Creating the Future:
Gender, Race and SET Sector Policies
for Capacity Building and Innovation

POLICY ADVICE TO THE MINISTER OF SCIENCE AND TECHNOLOGY
AUGUST 2006

EXECUTIVE SUMMARY

The goal of this document is to provide a gender, race and SET sector policy framework within which institutions in the SA national system of innovation (NSI) can implement effective measures for ensuring that South African women participate fully in, and benefit from, innovative SET research, production of SET products and provision of SET services. Through the increased participation of women in SET, South Africa can increase its capacity for innovation and grow the size of the contribution of R&D to GDP.

The goals of this policy for the period 2006 - 2020 are:
- To achieve parity in the participation by South African women in SET research, production of SET products and provision of SET services.
- To ensure that women in South Africa benefit from innovative SET research, production of SET products and provision of SET services.
- That through the human capital development of all of its citizens South Africa realizes its scientific and innovation potential.
- To ensure that institutions within the NSI regularly collect data[1], disaggregated by gender and race, on women's participation in and benefit from the SET sector and that such data is compiled and used in all relevant decision making processes in order to promote the aims of this policy.

With respect to achieving greater participation by women of all races in science, engineering and technology **(SET by Women)**, *this policy seeks to:*
  i.   increase the number of women who enter, remain and advance their careers in all fields of science, engineering and technology, in particular to increase the scientific workforce by 3000 productive women researchers by 2014;
  ii. ensure that more women scientists, engineers and technologists have access to and benefit from public funds earmarked for SET activity, research and innovation
  iii. strengthen inter-departmental collaboration on all issues affecting the professional growth and development of South African women scientists, engineers and technologists

With respect to ensuring that women of all races benefit equitably from scientific and technological innovation **(SET for Women)**, *this policy seeks to:*
  i.   introduce measures to transform the lives of women through SET, in particular the lives of black urban and rural women living in poverty
  ii. promote the production of SET products and services that are beneficial to women
  iii. support further research into identifying the SET needs and priorities of women in South Africa in order to define a funding agenda for "New Frontiers in Engendered SET Research"

This policy specifies a number of related measures to be implemented by the Department of Science and Technology, and at times, jointly with the DoE, DTI, and the DoL, as well as by the NRF and other granting institutions, by the CSIR and other public research institutions, and by all institutions of the South African NSI. The policy presents a Gender, Race and SET Monitoring and Evaluation Framework.

In describing the policy context, findings from studies conducted in South Africa in the period 2003 – 2005 are used to provide an explicit account of the major challenges confronted by women with respect to achieving greater participation in SET, as well as in ensuring that women in South Africa benefit from innovative SET research. Three consultative conferences were held in May – June 2005, at which women scientists discussed their experiences of the needs, challenges, opportunities and barriers facing women in SET. Evidence from these studies and consultative conferences provided the empirical basis upon which this policy was developed. In addition, reference is made to a range of studies conducted in other countries and regions.

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[1]   see for example: the UN Publication entitled: *The World's Women- Progress in Statistics* (2005).

Chapter 1. GOALS, OBJECTIVES AND RECOMMENDATIONS

1. Introduction

In South Africa since 1996, there has been an emphasis on economic development through innovation. Recent initiatives on accelerated and shared growth policies create greater demand for a well trained scientific and technical workforce as science and technology are fundamental to such development. However, the scientific population is aging and shrinking, resulting in a *shortage of highly skilled men and women* in specialized fields of Science, Engineering and Technology (SET)[2]. One of the factors contributing to this shortage is 'out-ward mobility' of Research and Development (R&D) workers[3].

A second and more critical factor is *under-utilization of the SET potential of women*, who constitute over 50% of the national population. The _Facing the Facts_ study clearly demonstrated that *women, particularly black women, are grossly under-represented* in SET education programmes and at SET workplaces, particularly at senior levels. Efforts must be made to address the lack of full representation of all South Africans in the SET sector. Therefore a dual strategy of gender mainstreaming and the use of the Principle of Fair Discrimination through targeted programs will be advocated. The goal is to achieve equality of representation for both men and women of all races in the scientific and technical workforce that mirrors the population in South Africa.

The policy recommendations articulated in this document reaffirm the importance and value of science and technology to South Africa and the need to establish explicit programs with appropriate incentives that can have lasting impact.

Thus, in developing this policy, *the unique needs of various groups of women*, as defined by field of study and specialization, specific work environment, race, level of professional development, career stage, productive output required, and other aspects of the woman's lifecycle, were given due consideration.

This policy proposes wide-ranging and systemic changes within the SET sector. These changes seek to promote *greater participation by women in scientific production*, as well as ensure that *South African women benefit from innovative research, products and services*.

This policy outlines recommendations that should be implemented in all SET-based sectors of the South African National System of Innovation i.e. by the NRF and other granting institutions; by the CSIR and other public research institutions; at institutions of higher education; in industry; at government research institutes, museums and other statutory bodies; and any other publicly-funded organizations. Implementation of these positive actions would be instrumental in South Africa achieving its National R&D strategies.

2. Goals

The goals of this policy for the period 2006 - 2020 are:
   a. To achieve parity in the participation by South African women in SET research, production of SET products and provision of SET services.
   b. To ensure that women in South Africa benefit from innovative SET research, production of SET products and provision of SET services.
   c. That through the human capital development of all of its citizens South Africa realizes its scientific and innovation potential.

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[2]   See for example: Numbers and Needs – Addressing imbalances in the civil engineering profession, published by Allyson Lawless (2005).

[3]   See Kahn, Blankley, Maharaj, et al (2004). Flight of the Flamingos – A study on the mobility of R & D workers. Published by HSRC/NACI/CSIR.

d.   To ensure that institutions within the NSI regularly collect data[4], disaggregated by gender and race, on women's participation in and benefit from the SET sector and that such data is compiled and used in all relevant decision making processes in order to promote the aims of this policy.

3. Recommendations

It is a policy imperative that institutions in the National System of Innovation undertake the measures and actions proposed here, in order to create gender and race diversity in the system in the current period. This can be achieved through increasing the participation of women, in particular black women, in SET and in so doing, improving the capacity of the system for excellent, R&D and innovation with local relevance and global significance.

The policy principles enshrined in this document are race and gender equity, parity of resource allocation, gender targeting and mainstreaming, fair discrimination, valuing women in SET, collaboration in promoting equity for women across all institutions in the NSI.

3.1 Enhancing women's participation in SET (SET by Women)

3.1.1. Increasing the number of women in SET

Mechanisms should be put in place with immediate effect to ensure that a significant increase in the number of women in SET, both as students and as professionals, is achieved between 2008 and 2020. To this end, all institutions in the South African NSI are required to devise, implement, monitor and report on specific programs for achieving **equitable participation** by gender and race at all levels and across all SET fields, with particular attention to undergraduate enrolment and throughput at universities; postgraduate selection and graduation levels; staffing levels across the SET sector, especially within the Professoriate and SET expert researchers; SET output; professional career development and promotion opportunities. In certain fields and institutions, equitable participation may require government and institutions in the NSI to address the need to increase male participation, for example, medicine or biochemistry at certain universities. All *future SET policies and strategies should explicitly mainstream gender* in their foundation analyses, goals, objectives and recommendations.

In order to achieve this objective, as well as to maximise women's contribution to innovative SET research and development, a number of actions, strategies and support measures must be put in place, inter alia:

Funding to increase the number of productive women researchers from the current level of 6500 to 9500 by 2014. An additional 3000 productive women researchers is required to increase women's participation in SET to the level at which women will make a marked contribution to the size and output of the scientific workforce in South Africa, the so-called *"critical mass"*, of whom the majority will be new entrants.

Measures to increase the flow of girls and young women into SET fields, should include an enabling environment to study and practice science and mathematics, engineering and technology throughout the education system, as well as incentives to encourage women to enter and remain in SET careers. *Explicit measures* must be designed and implemented by institutions in the NSI *to address the accumulation of barriers to women's participation at post-graduate and post-experience career stages* and hence to address the disproportionately low participation of women at these advanced career stages. Such measures would include *greater accessibility and availability of SET infrastructure* to girls and women. This should further include expansion of the *amount and the quantity of bursaries* for students at all levels of SET. Explicit targets should be established for participation of black women and other under-served populations. Additional funding should be budgeted to provide bursaries and support to encourage

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[4]   see for example: the UN Publication entitled: *The World's Women- Progress in Statistics* (2005).

students at Masters level, particularly black women, to seek doctoral degrees in SET. *Full PhD funding* should be provided annually for cohorts of women studying in these fields.

Funding structures should be established that take into consideration the "life cycles" of SET women researchers and ensure promotion through the various phases of post-doctoral studies, R&D and publications output, entering the Professoriate or research management, achieving research ratings and contributing to SET and innovation. Such *"life cycle grants"* should have no age restrictions or penalties for interruptions of careers. Institutions in the NSI should create *re-entry programmes* that support women and men who have stopped their SET education or training due to family obligations.

The NRF and other granting institutions should conduct a *review of existing mechanisms for awarding researcher ratings and other scientific criteria* critical to status with the South African SET funding agencies and design mechanisms that would lead to greater participation of women at all levels.

Institutions should establish *leadership and mentoring programs for the SET workforce* that have an emphasis on inclusion of women and black people in the program. These mentoring programmes must be well-structured, co-funded by government, and mentors must be appropriately incentivised.

Mechanisms should be established that facilitate *collaboration and engagement with SET-oriented industry and universities* in government efforts to expand the SET workforce. With regards to promoting women's participation in industrial SET, the DST and the dti will, in consultation with industry, *explore options for establishing a "Women's SET Trust"* to encourage active women scientists to engage in the commercialisation of technologies and promote SET start-ups. A *Science Entrepreneurship Programme* would create further opportunities for women to remain in SET across the private sector, science councils and the service industry that arises from SET.

Actions to promote women's participation in SET should include measures for the *public recognition of successful women scientists,* and other actions in which government and institutions in the NSI play an active role in changing the widely held perception that science is a 'white, male profession'. It is a policy imperative that *women participate in all decision-making structures of the NSI*.

Training programs should be established at DST, at NRF and other granting institutions, at CSIR and other public research institutions that would provide *appropriate training and support for SET staff on gender awareness* in the context of their scientific programmatic responsibilities. These programs would have explicit components addressing targeted programs and gender mainstreaming mechanisms. These programmes would support efforts to build the capacity of government SET staff to effectively implement gender, race and SET sector policies.

3.1.2. <u>Utilization of public funds for enhancing women's participation in SET</u>

To attract women's participation, the DST, DOE and other line departments responsible for their associated science councils, research institutes and state owned enterprises; as well as the NRF and other granting institutions, should propose and implement *special financial measures* that will achieve the equitable participation of women, in particular black women and other under-served groups, in the SET sector, prioritising the natural sciences and engineering. Such measures should include *public funding for mentoring and supervision programmes* and *investment programmes in developing the research skills base*, with focus on black women and the natural sciences and engineering.

Mechanisms for allocation of public funding must ensure that all barriers that limit women's access to SET research funding, inter alia *age limits and other systemic barriers* that prevent women from accessing or otherwise utilising funding for the study of SET disciplines, conducting SET research, producing SET products, and advancing their careers within the SET sector are eliminated.

There should be *equity in the value of public funds* allocated for R & D work conducted by women, as defined by both gender and race. This should include dedicated funds for women to be lead or principal investigators in order to enable women to compete in the various SET domains.

The National Research Foundation (NRF) is required to *promote gender mainstreaming and apply the Principle of Fair Discrimination* in order to ensure parity in the award of its 210 Professorial Chairs by 2010. As part of this initiative, it is required to significantly increase the numbers of women post-graduate students studying and/or conducting research under the supervision of the NRF chairs and other grant-holders.

In both universities and in government research institutes, *public funds must be utilised to increase the volume and enhance the quality of scientific output performed by women*, including but not limited to scientific articles, patents, licences, prototypes and other scientific outputs.

Public funds may also be utilised towards providing the requisite environment for improving scientific and innovation-based output by men and women including *access to and/or co-funding of childcare and family services* and in relation to this, minimum standards and rules for levels of subsidisation should be set by the institution.

3.1.3 Strengthening inter-departmental collaboration in SET

The Department of Science and Technology will, through appropriate structures and mechanisms, take steps to ensure that *government departments achieve greater synergy as regards public funding of the national system of innovation* and work together in a more coordinated manner towards attaining the common goal of *promoting and enhancing women's participation in all domains of the SET sector.*

A critical component to increasing women's participation in the SET sector is the *successful maths, science and language education of girls and young women*. The Department of Science and Technology will collaborate with the Department of Education regarding the active promotion of women's participation in science, mathematics, engineering and technology across the education system. Inter alia, girls and women must be given equal access to extra-curricula SET learning opportunities and outdoor SET activities.

Given the distinctions in challenges and responses required across different fields of the broad SET domain, departments should conduct *studies regarding the barriers and corresponding strategies to be implemented at the level of each distinct SET field and career*.

In order to attract and retain women in the SET workforce, the Department of Science and Technology will develop a *Code of Good Practice on Women's Participation in SET*. This will be done in collaboration with the Department of Labour and the Department of Trade and Industry, and in consultation with those departments who have associated science councils, research institutes and state owned enterprises. The code will require institutions to implement effective strategies for, inter alia: provision of a SET working environment that is conducive for women to contribute high quality output; the participation of women scientists in high-level decision-making processes at the SET workplace; programmes to ensure career continuity during child-bearing years including funding remote access and/or child-rearing grants; establishing and implementing programmes for women to re-enter careers in research/SET; training programmes to promote gender sensitivity in SET production; preventing sexual harassment of women in SET workplaces; and offering effective mentoring programmes.

Among other things, institutions are required *to ensure that women scientists are not discriminated against* (i) during recruitment and promotion, (ii) in terms of allocation of resources, facilities and equipment at SET workplaces, (iii) as a result of career interruptions, and (iv) when seeking re-entry into the sector.

3.2. Ensuring Women Benefit from SET (*SET for Women*)

3.2.1 Transforming the lives of women through SET

The relevance of SET research and knowledge production to South African society is directly linked to *whose needs and priorities are served*, how such research is designed, conducted and communicated. This policy aims to ensure that women's research agendas are valued and that the results of SET research provide tangible benefits for women, in particular black urban and rural women living in conditions of poverty.

In order to ensure that SET research benefits women in relation to, inter alia, access to SET-based services, health effects, the utilization of science, engineering and technology for social and economic advancement, and that a race and gender lens is applied to SET research, three main actions are required:

Funding mechanisms for SET research and innovation must incorporate an explicit gender and race focus i.e. acknowledge that research may benefit men and women differentially; or equally; or benefit only one gender or the other; and that each of these varying dimensions have funding implications.

Institutions within the national system of innovation are required to ensure that women active in SET and research are *equitably represented on committees and panels* at all levels of decision-making regarding research activity and SET output, including (i) assessing project proposals, (ii) making funding decisions, (iii) implementing research programmes, (iv) editing publication of SET research outputs, and (v) evaluating the quality and impact of SET research.

Evaluation and reporting of the results of publicly-funded research must include statements on the impact of such research on transforming the lives of women, in particular on SET for poverty reduction.

3.2.2 Promoting production of SET products and services for women

In order to encourage gender mainstreaming in research and innovation output, the Department of Science and Technology, in collaboration with the Department of Trade and Industry and other government departments, will coordinate *gender awareness programmes*, which highlight perspectives on incorporating women's needs in the production of SET products and in the provision of SET services. Such programmes may include, but are not limited to, *show-casing SET products beneficial to women* and *public recognition of institutions and individuals* who design and produce SET outputs relevant to women's needs and priorities.

3.2.3 Promoting further research on SET for Women

The Department of Science and Technology, in collaboration with institutions in the NSI will conduct further research on identifying what constitutes 'SET for Women' across a range of science and technology domains, leading to development of an associated agenda for R&D funding, under the banner of *"New Frontiers in Engendered SET Research"*. In particular, given South Africa's stage of development, *the SET needs of rural women* and *women living in disadvantaged communities* should be clearly identified. Furthermore, the *ethical issues* relating to SET research conducted on women requires greater exploration. These examples illustrate the need for research that explores further the gender aspects relating to what is often referred to as '*science in the service of global stewardship*'.

3.3. Monitoring & Evaluation

The *Gender, Race and SET Monitoring and Evaluation Framework* will utilize the following nine constructs to measure the extent to which this policy is being implemented across the national system of innovation: (i) *SET potential* (ii) *SET labour force* (iii) *R & D workforce* (iv) *Funding issues* (v) *Rank and employment* (vi) *Scientific agenda setting* (vii) *Scientific recognition* (viii) *Scientific output* and (ix) *Scientific collaboration and networking*.

The framework consists of six-year cycles, in which there will be (i) *annual* monitoring of the R&D system for reporting to the Minister, (ii) a *three-year cycle* of SET sector monitoring and reporting, (iii) *international comparison*, and (iv) a *six-yearly comprehensive* review that evaluates the impact of new or ongoing interventions in the system.

These constructs and reporting cycles will be incorporated, as appropriate, into the National Research and Development Survey which is conducted on an annual basis; into the Innovation Survey; into the DST-led institutional review processes; and into the National Census.

The DST will disseminate on a regular basis the data it collects on the scientific and technical workforce. This data will be disaggregated both by gender and race so that participation of all populations and the value generated by women in SET can be tracked. In addition, the DST data collection will include constructs that measure the impact of SET outputs on women, using data disaggregated by race and gender. On the basis of the evaluation reports generated, the DST will prepare an annual publication *"Gender and SET at a Glance"*.

Publicly-funded institutions should include a *"State of Gender in SET"* in their annual reports, making reference to the broad constructs set out in the *Gender, Race and SET Monitoring and Evaluation Framework*.

Publicly-funded institutions should conduct regular reviews of their *institutional monitoring and evaluation mechanisms* established for SET related programs and ensure that they are regularly renewed. These monitoring and evaluation mechanisms should enable the institution to test the impact of SET development programs on women and especially on black women.

In order to implement this monitoring and evaluation approach, and to produce sufficiently rich datasets to inform future decision-making on SET by Women and SET for Women, *capacity for data gathering and analysis should be increased and funded* in the relevant agencies and institutions.

Chapter 2. POLICY CONTEXT

4.1   Background

South Africa is striving to create an economy and society that is globally competitive, with associated benefits for firms and households and sustainable livelihoods for all people. There is particular attention to promoting greater economic participation of and benefit for women.

The Accelerated and Shared Growth Initiative, ASGI-SA, adopted in 2005, proposes that the "social partners", government, business, industry and other non-governmental players make well-considered interventions in the economy, with the aim of generating 5% average growth between 2004 and 2014. This implies levels of growth of 6% and above by 2010. Inter alia, it identifies shortages in the resource pool of skilled professionals, with particular reference to engineers and scientists. It proposes investment in sectors including chemicals, metals beneficiation, clothing and textiles, and wood, pulp and paper – sectors in which science, engineering and technology innovation are necessary to promote consistent growth.

A range of strategies have been adopted and innovation-focused projects launched in the past five years that requires the participation of greater numbers of South African scientists and researchers. These include the Advanced Manufacturing Technology Strategy, the National Biotechnology Strategy, the SA Large Telescope and repositioning of world-class research institutions such as iThemba Labs. In this context, it should be noted that, given the current slow rate of replacement of the scientific workforce and the relatively low levels of participation of women, South Africa can only meet its growth and development targets if it addresses the barriers to more productive participation of women and black people in the scientific and engineering workforce.

4.2 South Africa's Economy and Society

South Africa's GDP growth for the year 2005 was stated as 4.9%. The population of South Africa is estimated at 46.8 million (Stats SA 2005 mid-year population estimates), of which it is estimated that 49.2% are men and 50.8% women, 79.4% are African, 8.8% are Coloured, 2.5% are Indian/Asian and 9.3% are white. GDP per capita growth for 2005 was stated as 8.3%, with continued racial and gender inequalities. Poverty levels remain significant, particularly in the provinces of KwaZulu Natal, Mpumalanga, Limpopo, Free State and Eastern Cape.

4.3 South Africa's National System of Innovation (NSI)

South Africa's gross domestic expenditure on research and development (GERD) stands at 0.81% of GDP (2003/4), well below the 1% threshold of emerging innovation-based economies. South Africa's NSI consists of six main components: (i) industry (both privately- and publicly-owned), (ii) institutions of higher education, (iii) science councils (both performing and agency), (iv) government departmental research institutes, (v) museums and other statutory bodies, and (vi) non-governmental organizations. All these institutions are embedded within the financial system of innovation, the country's legal framework and a national polity that includes learned societies, associations, trade organizations and other civil society organizations.

During the 2005 fiscal year, the South African government's role in the NSI was, in accordance with the recommendations of the 2002 R&D Strategy (DST, 2002b), reorganized to achieve greater coordination. In particular the centralized Science Vote was abolished, with each line department now being responsible for the funds allocated to its associated science councils or research institutes. The Department of Science and Technology assumed an overarching coordinating role with the requirement that it deliver an annual report on S&T to Cabinet. Treasury is the 'hub department'; with all others in subordinate line roles (see Figure 1)

South African Government Science Funding System

Department of
Trade & Industry
South African Bureau for Standards (SABS)
Companies & Intellectual Property Registration Office (CIPRO)

Department of Arts & Culture
Museums

Department of Communications
Institute for Satellite & Software Applications (ISSA)

Department of Water Affairs & Forestry
Water Research Commission (WRC)

Department of Minerals & Energy
(MIN TECH)
Council for Geoscience (GEOSCI)
Nuclear Energy Corporation of South Africa (NECSA)

Department of Environmental Affairs & Tourism
South African Weather Service (SAWS)
South African National Bidiversity Institute (SANBI)
Marine & Coastal Management (MCM)
Nature Conservation (NAT CONS)

Department of Agriculture
Agricultural Research Council (ARC)
Onderstepoort Veterinary Institute (OVI Stations)

Department of Health
Medical Research Council of South Africa (MRC)
National Health Laboratory Service (NHLS)
Academic Hospitals

Department of Public
Enterprises
Denel
Transnet

Department of Education
Universities &
Technical Colleges

Department of Defence
Armaments Corporation of South Africa (ARMSCOR)

Department of Science & Technology
National Research Foundation (NRF)
Human Sciences Research Council (HSRC)
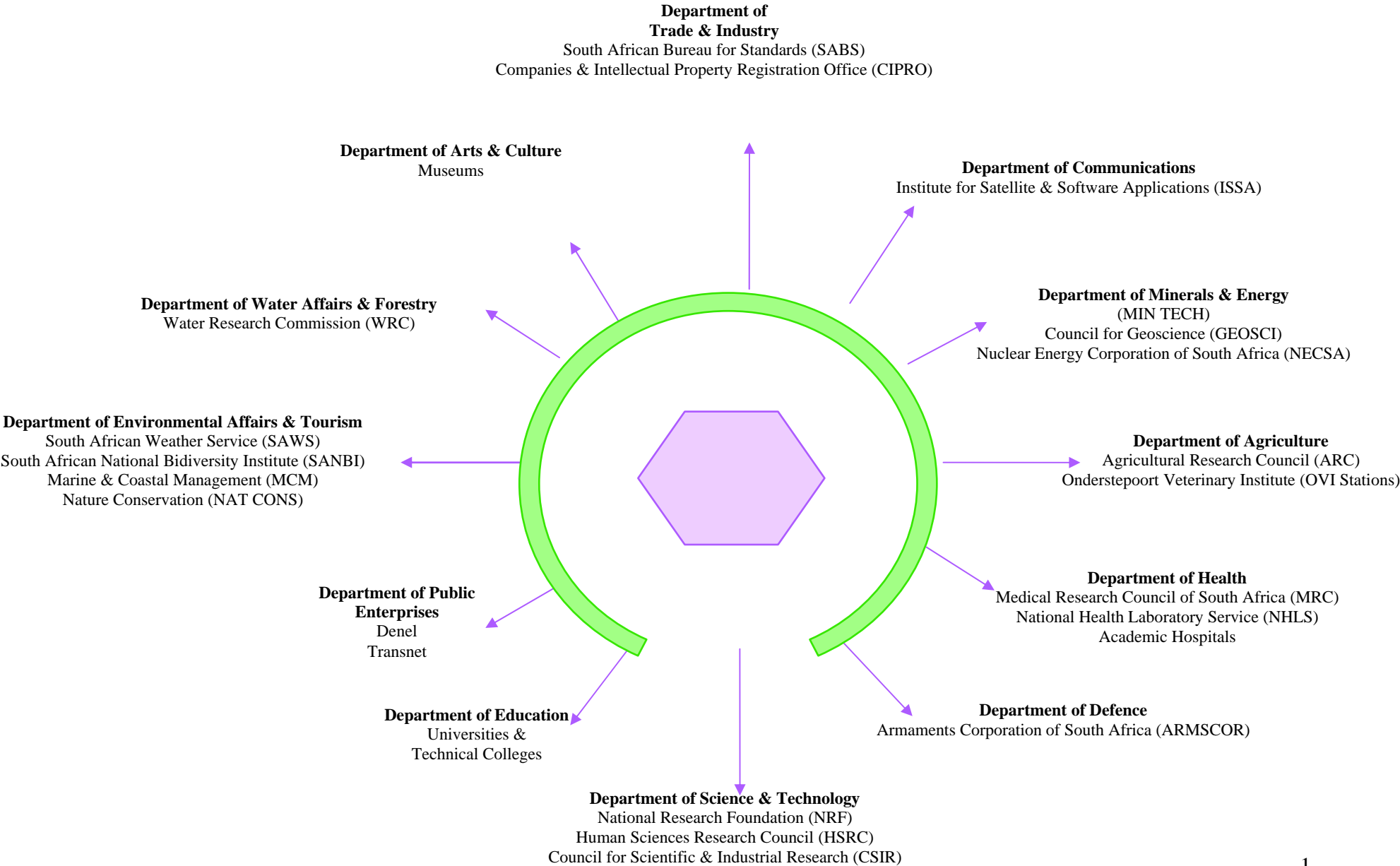Council for Scientific & Industrial Research (CSIR)

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Figure 3

By virtue of its coordinating and reporting role, DST is *primus inter pares*. Each department is expected to produce an annual S&T plan and budget and to report on its performance. A large proportion of funding is allocated for R&D work within two key parastatals, namely weapons producer Denel (state shareholder DPE) and energy utility Eskom (state shareholder DME).

Like all competitive economies, South Africa must deal with the issue of mobility of scarce skills. The apartheid legacy makes the management of mobility especially complex, hence ***issues of brain drain, brain gain and brain retention do have racial as well as gender dimensions*** (see e.g. AS&TS, 1988). In addition, there is the problem of an ageing scientific workforce that is particularly acute in higher education. For example, white men make up around 21% of researchers over the age of 45 years. The proportion of black researchers is greatest in the state sector where it has grown from around 7% in 1994 to 28% in 2001 (Kahn & Blankley, 2005). Female representation is lowest in the business sector and highest in academia, though well below the 50% participation rate. Ultimately, it is the availability of human resources for science and technology, researchers, engineers, technologists and technicians that determines the size and vitality of any system of innovation, and this supply is severely compromised by the apartheid legacy.

Government currently pursues an agenda of social upliftment coupled with policies for growth. Thenational system of innovation is key to achieving these goals, both of which are modulated to avoid dislocating the links between the first and second economy.
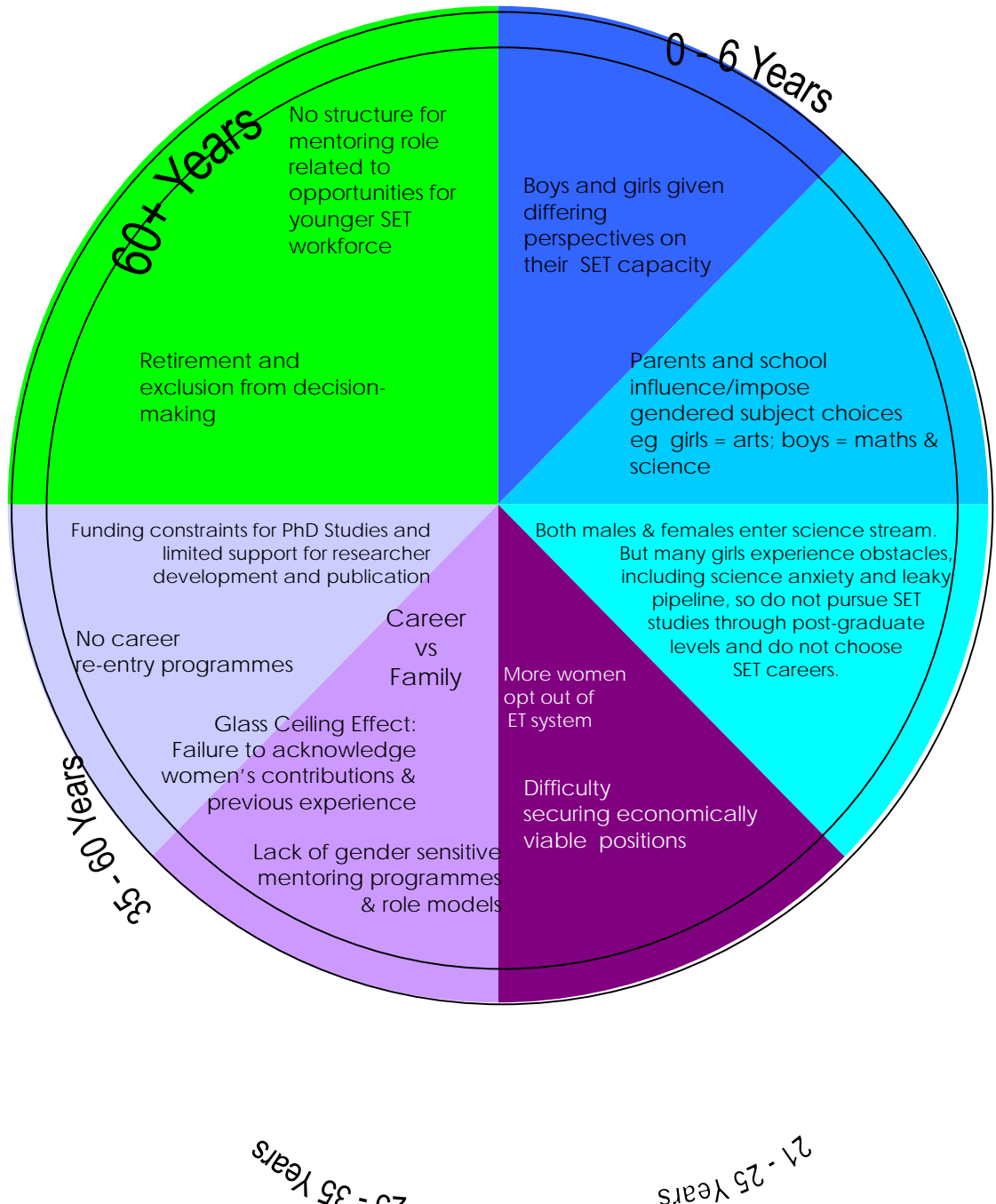
Some efforts have already been made to assess how well this system of innovation is performing (e.g. the National R & D Survey, Innovation survey, etc). However, these efforts could be improved upon by, among other things, ensuring that sex-disaggregated data is collected, evaluated and used in decision-making processes.

4.4 Women's participation in the SET sector in South Africa: The Challenges

One of the key objectives of the <u>*Research and Development (R&D) Strategy*</u> is to identify ways in which the human resource base can be expanded, with particular attention to women and black people. The R&D Strategy outlines the basic requirements for a human resource development approach for SET that includes an explicit gender dimension. These requirements include: (i) a clear definition of what such a 'gender perspective' involves, (ii) sex disaggregated statistics on men and women in the science system, (iii) programmes which encourage previously marginalized groups (including women) to participate in science, (iv) a strong gender-inclusive policy in Centres of Excellence, (v) the consolidation of current policies for women into a programme of empowerment for women, and (vi) the development of policy for women in SET that is not punitive in respect of career development.   The recommendations listed under section one above give substance to these requirements and set out the broad goals and specific objectives that SET institutions are required to meet.

The National Research and Development Survey 2003/4 reports that, of the 18 500 researchers in South Africa, only 6 500 are women. Women experience a number of barriers, obstacles and constraints to their entry into, retention in and advancement within the SET sector throughout the ***life cycle*** (see Figure 2).

Figure 2: Challenges Women Face in SET during their Lifecycle

0 - 6 Years

Boys and girls given differing perspectives on their SET capacity

Parents and school influence/impose gendered subject choices eg girls = arts; boys = maths & science

Both males & females enter science stream. But many girls experience obstacles, including science anxiety and leaky pipeline, so do not pursue SET studies through post-graduate levels and do not choose SET careers.

More women opt out of ET system

Difficulty securing economically viable positions

60+ Years

No structure for mentoring role related to opportunities for younger SET workforce

Retirement and exclusion from decision-making

Funding constraints for PhD Studies and limited support for researcher development and publication

No career re-entry programmes

Career vs Family

Glass Ceiling Effect: Failure to acknowledge women's contributions & previous experience

Lack of gender sensitive mentoring programmes & role models

35 - 60 Years

25 - 35 Years

21 - 25 Years

The _Facing the Facts_ study conducted in 2003 - 04, reporting on women's participation in the publicly-funded science system, documents the following issues relating to the future SET workforce. In 2001, female students represented the greater percentage of enrolments (53%) and graduations (58%) across the higher education sector. However, at postgraduate, especially upper postgraduate levels, there were fewer enrolments and women represented only 43% of graduates at Masters and Doctoral levels. In particular, black women were very poorly represented in enrolments and graduations at the Doctoral level of study, in

comparison both to white women and black males. Women were significantly under-represented in enrolments at Doctoral level in the Natural Sciences and Engineering, as well as in the Social Sciences and Humanities. While these figures may suggest barriers in the pipeline at pre-university stages, they illustrate that major problems are encountered within the university system and at specific stages of the lifecycle.

The study further documents weaknesses in providing for women's participation in the current SET workforce. While the numbers of female academic staff in universities and female R&D staff in science councils and other SETIs increased over the period 1992 – 2001, female academic and R&D staff were less qualified than their male counterparts, generally holding lower postgraduate degrees, rather than Masters and Doctoral level qualifications. Furthermore, women are under-represented in the Professoriate. As with students, the racial imbalances in the female scientific population are documented in the study. The Natural Sciences and Engineering, with the exclusion of the life sciences, are particularly noteworthy for their failure to attract women instruction and research staff. Publication outputs attributed to women are low. Women received a much lower proportion of NRF research grants and Masters and Doctoral scholarships than men, while men received a lower proportion of MRC funding and Masters and Doctoral scholarships than women. This data presents a picture of gender bias in state funding for various fields of study that replicates historical gender bias. There is no evidence to suggest that there has been a dramatic shift in any of the abovementioned trends in the last five years.

The study _Women in the SET Workplace: Exploring the Facts, Experiences and Opportunities_ 2005 and the _Consultative Conferences on Women in Science_ organised by the DST in May-June 2005, highlighted a number of critical challenges that South African women in the current SET workforce are confronted with throughout their _life cycle_, challenges which must be addressed at policy level in order for women to participate in and benefit equitably from the SET sector. These include: (i) historical factors, (ii) gender stereotyping within the family and society, (iii) barriers experienced at primary, secondary and tertiary education levels, (iv) barriers, obstacles and constraints at SET workplaces, and (v) public funding of SET/R & D activities.

4.4.1 **Historical factors.** During apartheid, black women, were denied the opportunity to gain SET qualifications by the discriminatory educational policies of that era. Furthermore, white, asian and coloured women were not encouraged to gain SET qualifications. The legacy of these policies and practices is that there are at present very few women in the SET sector to serve as role models for young girls and women intending to pursue a career in SET.

4.4.2 **Gender stereotyping in the family and society.** Studies have shown that, while parents do encourage high achievement among all their children, most parents in South Africa tend to encourage gender-consistent study preferences and career choices. For many young girls, doubts about their abilities in science and maths (*science anxiety*) are deeply entrenched either well before or soon after they enter the formal education system. Social institutions such as playgroups, religious organizations and the media also tend to reinforce myths about male superiority in scientific and mathematical aptitude.

4.4.3 **Barriers experienced at primary, secondary and tertiary education levels.** The education system plays a significant role in shaping and further entrenching gender stereotypes with regards to intellectual competence and career choice. Thus, in terms of science education, for many women, the education pipeline is a 'leaky' one. This reality contributes significantly to the under-representation of women in the SET sector. For the sake of parsimony and clarity, these barriers are discussed under five broad sub-sections.

4.4.3.1. Science Anxiety and Pedagogic Issues. Despite evidence to the contrary, there is a general belief among many educators (teachers, lecturers, and professors) in South Africa that science,

mathematics, engineering and technology are fields of study that women cannot excel in, and that girls' achievement in these areas is due to a disproportionate level of effort rather than innate capability. This false belief impacts negatively on classroom interactions, as SET educators (who are mostly men) tend to ask girls and women fewer difficult questions, direct comments less often to girls and women, and tend to avoid using girls and women in scientific classroom demonstrations. As a result, *female learners are not provided with optimum conditions under which they can confidently learn, master and excel in science, mathematics, engineering and technology*. Educators' negative attitudes contribute significantly to the phenomenon of 'science anxiety' among girls, young and mid-career women with potential in the various SET fields.

4.4.3.2. Specific Curriculum Issues. Participants at the DST consultative conferences[5] noted specific weaknesses in the *content of science education in South African schools and institutions of higher learning*. It was noted that the illustrations, examples, and demonstrations used in textbooks by (the mostly men) science educators contain a strong gender bias that portrays boys and men as active participants in scientific activities, while girls and women are portrayed as passive observers or 'amazed onlookers'. In addition, girls and young women are seldom encouraged to take part in events such as 'science fairs' or 'school science clubs'. Increasing the presence and contribution of women SET educators and professionals throughout the education system, and designing the content of SET curricula to validate women as participating scientists rather than as curiosities, would contribute significantly to developing self esteem and reduce 'science anxiety' amongst girls and young women. Studies have shown that girls tend to be more attracted to 'science' if they see it as relevant[6].

4.4.3.3. The Time Factor. Throughout the life cycle, girls and women experience the debilitating effects of the time factor differently than boys and men. During childhood, girls and young women are expected to take up numerous domestic chores, which are time consuming and exhausting. For many young women, these chores remain a burden throughout higher education. Leaving home often increases the gender imbalances in the allocation of household responsibilities, especially as regards caring for children, often resulting in the young woman failing to complete her studies. SET disciplines are demanding in terms of time, requiring long hours in the laboratory and the library. *Gender imbalances in time allocation disproportionately disadvantages girls and young women* and tends to limit their successful pursuit of SET studies ie. their ability to learn, excel and master the necessary skills and knowledge required for a career in the SET sector.

4.4.3.4. Financial Constraints. In poor families and communities, financial constraints may result in (i) girls' access to primary and secondary education being sacrificed altogether, (ii) girls being forced to take less expensive high school subject combinations outside the science stream, and, ultimately (iii) girls pursuing studies in arts and humanities, thus not ending up in SET careers. In tertiary education institutions, studying SET disciplines is considerably more expensive, not only in terms of the fees, but also in terms of the cost of essential equipment and practical training. *Raising the necessary funds presents a major challenge for young women from disadvantaged communities and families*. The few existing preferential programmes and funding mechanisms for women in SET[7] target women who are studying towards or already have doctoral degrees in SET and who wish to conduct postdoctoral research, or those who have played leading roles in research.

4.4.3.5. Information about SET careers. Crucial to encouraging girls and young women to pursue studies in SET disciplines is the need for relevant information about SET careers and opportunities. This information should be communicated to girls and young women throughout the education system,

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[5]   Three Consultative conferences were held in Durban, Cape Town and Johannesburg in 2005.

[6]   see Missing Links (p. 190).

[7]   e.g. the Thuthuka "Women in Research" programme of the NRF; the "Women in Water Awards

from a very young age. Many women scientists who participated in the DST consultative conferences indicated that their *decision to study SET disciplines was greatly influenced by science expos and visits to SET workplaces* organized by their schools.

4.4.4 Barriers, obstacles and constraints at SET workplaces. There is a considerable degree of diversity in terms of the specific experiences of individual women across SET workplaces (private *vs* public SET sectors; small *vs* large corporations; academic vs productive SET sectors, etc), institutions (science councils *vs* universities), and field of SET specialization (Engineering *vs* Astronomy). The study *Women in the SET Workplace: Exploring the Facts, Experiences and Opportunities* revealed a number of factors that must be addressed in order to make workplaces more attractive for women with SET potential. These factors include: (i) SET sector Recruitment Practices; (ii) SET sector Professional Growth and Career Development; (iii) SET sector Decision-making Processes; (iv) SET sector Funding Systems and Structures.

4.4.4.1   SET sector Recruitment Practices. Given the dominance of men in SET workplaces in South Africa, there is a false but strongly held perception among recruitment agencies, HR practitioners and employers in the private and public sectors that the majority of SET workplaces are not suitable for women due to, inter alia, lack of physical strength, resilience, emotional strength. Doubts about the competence of women in the SET field, which are a product of the socialization effects of the education system and the perpetuation of gender stereotypes, place women with SET potential way below their male counterparts on the recruitment preference lists. Such *negative recruitment practices tend to discourage women graduates with SET qualifications from seeking a career in SET workplaces*. Women are also disadvantaged at the recruitment stage because their grades are generally not perceived as "impressive" compared to those of their male counterparts eg. repeats, average marks, discontinuities in studies. The competitive nature of the recruitment process and the desire among recruitment practitioners to recommend the 'best candidate' often means that women are at a distinct disadvantage, because their potential for professional growth and development in SET is masked by their academic records.

4.4.4.2   SET sector Professional Growth and Career Development. A number of factors contribute negatively to women's professional growth and development within the SET sector. These include discriminatory practices at the work place; inequitable allocation of resources, equipment and facilities; the time factor; the impact of pregnancy and lack of child care facilities, and lack of gender sensitive mentoring programmes and role models;

Discriminatory practices and gender-insensitive behaviors are prevalent in the male-dominated SET workplace, including patronizing behavior that impacts negatively on women's self-esteem and sense of achievement; dissociating successful women from their high quality outputs; failure to acknowledge women's contributions; low input/reward ratio – opportunities and remuneration offer poor incentives for professional advancement; older generations restraining young women scientists' rapid progress. A number of participants at the consultative conferences highlighted sexual harassment as one of the key inhibiting factors, often leading to their decision to reluctantly quit their jobs and move to careers outside the productive SET workplace.

Women's professional development in SET is also *inhibited by lack of appropriate facilities and equipment necessary to operate productively*. This includes inequitable resource allocation, for example, some companies/institutions consider allocation of high quality equipment and specialized facilities for women as an unnecessary expense, or women being given either "older" or "less efficient" tools, computers and other job-specific equipment. Furthermore, women tend to be excluded from large-scale, high impact projects. Such discriminatory practices impact negatively on women's ability to develop to their full potential and to rise up the ranks. Failure to achieve promotion, in turn, leads to the exclusion of women SET practitioners from decision-making

structures and processes. With few women represented in the upper echelons of the National System of Innovation, women's concerns are often not addressed, resulting in a system that is unable to attract and retain sufficient numbers and calibre of black, coloured, asian or white women.

The SET workplace, characterized by a high degree of competitiveness and demand for innovative work, requires a considerable investment of time and effort, including setting up equipment for new research projects; numerous tests for efficacy; seemingly endless modifications of research design and apparatus. The rate of change in SET knowledge is high, requiring any SET worker to constantly update their knowledge through reading; attending conferences, seminars and training/renewal courses; in addition to the 'normal' requirements of the job. Gender imbalances experienced in relation to family responsibilities, means that *most women experience time and social constraints*, limiting their ability to develop within a demanding SET work environment. Work-related social activities tend to be male dominated, such as golf clubs, giving women limited opportunities for networking, a critical factor for success. Women report that they often do not join social activities where networking takes place among their male colleagues to avoid "… any hint of impropriety".

Many *women's careers in SET are interrupted* due to child-bearing and child-rearing. This reality is a double-edged sword. On the one hand, most employers tend not to be sympathetic to women's needs at this time, perceiving them to be unproductive or under-productive. On the other hand, the woman's career is at a standstill, while technological advances in her field and the professional growth of (mostly male) colleagues continues unabated. Re-entry presents its own challenges, often requiring 're-orientation' and/or re-training following extended absence. For these reasons, many women opt to leave and seek opportunities elsewhere. For those who remain in SET, their professional development is often severely compromised.

Lack of appropriate and beneficial mentoring is an important factor that curtails women's professional SET development. Given the limited number of senior women in the sector, many young graduates work with male mentors, some of whom are not sensitive to gender issues. While some women report positive experiences with their male mentors, many more have negative experiences, including sexism, victimization and sexual harassment. In the majority of cases, such negative experiences result from the fact that SET workplaces do not have gender-sensitive mentoring programmes and female role models. Race and gender insensitivities tend to create an environment that is more hostile than hospitable to young black women. Without adequate mentoring, fewer women have the opportunity of reaching the peak of their SET careers, which limits their potential as future mentors.

⬚⬚⬚⬚⬚⬚⬚ *SET Decision making Structures and Processes*. Existing gender imbalances in decision-making processes within the SET sector are of particular concern in so far as it affects how science budgets are spent, who is involved in recruitment processes, who presides over promotion decisions, who sits on prize-giving and peer review committees, who should be admitted into elite scientific societies, "who speaks for" science in the media, and so on. In South Africa, as in many other countries, very few women scientists, engineers and technologists are involved in these crucial decisions. As a result, women's professional needs and priorities do not take center stage in the process of defining scientific excellence, what topics are investigated and how.

4.4.4.4 *SET funding systems and structures.* R&D and SET funding is regarded as an issue for attention by many women scientists, especially those in the natural sciences and engineering. Of particular concern is the fact that instances abound where conditions for PhD and research grant funding have age restrictions. Such age restrictions discriminate against women "… because of the

different lifecycles of women and men and the greater discontinuity in women's careers" (Braithwaite, 2001:151). Given women's limited participation in key decision-making processes at institutional and national levels, funding for R&D activities continues to flow in significantly higher proportions towards males. As discussed earlier, a significant proportion of R&D funding comes from the National Treasury. This presents the South African government with a potent lever with which to effect change.

4.5   SET Benefits for Women: The Challenges

In South Africa, a number of factors contribute towards women's limited access to the benefits of innovative SET research. These include (i) The exclusion of women from defining what is to be included in SET research agendas on the basis of race, income level, degree of urbanisation, poverty levels, level of education, other reasons (ii) Failure to mainstream gender in SET research, (iii) Gender-blindness among owners of SET companies, and (iv) Criteria for R&D funding.

4.5.1. Exclusion of Women from defining SET Research Agendas. **The needs and priorities of women, especially black, rural and poor women are often not accounted** for in deciding what kind of SET research is conducted. Given the fact that only a small proportion of women scientists, engineers and technologists reach senior levels in their professions, women's interests, concerns and priorities are not adequately considered when research agendas are set in the various institutions of the NSI. Furthermore, women's voice is weak or absent from the national scientific and technological endeavour, because SET R&D agendas do not seek out black, low-income, rural, poor, women to inform these agendas and the consequent studies. The domination of male research perspectives in professional bodies and societies, science councils, research divisions and universities, impacts negatively on directing research funding to issues and perspectives that could promote women's benefit from SET.

4.5.2. Failure to mainstream gender in SET research processes. In order to **ensure that SET research benefits women and men respectively**, gender questions need to be addressed throughout the SET research process. Attention should be paid to whether the research question addresses both women's and men's needs. If human participants are involved, as in clinical trials, questions need to be raised about the proportion of men and women represented in the sample. Questions about the differential impact of research outputs or products on women and men are crucial questions for mainstreaming gender in research[8]. The *Facing the Facts* study showed that only a tiny proportion (6.4%) of SET research conducted within the NSI has an explicit gender dimension. This means that the potential benefits for women (and possible negative consequences for women) of most SET research currently being conducted in South Africa is not considered during project conceptualization and implementation. It is unlikely that asking SET researchers to consider the gender implications of their research will, on its own, result in the desired outcome.

4.5.3. Gender-blindness among producers of SET products and service providers. Where SET researchers develop a product or model of service provision that meets the needs of women, such innovations may fail to reach the intended beneficiaries, if SET producers and service providers are gender-blind. For example, financial considerations may result in a particular company or service provider 'opting out' of the gender focus. For example, Phillips committed both resources and research effort towards the construction of KidCom using a gender-sensitive approach, but decided "… not to put the product on the market, partly for technical reasons but also because it became too expensive" (Sorenson, 2004: 27). As regards the provision of SET services, providers tend to perceive gender considerations as expensive and time-consuming, and often, strategies are unofficially implemented for 'by-passing' gender considerations.

4.5.4. Funding criteria for SET research. Given that a large proportion of SET research in South Africa is publicly funded, an important lever for ensuring that both women and men benefit from SET research

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[8]   see the European Commission's report: Gender in Research: Gender Impact Assessment of specific programmes of the Fifth Framework Programme (2001), for examples of this.

and development is to *ensure that the funding criteria for all SET research includes gender impact assessment*. This particular challenge may be addressed through measures that require funding agencies such as the NRF, other granting institutions, science councils and other public research institutions to ensure that gender impact assessment is included in SET research projects and used as a criterion for the award of a research grant.

4.6   An ICT perspective on Women in SET – insights from a selected field of SET activity

In order to understand the specific issues and challenges within each field of SET activity, it is necessary to study that field and hence to decide specific interventions, in addition to the generic interventions. One such field is ICT, but there are innumerable others, where women's participation is low, even if their participation in the broad field is high. Another example would be that participation of women in the surgical profession is low, despite their relatively high participation in the broad field of health sciences. For the purposes of this policy framework, the ICT sector is used as an example.

According to the study, <u>Increasing the Participation of Women in ICTs 2006</u>, the ICT sector has been identified by the South African government as a national priority, with numerous initiatives already in progress - the Meraka Institute (Africa Advanced Institute for ICT), the DST's ICT foresighting and roadmapping, centre of excellence in high-performance computing; the dti's SAVANT programme to promote international competitiveness in ICTs; and NRF funding for research in ICTs. However, there is concern that South Africa does not have the required skills base to conduct R&D and innovation in the ICT field and that skills shortages are likely to be critical in the future, unless human capital development is aggressively pushed by government and other sectors:

> *"..the ICT sector in South Africa is growing, but this growth is focussed mainly on domestic consumption rather than export, and is mainly in communications and IT services, rather than in software development and, to an even lesser extent, hardware supply."*

> *"The qualifications profile of ICT workers is particularly illuminating….. The data suggests that the high number of workers with intermediate ICT skills is reflective of an ICT economy that has limited expertise in R&D and technological development. The ratio of high-level to intermediate skills corroborates the economic picture of the South African ICT sector as being more involved in ICT services and application of systems, than in the development of new products or utilities."* [9]

There is limited data available on the participation of women and their contribution to developing the ICT sector:

▪ The number of women in ICT leadership positions is dismal. A recent survey (Evans, 2005) of 127 women in ICT leadership positions indicates that 48% are in senior and executive management positions and 33.1% in middle management. 45.7% of the participants have a national diploma or a B degree. 38.6% have postgraduate qualifications. Only 6% have no post-matric qualification. The demographic breakdown shows 71% White, 18% Black, 8% Coloured and 2% Asian;

▪ An increasing number of graduates are women, but that they still represent a minority in the ICT disciplines.

The South African government has adopted a strong gender equity approach in many of its policies and strategies. The reality, however, is that in many of the technology sectors, and particularly in the ICT sector, much has to be done to encourage girls and women to pursue a career in this direction. Given that ICT is a priority sector, there is a strong argument for concerted interventions to increase the number of women in the ICT sector, aimed at achieving participation levels that will reflect the demographics of the country.

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[9]   Human Sciences Research Council. HRD Review 2003. Chapter 27: ICT and Associated Professionals. http://hrdreview.hsrc.ac.za, pages 638 & 643

Many of the issues and challenges identified by women in the ICT sector relate to societal issues such as work/life balance and conflict, the under-valuing of women's contributions in the workplace, the negative perception and stereotyping of women in general, and so on. There are however specific issues that relate to the ICT sector:

- The *fewer number of girls who are given access to adequate mathematics and science education* continues to be regarded as the most important critical success factor. Without this fundamental basis at the primary and secondary school levels (and even at the foundation phase if possible) any interventions beyond school will already be too late.
- The *masculine nature of ICT* - the technology is seen as masculine in terms of the equipment used e.g. design and ergonomics in terms of use by women, the environment in which it is deployed, etc;
- The *lower levels of access to ICTs by women and girls*, particularly in rural, underserved areas. Access to computers and other ICTs is much lower for women for numerous reasons: ICTs are seen as for boys; girls are required to do chores after school, boys can go to computer clubs where they exist; telecentres/internet cafes are not always seen as girl-friendly environments; girls are generally less likely to be encouraged to use ICTs by teachers; and affordability of ICTs is an issue.
- The *limited access to research funding for Masters and Doctoral studies* due to barriers which generally apply during the period when women are actively involved in parenting young children, or when they are exiting the parenting years eg age restrictions.
- The *ICT sector is a fast moving sector and re-entry into the field is very difficult.* Few opportunities exist for re-training or re-integration into the workplace, particularly for women who may have left due to family commitments (elderly parents, child-raising).
- The *lack of female role models in ICTs* – as the data indicates, there are few women in ICT leadership positions and where these do exist, they are not visible in the media or in their communities. Young women therefore have no role models to emulate.
- The *lack of mentorship for young women* – this relates to the dearth of women who could play mentoring roles at present.
- The *lack of available career guidance on ICTs* – there is no information available to schools, career guidance teachers and parents that promotes ICTs as a possible career direction, whether as a researcher, entrepreneur or in the corporate ICT sector. For example, the research conducted by Evans (2005) indicates that only 8 out of 127 women were motivated to study IT by their career guidance teacher.

A general underlying issue specific to the ICT sector which will impact on the implementation of a gender equity policy, is the lack of clarity on what exactly is meant by the ICT sector (Galant, 2006 personal communication).[10] Data on the sector is incompatible across the various survey instruments. This will create significant problems for monitoring and evaluation of policy interventions, and the identification of critical leverage points in stimulating women's participation in ICTs. A lifecycle approach with integration between early schooling, primary and secondary education, tertiary education, and the ICT workplace and beyond, will be based on qualitative and subjective conjecture. *The streamlining of data collection, and a clearer indication of what is meant by ICT skills and career categories is therefore a major challenge.*

Six intervention programmes are proposed in the study:

4.6.1 Establishing a South African Resource Centre for Women in ICTs
The resource centre would fulfil a facilitating role in bringing together women-in-ICT activities:
acting as a central repository and portal for women-in-ICT information, including statistics and data, and dissemination of research; establishing a recognised brand and accreditation system for companies and institutions that are women-friendly in terms of their employment practices, training opportunities,

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[10]   Other categorisations have also been used e.g. SAPSE, Human Sciences Research Council's data, SAITIS studies, National Qualifications Framework. None of these appears to be compatible – further research is needed to verify the extent of the incompatibility and the implications.

workplace culture and career opportunities; develop research capacity in multidisciplinary research on girls and women in ICT.

4.6.2 Strengthening the Research Capacity in Women and ICTS
The establishment of a coordinated network for researchers, with an emphasis on female ICT practitioners and academics, would enable implementation of research projects in the field of Women-in-ICT with expertise in diverse areas such as gender, information society, education, economics, ICT for development, technological research and statistics.

4.6.3 Developing a Workable and Integrated System for Measuring ICT in Working Life and the Education System
For the successful implementation of any intervention in ICTs, and particularly if a lifecycle approach is to be adopted, a workable categorisation of ICT skills needs to be adopted. Where possible, this should be applied within existing frameworks. A concerted effort needs to be made to streamline definitions across government departments (e.g. Education, Science and Technology, Trade and Industry, and Labour), as well as those institutions involved in monitoring and evaluation of ICTs.

4.6.4 Training programme for Schoolteachers
It is necessary to offer programmes to strengthen the capacities of schoolteachers in career guidance for ICT careers and entrepreneurship; to provide gender sensitivity training for educators in primary, secondary and tertiary education institutions, especially for Mathematics, Science and Technology teachers; and to provide mathematics and science teachers with improved ICT and technical skills, with an emphasis on women teachers.

4.6.5 Training Programmes for Girls and Young Women
Training programmes for girls and young women that encourages the adoption of ICTs and careers in ICTs should be implemented from kindergarten through high-school and should focus on the development of ICT and entrepreneurial skills for young women, including ICT entrepreneurship training, technology camps, engendered ICT access in schools, exposure to ICT career opportunities through industry visits and establishing formal mentoring networks.

4.6.6 Dissemination and Awareness Raising Activities
Numerous studies have concluded that current dissemination and awareness raising activities are inadequate. The ICT profession is seen as a 'geek' profession and therefore unattractive to women. It is necessary to develop culturally- and gender-sensitive materials as part of a nation-wide communications strategy to attract women to ICT, while simultaneously promoting effective media coverage on women working in ICT and conducting ICT research.

4.7 Monitoring and Evaluation Framework
It is necessary to present a monitoring and evaluation framework, in order to ensure that the efficacy or failure of any policy interventions can be measured, documented, reported and acted on. In order to inform the rationale and development of the monitoring and evaluation framework, the CREST team reviewed and compared how the reports emanating from international initiatives on science and technology indicators have designed their frameworks using broad constructs or organising themes, and clustered indicators within these constructs or themes. Below we provide a summary and brief description of the European Commission and National Science Foundation frameworks, which are the only two frameworks that provide gender analyses of science and technology indicators[11]:

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[11]   Gender analyses of S&T indicators can have both quantitative and qualitative dimensions. Quantitative gender analyses involve the analysis of sex-disaggregated data, while qualitative gender analyses focus on the historical, political, economic and socio-cultural factors which give rise to these different experiences and impacts (McGregor & Bazi 2001:101).

Report	Organising themes (constructs)	Description
1. European Commission, *Women and Science and Indicators,* *She Figures 2003*	How many? (The "critical mass")	Provides an overview of gender patterns for the "critical mass" of scientists and researchers studying and working in Europe. Indicators included here measure the gender balance of the graduate population as well as gender patterns in scientific employment. With respect o the latter, gender patterns are examined separately for R&D
	Horizontal segregation	Measures gender differences across scientific fields among women and men graduates as well as women and men researchers in different sectors
	Vertical segregation	Measures the hierarchical distributions of the sexes within academia and R&D occupations. Included in this set of indicators is a measure of gender patterns in scientific performance and output
	Pay Gap	Here one indicator is used to measure the dissimilarity in salary by sex for different occupational grades.
	Fairness and Success rates	Measures the sex breakdown of applicants and beneficiaries of research funds and the sex composition of scientific boards, editorial boards and scientific review panels.
2. National Science Foundation, *Women, Minorities and Persons with Disabilities in Science and Engineering: 2000*	Undergraduate Enrolments	Indicators are clustered to measure sex and race differences in high school completion rates and undergraduate enrolments in different institutional types. In addition, sex and race differences in enrolments by field of study, with special focus on science, is examined.
	Undergraduate Degrees	Measures sex and race differences in first bachelor degrees across science and engineering fields of study.
	Graduate enrolments	Measures sex and race differences in graduate enrolments at different institutional types and across science and engineering fields of study. It also includes indicators that measure sex and race differences in enrolment status (i.e full-time versus part-time)
	Graduate Degrees	Measures sex and race differences in Masters and Doctorate Degrees across science and engineering fields of study. It also includes indicators that measure sex differences in post-doctoral fellowships across science and engineering fields of study

	Science and Engineering employment	Measures the sex and race distribution of scientists and engineers in different occupations and sectors, and compares their age, educational attainment and salaries within these occupations. In addition, it includes indicators that measure sex and race differences in unemployment rates of scientists and engineers in different occupations. Within the education sector, indicators are included that measure sex and race differences in type of institution employed at, rank within institutions and qualification levels.

Inspection of the indicators in these two frameworks and comparison with the framework being developed in the South African study did not reveal any major conceptual gaps, at the construct level, nor at the operational level (at the indicator category and indicator level).

Conceptual Framework

Drawing on the review of international sources on science and technology indicators and the brief to develop a monitoring and evaluation framework for women in SET that should support planning and resourcing of the National System of Innovation, the framework has been designed around nine core constructs, which reflect broad policy concerns and which have planning and resourcing implications.

The _Gender, Race and SET Monitoring and Evaluation Framework_ will utilize the following nine constructs to measure the extent to which this policy is being implemented across the national system of innovation and to identify areas for future intervention: **(i)** _SET potential_ – consisting of 15 indicator categories. The indicators of this construct are meant to show the 'leakages' in the pipeline as female students progress from school through to postgraduate studies. It will give an indication of the size and potential of the pool from which the future SET and R&D labour force will be drawn. **(ii)** _SET labour force_ – 8 indicator categories. This construct is meant to provide a gender and race profile of the SET human resource capacity and show the horizontal distribution of women and men in different SET occupations. **(iii)** _R & D workforce_ – 6 indicator categories. The indicators in this category are meant to provide not only a gender and race profile of the R&D human resource capacity, but also to show the horizontal distribution of women and men across sectors at all levels of R&D. **(iv)** _Fairness and success in funding_ – 16 indicator categories. This construct is meant to measure whether there are gender and race differences in access to funding and success in obtaining funding. **(v)** _Rank and employment_ – 7 indicator categories. This construct will monitor the distribution of women and men at different ranks and statuses of employment and can be used to highlight differences between the sexes in career opportunities and progression within different sectors. **(vi)** _Scientific agenda setting_ - 4 indicator categories. This construct sets out to measure the gender and race profiles of decision-making bodies that set research agendas and make policy decisions that affect the work and performance of scientific institutions. **(vii)** _Scientific recognition_ – 9 indicator categories. This construct recognises that assessing the quality of scientific work is primarily achieved through peer review and will hence monitor the race and gender participation in existing peer review mechanisms. **(viii)** _Scientific output_ – 4 indicator categories. The indicators of this construct are meant to map gender and race patterns in scientific output, which is most commonly used as a measure of academic success. **(ix)** _Scientific collaboration and networking_ – 6 indicator categories. This construct recognises that scientific collaboration and networking has become another form of scientific recognition and will hence monitor the gender and race patterns in scientific collaboration and networking mechanisms.

The selection and sequencing of the above constructs, with their clusters of indicators, have been designed to provide a comprehensive national profile of women in SET in South Africa, that will monitor, for example, how many women are potentially available to participate in the NSI; how women are distributed

horizontally and vertically within the NSI; how women are supported to participate in the NSI, what recognition women get as scientists and what women's contributions are to scientific output.

The framework proposes four application scenarios that take into account the purpose of the monitoring exercise, the audience, and the cost and time implications of data collection and reporting. The application scenarios represent complimentary schemes in a six-year cycle of monitoring and evaluation activities: **(i)** A*nnual monitoring* of the R&D system for reporting to the Minister. Monitoring in this scenario is at a national level and given the frequency of expected reporting, this scenario ideally has to be limited to routinely collected data in the system. **(ii)** *Three-year cycle of SET sector monitoring* and reporting. In this scenario the purpose of monitoring is to inform sector level policies and interventions. Each sector is given three years for collecting data before the next sector report, which will allow each sector to invest some time and resources to indicator categories for which data is not routinely collected in the system. **(iii)** *Three-year cycle of International Benchmarking*. Monitoring and reporting in this scenario is geared towards international comparisons. In this scenario indicator categories are selected on the basis of currently available international data. **(iv)** *Six-yearly comprehensive review* that evaluates the impact of new or ongoing interventions in the system. It will mark the end of two three-year cycles of sector reports and international comparisons. The purpose of this review will be to inform all stakeholders in the system of all aspects of the NSI. In this scenario attempts will be made to include all constructs and data categories, especially those that require great effort or investment of time and money to collect the data.

The different levels and cycles of the application scenarios imply that the M&E framework is a dynamic measuring instrument that expands or contracts in terms of constructs, indicator categories and indicators, depending on the purpose it is to serve. These constructs and reporting cycles will be incorporated, as appropriate, into the National Research and Development Survey which is conducted on an annual basis; into the Innovation Survey; into the DST-led institutional review processes; Higher Education Audits, SETI reviews and into the National Census.

ABBREVIATIONS

CREST	Centre for Research on Science and Technology
DoE	Department of Education
DST	Department of Science and Technology
DTI	Department of Trade and Industry
GDP	Gross Domestic Product
GERD	Gross Domestic Expenditure on Research and Development
NGO	Non-Governmental Organization
NRF	National Research Foundation
NSI	National System of Innovation
R & D	Research and Development
S & T	Science and Technology
SET	Science, Engineering and Technology
SET4W	Science, Engineering and Technology for Women
SETI	Science, Engineering and Technology Institutes

GLOSSARY OF TERMS[12]

Engender – refers to the process of integrating gender considerations and concerns into words, action and assessment.

Gender – the socially constructed characteristics, roles and behaviour patterns that society ascribes to women and men. Gender is distinguished from sex, which is biologically determined.

Gender awareness – refers to a state of knowledge of the differences in roles of and relations between women and men, as well as how such differences manifest themselves in power relations, status, privilege and needs.

Gender blindness – the opposite of gender awareness

Gender equality – refers to a situation where women and men have equal conditions for realizing their full human rights and potential; are able to contribute equally to national political, economic, social and cultural development; and benefit equally from the results.

Gender equity – refers to the fair and just distribution of all means of opportunities and resources between women and men.

Gender mainstreaming – is a goal-oriented process that promotes the full participation of women and men in decision-making such that women and men's needs are at the centre of development planning and resource allocation.

Gender perspective – an approach in which the ultimate goal is to create equity and equality between women and men.

Gender sensitive – refers to the state of knowledge of the socially constructed differences between women and men, including differences in their needs, as well as use of such knowledge to identify and understand the problems arising from such differences and to act purposefully to address them.

Substantive equality – refers to a stage of real equality underpinned by equality of opportunity, access and treatment between women and men.

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[12] *Some of the definitions are based on the definitions adopted by the Office of the Status of Women (OSW) in the National Policy Framework for Women's Empowerment and Gender Equality. Also, international sources (e.g. UN publications) have been used where necessary.*

ANNOTATED LIST OF REFERENCES

AS&TS (1988) People for Research and Development 1988 Proceedings of a Conference held at the CSIR 23-24 August 1988 Johannesburg: The Associated Scientific and Technical Societies.

Edited (Richards B J and Hettema JA). Proceedings of a conference that focused on the education and training needs needed to meet the demands of R&D into the future. The conference inter alia found that there were blockages in science education at school level, that SET careers were proving unattractive and that high level skilled manpower was in short supply. Moreover supplementing skills through emigration was no longer viable. The entire population would have to be seen as a source of skill.

Beck, T. (1999). *Using Gender-Sensitive Indicators: A Reference Manual for Governments and Other Stakeholders. London***: Commonwealth Secretariat.**

Published by the Commonwealth Secretariat, this manual provides detailed information on current approaches to national development planning; the process of putting together a national plan; and the link between the national plan, the national budget, and sector plans. The manual also explains how to mainstream gender at each key stage of various planning cycles: the medium-term planning cycle, the annual budget cycle, and the project cycle. It features easy-to-follow diagrams, checklists of interventions, and case studies.

Department of Science and Technology (2002). *South Africa's National Research and Development Strategy***. (2002). Pretoria.**

The national R & D strategy, designed to be a key enabler of economic growth in South Africa, is an indicator-based initiative that rests on three pillars: *innovation*, development of strong SET *human resources base*, and the *creation of an effective government science and technology (S&T) system.* This Strategy is the pinnacle of the policy review process that started with the Green Paper of 1995. The strategy lays out proposals for new technology missions for the national system of innovation, and lays out a new reporting and governance model.

Department of Trade and Industry. (2003). *A strategy for Women in Science, Engineering and Technology***. Department of Trade and Industry. UK.**

This strategy document is the UK government's response to an earlier report *SET Fair*, prepared by Baroness Greenfield at the request of the Secretary of State for Trade and Industry on barriers faced by women in science, engineering and technology in that country. The document laid the foundation for the UK's *Gender Equity Action Plan*, a blueprint that was produced to facilitate a number of new initiatives designed to achieve gender equity in the SET sector (e.g. establishment of a new resource centre, introduction of a new funding system, improved statistical monitoring designed to track women's participation in SET, and so on.

European Commission. (2004). *Gender and Excellence in the Making***. Belgium. European Commission.**

In October 2003, the European Commission's Women and Science Unit, together with the Joint Research Centre and the European University Institute organised an expert workshop to look at gender issues in relation to scientific excellence. The report: *Gender and excellence in the making* provides a synthesis of the workshop activities. It analyses the extent to which existing procedures, definitions and criteria relating to scientific excellence are gender neutral. The report reflects the diverse nature of the workshop discussions and lists recommendations for future action that could minimise gender bias. It offers the reader diverse resources for thinking about the problems of defining and measuring excellence, which the authors believe, will lead to some new research initiatives and improved practices.

International Development Research Centre (1995). *Missing Links: gender equity in science and technology for development.* **International Development Research Centre: Ottawa, Canada.**

This book consists largely of essays written by distinguished scholars and experts identified by the Gender Working Group of the United Nations Commission on Science and Technology for Development (UNCSTD). Each contributor explores the issues related to science, technology, and gender in a given area of expertise. Examples of areas where technological changes differentially affect the lives of women and men are given. The topics chosen by the Gender Working Group reflect an earlier decision to focus its work primarily on the basic needs of people in rural areas of the developing world. However, a few essays do also explore the wider impact of new technologies on the lives of women in both urban and rural environments and the relationship between gender and science in the developed world.

Kahn, M., Blankley, W., Maharaj, R. et al (2004). *Flight of the Flamingo: A study on the mobility of R&D workers.* **Cape Town: HSRC Press.**

The publication: *Flight of the Flamingos* arose out of a study on the mobility of R&D workers that was conducted by the HSRC's Assessment Technology and Education Evaluation Research Programme (ATEE) in partnership with CSIR. The publication is a comprehensive piece of research that goes beyond a simplistic "brain drain" approach by seeking to provide evidence on the production, stocks and flows of R&D personnel. Related to this work is an on-going analysis of the production of high-level mathematics and physical sciences students in South African schools, which is key to the ensuring the attainment of racial and gender imbalances that exist in the SET sector of South Africa.

Kahn, M.J, Blankley, W, Reddy, V, Pogue, T, and Maharajh, R. (2004) Flight of the Flamingoes: A study on the Mobility of R&D Workers Pretoria: HSRC

The report presents a system model of the problem of mobility of the highly skilled. The work examines sources, flows and stocks of personnel by interrogating both primary and secondary data. The primary data was generated through the 2001/2 R&D survey, while secondary data was gleaned from national statistics for South Africa and for the six most important foreign countries that accept South Africans as immigrants.

Lawless, A (2005) *Numbers and needs: addressing imbalances in the civil engineering profession.* **SAICE: Johannesburg**.

This book highlights the challenges faced by the civil engineering industry in attracting, recruiting and retaining qualified and efficient staff in this field. Allyson's book presents statistics and bottlenecks identified from 24 months of detailed research. It seeks to make practical recommendations in terms of education, learnerships, training, coaching and mentoring. The book also includes specific suggestions on how to attract and retain engineering professionals in South Africa in order to develop sufficient civil engineering capacity to unblock existing bottlenecks.

National Advisory Council on Innovation (NACI) and The Department of Science and Technology (DST). (2004) *Facing the Facts – Women's participation in Science, Engineering and Technology.* **Pretoria.**

Using a wide range of data sources within the public science system of South Africa, this report serves to benchmark the status of women's participation in SET in the country. This report, which is a condensed version of an earlier, more detailed research report commissioned by SARG, highlights the salient findings with respect to sex disaggregated data on overall doctoral graduations, doctoral graduations in natural sciences, engineering and technology disciplines, academic staff in higher education, as well as gender differences in senior levels at academic institutions.

National Advisory Council on Innovation (NACI) and the South African Reference Group on Women (SARG). (2005) *A Monitoring and Evaluation Framework for Benchmarking the Performance of Women in the NSI, Final CREST Report to the South African Reference Group on Women in Science and Technology*, **Pretoria**

This report provides a model for understanding monitoring and evaluation and presents a framework designed to provide a comprehensive national profile of women in SET in South Africa, that will monitor, for example, how many women are potentially available to participate in the NSI; how women are distributed horizontally and vertically within the NSI; how women are supported to participate in the NSI, what recognition women get as scientists and what women's contributions are to scientific output. The final report consists of two volumes: Volume I comprises the main body of the report and describes the conceptual framework, based on nine core constructs around which the indicators are organised in the framework and provides a rationale for the inclusion of the indicators. This volume also describes four application scenarios for monitoring and evaluating the performance of women in the NSI. Volume II sets out the full list of indicators for each indicator category and sub-category within each construct. In addition, it includes data tables that recommend forms of data collection and reporting.

National Advisory Council on Innovation (NACI) and the South African Reference Group on Women (SARG). (2004) *Synthesis Report – Women's Participation in Science, Engineering and Technology in South Africa, Final CREST Report to the South African Reference Group on Women in Science and Technology*, **Pretoria**

Commissioned by the Department of Science and Technology, this report provides a detailed analysis of women's participation in and benefit from the SET sector in South Africa. It is on the basis of this report that a condensed version of the report findings entitled: *Facing the Facts – Women's participation in Science, Engineering and Technology* was produced and published. The report provides a more detailed analysis of sex disaggregated data on overall doctoral graduations, doctoral graduations in natural sciences, engineering and technology, proportions of academic staff in higher education, as well as gender differences in senior levels at academic institutions.

Office on the Status of Women (2000). *South Africa's National Policy Framework for Women's Empowerment and Gender Equality*. **Pretoria, South Africa.**

This policy document defines the South African government's vision as well as what it plans to do to achieve gender equity and equality in all spheres of the South African society. It provides a framework within which sector-specific policies for achieving gender equity and equality are to be conceptualized, developed, implemented, monitored and evaluated.

United Nations Publications (2006). *The World's Women 2005: Progress in Statistics*. **New York.**

This UN report focuses on the need to report sex-disaggregated statistics in such areas as demographics, health, education, work, and violence against women, poverty, human rights and decision-making. It reviews and analyses the current availability of data and assesses progress made in the provision of national statistics that are relevant to gender concerns. This report proposes a set of strategies to strengthen national capacity to collect and report statistics and also for improved mainstreaming of gender concerns. It also provides updated figures for many of the indicators presented in The World's Women 2000: Trends and Statistics, plus some additional indicators on the status of women and men.