An Analysis of the Skills Requirements in the Electricity Value-Chain

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Employment Promotion Programme

Executive Summary

The purpose of this report was to assess the skills requirements in the electricity value-chain. For the purposes of the work completed, the value-chain was defined as the generation, transmission and distribution of electricity. It also examines the upstream manufacturing activities that produce the equipment that is used in these elements.

Although the proposal was premised on the assumption that the project would receive co-operation from Eskom, Eskom chose not to support the project and as a result this report is based primarily on available information (both secondary sources and previous interviews with Eskom personnel) and around thirty other interviews with people across the value chain. Nevertheless, the report seeks to present a reasonably comprehensive picture of the skills demand in the electricity value chain with the possible exception of the transmission elements which fall primarily under Eskom. It was largely compiled in the last six months of 2008 and, although effort has been made to address issues that have arisen recently due to the magnitude of the global economic downturn, it primarily reflects the information available to the author in this period.

The report covers a number of sections:

1. The level of demand for infrastructure investment in the South African environment is reviewed so that the magnitude of the proposed spending on electricity infrastructure can be assessed relative to proposed total infrastructure spending. It will be seen that the electricity infrastructure will account for almost 40 percent of proposed spending but much of this is on equipment and other technology manufactured outside of South Africa. However, given the recent world economic turmoil, and the subsequent announcements of project postponements and retrenchments in all infrastructure sectors, it is likely that the short-term demand for skills in the electricity value-chain will moderate and that such moderation will provide additional time to adequately address many of the potential skills short-falls;

2. The level of demand within the electricity value-chain is described with a focus on large projects and other critical skills shortfalls especially in the distribution sector. What we discover is that, due primarily to the current economic slow-down relatively few large projects will progress. We can expect that those projects that are already underway are already making use of the existing skills and it is assumed that many of these skills will become available to future projects, therefore mitigating the future demand for additional skills on new projects. Whilst it can be assumed that some new projects, particularly in the nuclear field, will require specialised skills currently not available on existing projects, many of the more generic and basic skills will become available due to the hiatus created by the global economic recession and Eskom's

own financial difficulties. We cannot however assume that the skills challenges in the distribution sector will be as easily overcome unless the structure and employment practices of this sector are immediately and dramatically addressed.

3. Once the project pipeline is described in the report below, the report then seeks to enumerate the skills demand for the critical projects. Whilst these projects do not represent the sum-total of skills demand, they do provide an indication of the magnitude of demand for skills over and above what could otherwise be expected by current operations, maintenance and rehabilitation of the electricity value-chain. What is being argued in this report is that a certain level of electricity infrastructure investment has been taking place since 2005. Since these projects represent, along with the other infrastructure sectors, a current level of demand that is being met by the available skills pool, what we are primarily interested in this report is the extra-ordinary requirements for skills over and above current levels of investment. We find that this extra-ordinary demand will translate into the construction of between two to six generation units at a time which we seek to show should not over-whelm the available and future supply of skilled personnel. In other components of the electricity value-chain, such as distribution and transmission, there may be skills shortages, but as is argued below, many of these shortages are a consequence of policy and institutional choices made over the deployment of personnel rather than a result of a net shortage of such personnel per se. However, if the structural and institutional arrangements that currently prevail in much of the distribution sector controlled by local government are not addressed, then we can anticipate serious problems arising in distribution that arise from the skills shortfall in distribution.

4. Once the extra-ordinary demand for skills is established, the report then seek to understand what categories of skills are in high demand and which of these types of skills will require special effort to ensure that the demand is met. What we find is that there are several categories of professional and artisanal skills which pose the greatest challenge, but that these make up a relatively small number of people requiring training, work experience or recruitment. This analysis confirms research previously undertaken by the author that the main skills requirements are in the order of magnitude of tens for some key professional skills and in the order of magnitude of hundreds for some key artisan skills. Key to this analysis is the understanding that the main skills deficit is more of a quality rather than quantity gap. What is needed are relatively few individuals with specific (and highly specialised) training and experience. Even though the total requirements for professional and artisanal skills in the electricity value-chain may reach more than fifty thousand, the majority of these skills will be semi-skilled non-professional and the more generic professional skills which can be relatively easily sourced and/or developed in the lead-times arising from future

projects. The report does comment, somewhat obliquely it must be recognised, on the issue of racial and gender transformation and concludes that current initiatives to address racial and gender balances are already having an impact on the social composition of the skills profile. It is unlikely that further interventions will accelerate this process. What is central to the success of the transformation process is that all new entrants, regardless of race and gender, develop the experience required to use their skills appropriately;

5. This report, having established where the critical skills gaps are likely to arise from future infrastructure investment, then proposes a number of interventions which should help mitigate the extremity of the estimated skills challenges. As noted in the previous point, the gap is more about quality than quantity of skills, and there exist several initiatives to develop and deepen the work experience of new entrants so that they can apply their skills more effectively. These interventions involve the integration of theoretical and practical training mainly for artisans and the formal use of mentoring for tertiary graduates. In both instances, the intention is to ensure that the new entrants to the skills pool develop the same understanding and ultimately the same depth of experience as those that are reaching the end of their working lives. In addition, in particular with regard to the distribution sector but also more generally, it is argued that one of the major reasons why there are skills deficits arise from decisions taken by those involved operationally or in a policy context in the electricity value-chain. Reviewing these decisions can go a long way to mitigating any future skills short-fall. This conclusion do not suggest that certain interventions are not required to increase the supply of certain skills but rather that these interventions will only succeed if key decisions around electricity delivery are adjusted to meet reality.

In conclusion, it is argued that, although the skills challenge cannot be downplayed and that many organisations are going to have to continue to focus their efforts on improving the current skills pool in the electricity sector, the most critical skills shortages can be addressed without a significant impact on the future of infrastructure delivery in the electricity value-chain. The report concludes with a series of recommendations which builds on the understanding arrived at in the report about the nature of the skills challenge in the electricity value-chain. In summary (the full recommendations are in the final section), the conclusions and recommendations are as follows:

1. Government, the private sector, the unions and parastatals should stop obsessing about the quantity of skills and rather turn their attention to the quality of skills and the skills pipeline.
2. They should acknowledge that due to the scale of these large projects and the significant decisions (such as financing, pricing and demand) surrounding their initiation and development, it is likely that there will be instances of short-terms gaps in available skills

when new projects come on line but that if the skills pipeline is restored that many of these short-term gaps will be reduced to a minor inconvenience.

3. The analysis should show that whilst the most critical skills require much training and many years of experience for both professionals, managers, supervisors and artisans alike, the demand for such critical skills is relatively low and the main demand in terms of numbers is for skills in categories that require far less training and work experience (and these skills categories are easier to create in the project lead times).

4. The analysis should also alert decision-makers to the obvious truth that they need different strategies to address the various skills gaps expected to arise. In terms of the short-term requirement for the most critical skills, they will mainly have to compete on the international market place for a relatively small number of individuals. In terms of the medium level skills, they should be looking to enhance the manner in which people with existing training and some work experience can enhance and deepen these skills through mentoring and similar programmes. For those newly entering the training or work cycle, they should be looking for ways to ensure that fewer individuals drop out before achieving a final qualification. Each of these interventions will be addressed further below.

5. In terms of the professional, managerial and supervisory skills required, a mentorship programme needs to be established to ensure that those being taught skills be taken through a comprehensive programme of work experience to develop the appropriate skills required to assume more senior positions.

6. It is also suggested that an investigation be held on several programmes that have been designed to use retired (or otherwise under-employed) engineers to support or supplement the engineering skills base of provincial and municipal service delivery agencies. Whilst these programmes primarily focus on support, they also are expected to provide some mentoring by older professionals to younger professionals and an examination of their successes and failures will better assist in designing other such support and mentoring programmes.

7. It should become evident from the report that part of the skills shortfall currently being experienced is a result of certain policy choices such as the promotion of affirmative action. It is not the intention to discuss the merits of such policies in this report but it may have to be acknowledged that the problems arising from the above-mentioned policies are of such a scale that the programmes needed to be adopted to help overcome any difficulties arising from these policies may need also be of a similar scale.

8. It is recommended that policy makers in particular look to other interventions to address the possibility that planning may fail to correctly anticipate the future. One such intervention mentioned in this report is to spread the risk of making incorrect long-term decisions (and of financing them) by actively encouraging Independent Power Producers (IPPs). The second mitigating strategy to avoid the pitfalls of poor long-term planning is for Government to support or carry the additional costs of skills development through tax deductions and/or subsidies even if these skills prove to be in surplus in the future.

9. It is recommended that urgent and specific attention be given to addressing the infrastructure failures in local government along the lines of the REDs even if that model is not necessarily adopted in its current format. At the very least, it will require that these services become ring-fenced in order to ensure financial sustainability and managed in terms of basic business principles rather than politics.

10. The final recommendation of this report is to suggest that further work needs to be done on the deployment of the available skills. It is therefore recommended that, with the co-operation of the relevant agencies in Eskom and Local Government, that the delivery

systems be examined in depth to discover how the current skills gap can be addressed through the redesign of such systems.

Contents

1. Introduction

The initial request for a proposal stated that "The EPP Reference Group would like … a skills audit for Eskom – specifically focusing on the current skills shortages in both the build and maintenance processes". This project was an attempt to address this brief by adopting a methodology which combined the use of available secondary material with interviews with key personnel to describe the electricity value-chain, the skills requirements across that chain and to propose specific interventions which could assist in addressing some, if not all of the skills gaps anticipated in the industry.

Unfortunately, Eskom chose not to co-operate with this study and as a result, it relies to a greater extent on secondary material and off-the-record interviews than initially planned. Fortunately, the Nuclear Industry Association of South Africa (NIASA) assisted in providing access to their members for the nuclear component of the study and this helped provide more insight than would have otherwise been achieved due to Eskom's lack of participation. Unfortunately, Eskom's lack of participation meant that the researcher was unable to get direct access to many involved in the project cycle whether these people worked for Eskom or, in the case of the major contractors and suppliers, provided goods and services on the current and future projects. Therefore most, if not all the objectives, of the study were achieved, albeit with less formal information and more informed speculation than was initially intended. Where possible, the sources of this informed speculation are cited but for obvious reasons, some informants chose to remain anonymous.

When seeking to understand the skills requirements for infrastructure development and operations, one starts with a series of assumptions[1]:

1. It can be assumed that the available stock of infrastructure must be operated, maintained and perhaps rehabilitated or decommissioned. The state of the infrastructure stock matters. Firstly, if it, as in electricity, under-supplies current and

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1 These assumptions are based on the work of the author dealing with skills issues including:

Procurement Dynamics, Skills Audit (Demand Side) of the Built Environment , CBE (2008), Merrifield, A et al (2006) Increasing the supply of Engineers and Built Environment Professionals, Technologists and Technicians – A JIPSA Proposal (JIPSA 2006), Merrifield A Demand for Skills– an analysis of the proposed infrastructure spending programme, CIDB (2006), Merrifield, A et al Review of the Prevailing Framework for the Implementation of Capital Investment in Infrastructure Projects in the nine provinces (National Treasury 2002), Merrifield, A "The role of the construction industry in the delivery of infrastructure in South Africa", chapter in Khosa, M, Infrastructure Mandate for Change, 1994-1999 (HSRC Press 1999), Merrifield, A et al Creating an enabling environment for Reconstruction, Growth and Development in the Construction Industry (DPW Green Paper 1997), Merrifield, A The performance and capacity of the formal construction industry in the 1990's (National Housing Forum 1994) future demand then it can be expected that in addition to continuing to operate and maintain such infrastructure, it will be necessary to add the current stock to meet new demand. Such an increase in supply will have skills requirements over and above what would normally be required for operations and maintenance. Secondly, if the existing infrastructure stock has not been maintained adequately, the condition of the infrastructure is likely to affect normal operations, and therefore, given the likelihood of an increased level of outages, additional skills may be required for operations, maintenance and even rehabilitation to restore the current stock to an acceptable service level.

2. It can be assumed that there is an available stock of skills to operate and possible development of new infrastructure. As a result of the stagnation in infrastructure development since the early 1990's, it is likely that the stock of people with the skills and experience of developing and operating such infrastructure would have diminished due to retirements, emigration and death (amongst other things). Thus, in determining skills requirements, it is necessary to estimate current and future needs but also understand the state of the skills supply (both in terms of whether the replacements have appropriate training and experience). If the supply is unable to replace those lost and those required for new infrastructure development, then it can be assumed that there will be a skills deficit.

3. It can be assumed that where the technologies, construction, manufacturing and labour processes remain the same as before, the skills shortfall will largely be the difference between the skills required to meet the deficit in infrastructure stock and the available skills. However, where technologies, construction, manufacturing and labour processes have changed significantly from those in the past, then even if there is a sufficient stock of available skills, these may not be appropriate for the new infrastructure developments. It can also be assumed that some replacement skilled personnel may have the appropriate training in these new technologies, construction, manufacturing and labour processes, but not sufficient work experience to apply this training, whilst those within the existing skills pools may have work experience but insufficient familiarity with the new technologies, construction, manufacturing and labour processes. In either circumstance a skills deficit will arise.

4. It can be assumed that the degree of specialisation will intensify with both training and experience. Whilst the majority of skills required will be more basic and generic which means that people with these skills can be assigned to a variety of tasks without loss of quality or productivity, those with the more specialised skills will be more difficult to substitute. Fortunately, previous research shows that the demand for highly specialised skills is relatively low and therefore can be more easily addressed than is

generally assumed in the discourse over skills shortages. Key to this assumption is the understanding that skills shortages are often inversely related to the level of specialisation. It may be expensive and may require a significant amount of time and energy to recruit such specialists, but ultimately the cost, time and energy is mitigated because there are only a small number of such specialists required. By contrast, there may be a need for many more basic and generic skills, but this demand is mitigated by the fact that there is greater substitutability amongst these more basic skills sets and, also, that it is easier to recruit, train and provide the appropriate work experience for the greater numbers of these basic skills.

5. It can be assumed that the state of the national and international economy has an impact on the demand for skills. When the skills first became an issue in 2006, the South African and World Economy was undergoing the longest commodities boom since the Second World War. In addition, after almost twenty years of neglect, the government and parastatals had embarked on an ambitious infrastructure investment programme. Notwithstanding the pressures arising from these two drivers, there have been few reports of any projects being delayed or postponed because of skills shortages. Skills were difficult to come by, but they have not yet interrupted the new infrastructure development. Now, with the world and national economy in a significant recession, with little prospect of an early improvement, it can be assumed that more skills will become available as firms postpone new investment and those firms involved in infrastructure delivery downsize.

All the above assumptions have been tested in the research process and will be discussed more fully in the report that follows.

2. Research Outline

Through several discussions with personnel at Eskom and in the related industries, it was evident that although there are a number of studies being undertaken on aspects of this subject[2] as well as several studies in the past (CIDB 2006, PCAS 2007, CBE 2008)[3] that there was still further work to be done in consolidating a synthesis perspective of skills requirements for the electricity value-chain.

It was therefore proposed that a study be conducted that will seek to build upon these previous and current initiatives and provide such a synthesis. This study attempted to use an interview approach to gather information from key stakeholders involved in all aspects of the energy value-chain. The final deliverable was intended to be a validated audit of skills required for both the operational and project demands of the electricity sector.

Unfortunately, the proposed methodology was thwarted at the outset by Eskom. Unlike previous studies where the author approached individuals in Eskom directly, for this project, with EPP support, the author made a formal request to Eskom management for co-operation. This request was denied. Fortunately, the author had access to some earlier interviews with Eskom personnel which were on the record and have been cited in the study below. In addition, as part of other activities that the author is involved in, he was able to conduct several informal off-the-record interviews with people who have been involved in the development of current Eskom projects. These interviews are not cited but were used to validate other information already in hand. The Department of Public Enterprises (DPE) also assisted in making certain research outputs available.

As noted above, the Nuclear Industry Association of South Africa (NIASA) provided some access to their members which assisted to completing this study. It was suggested in a progress report submitted to the EPP Reference Group on 25 August 2008 that a Plan B could be pursued to fill in some, if not most, of the gaps arising from Eskom's lack of participation. NIASA was seeking

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2 The DPE was kind enough to provide access to the McKinsey Study 'The South African Power Project' (TSAPRO) which updates in some ways the earlier research cited. Through access to international resources and through interviews with NIASA members, the author was able to provide a commentary and validation of the TSAPRO work.

3 Merrifield A. (2006) Demand for Skills– an analysis of the proposed infrastructure spending programme, Research report, CIDB, Sudeo IBC (2007) Draft Research Report for the Infrastructure Inputs Sector Strategy, PCAS Presidency, Procurement Dynamics (2008) Skills Audit (Demand Side) of the Built Environment , CBE (2008). The author was instrumental in conducting the first and third studies whilst the second study was independent it copied the same methodology as the CIDB and subsequent CBE studies.

someone to provide them with information on skills requirements for the nuclear programme. It was suggested that this could be done within the purview of this project since the nuclear component may make up to 50 percent of future generation capacity and would need to be covered anyway. In the course of refining the focus of this research it became apparent that there are significant similarities between the nuclear plants and non-nuclear. Given that the fuel by which coal and nuclear plants heat the steam that drives the generators is different, there are major differences between these plants in terms of boiler design and fuel handling. Nuclear plants are also constructed in terms of much more stringent safety standards. However, much of the conventional plant including the turbines, generators, balance of plant and civil works are comparable although levels of complexity may differ between conventional and nuclear plants. It was therefore proposed to use the information supplied through investigating the nuclear generation industry to validate the information gathered through other sources.

Thanks to the assistance of NIASA, the author managed to engage with about twenty five organisations (about 80 percent of the NIASA membership) and interview nineteen of them.[4] These organisations ranged across the electricity value-chain from research, engineering, construction, manufacturing and operations and maintenance. Given the great uncertainties surrounding Eskom and the Government's commitment to the nuclear programme, and given the relative immaturity of the nuclear industry, it was not always possible to acquire hard numbers on the skills requirements. Nevertheless these interviews provided valuable insight into the strategic questions surrounding the nuclear industry, and because many of these organisations were also involved in other electricity projects, they also enabled the author to understand some of the constraints facing the more traditional components of the electricity value-chain.

It was proposed that the study of skills requirements in the electricity value-chain be addressed in three phases, by investigating the following:

2.1 Future Demand

Provide an overview of the proposed demand in the electricity sector over the next 20 years. This was to be accomplished by updating existing work (for CIDB, CBE) through targeted interviews with current and future project owners and the operational managers of existing infrastructure (covering the generation, transmission and distribution components of the electricity supply-chain). The purpose of these interviews was to identify key bottlenecks and future improvements to electricity infrastructure that are likely to shape future demand for operational and project skills.

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[4] Unfortunately some of the main bidders were unwilling to discuss their projects in much detail given the uncertainty surrounding the bid-decisions on nuclear. Fortunately engagement with even these organisations provided some insight as to the future of the industry.

The main output of this phase was to be a set of demand scenarios for the electricity sector. Sections 4, 5 and 8 of this report attempt to provide this understanding.

2.2 Capacity requirements for electricity operations and future projects

Provide an in-depth overview of the demand for specific skills through a project by project, and operation by operation analysis of skills demand (restricted to the major projects and operations at Eskom and elsewhere identified in phase 1). Given the lack of participation by Eskom, this information was collated on the basis of available material and selected informal off-the-record interviews with those involved in the build programme. It is possible that the actual numbers for different skills may differ from those provided but it is unlikely that the order of magnitude will be significantly different. This demand profile is aggregated to protect commercial proprietary information but provides a sufficiently dis-aggregated picture of demand so that a skills-analysis can be reflected in sufficient detail to aid future planning for skills supply. The deliverable of this phase as described in sections 6 and 7 aim to provide an in-depth understanding of the demand of electricity infrastructure related skills.

2.3 The most appropriate delivery mechanism

The supply and demand for skills is not merely a question of numbers but also depends upon the manner in which these skills are used within the electricity supply-chain. This entails understanding the way in which such personnel are deployed. In particular, existing or proposed work-activities, procedures and institutional arrangements which give rise to the demand and supply of such skills. Due to the limited exposure to Eskom personnel, which was in part compensated by discussing project delivery and operations with people outside of the Eskom group, this deliverable is less well developed than originally anticipated. Unfortunately, even though this input was seen to be a major part of the final recommendations, it is impossible to comment in-depth about improvements in current delivery mechanisms if one is denied access to those engaged in delivery.[5] However, the final section of this report includes recommendations as to how the delivery mechanisms may be improved to ensure the better utilisation of available and future skills. In the process of doing the research, it was found that some of the recommendations refer to broader macro-economic and political considerations than was initially expected. Whilst detailed interviewing of those directly involved in the project and operations processes may have revealed additional recommendations concerning institutional, procedural and process improvements, the recommendations provided in Section 9 speak more to the delivery system in

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[5] In the author's previous work on skills, for instance Merrifield A *Demand for Skills– an analysis of the proposed infrastructure spending programme*, CIDB (2006), he was able to gain insight from those engaged in developing the Eskom projects. Unfortunately those projects had not yet progressed sufficiently to enable those interviewed to reflect on how they may improve or restructure their delivery mechanisms once the projects actually started.

general. Although it is more of a policy than process discussion than originally envisaged, it is still intended to provide ideas on how skills utilisation can become more effective.

3. South African Literature Review of Built Environment Professional Skills Challenges

There are a number of recent South African studies that have sought to understand the skills challenges around built environment professionals. These include:

- the 2003 National Advisory Council on Innovation (NACI) study,
- the 2005 South African Institute of Civil Engineering (SAICE) study,
- the 2006 Construction Industry Development Board (CIDB) study,
- the 2007 study done for the Policy Co-ordination and Advisory Services (PCAS) in the Presidency, and
- the 2008 CBE Skills Audit (Demand Side),
- the 2008 CBE Skills Audit (Supply Side).

This review seeks to identify the methodology, findings and key outcomes from each of these studies as they apply to estimating infrastructure skills requirements in the future.

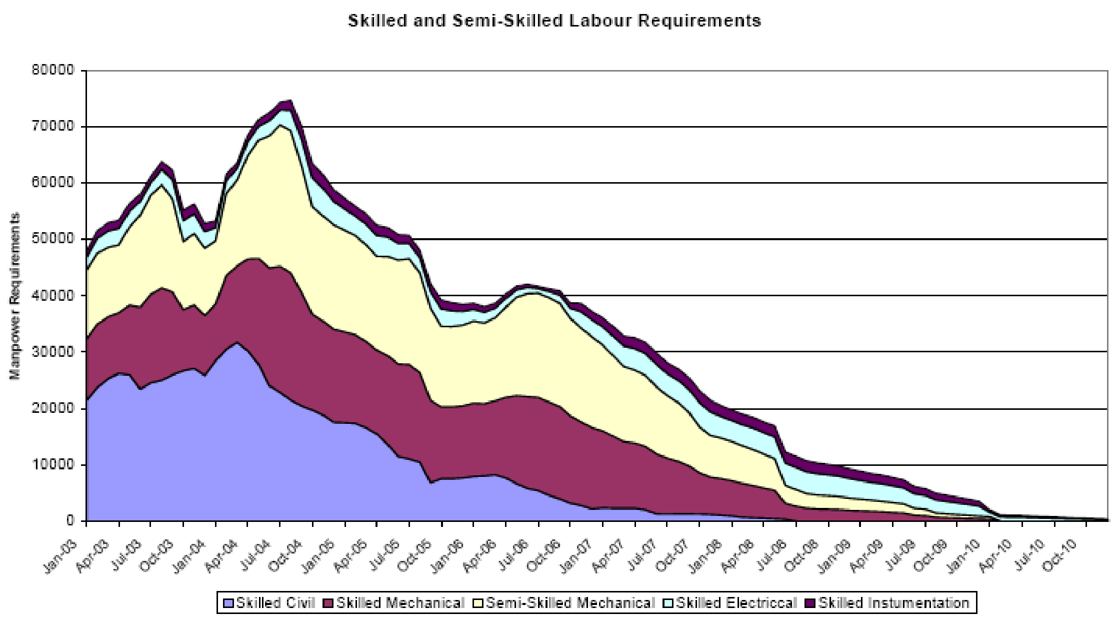
With the exception of the SAICE and the CBE (Supply Side) studies which will be discussed further below, the four other studies employ a similar methodology. All these studies seek to estimate the future growth in the particular environments they analyse, and on the basis of that estimate decompose the volume of growth into specific industry and project sub-sectors. They then use estimates of skills required per project type to calculate the number of people with particular skills that are required. In other words, these studies seek to quantify the amount of future work and then attempt to account for the numbers required to perform that work. In all these instances they use expert opinion to quantify the skills requirements.

The four studies tend to focus largely on the future flow of work (and skills required) and do not provide sufficient analysis of the existing stock of skills. The implicit assumption here is that this new quantum of work was over and above the existing levels of demand. Although in at least two instances (the CIDB and the PCAS studies) flow as well as stock of skills was estimated, neither of these studies focused on the issue of the stock of available skills. By contrast, the SAICE study provides an in-depth analysis of the current stock of civil engineering skills and shows how this stock is rapidly being depleted. The CBE (Supply Side) study attempts to provide similar analysis for all the built environment professions but the level of data aggregation only offers a macro perspective. Clearly the future demand for skills will ultimately be determined both by the increase in the level of new work as well as the current depletion of the infrastructure skills base.

3.1 2003 NACI Study[6]

The NACI study set out to answer a similar question to many of the other studies referred to herein. Given that the country was anticipating a dramatic increase in construction related work (in this case R100 billion worth of new projects mainly in mining and petrochemicals between 2002-2007) the NACI team wanted to understand what the skills requirements may be and whether it was likely that these skills would create supply bottlenecks for delivery. The overall findings of the report suggested that the skills constraint was serious and implied that they may actually hinder the delivery of the proposed projects (see Graph 3.1 below).

Graph 3.1: NACI Skills Projections



Source: NACI Survey

The report's conclusions have proved in hindsight to have overestimated the skills shortages given that all these projects were completed as scheduled. Nevertheless, the NACI study helped sensitise both public and private sector decision-makers to the long-term concerns arising from the decline in the skilled and semi-skilled groupings in South Africa over the previous decade and a half. The report was also useful in analysing the supply constraints and making many valuable suggestions as to how the long-term supply of skills could be restored. Unfortunately, the NACI team was unsuccessful in ensuring that these recommendations were implemented although they have been resurrected at JIPSA.

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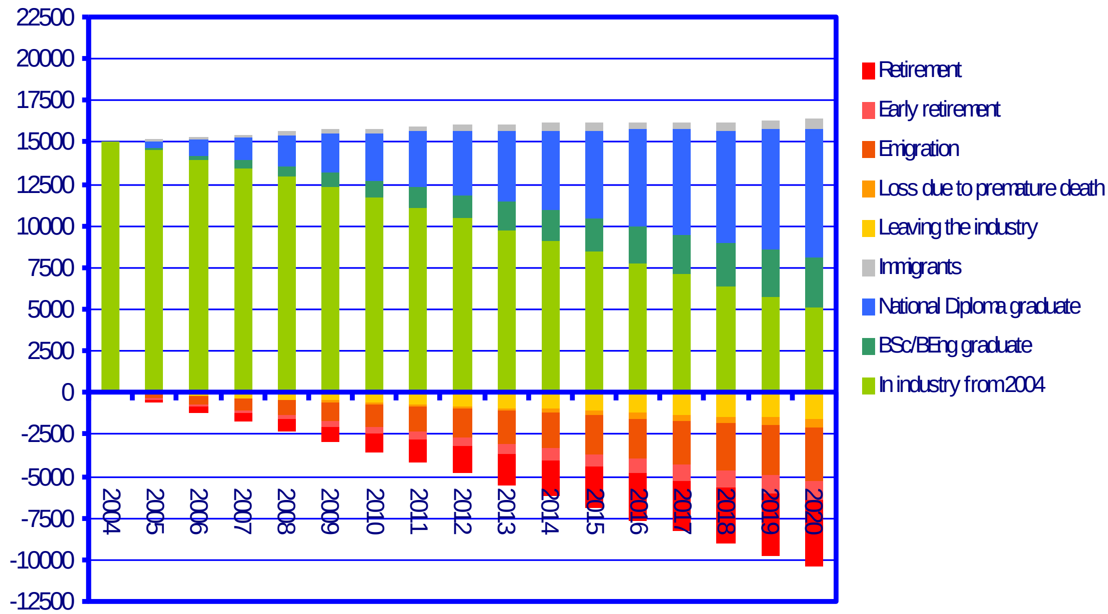
6 NACI 2003 The Potential Impact Of Skills Shortages On The Innovative Capacity Of Major Capital Engineering Projects

The NACI study was a pioneering attempt to understand the implications of a quantum leap in new construction related investment and its consequences for the supply of infrastructural skills. It was also important to mobilise both public and private sector decision-makers to act on skills development. Moreover, the NACI study created a methodology which has, with variation, been emulated in the CIDB, PCAS and CBE studies.

3.2 2005 SAICE Study[7]

Unlike the other studies discussed in this section the SAICE study does not make much effort to project the level of demand for construction goods and services for which built environment skills are required (although it does refer to other such studies[8]). However, it does provide a detailed analysis of the stock of civil engineering skills and in particular tries to understand both the inflow and outflow of these skills from the overall stock (see Graph 3.2 below).

Graph 3.2: Stock of civil engineers with inflows and outflows



Source: Lawless (2005)

7 Lawless, A. (2005) Numbers and Needs – Addressing the imbalances in the civil engineering profession, SAICE

8 The SAICE study does also refer to projections of future construction demand although it relies on projections from SAFCEC for these projections.

There are many valuable insights in the SAICE study, but this analysis of the stock and the flows is perhaps the most useful for our current purposes. It is likely that the inflows and outflows will be similar for other infrastructural professions (and possibly for artisanal skills).[9] The key lesson learnt from this study is that even with a large increase over time of graduates, the stock of civil engineers remains largely constant because the outflows are also quite significant. Whilst some of these outflows can be addressed (early retirement, people leaving the industry or country),[10] others, such as premature death, may be unavoidable. However, the path-breaking SAICE study also emphasises the message that there is a need to better understand the current and future stock of infrastructure skills and in particular to understand the factors that impact on it positively and negatively.

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9 Most of the above-mentioned studies, with the exception of the CIDB and PCAS Studies, focus on the professional skills requirements. It will be argued in this report, as it was in the CIDB report, that the stocks and flows for artisanal skills would be subject to similar factors.

10 The rates at which these factors result in a decline are of course a function of the level of growth or lack of it in the industry as a whole. In more favourable circumstances such as we are expecting, these rates of decline may not be as significant.

3.3 2006 CIDB Study[11]

The CIDB study was an attempt to assess the demand for construction and related skills (both professional and non-professional) in the face of what seemed to be a dramatic increase in demand for construction goods and services. At the time the study was commissioned, mega-projects, largely from the public corporations and public sector, were expected to generate an additional R372 billion worth of work and again the industry and construction industry policy makers were concerned about the skills constraints.

To some extent, the CIDB replicates the methodology of the NACI study in that it made use of expert opinion to determine the needs of certain skills categories required for different types of construction work. It, however, developed the methodology further by providing a much deeper analysis of the historical trends for different construction sectors and it helped interpret the future demand by comprehensively disaggregating the demand for different construction sectors.

The historical trends provided a decomposition of demand in terms of both construction sectors and client types (updated versions of this analysis will be shown in Section 4) and helped explain that the current levels of demand were comparable to earlier periods in the 1980s. Whilst this did not suggest that the skills challenge was inconsequential given the significant declines in the industry in the later 1980s and 1990s, it did however argue that if the South African industry could previously have performed at those historical levels it should be possible to reach those levels of performance again, especially with the new techniques and technologies introduced in the subsequent two decades.

The primary improvement of the methodology was to disaggregate the projections of construction demand into the different sectors and in particular, into the particular mega-projects. When this disaggregation is performed, it is then evident that the different sectors have quite specific skills and technology requirements. This implies that the competition for resources is considerably lower than may be assumed from the concerns arising from R372 billion increases in infrastructure spend. For instance, Transnet's R50 billion worth of projects was divided between port projects (either dredging or container handling – both requiring completely different resources and skills) or rail projects which were completely different from the port projects and which would draw upon different industrial sectors. A similar analysis was provided for Eskom's R97 billion spend (aspects of this analysis are reproduced in sections 6 and 8 below).

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[11] Merrifield A. (2006) Demand for Skills– an analysis of the proposed infrastructure spending programme, Research report, CIDB

Whilst it is recognised that there may be some competition for resources at the more junior skills levels, there was virtually no competition for the specialist professional skills which were most scarce. For instance, whilst Eskom was extremely concerned about finding appropriately experienced turbine engineers, they only required relatively few of these people, approximately 12 at the time of conducting the research, and these individuals would not be in demand by other infrastructure sectors. Similar arguments could be made for most of the scarce skills categories.

The other benefit of disaggregating construction demand was to show that much of the professional knowledge required to build these mega-projects would be embodied in the equipment (boilers, turbines) that made up the bulk of the investment. Therefore, even though the public corporations would require appropriately skilled professionals to specify and oversee the acquisition of this technology, the skills demands for such services is considerably less since much of the design skills would be placed at the manufacturers' facilities (in most instances not in South Africa). Even where this plant and equipment would be assembled in South Africa and thus require the use of local skills, these personnel would be supervised by the skilled personnel sourced by the international suppliers.

The conclusion of the CIDB study was that even though there were severe skills challenges facing the construction industry, these challenges were mitigated by the issues raised in the previous paragraphs. Given that demand for extremely scarce skills was limited (in the order of tens and hundreds), the bigger challenge for the nation was to ensure that there were adequate junior skills levels to support the activities of the former. Even though several hundred additional professionals (of different types) and several thousand artisans (of different types) would be expected to participate in the infrastructure ramp up, it was argued that the current strategies for sourcing these skills could be managed.[12]

3.4 2007 PCAS Study[13]

The PCAS study is part of an initiative by the Presidency to develop sector strategies for the nation. Of particular concern to the originators of the study, was the fact that input costs, including personnel costs, had increased significantly from the early 2000s and the PCAS study was intended to understand the major supply-side constraints of the intended infrastructure drive.

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12 To this extent the author and the author of the SAICE study collaborated to propose a series of supply-side interventions for the JIPSA secretariat. Since the main focus of this research is on skills requirements, the JIPSA work was only referred to in passing in Section 9 of this report.

13 Sudeo IBC (2007) Draft Research Report for the Infrastructure Inputs Sector Strategy, PCAS Presidency

Although the PCAS study addressed the main supply-side constraints (materials and personnel) it adopted the same approach as the earlier CIDB study, decomposing the projected infrastructure investment into the different construction sub-sectors and mega-projects and then estimating the resource demands for each. Like the NACI and CIDB studies it made use of expert information to estimate the skills requirements, and in the PCAS case, was able to get very accurate information particularly on the skills (and other resource) demands of the mega-projects that make up the bulk of future demand.[14]

For the purposes of this study, the critical findings from the PCAS study are that it (i) confirms the CIDB estimates of the demand for built environment professional skills and (ii) that the immediate challenge from the current increase in infrastructure spending is manageable. The PCAS analysis of the mega-projects (see Table 3.1 below) shows that the demand for construction and project managers is around 500 during the peak years of 2008-2009, the demand for engineering professionals is around 1000, whilst the demand for other built environment professionals is around 2200.[15]

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[14] It is unclear whether this was because the client was the Presidency or whether the planning of these firms had advanced much further than when the NACI and CIDB studies were completed.

[15] Neither the PCAS nor the CIDB got official estimates from Transnet, but, from figures that this author (Merrifield) informally obtained through interviews with the Transnet project team, the total professional skills requirement across the above three categories is around 150. These figures were included in the above estimates.

Table 3.1: Demand for skills on the Mega-Projects

	Peak Demand	
	2008	2009
Eskom		
Project and Construction Managers	154	40
Engineering Professionals	250	50
Built Environment Professionals	100	60
Gautrain		
Project and Construction Managers	17	17
Engineering Professionals	25	25
Built Environment Professionals	35	35
2010 Stadia		
Project and Construction Managers	60	50
Engineering Professionals	160	120
Built Environment Professionals	180	90
Sanral		
Project and Construction Managers	166	227
Engineering Professionals	166	227
Built Environment Professionals	330	453
	1643	1394

Source: Extracted from Sudeo IBC 2007

The PCAS study also estimates professional skills for some other categories (public sector residential and non-residential) but these are assumed to be covered by the existing skills pool.[16] In other words, the above skills estimates can be seen as the additional skills requirements and that the current stock of professional skills will be distributed over existing and new projects.

3.5 CBE Skills Audit (Demand Side)[17]

The key outputs of the study were the development of a number of demand scenarios which presented an outlook for both infrastructure demand and demand for skills. The infrastructure scenarios were based on a review of general forecasts of the economy, GFCF projections, the anticipated impact of potential mega-projects and public sector spending and recent forecasts of the civil engineering industry (discussed further below). Two growth scenarios for the built environment were produced.[18] These were a high scenario and a low scenario, with the high scenario anticipating consistent increase in sector spending to about R336 billion per annum in 2025 and the low scenario witnessing growth to approximately R120 billion per annum in 2025. As was discussed in some detail in the report, these trends would be greatly influenced by the impact of the slow-down in the world economy, national economic trends and capital-output ratios.

On the basis of the growth scenarios for the built environment, forecasts were undertaken for the different built environment skills categories. These scenarios found that[19]:

1. Civil engineering is the only sector to grow under both the high and low scenarios.
2. Under the low scenario

    a) demand for quantity surveyors is likely to hover around 2300-2600 till 2020 before reaching about 3400 by 2025.

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[16] Whilst the estimates from the mega-projects reflect the results of careful planning, the estimates for some of these other sectors are pure (and wrong) speculation. As someone who has worked in this field for more than two decades, this author cannot support these other estimates.

[17] Procurement Dynamics (2008) Skills Audit (Demand Side) for the Council for the Built Environment (CBE). The author was one of the main researchers and authors of the report.

[18] Electricity was seen as a major component of the built environment growth scenarios.

[19] Only those built environment professions relevant to the electricity sector are discussed. The original report covered all professions. Whilst a few architects, property valuers and landscape architects will no doubt be needed, they would not be on the critical skills list.

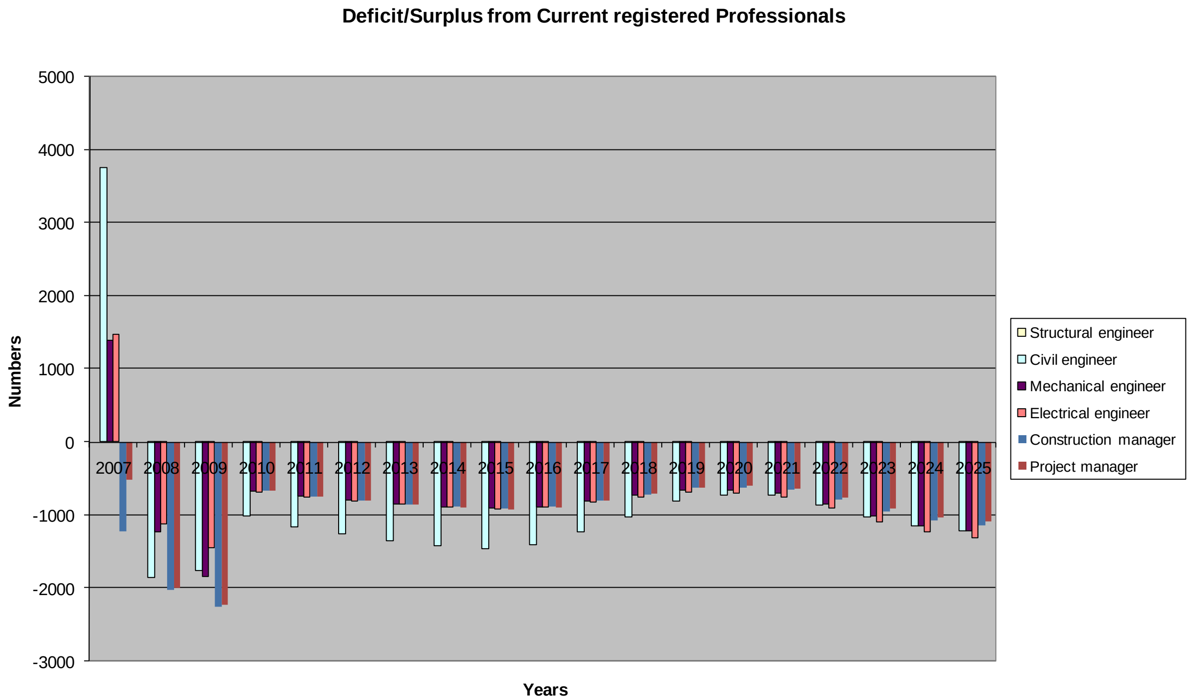
b) demand for structural engineers in the low scenario therefore rises from 1700 to about 2100 in 2012 where it hovers at this level until 2021 and then increases marginally to 2500 in 2025
c) demand for civil engineers is expected to grow from about 2200 to 3500 in 2017 before slipping back to around 3200 in 2025
d) demand for mechanical engineers rises consistently from about 1700 to around 2200 in 2012 and stays at this level till 2022 before taking off in the last three years of the forecast to reach about 2500
e) demand for electrical engineers increases marginally from 1800 to reach 2300 by 2012, stays at this level until the last three or four years when it should increase marginally to 2600.
f) demand for construction managers should moderate between a low of 1600 to a high of 2400 by 2025
g) demand for project managers varies from above 1600 to approximately 2400.

3. Under the high scenario

a) Demand for quantity surveyors rises steadily to about 9700 by 2025.
b) Demand for structural engineers increases steadily over the period to 7000 in 2025
c) Demand for civil engineers rises significantly and consistently to 9100 in 2025.
d) Demand for mechanical engineers grows linearly to about 7000 at 2025
e) Demand for electrical engineers sees an almost linear increase to about 7500 in 2025.
f) Demand for construction managers grows to around 6800 by 2025.
g) Demand for project managers rises steadily to 6700 by 2025

The projections merely provide an indication of the potential demand for built environment professional skills based on forecasts of future demand in the built environment. The low scenario, which now resembles the most likely scenario given the current slow-down, would result in a deficit

Graph 3.3 Anticipated shortfall in professional skills (low scenario)



Source: Adapted from data used in Procurement Dynamics (2008)

What is notable is that even under the low scenario the demand does not exceed current supply by more than a thousand with the exception of the immediate period.[20] Given that the supply is anticipated to grow by at least this number per annum,[21] it is unlikely that there will be a long-term deficit for these critical skills categories.

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20 Updated graph from Procurement Dynamics (2008) Skills Audit (Demand Side) for the Council for the Built Environment (CBE). It was not in our brief to examine the Supply Side so it is not possible to elaborate on future supply of these skills except in the broadest of manners. The CSIR which conducted the supply-side analysis did not provide a complementary approach so results cannot be easily aggregated. The CBE is currently conducting such and exercise but the results are not yet available to this author.

21 Merrifield, A et al (2006) Increasing the supply of Engineers and Built Environment Professionals, Technologists and Technicians, for the JIPSA Secretariat.

3.6 CBE Skills Audit (Supply Side)[22]

As noted in the introduction, the Supply Side Skills Audit sought to understand the supply for built environment professionals. Of the many aspects of the project, the study also sought to estimate the current and future supply of such professionals. Unfortunately, as noted above, the level of aggregation used in the study only allows us to make the most general of observations.

The study notes for instance that "data sourced from the statutory councils and national statistics indicate that there are about 50 000 BEPs in South Africa, of which about 35 000 are registered and 15 000 unregistered". These numbers by far exceed (by an order of magnitude of ten) the number of professionals likely to be involved in new electricity infrastructure supply.

The research sought, like the SAICE study, to understand both the inflows and outflows from the current pool of built environment professions and noted the following (emphasis added by this author):

> there are between 2,600 and 4,700 new positions available to BE (Built Environment) professionals in 2006, increasing to between 3,400 and 5,700 in 2011. The data on graduations indicates that there were an estimated 5,300 graduates seeking work as BE professionals in 2005 and that this number will increase to 7,200 in 2011. ***The number of potential employees, thus, exceeds the total number of positions available***, although the difference at the upper end of our estimate is not substantial. The projections indicate that, at current employment trends, the disjuncture at the level of absolute numbers will continue to widen. ***It is, therefore, unlikely that all of these graduates will be employed in the BE sector.***

The study went on to suggest:

> that the growth rate of BEP [built environment professions] university graduates (eight percent) exceeds the estimated growth rate of BEP employment (2.5 percent) and thus concludes that (emphasis added by this author):
>
> i) there are more BEP graduates than the BEP is currently employing; and
> ii) the central discourse on BEP skills should shift from the quantitative to the qualitative, particularly with regard to low-level and high-level skills and employability.

[22] CSIR Built Environment, Pretoria, January 2008, CSIR Report number CSIR/BE/CON/ER/2008/0061/B

> The study finds that BE programmes at tertiary institutions are producing about 8 200 BE graduates per year.[23] Most of the experts interviewed believed that this trend would remain more or less the same. Thus the study expects that an additional 13 752 graduates will be produced over the next five years. ***This exceeds by some margin the expected growth in BE employment.***

The report therefore concludes that the discourse on skills needs to shift from a concern about quantity (which it believes is being addressed by current graduations) to one about the quality of those obtaining professional qualifications:

> The study as a whole finds that generally there is a quality-deficit with regard to BE qualifications, specifically from an employability perspective, that the deficit is wider at the lower levels of registration, and that its causes are located in the drive to increase student numbers in BEP programmes, the decreasing number of skilled staff, and the poor level of schooling that many of the learners have, especially black learners.

3.7 General lessons from South African Literature

The above review of six major recent South African studies suggests that there may be a future professional skills deficit but that the quantum of demand is within manageable levels. All studies have sought to project future skills demands by understanding the level of demand in the industry as a whole, and three studies, CIDB, PCAS and CBE (Demand Side), this future demand is disaggregated into specific construction sub-sectors and mega-projects. Such an analysis reveals that much of the value of future infrastructure investment will be in materials, plant and equipment, and that the demand for professional skills is in the order of magnitude of hundreds and artisanal skills in the thousands. If, however, one were to decompose these hundreds and thousands, the demand for high-level specialists will be in the order of tens, and it is only in the more junior categories where there is a demand for a couple of hundred in each sub-sector.

It is important to note that such analyses shift the focus of discussion around skills shortfalls from that of quantity to one of quality. The discourse of skills shortfalls is therefore more about understanding the precise requirements

Finally, it should be noted that despite the concerns expressed in the earlier studies that the industry would not be able to cope with the 'sudden' increase in demand, almost six years after these early studies were initiated the industry is still coping, albeit at high levels of capacity utilisation. What this indicates is not that concern over skills shortages is misplaced (there is

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23 The report does not disaggregate beyond indicating that by 2011 about ten percent of these will be Architects and the remaining 90 percent non-Architects.

ample evidence discussed further below that skills constraints will continue to be a problem), but that it is reasonable to anticipate that the industry, and the professions, will also seek ways to mitigate these constraints. By so doing, the overall productivity of infrastructure delivery will improve.

4. Understanding the Demand for Fixed Investment

In many of the previous studies undertaken by the author, a comprehensive picture was presented of historical and future demand in the infrastructure sectors. The most recent of such analyses was completed in April 2008, and even though it anticipated the massive international recession that has materialised in the past three months, the projections made in April 2008 still incorporated the rather optimistic project announcements that were being made in most sectors till November this year. What follows therefore, is an abbreviated, but updated discussion of that forecast. The reason why it is important to analyse the infrastructure and construction sectors prior to focusing on the electricity sub-sector, is that many of the same contractors, engineering firms, equipment and skilled personnel will work in different infrastructure sectors. It is therefore useful to have some sense of possible competing projects when reflecting on skills requirements for the electricity sub-sector.

4.1 Forecasting future fixed investment demand

To forecast future demand for the infrastructure and related electricity sub-sector, it is necessary to first understand the historical trends that constitute current demand. Whilst the future does not necessarily follow past trends and there are occasionally some dramatic discontinuities, an understanding of the historical trends provides insight into the patterns of investment for different client groups and in specific construction and property sectors. There is no method of forecasting the future demand in different sectors with any great precision and such projections should be seen as part of an ongoing process rather than a final figure.[24] An examination of past trends will show that the investment in construction goods and services has shown large variations across client groups, economic sectors, construction sectors, and by asset type.

4.2 Gross Fixed Capital Formation

The first historical trend that should be considered is the Gross Fixed Capital Formation (GCFC) over the past four decades. The graph below shows that since 2004, South Africa has exceeded all previous levels of GFCF (previous highs in the early 1980s) and also shows the long decline in the 1990s which has contributed to current supply-side constraints. In the past three years, GFCF has increased 39 percent more than the historic highpoint in the 1980s and 69 percent since the beginning of the investment upturn in 2000. As can be expected, such increases, even if not anticipated by future expansion, would have already placed a significant burden on the current skills pool.

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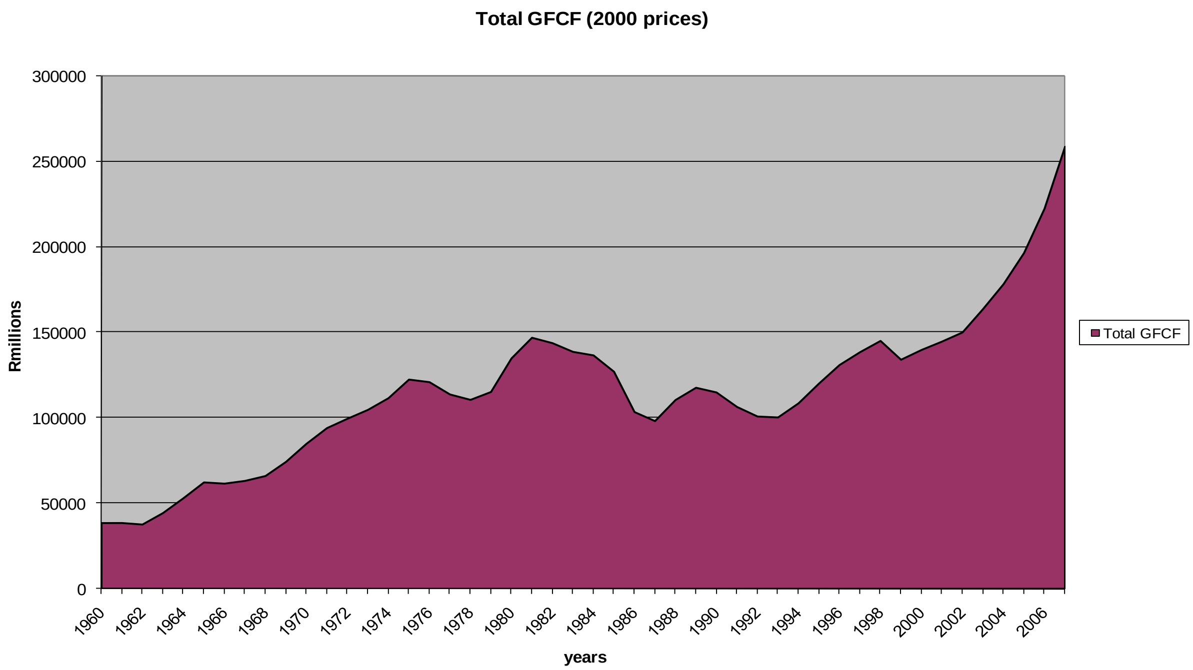
[24] Wilson, R., Woolard, I. and Lee, D. (2004) *Developing a National Skills Forecasting Tool for South Africa*, Warwick Institute for Employment Research, Warwick

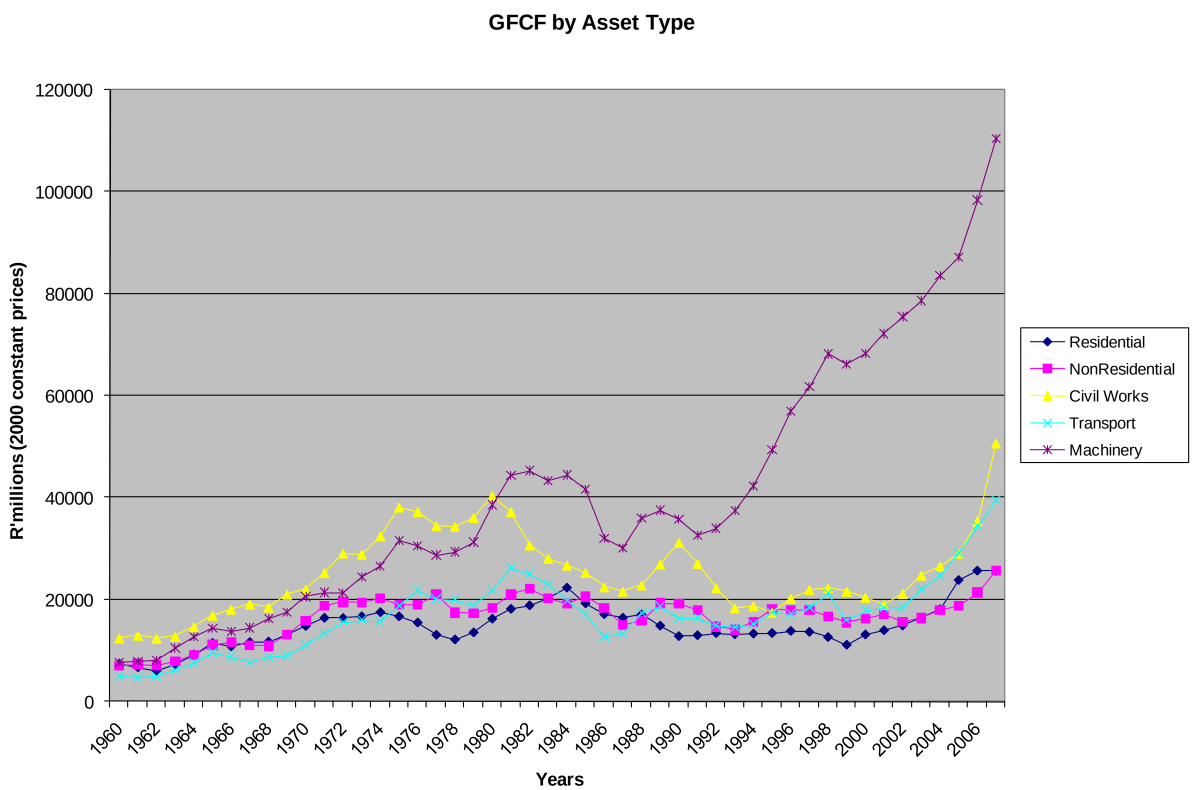
Graph 4.1: Total Gross Fixed Capital Formation



Source: SARB Q42008

Although GFCF has increased beyond the historical highpoint, not all of this increase has occurred in the construction sectors. Examining the GFCF by Asset Type indicates that machinery, equipment and transport contribute significantly to this growth in GFCF. Whilst it is useful to discount these sub-sectors when considering the demand for construction skills, it should be noted that machinery and equipment and transport make up a significant component of the electricity projects which constitute a large part of current infrastructure investment expansion (see forecast below).

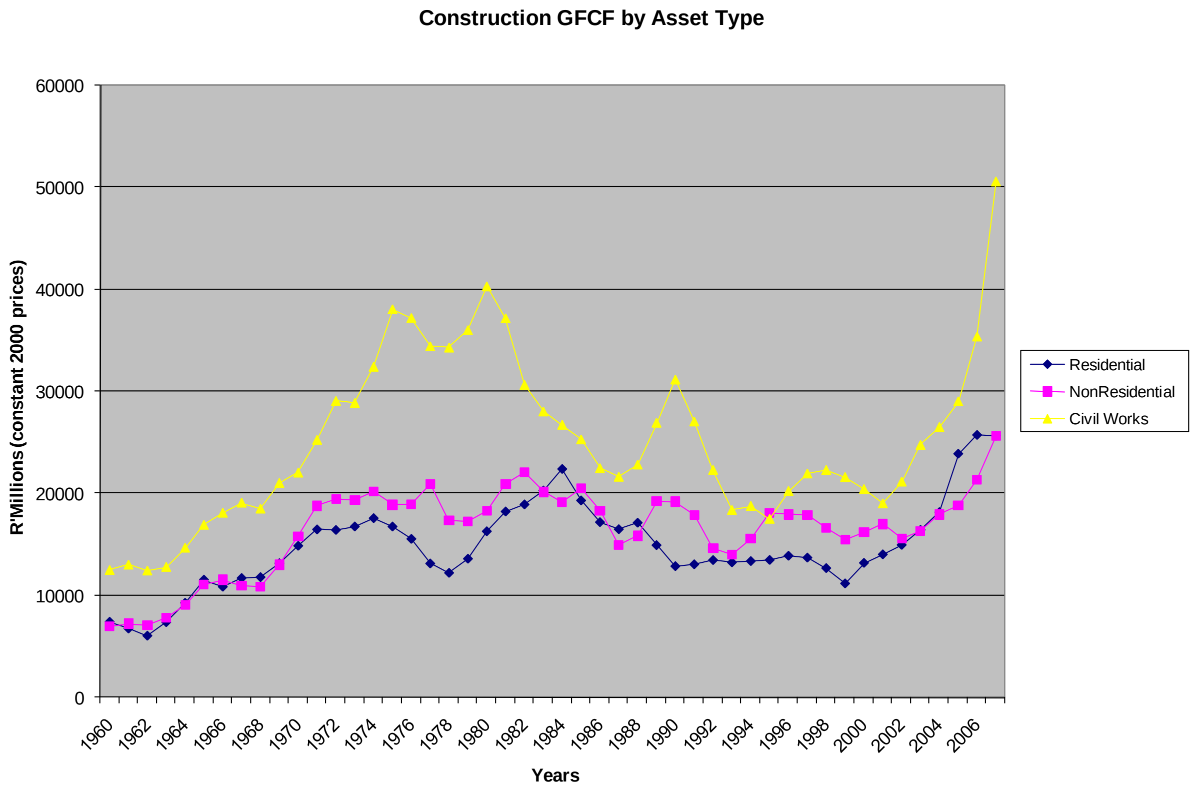
Graph 4.2: Gross Fixed Capital Formation by Asset Type



Source: SARB Q42008

The construction-specific GFCF shows that the rise in investment is not as significant as shown above. Civil works has seen the largest increases and declines, followed by residential and then non-residential construction. These sectors are only now approaching the traditional 1980s high-point, and only in the last year has construction works, largely due to the new coal plants, exceeded the previous high.

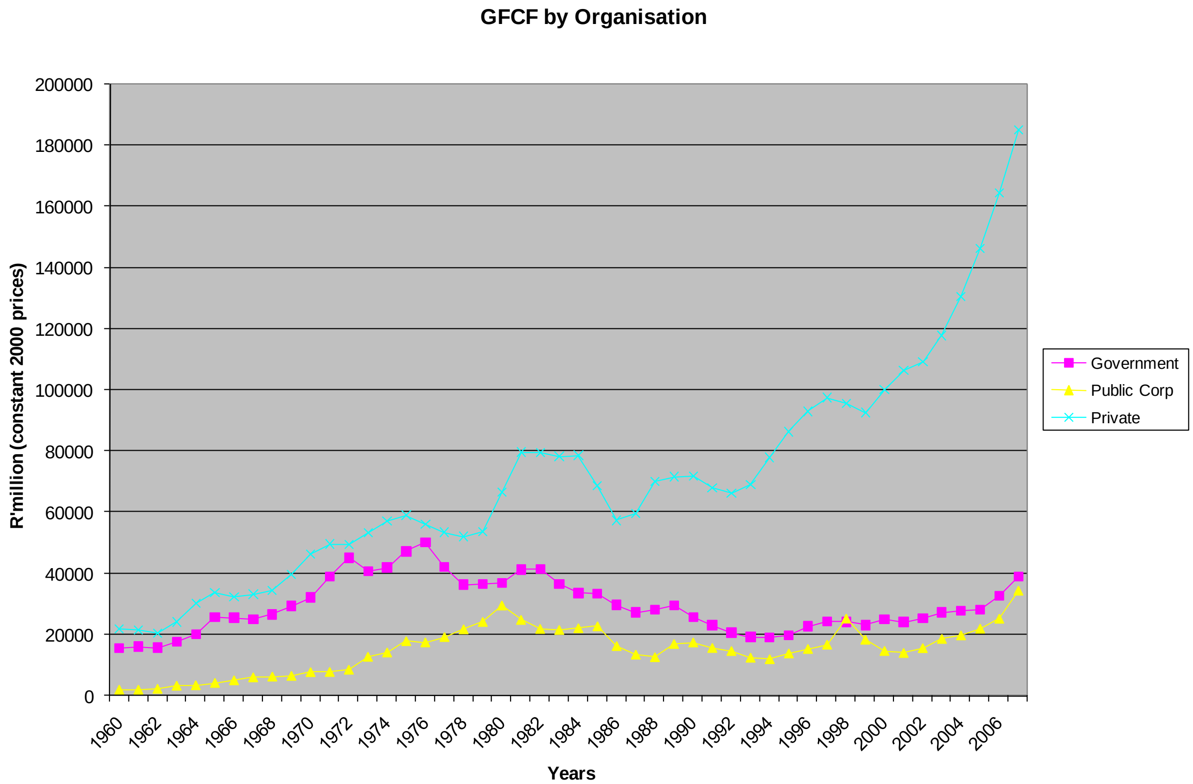
Graph 4.3: Construction GFCF by Asset Type



Source: SARB Q42008

To conclude this brief discussion on GFCF, we find below that the private sector has been the main driver of such investment over the whole historical period. Over this long historical period private sector growth has by far outstripped both the public corporations and the public sector, although in recent years the public corporations have shown a modest improvement. The decline in GFCF during the 1990s is also primarily a result of the public sector and public corporations reducing their investments. We, however, anticipate the future growth to come from these two sectors.

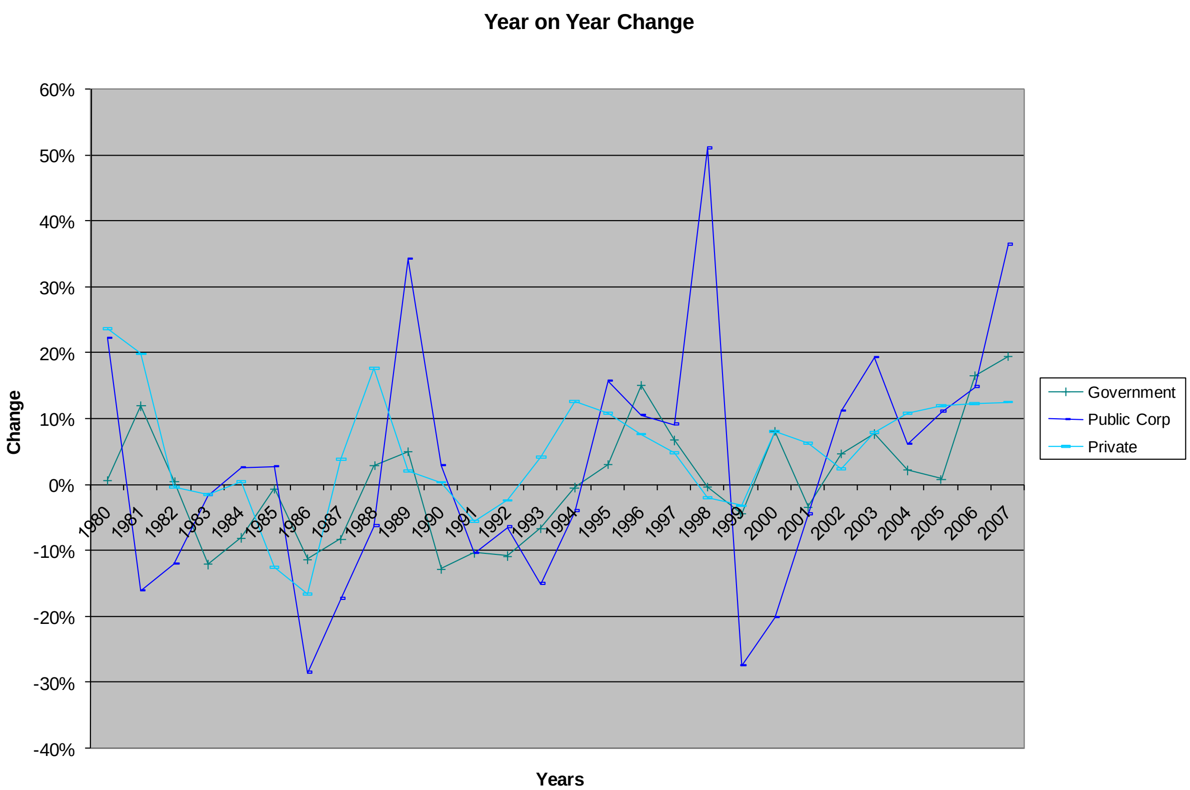
Graph 4.4: Gross Fixed Capital Formation by Organisation



Source: SARB Q42008

Examining the year on year variations by client groups, we find that the private sector was the main driver of such investment, and it was also the most consistent in its investment flows over the four decades. The public sector, and especially the public corporations, show extreme variations year on year. Such variations of course make capacity building and skills development a lot more difficult. We will return to this argument in Section 9 below.

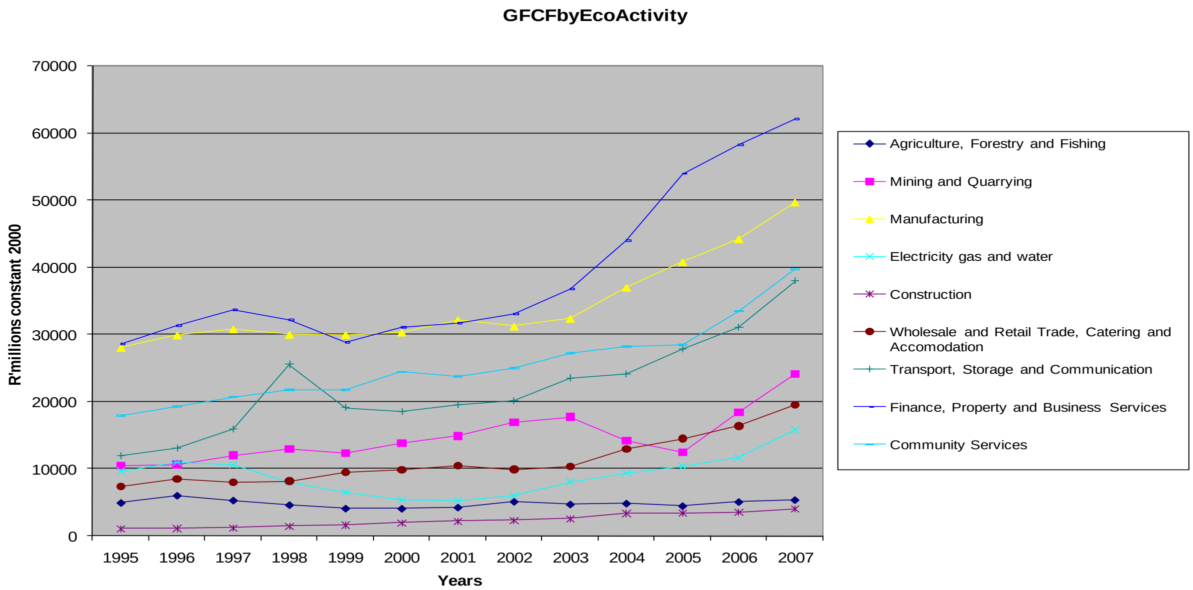
Graph 4.5: Year on Year Change in GFCF by Organisation



Source: SARB Q42008

It is useful to understand which sectors have contributed most towards this growth in fixed investment described above. From the graph below, it can be seen that finance, property and business services have been the lead sectors closely followed by manufacturing and community services.

Graph 4.6: Gross Fixed Capital Formation by Sector



Source: SARB Q42008

What is not so evident from the above graph but what can be seen below is that electricity, gas and water has shown a 122 percent growth in the past six years (2002 to 2007) and reflected the highest growth of all sectors in the six years but especially in the last year recording a growth rate of 35 percent for 2007. It should also however be noted that in the six years previous to the growth phase (1996-2001), electricity, gas and water reflected a decline of 52 percent. There can be little doubt that this decline, with a resultant loss of skills,[25] contributed significantly to the skills shortages in the sector once it began its turnaround.

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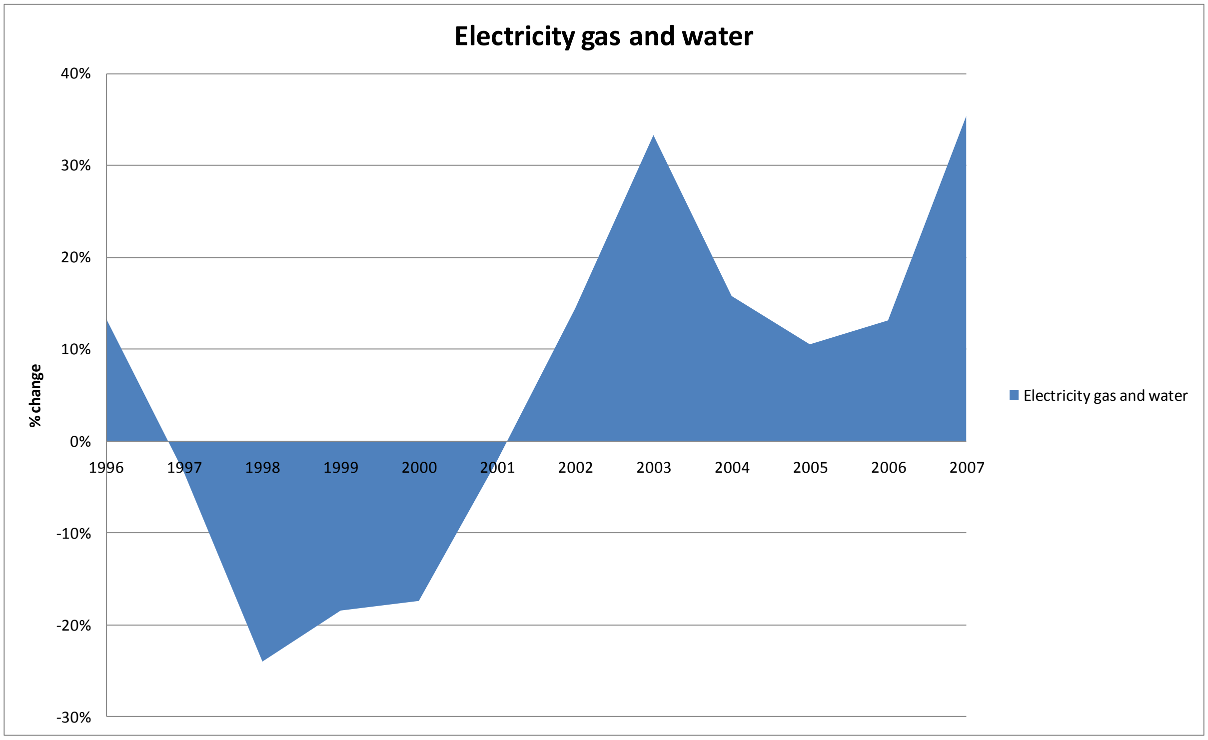
[25] In almost all the interviews cited in this report, people spoke of the period of stagnation and decline where their skills complements were eroded.

Graph 4.7: Year on Year change of GFCF for Electricity, Gas and Water



Source: SARB Q42008

4.3 Mega-Projects

Mega-projects have the potential to upset longer-term trends in the South African economy because these projects have a major once-off impact on the relatively smaller construction economy. In the past, such projects as Mossgas, the various SASOL projects, the aluminium smelters, Eskom's power station building spree in the 1970s and 1980s have accounted for the main volatility in fixed investment (see above graphs of GFCF). At present, a large number of such mega-projects have been announced. To get a handle on these mega-projects and their impact on construction economy, the Nedbank Project Listings[26] were consulted along with the Engineering News database from which the Nedbank listings are compiled. Whilst these data sources are the best record of future projects, there are a few problems associated with making use of them without further interpretation.

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[26] Nedbank Capital Expenditure Project Listing 1 January 1993 to 30 June 2008, 25 August 2008 is the latest consulted. The author has reviewed this source for the past three years and the observations made in the main body are based on this review.

Firstly, there is some discrepancy between the two listings largely due to the manner in which project announcements are classified mainly in the Nedbank listings. For instance, a company may announce an investment programme worth a significant amount, and then later announce some of the specific projects that make up that investment programme. Secondly, there are some projects in the Nedbank listings that may not be in the Engineering News data due to classification differences (what is a large project or not). As a result there are differences in the two project listings of close to 50 percent.[27] An informed assessment of these differences suggests that 60 percent of that is due to the first problem and 40 percent due to the second.

However, it is not considered useful to explore these differences further because of an even more significant problem. Both project listings record the intentions of the investors, and although they update the status on the projects (more so the Engineering News) the data is still classified largely by value. What is at stake here is both the certainty that the project will go ahead and the timing of the project. It is generally agreed that the probability of a project going forward increases as the project moves from a scoping exercise (five to ten percent) to pre-feasibility (10-25 percent) to bankable feasibility (25-75 percent) to a fully funded project (75-100 percent). All these probabilities are rules of thumb, and individual projects will vary significantly.

The manner in which listings are assessed can express large variations. Some of this variation may be in time, in other words a project may be delayed for a number of years, and some may result in cancellations. What it does suggest however is that there is at least a lag in the project listings and in some cases that these announced projects may never materialise (thus out of the forecast). From a historical perspective, the GFCF figure differs significantly in some years (1994-1998, 2001-2003, 2007) from the Nedbank listings.[28] This can in part be attributed to the lag factor discussed above and in part due to the fact that some projects may never have proceeded and others, mainly smaller projects, may have been excluded by the listings. In this discussion below the listings are used but adjusted qualitatively with appropriate assumptions.

By making use of the Engineering News project database and adjusting for the above difficulties (including factoring in a lag for projects in the feasibility stages) it is possible to project a trend of projects going forward ten years. There is an immediate bulge of listed projects that are on-going or just starting. With the exception of some mega-projects in electricity and petrochemicals, many of the listed projects will be completed within five years.

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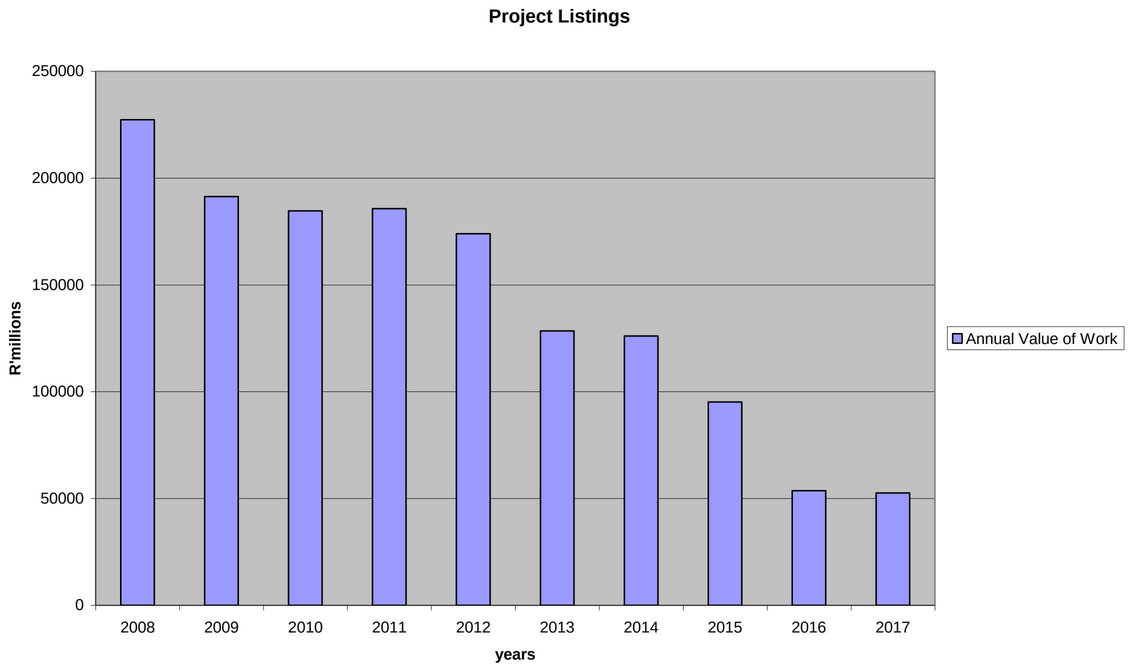
[27] This assessment was done by the author on the basis of the Nedbank Project Listings for the past three years and the Engineering News database.

[28] Nedbank Capital Expenditure Project Listing 1 January 1993 to 30 June 2008, 25 August 2008

Graph 4.8: Mega-Projects



Source: Engineering News Database[29]

It is expected that new listings will replenish the stock of projects going forward so this declining trend must be viewed as being less and less reliable when projecting forward more than five years. As noted from the previous discussion, the public corporations are expected to lead with the mega-projects in the next five to ten years as the private sector demand seems to be softening. Breaking down this forward projection into sectors reveals that mining and electricity are key drivers in the early years followed by transportation and industrial projects. Over the decade, the electricity projects dominate and the prospect of a major petro-chemicals project sustain demand.

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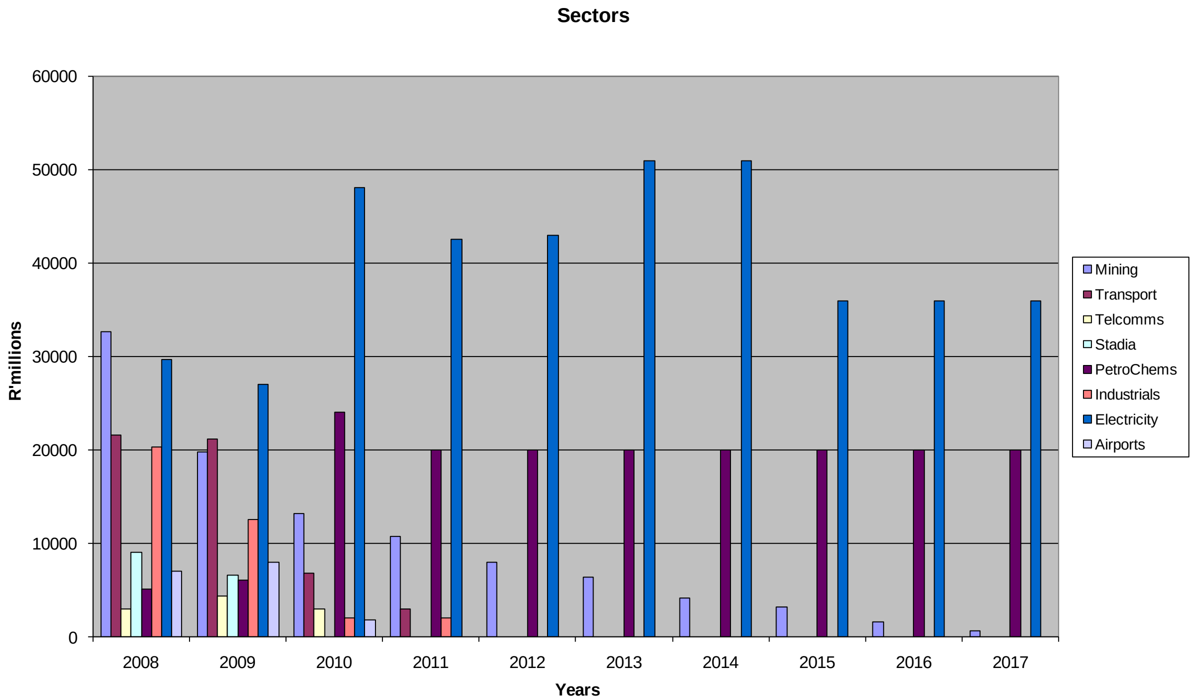
29 This analysis was first done in April 2008 and revised in September. Since late November there has been a rash of announcements concerning the postponing of many mining projects. This information is too new to have been added to the Engineering New Database. It would perhaps be more useful to do such an analysis once the majority of announcements have been made.

Graph 4.9: Mega-Projects by Sector



Source: Engineering News Database

It is worth noting that some sectors including the 2010 stadia, telecommunications and water[30] hardly affect the future project trend at all. As suggested above, over the next couple of years some sectors such as mining and industrials (manufacturing in the historical data discussed previously) may be expected to restore their current level of demand but it can be expected in light of recent announcements that some of these projects will be postponed and/or even cancelled. In the case of the electricity, transport and petro-chemicals projects, these are more likely to be once-off additions to current capacity.

[30] The water projects were too insignificant to feature on the chart.

5. Future Demand for New Generation Facilities

There have been a number of documents that were prepared to provide information on the future demand for electricity infrastructure in South Africa. These include the Integrated Strategic Energy Planning (ISEP) conducted by Eskom and the National Integrated Resource Plan (NIRP) developed by NERSA.[31] The purpose of this discussion is not to attempt to analyse or critique these projections but to make use of them to determine the future project mix required to determine skills requirements. Both plans use a 2026 end-date.

In terms of the NIRP projections, they forecast a low maximum demand of 59 863 MW assuming an average annual growth in GDP of 2.69 percent and an average annual growth in electricity demand of 2.55 percent and a high maximum demand of 101 571 MW in 2026 assuming an annual average growth of GDP of 6.06 percent and an annual average growth in electricity demand of 5.29 percent .[32] NERSA's medium projection assumes a 4.74 percent annual growth in GDP and an annual 4.17 percent growth in electricity demand to reach a maximum demand of 81 910 MW in 2026. The NIRP3 conclusion is that:

> To meet the 19 percent reserve margin there will need to be more than 60,000 MW of new capacity built by 2026. A combination of fast growing demand and planned decommissioning of existing older power plants will require new capacity to be brought on line almost every year in order to maintain the 19 percent reserve margin.[33]

In reaching this conclusion, the NIRP3 noted that:

> Today there is about 45,000 MW of capacity (including contractually interruptible loads) available to serve an expected peak demand of approximately 40,000 MW. The reserve margin in 2008 not including interruptible loads is about six percent. The current reserve margin in South Africa today is well below the optimal 19 percent target reserve margin. This low reserve margin has left the South African electricity grid vulnerable to service interruptions and blackouts.[34]

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31 Obviously, ESKOM did not make their current ISEP available and the author worked from information provided in the 2008 Annual Report although the author is aware that a new ISEP is in preparation. In the case of the NIRP, the latest documentation available indicates a February 2008 date although the latest demand projections were provided in January 2007. NERSA also indicated that further work is being done on the NIRP.

32 Updated National Demand Forecast NIRP 3 January 2007.

33 Stage 4 Report – 5 February 2008.

34 Stage 4 Report – 5 February 2008.

The key points we can take away from the NIRP3 discussion, is that we can assume a current supply of around 40 000 MW, and depending on the rate of economic growth over the period till 2026, we can therefore expect that there needs to be an additional 20 000 MW, 40 000 MW or 60 000 MW depending on whether South Africa experiences a low, medium or high growth scenario. What matters in the following discussions should be the orders of magnitude not necessarily the actual numbers.

The NIRP3 provides some analysis of the supply constraints. These include the suggestion that by 2026 around 10300 MW will be decommissioned (including about 7000 MW from Eskom's Camden, Arnot, Hendrina, Komati and Kriel coal-fired units starting around 2020) and between 1100MW and 1500MW from the expiration of interruptible load contracts between 2013 and 2026. In terms of new demand, the NIPR3 identifies that an additional 10 789 will come on stream by 2013 from current projects including 4428 MW from new coal stations (Medupi but not Kusile), 1322 MW from pumped storage (Ingula but not Lima) and 2140 MW from refurbishment (Grootvlei and Komati) the rest from gas, cogeneration and peaking plants.[35] Of most importance, is the NIRP3 assessment of the potential for certain types of electricity generation in the future.

Table 5.1: NECSA assessment of the availability of new capacity

New Resource Availability

Option	Possible Earliest On Line Year	Unit Size	Year	Annual Units	Annual MW	Total Units	Total MW
PFFGD	2012	774	2012	2	1548	84	65016
			2013	4	3096		
			2014-2026	6	4644		
CCGT	2011	387	2011-2026	3	1161	48	18576
Nuke	2013	800	2013-2026	2	1600	28	22400
OCGT	2010	120	2010-2011	6	720	Unlimited	Unlimited
			2012-2026	Unlimited	Unlimited		
PS	2013	371	2013-2026	4	1484	56	20776
DSMEE	2007	152	2007-2026	1	152	20	3040
CFBC	2013	150	2013-2026	2	300	6	900

Source: NIRP3 – Stage 4 Report

The value of the above analysis is that it provides an estimate of the types of plants that can be built to address the future supply shortfall. What is evident, is that the technologies which have the most potential to address the future power generation requirements include coal (Coal-fired pulverised fuel with Flue Gas Desulphurization – PFFGD), which could provide up to 65 000 MW assuming a build rate of between 1500 MW (2 units) and 4600 MW (6 units) a year starting in

[35] Stage 4 Report – 5 February 2008.

2012, nuclear (both conventional pressurised water reactors and the Pebble Bed) which could provide around 22000 MW by 2026 or about 1600 MW (2 units) a year, pumped storage (PS) which could provide about 20000 MW at a rate of 1500MW (4 units) a year and gas (Combined Cycle Gas Turbine – CCGT) which could provide almost 19000MW at a rate of around 1200 MW (3 units) a year. The NIRP3 also indicates that the potential for renewable energy is limited to perhaps 900 MW due to environmental constraints.[36]

The selection of the particular technology mix of generation facilities is mediated largely by the fixed and operating costs of the different units as well as other factors discussed below which would mean that we can expect the coal plants to make up the vast majority of new plants followed by nuclear.[37] As we will see when we review the ISEP projections, Eskom reached a similar conclusion. In the next section, we will make use of these projections to quantify the types of skills required. It is possible to project the skills required for different types of facilities and then aggregate depending on the mix of technologies used.

The Eskom ISEP process comes to the same conclusions as the NIRP3 study. Even though Eskom focuses on its own build programme and not the national picture like the NIRP3 study, it makes similar assumptions about demand and the technology mix for new generation. The ISEP recognises that coal generation is likely to make up the largest proportion of new build, Eskom is hoping to limit that to less than 70 percent. Nuclear and hydro generation projects are likely to make up the balance of between 17 and 28 percent whilst pumped storage may provide between six and ten percent and renewables are likely to just exceed two percent. Gas turbines are mainly to be used to address peaking demand[38].

[36] Stage 4 Report – 5 February 2008.

[37] There are a limited number of localities for pumped storage and gas plants have higher fuel costs.

[38] Eskom Annual Report 2008; Status Report on New Capacity Projects (April 2009).

Table 5.2: ESKOM projections of new capacity

MW	F2009/2010	F2010/2011	F2011/2012	F2012/2013	F2013/2014	F2014/2015	F2015/2016	F2016/2017	Total
Grootvlei (Coal Fired)	800								800
Komati (Coal Fired)	125	325	300						750
Arnot (Coal Fired)	70	30							100
Medupi (Coal Fired)				1588	794	1588	794		4764
Kusile (Coal Fired)					1600	800	1600	800	4800
Ingula (pumped storage)				338	1014				1352
Annual total MW	995	355	300	1926	3408	2388	2394	800	12566

Source: Eskom Status Report on New Capacity Projects (April 2009)

In terms of the new-build programme so far, resources have been focused on coal refurbishment projects (Camden, Grootvlei and Komati) and open-cycle gas peaking plants. These refurbishment projects have already provided around 2200 MW since 2005 and will provide an additional 1650 MW by 2011/12. In terms of the open-cycle gas turbines, 1043 MW have already been commissioned (seven 149 MW units) and an additional 1043 MW were anticipated by 2009.[39] It can be assumed that firms and individuals working on these projects will be available to work on the future build programme depending on their role in the project cycle. Therefore those initially involved in design and commissioning should have already moved onto new projects, those involved in construction should be coming available around now and those involved in project management and commissioning should become available from 2009 onwards.

Eskom has also started on two coal generators (Medupi and Kusile at approximately 4800 MW each) and one pumped storage (Ingula at around 1300 MW to be completed by 2013/14). The first coal unit will come into operation in 2012/13[40] at Medupi followed by three units a year (two at Medupi and one at Kusile alternating per year) till 2015/16. In 2016/17 the final two units of Kusile will be completed.[41]

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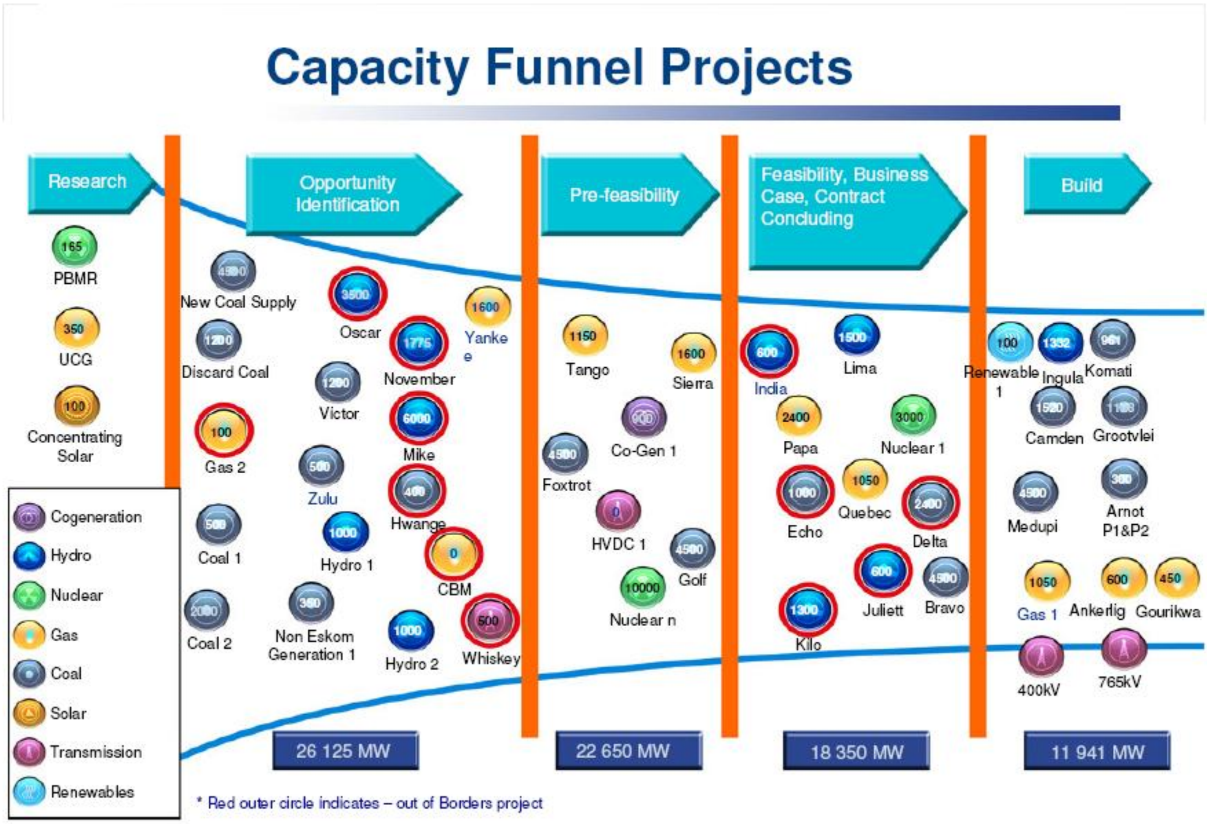
39 There are currently negotiations underway to finalise an IPP 'peaking' project using OCGT technology.

40 For ease of comparison, we refer to a unit comprising the complete power train (boiler, turbine and generator, fuel and waste handling equipment, control and instrumentation and construction works) sufficient to produce between 500 and 750 MW. Each unit will operate as a separate power-station although these are combined in the case of Medupi and Kusile into so-called 'six-packs'.

41 Eskom Annual Report 2008; Status Report on New Capacity Projects (April 2009).

A description of the projects underway can be found in the project pipeline presented to NIASA in February 2008.[42]

Graph 5.3: ESKOM's Project Pipeline



We can see that all the above-mentioned (coal, RTS, and gas) projects are covered under the build phase with the exception of Bravo (now Kusile) which was in the second (feasibility, business case and contract concluding) phase. It is interesting to see that there are no other coal projects are identified locally (only two external projects) in the second phase. There are a number of gas projects and one nuclear project (more about that below). The only other local pumped storage scheme (Lima) is also in this second phase along with several external pumped storage projects. Whilst it would be wrong to assume that these external (mainly SADC) projects won't proceed, they are also likely to be subject to the same (if not greater) constraints as the local projects. It is instructive that the additional local coal (9000 MW) projects (Coal 3 and 4) and additional (10 000 MW) nuclear projects are largely in the third (prefeasibility) phase and are unlikely to proceed within the next five years. If Graph 5.3 reflects Eskom's planning as of

42 Eskom presentation to the NIASA Manufacturing Sub-Committee, 14 February 2008. In 2006, Braam Conradie took me through a similar analysis.

February 2008, it is likely that the current situation (post-world recession) may present a more pessimistic viewpoint going forward.

A decision on the nuclear plant (3500 MW) was pending during the research period for this report. There was of course a lot of ‘chatter’ as to whether the nuclear project will proceed and to what extent the fleet will be commissioned and announcements regarding the future of the nuclear programme were imminent.[43] On 5 December 2008, it was announced that the nuclear project (Nuclear 1) would not go ahead due to adverse financial conditions.[44] Whilst government endorsed the Eskom decision to postpone the nuclear project, it reiterated its support for nuclear projects in the future. Portia Molefe, Director General at the Department of Public Enterprises noted at the press conference “The South African government remains committed to introducing nuclear because we have to deal with our carbon footprint and we have to diversify our energy mix”.[45]

Given that nuclear projects have a six to eight year project cycle largely arising from the design and manufacture of the nuclear pressure vessel it is unlikely that local skills will be required for such projects till after the initial peak demand for such skills arising from the two coal projects (see discussion below). Eskom actually reflected this in their planning for Nuclear One. Their NIASA presentation in February 2008 suggested that if a preferred bidder was selected in June 2008 and a limited notice to proceed awarded (which would enable the main components to be ordered from OEMs), then construction could be expected to commence in January 2010 with the first unit going into commercial operation in 2016.[46]

On 12 January 2009, it was indicated that the nuclear may be completed by 2019.[47] Given the projected eight year cycle, it is possible that the project will be commissioned around 2011. As things stand, the only likely nuclear project in the 2008-2012 period is the PBMR demonstration project which is planned to be constructed around 2012 although much of the research and

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43 The Department of Minerals and Energy would publish its Nuclear Energy Policy by the end of the week (ostensibly the 14th November 2008), said Department of Minerals and Energy (DME) acting DDG of hydrocarbons and energy planning Tseliso Maqubela on the 13 November 2008 (Business Report, 13 November 2008).

44 Business Day 5/12/08.

45 Business Day 5/12/08.

46 Eskom presentation to the NIASA Manufacturing Sub-Committee, 14 February 2008.

47 Nelly Ngubane, DDG DME, Business Report and Engineering News 12/01/09.

design is on-going. This is a relatively small project (165 MW) and it is therefore unlikely to make a large impact on the skills required for the conventional coal projects.[48]

Nellie Ngubane, DDG for Energy at DME, indicated that notwithstanding the nuclear decision, approximately 18 000 MW from other (mainly coal) projects will come on stream by 2017[49] but it is unlikely that this can happen directly through the Eskom new build programme. We can therefore assume that at least some of the proposed 4500MW announced potential IPP Base-load project will be commissioned. There is currently little indication when, and if, Eskom will proceed with the process.

Eskom is still sorting out the institutional and market arrangements for the proposed Independent Power Producers (IPPs).[50] There are in fact three programmes which introduce new private sector investors into the generation market:

- Pilot National Cogeneration Programme (PNCP) to secure about 900MW of cogeneration capacity;
- Medium Term Power Purchase Programme (MTPPP) for power supply solutions ranging from 5MW to 1000MW that have the ability to reach commercial operation by at the latest 2012;
- Multi-site Base Load Independent Power Producer Programme ('Base Load IPP Programme') to provide between 2100MW and 4500MW of base-load capacity.

Cogeneration which uses waste heat (and gases with low calorific value) from industrial processes is expected to provide up to 900 MW, a realistic target given the limited number of potential sites.[51] Although there has been some progress towards identifying such cogeneration prospects, as one participant indicated as late as December 2008[52]:

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48 Obviously the PBMR draws significantly on the research and engineering design communities but these skills are largely in place and are also unlikely to be in competition with those used for other conventional projects. We'll discuss this further below.

49 SABC News 5/12/08

50 Bidders Guide to Power Purchase Programmes 13 May 2008

51 The author helped develop one of the more recent cogeneration opportunities in the market. There are a limited number of industrial processes in the country that produce a sufficient and continuous flow of heat or gases that can be converted into cogeneration projects.

52 Engineering News 24/12/2008

> Eskom, the National Energy Regulator of SA and the minerals and energy department are supportive of independent power producers but that needs to manifest rapidly in realistic legislation, policy and an enabling environment.

Although Eskom announced that it would unveil their approved cogeneration (and MTPPP) projects in September 2008, nothing further has been announced. The MTPPP is also intended to relieve short-term demands and it is expected to be phased out in 2017 (although it is assumed that some projects may be incorporated into the Base-Load IPP). Like the cogeneration (and Base-Load IPPs) these projects seem to be waiting for a policy framework.

The Baseload IPP programme is expected to have the most impact in addressing the current and future supply shortfalls with the potential of as much as 4500 MW. Although 23 bidders have now been pre-qualified in November 2008, the process of requesting proposals, originally scheduled for that month was first extended to February and now May 2009:[53]

> Eskom wishes to announce that it has extended its postponement of the release of the request for proposal (RFP) for its Base Load Independent Power Producer (IPP) Programme to May 2009, at the earliest. This is in order to allow the regulatory environment to follow its due process of public comments, consequential revisions and final sign off by the State Law Advisor. It includes the draft regulation on new generation capacity, which was gazetted on 30 January 2009. This postponement follows an initial delay of the release of the RFP due to the finalisation of the regulatory framework and government support package needed to successfully support the Base Load IPP Programme.

It is therefore unlikely that bidders will be short-listed before the end of 2009 given the time it will take to prepare and submit proposals (minimum of six months), and then to adjudicate these proposals and select a limited number of preferred bidders from the pool of 23 pre-qualified bidders (between three and six months at a minimum). It can be anticipated that at the earliest, financial closure may be reached by the end of 2010, suggesting that the earliest that any of these projects can begin design and construction (and hence require significant skills) is likely to be in the 2011-2012 period.[54] Anticipating a three to five year project cycle for the larger projects,

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53 3 March 2009 – Eskom Media Release.

54 These assumptions are based in part on the process currently underway through Eskom to commission an IPP peaking plant. Such peaking plants (OCGT) are somewhat less complicated technologically requiring only that the turbine/generator set be connected to a fuel source (gas/diesel). The engineering and construction components are significantly less than those required for a green-fields coal or nuclear plant (discussed further in the next section). The negotiations to reach financial closure on the IPP peaking plant are in part delayed by the same regulatory vacumn that affects the other IPP projects although financial closure was announced by Eskom to be January 2009.

would suggest that it is unlikely that there will be serious competition from the IPPs for such skills before the 2012 period (for design and procurement) and the 2014 period (for construction and commissioning). Excluding the smaller projects therefore, we can perhaps assume that if all goes well in the procurement of these IPPs that the market may have to cater for the skills requirements of an additional unit or two at this time.

One issue that has not been fully explored in the discussion above is whether the assumptions about future demand are justified and whether or not, like the 1980's, we could over-invest in electricity generation capacity. Obviously the impact of such a misjudgement on skills demand will be dramatic. If we discover in the next couple of years that our assumptions about electricity demand are too optimistic, then is it likely that future projects will be postponed, or even cancelled, and the skills requirements in the sector will be smoothed out (that is, a greater number of those currently employed will be moved onto future projects and, as a result, the demands for new skills reduced significantly).

There is already talk, or more correctly, gossip, that indicates that the immediate problem with the low reserve margin has been addressed and that in fact we may have already over-invested in peaking capacity (one of the reasons why it is believed that the second pumped storage project was postponed recently). There is some evidence already that with the current global economic crisis that electricity demand has plummeted in recent months. Data released by Statistics South Africa showed the estimated consumption of electricity in South Africa in January 2009 declined 7.0 percent year-on-year compared with an 8.4 percent drop in December 2008.[55] Total volumes were reported down to 17,918 gigawatt-hours (GWh) from 17,541 GWh in December compared with 19,261 GWh a year ago.

Whilst it can be expected that the global economic slowdown, and especially the closure of major electricity users such as the smelters, is largely responsible for this state of affairs, there is a possibility that other factors may influence the demand for electricity in the future. One of the most fundamental of these factors is the price of electricity which has not historically reflected the true cost of production in South Africa.[56] A recent (and as yet unpublished) paper from the

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55 Electricity consumption slumps seven percent y/y, I-Net Bridge, 5 March, 2009

56 The author made these remarks at the DPRU conference in October 2008 as a discussant on Rob Davies's paper, 'Electricity shortages and the South African Economy'. The comments suggested that electricity supply and demand could not be considered without reference to price. The issue refers to basic economics but such basic economics are absent from most analyses of the electricity value-chain.

University of Pretoria has sought to understand the impact of prices rises on electricity demand in the future.[57] Using econometric analysis on three different growth scenarios, the author indicates:

> According to all three scenarios, the demand for electricity will decline after the price restructure that is being promoted by Eskom and the National Energy Regulator of South Africa (NERSA) for the period until 2009. Furthermore, significant forces that drive the fall of the electricity use are also the lower population growth and the lower, more stable, economic growth of the country. More specifically, South Africa can experience up to 56 percent decrease of the electricity demand (comparison of 2005 to 2020 values) if Eskom continues increasing the average prices annually and the country's economic growth will not exceed the three percent level. On the contrary, if Eskom keeps the prices constant after 2009, the decrease in demand (comparison of 2005 to 2020 values) will be closer to 33 percent if the country can reach the target of six percent economic growth.

In any of these scenarios we can expect a decline in demand from current levels as a result of current and future price increases. The author concludes "[b]ased on our findings, the needs of Eskom for funding in order to expand current power plant capacity can be questioned". It is therefore also appropriate to conclude to acknowledge that if the demand scenarios upon which the skills requirements are assessed are shown to be too optimistic in light of expected price rises, then the skills demand in the future is all the more likely to be manageable.

Given the above analysis of the potential new build, we can assume that until 2012, only one unit of coal will be built and another three units will be in the process of being built (using one year construction cycle per unit). Obviously, the earth and civil works on both coal projects have already started but the procurement of the large items (boiler, turbine, generators) will delay the actual completion of these units till the above dates.[58] In terms of skills requirements, we can therefore assume that there is sufficient lead time to train, qualify and code even the most sophisticated of artisanal skills (discussed in detail in the next section). From 2013 onwards, the potential number of coal units coming on stream per annum increases to three (ISEP) or four (NIRP3) and can possibly encompass six units a year of coal from 2014.

We can also expect that there are some overlapping resources from the proposed and committed gas and pumped storage projects.[59] Depending on whether Eskom will proceed with a nuclear

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57 Roula Inglesi, Aggregate Electricity demand in South Africa: Conditional forecasts to 2020' unpublished paper made available with permission.

58 Eskom New Build News January 2009.

59 The other area where there is some, but limited, overlap in skills demand, is in the transmission and distribution capital expenditure. This will be covered in Section 8.

project, there may be some competition for these skills, but, as will be suggested, it is unlikely that this will occur during the peak demand for skills for the coal projects. Given the long lead times for nuclear, it can be assumed that there be will sufficient time to prepare for artisanal skills for both manufacturing and construction for two units a year (NIRP3 estimate).[60]

Key to the analysis in this report is an assumption that although there will possibly be significant competition for skills around the more generic construction and erection skills categories, it is expected that there is less likely to be competition for the more specialised artisanal skills used to construct the boiler, commission the turbine and generators etc. which are more technology and product specific. However, as the above information reflects, the time required to reach the stage where these specialist skills are necessary, should be sufficient to ensure that enough specialised artisans will be trained, qualified and coded to become available when required.

[60] Given that the high cost of nuclear power plants was cited for postponing the decision to proceed with such projects at this stage, it is unlikely that the ambitious 'fleet' programme will be undertaken and, as a result, it is unlikely that the full extent of 'localisation' will be pursued. We will return to these questions below.

6. Capacity Requirements for Electricity Operations and Future Projects

Section 5 of this report provided some indication of the potential scope of work for new build in generation (transmission and distribution are dealt with in section 8 below). In this section, it is intended that the skills requirements for this new build programme are spelt out. Given that the largest and most complex projects lie in the generation side, it is safe to assume, with some exceptions, that the most extensive demand for skills will be here. As we noted above, there are currently two return-to-service projects underway (1600 MW still outstanding) and one capacity enhancement (270 MW), two large-scale coal projects underway (9606 MW), one pumped storage project (1352 MW) and two gas projects to be completed.[61] In addition, 23 bidders have been shortlisted for base-load IPP projects which could see an additional 4500 MW could come on stream around 2014-2017. Whilst the nuclear project has just been postponed, it is possible that, given the demand for non-carbon based energy, it may be re-initiated once the current financial crisis stabilises.

In this section, the skills demand for these different projects will be assessed. We will start with the two coal projects which we will assume will make up the bulk of the new activity till at least 2012.[62] Key to this analysis is not only to quantify the skills requirements but also to make some assessment of the quality of the skills required. Due to the data-gathering problems mentioned in the introduction, it is not possible to do this for all skills categories but fortunately we have some data on some of the most critical and most complex of these skills. This should be illustrative of the type of analysis one could perform if further data is made available.

It is useful also to indicate that the assessment of such skills stretches across the value-chain. Obviously in an environment whereby a number of large new build projects are coming onto the market, especially in an environment where such projects have not been executed for almost two decades, the immediate concern is whether there are resources available for these new projects.

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61 It is impossible to get new information on the completion of these projects given the Eskom lack of co-operation but it is likely that given that they started in 2007 and that they will be completed in 2009, that less than half the units are currently outstanding. The Eskom New Build News January 2009 indicates the last gas units will be completed in March 2009.

62 As noted in the introduction, what needs to be done is that the additional demand for skills needs to be assessed assuming that on-going projects already have their skills requirements met. In some instances the scheduling of different projects may mean that there are short-terms pressures, but, given the transfer of skills from project to project, the two coal projects would represent the 'excess' or 'extra-ordinary' demand. If this demand can be met we can assume that the 'ordinary' demand is also covered.

In documenting the skills requirements, it is useful to follow the project cycle. The initial phases of the project development are designed to test the (commercial, technological and environmental) feasibility of the project and to apply for, if not acquire, the relevant statutory/regulatory permissions to proceed. The second phase involves design and fabrication of equipment which in the electricity market involves long-lead times due to the sophistication and complexity of these items. In the third phase, which can overlap with some aspects of phases one and two, the site is prepared and the main civil and structural work commences installing the basic foundations, structures and services reticulations that will support the equipment procured in phase two.

Phase four involves the installation and commissioning of that equipment. As noted above, power stations are most often built one unit (450-750 MW boiler/turbine/generator/auxiliaries) at a time although a significant part of the work in phases two and three would have been done on all units (assuming a 'six-pack' format) before the erection of the first unit begins. The normal plan is for the erection of these units to occur twelve months apart to enable there to be a balancing and carrying over of resources from one unit to subsequent units. It was initially believed that the current Medupi and Kusile projects have reduced the staging to six months indicating that there will be a higher requirement for skills since the carry over to subsequent units will be lower.[63] However recent information, including Eskom's own pronouncement on the delivery of these units suggest that the 12 month cycle has now been adopted.

The fifth and final phase involves the operation of the newly built power station. In South Africa, it has generally been the case that some of the staff involved in the construction of a power station would remain behind to operate the power station. Obviously not all involved in the construction phase (about 2500) would be required for operations (about 200-600)[64] and a significant proportion would move onto the construction of further power stations. However, historically there has always been a growing pool of skilled and experienced personnel to operate drawn from the larger project pool.

Unfortunately, with the suspension of construction for about two decades, this traditional route of supplying operational staff was obstructed and the biggest challenge addressing the operational skills requirements in the past decade or so has been to find adequately skilled people of the appropriate racial categorisation to fill the shoes of an aging and predominantly white operational crew. Whilst this challenge is likely to remain for at least the next five years, it can be assumed

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63 The author was unable to officially confirm this assumption but is working on information supplied by an 'informal' source. Obviously the staging of the erection process has massive resource implications which will be addressed in Section 9.

64 The new stations will require about 200, existing stations use about 600. Joos Du Plessis, presentation to NIASA workshop 19 September 2008.

that once the new build programme is in process, this gap is likely to be overcome. As will be seen from the data shown below, the first peak in skills demand is in 2011 which is followed by a scaling down of demand until the next peak. It can be assumed that some of the people used in the peak period will remain behind to operate the newly built units. It can also be assumed that the racial profile of this new operational workforce is likely to better reflect the employment equity requirements since these same requirements are being applied during the construction phase.

The analysis that follows is derived from four sources. The first is reference to available secondary material.[65] In some instances, this information is dated as there has been an international hiatus in the construction of power stations. The second is comments made to the author by those involved in the planning of the new build at Eskom.[66] The third source is the data assembled by McKinsey for the TSAPRO study which is primarily sourced from Eskom.[67] Finally, some other material is referenced from presentations made in different forums during 2008.

Using skills analyses from the secondary literature has its disadvantages especially since they describe a labour market and industrial processes which may not be similar to the current situation in South Africa. Obviously, the technology chosen, the manufacturing processes adopted to produce the major items, and the organisation of work on site (built-in-situ or prefabrication) can have a major impact on skills requirements.[68] In addition the organisation of the labour market, the skills set specific to a time and place, and the quality and productivity of those skilled workers (including the state of labour relations) can significantly influence the skills requirements. Countering these disadvantages, is the fact that power station construction was in a hiatus in many parts of the world since the 1970's and 1980's and that many of the current power stations are likely to be only an evolutionary modification of those built in the earlier era. Therefore we can draw some comfort from the fact that the technologies are not very different from those used in the past. This is not however necessarily the case in terms of the social, regulatory and geographical differences.

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[65] The main texts used include J. Willenbrock and R Thomas Planning, Engineering and Construction of Electric Power Generation Facilities (1980), J Willenbrock Construction of Power Generation Facilities (1982) and L Grigsby (ed.) Electric Power Generation, Transmission, and Distribution (2007). Unless explicitly cited, these texts served as background to check and validate the TSAPRO data.

[66] Given the Eskom lack of co-operation on this project, the author made use of interview data he collected in previous projects prior to Eskom's lack of co-operation (Merrifield, A. Demand for Skills– an analysis of the proposed infrastructure spending programme, Research report (CIDB 2006), Procurement Dynamics Skills Audit (Demand Side) of the Built Environment (CBE 2008)). The author did not approach anyone currently at Eskom for answers after Eskom denied him access to their personnel. However, in the course of work for NIASA, he was told certain things by people involved in related electricity work.

[67] As noted before, DPE officially made this McKinsey data available to the author.

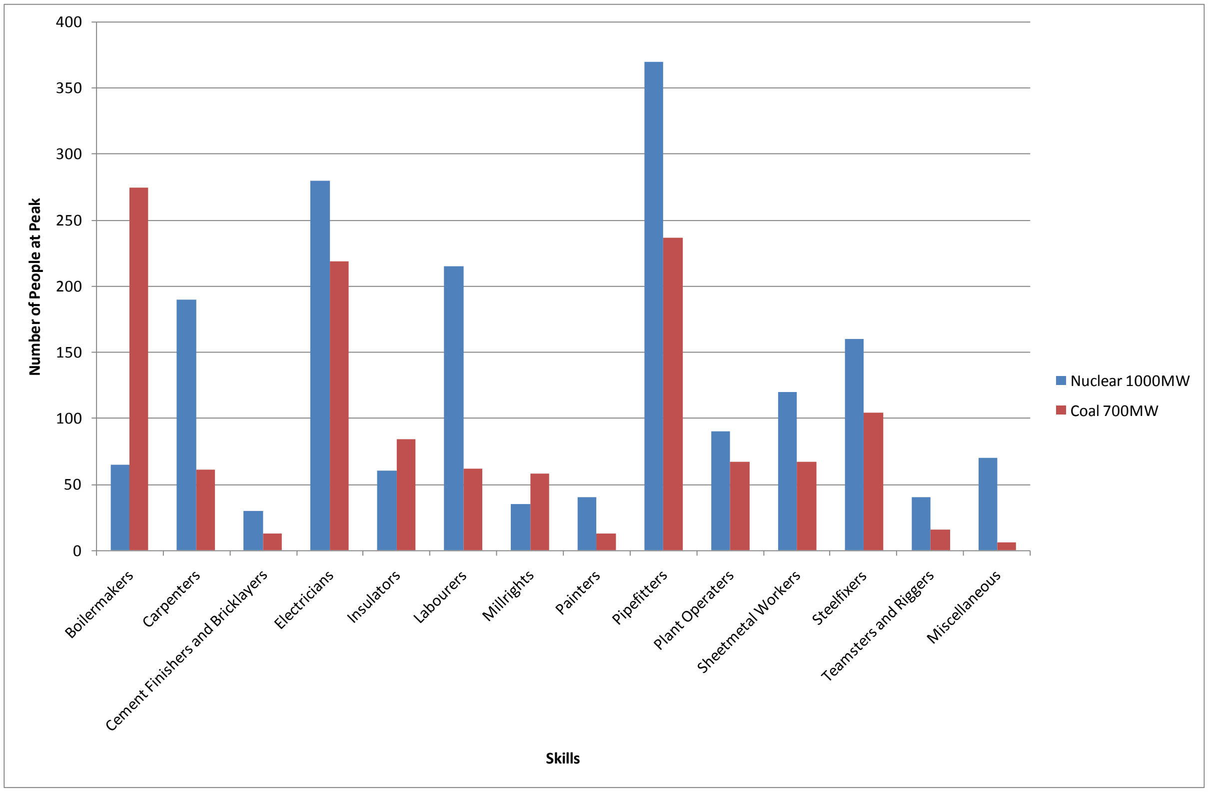
[68] J. Willenbrock and R Thomas Planning, Engineering and Construction of Electric Power Generation Facilities (1980).

The textbook estimates used below are based on the US history of power station construction in the 1970's and the authors indicate that some aspects are subject to variation. For instance, power stations built in the Sun-belt (with climate conditions similar to South Africa) needed two to five percent fewer skills due to improved weather conditions. Environmental regulations which were being introduced at the time were expected to increase costs (and perhaps skills requirements) by 20-35 percent because of the need for additional auxiliary equipment and more complex designs. It is worth noting that similar environmental regulations will now apply in South Africa and may have a similar impact on skills estimates. Most significantly, however, is that the skills set, the quality of those skills and the labour market conditions are very different.

Nevertheless, in the absence of better information, the textbook examples provide some guidance as to the main skills requirements. The graphs that follow describe the skills requirements for both a 1000 MW nuclear and a 700 MW coal plant. As noted before, the construction of such power stations involves the phasing of the skills required unit by unit with some overlapping between sequential units. The construction of both coal and nuclear power stations in South Africa will involve units of approximately these sizes so the tabulation of skills requirements may be reasonably applicable.[69] What we find is that the peak requirements for personnel differ significantly between nuclear and coal.

[69] The coal units at Medupi and Kusile are around 790 MW each. No information has been released on the possible size of the nuclear units but Koeberg has two units of 965 MW.

Graph 6.1: Number of skilled and semi-skilled artisans required at peak demand



Source: Adapted from Willenbrock and Thomas (1980)

For both types of power station, the main skills in demand involve boilermakers (especially for coal), pipefitters and electricians (significant in both). Leaving aside the labourers (assuming no specific skills), other significant skills include carpenters (shutter-hands in South Africa), steel-fixers and plant operators. If we compare these two power station types in terms of hours worked (as opposed to peak numbers), we find that the differences between the two technologies is much more significant in certain skills categories. This is particularly true for pipefitters, carpenters, boiler-makers, sheet-metal workers and steel-fixers. The above qualifications about differences in technologies and manufacturing and construction techniques apply, but what must also be apparent for these comparisons, is that nuclear is much more skills intensive requiring 11.5 million person hours as compared to the 4.4 million for coal.[70] We will return to this issue below.

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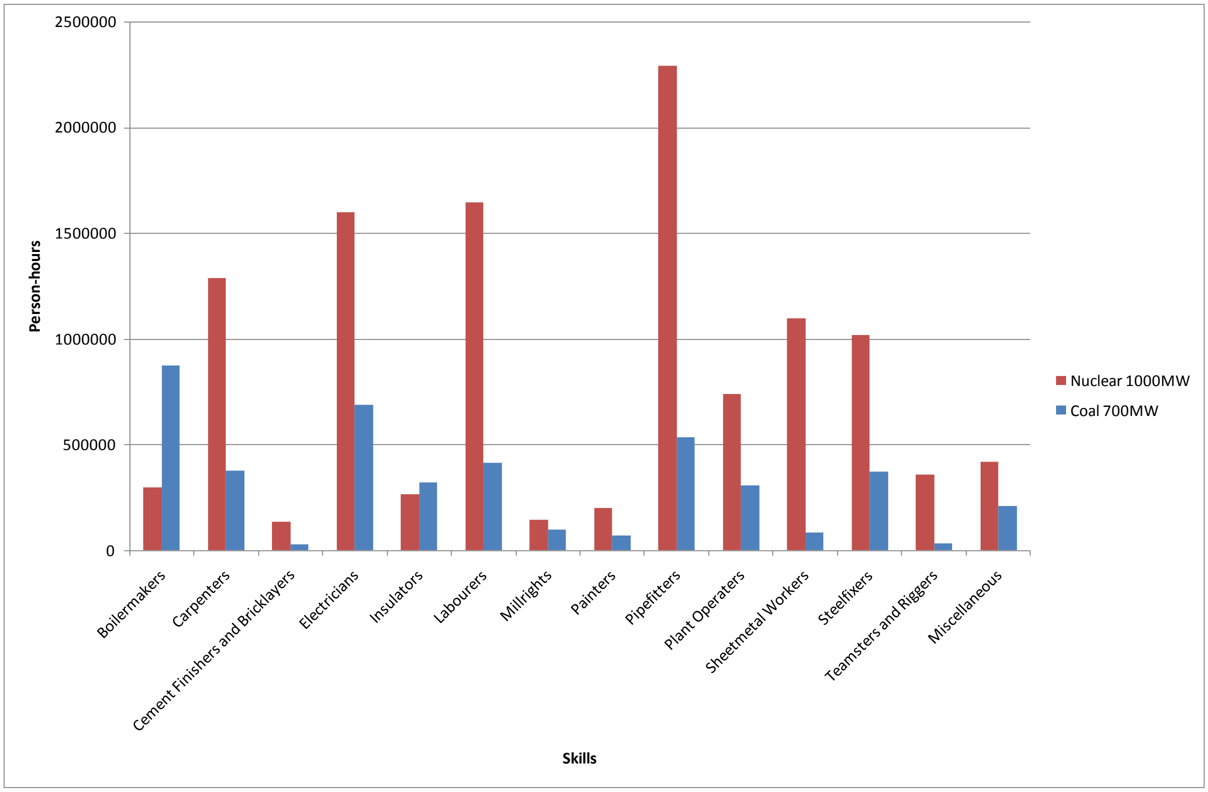
70 J. Willenbrock and R Thomas Planning, Engineering and Construction of Electric Power Generation Facilities (1980).

Graph 6.1: Person-hours required per skill category

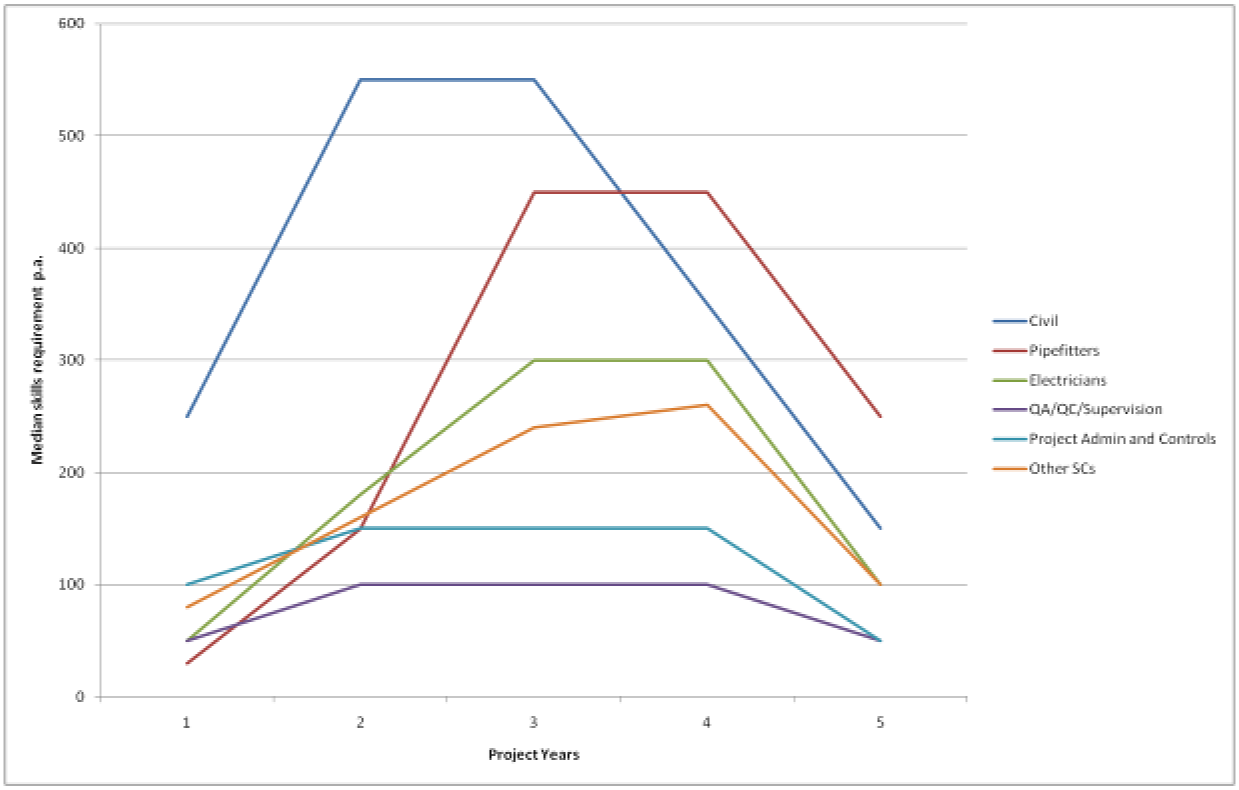


Source: Adapted from Willenbrock and Thomas (1980)

The textbook description of skill requirements in the power station skills cycle reflect that certain skills are in demand at different times in the project cycle as reflected in the graph below.[71] The civil engineering skills, which also make up the largest component, come early and phase out sooner. The second most significant skills requirements are for pipefitters which come in much later in the project cycle. Other significant skill groups such as electricians follow a similar trajectory. The QA/QC, Supervision, and project controls and admin, which make up about 20-30 percent of the project staff complement, reflect a more consistent utilisation across the project cycle.

[71] J. Willenbrock and R Thomas Planning, Engineering and Construction of Electric Power Generation Facilities (1980).

Graph6.3: Median Skills Requirement across the Project Cycle for a 1150 MW Facility



Source: Adapted from Willenbrock and Thomas (1980)

Although the author was unable to interview Eskom personnel for this research, he is fortunate that two years ago he managed to interview many of the senior managers involved in setting up the Medupi project.[72] Even though this material is somewhat dated, and would benefit from additional interviews now that these projects are underway, it does provide basic validation of the arguments being presented in this section. Those interviewed in 2006 indicated then that there may be shortages of both skilled and experienced project management, engineers and artisans, but the data supplied to the researcher showed that these skills deficits are relatively small given the nature of the work.

To understand the skills requirements for the Medupi project (Kusile would present a similar picture), it would be useful to describe the project value-chain as shown in the table below.

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72 This material is based on interviews conducted with Eskom employees in 2006 for the report, Merrifield A. (2006) *Demand for Skills– an analysis of the proposed infrastructure spending programme*, Research report, CIDB. Tom Jacobs, Jan Oberholzer, Doug Dewey and Clive Le Roux contributed information on the generation new build in 2006. I was also able to interview Jan Oberholzer again in March 2008.

Table 6.1: Project Value Chain[73]

Component	Percentage of Project	Percentage Local Content
Boiler	41%	18.5%
Turbine	31%	11%
Coal Handling	6%	5%
Control and Instrumentation	4%	1%
Water and Cooling	3%	2%
Civil and Building Work	4%	4%
Tech Equip and BOP	2%	2%
Generator Transformer	1%	0%
Other	7%	6%

Approximately 49 percent of the value of the project is being locally sourced although a significant proportion of this will be in the form of equipment supplied by local firms whose technology is developed abroad. In the case of the main two components, the boiler and turbine, although there is a significant degree of local content, the primary design and manufacture will be done by an international Original Equipment Manufacturer (OEM). This means that the primary requirement for skills will rest with the OEMs which will be off-shore. Whilst there was some concern in Eskom that the main OEMs were already heavily committed internationally, they were expected to be able to supply the appropriate skills for the local projects. In most instances, Eskom was expected to need very skilled and experienced engineers and project managers to specify their requirements to the OEMs who would then supply the necessary expertise (much of it embodied in the design of the product). Eskom also needed sufficiently skilled and experienced project managers to oversee the installation of equipment supplied by the OEMs.

Although Eskom personnel are expected to have an understanding of new technologies sufficient to brief and oversee the staff of the OEMs, the actual engineering will be undertaken by the OEMs. Discussions with Eskom in 2006 suggest that their skills requirements are for a number of very senior project management and engineering personnel with a minimum of 15 years

[73] Some of the figures we rounded off and items were grouped.

experience in their respective disciplines. The total number of such senior project personnel is relatively small, perhaps between five and ten of the most experienced project managers and around 30 to 50 of less senior project managers. The overall client team will be in the order of around 200-300 management and engineering staff. If Eskom was to scale up to address future demand (including projects at DFS stage in 2006), it was expected to have to increase its engineering component from about 250 skilled engineers to about 700. Although this was considered to be a significant challenge going forward, in terms of specific skills categories, the challenge was more manageable. For instance, in 2006 it was projected that they will need to increase the existing complement of senior turbine engineers from four to about eighteen if the expected future workload materialised.[74] Projections of similar proportions were made for senior engineers for boilers, instrumentation and control, etc.

To complement their internal staff and to access suitable expertise and knowledge of the latest technologies, Eskom has entered into an arrangement with a consortium of international and local consulting firms.[75] They envisage that about 75 percent of the required skills will come from outside in the initial stages of conceptual design, scoping of work and procurement where the most technological skill and experience is required and that this will scale down to 66 percent external skills for the detailed engineering and around 50 percent external skills for the site engineering and project co-ordination.

In the case of the skilled artisans, they have estimated that they will need around ten skills categories ranging from fitters, welders, riggers, erectors, boiler makers, technicians, QC inspectors and sheet metalworkers. In 2006 they indicated that even though just over a thousand artisans are required per new project, per category this requirement is in the order of tens or hundreds as shown in Table 6.2 below. Given that the generation projects will be constructed sequentially and given that there will be significant migration from one project to the next, including from the RTS projects, it is difficult to understand why this skills challenge cannot be largely met through redeployment, training and some importation.

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[74] These estimates included at least one but possibly two nuclear projects which are no longer on the immediate horizon.

[75] Those interviewed at Eskom in 2006 and March 2008, indicated that while they had access to a number of very experienced 'greybeards' who had taken early retirement, because they had been active primarily in the 1970's and 1980's, not all of these individuals were up to date with more recent technology developments.

Table 6.2: Artisans Required for Generation New Build[76]

Category	Boiler	Turbine	Total
Pipe Fitters	180	100	280
Turbine Fitters	0	20	20
General Fitters	30	10	40
Welders – Class A	80	30	110
Welders – Class B	40	50	90
Boiler Makers	50	0	50
Technicians	50	50	100
Riggers	20	10	30
Steel Erectors	180	25	205
QC Inspectors	40	15	55
Sheet Metal Workers	30	15	45
	700	325	1025

Whilst the new Medupi and Kusile projects were presenting Eskom with challenges, the general view in the organisation in 2006 was that the other generation projects (RTS, Pumped Storage, OCGT) were in hand. This confidence partially arose from the fact that most are already work in progress, while in the case of the OCGT, most of the skills required were being imported along with the equipment.

As is the case for such projects elsewhere in the world, the OEMs in South Africa continue to play a major role in supervising the work of the local firms. In one example, which can be discussed openly in this report,[77] the local engineering firm provides about 500 people ranging from engineers to skilled artisans to construct and commission the Open Cycle Gas Turbines

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[76] Tom Jacobs, Jan Oberholzer, Doug Dewey and Clive Le Roux contributed information in 2006.

[77] The interview discussed here was conducted under the auspices of NIASA and therefore was not in violation of the Eskom embargo.

(OCGT) facilities being built in the Western Cape.[78] The OEM has around 25 senior engineers supervising the work in South Africa. The local workforce would involve around 40 mechanical and electrical engineers and about 140 skilled artisans (welders – 6G to 9G coded, mechanical fitters – Trade Tested, pipe fitters/boilermakers – Trade Tested and industrial refrigeration mechanics -Trade Tested). It is part of the local company's strategy to use this exposure to develop and refine their skills so that they can work on other power (especially nuclear) projects in the future. Whilst it is likely that these personnel will gain both knowledge and experience from the work on the OCGT, it is not expected that technology transfer would ever be sufficient to eliminate the role of the OEM.

Even though the scale and complexity of activity on the OCGT is significantly less than that for a coal or especially a nuclear power station, the model presented of localisation would seem appropriate to future projects. There is no doubt that the largest component of the workforce from engineers and project managers, to skilled welders and riggers, to the unskilled labour on site or in the factories is going to be South African. There is also reason to believe that much of this labour can be trained in the lead-period leading up to future projects, given that in most cases people will either have some experience from previous projects, therefore requiring only to upgrade their skills set, or the level of skill required will be such that all the skilled people necessary for a particular task will be able to be trained and gain work experience in the period leading up to the project. Therefore in unpacking the skills demands from the different projects we need to bear in mind that the skills pool is largely cumulative, that is, people trained or gaining work experience on one project will, with possibly some additional training, be available for future projects. People working on gas or coal projects may need their skills-set to be upgraded to work on a nuclear project, but, as in the past, their previous qualifications and experience will make it easier to make these advances. Given the lag-time now arising by the postponing of the nuclear project(s), the pool of skills from which the nuclear team will be drawn will already contain many of the basic skills that will be needed.

To take this analysis further it is worth making use of the South African Power Project (TSAPRO) research because it made considerable headway in estimating and quantifying the skills required for one particular scenario for electricity expansion. Although it should be evident from the discussion above that this author is sceptical about the extent to which TSAPRO is likely to achieve its objectives (and this scepticism will be justified below), it is necessary that the TSAPRO assumptions about growth in the electricity sector be considered at this stage. TSAPRO estimates that the total number of local skills required won't exceed 78 000 even if all localisation objectives are achieved. As will be noted from the following graph is that the vast majority of the personnel required are in the artisan and semi-skilled categories. The second thing to note is that

78 Interview with David Whittal, Lesedi AREVA, 4 November 2008.

there are two skills demand peaks corresponding with the first two coal projects peaking in 2011 and the first nuclear project peaking in 2016.[79] The third note-worthy issue is that the TSAPRO model assumes a tailing off after 2016 once the first two coal and first nuclear stations are completed. As we have seen above from the NIRP3 and ISEP, it is likely that additional coal and nuclear stations will be commissioned.

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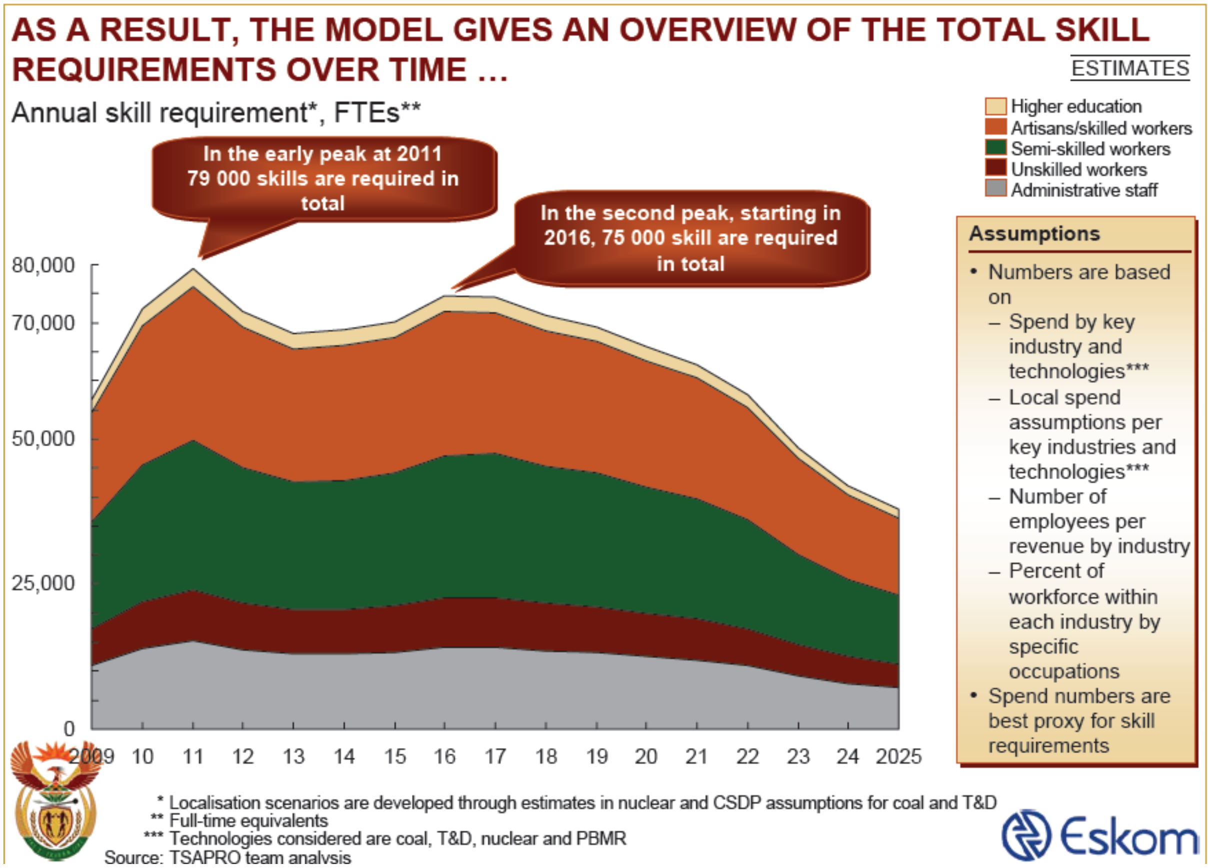
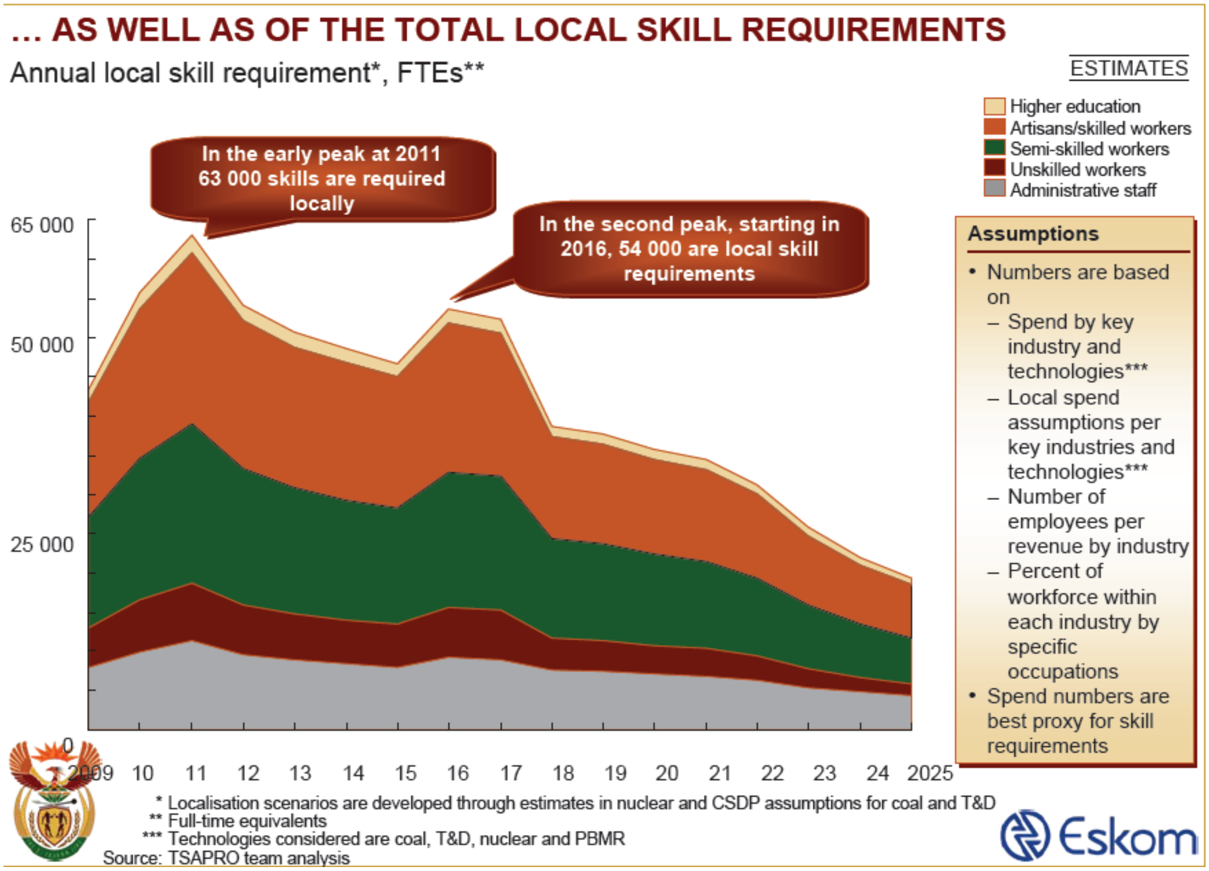
79 Obviously with the recent announcement of the postponing of the first nuclear project, this peak may shift outwards. Given that financial constraints at Eskom were cited as the main reason for the delay, it is also unlikely that the proposed Coal 3 and 4 projects will be initiated anytime soon. These delays will have significant impact on resource smoothing.

Figure 6.1: TSAPRO Total Skill Requirements



TSAPRO also distinguished between total skills required and local skills demand, although these figures are not very different at an aggregated level with the 2011 skills requirements peaking at 63000 and the 2016 peak at 54000.

Figure 6.2: TSAPRO Local Skill Requirements



As will be discussed below, the major skills challenge will be to ramp up the provision of required skills, and assuming reasonable retention strategies, ensuring that sufficient new stock is added to the pool to deal with attrition. It is useful to know is that the demand for higher educated engineering, research and project and construction management staff is expected to rise about 1400 to around 2400, artisans by 13 000 to 22000, semi-skilled workers by 11000 to 20 000, and administrative workers by 6000 to 11000. Whilst these are significant numbers, they do not suggest that such a ramp up is impossible to achieve within project lead-times. With the exception of the professional echelon which may need between seven and ten years to create from scratch,[80] most of these skills can be created within three years through focused education, training and work-experience.

[80] The exception being the very senior engineers and project managers which will have at least a four year tertiary qualification and between fifteen and twenty five years experience.

Table 6.3: TSAPRO Number of Skilled and Semi-Skilled Personnel

Skill types	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Higher Education	602	1 002	1 644	2 118	2 429	2 053	1 903	1 803	1 680	1 858	1 755	1 342	1 318	1 266	1 234	1 164	1 006	906	841
Artisans/skilled workers	5 708	9 045	14 618	18 975	21 699	18 875	17 973	17 560	16 827	18 919	18 214	13 008	12 682	12 029	11 685	10 649	8 825	7 546	6 710
Semi-skilled workers	4 778	8 557	14 117	18 067	20 271	17 315	16 052	15 267	14 776	17 306	17 096	12 697	12 335	11 627	11 148	9 978	8 108	6 738	5 835
Unskilled workers	1 848	3 092	5 099	6 609	7 308	6 324	5 813	5 582	5 470	6 327	6 281	4 106	3 966	3 697	3 557	3 081	2 395	1 868	1 516
Administrative staff	2 527	4 793	7 888	9 977	11 421	9 603	8 939	8 410	7 963	9 238	8 955	7 583	7 424	7 099	6 822	6 357	5 428	4 810	4 409
TOTAL	15 464	26 489	43 366	55 746	63 127	54 170	50 679	48 622	46 716	53 648	52 300	38 736	37 725	35 717	34 445	31 228	25 761	21 868	19 311

In estimating the ramp up phase we can see from the following table that, assuming the 2008 stock, professional skills will need to increase around 64 percent in 2009 over the previous year's stock and increase by 29 percent and 13 percent respectively in 2010 and 2011 to suggest a cumulative demand increase of about 240 percent from current levels.[81] It is only again in 2016 that we would expect an increase of around 15 percent over the previous year's stock. These increases are reasonably consistent across the various skills categories.

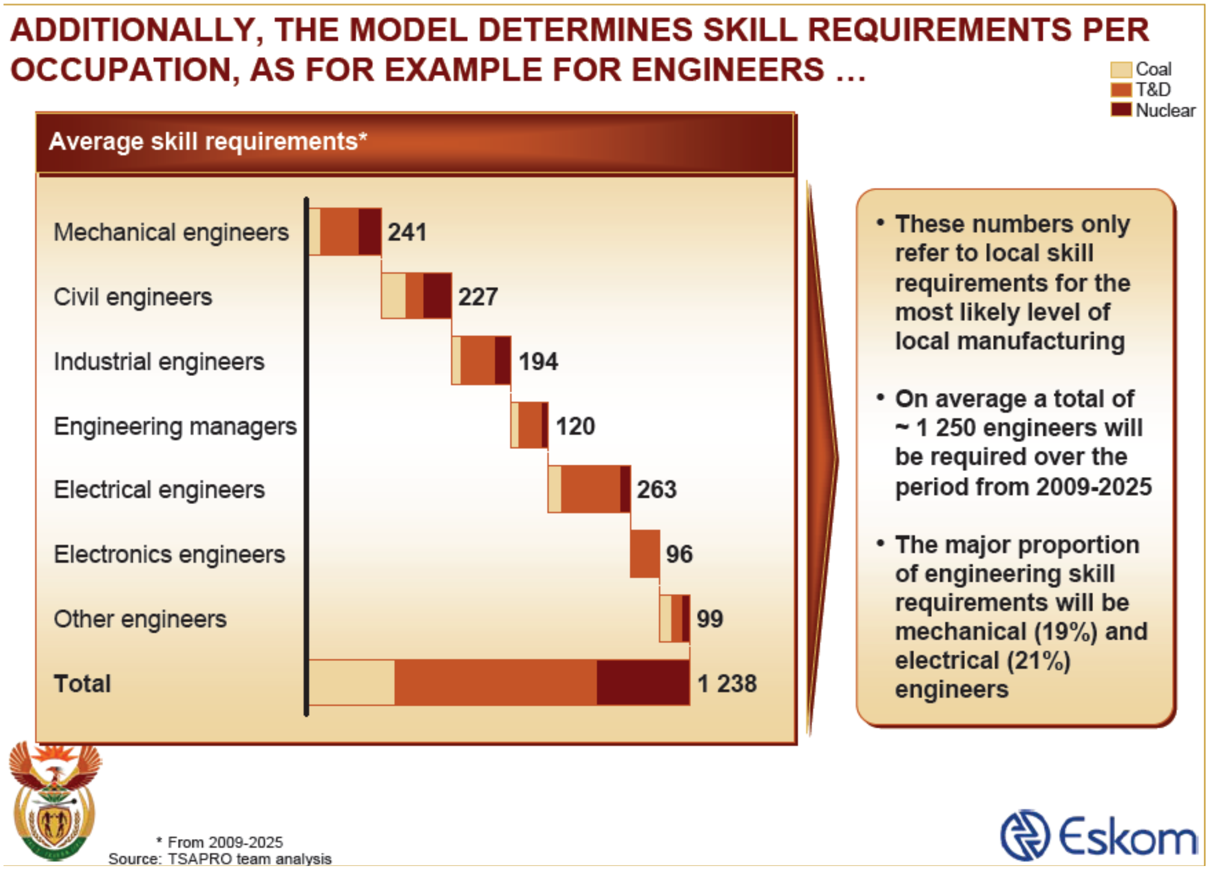
Table 6.4: TSAPRO Skilled and Semi-Skilled Personnel (Year on Year Change)

Skill types	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Higher Education			1.64	1.29	1.15	0.85	0.93	0.95	0.93	1.11	0.94	0.76	0.98	0.96	0.97	0.94	0.86	0.90	0.93
Artisans/skilled workers			1.62	1.30	1.14	0.87	0.95	0.98	0.96	1.12	0.96	0.71	0.97	0.95	0.97	0.91	0.83	0.86	0.89
Semi-skilled workers			1.65	1.28	1.12	0.85	0.93	0.95	0.97	1.17	0.99	0.74	0.97	0.94	0.96	0.90	0.81	0.83	0.87
Unskilled workers			1.65	1.30	1.11	0.87	0.92	0.96	0.98	1.16	0.99	0.65	0.97	0.93	0.96	0.87	0.78	0.78	0.81
Administrative staff			1.65	1.26	1.14	0.84	0.93	0.94	0.95	1.16	0.97	0.85	0.98	0.96	0.96	0.93	0.85	0.89	0.92
TOTAL			1.64	1.29	1.13	0.86	0.94	0.96	0.96	1.15	0.97	0.74	0.97	0.95	0.96	0.91	0.82	0.85	0.88

Unfortunately although the DPE and McKinsey were generous in making some components of their model available, not all the information was available in the model they provided. However, we can see from the following slides that the requirements for specific engineering skills is not excessively challenging. Around 200 to 250 electrical, mechanical and civil engineers each will be required on average for the two coal stations, the nuclear and the transmission and distribution projects to be undertaken. It should also be noted from the graph below, that for some skill categories, mechanical, industrial, electrical and electronics engineers, the majority will be used in the transmission and distribution sector discussed in Section 8 below. Although the graphs don't allow for accurate scaling, the actual demand for the coal (and nuclear) new build is somewhere between ten and fifty percent for most professional skills categories.

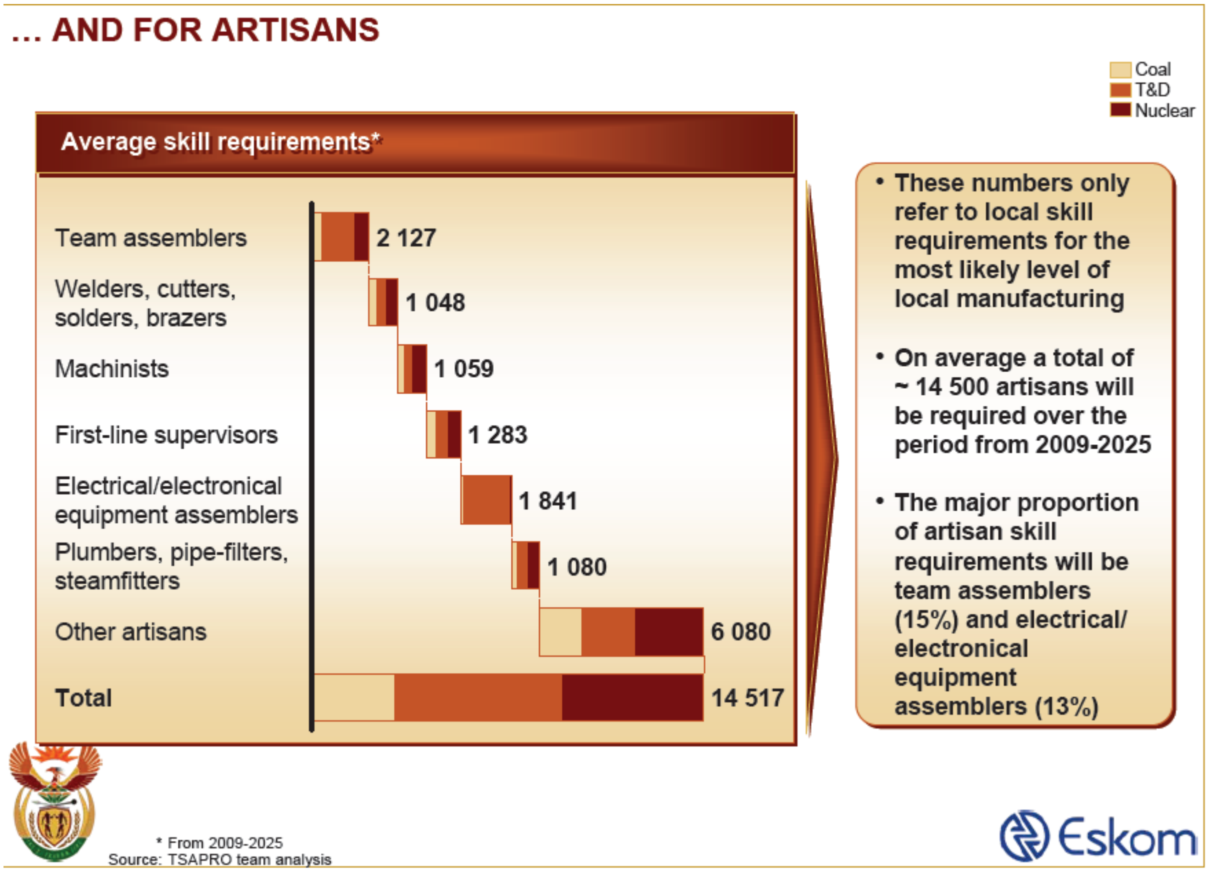
[81] It is assumed that the model estimated current levels correctly (as it should since it was based on detailed Eskom data).

Figure 6.3: TSAPRO Professional Skills Required



Similarly, on the non-professional side, around 1800 electrical and electronic equipment assemblers each are required on average annually along with another 2000 team assemblers and around 1000 plumbers, welders, machinists and supervisors required on average. We will examine these skills requirements in more detail below, but what is shown by the TSAPRO projections, that even with a strong localisation agenda, the skills demands remain in a manageable zone. Again it should be noted that in certain categories, especially those involved in assembly, the majority of these artisanal skills will be used in transmission and distribution projects.

Figure 6.4: TSAPRO Artisanal Skills Required



As we can see from the above analysis, the skill requirements are in the order of magnitude of tens for senior professionals and managers, in the order of magnitude of hundreds for other professionals and managers and perhaps in the order of magnitude of thousands for artisan and semi-skilled workers. The above estimates from TSAPRO include the nuclear project which we now know will be delayed.

If we want to take the analysis further, we can use the analysis of artisanal skills undertaken by McKinsey for the TSAPRO projects to provide a picture of the artisanal related skills required for the coal projects in Graph 6.4 below. The data for this graph has been modified from the TSAPRO model to make use of categories which are more familiar in the South African skills environment.[82] It has also been validated both against secondary sources and through interviews

[82] In order to make these figures comparable to other estimates, the author has tried to take out those skills concerned with the manufacturing aspects of the project which will be dealt with below.

and discussions with those involved in power station construction.[83] What we find is that the two categories of skills in most demand are supervisors and boilermakers[84] both peaking around 1000 in 2009 and 2010 (median of 675),[85] closely followed by pipefitters and welders each peaking in the same period at around 900 skilled people required (median of 600). Shutter-hands and steel-fixers and electricians each peaking around 4500 (median of 275) are the only other skills categories that reflect significant demand.

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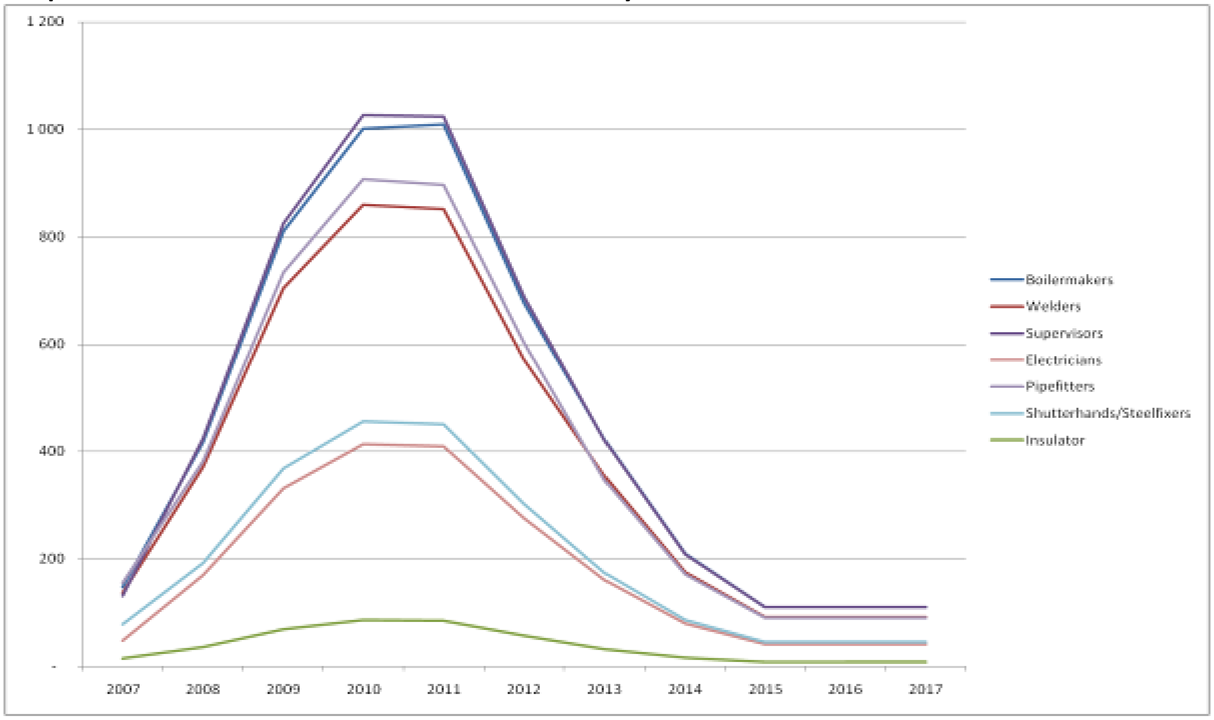
83 Certain demand numbers did not tie up with the other sources and were modified accordingly. What ultimately matters here is the order of magnitude rather than the specific number.

84 Including fitters and turners.

85 Statisticians prefer the median to average since it gives a better indication of the middle values and is not overshadowed by outliers. The averages are greater by about an additional ten engineers.

Graph 6.4: Demand for Artisanal Skills as defined by TSAPRO



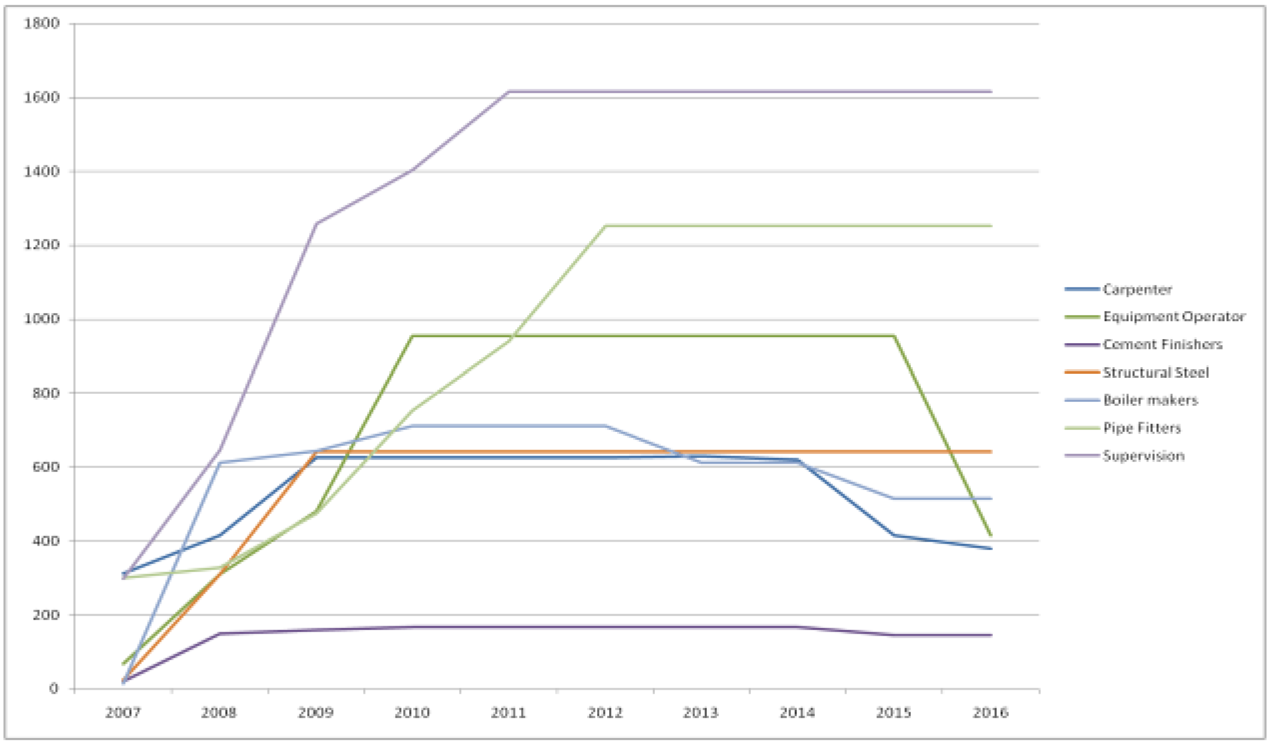
Source: TSAPRO Skills Model Handover, Willenbrock and Thomas 1980, and interviews.

It is possible to highlight certain observations. The demand scales up rapidly, maintains a peak for a short period and scales down less rapidly although effectively by 2012, the bulk of the skills would be available for another project. Secondly, the operational requirements of the newly built plant will largely be covered by the residual skills. Thirdly, and perhaps more controversially, these skills requirements do not seem to be significantly in excess of the current supply and stock of such skills available to the electricity sector. What is perhaps of more concern, which will be discussed in much more detail below, is that the quality of the skills available may not meet the requirements. Fourthly, what is also of concern is the rapidity of the scale-up. Since it takes between two and three years to produced a qualified and appropriately certified artisan, the above graph suggests that, if these skills are not already available[86], that there may be some need to source some of these skills from off-shore.

86 As will be argued below, there have been a number of projects in South Africa since 2003 which should have generated at least some of the appropriate trained and experienced skilled personnel required.

As noted, the above graph for artisanal skills is a composite of a number of sources and may still need further validation.[87] One estimate of skills required provided to the JIPSA team that were assisting DPE and McKinsey to validate the TSAPRO assumptions.[88] Although some of the skills categories are different, the graph below identifies many of the same priority skills as those drawn from the TSAPRO model discussed above.

Graph 6.6: Demand for Artisans



Source: Eskom/DPE

We again find that the highest demand is for supervisors, followed by pipe-fitters, equipment operators and boiler makers which are similar to the above model. The actual difference in numbers is less significant than the rate at which different trades are required. What is noticeable, and closer to the textbook example as discussed in Graph 6.1 above, is that the scaling up period for various trades is different. As can be expected, carpenters (which are classified as shutter-hands above) are brought in earlier as are boiler makers (although at a slower rate). Pipefitters would also be expected to scale up later in the project process than some of these other trades. The indication in the above graph that most skill categories do not decline significantly is a result

87 Obviously if Eskom allows the author access to its staff these concerns could be addressed quickly.

88 Sean Phillip of DPE asked the author, Carmel Marock and Gail Elliot to assist the McKinsey team.

of an assumption, quite plausible at the time it was made,[89] that the skills created on the first projects would thereafter be utilised on the ones that followed. The TSAPRO data reflected in the previous graph described the case for one project.

Turning to professionals, the analysis of professional skills undertaken by McKinsey for the TSAPRO projects indicates that civil engineers make up the greatest numbers and generally spend the longest time on the project. From Graph 6.7 below, we can see that at the peak, about 260 civil engineers will be involved but the median for the most busy six years (2008 to 2013) it is closer to 200.[90] The next most active profession are the mechanical engineers which peak at around 160 and have a median at around 120 for the six critical years. The only two other engineering categories that exceed hundred in number are industrial engineers (105) and electrical engineers (115) and they have a median of 75 and 85 respectively for the critical period. The graph shows the requirements for the other categories of engineers. It also gives a reasonable indication of the period of utilisation.

Most engineering requirements scale up rapidly from 2007 to reach a peak around 2010-2011 and then tail off more gradually after that. In line with our discussion of the operations taking over some people, it is evident that some people will be retained, but the majority of these skills could move onto new projects after 2012. As noted above, not all these skills will be used on the coal projects (perhaps only ten to forty percent in some categories) but will be active in transmission, distribution and possibly also nuclear activities.

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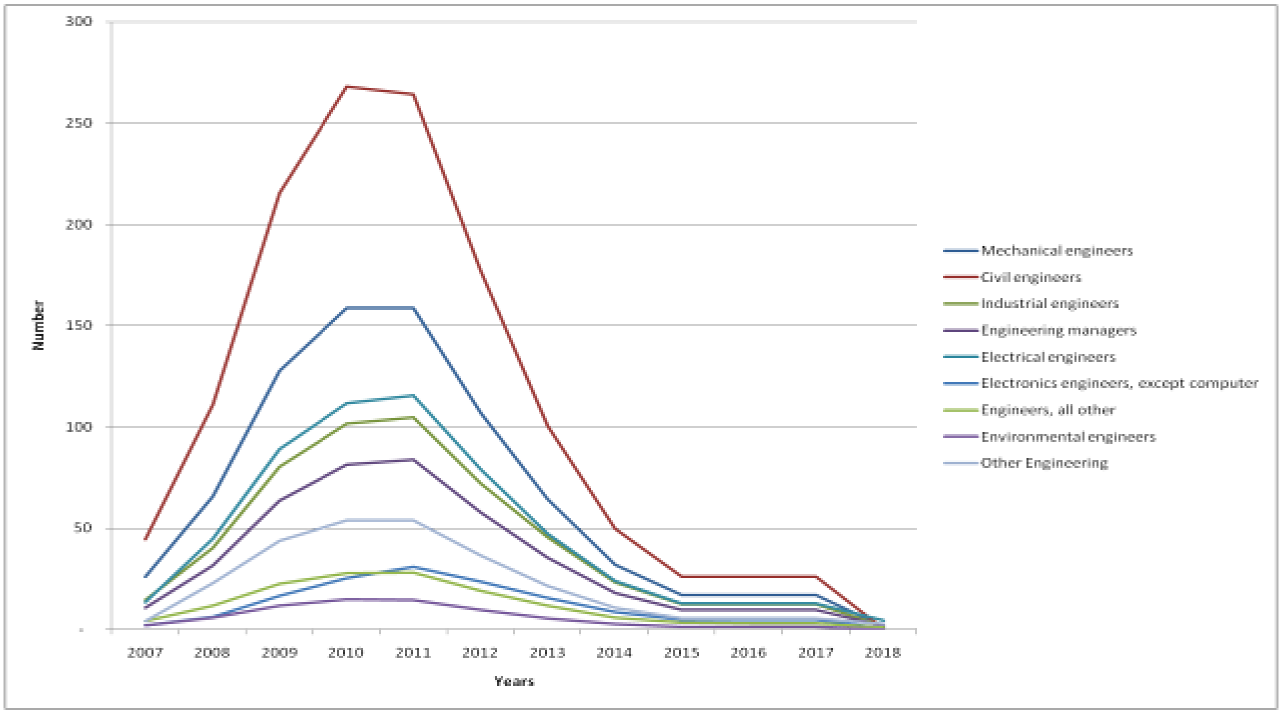
89 The author assumes that this data was compiled somewhere between 2007 and June 2008 when it was made available to the JIPSA team.

90 Statisticians prefer the median to average since it gives a better indication of the middle values and is not overshadowed by outliers. The averages are greater by about an additional ten engineers.

Graph 6.7: Demand for professional skills as defined by TSAPRO



Source: TSAPRO Skills Model Handover

The DME/NERT offered their own summary of skills requirements for Eskom projects in a presentation in August 2008[91] in which they indicated that the demand for skills is in line with the various estimates discussed above. The demand for project managers and engineers would double from around 2600 in 2008 to around 5000 in 2014, whilst the demand for technicians and technologists is expected to increase from around 3000 to just over 4000 (the vast majority being technicians). Even their estimate for artisans is in line with the assumptions above indicating an increase from around 5000 to 10000 over the same period.

[91] NERT RSA Electricity Status Report August 2008.

Table 6.5 NERT Skills Estimates

	Mar-08	Mar-09	Mar-10	Mar-11	Mar-12	Mar-13	Mar-14
Engineers	2682	3099	3515	3932	4349	4765	5182
Technologists	153	195	236	278	320	361	403
Technicians	2896	3063	3229	3396	3563	3729	3896
Artisans	5307	6140	6974	7807	8640	9474	10307
Accountants/Commercial	246	329	413	496	579	663	746
Other	21670	21828	22295	21778	20921	20058	20221
Manpower	**32954**	**34654**	**36662**	**37687**	**38372**	**39050**	**40755**

Source: NERT RSA Electricity Status Report August 2008

Before leaving the discussion of skills requirements, it is important to comment briefly on the potential nuclear projects which may again make demands for skills in the future. For the nuclear industry specifically, Professor Greyvenstein has estimated the period of scaling up and reflect the three period peaks of peak demand (unlike the two of the TSAPRO model) although in this case it is for the PBMR and two conventional PWR reactors.[92] What we find is that the demand for mechanical engineers is highest (reaching a peak of around 400), followed by civil and structural engineering (about 200), electrical and control and instrumentation (around 150 for each), and chemical engineering (about 50 at the peak). Project development (less than 50), project management and support (around 150 at peak) and project controls (about 150) makes up the balance of professional skills.

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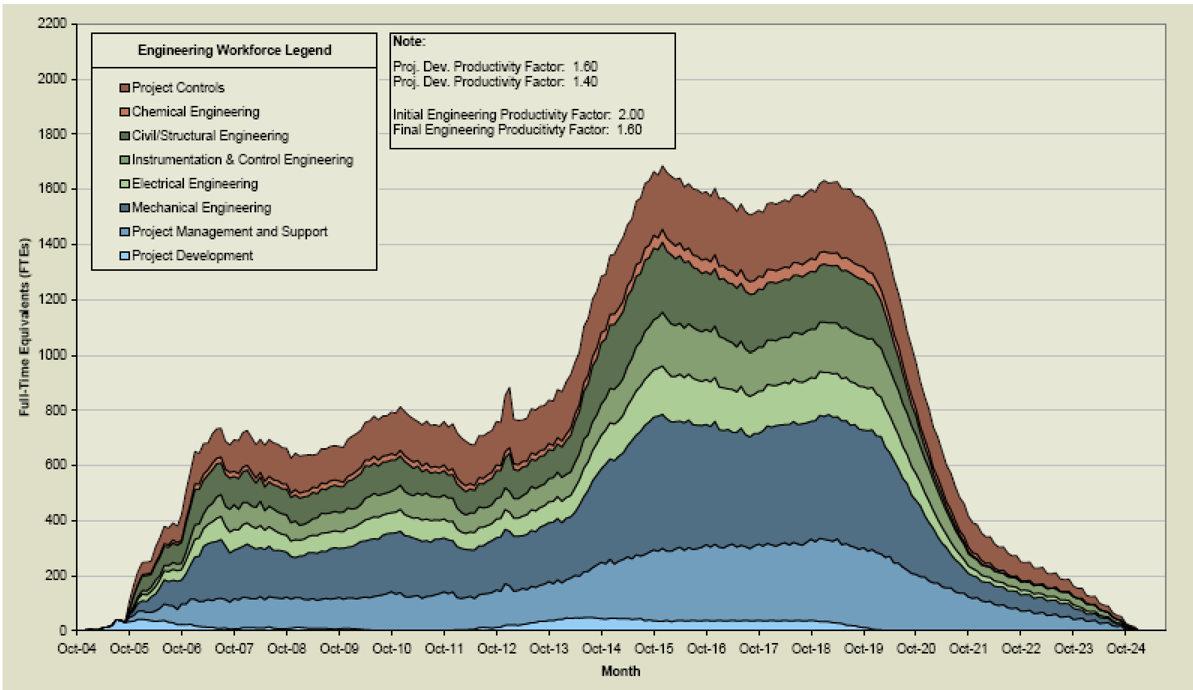
92 Professor G Greyvenstein, Nuclear Science and education in South Africa, presentation to NIASA workshop 19 September 2008.

Figure 6.5: Demand for Professionals on the Nuclear Projects



Source: Professor G Greyvenstein, Nuclear Science and education in South Africa, presentation to NIASA workshop 19th September 2008.

As noted above, with the exception of the PBMR, the nuclear programme has largely been put on hold due to financial constraints. Therefore for the PBMR only we can expect a demand for perhaps 150-200 mechanical engineers, about 100 each of civil and structural engineers, 60-80 for each electrical and control and instrumentation engineers, and perhaps 20-30 chemical engineers. Project development (less than 30), project management and support (around 80 at peak) and project controls (about 80) makes up the balance of professional skills.

In assessing the skills demand for both artisans and professionals in the electricity supply chain, it would have been preferable to fully describe the supply situation as well. This has not been achieved in this report for several reasons. The first, and perhaps most important, reason is that the analysis provided above indicates that, in most instances except for the most experienced and specialised skills, the demand for both skills represents a small proportion of the current supply of skills in most categories. For instance the following table drawn from the updated sector skills plan of the Energy SETA (ESETA) would suggest that the demand for skills enumerated above for most skills categories, except at the highest levels, would perhaps represent about five to ten percent of the current supply (see Table 6.6 below).

Table 6.6: Supply of skills in the electricity and water sectors

NQF Band Levels	NQF Level	African			Coloured			Indians			Whites			Total		
		M	F	D	M	F	D	M	F	D	M	F	D	M	F	D
Higher Education and Training (HET)	8	112	59		20	1		27	7		201	160	1	**360**	**227**	**1**
	7	262	180		61	34		92	44		409	118	2	**824**	**376**	**2**
	6	755	677	4	230	95	1	281	124	5	863	344	9	**2 129**	**1 240**	**19**
	5	2 734	1 882	18	462	193	6	325	125	7	2 558	672	7	**6 079**	**2 872**	**38**
Further Education and Training (FET)	4	2 975	1 236	45	560	312	15	231	164	17	2 456	1 093	27	**6 222**	**2 805**	**104**
	3	1812	595	13	230	83	3	43	23	10	698	456	52	**2 783**	**1 157**	**78**
	2	3 567	328	32	310	59	8	43	28	6	765	330	16	**4 685**	**745**	**62**
General Education and Training (GET)	1	5 129	402	50	432	14	2	30	9	5	222	62	12	**5 813**	**487**	**69**
Undefined		3 744	248	62	541	19		19	10	5	138	67	10	**4 442**	**344**	**77**
Sub Total		21 090	5 607	224	2 846	810	35	1 091	534	55	8 310	3 302	136	33 337	10 253	450
TOTAL	44 040 WORKERS REPORTED IN THE SUBMITTED WSPS 2006-07.															

Source: ESETA, Sector Skills Plan 2007/08 (updated).

The second, and less excusable, is that the current information on the supply of skills is inadequate and it was not seen by this author to be within the scope of the project to compile a detailed enumeration of all categories of skills in the related labour markets. The sector skills plans of the relevant SETAs were reviewed and in most instances found to provide insufficient information beyond broad aggregates.[93] The third reason was that those interviewed did not see the problem as being in terms of the quantity of those deemed skilled but rather the quality of those skilled which will be discussed in some detail below.

Whilst most informants were confident that most artisanal skills could be acquired and upgraded to a level suitable for the proposed projects, the one category of skill that raised the biggest concern in both the industrial and project environment was for welders. The main reason why welding seems to be a challenge, is that it not only involves a high degree of hand/eye co-ordination and good motor skills, but also a reasonable understanding of metallurgy and the properties of metals under heat conditions.[94] There are training courses available to ensure that welders are so qualified but in recent years, especially since the introduction of the unit standards in terms of the National Qualifications Framework, employers have become increasingly concerned about the quality of the output of such welders. In order to address the current shortcomings in the qualification of welders, MERSETA and the SAIW have developed an 80 week programme that will provide both the theoretical and physical training required to weld at international standards. Unfortunately it is too early to see the results of this programme,[95]

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93 The Sector Skills Plans of the ESETA, LGSETA, MERSETA and CETA were reviewed.

94 Interviews with Helen Brown at MERSETA 13 October 2008 and Jim Guild, SAIW, 15 October 2008.

95 Most of the larger industrial firms use the SAIW training but not all of them train through the complete cycle.

although some concerns were raised that there were insufficient work opportunities after the theoretical component to provide the practical training.

The reason why welding remains an anxiety in the project and industrial environment is that, on such power projects, each weld is tested and those that fail need to be redone. For both nuclear and coal projects, the American Society of Mechanical Engineering (ASME) has defined a set of design and fabrication codes for the pressure vessels. These design and fabrication codes are quite explicit as to the requirements for welding (amongst other things) and each weld has a specific procedure which must be followed, checked and certified that it has been checked. The ASME qualifications are held by the firm not the welder and if the welder does not perform such welds for a certain period, then they must re-qualify. Further, if an individual has a certain percentage of failed welds he has to be reassessed and re-qualify. The ASME qualification of welders merely adds an additional set of procedures that have to be monitored and documented in the welding process although they do not address the quality of the welders themselves. Despite the requirements for such ASME certification and despite the challenges of the MERSETA/SAIW welding programme, most people interviewed believe that it is possible to produce such welders locally. The big question however is in the scheduling and continuity of work.

As noted above, the recent CBE study on skills supply discussed in Section 3 indicated that in the next couple of years the supply of professional skills is likely to exceed demand:

> the data on graduations indicates that there were an estimated 5,300 graduates seeking work as BE professionals in 2005 and that this number will increase to 7,200 in 2011. ***The number of potential employees, thus, exceeds the total number of positions available***, although the difference at the upper end of our estimate is not substantial. The projections indicate that, at current employment trends, the disjuncture at the level of absolute numbers will continue to widen. ***It is, therefore, unlikely that all of these graduates will be employed in the BE sector.***[96]

Although this estimate focuses on the new entrants, it does suggest that the skills pipeline is being adequately replenished (the numbers are adding up) and that the challenge, as discussed below in Section 9, is to ensure that the quality of these skills meets the requirements for the new projects. Unfortunately the CBE (Supply Side) does not go into as much detail on the supply of specific professional categories as the above-mentioned CBE (Demand Side) study but it should be evident from the projections described in Graph 3.3, that the skills gaps should close (if the

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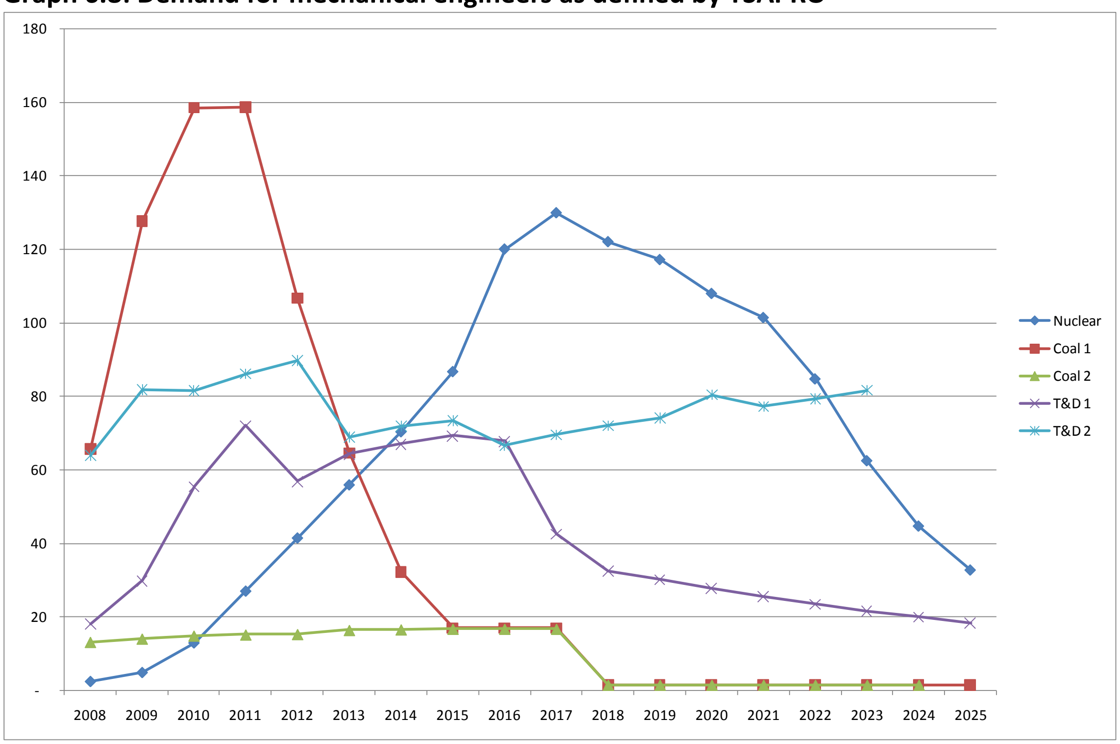
[96] CSIR Built Environment, Pretoria, January 2008, CSIR Report number CSIR/BE/CON/ER/2008/0061/B, emphasis in the original.

quality of the skills can be assured). If we consider one of the more critical areas of demand for professional skills, civil engineering, we can conclude from Graph 3.2 that the supply of such skills will increase at a faster rate than the demand for such skills on such projects.

It has been argued above that the demand for professional skills in the electricity value-chain is unlikely to overwhelm the supply of such skills. Evidence to support this argument will be presented below. To support this argument, it should be useful to know that the demand for professional, and in particular engineering, skills will be smoothed because skills used on one project will be carried over to future projects. Using the TSAPRO data again, we see from Graph 6.8 below that the demand for mechanical engineers will peak at 359 in 2011 and then remain below this figure throughout the extended project period. Given that there are 3294 registered professional mechanical engineers, 872 candidate engineers and 490 technologists[97], it is reasonable to assume that the profession can cope with such a demand. Such an assumption is reinforced if we recall from Graph 4.9 above that the electricity projects discussed in these graphs make up by far the bulk of the mega-projects anticipated over the next decade.

Graph 6.8: Demand for mechanical engineers as defined by TSAPRO



Source: TSAPRO Skills Model Handover

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97 Procurement Dynamics (2008) Skills Audit (Demand Side) for the Council for the Built Environment (CBE).

In the above graph, and the two that follow, Nuclear refers both to the two proposed nuclear stations as well as PBMR, Coal 1 and 2 refer to Medupi and Kusile (note the carryover of skills) and T&D 1 and 2 refer to all the proposed Transmission and Distribution work falling under Eskom.[98]

Demand for civil engineers only reaches a peak of 427 (in 2010)[99] when all the Eskom projects are taken into account (see Graph 6.9 below). Given that there are 6205 registered civil engineers, 885 candidate engineers, and 1315 civil engineering technologists[100] it is again possible to assume that this demand can be met.

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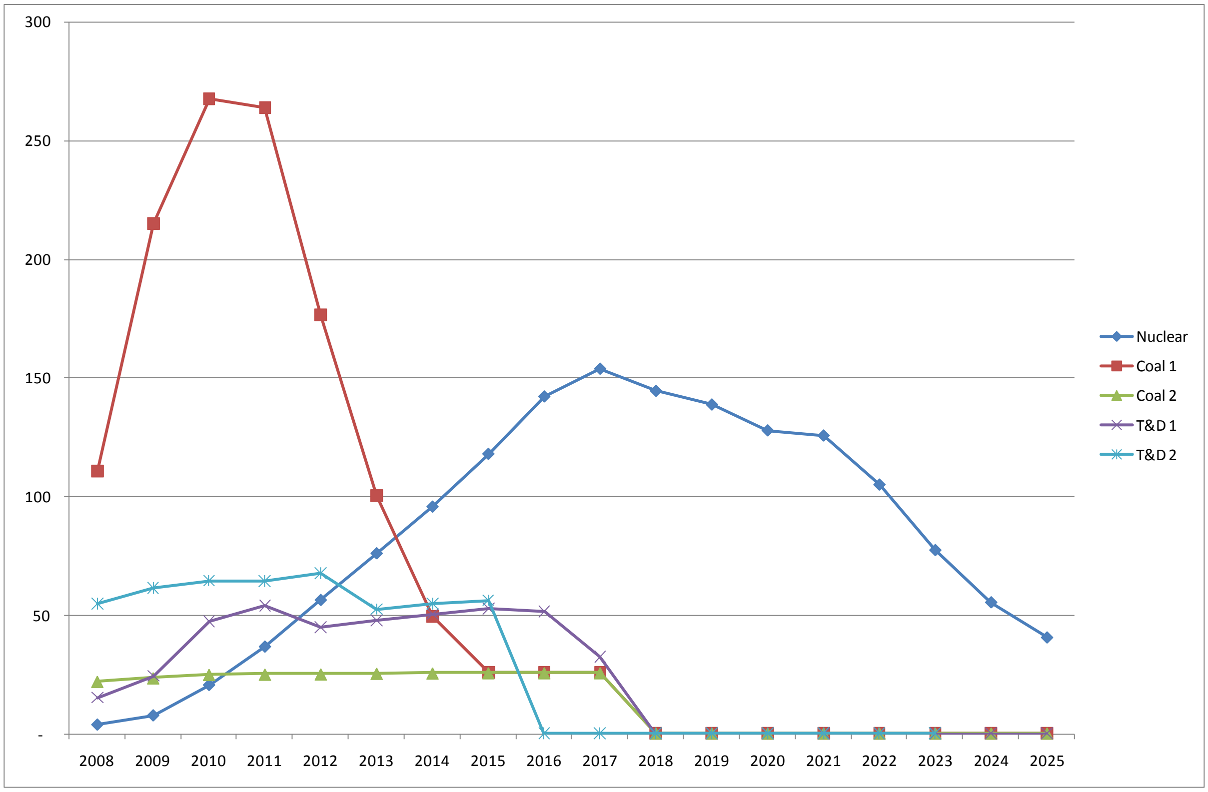
98 Even if the local government distribution network was to be included, it is unlikely to significantly increase the numbers shown here (see discussion of these issues in Section 8 below).

99 Given that this was based on TSAPRO data which was compiled in the early months of 2008 and that there have been several announcements of project delays (discussed in Section 5 above), it is unlikely that this peak will be reached.

100 Procurement Dynamics (2008) Skills Audit (Demand Side) for the Council for the Built Environment (CBE).

Graph 6.9: Demand for civil engineers as defined by TSAPRO



Source: TSAPRO Skills Model Handover

The demand for electrical engineers only reaches 387 in 2011 (see Graph 6.10 below). Given that there are at least 3445 registered professional electrical engineers, 1057 candidate engineers and 967 electrical engineering technologists[101] it is again reasonable to assume that this demand can be met.

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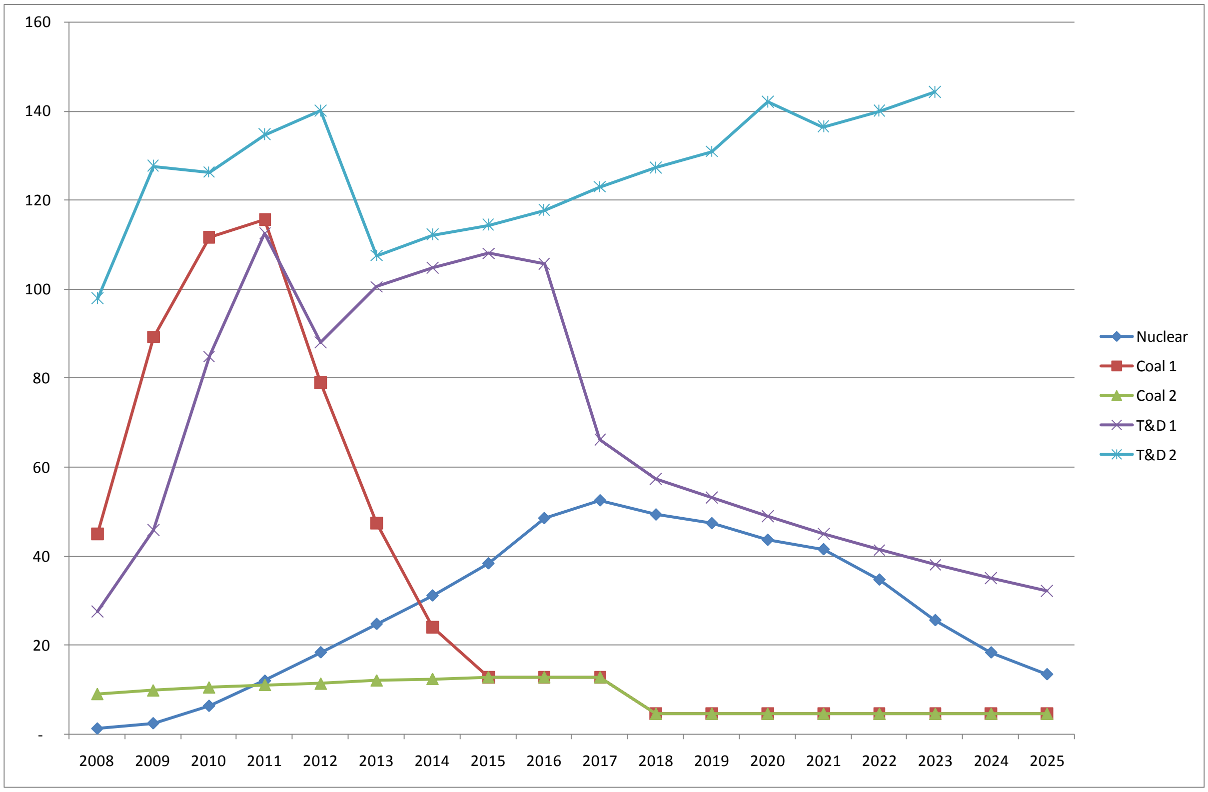
[101] Procurement Dynamics (2008) Skills Audit (Demand Side) for the Council for the Built Environment (CBE).

Graph 6.10: Demand for electrical engineers as defined by TSAPRO

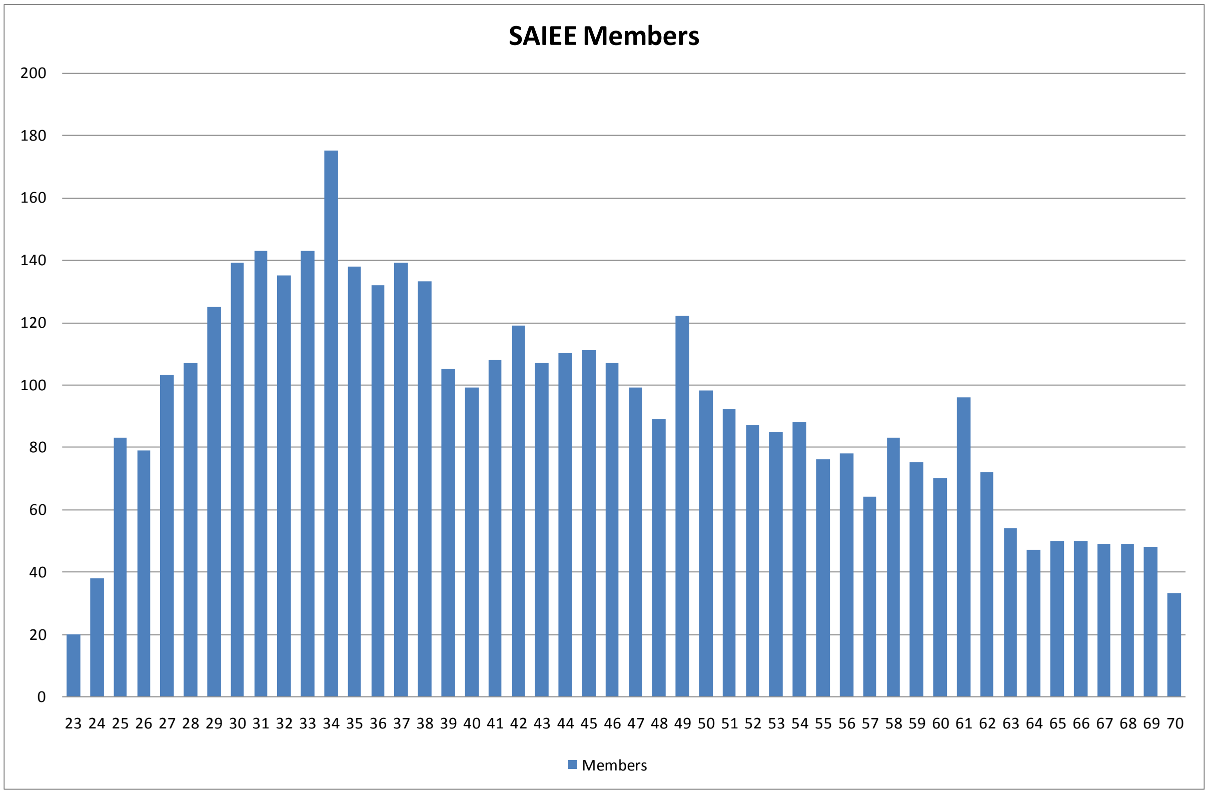


Source: TSAPRO Skills Model Handover

Further information provided by the South African Institute of Electrical Engineers (SAIEE)[102] provides further confidence that these assumptions that supply can match demand in terms of mere quantities. The institute confirmed that they perceived a skills shortage but in line with the arguments presented in this report, they believe the problem lies primarily in terms of the quality rather than the quantity of such skills. They presented data which shows that not only do they have sufficient numbers (in excess of 5000 members) but that the age profile of their membership gives confidence that the current shortfall is likely to be overcome (see Graph 6.11 below).

102 Interview with Stan Bridgens, SAIEE 6 July 2009.

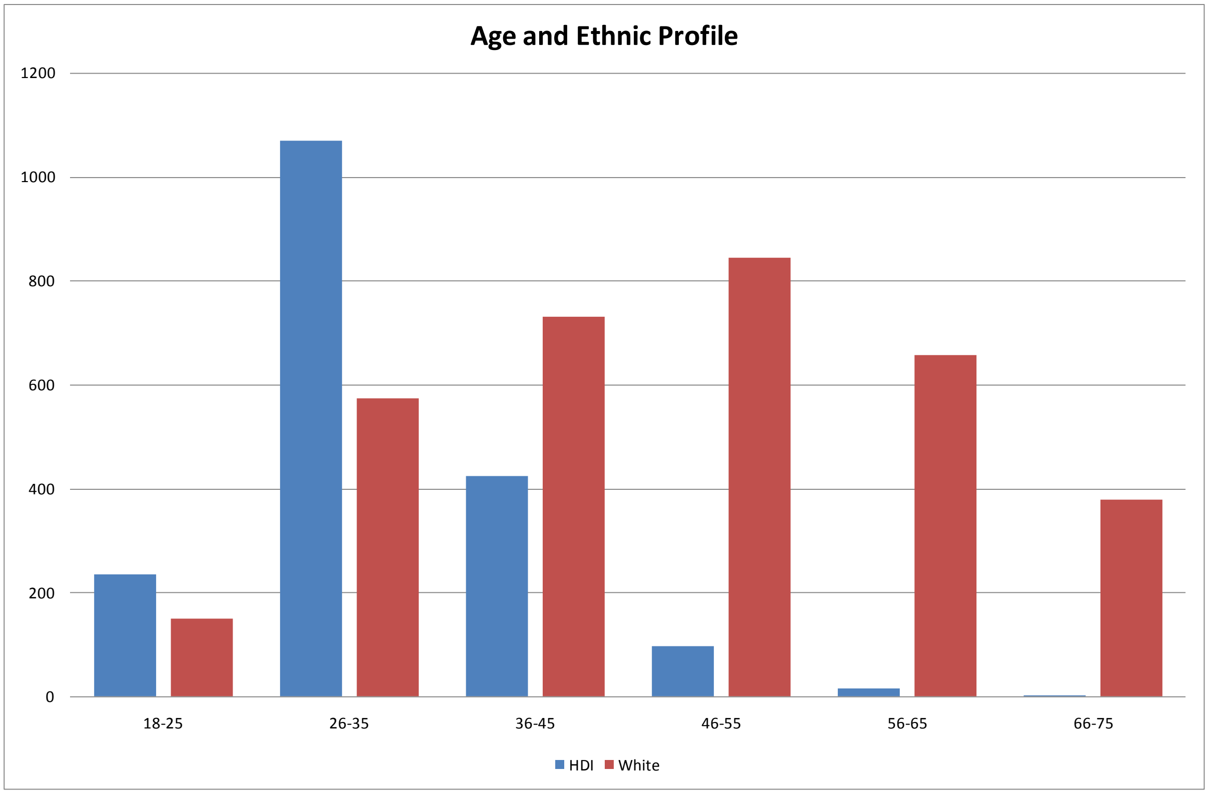
Graph 6.11: Age Profile of SAIEE members



Source: Data from the SAIEE

As can be seen from the above graph, the vast majority of the membership is below the age of 50 which augurs well for the electricity industry. In addition, the SAIEE membership gives some comfort that the racial profile of the profession is likely to change significantly in the future. Although around 3300 of the current 5200 members are white, the balance, 1840 are younger members that suggest that the professional profile of the sector is likely to change significantly in the future (see Graph 6.12 below). If these new members can be properly mentored (see Section 9 below) so that they acquire the relevant experience to replace their elders in the future, then we should have few concerns about electrical engineering skills in the future.

Graph 6.12: Age and Ethnic Profile of SAIEE



Source: Data from the SAIEE

In the discussion of skills requirements we have seen a number of common features. All estimates postulate a scaling up and scaling down of resources. All estimates see the civil engineering component having the highest demand for skills and there is general agreement (but not complete uniformity) as to which other skills requirements are significant. However the most significant finding is that the demand for engineering skills is in the order of magnitude of one to two hundred specialised engineers per category. The demand for administrators and managers are of the order of magnitude of the hundreds. The order of magnitude for artisanal and semi-skilled occupations is in the order of magnitude of thousands although no single category is significantly above a thousand. Even if the number of projects is increased beyond the current two mega coal projects, these orders of magnitude are unlikely to more than double. Ultimately, however, the real critical skills requirements are likely to be in the order of magnitude of tens rather than hundreds.[103] To understand this, we must examine the project structure in greater detail.

[103] What is being argued here, is that even if say 250 civil engineers are required, only a few will necessarily require significant training and experience for the key posts. Most will be junior engineers, technologists and technicians with only limited post-qualification experience.

7. The Project Structure

The above enumeration of professional and artisanal skills provides a useful description of the primary design, fabrication, construction and management skills but unfortunately it does not address critical project and construction management skills. Fortunately in interviews conducted earlier this year, prior to the author's contact with the Eskom HR management on this project, it was possible to acquire some information on the project management structure for these mega-projects. In addition, the author attended a nuclear project management seminar hosted by NIASA where the project management structure was discussed in great detail. As can be assumed from the discussion above, nuclear projects require almost three times the person-hours than coal projects, and even if the new environmental regulations are applied (discussed above), it can be assumed that such projects would represent the upper limit of skills demand. If the skills enumeration can accommodate a nuclear sized project management team, it should easily cover a conventional coal power station.

The project structure described at the seminar was for the Taishan EPR project being built by AREVA in China. The value of using this example is that through the joint venture between AREVA and TSNPC (a Chinese company will be engaged in technology transfer). As such this relationship would best resemble the relationship that Eskom is seeking to develop with its technology providers for the South African projects. In the Taishan project, AREVA will provide the nuclear island (nuclear pressure vessel, fuel and safety systems), Alstrom would be the suppliers of the conventional island (turbine and generator) and TSNPC will be responsible for construction, commissioning and the balance of plant (civil engineering, supporting structures).[104] This division of labour is not dissimilar to that being proposed for the South African projects although the exact nature of the proposed technology transfer will only be negotiated with the winner bidder when the projects goes ahead. It is however similar to the current structure of the two coal projects whereby Alstrom is providing the turbines and generators, Babcock Hitachi are supplying the boilers, and much of the balance of the plant is being supplied by South African based firms.

The Taishan project is expected to take seven years largely due to the time taken to manufacture the nuclear pressure vessel. There are about 100 people involved in the project team (described below), 400 people involved in engineering, and about 3000 people involved in construction and commissioning.[105] Again it should be noted, that these numbers are of the same order of magnitude as the teams described above. Approximately four million person hours will go into the

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[104] North West University, Nuclear Project Management Seminar, Thierry Rolland 23 October 2008, p 15

[105] North West University, Nuclear Project Management Seminar, Thierry Rolland 23 October 2008, p 17

technology studies, design and management of the project. Another 1.2 million will be expended by the Chinese partner in localisation.[106]

The top management structure involves a project director and five other deputy project directors dealing with the nuclear island, technology transfer and production of fuel (and associated technology transfer).[107] As such, the top structure is not much different from those used on the existing coal projects (and proposed nuclear plants) in that Eskom is seeking to have a primary project manager and discipline project managers for each of the main components (turbine/generator, boilers, and balance of plant). The Eskom team structure is somewhat broader in that they were planning to have a local project manager, a local mentor and an international mentor to support the primary project manager. All these people would need a minimum of 15 years post qualification experience in the area in which they practice.[108]

Thanks to the co-operation of some Eskom personnel responsible for the project execution of the new build projects,[109] it is possible to describe the type of skills required for the project management component. At the time of the interview (March 2008), when several new coal stations were being considered, along with one or more nuclear projects, in addition to the above mentioned projects already underway (Medupi, Kusile, the OCGT projects, Injula pumped storage), it was estimated that around ten such senior project managers (with a four year Bachelors Degree in Engineering (Mechanical or Electrical) with Project Management Certificate and a minimum of twelve years 'big project' experience) and another forty other project managers (with around seven years experience in both project management and plant operations) were required. Since then, it is unlikely that in the next four years either the nuclear or new coal projects will proceed. Therefore we can assume the demand for such personnel will be reduced by as much as half. We can also assume that at least some, if not all, of the senior and other project managers working on existing projects will be available to be redeployed on the new projects.

The key characteristics of the required senior and other project managers required for the Eskom projects were provided to the author[110]:

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106 Thierry Rolland did not indicate the numbers actually involved in construction but given that the other number indicated are in line with the data provided in Table 6.1, we can expect between 6 and 7.5 million hours involved in construction, erection, and commissioning.

107 North West University, Nuclear Project Management Seminar, Thierry Rolland 23 October 2008, p27

108 Interview with Jan Oberholzer, Hakeen Pedro and Joos Duplessis, 10 March 2008.

109 Interview with Jan Oberholzer, Hakeen Pedro and Joos Duplessis, 10 March 2008.

110 Documents supplied by Jan Oberholzer and Hakeem Pedro, 10 March 2008.

A senior project manager (also referred to as a Project Manager 'Mega' Projects or Project Manager Large Projects) is being used for the return to service projects, the new build OCGT, coal and pumped storage, as well as the major transmission projects (Cape Strengthening, Platinum Basin) would be expected to spend around 55% of their time managing the following tasks:

- *Contract administration and resolution disputes*
- *Managing the Site and Project Managers and Engineers*
- *Developing the execution schedule in conjunction with client and contractors*
- *Managing project time, cost and quality*
- *Determining the resources required for the project and managing the sourcing process for these*
- *Including change and integration management into the project*
- *Chairing/holding regular project progress and review meetings with the client and other stakeholders*
- *Obtaining release of funding for project phases*
- *Arranging for the required contract management skills*
- *Accepting responsibility for all safety requirements for the project*
- *Ensuring project performance against the organisation's standards*
- *Performing post project reviews*
- *Accepting responsibility for the commissioning and hand over of the project to the client*
- *Ensuring adequate and appropriate implementation and managing of ISO 9000, 10006, 14000 &18000*
- *Ensuring project earned value*
- *Ensuring effective project integration*
- *Managing the overall project tender process*
- *Ensuring adequate and appropriate project support (e.g. cost engineering, planning, contract administration, etc)*

They would spend about 15% of their time on the following reporting tasks:

- *Identifying, analysing and interpreting strategic KPI's, timeously identifying and informing management of potential problem areas and recommending corrective action strategies to the senior management with respect to focus areas*
- *Developing, implementing and ensuring the maintenance of an information support system focused on Project Management*
- *Benchmarking the business reporting process against industry leaders and advising on adjustments*
- *Reviewing and consolidating project reports for external stakeholders*
- *Performance management and reporting to client and Divisional Client Office*
- *Providing ongoing feedback to the Executive Committee on Project progress*

They would spend about 15% of the time on stakeholder management including:

- *Developing and implementing strategies for communication with internal and external stakeholders*
- *Liaising with contractors regarding project deliverables*
- *Interfacing with Eskom Client Offices i.r.o*

    - Providing Project Programme status reports to Client Office

    - Contracting with line Divisions for execution phase of project

- *Representing the Department at appropriate forums*
- *Leading and participating in work groups, planning interventions and problem solving sessions*

They would spend the remaining 15% of their time on managing the project management office including:

- *Accepting accountability for financial plans and budgets for the Department and managing performance against the budget*
- *Participating in and contributing actively to strategy sessions, review meetings and other forums*
- *Ensuring that staff are appropriately trained and allocated to the work*
- *Managing the outputs of staff*
- *Ensuring good corporate governance by adhering to Public Finance Management Act and King Report.*

- *Acting as the Department representative/account executive when working with implementation partners*

The less senior project managers would perform many of the above tasks on behalf of and under the supervision of the senior project manager. Many of these tasks are generic to large projects.

There is however one type of project manager responsible for integration that has a range of tasks that is quite specific to power station construction, commissioning and operations. This project manager would ideally have a four year degree in electrical or mechanical engineering and a project management certificate or three year diploma in project management. On a new build or return to service they would focus on one or two units at a time. Around 40 percent of their time would be concerned with:

- *integrating the plans and activities of various role players on a unit being returned to service*
- *managing all pre-commissioning outages on a unit being returned to service ensuring that time, quality and safety is adhered to, by holding outage progress meetings, producing outage plans as well as permit to work plans*
- *taking decisions (hold or proceed) concerning coordinating discipline project plans in conjunction with Discipline Project & Commissioning managers to meet KPI's of: time, quality, cost, & safety.*
- *Co-ordinating all activities relating to plant readiness involving the common plant areas (coal supply, water production, ash system, etc), the boiler plant, turbine plant, electrical and control systems.*
- *monitoring execution and progress of the optimisation of a unit performance to ensure that the plant performance meets pre-determined criteria for certifying the commissioning process.*
- *assisting in the evaluation of the performance of the unit against performance criteria (KPI's) and identifies potential problem areas.*
- *recommending corrective action with the assistance of the site engineering team, technical experts and consultants.*
- *liaising with Client on units in commercial operation to ensure consistent focus in terms of RTS project responsibility to ensure reliability of units during the defect period.*
- *ensuring quality plans are executed to meet client quality requirements.*
- *chairing the weekly project progress and review meetings for a unit being commissioned and/or prepared for commissioning.*

- *reporting to the Project Manager on progress.*

- *Conducts the close-out process for each unit returned to commercial service at the end of the defects period.*

- *Formulates and presents the final report for project close-out on each commercial unit.*

- *Conducts project close-out meetings on each unit returned to commercial service to provide project feedback, highlight problems encountered and lessons learnt.*

About 20 percent of their time would be focused on compiling project integration plans to ensure the integration of the processes and systems of the power station. About ten percent of their time is spent on managing the resources in terms of the project plan including liaison with discipline project managers, technical experts and the OEM. Around ten percent of the time of this project manager is spent on stakeholder relationships between the engineers, contractors, client and project management team, and the remaining ten percent of the time is spent on safety and risk management.

Reviewing the task requirements discussed above, there are not many tasks that are electricity specific (with the exception of the integration) although it was suggested that only people with experience with the industry would have the judgement necessary to manage the new build projects. The main concern that was expressed is that in the electricity sector, and in particular in Eskom there were many managers with the required level of experience (ten to fifteen years) of electricity operations at the big power stations but most of these have not been involved in a project management capacity where a different, more dynamic, set of risks were involved. Although there seemed to be some debate about certain candidates for these positions, the mentoring structure was designed to mitigate the lack of experience and lack of technological know-how that some candidates may have.[111] Unfortunately this risk mitigation strategy came with a cost since Eskom would effectively be paying three senior salaries instead of one.

Returning to the Taishan project, we can unpack the project structure further. Under the project directors, come the main team members. These include an engineering manager for the design team, several project managers for each of the main components of the power station, a project control manager, a project schedule manager, a contracts and deputy contracts manager, procurement manager, a project office manager and assistant manager, a quality and environmental manager, and several managers to deal with local liaison and regulations. This main project team is supported by legal, IT, insurance, finance and human resources support structures.[112] There is a smaller team of eight involved in Germany providing some of the support

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111 Interview with Jan Oberholzer, Hakeen Pedro and Joos Duplessis, 10 March 2008.

112 North West University, Nuclear Project Management Seminar, Thierry Rolland 23 October 2008, p28

functions as those on site.[113] Again it should be noted that the project structure is not that much different to those currently being used on the coal projects with a team of around fifty people performing these different jobs. Most of these people would have between five and ten years post-qualification experience.[114]

If we review the engineering requirement on Taishan we find that there is a management team dedicated to the design, manufacturing and procurement of the NSSS system (reactor vessel, steam generator, pressuriser, pumps, and safety related instrumentation and control). This team also is responsible for local regulatory compliance (Chinese laws and regulations) and the localisation initiatives around the NSSS. It comprises eleven people headed by a project manager, project engineers responsible for particular equipment and several engineers responsible for different components including safety control and instrumentation design.[115] There is also another eleven project engineers responsible for safety, process engineering, interface and configuration, primary and auxiliary components, instrumentation and control and construction and commissioning.[116]

In total, more than 500 people make up the engineering team in three countries. There is a project management component of 60 (52 in France and eight in China), there are 230 engineers in France and another 140 in Germany involved in the basic design and 54 engineers in China involved in detailed design. There is also a team of 44 mainly based in France responsible for equipment supply.[117] The European engineering team is responsible for approximately 1.5 million hours of basic design for systems and lay-out, technical specifications for procurement, manufacturing and civil work, the 3D model, detailed design of some components, (piping, cabling, structural support), interface management with partners and customer, configuration management (technical change), safety reports and assistance of the customer for licensing, follow up of the procurement, manufacturing, erection and commissioning on the technical aspects.[118]

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[113] The AREVA EPR is a joint French/German project.

[114] Interview with Jan Oberholzer, Hakeen Pedro and Joos Duplessis, 10 March 2008.

[115] North West University, Nuclear Project Management Seminar, Thierry Rolland 23 October 2008, p32-33

[116] North West University, Nuclear Project Management Seminar, Thierry Rolland 23 October 2008, p39

[117] Despite the terminology, the basic design is where most of the intellectual property resides. Detailed design is better described as 'grunt' work which is often sub-contracted to off-shore parties in India or China in the current global environment. North West University, Nuclear Project Management Seminar, Thierry Rolland 23 October 2008, p41

[118] North West University, Nuclear Project Management Seminar, Thierry Rolland 23 October 2008, p38

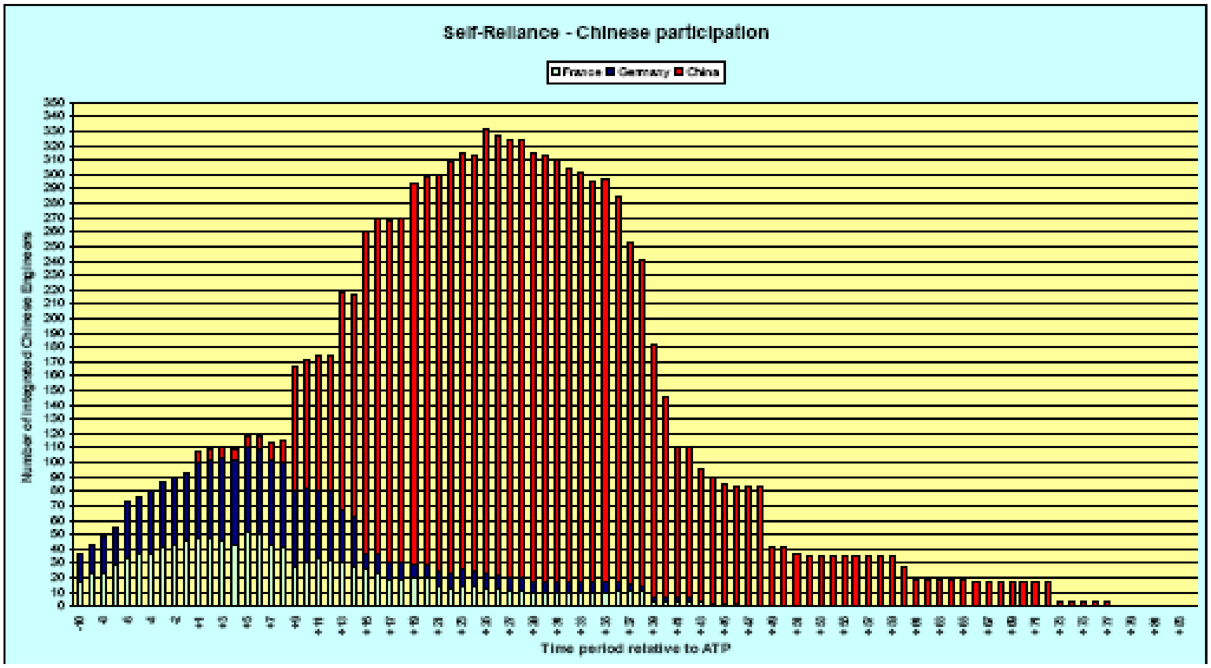
The Taishan project involves a localisation or 'self-reliance' component whereby certain elements of the nuclear technology (both generation and fuel production) will be transferred to China over the course of the 20 year project cycle. There will be a total of 80 Chinese engineers in France and another 37 in Germany providing 300 000 hours towards the basic design.[119] There is also a Chinese team dedicated to the balance of the nuclear island and civil works. As can be expected, this team is largely responsible for all the design and liaison around the construction works which are performed by the local (Chinese) partner. Approximately 1.2 million hours of detailed design undertaken by the Chinese partner supervised by a team of about 21 people from AREVA (mainly project managers and project engineers).[120] The involvement of Chinese engineers in the localisation elements of the Taishan project are best described by the resource chart shown below.[121] As can be seen from the graph the average number of Chinese engineers is around 200, with a peak rising to just over 300 engineers for a brief one year period.

[119] North West University, Nuclear Project Management Seminar, Thierry Rolland 23 October 2008, p50

[120] North West University, Nuclear Project Management Seminar, Thierry Rolland 23 October 2008, p55

[121] North West University, Nuclear Project Management Seminar, Thierry Rolland 23 October 2008, p52

Figure 7.1: Resources required for localisation on the Taishan project



Source: North West University, Nuclear Project Management Seminar, Thierry Rolland 23rd October 2008.

Key to the project management of such large projects is project administration and controls. Not only was this aspect highlighted in earlier interviews with Eskom, but also in a similar engagement with the major project owners' group (Sasol and Anglo American).[122] Both Sasol and Anglo American have reassessed their project needs since the author's 2006 interactions with them.[123] What they have come to realise in 2008 is that they need a project team of around 200 to cover their own project management responsibilities as a client team for project delivery assuming that their EPCM or EPC contractors will provide the balance of skills.[124] What was especially interesting about this reassessment is that they no longer believed that their major constraint lay with professional engineering or project management capacity but rather with project administration and control personnel which they anticipate will make up at least 50 percent of their project teams.

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122 Interview with Roel Stausebach, Herman Van Heerden, 5 March 2008.

123 Interviewed for Merrifield A. (2006) Demand for Skills– an analysis of the proposed infrastructure spending programme, Research report, CIDB.

124 It is likely that their requirements will be considerably less since Anglo American announced in early December that up to half their projects will be put on hold Business Day 17/12/2008.

Table 7.1: Skills breakdown for client teams[125]

	Total Req	Cost controller Req	Document controller Req	Estimator Req	Mech/Elec Eng Req	Mining Engineer Req	Project Manager Req	Process Eng Req	Scheduler Req
Anglo Base RSA	**6**	0.5	0.5	0.7	0.5	0.5	2.0	0.5	0.5
Anglo Coal RSA	**30**	5.0	5.0	2.0	2.0	2.0	6.5	2.0	5.0
KIO	**22**	3.0	3.0	3.5	1.0	1.0	6.5	1.0	3.0
Anglo Platinum	**136**	20.5	20.5	13.2	9.5	9.5	33.0	9.5	20.5
	193	29	29	19	13	13	48	13	29

An indication of the types of skills required is provided in Table 7:1 above. Although the table describes the skills demand for the Anglo American projects, Sasol indicated that they were considering a similar breakdown of requirements. At around the same time, Eskom indicated they were expecting to use a similar proportion on their new build projects.[126] Finally, it should also be noted that unpublished research by the author confirms that project administration and especially document control, mainly commercial transactions but also legal and other regulatory requirements, can use up to 50 percent of senior management time of site.[127]

Of a total of 193 post identified by Anglo, 25 percent will be project managers, a total of 20 percent will be mechanical, electrical and process engineers, and the balance, 55 percent, will involve project administration and controls. Although these people often have tertiary qualifications, and some may even be recent graduates from universities or technikons, it is not uncommon to find many people performing these functions without formal qualifications. Even though a tertiary qualification is preferable, it is also possible to train matriculants to perform these tasks within one to two years. It can be seen from the table that, estimators make up about ten percent of the total, cost controllers another 15 percent, document controllers 15 percent, and schedulers (project programmers) make up the remaining 15 percent.

125 Data provided by Anglo American.

126 Interview with Jan Oberholzer, Hakeen Pedro and Joos Duplessis, 10 March 2008.

127 A Merrifield, 'The process mapping of seven large construction projects for the Construction Improvement Initiative and Construct-IT', 1997-8, unpublished. The purpose of the research was to understand the use of IT in the construction process. Seven of the largest projects in South Africa at the time were process mapped. It became evident that project controls especially around transactions, contractual obligations and regulation were a major focus of activity for site management from project director down.

On the Taishan project, project controls are responsible for financial and project financial reviews, invoicing customers and suppliers, cash in and cash out follow up, following up internal costs, participation to the negotiation of the subcontracts, risk planning and mitigation plan and insurance of the project.[128] A team of eight people focused primarily on cost control, sub-contractor relationships and risk management perform this function. The risk manager, who is specially appointed for this function, manages a rolling list of about 100 identified technical and commercial risks and matches this with a risk mitigation plan which is updated daily.

Associated with the project controls function is the project management office on Taishan which comprises seven people, of which about half are directly responsible for document control. The project management office is responsible for project programme, project procedures, documents data bases (for 100 000 documents – more on this below), correspondence with partners and the customer, monthly reports (internal and external), action list follow up, communication plan, progress indicators for the whole project, and support for all project related meetings.[129] As part of the project management and project controls function is a specialised team focused on the project programme comprised of six people headed by the project programme manager. The project programme is managed by separate teams dealing with procurement, engineering and construction and commissioning.[130]

Finally, and part of the project controls and administration, is the procurement team of six which manage the procurement of about 276 packages for the whole Taishan contract. AREVA is responsible for about 40 percent of these packages related to the primary nuclear components (reactor vessel, steam generator, pressuriser, pumps, and safety related instrumentation and control) and the Chinese partner is responsible for the balance. The AREVA team however provides support to the Chinese partner by providing the technical files for the components and general contractual terms and conditions, reviewing and validating the technical and financial offer received by the partner, assisting with the identification and qualifying of suppliers in order to enlarge competition and reduce costs.[131]

To conclude this discussion of the project structure, this research project initially was hoping to provide an in-depth understanding of the skills challenges arising from the current and proposed Eskom build programme. Unfortunately due to Eskom's lack of co-operation, the author was unable to interview the relevant people at Eskom. However, thanks to the foresight of NIASA and

128 North West University, Nuclear Project Management Seminar, Thierry Rolland 23 October 2008, p34-35

129 North West University, Nuclear Project Management Seminar, Thierry Rolland 23 October 2008, p43-44

130 North West University, Nuclear Project Management Seminar, Thierry Rolland 23 October 2008, p44-45.

131 North West University, Nuclear Project Management Seminar, Thierry Rolland 23 October 2008, p47-49.

the NWU Nuclear Engineering Department, and the generosity of AREVA, who shared the above information in several public seminars, we are able to better understand the skills demands of such projects. It is likely that the Taishan nuclear project is several orders of magnitude more complex than the current (and future) coal projects in South Africa,[132] and would represent perhaps the most optimistic localisation scenario of any future nuclear projects. Nevertheless, a breakdown of the skills required suggests, as did previous work of this author,[133] that the demand for high end engineering and project management skills remains in the order of magnitude of tens, whilst the demand for intermediate engineering and project administration and control personnel may reach an order of magnitude in the hundreds if multiple projects are being undertaken at once. There is no doubt that the total number of people involved in any one project may reach 2000 to 3000,[134] but the reality is that the vast majority of these personnel will be involved in basic construction work.

Why it so important to reiterate this point, is that the strategies to source these various categories of people with skills is very different and that these different strategies (recruit, train, mentor) impose a different type of urgency in addressing the skills challenge. There is no doubt that the most senior engineering and project management expertise will need to be recruited in the global skills market place and there will be specific challenges to acquiring these skills. It can be assumed from previous work[135] that many of the inter-mediate project and engineering skills can be acquired from the local pool, although these personnel may require additional training and specific mentoring. Finally, there is no doubt that thousands of people will need to be recruited and trained to perform the bulk of the construction, manufacturing and erection tasks that these projects entail, but, for most part the training for such tasks is by far shorter than the lead times for most of these projects. We will return to these arguments below.

[132] As will be discussed further below, nuclear projects involve a significantly higher degree of regulatory obligations and therefore place a much higher regulatory burden on the project and engineering staff than conventional projects.

[133] Merrifield A. (2006) Demand for Skills– an analysis of the proposed infrastructure spending programme, Research report, CIDB.

[134] If the most optimistic localisation scenario is adopted, as per the TSAPRO project, then the total number for multiple projects may reach around 65000, but most of these would be involved on the manufacturing and fabrication side. These projections will be discussed further below.

[135] Merrifield, A et al (2006) Increasing the supply of Engineers and Built Environment Professionals, Technologists and Technicians – A JIPSA Proposal (JIPSA 2006), Procurement Dynamics, Skills Audit (Demand Side) of the Built Environment , CBE (2008).

8. The Distribution and Transmission Network

The various power stations discussed above will be the largest and the most complex of the electricity related projects facing the industry, but there are other aspects such as transmission and distribution which also need significant investment. Whilst these projects are not as large as the power stations, they do require a significant range of skills even though these skills will in large part not be in competition with those required for the power stations.

Eskom is primarily responsible for the transmission network comprising the 765, 400, 275 and 220 KV alternating current (AC) lines and the 533 KV direct current (DC) lines. Over the next five years, Eskom plans to spend about R38 billion on transmission infrastructure. This investment will scale up from about R5 billion in 2009 to about R11 billion in 2011 before scaling down to around R5 billion in 2013.[136] Major projects currently underway include:

> 765kV Zeus to Omega: This project involves the construction of a 765kV transmission power line and associated substation infrastructure from Zeus substation in Mpumalanga down to Omega substation, near Koeberg power station – approximately 1 450km. This line will considerably strengthen the electricity supply to the Western Cape. The target date for completion is in 2010/11. To date, 125,3km of this line had been strung.
>
> Duvha-Leseding line: This project is aimed at increasing the capacity into the Steelpoort area. The project comprises the 400kV yard extensions at Leseding substation and the construction of 206km of line from Duvha to Leseding. The project completion date is 2009.

That this investment is necessary is shown by Eskom's own assessment of Transmission's performance. It reported that in the 2007-2008 the performance of its transmission network was significantly below par (see Figure 8.1 below) and reflected its worst performance since 2002. The number of interruptions affecting supply (with or without load-shedding) was more than 70 percent greater than the previous period and about 33 percent higher than the target. The number of major incidents (severity one) were five time higher than both the previous year's performance and the target. This was due to major equipment failure. The number of line faults per 100 km was above the target but an improvement on the previous performance.[137]

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136 Eskom Annual Report 2008. Of concern, is recent feedback from personnel in Eskom that a significant number of Transmission projects are being put on hold due to Eskom's financial constraints.

137 Eskom Annual Report 2008.

Figure 8.1: Transmission Performance

Transmission system performance

Measure	Description of measure (and unit)	Target 2008	Actual 2008 (include load shedding)	Actual 2008 (exclude load shedding)	Actual 2007	Comments
Number of interruptions	Interruptions affecting the continuity of supply	≤36	49	48	28	Not achieved. A significant deterioration from last year and worst performance since 2002. See comments below
Number of system minutes lost	Total number of system minutes lost (for incidents of less than one system minute)	≤3,90	3,56	3,56	3,67	Results within target, although the number of interruptions increased
Number of major incidents	Records number of incidents with a severity greater than one system minute					Not achieved
	– severity degree-one (≥1, but less than 10)	≤1	5	5	1	The five major incidents of degree-one severity were the result of equipment failure
	– severity degree-two (≥10, but less than 100)	0	0	0	1	
	– severity degree-three (≥100)	0	1	0	0	The degree-three incident was the result of load shedding
Number of line faults	Number of transmission line faults per 100km	≤2,2	2,31	2,31	2,43	Not achieved, although this is an improvement from last year's performance

Source: Eskom Annual Report 2008

Eskom currently still plays a significant role in the distribution network comprising the 132, 88, 66, 44 and 33 KV high voltage lines alongside the municipalities discussed below. Eskom is planning to spend about R32 billion on these distribution networks at around R6 billion a year.[138] However, the future of such investment may depend on the speed at which the Regional Electricity Distributors (REDs) will be established.

Eskom's performance on their distribution network is reflected in Figure 8.2 below.

[138] Eskom Annual Report 2008.

Figure 8.2: Distribution Performance

Distribution network interruption measures

Measure	Description of measure (and unit)	Target 2008 (exclude load shedding)	Actual 2008 (exclude load shedding)	Actual 2008 (include load shedding)	Actual 2007 (include load shedding)
Distribution supply loss index (DSLI)	Transformer unavailability index (minutes per month)	≤ 5,10	**10,36**	**31,50**	9,10
Reticulation supply loss index (RSLI)	Total transformer unavailability index (hours per annum)	≤ 1,55	**2,24**	**3,39**	1,95
Reticulation supply loss index (RSLI)	Unplanned transformer unavailability index (hours per annum)	≤ 1,10	**1,68**	**2,82**	1,33
System average interruption frequency index (SAIFI)	Reliability of supply index (number per annum)	≤ 22,80	**25,36**	**33,72**	25,20
System average interruption duration index (SAIDI)	Availability of supply index (hours per annum)	≤ 42,30	**55,51**	**73,70**	51,40

Source: Eskom Annual Report 2008

As shown in the above table, performance has not improved since the previous year and was significantly above the targets for 2008. This was the result of a higher number of planned interruptions for maintenance and refurbishment and an increase in unplanned interruptions, caused by an increase in conductor theft, energy theft and bad weather.[139] According to a number of informants, load shedding probably contributed most to the poor operational performance.

The major component of the distribution network lies with the municipalities which service 60 percent of the clients and about 40 percent of the sales volume (the balance is provided by Eskom). There has been a proposal since 1992 to consolidate the distribution industry into six REDS that would cover the nation. There are many motivations for such a consolidation, but the one most relevant to this report is the argument that the municipalities have been neglecting the maintenance and rehabilitation of the network. There have been several indications of the extent of the maintenance backlog. In 2007, the EDI Holdings were still talking about a backlog of R5 billion.[140] Amos Masondo, as the chairperson of SALGA, indicated that the price was R25.7 billion

139 Eskom Annual Report 2008.

140 EDI Restructuring for Security of Supply and Sustainable Development, Commission 3, Phindile Nzimande, 26 September 2007. This ascertain was also evident in several other presentations and the EDI Holdings Annual Report 2004/05 and other presentations by Dr Willie De Beer such as Presentation made by the EDI Holdings COO, Dr. Willie de Beer to AMEU, Eastern Cape: 51st Annual General Meeting on 24 May 2007.

at the Electricity Distribution Maintenance Summit in June 2008.[141] Recently EDI indicated that the price may be R27.8 billion at an ASGISA forum.[142]

In that same presentation, they gave some examples from seven municipalities of the gap between the current spending on maintenance and the requirements. On average the level was around 50 percent of what was required but in the case of Nelson Mandela Metro six times the current level of spending would be required to address the shortfall, Mbombela and Mfuleni would need four times their current spending and Msundusi about three times its current spending. Interviews conducted by the author for this report (discussed below) would support the figures from the individual municipalities. It is not evident from the EDI presentation how the new figure for the backlog was estimated, and although it represents a ten-year horizon, it would need further substantiation before it can be accepted as credible.[143] Notwithstanding the discrepancy of figures, it is evident from both the EDI presentations and the interviews conducted by the author that the distribution infrastructure is being neglected and we should anticipate expenditure in the order of R1-2 billion per annum to restore it to operational efficiency. Whilst this investment will have skills implications, the bigger challenge in the distribution sector arises from the decline in operational and maintenance staffing across the municipalities visited. This issue will be discussed further below.

In terms of transmission, which accounts for about R38 billion of projected investment, Eskom has a skills challenge but, again, it was not considered by them to be beyond their capabilities to manage.[144] The two main challenges for Transmission concern the erecting the lines and building and equipping the sub-stations. On the line erection, Eskom had done a number of detailed capacity studies which indicated that local firms have the plant and equipment and staff to do about 800kms of line per annum which will be about 50 percent of the required workload as activities were scaled up (and they were expected to scale down equally fast thereafter). Eskom believed that although international firms would enter the market, bringing with them additional specialised equipment, they were likely to recruit from the local pool of skills to run their

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[141] IOL Business Report, 9 June 2008.

[142] Dr Willie De Beer, Presentation to the Inter-Ministerial Committee of ASGISA, 31st October 2008.

[143] Dr De Beer has asked DME for permission to release the report to the author on which the new assumptions were based but to date he has not heard from him. Given that the presentation only refers to about R2 billion urgent spending (before the 2010 World Cup) and given that they have requested R80 million to provide a comprehensive survey on the distribution maintenance and rehabilitation backlogs, the current figure should be treated with caution.

[144] Sandy Dalgleish, Sarel Marais, Francois Bothma, Subhas Maharaj, John Mokoena, Charit Buchner, and Mmamoloko Seaba assisted here in 2006 for the report Merrifield A. (2006) Demand for Skills– an analysis of the proposed infrastructure spending programme, Research Report, CIDB.

operations locally.[145] Although this may place further pressures on the local demand for skills, the scheduling of line activities was such that much of this local capacity was expected to be trained before peak demand is reached (2008/09). On the engineering side, Eskom people responsible for lines indicated that they had kept up with technological innovations and in some instances are world leaders. They also believed that they would have to scale up on the client side to meet the proposed challenges but that this was manageable.[146]

The main transmission challenge on the line side was to be on securing the servitudes or right-of-ways for the transmission lines to run. Eskom indicated that they have to secure around 3 200 kms of servitudes in order to meet their expansion targets. The key skill required here is sourcing appropriately skilled and experienced negotiators (with property valuation/land negotiation skills) who will acquire the rights. Eskom had six such skilled individuals and was expected to contract in another dozen to meet demand.[147] After three years they are expecting the demand for such skills to decline. The other challenge on the servitudes is in securing the necessary planning permission. By law ESKOM uses independent consultants and has no difficulty in sourcing the skills. Their biggest concern is that the National and Provincial departments of the Environment (DEAT and its provincial counterparts) do not seem to have the in-house skills or capacity to process applications timeously.[148] Although they were heartened by the new regulations which will require action within 90 days, they believed that the under-capacitated departments would continue to find ways to circumvent these deadlines and delays in acquiring environmental approvals would continue.

The transmission challenge in building sub-stations was also seen to be significant but not necessarily overwhelming. The main challenge lay with primary plant (Transformers, Circuit Breakers, Current Transformers etc). Eskom personnel indicated that they were reasonably confident that they could cope in the areas of a secondary plant (Control and Instrumentation, Protection Systems). In particular, their concerns are that they do not believe that they were up to date with the primary plant technology and even where they had access to ‘greybeards’, these individuals have not been working with the most recent technologies. Although the sub-station

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145 In two recent interviews conducted in October and November 2008 under the auspices of NIASA, two local firms were under-whelmed by volume of transmission and distribution work that was being put out for tender by Eskom. They felt that the low prices currently reflected in the market did not justify a major effort on their part to tender and therefore they were happy to look for work elsewhere.

146 Again we are talking in the order of magnitude in the tens here.

147 There are currently 1300 registered property valuers so this requirement should not outstrip demand, Procurement Dynamics, *Skills Audit (Demand Side) of the Built Environment* , CBE (2008),.

148 The Transnet Capital Projects Group voiced similar concerns, interviewed for the report, Merrifield A *Demand for Skills– an analysis of the proposed infrastructure spending programme*, CIDB (2006).

engineering competence will have to double over the next five years from around 100 to about 200, the actual demand for highly skilled and experienced staff is much more limited. For instance, they would have to recruit an additional five to ten people with the appropriate fifteen to twenty years of sub-station design experience to meet the future challenges. Obviously to ensure sustainability, they would have to ensure that their pipeline of less experienced staff is maintained. The Sub-station group however believes that the required skills and experience are in the market.

In the area of Distribution, Eskom has around R32 billion to invest going forward. Here, like in the other areas above, there was concern about skills shortages but no overwhelming panic.[149] Distribution in Eskom is also divided up between reticulation/connections and sub-stations and they also subdivide their work between a relatively small number of direct industrial clients who receive both transformers and reticulation and individual household connections. For example, in the 2005/06 year, in one region, there were about 14 000 direct customers (33kV and below), but only around ten major industrial clients (requiring sub-transmission and transformers in the 44/165kV range).

The main area where Eskom was likely to experience capacity constraints was in the individual household connections. In 2006, they were doing about 135 000 connections per annum but they were aiming to get back to about 300 000 connections to meet DME expectations. The Distribution people were also concerned about the refurbishment of existing installed stock where they hoped to increase the current refurbishment rate of about one percent of installed capacity to about 2.5 percent. This can be more difficult work because of the individual challenges that refurbishment entails.

The key skills shortfall for distribution were considered likely to be in the area of clerks of work since all these new and refurbished connections would need to be inspected. Unfortunately, the traditional pool of ex-artisans who did this work were thinning out and many of the new entrants move onto other responsibilities within a few years thereby draining the skills pool yet again. In 2006 there was a 30 percent turnover rate with staff involved in these clerks of work functions. Eskom were however putting in place a programme to develop this pool of skills further. But again the demands are limited, in the order of magnitude of tens (perhaps 30-40) rather than hundreds.

Distribution also involves the arena of local government and here the picture is much more varied. A range of municipalities were interviewed including three metros (Tshwane, Ekhuhuleni, Nelson Mandela Metro), four medium sized industrial cities (Sebideng, Motheo, Mogale City, and

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[149] Peter Underhay provided information in 2006 for the report, Merrifield A *Demand for Skills– an analysis of the proposed infrastructure spending programme*, CIDB (2006).

Matjibeng) and one small town (Heidelberg).[150] Across all the sites interviewed, everyone acknowledged that there were skills deficits but the extent of the problem differed from the merely manageable (three instances) to the critical (four cases) to one absolute emergency situation. In all these interviews, the impression gained was of competent professionals battling under increasingly difficult circumstances. Those interviewed were primarily involved in distribution, although some were running municipal power stations. The primary focus of the interviews was the skills challenges at municipal level.

Notwithstanding the severity of the problem, all those interviewed indicated that skills shortages have increasingly become a problem. The primary cause of the problem was that electricity is seen by local government as a ‘cash cow’ which can generate revenue to support municipal spending. In one extreme case, 90 percent of municipal revenues came from electricity sales. In all instances, there was no relationship between revenue collected from electricity sales and the money spent on operating and maintaining the electricity infrastructure in the municipality.

The most obvious manifestation of this imbalance between revenue and spending on electricity infrastructure was that there was in almost every instance a major dis-investment on the maintenance and rehabilitation of physical assets. Not only has this resulted in a dramatic increase in outages (exacerbated by the power-shedding in early 2008), but it has increased the demand for skilled personnel who have to spend the bulk of their time fixing faults and resetting the system rather than on routine maintenance and new connections. As noted above, the most recent estimate of infrastructure backlog in the local government sector is around R28 billion. Figures shown to the author by those interviewed reflect that maintenance (not even rehabilitation) budgets are currently being under-funded by 40-90 percent per annum. Most of those interviewed also endorsed the view that between R20-30 billion would be needed to restore the operational capacity of the distribution network run by local government.

One of the key concerns raised about this under-investment was that in the majority of the networks, there was equipment (transformers, circuit breakers, etc.) which was more than fifty years old. Not only is such equipment subject to more outages, but it also is much more idiosyncratic, requiring that those individuals who performed skilled work such as switching (particularly during load-shedding), to understand the specific characteristics of each piece of

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[150] The selection of interview sites was largely based on the relative complexity of the distribution network they controlled. In the case of Tshwane and Ekhuhuleni several different interviews were conducted because those interviewed were involved in different aspects of the business. In the majority of interviews conducted several personnel participated in the interview. The author approach a dozen smaller municipalities but their distribution network was being run by Eskom and therefore covered in the comments above. All the above mentioned municipalities agreed to speak to the author (the one exception was the Cape Town Metro who agreed to an interview but failed to allow it to happen even after the author had flown into the city to conduct it). None of the municipalities interviewed were subject to the Eskom embargo on this project.

equipment. This created a much higher requirement for 'tacit' knowledge of the system than a much newer infrastructure would need, and such an understanding placed an even greater pressure on those skilled individuals who currently operated the system. An example of the problem created by load-shedding is that whilst newer vacumn circuit breakers can be switched many hundreds of times without servicing, some of the older mechanical circuit breakers would need to be serviced after three switches. Obviously this led to much higher outages and a much greater demand for skilled personnel.

The other obvious problem with the mismatch between revenue collected and spending on the municipal electricity system is that in all cases, the shortage of funds in the electricity departments meant that there was between 30-60 percent vacancies in most skilled categories. Even these numbers underestimate the problem because in most instances, the official organograms did not reflect the true skills requirements, but the number of posts (and levels of seniority) that the municipal councils would allow. A majority of those interviewed indicated an appalling lack of understanding demonstrated by councilors and senior municipal officials as to the actual work-processes involved in operating the municipal electricity systems.

In these discussions, it was evident that there is a shortage of electrical engineers (four year degree). In most municipalities this shortage was estimated to be around 30-40 percent of what is required. The main reasons for the shortfall, is that many of those previously employed are getting older, and there has been very little replacement over the past decade. Many leave the municipality when they reach 55 years of age because they qualify for their full benefits yet can still operate as a private consultant for many years further. The 55 year old cut-off point is because most senior managers get five-year contracts. If they leave at 55, they have time to establish themselves in the private sector and still retain their benefits from the municipality. If they sign on for another five years, they have no guarantee of a subsequent appointment and could find themselves trying to establish a practice when they are in their 60s. This may be simple administrative arrangement perhaps, but one that seems to be increasingly depriving local government of senior professional skills.

Obviously the loss of engineering and managerial expertise is not only attributed to the 55 year exodus. Allyson Lawless in her studies of civil engineering has shown that retirement, emigration, working in an alternative industry or sector, and death (either premature or on schedule) is a major cause of outflow from the professions.[151] Her informal estimates of the electricity departments of local government suggest that the shortage of qualified electrical engineers is around 30-40 percent of those required by local government. Her own experience with supporting

151 Allyson Lawless, Numbers and Needs (SAICE, 2005), Numbers and Needs in Local Government (SAICE, 2007).

mentoring programmes in local government is that many municipalities have lost the resources necessary to maintain their systems although she has not formally studied the problem.[152]

Apart from death (and ill-health resulting in death), all the other factors identified by Allyson Lawless can in fact be addressed by improved working conditions and practices in local government. Many of those interviewed spoke of how they have lost staff due to the many frustrations that currently afflict their municipalities. For many themselves it was not a question of whether but when they would choose to leave the municipality. For the majority, who were White, they indicated that employment equity played a major role because it prevented them from retaining and/or recruiting staff with the appropriate skills and experience. Often they found themselves with vacancies even though, in their opinion, there were competent people seeking employment. They also felt that employment equity had put pressure on younger staff to seek alternatives since they assumed their career prospects would be limited. A majority of those interviewed also indicated that many White staff were in 'acting' positions and were in fact doing several jobs because there were insufficient qualified Black candidates applying for these jobs.

Employment equity was not however the only frustration and cause of exit. Many interviewed, including some Black professionals, cited the over politicisation of the municipalities. Some indicated that professional (and other) positions were allocated purely on the basis of political alignment and even employment equity was not sufficient to ensure career advancement. The more invidious impact of the politicisation, however, is that even though the technical staff made recommendations about infrastructure plans and budgets, these recommendations were often over-ridden by executive managers and councilors who had different (political) agendas. The majority of those interviewed confirmed that they were unable to secure the funds needed to maintain and rehabilitate their infrastructure because their technological rationale was trumped by the broader political motivations of the local municipalities.

In some instances, even though posts were identified and people were found to fill those posts, the planning and budgeting processes did not ensure funds were allocated for those posts. One glaring example of this problem is where some municipalities have embraced the DBSA's infrastructure mentoring programme whereby older professionals are seconded to the municipalities to mentor young professionals, but there are insufficient funds to employ such young professionals. As a result, these 'mentors' end up performing functions that support on-going operations and no capacity-building in fact takes place.

The problems described above for professionals and managers are also apparent for the skilled artisan trades. Traditionally local government trained their own electricians and semi-skilled

[152] Interview with Allyson Lawless, 23 September 2008.

operatives such as linesmen and cable-jointers. Many of those interviewed reported that they had lost a significant number of their existing staff and that they were struggling to retain newly trained skilled and semi-skilled personnel. As noted above, employment equity plays a role in the loss of staff, since many municipalities have prevented White candidates from taking up or keeping permanent positions. In many instances these disqualified artisans are employed on a contract basis (up to 30-40 percent of staff performing those functions could be contract staff), but as contract staff they are more inclined to pursue other opportunities when these arise in the market.

Even a significant number of those skilled and semi-skilled artisans who qualify in terms of employment equity have left for better opportunities elsewhere because municipal remunerations scales are significantly below (around 20-30 percent) those found elsewhere. One of the key problems that this staff exodus is causing is that a significant proportion of artisanal and semi-skilled workers leave before their training is completed and therefore the pool of skilled workers both in the municipalities and in the broader market is diminished. There are fewer people reaching the stage where they can undertake the trade-tests, and therefore the available pool of artisans is being depleted.

One area where this skills depletion has become most critical is in the area of high-voltage switching. Many municipalities discovered during the 'load-shedding' era that the number of people competent to switch – open or close the circuit breakers – was extremely limited. Ordinarily a qualified electrician or supervisor with an artisans background would be qualified to switch but, with the staff losses over the years with a concomitant loss of tacit knowledge about the specific system, there were fewer and fewer people able to do this. Part of the problem lies in the fact that all electricity circuits are notoriously vulnerable to surges (for instance when a large factory switches on) and part of the problem lies in the reality that some of these municipal systems were made up of components (transformers, circuit breakers) which were old (in some cases more than fifty years old). Only someone who had the knowledge of the system and its specific vulnerabilities is able to ensure that the switching takes place without serious incident.

Although several of the metros have training courses that have qualified hundreds of people for high-voltage switching, in some of the larger industrial cities there are less than five people who can perform these tasks. The main difficulty with such high-voltage switching, is that it requires a significant amount of 'tacit' knowledge of the users – who are the main users and what is likely to happen if the power is switched on again – and of the components – how are some transformers and circuit breakers going to perform under certain load conditions. Unfortunately, much of this tacit knowledge has left with the people who previously worked in local government leaving several cities and towns extremely vulnerable to switching mistakes. In one city there are two people (both senior artisans close to retirement) and in two other cities there are about four (including the manager responsible for electricity). All three of these municipalities expect there to be a major incident in the future arising from their constraints around switching. Whilst training courses can ensure that new people have the practical and theoretical understanding, it is much more difficult to transfer the 'tacit' knowledge of the system.

Ultimately the eight municipalities interviewed confirmed a basic argument around distribution (and other infrastructure). It needs to be ring-fenced so that the revenues generated from these services can be used to operate, maintain and, where necessary, expand the services. This argument has long been behind the motivation for the Regional Electricity Distributors (REDs) which seeks to consolidate and rationalise the distribution sector. Unfortunately, as many informants indicated, the concept of REDs has been promoted since 1992 and sixteen years later they have not yet become a reality. It is not appropriate to comment on the politics of REDs in this research, except to raise one issue related to the skills crisis in distribution. A number of informants who have had experience of such ring-fenced services are strong believers in the REDs approach but they question the current composition of the six designated REDs on operational grounds. Although the REDs were established to ensure economic sustainability,[153] these informants argued from more practical and logistical grounds that perhaps it would make more sense to have smaller and more regionally coherent REDs which could benefit from operational economies of scale. They pointed out that several of the existing metro electricity departments have operated on such a regional basis in the past (and currently in the case of one city), and they may better address the problems discussed in this section than the currently proposed six mega-REDs.

[153] The policy documents arguing the case for the REDs motivate on the basis of economic sustainability but they do not provide adequate information to test this motivation.

9. Learning from Experience in the Journey from the Quantity to the Quality of Skills

The main approach of this, and previous studies undertaken by the author, is that the skills challenge is quite different for various elements of the electricity (and general infrastructure) value-chain. Although some projects involve a cast of thousands, even this multitude comprises many different types of skill and requires a variety and quality of experience.

On power projects, the engineers involved in turbine design, the basic design of the super-critical boilers or the nuclear reactors and pressure vessels are likely to be world-class experts with decades of process knowledge and experience. The senior project managers would be in a similar category. The key challenge here is to find these types of people and then procure and retain their services. Below them come hundreds of engineers and project administration personnel who would need considerably less knowledge and experience. Whilst recruitment, procurement and retention of such personnel remains a challenge, the bigger challenge is to ensure that these people can productively apply their current knowledge and experience to the projects in hand.

A significant aspect of this process is to develop their existing knowledge and experience and adapt it to the specific projects being undertaken, a process more commonly referred to as learning.[154] In the South African context, where there has been a long-term hiatus in building such projects, it can no longer be assumed that the target population of skilled personnel have the required experience and knowledge of new technologies. In addition, affirmative action and employment equity has placed its own demands on the skills pool.

Therefore the primary challenge is to develop candidacy and mentoring programmes whereby these people can develop the requisite skills, knowledge and experience to participate more productively in such projects. The long-term benefit of such an approach is that, as in the past in South Africa, those that develop their skills in such initial projects most often go on to perform more senior roles in future projects thereby addressing future skills deficits that will arise from new projects. It is evident from almost any interview with senior Eskom staff, that this was how they developed their own skills in the massive build programmes of the 1970's and 1980's, and almost every person can describe their skills development trajectory project by project over those decades. There is no reason to doubt that a similar process will arise as the current build

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154 The author explored this issue in much greater depth in Merrifield, A (2001) 'Is there a future for 'old economy' firms in the West Midlands', School of Engineering and the Built Environment, Built Environment Division Occasional Paper, ISSN 1474/7502

programme comes to an end (including the refurbishment) releasing more knowledgeable and experienced people to either build or operate new facilities in the future.

In many cases, the number of high level engineering specialists required would merely be limited to those required for the client's team since the basic design would be done by the OEM (original equipment manufacturer). In many of these instances, the real intellectual property does not lie in the science, much of which could be replicated by a moderately intelligent high-school student, but in the process engineering knowledge and experience that enables that specialist to optimise the design to use that technology.[155] It has been argued previously by the author[156] that many of the crucial professional skills on the engineering design side will be embodied in the technology that is to be used. Whilst some now view this assumption with doubt,[157] the information gathered through interviews with willing participants confirmed that the primary methodologies used in power generation are encapsulated in the physical products (boilers, turbines, bag-filters, heat-exchangers, conveyors etc.) that are used to build and operate such power stations.

This means that the professional skills required by the clients are limited to those necessary to specify and oversee the process of acquiring that technology. In an interview conducted by the author almost two years ago with an international firm, the CEO famously noted that his company had to provide the process guarantees for the equipment and that the only South African hands that are likely to touch the equipment will be those helping to move the crates in which the equipment arrived.[158] Happily, some South African engineers are being used to assemble and commission the equipment but this work is being done under strict supervision of the OEM (original equipment manufacturer) professional staff, and most importantly, that OEM retains responsibility for all process guarantees.

Ultimately, this author believes that the client's need to ensure that OEM provides these process guarantees which will limit the demand for local design and engineering professionals in the electricity expansion programme. This perspective is of course reinforced by the OEM's own interest in profiting from its own intellectual property. Given that this intellectual property is generally a fundamental asset on the OEM's balance sheet, it is unlikely that the OEM transfer such knowledge without a commensurate payment. Both these views, and the interviews conducted for this study, suggest that the potential to localise a significant component of the new

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155 P Watermeyer *Handbook for Process Plant Project Engineers* (Professional Engineering Publishing Limited 2002).

156 Merrifield A. (2006) Demand for Skills– an analysis of the proposed infrastructure spending programme, Research Report, CIDB, Procurement Dynamics (2008) Skills Audit (Demand Side) of the Built Environment , CBE (2008)

157 DBSA Infrastructure Barometer 2008.

158 In order not to embarrass the individual or firm the names and types of equipment will not be identified.

electricity infrastructure is perhaps a lot more limited than may have been expected. It is worth pausing here to reiterate, that because of the OEM's process guarantees and intellectual property, the demand for local professionals is likely to be limited.[159]

It is evident in such projects like Taishan that some form of technology transfer can occur with the local engineering team being involved in the basic and detailed design processes, but it is not clear to what extent the intellectual property will be transferred. As far as it can be understood from such presentations and discussions with those who have experienced similar technology transfer processes in South Korea, the technology transfer is limited to the technology buyer being able to produce that technology in the host country under license from the technology provider. It would seem that where such technology transfer has taken place, it is under license to the original OEM, and if there is an intention to supply to a third party market, the OEM would be involved and would earn fees or royalties from the transaction.[160]

In the process of doing this research, Eskom's lack of participation prevented the researcher from speaking to the project teams on the current coal projects, it was impossible to discover the exact nature of the technology transfers, if any, that are currently being undertaken on these projects. Certainly those interviewed around the proposed nuclear projects were unwilling to be explicit as to the extent of technology transfer saying that those discussions were commercially sensitive. However, this author's previous experience in the process engineering environment, both in South Africa and abroad, where both technology supply and acquisition were part of the business, technology transfer was always restricted in terms of markets and the extent to which the supplier would be recompensed for their intellectual property. In most of these instances, the technology supplier continued to control the intellectual property and process knowledge but allowed the local partner to do detailed design and/or manufacture, construct or commission plant under its supervision (as is the case for Taishan).[161]

In the South African electricity value-chain, there have been some efforts at 'deepening' the extent to which local companies will add value to the final output. In the Eskom /TSAPRO model,

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159 Such limited demand for professional skills will also arise from the 'fleet' approach to procurement whereby more of the same equipment/plants will be acquired than if procurement was competitive.

160 The author has several informal discussions with a range of South Koreans about the extent to which technology transfer has taken place in South Korea, the model upon which South Africa has based its own localisation ambitions. These were informal discussions tangential to other business dealings. These assumptions were however confirmed in a recent visit to these and related firms in South Korea where it was also discovered that the top-tier Chinese firms engaged in equipment manufacture operate under similar constraints.

161 In a number of legal cases the question of process knowledge was tested and findings were made to the extent that it could be seen as intellectual property. Since most of these cases are still being resolved, no further details can be shared. However, it should be noted that the easiest way to ensure that some process knowledge was retained by the OEM was to have it embodied in specific equipment.

such localisation has been classified in terms of ‘shallow’, ‘medium’ and ‘deep’.[162] For all intents and purposes, shallow localisation is already occurring on the current coal projects. It involves (amongst other things):

- Earthworks
- Foundations
- Concrete Works
- Intake and outfall infrastructure
- Roads (60km)
- Auxiliary buildings
- Substations
- Transmission Lines
- Cranes

Medium localisation would involve the fabrication and installation of much of the equipment which is currently being produced in South Africa under license from an OEM:

- Pumps
- Fans
- Valves
- Filters
- Vessels
- Pipes
- Motors
- Transformers
- Switchgear

And deep localisation (on a nuclear project) would involve:

- Uranium mining
- Uranium conversion
- Uranium enrichment
- Fuel fabrication
- Spent fuel reprocessing
- High level waste storage
- Steel works

162 New Nuclear Power Plants Programme Overview, Presentation to NIASA Manufacturing Sub-Committee, 14 February 2008; A Model to Project Skill Requirements for the Capital Expansion, Design and Manufacturing Programme, Workshop with DPE, Eskom –CSDP, Eskom Corporate University, CSIR, JIPSA26 June 2008.

- Forgings
- Reactor Pressure Vessel and Steam Generator manufacture
- Turbine manufacture (combined with coal steam turbines)
- Heavy electrical manufacture
- Engineering Intellectual Property

Although it was not necessarily in the brief of this project to investigate the localisation challenge, the issue was raised in the course of understanding the skills requirements of many of the industrial concerns who were NIASA members.[163] It became evident that even though these firms would welcome any attempt at reaching deep localisation they were sceptical of this objective being achieved. As noted above, many of these firms were involved in current projects as suppliers of such equipment mentioned under 'medium localisation' from OEMs abroad. In most instances this equipment was manufactured or at least assembled in South Africa and they often played a big role in servicing and rehabilitating the original equipment. Whilst they hoped to continue to play such a role in the future, and whilst they hoped that the proposed nuclear projects may expand this role, for the reasons discussed above, they did not expect localisation to result in the intellectual property being transferred to this country.

These firms indicated that in most cases they had the staff necessary to produce the equipment required for the current coal projects. In the case of the proposed nuclear project(s), they expected to expand their staff by one to two hundred skilled personnel. However, this expansion would be dependent on the extent to which the nuclear project would be rolled out. In the case of a single project roll-out, most firms did not expect to invest in further plant or equipment, although they expected to spend time on money qualifying for accreditation in terms of international standards bodies such as American Society of Mechanical Engineers (ASME) who provides design and manufacturing standards for the construction of certain aspects of the power station (particulary pressure vessels).

In most cases the additional staff would be trained in South Africa although the trainers of such staff were expected to come from the OEM (or at least be trained in the OEM factories). With the exception of welders (discussed further below), these firms indicated that the types of skills they required would largely be dependent on the equipment they were sourcing from the OEM. Training of pipefitters and boilermakers would largely be related to that equipment although they expected them to become qualified artisans. The main concern of these firms was whether there would be a sufficient volume of work to justify this training and accreditation. One of the difficulties

163 Given that some of the comments may embarrass these firms, individuals interviewed will not be cited. Twelve industrial firms who were NIASA members were interviewed and the above comments reflect a summary of their views.

they had with qualifying artisans was that there was an insufficient flow of work to ensure that the artisan training cycle was completed.

There was a lot more scepticism about the deep localisation and almost all these firms admitted that they did not expect it to be realised. The main argument against deep localisation, although supported by the arguments around process knowledge and intellectual property discussed above, rested on the grounds that the South African (and even African) market was too small to justify the investments in the plant and equipment that such deep localisation would require. In addition to having small markets, these firms indicated that South Africa had logistical constraints being too far from some of the larger and more dynamic markets. In these exchanges, it was evident that these firms had almost no expectation that such deep localisation would occur.

One example of the difficulties of deep localisation that was raised by those involved in studying the nuclear fuel cycle. It was noted that of the four phases of the nuclear fuel cycle (mining, conversion, enrichment, fuel fabrication), only enrichment was difficult to do and also the only part of the cycle that made real money.[164] These informants explained that even though South Africa had done enrichment in the past, the process knowledge that produced the South African outputs and the process knowledge required for the most advanced outputs (in the US) was decades apart. It was perhaps possible given many other unknowns that the South African scientists and engineers may develop this process knowledge but that would take ten to fifteen years. In the interim, the current process leaders would also be learning and innovating. Although it could not be said in the interview, there was little expectation that such deep localisation would occur.

If it can be accepted that localisation is likely to be less deep than originally expected, then the skills requirements described by the TSAPRO model will be considerably lower than the 63000 local jobs projected. If the information gathered from the interviews with local firms engaged in supplying technology for overseas OEMs is to be accepted, then under the most optimistic scenarios, we could expect to see a demand for several thousand artisans evenly spread amongst the main categories of boilermakers, pipe-fitters and welders. In most of these interviews there was little anxiety about the training of such additional artisans except around the continuity of work (discussed again below).

[164] Interview with Piet Bredell, 10 November 2008.

10. Conclusion and Recommendations

This report has sought to provide an understanding of the demand for skills across the electricity value-chain. Notwithstanding the obstacles that the author has had to face, the report seeks to develop this understanding in the most practical manner possible. Identify all the main components of the electricity value-chain, quantify the infrastructure investment required for these components, and then seek to understand, on a project by project basis, the skills requirements for this infrastructure investment. Despite major obstacles in sourcing information, the findings across multiple sources of data (previous research, secondary material and other projects) indicate that the skills challenge remains manageable. The reason for such a benign conclusion is that the most highly skilled resources are in low demand (in numbers) and therefore the challenge to acquire them cannot be over-whelming. Many more less skilled professionals and artisans are required but even here the numbers are not overwhelming (in the order of magnitude of hundreds for the former and thousands for the latter) and in most cases can be trained and given work experience within the lead times of current and future projects. Ultimately the skills challenge will depend less on the efforts of project managers and trainers and more on the big questions decided by policy makers.

In the process of doing this research, as was the case in previous research projects, those interviewed expressed deep concerns about the demand for an acquisition of skills. However such concerns reflected a contradiction about the project delivery process. In most instances cited, the informants were concerned about the rate at which they had to scale up to participate in certain projects. Almost all indicated that they did not doubt that in the medium term sufficient professional and/or artisanal skills could be acquired for future projects but they were worried about short-term demands. On the other hand, the same informants suggested that the nature of the short-term demands was such that they did not provide adequate continuity to ensure the full cycle of training and work experience required to produce a competent professional and/or artisan. Despite the large publicity surrounding the Government's infrastructure programme, many indicated that they were postponing the acquisition and/or development of such skills until they had some form of 'order' in hand. Unfortunately, especially for the downstream industrialists, such an order would only come long after the project is procured by the primary contractor.

This dilemma reflects a problem that has bedevilled the construction and allied sectors involved in infrastructure delivery for many decades. As we saw from Graphs 4.1-4.5, investment in the sector has been sudden and intermittent which has had serious consequences for skills development and retention. We also saw from Graph 4.5, that, ironically, the State Owned Enterprises (SOEs) exhibited the greatest year on year variation in their infrastructure demand and the private sector, which should be more subject to the fickle fortunes of the market, demonstrated the least variation in demand. Although it is unlikely that the high-powered decision makers in the SOEs would ever subordinate their right to change their minds to the altar of capacity development, there must be other ways of ensuring greater continuity of demand in the infrastructure sector. One possible intervention that will contribute to a greater continuity of demand is if the IPP sector is allowed to develop.

The analysis of the electricity generation project pipeline shows that most of the projects in the Eskom pipeline are already underway and that there is little likelihood of new projects materialising before the initial skills demand peak of 2011 is reached. That will mean that there is a reasonable possibility that the skills resources that are being mobilised to address these projects will be available for future projects. In some cases, such as with the introduction of new nuclear plants, these resources will need additional training and work experience to adapt to the new type of projects but as long as current resources are retained within the industry, these additional projects are unlikely to require further skills expansion.

In the case of the transmission and distribution components, the picture is more complicated. If one takes a narrow view about the acquisition, development and retention of skills in these sectors, it can be argued, especially for Eskom, that the resources can be acquired or developed at a sufficient pace to meet future demand. Unfortunately, the major skills gap in the distribution sector comes in the local government arena and it is unlikely that anything can be achieved until the bigger question about who controls these networks can be addressed. In local government distribution the biggest problems with skills arise firstly from the increasingly precarious condition of many of these local networks and therefore can only be addressed by more investment in the maintenance, rehabilitation and upgrading of this infrastructure. Beyond the physical infrastructure needs, however, those local government systems need to be able to correctly identify their human resource requirements and ensure that such resources are acquired and/or developed. Unfortunately the research done on local government does not leave this author with any sense that these practical steps will be addressed.

The conclusion of the report therefore is that there are challenges, especially in local government, but that these challenges can be addressed. It is possible to indicate, in outline terms, how these challenges should be addressed but the actual details and proposal will need further investigation and a meaningful engagement with all stakeholders which was not possible in this project. The report therefore concludes with the following recommendations:

1. Government, the private sector, the unions and parastatals should stop obsessing about the quantity of skills and rather turn their attention to the quality of skills and the skills pipeline.
2. In light of the analysis contained in the above report, they should acknowledge that due to the scale of these large projects and the significant decisions (such as financing,

pricing and demand) surrounding their initiation and development, it is likely that there will be many instances of short-term gaps in available skills when new projects come on line but that if the skills pipeline is restored that many of these short-term gaps will be reduced to a minor inconvenience as has been the case in the past and present.

3. The analysis should also have shown that whilst the most critical skills require much training and many years of experience for both professionals, managers, supervisors and artisans alike, the demand for such critical skills is relatively low and the main pressures for skills is in categories that require much less training and work experience. It is possible therefore to suggest that by restoring the skills pipeline to ensure that there is a greater flow at the bottom end of the skills pyramid, and, ensuring that at least a sufficient number of skilled personnel make it through to the most critical categories, that in time the skills pipeline will provide the necessary skills across the spectrum.
4. The analysis should also alert decision-makers to the obvious truth that they need different strategies to address the various skills gaps expected to arise. In terms of the short-term requirement for the most critical skills, they will mainly have to compete on the international market place for a relatively small number of individuals. In terms of the medium level skills, they should be looking to enhance the manner in which people with existing training and some work experience can enhance and deepen these skills through mentoring and similar programmes. For those newly entering the training or work cycle, they should be looking for ways to ensure that fewer individuals drop out before achieving a final qualification. Each of these interventions will be addressed further below.
5. In terms of ensuring that highly skilled personnel are effectively recruited on the international market, there is little that can be added to the current practices of firms involved in such recruitment. The international labour market is reasonably information efficient and under current circumstances such recruitment should be easier. However, there remain some problems with ensuring that those recruited get the appropriate visas and permits to work in South Africa in a timely fashion. In 2006, certain proposals were made in a JIPSA proposal[165] to expedite these processes although it is not known whether any of these proposals have been implemented. Recent feedback from a variety of firms indicate that the processes of acquiring such visas and permits has improved but a number indicate that there is still concerns about visas and work permits which need attention. Readers are referred to that document (provided as Appendix A) for recommendations to address these concerns.
6. In terms of ensuring that those who have qualified with certain technical skills (whether professional or artisanal) gain the appropriate work experience (and/or additional skills

[165] *Increasing the supply of Engineers and Built Environment Professionals, Technologists and Technicians – A JIPSA Proposal (JIPSA 2006).*

training) to progress up the skills pyramid have partially been addressed in this document. On the one hand, the current programme of the SAIW/MERSETA to develop world-class welders discussed above should be assessed (the first cohort has not yet completed the whole programme) and if such a combination of training and work-experience and training is successful, then it is recommended that it be replicated in the other trades. To the extent that problems may exist with this pilot programme, they can also be addressed and the lessons learned adopted in the other trades. For such programmes, the key is to ensure a continuity of training and work experience to ensure that trainees do not drop out but rather graduate with recognisable qualifications.

7. In terms of the professional, managerial and supervisory skills required, the above-mentioned JIPSA Proposal[166] also tackled the issue of continuity and in particular proposed that a mentorship programme[167] be established to ensure that those being taught skills be taken through a comprehensive programme of work experience to develop the appropriate skills required to assume more senior positions. Recent discussions with individuals involved in developing professional skills[168] indicate that little has been done to implement the recommendations of those proposals. Since the basic mechanisms and/or financing of mentoring proposals have not changed, we would need to understand what obstacles exist to their implementation. It is recommended that this proposal be revisited and implemented. Given that the JIPSA structure no longer exists, the EPP may need to identify the appropriate institutional structures to take these recommendations forward.
8. In light of the previous recommendation, it is also suggested that an investigation be held on several programmes that have been designed to use retired (or otherwise under-employed) engineers to support or supplement the engineering skills base of provincial and municipal service delivery agencies. Programmes such as the Infrastructure Delivery Improvement Programme (IDIP) run by National Treasury and the Siyenza Manje project of the DBSA which is deploying professional staff in areas such as finance, engineering and project management, to provide hands on support to municipalities. Whilst these programmes primarily focus on support, they also are expected to provide some mentoring by older professionals to younger professionals and an examination of their

166 *Increasing the supply of Engineers and Built Environment Professionals, Technologists and Technicians – A JIPSA Proposal (JIPSA 2006).*

167 See also *Stage 2 – from Graduation to Registration of Engineers, Built Environment Professionals, Technologists* (JIPSA 2006) which served as an appendix to the above report and details the actual interventions and costs for such a mentorship programme.

168 Allyson Lawless, 23rd September 2008 and Stan Bridgens, 6 July 2009.

successes and failures will better assist in designing other such support and mentoring programmes.[169]

9. It should be evident from the report that part of the skills shortfall currently being experienced is a result of certain policy choices such as the promotion of affirmative action. It is not the intention to discuss the merits of such policies in this paper which are driven partially by deep historical inequalities and partially by the ambitions of an emerging middle-class. Nor is it the intention to dwell on some of the problems that have arisen from such policies which have been noted in the document above. Rather, it is to make the point that where such problems are themselves a consequence of policy choice rather than natural forces, or acts of god, they can themselves be addressed through policy interventions. This is not to recommend that such policies be rescinded, but rather to suggest that any difficulties arising from such policies are themselves amenable to policy intervention. An example of this, of course, are the above-mentioned IDIP and Siyenza Manje programmes which it is recommended need to be assessed and further replicated. If the lessons learnt from these two programmes are worthy of further replication, it may have to be acknowledged that the problems arising from the above-mentioned affirmative action policies are of such a scale that the programmes needed to be adopted to help overcome any difficulties arising from these policies may need also be of a similar scale. What is being said, is if these support programmes are adding value, they may need to be massively scaled up to address the problems identified in the report.
10. It has been argued in the report that one of the reasons for current skills gaps in electricity arise from the stop-start nature and scale of the investments in this sector. It may be possible that the new long-term planning capacity in the Presidency (and elsewhere it is hoped) will help address these problems by ensuring that the project pipeline is better managed in the future. However, it is likely that such planning will be complicated by investment shortfalls, significant changes in demand and other challenges mentioned in the report above such that those long-term plans may fail to anticipate significant change in electricity demand (as happened in the 1980's and 1990's). Whilst it is not suggested that such long-term planning should be abandoned before it has been fully introduced, it is recommended that policy makers in particular look to other interventions to address the possibility that planning may fail to correctly anticipate the future. One such intervention mentioned in this report is to spread the risk of making incorrect long-term decisions (and of financing them) by actively encouraging Independent Power Producers (IPPs).[170] The second mitigating strategy to avoid the

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[169] Comments from Allyson Lawless and Stan Bridgens and personal experience by the author who participated in the IDIP programme for a period.

[170] Something Eskom still seems reluctant to support, Engineering News 17 July 2009.

pitfalls of poor long-term planning is for Government to support or carry the additional costs of skills development through tax deductions and/or subsidies even if these skills prove to be in surplus in the future. Ultimately the cost of surplus skills development in the electricity sector (perhaps not more than several billion Rand but in most likelihood a fraction of this amount) are far below the costs to the national economy of not being able to develop the required infrastructure in the future because our skills base remains inadequate.

11. This report has identified the skills gaps in local government electricity distribution (and a lesser extent generation) are some of the biggest causes for concern and the research conducted suggests that unless immediate steps are taken to address these shortfalls the distribution networks in several (if not more) municipalities is likely to collapse with severe social and economic consequences for such localities. It is tempting to believe that the proposed Regional Electricity Distributors (REDs) will address the problem, as they may, but they have been sixteen years in development and it is still unclear whether government will ever succeed in their introduction. There is also a deeper problem even if the REDs are successfully introduced. Over the past decade we have seen so many examples of spectacular institutional failure in public sector organisations, normally resulting from the bold introduction of new policies, it is difficult not to assume a similar result. Such an outcome is also likely given that the local government arena has been the target of so many unsuccessful interventions and restructurings over the past 15 years that one can only assume that any further interventions are likely to experience a similar fate. Whilst such conclusions are likely to lead to further inaction, it is recommended that urgent and specific attention be given to addressing the infrastructure failures in local government along the lines of the REDs even if that model is not necessarily adopted in its current format. At the very least, it will require that these services become ring-fenced in order to ensure financial sustainability and management in terms of basic business principles rather than politics. Whilst such a bold move may seem, in light of the above comments, too ambitious given the previous record of failure, it is worth noting that South Africa has thousands, if not hundreds of thousands of such entities operating successfully everyday although not many of them are in the public sector.
12. The final recommendation of this report is to suggest that further work needs to be done on the deployment of the available skills. As has been argued above, there would seem to be a situation whereby for reasons of a lack of quality, affirmative action policies and an experience gap, even though the number of potential candidates would exceed the demand in most categories, we currently are experiencing a skills shortfall. In the original proposal for this paper, it was proposed that delivery systems be examined to see how these gaps could be addressed. Unfortunately for the reasons enumerated above such an examination was not possible. It is therefore recommended that, with the co-operation of the relevant agencies in Eskom and Local Government, that these delivery systems be

examined in depth to discover how the current skills gap can be addressed through the redesign of such systems. It is assumed, but not tested, that Eskom and other organisations such as IDIP and Siyenza Manje are redefining the delivery models to better make use of the skills we currently have available and to develop the skills we need in the future but such an assumption will still need to be validated through a detailed examination of such delivery mechanisms.

Appendix 1

Increasing the supply of Engineers and Built Environment Professionals, Technologists and Technicians – A JIPSA Proposal

Over the past six years, the country has been experiencing a major increase in the demand for infrastructure and other major capital projects. All projections forward suggest that this growth phase will continue for the next couple of decades as the ASGISA strategy takes effect. As a result of current and future growth, the construction and engineering industries have been experiencing skills shortages in the managerial, professional, technological and technical fields which, unless addressed immediately, run the risk of stifling the growth trajectory of the nation.

Whilst the industries have been stretched to their limits, they have managed to mitigate these skills shortages in the short-term, but they face even more drastic shortages as demand increases and the current population of infrastructure specialists reaches retirement over the next decade. In order to meet future demands for further skills, address equity concerns and to overcome the inevitable loss from retirement, the JIPSA Secretariat proposed that the skills pipeline be restored to ensure an adequate supply of skills for the future.

Studies conducted by both public and private sector organizations[171] indicate that the skills profile required to meet current and future demands include a range of skills and experience stretching from a couple of hundred senior managers and professionals with in excess of twenty years experience to several thousand more junior professionals, technologists and technicians to restore the industry's skills profile. Within these broad categories, the specific demand for senior specialists may be an order of magnitude of tens while the demand for more junior staff may be of an order of magnitude of several hundreds for certain skills categories. The range of skills required include general and project managers, specialist engineers, architects, quantity surveyors, planners and construction managers, and the related technologists and technicians that fill out the supervisory ranks.

The JIPSA Secretariat investigated the feasibility of increasing the number of engineering and built environment professionals, technologists and technicians (referred to in brief as EBEPTTs). On the basis of this study it believes that it should be possible to increase the pool of infrastructure skills by approximately

171 *CIDB Demand for Skills (2006), SAISC Needs and Numbers (2004).*

1000 per annum through a comprehensive set of interventions which encompass the following:

1. increasing the throughput of EBEPTTs at universities and universities of technology;
2. supporting the candidature process of guiding EBEPTTs from graduation to registration with their respective professional council;
3. removing current bottlenecks in the process of importing scarce and critical skills.

This document goes on to describe these interventions in more detail below.

1. Increasing the throughput of EBEPTTs at universities and universities of technology

In South Africa approximately 1 400 engineers, 800 built environment professionals graduate from universities and about 2 300 engineering and about 850 built environment technologists and technicians graduate from Universities of Technology. The throughput rate[172] is around 65% our top institutions and about 20% at some others. Comparable throughput rates in East African Indian and US institutions are around 80-90%[173].

It is therefore proposed that by focusing on improving throughput of those currently within the system, our tertiary institutions can increase their output of EBEPTTs by at least 1000 in the next couple of years by focusing on relatively inexpensive interventions. These institutions can further increase their input by increasing enrollments, and though much large investments in bursaries, subventions and infrastructure.

The research undertaken for this proposal indicates that many institutions already have programmes in place which could be expanded by a relatively small increment (between R3-6 million per institution) to boost throughput. These interventions include the following:

i) **Improved selection –** current matric results (including maths and science grades) are poor indicators of success in engineering and the built environment. Some institutions have had dramatic improvements in results by using selection procedures that also measure aptitude

[172] For the purposes of this study, throughput rate is defined as the number of graduates within 6 years of a four year programme. Throughput rates in minimal time are around 35% at the best institutions and between 5-10% at the others.

[173] Whilst the national average for the US Foundations of Engineering exam is around 75%, many of the top institutions boast a 100% pass-rate. Data from East Africa and India suggest that80-90% is achievable at institutions that have a significantly less resources than those in South Africa.

and motivation for these courses. It is proposed that these selection processes be supported in institutions which seek to apply them. In particular, selection could have a major impact at Universities of Technology which currently experience throughput rates of between 5-15%.

ii) **Academic support** – because of historical gaps in secondary education, academic support programmes have been developed in most institutions to address identified gaps and shortcomings in secondary education. Many of these programmes use senior students as mentors (thus providing them also with some financial support) to assist new students become familiar with the demands of the tertiary environment. For a relatively limited annual expenditure of between R2-5 million, many of these programmes can be expanded at participating institutions.

iii) **Academic development** – it has been recognized that academic support alone is insufficient and that institutions have to focus on improving the teaching and course content for all students to improve outputs. Some institutions have already embarked on such exercises to develop curricula and teaching practices more suitable for current and future demands. One example of adopting distance learning for quantity surveying and construction management suggests a method of enhancing skills of those currently in employment. It is proposed that these initiatives be supported involving a once-off expenditure of between R5-15 million in total for the participating institutions.

iv) **Pre-entry support** – some engineering and built environment faculties have proactively addressed the short-comings of secondary education by offering specialized Saturday and Holiday School training to matric students. In addition to addressing maths, science and language deficiencies, these programmes also give students exposure to their future professions through site visits and lectures on different aspects of engineering and the built environment. What makes these programmes all the more special is that they have been targeting rural schools in their respective provinces. An annual investment of around R10 million would ensure that these programmes continue and are expanded.

On the basis of the research carried out, we estimate that for a relatively low investment in the order of between R60-100 million (of which about 10-15% will be once off and the rest recurrent), the above interventions could ensure that the throughput at Universities and Universities of Technology are improved dramatically and that the overall output is increased by at least another 1000 students.

In addition to the above investment, other institutions indicated that they could further increase output (both throughput and additional students) if investments were to be made in the following areas:

i) **Infrastructure** – many institutions indicated that their current facilities were out-dated and under-capacitated. They indicated that further investment in computers, laboratories, studios, and in one instance, dedicated residences, could assist them in improving outputs. From the data received, we estimate a once-off investment in the order of between R300-600 million for all institutions.

ii) **Staff** – Institutions indicated that their current staff was stretched to their capacity and that if they were to increase output further, they would need to hire additional lecturers and/or laboratory personnel. In some instances, they indicated that academic salaries would need to be subvented to retain or attract staff. It is estimated that between R150-300 million annually is required.

iii) **Student Bursaries** – Institutions indicate that one of the main reasons for students failing to complete courses is lack of financial resources. Beyond financial resources, students need additional support and mentoring. In one instance, the Western Cape Province is providing a bursary scheme and support programme that provides a supportive environment and resources to such vulnerable students which is integrated into the Province's infrastructure delivery objectives. It is estimated that additional student support would require around R150-250 million annually.

Actions:

i) **Consultation with DOE** - The Jipsa Secretariat has been in consultation with the Department of Education around these targets and investments. It is believed that an additional 1000 graduates could be achieved with a limited investment of resources. Unfortunately this engagement must be taken further before definitive targets and budgets could be proposed.

ii) **Develop a funding proposal** – Subsequent to i) above, and in addition to the Stage 2 proposal discussed below, the Jipsa Secretariat can formulate a funding proposal which can identify the appropriate public and private sector sources that may be approached to assist in mobilizing the resources required.

Stage 2 – from Graduation to Registration

Producing more tertiary graduates will contribute to expanding the pool of Engineering and Built Environment skills in the future, but these skills will not be able to be appropriately deployed unless some attention is paid towards ensuring that graduates are guided through a process of further professional development from graduation to registration with their respective professional council. The experience deficit of most graduates means that they cannot fully productive for several years, and they are least effective in the initial post-graduation period prior to their professional registration.

Previously, the engineering and built environment industries were able to take responsibility for this professional development, but the impact of the two decade decline, and the subsequent restructuring of these firms, has meant that they are less able to ensure the development of these entrants than before. In the face of immediate pressures to deliver during this current upswing, there is even less capacity to assist in the professional development of recent graduates. Once the skills pipeline is restored and on the back of sustained future growth, these firms will again be able to manage this process of professional development.

It is therefore proposed that a candidature programme be developed for EBEPTTs. These candidature programmes would include a combination of the following activities over approximately three year period:

1. workplace experience;
2. technical training programmes;
3. discipline specific management training;
4. business and life-skills coaching;
5. mentorship and supervision.

The objective of such candidature programmes will be to ensure that new graduates effectively make the transition from graduate to professional in the shortest possible time period. In addition, the training programmes will seek to ensure that the registered professionals are equipped with the appropriate range of skills that is required to fulfill their professional duties in the future. The nature of these programmes is described more fully below.

2. The nature of the problem

There are a number of indications that the development of professionals in the post-graduation pre-registration phase is not optimal. One such indicator is that the average age of registration has been slipping and now many professionals are registering in their mid-thirties. This would suggest that it is taking them longer in the current environment to cover all the pre-requisites for registration. Another indication is that the average first time pass rate for the Government

Certificate of Competence (GCC) is around 8% as few are gaining adequate workplace training to achieve the required level of competence. Although the GCC only applies to mechanical, electrical and mining engineers working in factories, local authorities, mines and plants, provided they have had sufficient design experience, those who do pass have no difficulty registering with ECSA.

As noted above, the main reasons for the deterioration of the process of professional registration would be the change in the structure of firms due to the long decline in the engineering and built environment industries. As a result there are fewer mid-level people to play a role in supervising and mentoring and the senior staff are fully committed in producing output. There are other reasons, the introduction of IT systems which has reduced the need for detailing, the rise of new BEE firms who tend to have younger less experienced principles, the increased role of non-professionally specific executive managers which means fewer discipline specific mentors per firm and the long-term reduction of public sector and corporation training programmes have all led to the deterioration.

Whilst some of these reasons will remain (role of IT, new emerging firms, role of non-professionally specific managers), it is believed that once the skills pipeline is again restored and that many of those currently at the bottom of the skills hierarchy gain experience, the need for a supplementary professional programme may fall away. In the next five years or so, however, such a programme is necessary to ensure that there are adequate EBEPTTs going forward.

3. Description of the programmes

As noted above, the Stage 2 intervention has a number of components. These include:

3.1 Workplace Experience

It is necessary for graduates to be involved in one or more technical fields during their experiential phase. The entire project cycle needs to be understood and the young graduate must be exposed to all components, including investigation, planning, design, draughting, detailing, procurement, site work, and process, operations, maintenance and costs efficiencies[174]. The graduate requires exposure to all phases and should be moved from department to department or from function to function to develop mastery in his or her chosen field. To ensure that graduates gain sufficient all round experience a series of log frames need to be developed detailing all aspects per sector and discipline to which the graduate

[174] This project cycle is more appropriate to engineering and some built environment professions but not all – it is merely an indicative description of the range of professional competencies that all will require.

should be exposed. These log-frames should help define the appropriate set of competencies required by different professions.

3.2 Detailed training programmes

In terms of workplace training, it may seem that training material would generally not be necessary. However, as a result of the huge loss of experienced senior staff, it is time that a team of 'wise fathers' develop reference material covering all the practical advice which was previously passed on from senior to junior. It will be necessary to locate the standards of the past now forgotten because of IT. Practical tips are missing, engineering judgment is not being developed and an understanding of the whole project process needs to be redeveloped. This information could be disseminated and absorbed in a number of ways as follows:

3.2.1 Specialist lectures

Universities cannot be expected to offer practical design and detailing training for every facet of engineering. The undergraduate degree essentially offers a foundation on which to build engineering experience. In order to fast track practical ability, young graduates should attend many of industry's practical courses. Typical organizations offering such practical training include SAISC (South African Institute of Steel Construction), C&CI (Concrete and Cement Institute), SARF (South African Road Federation), SABITA (South African Bitumen Association), and WISA (Water Institute of South Africa). More such courses need to be identified and developed in support of the candidate phase.

3.2.2 Group workplace training workshops

To address the many situations where there are insufficient experienced personnel to grow young graduates, ongoing group training regimes covering the full project cycle need to be considered. There are currently some successful block release courses offered over a 12 or 18 month period whereby a group of graduates working in a particular field attend one week training every 6 to 8 weeks. For instance where graduates are working in a particular field such as road design and construction, the block course covers what needs to be done in the workplace for the next 6 to 8 weeks in the project cycle and the young graduate then returns to the office well briefed on what he or she should be doing. Work carried out in the previous 6 to 8 weeks is also submitted for checking/critiquing by the lecturer(s). In this way one or two seniors are able to offer the coaching/supervisory function for all attending.

3.2.3 Computer based training

In instances where the details and processes are too complex to describe or visualize through formal documentation such as the operation and maintenance of machines, processes etc, Computer Based Training (CBT) displaying interactive, animated schematics and step by step operation of the actual item being studied offers a superb medium for practical training. The graduate can replay the module over and over again until he or she is fully conversant with the operation of the item being studied.

CBT can also be used to describe other complex processes such as structural design, industrial systems etc. There is substantial evidence, including OBE metrics, that the efficiency and effectiveness of CBT knowledge transfer is significantly higher with such content than traditional learning processes, and while the investment cost is initially high to develop the course content, as long as it is designed with the ability to be readily updated, the ROI is massive when measured in comparative pass rates.

3.2.4 Discipline specific management training

Experience and skills required vary per industry. In the consulting world, project management, ethics, indemnity etc are of key importance, whilst in the contracting world contract management, materials, labour and contract law etc are of key importance. In local authorities and other government departments, issues such as the budgeting cycle, Division of Revenue Act, procurement, working with decision makers, legislation etc is of major importance. Mining has its own challenges in terms of Labour, Mining rights, safety etc. Specific material needs to be developed per field.

3.2.5 Development of business and life skills

Over and above technical competence, proficiency in life skills including communications, negotiations, leadership, and inter-personal relationships must be honed during this phase. Further young graduates must be exposed to the many soft issues which are critical to the success of their projects including political, socio-economic, institutional, environmental, health, legal, financial and management issues. Many commercial courses are in place to address these aspects and graduate training should include attendance at a number of these courses as the needs arises in the workplace.

3.3 Developing a pool of mentors

The above set of candidate activities will have limited affect unless the candidates have access to mentors or coaches. In the past, the candidates' supervisors and managers would play a mentoring role, but in the current boom phase, these supervisors are over-stretched and unable to make such a contribution. Once a sufficient pool of new professionals is developed (perhaps 5-8 years) there will be less of a need for such mentors. Although the mentors and coaches can play a supplementary support role, further discussion is still needed to understand how these different roles can be integrated into the daily activities of the firm.

A pool of available mentors needs to be developed, many coming from the ranks of the active retirees, which can be tapped for the appropriate skills for knowledge coaching. The professions/voluntary associations can be tasked with managing this process, supplying material appropriate to their disciplines, orientating mentors and monitoring and evaluating progress. Much is currently being written about mentorship and mentorship programmes have been called for in the Construction Charter. The term mentor implies personal counseling and career path development, whilst the term coach implies knowledge transfer and skills training.

4. Costs and resources required

It is estimated that these candidature programmes will apply to initially to about 1 500 university graduates and 2 300 university of technology graduates in engineering and approximately 800 built environment university graduates and about 900 university of technology graduates (see attached table)[175]. The costs anticipate that Technologists and Technicians will require approximately twice the amount of mentoring and training as the University Graduates. If appropriate learning pathways are defined, this additional training and mentoring should equip the technologists and technicians to meet professional standards in most professions (there is already such learning pathways for the built environment). It is expected that individual firms employing these candidates will contribute 40% to 50% of the overall costs but that additional funding will need to be raised to support the candidature programmes. It is assumed that the programme will scale up by year 3, and there will be candidates in all years:

1. Developing candidature programmes and supporting courses — R 35 million once off.
2. Candidates for the private sector — R 84 to 227 million p.a.
3. Candidates for the public sector — R 112 to 304 million p.a.

There should be sufficient funds available through the public sector capacity building grants in provincial and local government to cover the public sector costs and the Skills Levy should be able to be tapped for additional funds for the private sector. Although the Skills Levy lists bursaries, apprenticeships, learnerships, internships and the candidate phase of professionals as learning pathways against which SETAs may pay skills rebates or discretionary grants, to date SETAs have only funded learnerships and to some extent bursaries. SETAs

[175] 2004 graduation figures are used.

will need to be persuaded that the candidature programmes need to be funded. The once-off costs may have to be sourced elsewhere.

5. Further Actions

Although the candidature process has been conceptualized, further work is required for the following:

i) Ensuring that the new candidature process is accepted as a learning pathway by SAQA;
ii) Verify and source funding to develop the candidature process (including completing the process of defining the competencies required) and supporting materials;
iii) Sourcing funding to develop a pool of retired engineers and other built environment professionals who can be used as supervisors;
iv) Ensuring SETAs provide rebates to encourage companies to train their graduates towards registration as professionals, technologists or technicians;
v) Establishing and funding an appropriate management structure involving the major Professional Association, Statutory Councils and major client groups including the Government.

3. Importing scarce and critical skills

In light of the overall skills challenge, there will be areas where there are few people with the requisite levels of experience available in South Africa for particular capital projects. In the case of senior professionals such as turbine or boiler engineers, this may mean a shortage of between five or ten senior people with international experience. In the case of artisans, this may run into several hundred specialist artisans per project. In this latter case, whilst there may be similar trained artisans in South Africa, the local equivalents lack the experience to complete certain highly specialized tasks and where they do work on these projects, their level of error is up to eight times higher than the international equivalent.

Unfortunately, even though South Africa makes a number of visa mechanisms available for the importation of these skills[176], the uneven implementation of these visas, and their overall complexity, often results in scarce skills being lost to other international projects before the paper trail can be completed in South Africa. It has been suggested that there is a 45 to 90 day window of opportunity to recruit

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[176] The main mechanisms referred to include the standard work permit, the quota permit, the corporate permit, the exceptional skills permit and the inter-company transfer.

these people and if, the permitting process takes much longer than that, these people will then go elsewhere. This means we either struggle to find the specialized skills and/or have to settle for people who are not as qualified. In many instances, the problem does not lie with one step in the process or one office but the bottlenecks occur between the various agencies and authorities governing different aspects of the skills acquisition pipeline.

Briefly, the importation of skills faces the following bottlenecks:

i) Inconsistent and ad hoc application of the various work permit options by different offices;
ii) Long delays in the processing of applications for various types of permits (delays at SAQA, Departments of Labour, Home Affairs, Trade and Industry);
iii) Disincentives to work in South Africa (tax regulations, treatment of spouses);
iv) Problems with personnel arising from the use of Lump-Sum Turnkey contracts on major capital projects;
v) General hostility to the use of foreign workers.

These issues will be dealt with sequentially.

i) Inconsistent and ad hoc application of the various work permit options by different offices

Most of the firms consulted indicated that each office of Home Affairs seems to use different regulations in the applications for visas and even applies these regulations in an ad-hoc manner. As a result these firms have to choose which visa mechanism to use and at which office to apply. Home Affairs acknowledges that there are problems with the different offices and that they have been providing training. However they indicate that this problem is likely to persist. It may be useful to identify the appropriate visa mechanism for the large-scale infrastructure projects (most likely the corporate permit) and then to train both the public sector officials and private sector applicants in their implementation.

ii) Long delays in the processing of applications for various types of permits

Although the corporate permit is the preferred mechanism on these large projects, previous bottlenecks in the Departments of Trade and Industry and Labour has meant that the major client groups are reluctant to use them. It should be possible to address these bottlenecks through consultations with the relevant departments. In addition, because many of the major capital projects are still in a feasibility or pre-feasibility stage, the major clients should have sufficient time to perform human resource planning and apply for these permits timeously once they have confidence that their applications will not be subject to arbitrary delays.

In addition to the corporate permits, other agencies of state have been responsible for delays in the past. In particular, SAQA approval of qualifications has proven to be a problem. Recently, SAQA has employed a significant number of new people to reduce these processing delays. They have also allowed qualifications to be validated retro-actively. It has been proposed that if the main clients would take responsibility for ensuring compliance with the different regulations, then many[177], if not all such requirement could be complied with retroactively. Obviously these clients would have to be monitored (which is not too difficult if one is referring to the major project groups) and these corporations would have to be responsible for dealing with situations where compliance is not obtained.

A third way in which these procedural delays could be addressed is to provide information ahead of time on the key skills and employment issues. This can be in two main areas. The current scarce and critical skills list does not provide sufficient detail on the skills required for the large capital projects and infrastructure roll-out. With the help of the major project owners, it should be possible to compile a skills register based on actual projects. Secondly, it is necessary for visa approvals to justify the salaries paid for those skills being imported and these justifications have been delaying approvals. Therefore once the skills register has been compiled, it should be possible to benchmark the salaries of the critical skills categories.

iii) Disincentives to work in South Africa

Client groups indicated that even if the visa process went smoothly there are a number of disincentives for skilled foreigners to work in South Africa. The two major disincentives are the current tax policies and the treatment of spouses[178]. It should be noted that especially with regard to professional skills, the people with the requisite experience, are most likely to be in their late 40’s or early 50’s and have both families and significant worldwide income.

In terms of recent tax legislation, permanent residents are liable for taxation on their worldwide income and capital gains if they are resident for more than 183 days in a year[179]. However, even if the foreigner is not going to be a permanent

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[177] It was unclear which compliances would be necessary upfront with different officials indicating that both SAQA and police clearances being waived in some cases.

[178] Interestingly enough, environmental issues such as crime were not described as being a major disincentive at the time of the research, whether this will change in light of recent publicity is unclear.

[179] The ruling is slightly more complex, but the example will provide a basic description of the problem being discussed.

resident as defined in the legislation, they are liable for taxation on their worldwide income from the first day of arrival. They must then reclaim the tax paid on their worldwide income if they are not here for the stipulated period. Apart from the immediate deductions, there is considerable amount of red-tape required for such a tax process. It is proposed that the employer importing these personnel pay a fixed percentage final withholding tax (say 10% of remuneration) on their remuneration in South Africa.

One of the ironies of a political regime that promotes the expanded role of women in the economy and society in South Africa, is that our current visa regulations prohibit the spouses (more generally women) of the skilled personnel from working in South Africa. They are required to apply for a general work permit in their own right. Apart from the burden of paperwork, these spouses may not qualify in terms of any of the quotas and so run the risk of being refused such a permit. In an era when two-income families are the norm, these visa provisions seem out of touch wit reality and must represent a major disincentive for many to come work in South Africa.

iv) Problems with personnel arising from the use of Lump-Sum Turnkey contracts on major capital projects

Most of the major capital projects and infrastructure rely on lump-sum turnkey contracts for the main components of the project (turbines, boilers, cranes, mechanical equipment, etc.). Although some of these contracts specify the proportion of the labour force to be trained and sourced locally, there have been cases where foreign contractors have sought to bring their entire labour and skills component with them in order to ensure that the execute the project in terms of their contractual conditions. This situation has led to tensions both with local communities who feel they have been excluded but also with the contractors who struggle to get visas for their imported labour.

The easiest solution is for the major clients and project owners to specify upfront what local labour and skills they expect the contractor to train and/or use. These expectations could be shared with the relevant authorities responsible for approving visas. Key to this approach is to ensure that the expectations of the contractors, authorities and local communities are addressed before the visa applications need to be processed.

v) General hostility to the use of foreign workers

Unfortunately, even once it has been established that we need certain categories of skills from abroad, there remains a climate of hostility amongst low-level officials amongst others towards these foreign workers which contributes to the procedural delays in securing work permits and other permissions and also acts as a disincentive for those workers to take jobs in South Africa. The only way in which this hostility can be addressed is through high level communication from the political leadership.

Once we have established the need for certain foreign workers to be used on the major projects, the political leadership should promote an unambiguous message that these foreigners are contributing to the long-term development of the country. It does not make sense to spend large amounts of money and time recruiting scarce and critical skills only to have these people be discouraged by the lack of welcome. Instead, government and the relevant clients should seek opportunities for making these workers and their families feel part of the longer term development project of the country.

Further Actions

As noted many things are currently being done in Government to address these concerns but unfortunately the problems companies are experiencing still persist. It is therefore proposed that a number of interventions be pursued to facilitate the skills importation on specifically the infrastructure and major capital projects:

i) Consultations with Departments of Labour, Trade and Industry and Home Affairs to address specific bottlenecks around corporate work permits;
ii) Consultation with SARS/National Treasury to discuss the option of a fixed final withholding tax payable by the employer;
iii) Compilation of a specific skills register for capital projects with comparable international salaries information;
iv) Consultations with Home Affairs to overcome the problem of visas for spouses;
v) Training of all Department of Home Affairs, Labour and Trade and Industry and Foreign Affairs officials involved in the work permit process to ensure that they are aligned with current policy and regulations;
vi) Re-engineering of the work-permit process to enable many of the approvals to apply retroactively subject to the major clients taking full responsibility for any violations of the regulations;
vii) Development with major project clients of an acceptable format for Lump-Sum Turnkey Projects to ensure that local skills are developed.

Because most of these interventions are short-term in nature and primarily involve consultation and agreements, many of these actions can be undertaken by appropriate senior government officials and senior people from the private sector seconded for individual tasks. It is not envisaged that a significant budget be required. Should however the JIPSA Task Team deem it necessary that consultants be involved, and it is believed that there is no real need for this, then provision should be made for a budget of several million rand at the most.

Depending on the co-operation of the identified departments, these tasks could be completed in less than a month.

Annexure A:								2007	2008	2009
Summary Costs of Candidature Programme	**Total Number**	**Salaries for Candidates**	**Hours Mentoring**	**No. of Mentors**	**Cost of Mentoring**	**Management Cost**	**Course Cost per Candidate**	**Total Cost (less candidate Salaries)**	**Total Cost (less candidate Salaries)**	**Total Cost (less candidate Salaries)**
Totals UT graduates	3300	396000000	528000	330	165000000	16500000	59400000	240900000	457710000	650430000
Totals University Graduates	2300	460000000	184000	115	57500000	11500000	41400000	110400000	209760000	298080000
Total - all graduates	5600	856000000	712000	445	222500000	28000000	100800000	351300000	667470000	948510000
Total - reduced number of graduates coming into industry	4480	684800000	569600	356	178000000	22400000	80640000	281040000	533976000	758808000
Total - Reduced coming into private sector	2688	410880000	341760	213.6	106800000	13440000	48384000	168624000	320385600	455284800
Total - Reduced coming into public sector	1792	273920000	227840	142.4	71200000	8960000	32256000	112416000	213590400	303523200
Private sector mentor subsidiesrequired (50% 0f the cost)					53400000	6720000	24192000	84312000	160192800	227642400

Assumptions:

1. 20% of students will not enter the programme in year 1 (currently around 50%), an additional 10% will drop out in years 2 and 3 respectively, and by 2009 there will be candidates in all years of a three year programme.
2. 2004 graduation numbers are used – these will scale up as the current intake reaches graduation.
3. Costs: R18 000 for technical and other training courses per annum, R5 000 management cost per student (as per current experience in similar programmes), R600 000 average full-time mentor cost p.a.
4. The same extent of mentoring for all disciplines (this might differ in practice), 2 hours per week for university graduates and 4 hours per week for university of technology graduates.