4 NEED AND DESIRABILITY FOR THE PROJECT

4.1 Introduction

In many countries, including South Africa, economic growth and social needs are resulting in substantially greater energy demands, in spite of continued and accelerated energy efficiency advancements. As a result, electricity demand is growing faster than the overall growth in energy supply.

Besides the return to service of Camden, Grootvlei and Komati power stations, South Africa has not increased its capacity to supply base load[1] capacity since the Majuba coal-fired power station was brought into operation in the late 1990s. However, the ***production of energy, including electricity*** has, on average, been increasing over the past four decades (***Figure 4-1***) ***in line with the increased demand. Several different projections for the future increase in electricity demand have been produced, based on different scenarios for the development of South Africa's economy. The most pessimistic[2] of these projections (Figure 4.1) indicates a growth in demand from the current approximately 250 TWh to about 400 TWh by 2034, whilst the most optimistic projection indicates an increase to almost 500 TWh by 2034.***

Despite the drop in electricity consumption in 2008/2009 (brought about primarily by steel and ferrochrome producers switching off their furnaces due to poor demand), South Africa is still experiencing an electricity baseload-capacity deficit. Eskom needs to increase its generation capacity to improve the reserve margin (the difference between the peak demand and the generating capacity) back to within acceptable limits. The reserve margin was 14 % in January 2009, which is still below the international norm of 15 % (Eskom 2009). Open Cycle Gas Turbines (OCGTs), which have been installed in the Western Cape, can only be used to a limited extent to make up for the shortfall, due to the high cost of fuel.

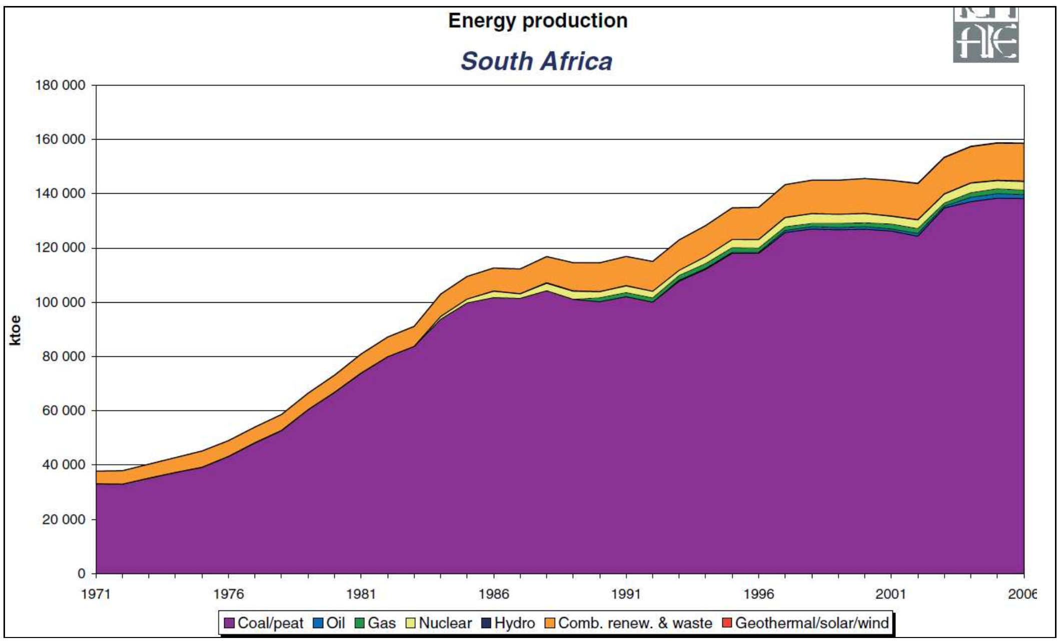

Figure 4-1: Total energy production in South Africa, categorised by fuel, since 1971 (http://www.iea.org/statist/index.htm accessed on 8 October 2009)

[1] **See "base load" definition in Chapter 1**

[2] ***Based on the lowest projection of annual GDP increase***

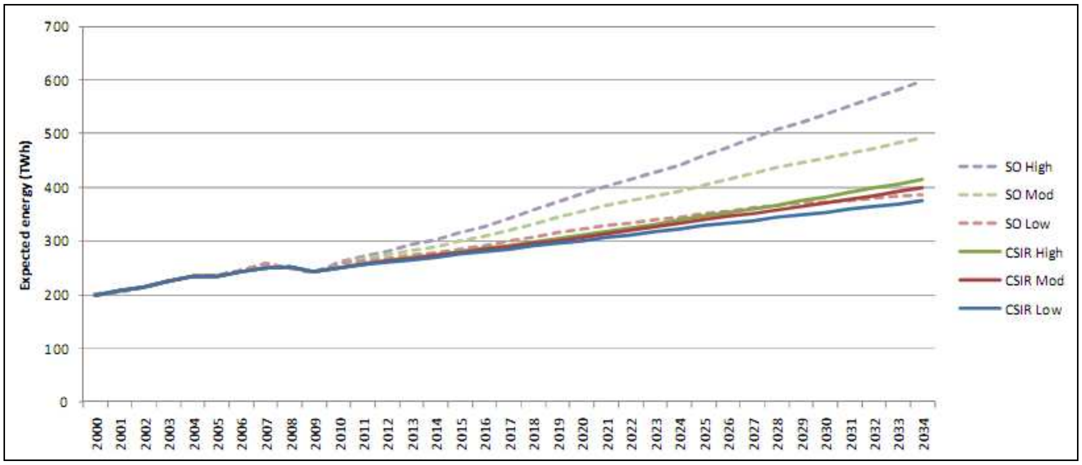

Figure 4-2: ***Projected electricity requirements for South Africa to 2034 based on different scenarios (Department of Energy 2010a)***

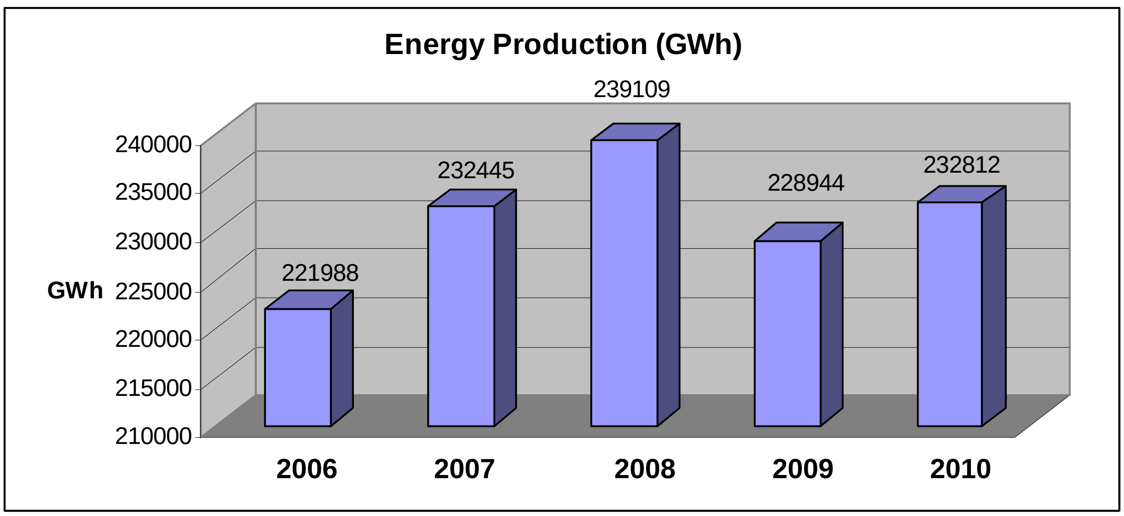

Figure 4-3: ***Energy supply in South Africa from 2006 to 2010 (Eskom 2010)***

The growth in the demand for electricity is expected to continue into the future, despite Government and Eskom having initiated energy-efficiency ***(Demand Side Management or DSM)*** and electricity conservation programmes. ***Although savings through DSM must form an essential part of the strategy to meet South Africa's energy demand, the IRP 2010 has predicted that DSM would be able to provide savings of 3 422 MW by 2020 (Department of Energy 2010b).***

As indicated in **Chapter 1**, in terms of the Accelerated and Shared Growth Initiative for South Africa (AsgiSA), the South African government sought a 4.5 % or higher between 2005 and 2009 and is seeking a growth rate of 6 % between 2010 and 2014 (www.info.gov.za/asgisa/asgisa.htm - accessed on 15 September 2009). Thus the growth rate of electricity demand can be expected to continue increasing and it will remain necessary to build new electricity generating capacity in South Africa. It is estimated that South Africa needs 40 000 MW of new generation capacity by 2025 (Eskom 2009). Of this, 12 476 MW is already under construction, including the Medupi and Kusile coal-fired power stations, the return to service of coal fired power stations and Ingula pumped storage scheme.

The additional generating capacity could potentially be obtained from a variety of energy sources, for example clean coal, liquid fuels, gas, uranium (nuclear), water, wind and solar energy. The challenge is to correctly match the supply and demand, to facilitate sustainable economic growth and development and environmental sustainability. There are a number of factors that must be considered whilst evaluating options for electricity generation, including costs, lead time for construction, environmental impacts and operating characteristics relative to base and peaking load[3] power generation. This section discusses the electricity supply and demand forecasts and the need for the proposed nuclear power station.

4.2 Balancing Electricity Supply and Demand

4.2.1 Energy demand

The urgent need for additional electricity generation capacity in South Africa was probably first realised by all South Africans in 2007 and early 2008, when country-wide load-shedding was introduced. Electricity demand in the country had exceeded Eskom's supply capacity and to ensure that the network remained stable, load-shedding was implemented. Load shedding was necessary to ensure that the generation and transmission systems did not collapse, by rotating the load in a planned and controlled manner[4].

Figure 4-4 outlines the projected growth in electricity demand up to 2025 ***as predicted by Eskom***. The pink line represents the electricity capacity requirements based on a moderate 2.3 % growth rate in electricity capacity (equating to approximately 4 % economic growth rate) while the blue line represents the requirements based on a 4 % growth rate in electricity capacity (equating to the AsgiSA economic growth rate target of 6 %). It is clear from this figure that at a 6 % economic growth rate, South Africa will have to make accommodation for approximately 80 000 MW by the year 2025.

In terms of the Energy Policy of 1998, while it was recognised that new electricity generating capacity would be required in the latter part of the 2000 - 2010 decade, it was Government's intention to encourage more players (i.e. Independent Power Producers - IPPs) to enter the generation industry in order to develop a competitive electricity supply market. However, in October 2004, the South African Cabinet decided that Eskom must supply 70 % of the new power generating capacity, while Independent Power Producers must supply the remaining 30 %[5].

[3] "*Peaking load power stations*" are typically usually smaller power plants that generate electricity when there are peaks or spikes in customer power demand. Examples in South Africa are hydro-electric power stations and lately gas-turbine power stations. These power stations generally generate electricity during periods of high demand for electricity, normally on weekdays from 07:00 to 09:00 and 18:00 to 20:00.

[4] What is load-shedding? (http://loadshedding.eskom.co.za/whatis.htm)

[5] Statement on Cabinet Meeting of 20 October 2004 www.info.gov.za/speeches/2004/04102109151001.htm

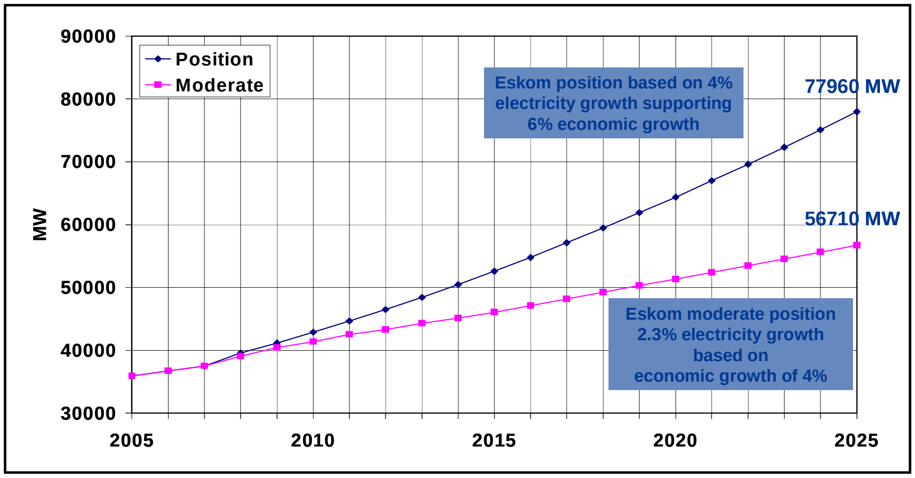

Figure 4-4: Projected electricity requirements for South Africa to 2025 (Eskom 2008)

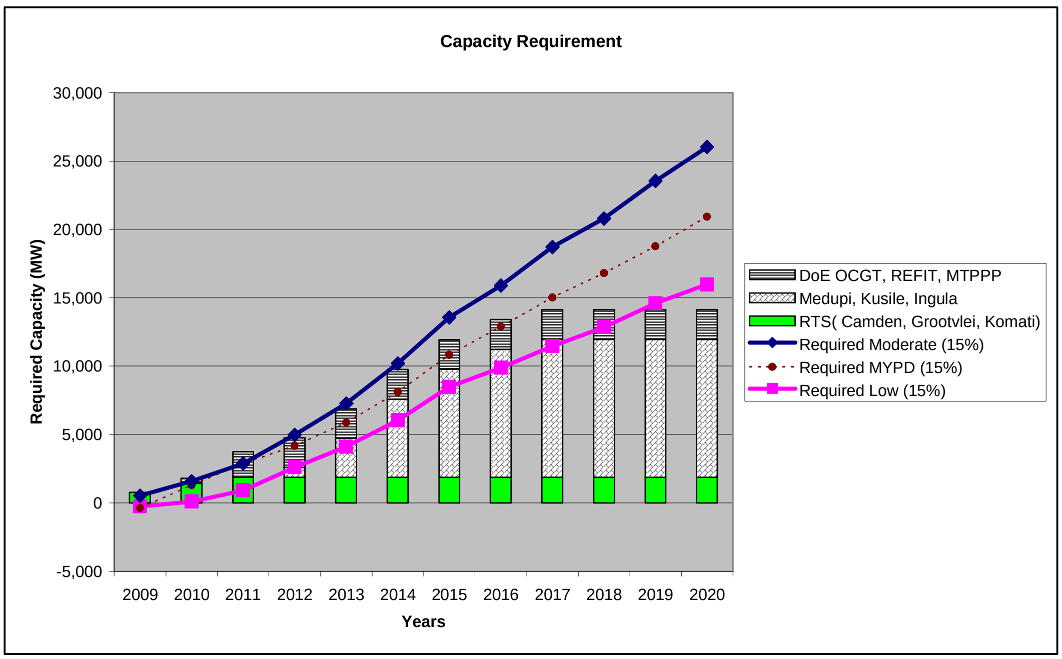

Figure 4-5: Capacity requirement 2009 – 2020 (Eskom 2009)

Figure 4-5 provides a view of the capacity required in each year from 2009 to 2020 to meet three different forecasts: the moderate forecast (and an assumed 15 % reserve margin) as the top end of the cone; the MYPD forecast (with an assumed 15 % reserve margin requirement); and the low forecast (also with an assumed 15 % reserve margin requirement) as the bottom end of the cone. This requirement (in each case) is the demand required (with reserve margin) less the existing South African generation capacity (43 385 MW). The projects currently under developed are indicated. These include the return to service (RTS); the base-load capacity under construction at Medupi and Kusile as well as the peaking capacity under construction at Ingula; and the IPP programmes represented by the DoE OCGT, the REFIT and the MTPPP programmes. These programmes (in various stages of commitment) fill the gap to some extent, but the graph highlights the shortfall throughout for meeting a 15% reserve margin on the moderate, or after 2017 to meet the reserve margin-adjusted MYPD forecast. This view excludes the energy constraints applicable to generators such as OCGT, pumped storage and hydro plants. The energy requirement would accelerate the need for additional capacity to a point before that reflected in this graph

Shortages in electricity in 2008 resulting in load shedding were brought about by a drop in the reserve margin to levels that were too low to cater for unexpected shutdowns of operating power stations. **Figure 4-6** shows the decreasing trend in the reserve margin in recent years.

It is essential to build new electricity generating capacity in South Africa, in conjunction with implementing energy efficiency and conservation programmes, in order to achieve and maintain a reserve margin at the international norm of above 15 %. It is also important to sustain the reserve margin above 15 % whilst the demand for electricity continues to grow.

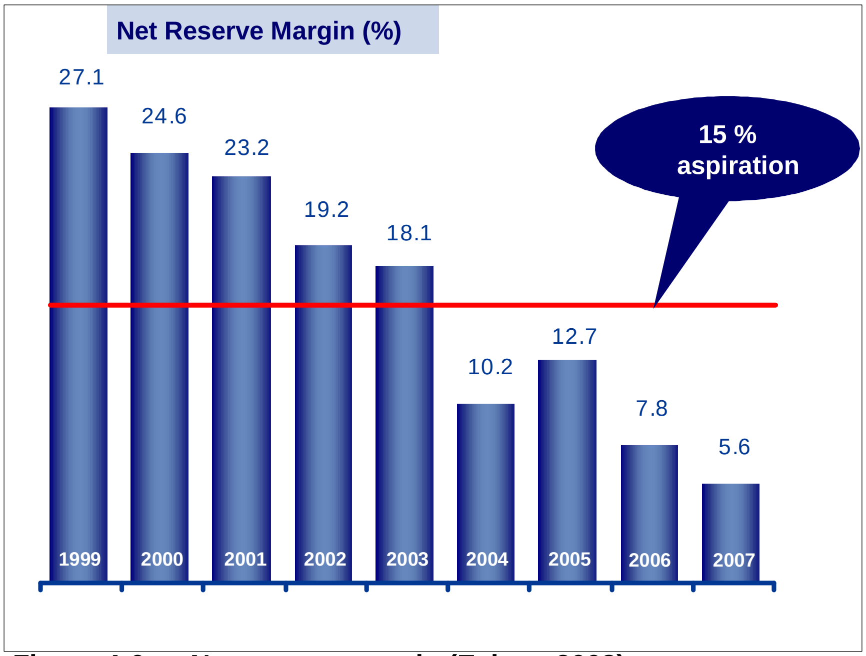

Figure 4-6: Net reserve margin (Eskom 2008)

4.2.2 Energy supply

The choice of electricity generation technology by Eskom is conducted within the context of the South African energy policy framework, the legal and regulatory framework, resource requirements and taking into account the required mix of generating technologies to optimally meet the daily, weekly and seasonal variations in demand for electricity and meet the sustainability aspirations of the country. In South Africa, Eskom currently uses a number of different technologies to convert primary energy sources into electrical energy (electricity), including both renewable technologies and non-renewable technologies.

An additional complexity is that demand for electricity in South Africa varies spatially (geographic) and temporally (with time). Spatially, South Africa's land surface area of 1,1 million km^2 consists of a mix of urban and rural areas, each with different requirements with respect to electricity. Areas of high electricity demand are not correlated with power generation centres. Coal resources, which accounted for 95 % of the electricity generated in South Africa in 2007 (International Energy Agency 2009), are primarily located in the north-east of the country. However, the demand for electricity prevails throughout the country, with the mining and industrial sectors accounting for approximately 40 % of the electricity demand[6].

[6] White Paper on Energy (1998)

The total demand for electricity in South Africa varies on a 24-hour basis, with peak demand in the early morning and in the late afternoon / early evening. Similarly, electricity requirements vary on a weekly basis, with the demand during the working week exceeding that over weekends. In most areas, the demand in winter exceeds that of summer periods. To optimally meet the total demand, it is therefore necessary to have both base-load electricity generating power stations, as well as peak-load power stations. This can be achieved by applying a variety of appropriate technologies and energy sources.

Figure 4-7 shows a typical demand profile for the hours of the day during winter and summer of 2008. The figure clearly shows the peak in the electricity demand each day in the morning and late afternoon periods. The peak demand exceeded 36 000 MW in the late afternoon / early evening. The figure also clearly shows that in 2007 the minimum base load demand for electricity in the early hours of the morning was approximately 24 000 MW.

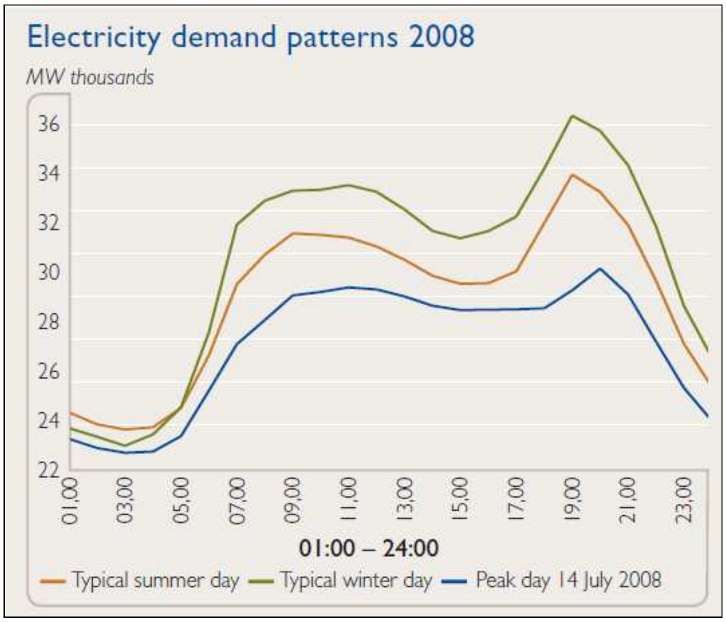

Figure 4-7: Daily electricity demand patterns (Eskom 2009)

The increasing demand for electricity impacts both the base-load demand as well as the peak-load demand. It is thus essential for Eskom to construct new base-load and peak-load power stations. The Nuclear-1 project is aimed at increasing the base-load supply capacity. Other projects are aimed at increasing the peak supply capacity.

Only a few energy sources capable of providing a sustained power supply are available in sufficient quantities suitable for base-load power stations. In South Africa, coal and nuclear power are used for base load electricity generation, while the OCGTs (using liquid fuel, such as diesel), two hydroelectric power stations on the Orange River, and pumped storage schemes are used for peaking and emergency electricity generation. At present, identified renewable forms of energy, for example wind and solar, are, due to intermittent supply and lower load factors are unable to equal viable large scale power generation facilities capable of supplying a reliable base load and being easily integrated into the existing power network in South Africa.

Internationally, natural gas and hydro power are also used for base-load electricity supply. However, South Africa does not have sufficient quantities of indigenous natural gas and does not have the large rivers required for base load hydro-electric power stations. Eskom imports hydro-electric power from Southern African countries, mainly from Cahora Bassa in northern Mozambique. Opportunities for importing hydro power from Southern African countries in the future are being investigated. This option will require the construction of new dams in the other country(s) and transmission lines between those countries and South Africa. These projects are thus longer-term projects and they require careful environmental consideration. However, to ensure security of supply, such imports would need to be limited to the equivalent of the prevailing reserve margin for South Africa.

In light of the above, coal-fired and nuclear power stations are currently the only feasible options in South Africa for base load electricity generation.

Currently more than 85 % of the generating capacity in South Africa comes from coal-fired power stations. While it will be necessary to continue to use coal-fired power stations into the future, security of supply considerations and the global requirement for low carbon growth to prevent climate change requires that the reliance on one primary energy source (i.e. coal) should be reduced to. Eskom is therefore aiming to reduce the contribution of coal-fired electricity to approximately 70 % of the total capacity by 2025 (Eskom 2009).

In addition to the above, climate change considerations require that South Africa reduces its dependence on coal as a source of fuel for power generation. At the international climate change negotiations held in Copenhagen in December 2009, emerging developing countries (including South Africa) were asked to submit their emission reduction plans to the international community to show that while will relying on coal for a period, our intention is to reduce this reliance and reduce our absolute emissions. South Africa is currently a significant emitter of carbon dioxide. In global terms, South Africa ranks fourteenth in the world for cumulative CO_2 emissions due to its reliance on coal for electricity production. However, measured by the quantity of electricity produced from fossil fuels, South Africa ranks sixth in the world (**Table 4-1)**.

Table 4-1: Electricity production from fossil fuels (top 10 countries) (Based on International Energy Agency 2007a)

Country	Annual production (Terawatt hours)
United States of America	2 154
People's Republic of China	1 972
India	480
Japan	309
Germany	305
South Africa	229
Australia	201
Russia	166
Korea	149
Poland	145

Eskom is committed to assess options to retard the rate of increase in CO_2 emissions and ultimately begin to decrease it. Its stated intention is to reduce its relative CO_2 (Mt CO_2/MWh) footprint until 2025, and thereafter to continually reduce absolute emissions in support of national and global targets (Eskom 2009).

Nuclear power provides Eskom and South Africa with a mitigation strategy for greenhouse gas reductions, since nuclear power generation produces significantly less carbon dioxide emissions than conventional fossil fuel technologies. When replacing coal-fired power, a 1 GW nuclear power plant can avoid emission of some 6-7 million tonnes of CO_2 per year (International Energy Agency 2007b). Over the full life cycle of nuclear power, from mining of the uranium, iron ore and other minerals, manufacture of the components and construction of the power station, operation and maintenance of the power station through to decommissioning and the management and disposal of waste, nuclear power emits less than 11 grams of carbon equivalent per kilowatt-hour (gC_{eq}/kWh) (Dones *et al.* 2003). This is the same order of magnitude as wind and solar power. This is also two orders of magnitude below (i.e. one hundredth of) the average for coal, oil, and natural gas (**Figure 4-8**). Apart from these benefits, nuclear power generation does not emit sulfur dioxides (SOx), nitrous oxides (NOx) and requires much less water than coal-fired power stations.

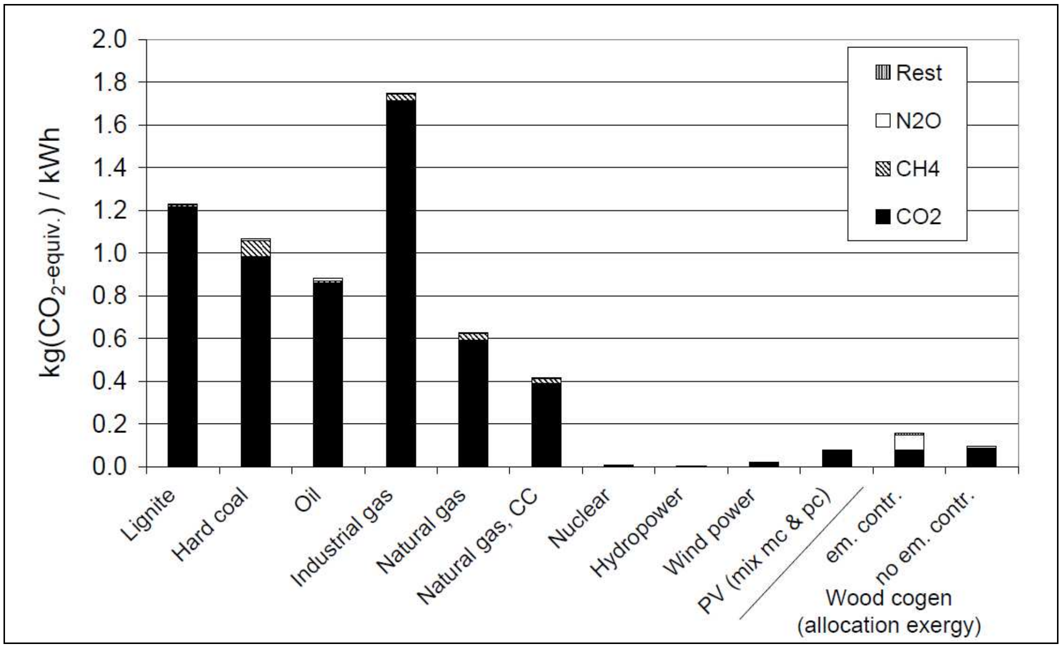

Figure 4-8: Comparison of life-cycle greenhouse gas emissions of different electricity generation systems (Dones *et al.* 2003)

Examples of the reduction in fossil fuel emissions can be found in France and Germany. France's carbon dioxide emissions from electricity generation fell by 80 % between 1980 and 1987 as its nuclear generation capacity increased. Germany's nuclear power programme has prevented the emission of over two billion tons of carbon dioxide from fossil fuels since it began in 1961.

At the December 2009 Copenhagen climate change negotiations, South Africa announced that it would undertake a range of voluntary nationally appropriate mitigation actions (NAMAs) to reduce its emissions. This undertaking will enable the country's emissions to deviate by 34 % and 42 % below the projected business as usual emissions by 2020 and 2025 respectively. This level of effort would enable emissions to peak between 2020 and 2025, plateau for approximately a decade and decline in absolute terms thereafter. The achievement of this aspiration is dependent on the use of non-fossil fuel electricity production such as nuclear and renewable sources, especially given that electricity generation currently contributes 45 – 50 % of South Africa's greenhouse gas emissions.

4.3 The proposed PWR Nuclear Power Station

Notwithstanding the need for additional electricity generation capacity in the short-term, Eskom's DSM Strategy is seeking to promote more efficient long-term use of energy in order to reduce the overall demand on the system (Eskom 2009). As part of Eskom's climate change initiatives as well as ensuring the security of electricity supply, the Eskom Board has approved the investigation of up to 20 000 MW of nuclear capacity over the next 20 years (Eskom 2009). The initial phase of this investigation concentrates on one nuclear power station of up to 4 000 MW, with the provision for future expansion, if the preferred site can accommodate such expansions.

South Africa possesses a wealth of natural resources including uranium, which is the fuel used for the generation of nuclear power. The use of nuclear power broadens the natural resource base available for energy, and particularly electricity production, and increases human and man-made capital. When safely managed, nuclear power can have a low impact on ecosystems. Nuclear power produces virtually no sulphur dioxide, particulates, nitrogen oxides, volatile organic compounds (VOCs) or greenhouse gases (GHG) during power generation. Nuclear power thus has the potential to make a substantial contribution to reducing South Africa's greenhouse gas emissions, over time, in association with a number of other alternatives, including demand-side management and renewable technologies.

4.3.1 Pressurised Water Reactor (PWR) Technology

Nuclear power plant alternatives belonging to the Pressurised Water Reactor (PWR) technology family are under consideration by Eskom for the proposed nuclear power station. PWRs are the most commonly used nuclear reactors both locally and globally. Eskom is familiar with the family of technology from health and safety and operational perspectives based on its experience with the existing Koeberg Nuclear Power Station.

Eskom's preference for a PWR is thus based on the following principles:

- Eskom has experience with the family of PWR technology;
- It is advantageous to have two similar nuclear power types in South Africa as the PWR has already been used successfully and the skills and experience required to use the technology are therefore readily available; and
- Standardisation in terms of world trends in technology is preferred (70 % of the thirty nuclear units currently under construction worldwide are of the PWR technology and utilities in China, Finland, France and United States of America have either signed memoranda of understanding or placed orders for PWRs).