ENERGY SECURITY IN A RESOURCE CONSTRAINED WORLD

Author and Presenter: E Johnson – Chief Officer, Networks and Customer Services, Eskom
Co-authors: K Bowen, S Prins

1. Introduction

While demand for energy is growing with the economic development of industrialising nations, the availability of resources to sustain this development is limited. The global market for fossil fuels has been impacted by this interaction between supply and demand with consequences for South Africa. Currently the ability to ensure a secure electricity supply has been impacted by high domestic electricity demand growth which coincides with substantial growth in demand for energy (and electricity) in the rest of the world, resulting in higher fuel costs as well as dramatically increased cost of construction and capital equipment. Eskom also has to compete for limited production capacity for key equipment, further constraining time lines and costs of new build. This paper discusses some of the issues regarding the global developments around energy, and then focuses on how these global trends are impacting on security of supply in electricity in South Africa. Of particular importance is the distinction between the adequacy of long term capacity to meet growing demand and the short term reliability of supply.

2. Resource Constraints

a. Supply limits

The bulk of energy sources internationally are strictly finite in that there is no feasible capability to replenish depleted resources. Even if additional resources were to be discovered and exploited (for coal, oil and natural gas for example) this does not alter the long term supply concern: that the total stock of the resource (including untapped resources) is falling as it is consumed.

This non-renewable aspect suggests that there will be some point where the resource will be exhausted globally, analogous to the steady and imminent depletion of the North Sea gas fields or the near exhaustion of British coal. However until recently the potential exhaustion of the resource stock had seemed remote, but with increasing demand being placed on these resources the possibility is that the exhaustion point may be approaching faster than expected.

South Africa has coal resources that will last for at least the next hundred years at current consumption. However as local consumption and exports grow the point of exhaustion will get closer. Even before that point it is likely that the costs of extraction will increase as cheaper resources are depleted.

b. Demand issues

A significant portion of the concerns for energy security is the growing demand for energy globally. This growing demand increases the competition for existing resources with resulting increase in prices in a market environment.

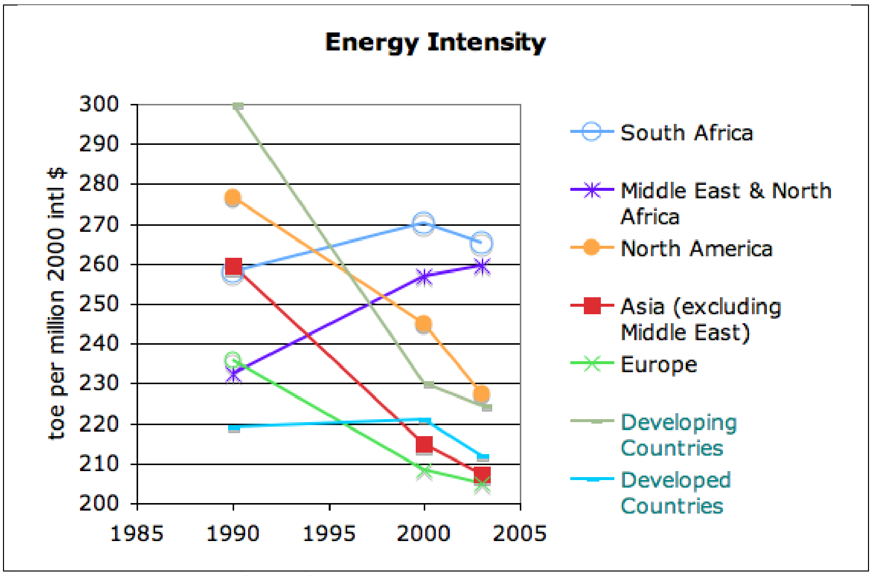
The industrialised world uses the majority of the available global energy. The United States uses about 21.8% of the world's energy resources, while having a share of about 4.6% of the global population. China consumes roughly 14.5% of the total energy produced globally (2005 figures). However growth in demand from industrialised nations is tapering off, to be overtaken by industrialising countries.

The increased demand for energy stems from the dramatic increases in wealth in certain developing countries. This is particularly evident in India and China which have large populations, thus compounding the rise in energy demand. As the human population develops, and countries become more affluent, a relationship between energy consumption per capita and GDP per capita can be expected, since higher incomes mean more appliances and cars, larger houses and other energy intensive activities. This relationship is not linear and depends on factors including but not limited to the non-commercial use of energy as well as energy intensity and the efficiency with which the energy is produced.

The relationship between economic growth and energy demand varies from region to region, as the different factors influencing economic growth and energy demand (e.g. energy efficiency) come to the fore. However the link between energy demand and economic growth is relatively weak in industrialised nations. The opposite is true for developing nations, where demand growth tracks economic expansion closely (Doman, 2004).

Energy intensity (the ratio of energy demand to GDP) is dependent on a country's stage of development. Developed countries which experience significant de-industrialisation (for example, the United Kingdom and USA) generally move toward less energy intensive sectors (financial services, information technology, etc.), while developing nations initially intensify their energy use (with the development of mining and energy-intensive industry such as, mineral beneficiation, etc.) until the economy shifts towards services and other less intensive sectors. Figure 1 below indicates how South Africa's energy intensity (measured as the tonnes of oil equivalent divided by GDP measured in 2000 'international' dollars) grew from 1990 to 2000 before dipping by 2004. This latter drop can be explained by the growth in tertiary sectors (such as wholesale and retail trade and financial services) relative to manufacturing and mining (which are more energy intensive).

Figure 1. Changes in energy intensity



Source: EPRI, WRI (2005), Earthtrends data web site

From an electricity-intensity perspective the relationship between economic growth and electricity consumption has changed over the past decade. Until 1998 the intensity grew along with the energy intensive users adding to demand. Since then economic growth has centred on less electricity intensive sectors of the economy reducing the intensity. Recently the electricity demand has been trending toward a level 2% below economic growth. The expectation is that this trend will continue. As government has stipulated in its ASGISA programme the target economic growth is 6%p.a. for future years. Eskom has adopted a position that 4%p.a. electricity demand growth will be supportive of the ASGISA target.

3. Energy security

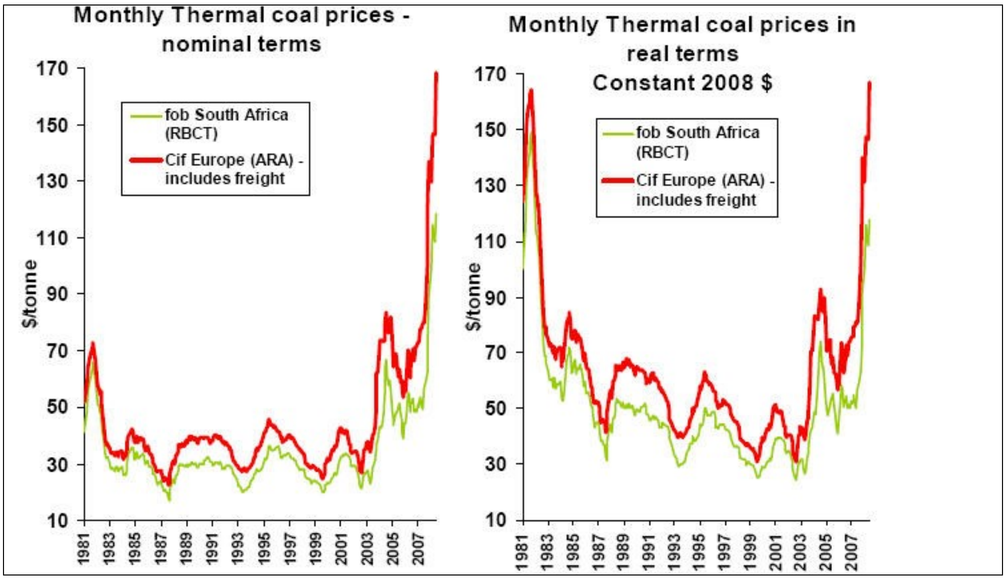
The global energy market is dominated by oil as the primary source of energy for many activities, in particular transport. Thus supply and demand for oil sets the global energy agenda with spin-offs for alternate resources such as coal or gas.

The Hubbert peak theory suggests that at some point production of fossil fuels in a region (or globally) would peak before going into steady decline. The theory has held true in a number of regions, especially US oil production which peaked in 1971 before gradually declining thereafter. Similarly a number of oil producing areas have passed their peak. The question remains whether the global peak has been reached or threatening to occur anytime soon. The price escalation in the past few months owes much to the spectre of reaching or passing the global oil peak. If the Hubbert peak theory holds true and the peak is about to be reached the reliance of the world's transport system on one dominant fuel source would have dire consequences for global trade and travel.

However, technology advances has assisted in identifying proven oil reserves over the past few decades. It has also assisted in the production of oil from previously unreachable locations. These developments have persuaded analysts to be more measured in their views regarding the future of oil reserves. It is now estimated that the peak production level of recoverable oil (i.e. oil that can be recovered at today's prices and technology) should occur around 2020 (Doman, 2004). Thereafter, it is estimated that the levels of oil will go into a decline, with resulting shortages and price increases.

A significant dependence on a particular resource increases the fallout from an event or constraint that occurs in that resource, even if the resource is renewable. For example, the prolonged drought in Brazil in the early 2000's which impacted on generation capability from hydro power stations, the main source of electricity generation (83% in 2004), highlighted the vulnerability to a single mode event. Similarly in South Africa the heavy dependence on coal has – at least on the margin – left Eskom exposed to rising international coal prices, as highlighted in Figure 2.

Figure 2. Thermal coal prices 1981-2008



Source: EPRI, Macquarie Research, June 2008 – Jim Lennon, "Overview of Bulk Commodity Outlook – Mainly About China" Baltic Exchange and FFA Broker's Forum, 8th Annual Dry Derivatives Forum, Hamburg 18-19 June 2008

The distribution of energy resources is not uniform and there is a great reliance on a few regions (even countries) for the supply of essential commodities. Not only is there a market power issue with these countries and their ability to influence pricing of the resource, but all too often these regions are inherently unstable. For example, the oil consuming countries have a great reliance on oil from Middle East countries where clashing interests (between East and West, and between governing elites and disenfranchised poor) regularly spill over into price instability in oil. As a consequence of the unequal distribution of resources there is also benefit to cartelisation. This is particular true of oil where the Organisation of Petroleum Exporting Countries (OPEC) has dominated oil production and pricing since the 1960's. Even though it has had less than 50% of world oil production, most of the excess capacity and reserves fall under OPEC's control. Similarly Russia, being the dominant supplier of natural gas to Europe, has significant pricing power over natural gas in the region.

Liberalising energy markets, especially in the presence of cartels and nationalised energy champions, would provide the correct incentives for investment in extraction and processing capabilities.

A significant concern in the current capacity outlook is that investment in capacity in energy production – be it extraction of oil, natural gas or coal; oil refining or electricity generation – is lagging behind demand growth. In some instances the incentives for additional capacity are distorted (as in Russia and OPEC nations) or instabilities hamper investment.

Investment in coal mining in South Africa has not kept pace with the growing local and international demand for steam coal, due mainly to uncertainties regarding mining rights. This has left a gap in coal supplies to existing and new power stations.

4. Climate change

The use of energy, its extraction and processing always involve environmental disruption, in the form of geological and ecological disruption, as well as pollution. Other impacts of energy use include noise from transport as well as land-use impacts such as the construction of roads and power lines (Stern, 2004).

Coal is the predominant source for electricity generation in many countries. Its widespread availability makes coal attractive for energy use, despite its higher carbon emission rate, when compared with other resources such as natural gas and nuclear. At current production levels, the known global coal reserves are expected to last another 200 years (Doman, 2004). Coal plays a major role in two of the world's fastest growing economies, namely China and India. Besides being used for electricity generation in China, coal is also an important resource for industrial uses. Linking the reliance of China and other countries on coal and their economic growth projections, suggests that coal will be a major source of energy for the foreseeable future.

The Intergovernmental Panel on Climate Change (IPCC) has clearly indicated that it is the burning of fossil fuels that is responsible for increased risk of climate change. Thus the focus for sustainability should be on shifting primary energy sources away from fossil fuels. This will impact on investment decisions regarding new build, toward new technologies that reduce carbon emissions at coal-fired stations (or increase sequestration thereof) and renewable options. In the ISEP-11 plan Eskom has targeted 1620 MW of new renewable capacity (specifically wind and solar options), including the building of a new wind farm of 100MW by 2010.

5. Technological change to reduce dependencies and combat climate change

The limitations imposed by existing technology, both in terms of extracting and processing capacity and the usage of energy, will have to be raised. Shifting out the production frontier for energy sources will increase the supply of product to consumers, while dramatic improvements in efficiency can assist in allowing existing volumes to stretch further.

a. Energy conservation and efficiency

An important mechanism to enhance energy security is to review the way in which energy is utilised. A fair amount of energy is lost to wasteful abuse of the resource. Pricing would take care of a large portion of such wastage by increasing the opportunity cost, but otherwise more stringent energy conservation mechanism are required (through state intervention) to ensure that domestic, commercial and industrial users take precautions against waste, and that producers of machinery and appliances are obliged to improve energy efficiency in the products they sell.

It is also possible that by shifting to higher quality energy fuels (with higher calorific values) reduces the total energy required to produce a unit of GDP. It also reduces the environmental impact of the remaining energy use. The use of natural gas instead of coal to generate electrical energy is an example, whereby natural gas is cleaner burning than coal, and produces less carbon dioxide per unit of energy (Stern, 2004). In areas where the infrastructure is available, natural gas has gained significant market share of the electricity sector. This is particularly relevant in Russia and the EU, where Russia holds 31% of the world's total natural gas reserves, and exports part of this to the rest of Europe (Doman, 2004). The shift in public sentiment and use of natural resources from coal to "cleaner" technologies has allowed countries like Russia to strengthen their international position by using the dependence of other countries on their resource as leverage.

b. Diversification of resources

The Energy White Paper of 1998 highlighted the need to enhance security of supply through diversifying generation fuels. The reliance on coal leaves South Africa vulnerable to shifts in international coal prices (as has been experienced of late) as well as the negative impacts with regard to climate change.Thus the push to diversifying into alternative fuel sources such as nuclear power and renewable resources.

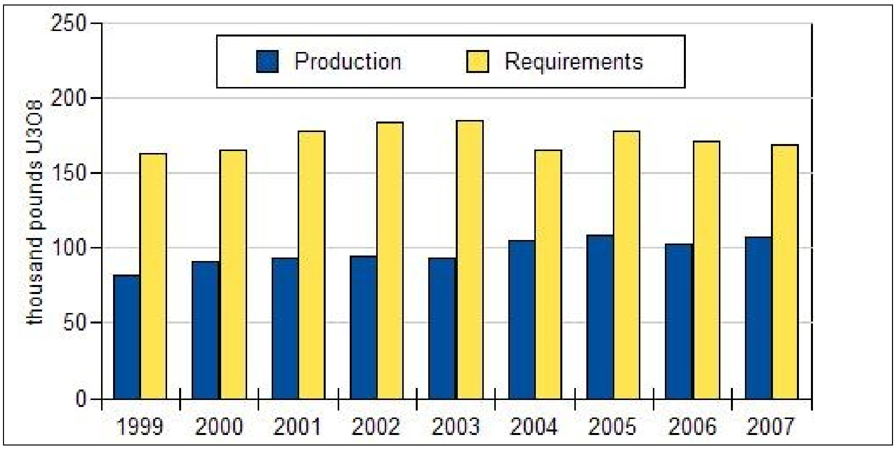
Nuclear power (along with renewable energy sources) has historically found it difficult to compete with fossil fuel in the race to meet growing global energy demand. The cost of nuclear energy relative to coal, especially in a country with cheap coal supplies like South Africa, has reduced the attractiveness of nuclear power. In addition the nuclear industry has encountered political and social opposition following the incidents at Three Mile Island and Chernobyl. Public sentiment against nuclear energy has generally relegated it to the back-burner, and in some countries (for example Sweden and Germany) there has been an active policy of phasing out existing nuclear power stations. However with the growing focus on climate change and the potential for emission caps or taxes on coal usage, there is renewed interest in nuclear as an alternative for base-load electricity.

The concern for nuclear power is the supply of uranium. From 1985 the production of uranium has been significantly lower than the requirements (as shown in Figure 3), mainly due to the release of supply from existing military stockpiles (in the West and in the East), which at 97% U-235 can be diluted to provide substantial amounts of reactor fuel (at only 4% U-235). This under-investment in uranium production could be problematic in the future should the stockpiles become depleted. Figure 4 shows how until 1985 uranium production far exceeded the reactor demand, the bulk of that production going into the military stockpiles.

It is interesting to note that since 1999 South Africa's production of uranium has almost halved (from 2,5 million pounds of U_3O_8 in 1999 to 1,4 million pounds in

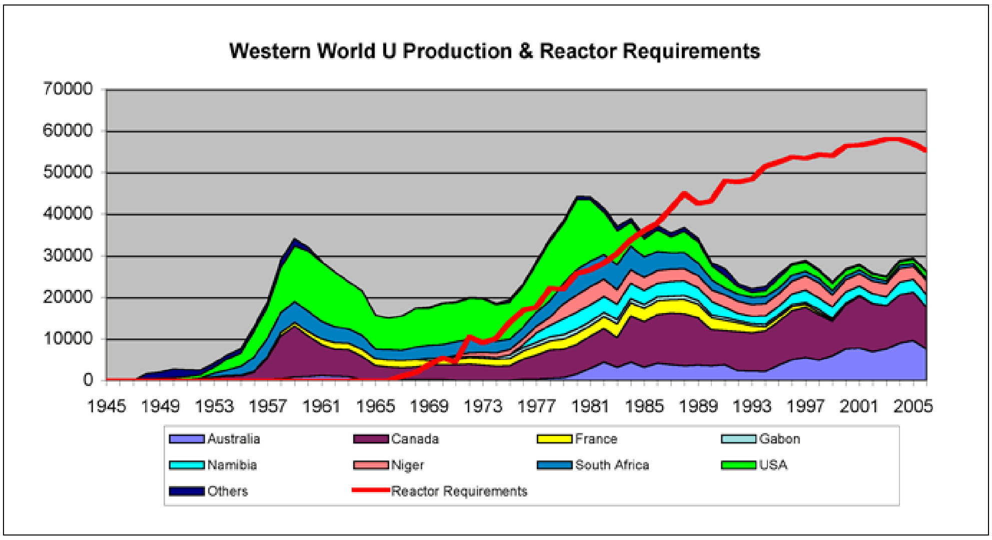
2007)[1]. From a security of supply point of view self-sufficiency in uranium production may be prudent if planning for a large-scale nuclear programme.

Figure 3. Global Uranium production and requirements



Source: http://www.uranium.info/index.cfm?go=c.page&id=48

Figure 4. Long term uranium production and requirements in the West



Source: World Nuclear Association, 2007. http://world-nuclear.org/info/inf22.html

Natural gas remains an alternative to coal in some regions, where natural gas is abundant. However Europe is finding that with the imminent winding down of the North Sea gas fields it will become even more reliant on Russia as the dominant supplier. Liquid natural gas can act as a break on pricing of piped natural gas, but is a weak substitute due to the costs related to the liquefaction and re-gasification processes. However the growth in LNG trade in the past decade suggests that LNG could substitute for other more expensive peaking alternatives and – in the presence of carbon taxes – may be a viable alternative for mid-term plant.

[1] TradeTech Uranium.Info, http://www.uranium.info/index.cfm?go=c.page&id=48.

c. Renewable resources

Renewable sources of energy hold a number of advantages over traditional (fossil fuel) resources (Goldemberg, 2004). These include the enhancement of diversity in energy supply markets, the securing of long-term sustainable energy supplies, the reduction of atmospheric emissions, the creation of new employment opportunities in especially rural communities and the enhancement of security of supply.

Many countries would like to expand their use of renewable energy resources. Some industrialised nations view the use of renewable energy resources (wind, biomass, etc) as an attractive alternative to coal or nuclear for the purpose of expanding their electricity supply capacity. The lack of negative environmental impact, together with the reduction in carbon emissions counts in its favour. Western European countries, such as Germany, Spain and Denmark, have instituted inventive schemes to help grow the use of renewable energy sources, such as wind, solar and hydroelectric power sources (Doman, 2004).

The use of renewable resources, such as wind, does have its drawbacks. Visual pollution caused by wind farms, together with noise pollution from the turbine blades, can limit the choice of sites. In the power system operations area, the use of wind as an electrical energy resource poses challenges to the utility in terms of optimal location, scheduling of generation dispatch as well as impact on system stability. The above negative impacts are felt to a larger or lesser degree, depending on the contribution of the wind generation to the overall generation capacity.

Hydroelectricity is the biggest and most widely used form of renewable energy in the world. In many developing countries, hydroelectricity is heavily relied upon to provide the required electricity supply. For instance, Brazil, Peru and Chile rely on hydroelectricity to meet up to 80% of their electricity needs (Doman, 2004).

The drawbacks associated with hydroelectricity revolve around the social impact of the construction of the required dams to help drive the generators. Large-scale displacement of parts of the population has been met with resentment in the affected areas, including on China's Three Gorges Dam project, as well as Malaysia's Bakun Dam project. Hydroelectric plants also pose environmental hazards to the surrounding wildlife, including animals and plants due to the disruption of the existing ecosystems. Governments persist with the construction of large scale hydroelectric projects, due to the environmental benefits associated with it, and in an effort to meet the ever increasing demand for electrical energy.

d. Changing culture

A component of the efficiency argument lies not in the technology employed in the usage of electricity but in the manner in which consumers interact with energy. All too often energy is wasted, not because the technology is inefficient, but consumers are not sufficiently aware of the impacts of behaviour that lead to waste. This is particularly true in a society that has enjoyed cheap energy. Households need to be educated to conserve energy use, along with commercial and industrial consumers. Small changes in household behaviour may have a compound effect on the demand for energy, and involve little additional outlay to achieve these benefits.

South Africans have learnt over years to conserve water due to the number of droughts that have highlighted the scarcity of water. However this same learning has not feed directly through to energy conservation. Perhaps after the events of our "summer of discontent" South African consumers have a different relationship with electricity and only time will tell how this manifests in terms of efficiency, but anecdotal evidence seems to suggest that there remain significant opportunities for further savings at little cost.

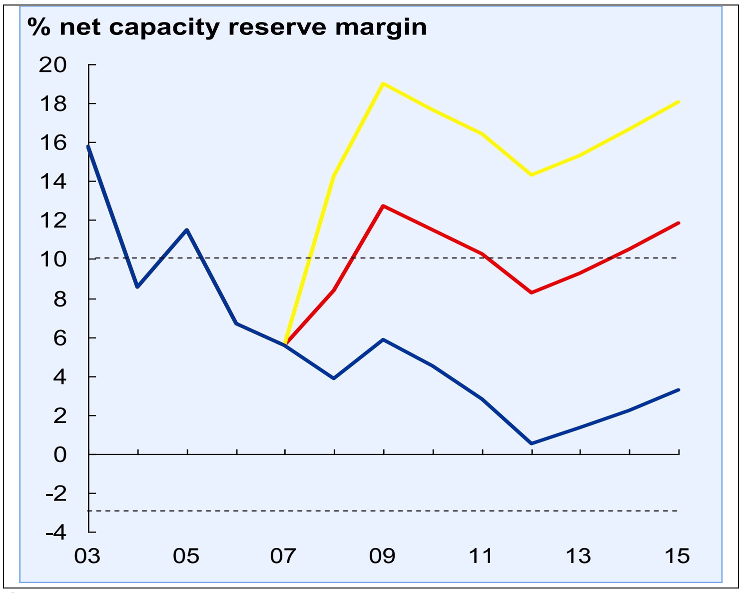
6. Security of supply in electricity

a. Long term

i. Reliability of electricity

Over the long term the growing expected demand must be met with significant investment in plant. Over the last decade the reserve margin (reflecting the capacity adequacy of the current system) has deteriorated as supply has not kept pace with demand growth. The immediate concern is on a large scale capacity programme to catch up with demand and overtake it in order to restore the appropriate buffer over demand. Figure 5 indicates the extent to which the reserve margin has reduced in the recent past as well as projections for the coming ten years under different scenarios. The blue line indicates the projection without any reduction in demand, the red with a 5% reduction and yellow a 10% reduction.

Figure 5. Net capacity reserve margin 2003-15



Source: Eskom

The current Eskom plans (based on ISEP-11) propose the construction of over 50GW of new capacity between now and 2026. Of this it is expected that up to 20GW will be nuclear capacity, although there is a limit to the amount of new nuclear capacity that can be added in the timescale. This means that at least 30GW will have to come from other sources. While some of this may come from renewable energy and natural gas, the bulk is likely to remain coal-based.

The implementation of ISEP-11 involves a ten-year plan including the construction of:

(i) coal-fired stations at Medupi (4332MW), Kusile (4332MW) and a third station (yet to be approved) of similar size required by 2014;

(ii) pumped storage facilities at Ingula (1332MW) and Lima (1480MW);

(iii) additional capacity being added to existing open cycle gas turbine stations at Ankerlig (additional 735MW) and Gourikwa (additional 294MW).

(iv) A wind farm of 100MW, commissioning in 2010.

In addition government is planning an IPP open cycle gas turbine of 1000MW.

If the expected growth (based on the 4%p.a. position) materialises the above plan is required. However there is some uncertainty regarding the impact of the measures adopted to cope with the short term capacity shortfalls in the next few years. If there is a long term impact the growth may not materialise as expected. In addition there is uncertainty regarding policy initiatives around climate change (amongst others) – these would impact on the relative costs of capacity options and therefore the optimal plan. Given these uncertainties, including risks regarding funding of the plans, robust planning is more relevant than ever.

ii. Pricing

The generation expansion programme will require significant capital injection which needs to be covered by revenues in order to sustain the business and provide for a secure and reliable energy supply. Even if all of the capital requirement associate with the build programme could be funded by debt, the increased borrowing costs would have to be funded by increases in prices, especially as the current pricing regime reflects low historic asset values.

In 2008/09 Eskom was permitted a 27,5% increase by NERSA. Similar increases will be required over the next three years (at least) to support the expansion programme. This will lead to at least a doubling of electricity prices.

iii. Energy efficiency

Partly due to the low historic costs of electricity there seems to be a great deal of waste in electricity usage. It is conceivable that with significant price increases over the next few years consumers will be prompted to conserve energy, but there will also need to be a focus from the utility and government to ensure that consumers see the benefits to conservation. This is one of the least cost mechanisms to ensure security of supply and, in the face of climate change, provides for opportunities for each citizen to contribute to saving our environment.

There should be an intensive focus on energy efficiency immediately because it is a powerful options for dealing with the short term capacity issues. However energy efficiency provides significant long term benefits in delaying new capacity as well as reducing the cost of production of existing plant. The benefits for climate change are also clear.

b. Short term

The earliest of the major base-load capacity investments will take another five years before they come online. Until then the reserve margin will continue to erode, placing the system in jeopardy from periodic events that could lead to significant disruptions. Thus the focus in the short term falls on demand side initiatives. Given the 4%p.a. growth assumptions the shortfall in capacity is in the region of 3000MW for the next five years. The following programmes have been proposed to close this gap.

The Power Conservation Programme (PCP) has been developed to manage the shortfall in capacity by constraining demand within the bounds of a secure margin of operation. There are two key arms to this programme, namely:

i) Growth Management, which will limit new projects coming on line (at least for demand in excess of 20MVA) until such time that the system can accommodate the additional demand (either through new capacity or reduced demand elsewhere); and

ii) The Energy Conservation Scheme (ECS) which mandates that consumers take responsibility for providing energy savings that will allow a return to safe operation. While price increases may assist in incentivising savings, the system will require that mandatory reductions take place in order to allow for Eskom to revitalise its generation capacity through an appropriate maintenance regime (which has suffered in recent years from the reducing reserve margin) and restoring coal supplies to safe levels. The current requirement for the ECS is a 10% reduction in consumption from the 2007/08 baseline determination. The actual demand for the 2008/09 year is currently trending below the expected demand by 4 to 5%, of which some of this is electricity savings, some weather impacts. It is clear, however, that the 10% is not being achieved through voluntary action.

On the supply side there is an active set of programmes to encourage private participation through independent power production inclusive of co-generation from industry. The three main programmes are:

i) The Pilot National Co-generation Programme (PNCP) which provides for co-generation facilities in particular, where Eskom will be the buyer of energy;
ii) The Medium Term Power Purchase Programme (MTPPP), which allows for independent power production – from whatever fuel source – that meets the price parameters released by Eskom, qualifying for medium term contracts;
iii) The Multi-site baseload independent power producer programme in which IPPs can tender to sell power to Eskom over a longer period.

It is as yet unclear how much capacity will be achieved through these initiatives, but we know that in the short term there is only a limited impact from the programmes. Thus the PCP is required to ensure that the capacity gap is closed in the short term.

The urgency of the shortfall in the short term is exacerbated by the upcoming sporting events (the Confederation Cup in 2009 and the World Cup in 2010). During these periods the focus on the world will be on South Africa and it is our responsibility to ensure the smooth operation of these events without any interruption. It is thus important that immediate electricity savings are realised in order to allow the necessary maintenance to ensure that the lights keep burning during these events.

7. Conclusions

It is clear that the issues regarding the supply and demand for electricity do not operate in isolation to other energy sources. The constraints of fuel sources and the increasing demand for energy applies across the board in the energy environment. Thus an Integrated Energy Plan (IEP) has a significant role in bringing these numerous issues together. An IEP can highlight the interaction between competing and complimentary fuel markets and attempt to promote efficiency in usage and appropriate investment in capacity to ensure optimal usage of existing resources.

The extent of capacity constraints and demand growth in energy globally was not anticipated by most global players three years ago. This only goes to highlight the uncertainties of planning for a resource constrained operation where constraints appear in delivery, transport, construction amongst others along with shifts in supply and demand. Over and above this the policy environment is as fluid, if not more so, and plans need to be able to adjust, if not anticipate, such changes.

Recent events in electricity and energy in particular highlight the importance of clear and decisive leadership and the importance of promoting efficiency at every level (including the utilisation of technology to support these ends).

The fuels peak may be decades away, but the increasing competition for these resources, as well as the global and local environmental impacts of their exploitation, require that we focus on new technologies and processes to ensure the future security and sustainability of economic development.

8. References

Goldemberg, J (2004), Development and Energy, Overview, Encyclopedia of Energy, Vol. 1

Stern, D (2004), Economic Growth and Energy, Encyclopedia of Energy, Vol. 2

Doman, L (2004), Global Energy Use: Status and Trends, Encyclopedia of Energy, Vol. 3