 (18%) more jobs than the Growth Without Constraints scenario. Figure 4 shows the employment by technology without coal export jobs, and the employment advantage of the Energy [R]evolution.

In the [R]evolution scenario growth in the renewable sector adds 72,400 jobs between 2010 and 2030, and the resultant jobs distribution is diverse compared to either of the two reference cases. The strongest growth is associated with biomass, but there is strong growth in wind, PV, solar thermal, and energy efficiency employment.

Figure 4 Electricity sector jobs at 2010, 2020 and 2030 (excluding coal export jobs)

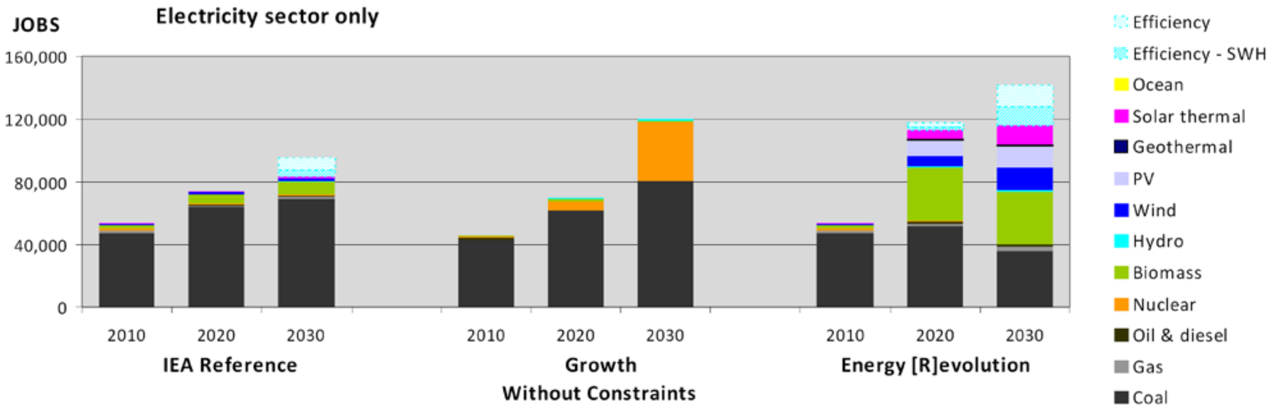


Figure 4 illustrates the change in job numbers in energy supply and efficiency under the three scenarios for each technology in 2010, 2020 and 2030. In the IEA Reference case there is marked increase in coal employment, by 20,000 in 2020 and by 24,000 in 2030. There is little increase in renewable employment over the period. In the Growth Without Constraints scenario, there is similar growth in employment numbers in 2020. By 2030, there are very significant increases in coal employment (38,000 jobs) and nuclear employment (36,000 jobs).

Employment numbers are indicative only, as a large number of assumptions are required to make calculations, particularly for energy efficiency. However, within the limits of data availability, the figures presented are indicative of employment levels under the three scenarios. See Section 5 for a discussion of the uncertainty involved.

Figure 5 Employment change in 2020 and 2030, compared to 2010

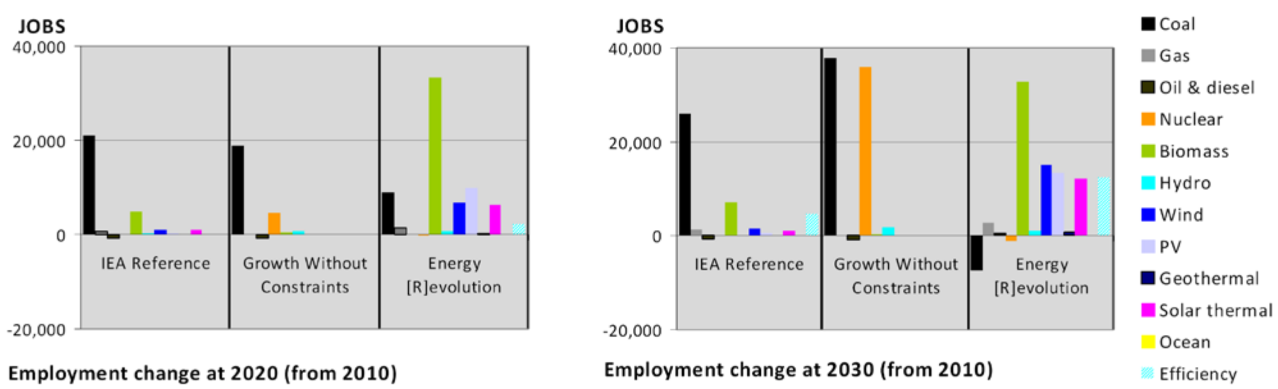


Table 12 presents South African electricity generation, jobs in energy supply by energy source and energy efficiency under the three scenarios from 2010 to 2030.

Table 12 Electricity sector employment and generation at 2010, 2020 and 2030

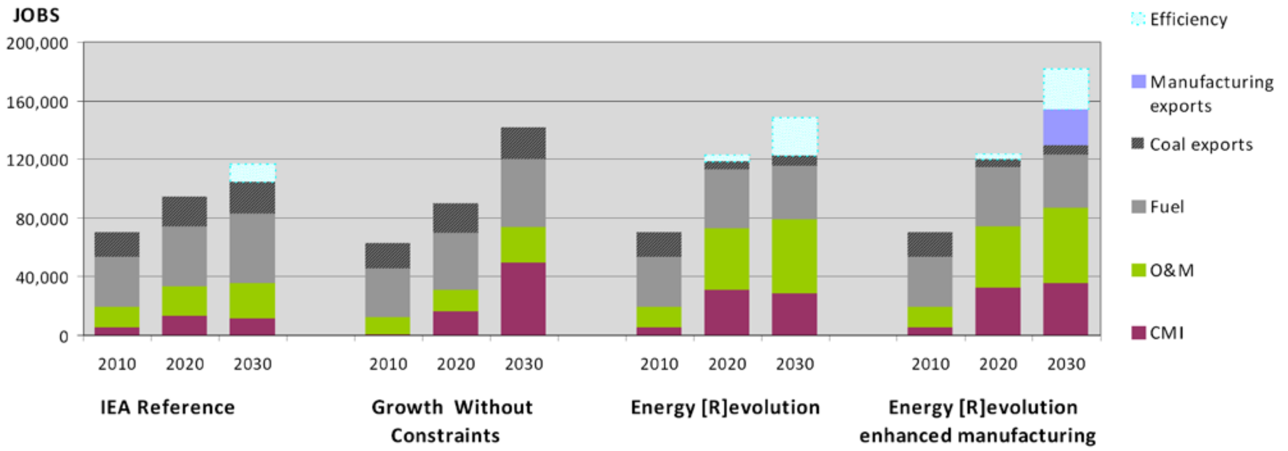
JOBS	IEA REFERENCE			GROWTH WITHOUT CONSTRAINTS			ENERGY [R]EVOLUTION		
	2010	2020	2030	2010	2020	2030	2010	2020	2030
Coal	47 000	64 000	69 000	43 000	61 000	81 000	47 000	52 000	35 000
Gas, oil, diesel	1 100	1 200	1 900	1 100	400	200	1 100	2 500	4 300
Nuclear	1 200	1 200	1 200	1 200	5 700	37 000	1 200	900	-
Renewable	3 600	8 000	11 000	800	2 100	2 800	3 600	58 000	76 000
Electricity supply	**53 000**	**74 000**	**83 000**	**46 000**	**70 000**	**121 000**	**53 000**	**113 000**	**116 000**
Energy efficiency	-	-	12 000	-	-	-	-	4 500	27 000
Coal exports	17 000	20 000	22 000	17 300	20 000	22 000	17 000	5 200	6 500
TOTAL JOBS	**71 000**	**94 000**	**117 000**	**63 000**	**90 000**	**142 000**	**71 000**	**123 000**	**149 000**
Electricity generation TWh									
Coal	263	343	410	261	337	437	263	271	225
Gas, oil, diesel	1.1	3	5	0.0	1	0	1.1	7	13
Nuclear	11	11	11	13	22	86	11	8	0
Renewable	3.2	9	18	2.5	2	3	3.2	51	135
Total generation	**279**	**366**	**443**	**276**	**362**	**527**	**279**	**337**	**372**

Note: Base case energy efficiency jobs are not calculated, so the energy efficiency jobs shown are only those additional to the Reference scenario.

4.1 Enhanced manufacturing

Job calculations are also carried out for an enhanced manufacturing scenario. In this scenario South Africa manufactures 50% of renewable technology equipment by 2030, compared to 20% in the standard assumptions, and services 30% of the growth in renewable electricity in the rest of Africa, compared to nil exports in the standard assumptions.[6]

Figure 6 Enhanced manufacturing - results by employment type



[6] This amounts to 15% of the manufacturing associated with renewable energy, as RSA manufactures the same proportion (50%) as for its domestic growth.

This has the potential to create an additional 33,700 jobs by 2030, including 25,000 associated with technology export. Figure 6 shows the job creation for the three scenarios. As can be seen, by 2030 there are more jobs associated with exporting renewable technologies than the jobs associated with coal exports in the IEA Reference scenario and the Growth Without Constraints scenario. This demonstrates the importance of South Africa introducing policies that support the growth of new industries in renewable technology manufacturing.

4.2 Employment in the electricity sector - technology results

Direct jobs by technology types are shown for the three scenarios in Figure 7 and Figure 8. By 2020, more than half of direct jobs in the [R]evolution scenario are in renewable energy, even though renewable energy accounts for only 15% of electricity generation. In the IEA Reference scenario, renewable energy accounts for 7% of energy sector jobs and only 2% of electricity generation. In the Growth Without Constraints scenario, renewable energy accounts for only 3% of energy jobs, and less than 1% of generation.

The higher percentage of employment relative to generation reflects the greater labour intensity in the renewable sector.

In 2010, coal accounts for more than 90% of energy employment in all three scenarios. This dominance remains in the Reference and Growth Without Constraints scenarios, with coal accounting for nearly 90% of employment in 2020. In the [R]evolution scenario, coal still accounts for 46% of energy employment at 2020, but jobs are much more diverse. Renewable energy accounts for 46% of energy jobs, with the largest share in biomass, followed by wind power, solar PV, and solar thermal technologies.

Figure 7 Jobs by technology in 2010, 2020 and 2030

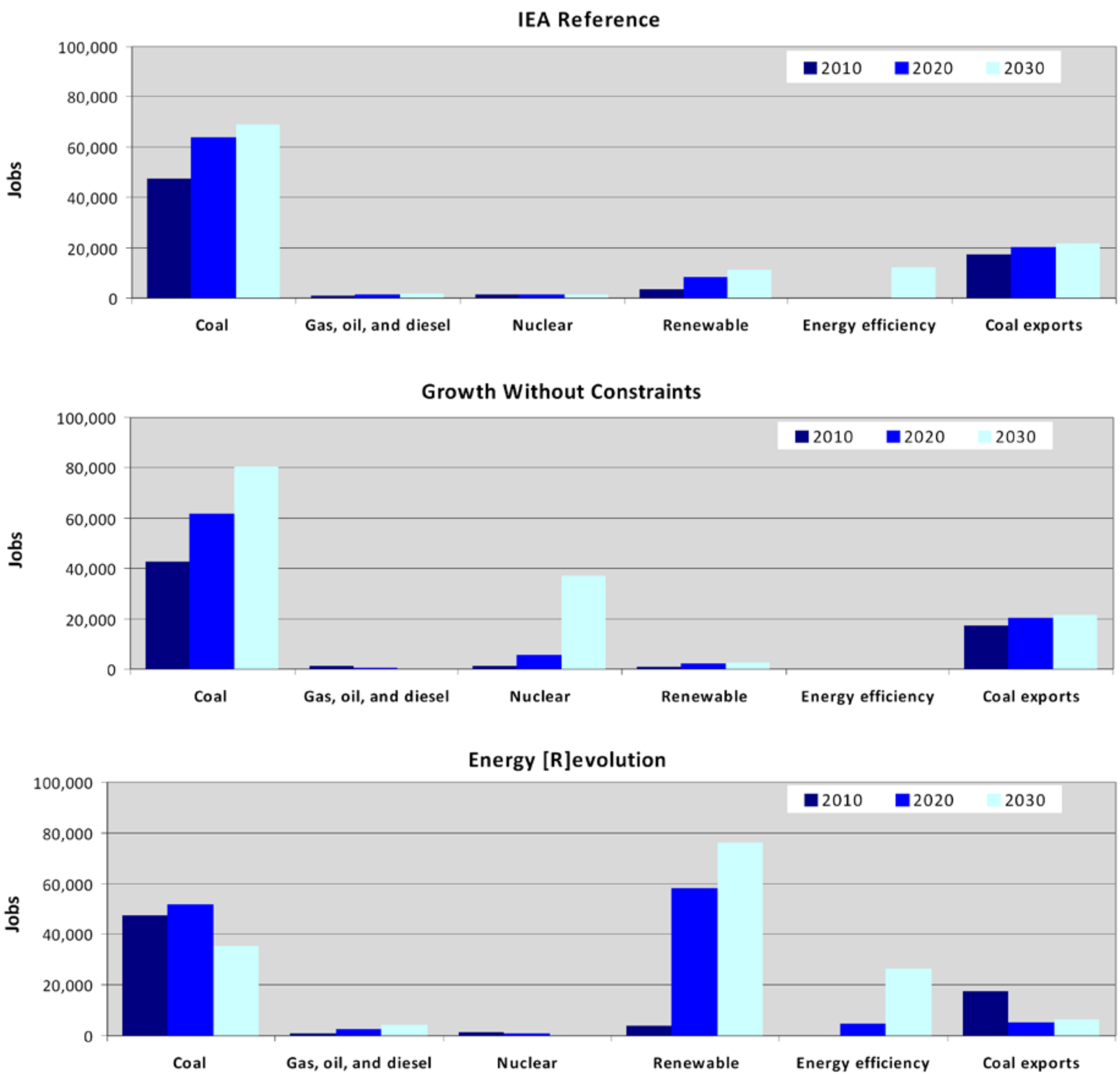
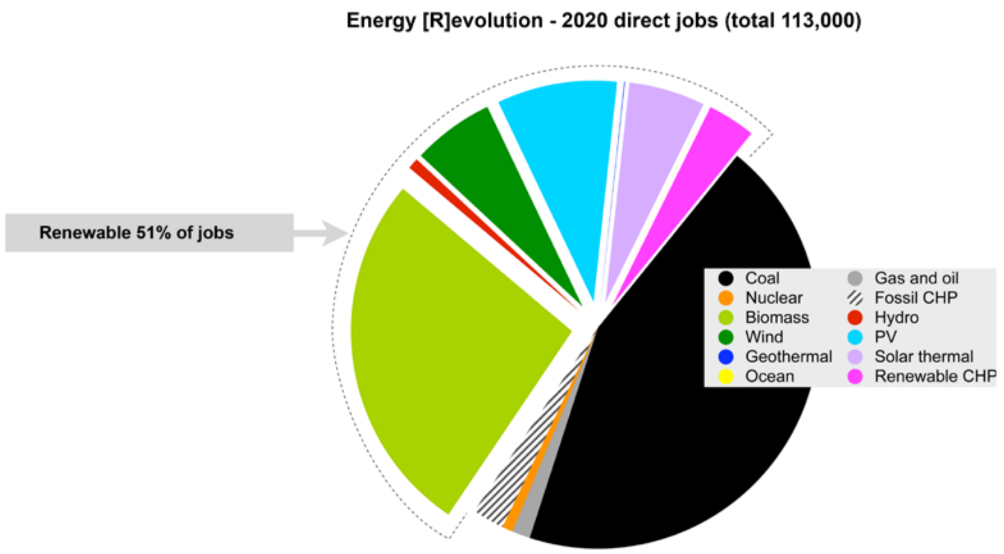
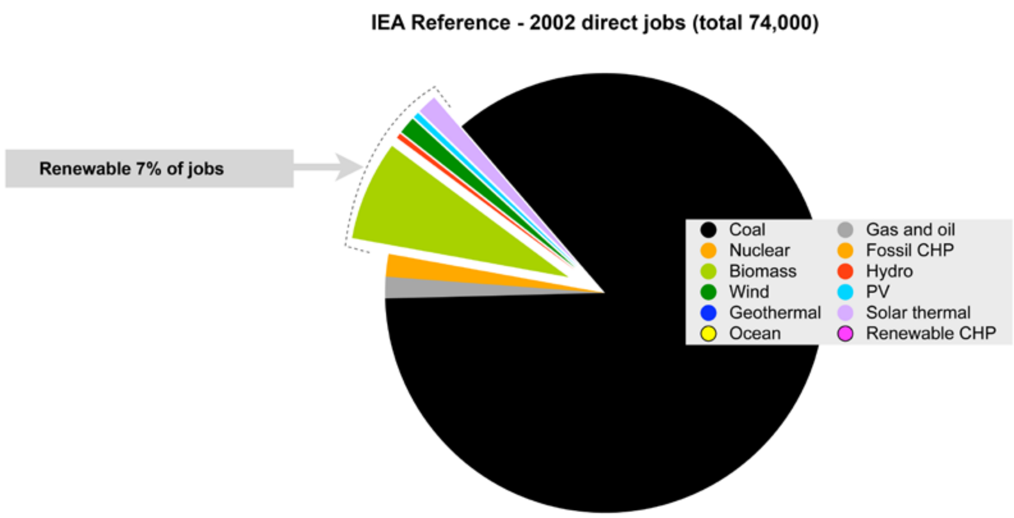
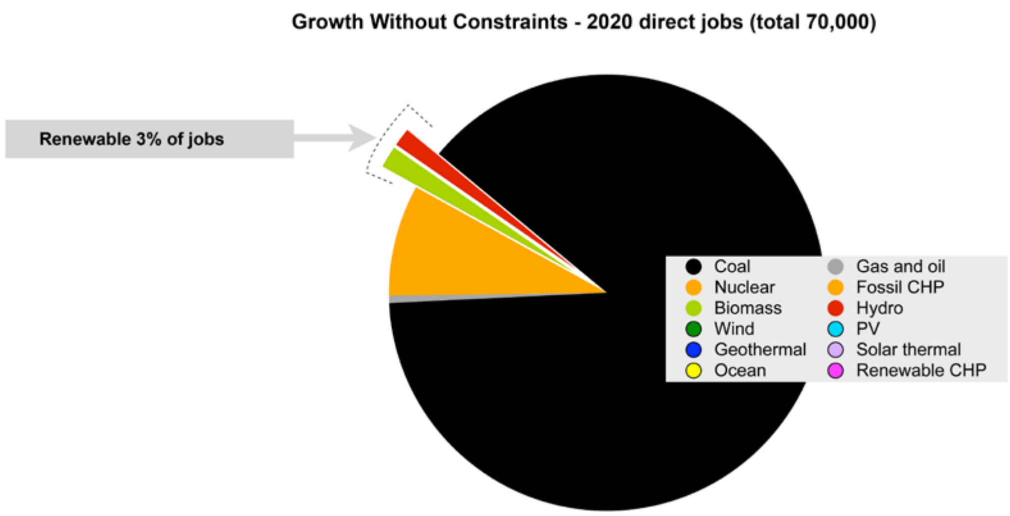


Figure 8 Employment by technology in 2020







5. Sensitivity analysis

A sensitivity analysis was conducted on a number of inputs to gain insight into the reliability of the results. The inputs chosen were:

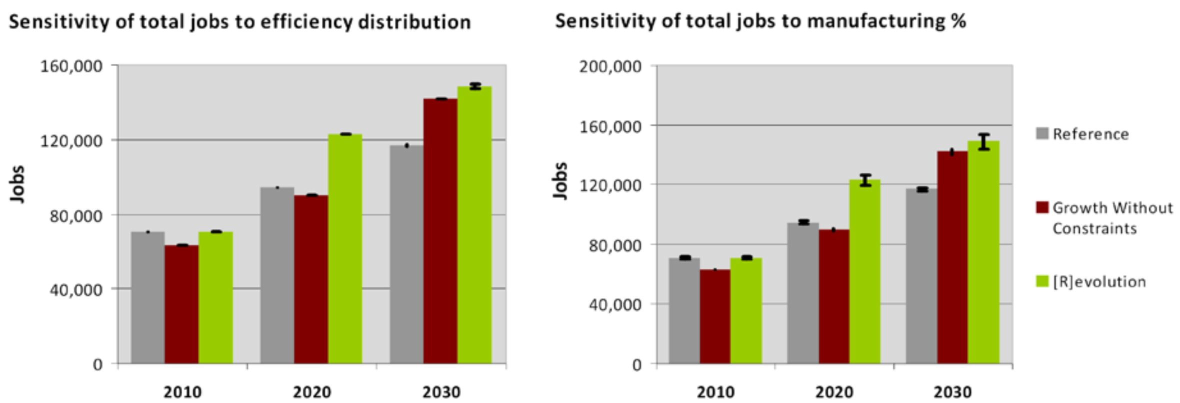
- The sectoral distribution of energy efficiency, which is used to calculate the energy efficiency multiplier from USA sectoral data.
- The percentage of manufacturing which is assumed to occur onshore in the standard assumptions scenario (note that no sensitivity analysis is carried out for the enhanced manufacturing scenario, because it is specifically examining the effects of increasing local manufacturing).
- The regional multiplier, which is applied to OECD factors where local employment factors are not available, to allow for the fact that labour intensity is higher where GDP per capita is lower.

Figure 9 shows the sensitivity of total jobs under each scenario to the sectoral distribution of energy efficiency, and to the proportion of manufacturing which occurs within the country.

The modelled energy efficiency assumes that 50% of electricity savings come from residential measures, with 25% from commercial, and 25% from industrial. This results in a factor of 0.47 jobs per GWh savings. The weighted factor was also calculated for a 50% commercial, 25% industrial, 25% residential, and for a 50% industrial, 25% residential, 25% commercial. The weighted factor was 0.5 in the 50% commercial case and 0.41 in the 50% industrial case.

The outcome of the sensitivity analysis is shown below in Figure 9, using energy efficiency employment factors of 0.5 and 0.41 jobs per GWh. As can be seen, the outcome is relatively unaffected. The greatest variation is in the 2030 [R]evolution case, and even that case shows only a variation of +0.7%, -1.1%.

Figure 9 Sensitivity of total jobs under each scenario to the sectoral distribution of energy efficiency, and to the percentage of manufacturing which occurs within South Africa



Modelling was carried out assuming that 20% of the manufacturing for all technologies (other than Solar Water Heating) occurs within the country; for Solar Water Heating the proportion is taken to be 50%. Sensitivity to the manufacturing percentage within the country was tested using values from 0% to 40%. Sensitivity is low, with the most significant case being the [R]evolution scenario at 2030. In this instance the variation is +/- 3.5%.

Sensitivity to the regional multiplier was tested by using the envelope values for the local employment factors, namely 2.99 and 1.6 (the weighted average of 2.15 is used in the modelling).

Sensitivity to the regional multiplier is high, as shown in Figure 10. Sensitivity to this input is high in all scenarios at 2030. There is variation of +16% to -22% in the [R]evolution scenario at 2030, +6% to -5% in the IEA Reference case, and -6% to +8% in the Growth Without Constraints case. Sensitivity is higher in the [R]evolution case because there is a very high penetration of renewable technologies, which generally (with the exception of Solar Water Heating and hydro) use OECD employment factors. Where local factors are available the regional multiplier is not used, so scenarios with high penetration of coal are much less sensitive to the regional multiplier.

Reducing the regional multiplier decreases jobs in all three scenarios, while increasing the multiplier boosts jobs in all of the scenarios. Thus, it is appropriate to compare the higher values between the scenarios, or the lower values between scenarios, rather than comparing an increased value in one scenario to a reduced value in another.

The difference between the [R]evolution scenario and the IEA Reference case is always significant, although it becomes less significant if the regional multiplier is reduced, and becomes greater if the regional multiplier is increased.

The difference between the [R]evolution scenario and the IEA Reference case is always significant at both 2020 and 2030. If the regional multiplier is too low (so that the relative increase in employment per MW compared to OECD data is higher than the multiplier of 2.15 which was used) the difference between the [R]evolution scenario and the IEA Reference case will be greater than suggested in this report. Alternatively, if the regional multiplier should have been set lower, the difference will be lower than suggested.

Similarly, if the regional multiplier is too low, then the difference between the [R]evolution scenario and the Growth Without Constraints scenario will be more significant that suggested in this report. However, if the regional multiplier was set lower, calculated employment in the Growth Without Constraints scenario would exceed the [R]evolution scenario employment at 2030, so the difference at 2030 is not significant.

At 2020 the difference is much greater, so despite the large error margin, the relative positions of employment within the scenarios would remain unchanged. If jobs associated with coal exports are not included, the relative employment benefit of the [R]evolution scenario is more robust, and the Energy [R]evolution always has a significant employment benefit.

Figure 10 Sensitivity of total jobs (including coal mining) to regional multiplier

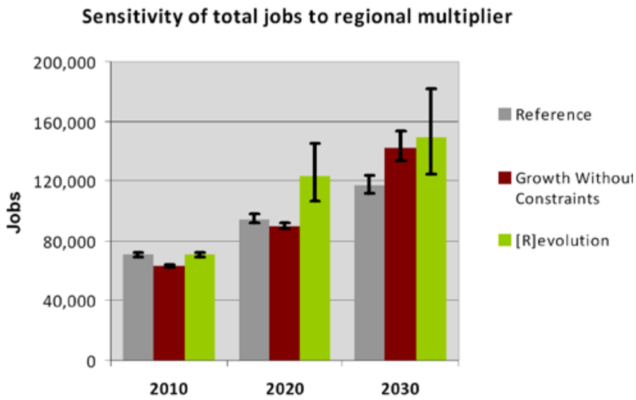
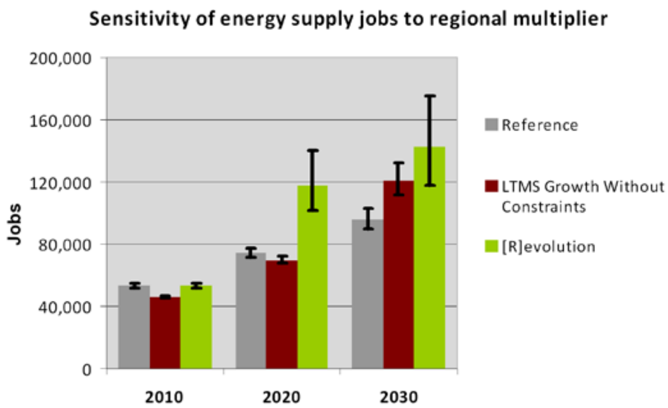


Figure 11 Sensitivity of total jobs (excluding coal mining) to regional multiplier



6. Conclusion

The Energy [R]evolution has the potential to create significantly more employment in the energy sector than continuing with Business As Usual. Energy sector jobs in the low carbon scenario grow by about 78,000 compared to 2010 energy sector employment. This compares to an increase of 46,000 in the IEA Reference case, and of 71,000 in the Growth Without Constraints case.

World demand for coal over the next decades will be determined by international agreements on climate change. If these result in action commensurate with that needed by science, world demand for coal can be expected to decline significantly by 2050. South Africa currently advocates such strong action, because the African continent is on the frontline, and is particularly vulnerable to the effects of climate change.

The employment analysis here shows that although South Africa will gain employment overall from a switch to a low carbon energy supply, it is likely to experience job losses in coal mining (with the associated loss of foreign exchange earnings) in a carbon constrained world. Despite the significant increase in employment overall in the [R]evolution scenario, coal mining jobs are reduced by about 11,000 compared to a 21,000 increase in the IEA Reference case and a 38,000 increase in the Growth Without Constraints scenario.

The enhanced manufacturing scenario demonstrates that employment in renewable technology manufacturing for export has the potential to exceed the jobs lost in coal exports. A determined low carbon scenario with rapid deployment of renewable echnologies creates the internal market to support local manufacturing. However, **active and progressive government policies will be required to support developing industries, and to train the local workforce both in installation and the technical skills required for manufacturing**.

Diversifying South Africa's energy supply by deploying renewable energy on a large scale, combined with industry support policies to encourage local manufacturing, has significant job creation potential. In the short term, this would occur alongside coal export jobs, as those are determined by the international market. In the event of strong international action on climate change, the country could be in a position to substitute renewable energy jobs for jobs lost in coal mining.

South Africa has to decide now whether to be a technology importer or an exporter in a carbon constrained world. Large scale development of renewable technologies combined with ambitious energy efficiency would reduce South African emissions, and make the South African economy more resilient in the face of declining demand for coal worldwide.

References

Abbreviation used	Reference
ACEEE 2008	Ehrhardt-Martinez, K. and Laitner, J.A.S. 2008. The Size of the U.S. Energy Efficiency Market: Generating a More Complete Picture. ACEEE May 2008 Report Number E083.
AGAMA 2008	AGAMA 2008 Employment Potential of Renewable Energy In South Africa. Prepared for The Sustainable Energy and Climate Change Partnership Johannesburg.
Bedzek 2007	Bezdek R. 2007. Renewable Energy and Energy Efficiency: Economic Drivers for the 21st Century (Boulder, CO: American Solar Energy Society, 2007).
BMU 2007	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). 2007. Innovation through research 2006 Annual Report on Research Funding in the Renewable Energies Sector.
BMU 2008a	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. 2008. Short- and Long-Term Impacts of the Expansion of Renewable Energy on the German Labour Market. Gross Employment 2007 - A first estimate - March 14, 2008.
CA-OE 2008	Co-ordination action on ocean energy (CA-OE). 2008, Work Session 5 Environmental, Economics, Development Policy and Promotion of Opportunities. Project co-funded by the European Commission within the Sixth Framework Programme (2002-2006). Project no. 502701.
Connell Wagner 2007	Connell Wagner 2007. NSW power generation and CO2 emissions reduction technology options. Report to the Owen inquiry into electricity supply in NSW.
DTI 2004	UK Department for Trade and Industry. 2004. Renewable Supply Chain Gap Analysis: Summary Report.
EPIA 2008a	European Photovoltaic Industry Association and Greenpeace. 2008. Solar Generation V – 2008.
EPIA 2008b	SolarGeneration V and PV Technology Platform 2008.
EPRI 2001	EPRI (Electric Power Research Institute). 2001. California Renewable Technology Market and Benefits Assessment. California Energy Commission, 2001.
EREC 2008	European Renewable Energy Council 2008 Renewable Energy Technology Roadmap 20% by 2020. Page 16.
ESKOM 2009a	ESKOM 2009 Annual Report.
ESKOM 2009b	ESKOM 2009 Annual Report Additional Information. Medupi power station facts.
ESKOM 2010a	ESKOM website, Koeburg nuclear power station, downloaded 5/1/2010. (1200 employees, capacity 1800 MW).
ESKOM 2010b	AGAMA Energy. 2003. ESKOM website, Gariep and Vanderkloof hydro-electric power stations, downloaded 5/1/2010.
EWEA 2009	European Wind Energy Association. 2009. Wind at work. Wind energy and job creation in the EU.
GEA 2005	Geothermal Energy Association. 2005. Geothermal industry employment: survey results and analysis. By Cédric Nathanaël Hance for the Department of Energy - Geothermal Program.

GPI/EREC 2008	Greenpeace International and the European Renewable Energy Council. 2008. Energy [R] evolution. A sustainable global energy outlook.
GPI & ESTELA 2009	Greenpeace International, SolarPACES, ESTELA. 2009. Concentrating solar power. Global outlook 2009.
GPI/EREC 2009	Greenpeace International and the European Renewable Energy Council. 2009. Energy [R] evolution. A sustainable South Africa energy outlook.
Hughes et al, 2007.	Hughes A, Haw M, Winkler H, Marquard A and Merven B, 2007 Energy Modeling: A modelling input into the Long Term Mitigation Scenarios process, LTMS Input Report 1, Energy Research Centre, Cape Town, October 2007.
IEA 2007	International Energy Agency 2007. World Energy Outlook 2007.
IEA 2008a	International Energy Agency 2008. Coal Information 2008.
IEA 2008b	International Energy Agency 2008. World Energy Outlook 2008.
ILO 2007	International Labour Organisation, 2007, Key Indicators of the Labour Market, Fifth Edition software.
JEDI model	NREL JEDI model, downloaded 30/4/09.
Kammen 2004	Kammen, D, Kapadia K, and Fripp, M. 2004. Putting Renewables to Work: How Many Jobs Can the Clean Energy Industry Generate? RAEL Report, University of California, Berkley.
NREL 2006	L. Stoddard, J. Abiecunas, and R. O'Connell, 2006, Economic, Energy, and Environmental Benefits of Concentrating Solar Power in California, National Renewable Energy Laboratory.
Pembina 2004	Pembina Institute. 2004. Canadian Renewable Electricity Development: Employment Impacts. Prepared for Clean Air Renewable Energy Coalition.
REN21 2008	REN21. 2008. Renewables 2007 Global Status Report (Paris: REN21 Secretariat and Washington, DC: Worldwatch Institute).
REN21 2009	REN21. 2009. Renewables Global Status Report: 2009 Update (Paris: REN21 Secretariat).
Rutovitz and Atherton 2009.	Rutovitz, J., Atherton, A. 2009, Energy sector jobs to 2030: a global analysis. Prepared for Greenpeace International by the Institute for Sustainable Futures, University of Technology, Sydney.
Scenario Building Team 2007	Scenario building Team 2007. Long Term Mitigation Scenarios: Scenario Document, Department of Environment Affairs and Tourism, Pretoria, October 2007.
SERG 2007	W.M.J. Batten and A.S. Bahaj. 2007. An assessment of growth scenarios and implications for ocean energy industries in Europe, Sustainable Energy Research Group, School of Civil Engineering and the Environment, University of Southampton.
Teske 2010.	Sven Teske, Energy [R]evolution Campaign Greenpeace International, January 8th 2010.
UNDP 2007	United Nations Development Programme. 2007. World population prospects: the 2006 revision, United Nations Population Division, Department of Economic and Social Affairs.
Winkler, 2007	Winkler, H (ed) 2007 Long Term Mitigation Scenarios: Technical Appendix, Prepared by the Energy Research Centre for Department of Environment Affairs and Tourism, Pretoria, October 2007.

Appendix 1 Employment factors used in global analysis

Table A 1 Employment factors used in global analysis

	CMI JOBS			O&M AND FUEL			MAIN REFERENCE
	Total CMI	Construction/ installation	Manufacturing	Total O&M and fuel	O&M	FUEL	
	person years/ MW			Jobs/MW		jobs/GWh	
Coal	**14.4**	14.4	0.003	**0.25-3.2**	0.10	Regional factors	JEDI model
Gas	**3.4**	3.4	0.001	**0.47**	0.05	0.12	JEDI model
Nuclear	**16**			**0.33**	0.32	0.0009	Derived from US and Au industry data
Biomass	**4.3**	3.9	0.4	**4.40**	3.1	0.22	EPRI 2001, DTI 2004
Hydro	**11.3**	10.8	0.5	**0.22**	0.22		Pembina 2004
Wind (onshore)	**15.4**	2.5	12.5	**0.40**	0.40		EWEA 2009
Wind (offshore)	**28.8**	4.8	24	**0.77**	0.77		EWEA 2009
PV	**38.4**	31.9	9.1	**0.40**	0.40		EPIA 2008A, BMU 2008a
Geothermal	**6.4**	3.1	3.3	**0.74**	0.74		GEA 2005
Solar thermal	**10.0**	6.0	4.0	**0.30**	0.3		EREC 2008
Ocean	**10**	9.0	1.0	**0.32**	0.32		SERG 2007/ CA-OE 2008

Note 1: Factors are all for OECD countries, and need to be adjusted for use in other regions. Regional factors are used for coal mining.

Note 2: Capacity factors from GPI/EREC 2008 are used to convert fuel factors to the totals given in the table for O&M and fuel.

Note 3: The CMI figures for gas and coal have been revised since publication of the global analysis, to 6.5 (construction) and 1.5 (manufacturing) for coal, and 1.4 (construction) and 0.7 (manufacturing) for gas. The factors shown here were calculated incorrectly from the JEDI model.

Appendix 2 World coal employment and production data

Table A 2 Regional data for coal production and employment in 2006

	Production	Domestic production	Coal for electricity	% of lignite in electricity production	Employment	Productivity	Employment factor (existing)	Employment factor (new)
	million tons	%	Tons/ GWh		'000s	Tons / person /year	Jobs per GWh	
World	6,669 m	99%	520	19%	n/a			
OECD North America	1,238 m	104%	403	9%	88	14,116	**0.03**	**0.02**
OECD Europe	550 m	84%	678	66%	298	1,843	**0.34**	**0.18**
OECD Pacific (data for Australia only)	371 m	257%	659	51%	27	13,800	**0.04**	**0.02**
India	466 m	92%	745	6%	464	1,004	**0.59**	**0.25**
China	2,525 m	97%	516	-	3,600	701	**0.55**	**0.02**
Africa (data for South Africa only)	247 m	138%	492	-	60	4,110	**0.11**	**0.08**
Transition economies (see Note 2)	347 m		772	56%	237		**0.43**	**0.20**
Developing Asia (data for Asia exc China)	801 m	108%	648	9%	n/a			
Latin America	90 m	198%	425	20%	n/a			
Middle east	3 m	20%	365	3%	n/a			

Reproduced from Rutovitz and Atherton, 2009.

Table A 3 Net Inter-regional hard coal trade, 2006 – 2030, IEA Reference scenario

		2006	2010	2015	2020	2030
OECD N America		15	38	67	75	90
OECD Europe		-202	-221	-245	-233	-209
OECD Pacific		-16	-2	16	44	101
	Asia	-232	-243	-256	-253	-246
	Oceania	216	240	271	296	347
E. Europe/Eurasia		52	68	88	91	96
	Russia	53	71	94	103	120
Asia		73	20	-47	-98	-199
	China	34	-10	-65	-73	-88
	India	-42	-67	-98	-139	-220
Middle East		-12	-15	-18	-23	-34
Africa		56	68	83	87	95
Latin America		42	48	56	57	60
World		613	698	804	862	979
European Union		-191	-208	-229	-216	-191

Negative values = imports, positive values = exports. Million tons of coal equivalent From IEA 2008b, Table 5.3, values for 2010 and 2020 calculated assuming linear change.

Appendix 3 Detailed results by technology

Table A 4 Capacity and direct jobs – COAL (thousands)

COAL		IEA Reference			Growth Without Constraints			Energy [R]evolution		
Electricity	**Unit**	**2010**	**2020**	**2030**	**2010**	**2020**	**2030**	**2010**	**2020**	**2030**
Installed capacity	GW	37	49	59	33	44	56	37	38	36
Generated electricity	TWh	263	343	410	261	337	437	263	267	216
Share of total supply	%	94%	94%	92%	94%	89%	61%	94%	79%	58%
Direct jobs										
CMI	1000 jobs	3.3	11.4	9.0	0.0	11.4	19.5	3.3	9.6	0.0
O&M and fuel	1000 jobs	44.1	52.4	59.8	42.7	50.1	61.0	44.1	40.3	32.6
Total jobs	**1000's**	**47.4**	**63.7**	**68.8**	**42.7**	**61.5**	**80.5**	**47.4**	**50.0**	**32.6**

Table A 5 Capacity and direct jobs – GAS OIL AND DIESEL (thousands)

GAS OIL AND DIESEL		IEA Reference			Growth Without Constraints			Energy [R]evolution		
Electricity	**Unit**	**2010**	**2020**	**2030**	**2010**	**2020**	**2030**	**2010**	**2020**	**2030**
Installed capacity	GW	1.4	2.1	3.5	1.7	1.7	1.7	1.4	1.9	2.4
Generated electricity	TWh	1.1	3.0	5.0	0.0	0.8	0.0	1.1	4.3	6.5
Share of total supply	%	0%	1%	1%	0%	4%	37%	0%	1%	2%
Direct jobs										
CMI	1000 jobs	0.6	0.2	0.4	0.9	0.0	0.0	0.6	0.2	0.2
O&M and fuel	1000 jobs	0.4	1.0	1.5	0.2	0.4	0.2	0.4	1.3	1.8
Total jobs	**1000's**	**1.1**	**1.2**	**1.9**	**1.1**	**0.4**	**0.2**	**1.1**	**1.5**	**2.0**

Table A 6 Capacity and direct jobs – NUCLEAR (thousands)

NUCLEAR		IEA Reference			Growth Without Constraints			Energy [R]evolution		
Electricity	**Unit**	**2010**	**2020**	**2030**	**2010**	**2020**	**2030**	**2010**	**2020**	**2030**
Installed capacity	GW	1.8	1.8	1.8	2	3	12	1.8	1.3	0.0
Generated electricity	TWh	11.3	11.3	11.3	13	22	86	11.3	8.0	0.0
Share of total supply	%	4%	3%	3%	5%	6%	19%	4%	2%	0%
Direct jobs										
CMI	1000 jobs	0.0	0.0	0.0	0.0	3.7	28.9	0.0	0.0	0.0
O&M and fuel	1000 jobs	1.2	1.2	1.2	1.2	2.0	8.2	1.2	0.9	0.0
Total jobs	**1000's**	**1.2**	**1.2**	**1.2**	**1.2**	**5.7**	**37.1**	**1.2**	**0.9**	**0.0**

Table A 7 Capacity and direct jobs – BIOMASS (including CHP) (thousands)

BIOMASS		IEA Reference			Growth Without Constraints			Energy [R]evolution		
Electricity	**Unit**	**2010**	**2020**	**2030**	**2010**	**2020**	**2030**	**2010**	**2020**	**2030**
Installed capacity	GW	0.2	0.6	1.0	0	0	0	0.2	3.5	3.1
Generated electricity	TWh	1.0	3.0	5.0	0	0	0	1.0	16.2	16.1
Share of total supply	%	0.4%	1%	1%	0%	0%	0%	0.4%	5%	4%
Direct jobs										
CMI	1000 jobs	0.3	0.3	0.2	0.0	0.1	0.0	0.3	2.5	0.0
O&M and fuel	1000 jobs	2.0	5.1	7.6	0.7	1.1	1.0	2.0	27.7	24.4
Total jobs	**1000's**	**2.3**	**5.4**	**7.8**	**0.7**	**1.1**	**1.0**	**2.3**	**30.2**	**24.4**

Table A 8 Capacity and direct jobs – HYDRO (thousands)

HYDRO		IEA Reference			Growth Without Constraints			Energy [R]evolution		
Electricity	**Unit**	**2010**	**2020**	**2030**	**2010**	**2020**	**2030**	**2010**	**2020**	**2030**
Installed capacity	GW	0.7	0.8	0.9	2	3	3	0.7	1.1	1.5
Generated electricity	TWh	1.3	1.8	2.1	2	2	2	1.3	2.6	4.1
Share of total supply	%	0%	0%	0%	1%	1%	0%	0%	1%	1%
Direct jobs										
CMI	1000 jobs	0.2	0.2	0.3	0.0	0.8	1.6	0.2	0.9	1.2
O&M and fuel	1000 jobs	0.0	0.0	0.0	0.1	0.1	0.2	0.0	0.0	0.1
Total jobs	**1000's**	**0.3**	**0.3**	**0.3**	**0.1**	**0.9**	**1.8**	**0.3**	**0.9**	**1.3**

Table A 9 Capacity and direct jobs – WIND (thousands)

WIND		IEA Reference			Growth Without Constraints			Energy [R]evolution		
Electricity	**Unit**	**2010**	**2020**	**2030**	**2010**	**2020**	**2030**	**2010**	**2020**	**2030**
Installed capacity	GW	0.1	0.6	1.0	-	-	-	0.1	4.1	12.2
Generated electricity	TWh	0.3	1.5	2.5	-	0.6	0.6	0.3	10.0	30.0
Share of total supply	%	0%	0%	1%	0%	0%	0%	0%	3%	8%
Direct jobs										
CMI	1000 jobs	0.2	0.5	0.8	-	-	-	0.2	3.7	7.0
O&M and fuel	1000 jobs	0.1	0.5	0.7	-	-	-	0.1	3.0	7.9
Total jobs	**1000's**							**0.3**	**6.8**	**15.0**

Table A 10 Capacity and direct jobs – SOLAR PV (thousands)

SOLAR PV		IEA Reference			Growth Without Constraints			Energy [R]evolution		
Electricity	**Unit**	**2010**	**2020**	**2030**	**2010**	**2020**	**2030**	**2010**	**2020**	**2030**
Installed capacity	GW	0.1	0.1	0.3	-	-	-	0.1	3.0	7.5
Generated electricity	TWh	0.1	0.3	0.5	-	-	-	0.1	6.0	15.0
Share of total supply	%	0%	0%	0%	0%	0%	0%	0%	2%	4%
Direct jobs										
CMI	1000 jobs	0.5	0.3	0.4	-	-	-	0.5	8.8	11.1
O&M and fuel	1000 jobs	0.0	0.1	0.1	-	-	-	0.04	1.2	2.3
Total jobs	**1000's**	**0.6**	**0.3**	**0.5**	**-**	**-**	**-**	**0.6**	**9.9**	**13.3**

Table A 11 Capacity and direct jobs – SOLAR THERMAL (thousands)

SOLAR THERMAL		IEA Reference			Growth Without Constraints			Energy [R]evolution		
Electricity	**Unit**	**2010**	**2020**	**2030**	**2010**	**2020**	**2030**	**2010**	**2020**	**2030**
Installed capacity	GW	0.3	0.7	1.2	0	0	0	0.3	3.7	9.7
Generated electricity	TWh	0.5	2.5	7.5	0	0	0	0.5	13.0	61.0
Share of total supply	%	0%	1%	2%	0%	0%	0%	0%	4%	16%
Direct jobs										
CMI	1000 jobs	0.0	0.6	0.6	0.0	0.0	0.0	0.0	4.3	7.1
O&M and fuel	1000 jobs	0.2	0.5	0.6	0.0	0.0	0.0	0.2	2.0	5.1
Total jobs	**1000's**	**0.2**	**1.1**	**1.2**	**0.0**	**0.0**	**0.0**	**0.2**	**6.3**	**12.1**

Table A 12 Capacity and direct jobs – GEOTHERMAL (thousands)

GEOTHERMAL		IEA Reference			Growth Without Constraints			Energy [R]evolution		
Electricity	**Unit**	**2010**	**2020**	**2030**	**2010**	**2020**	**2030**	**2010**	**2020**	**2030**
Installed capacity	GW	-	-	-	-	-	-	-	0.03	0.04
Generated electricity	TWh	-	-	-	-	-	-	-	0.20	0.30
Share of total supply	%	-	-	-	-	-	-	-	0.001	0.001
Direct jobs										
CMI	1000 jobs	-	-	-	-	-	-	-	0.02	0.01
O&M and fuel	1000 jobs	-	-	-	-	-	-	-	0.03	0.04
Total jobs	**1000's**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**0.05**	**0.05**

“…Our commitment to tackle climate change does not rest only on the achievement and implementation of international agreements. Our commitment must be borne out by what we do here at home. We have the means indeed, the responsibility to ensure that our policies, programmes and activities contribute to emission reduction and respond to the impact of climate change on our country and region…[and] we undertake to pursue and further explore the concept of ‘green jobs’…We have no choice but to develop a green economy…”

President Jacob Zuma*

*Keynote address, Green Economy Summit, 18 May 2010

GREENPEACE

RSA Office:
10A and 10B Clamart House,
Clamart Road, Richmond,
Johannesburg, South Africa

DRC Office:
Greenpeace Environnemental
Organisation 8, avenue lodja, Q.
“Socimat” Commune de la Gombe,
Kinshasa,
Democratic Republique du Congo

Postal address:
Greenpeace Africa
PostNet Suite 125
Private Bag X09, Melville
Johannesburg, 2109
South Africa

Tel: +27 (0)11 482 4696
Fax: +27 (0)11 482 8157
iafrica@greenpeace.org

Website:
www.greenpeaceafrica.org

Greenpeace exists because this fragile Earth deserves a voice. It needs solutions. It needs change. It needs action!

Greenpeace is an independent global campaigning organization that acts to change attitudes and behavior, to protect and conserve the environment and to promote peace. It comprises of 28 independent national/regional offices in over 40 countries across Europe, the Americas, Asia, the Pacific and Africa as well as a co-coordinating body, Greenpeace International.

Greenpeace has been working in Africa to end environmental destruction and fighting for the right of Africans to a healthy environment since the early 1990s. Our campaigns focus on climate change, halting the destruction of tropical forests and preventing the degradation of marine ecosystems.

Printed on 100% recycled post-consumer paper with vegetable based inks.