GENERAL NOTICE

NOTICE 425 OF 2012

DEPARTMENT OF SCIENCE AND TECHNOLOGY

FINAL REPORT OF THE MINISTERIAL REVIEW COMMITTEE ON THE SCIENCE, TECHNOLOGY AND INNOVATION LANDSCAPE IN SOUTH AFRICA

I, Grace Naledi Mandisa Pandor, Minister of Science and Technology, hereby publish the final report of the Ministerial Review Committee on the Science, Technology and Innovation landscape in South Africa, for public comments.

Members of the public are invited to submit their comments/inputs on this report, within 30 days of the date of publication of this notice. Written comments may be submitted to:

Postal Address: The Director General,
Department of Science and Technology
Private bag X894
Pretoria, 0001

Physical Address: Department of Science and Technology
Building 53, CSIR campus (South Gate entrance)
Meiring Naude Road
Brummeria,
Pretoria, 0001.

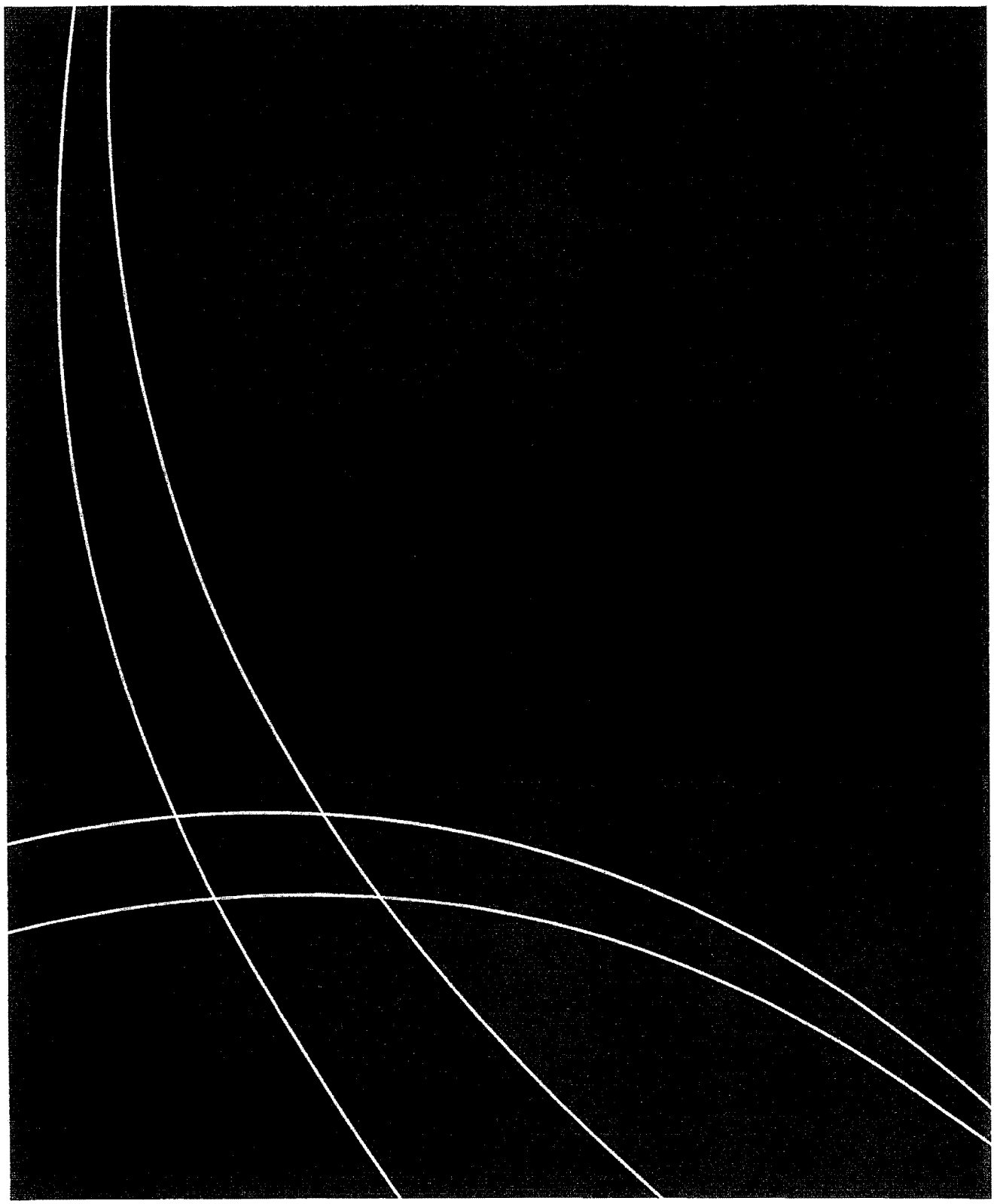
Attention: Mr M Cele

E-mail: Mlungisi.cele@dst.gov.za

The report can also be accessed online from: www.dst.gov.za.

G.N.M. Pandor

MRS GNM PANDOR, MP
MINISTER OF SCIENCE AND TECHNLOGY



science
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Department:
Science and Technology
REPUBLIC OF SOUTH AFRICA

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PREFACE

The mandate given to the Ministerial Review Committee has been a challenging one for a number of reasons, not least because of the complexity of the object **of study. In asserting the inclusive definition of the National System of Innovation (NSI) (rather than a restricted definition), the Committee set itself the task of appraising, and making recommendations on, a very extensive landscape of human endeavour, marked by widely differing** territories and strongly divergent fields of practice.

The Committee was conscious of the prior efforts of numerous reviews and evaluations that recommended significant NSI organisational and structural changes, only to see things remain as they were. Some of our advice may therefore carry echoes of previous recommendations, but now with measures that are intended to achieve the policy effects that we seek for the system.

We believe that this report provides fresh reflection on the issues and brings into discussion a range of considerations not assembled in this way before. We are aware of important dimensions that deserve further attention, however, either because their salience has been illustrated in the report or because the limitations of time and resources have not permitted their inclusion.

The process for preparing this report included a number of interviews with expert individuals, and the Committee is grateful for the important insights that were gleaned in this way. Furthermore, the report was to be informed by the commissioning of a number of specialist writers, identified by the Committee, to produce commissioned reports on one or another dimension of the planned report. While a great deal of excellent work has been delivered by these writers, some have inevitably been constrained in the levels of investment possible, especially in terms of time available for fresh empirical enquiry. The content of the specialist reports thus generally reflects the existing fields of expertise of the writers, and their capacity to undertake further desk research at short notice in response to our commissions. So, while some limited fresh research was undertaken to inform some reports, this has been somewhat less than the subject matter deserves. As the report indicates, there is an argument to be made for a strong research and evaluation capacity to be established, dedicated to informing the future strength and direction of the NSI. We trust that the discussions raised in this report will inform future research agendas, both in the short and longer term.

On behalf of the Committee, I would like to express our appreciation to the Minister for the opportunity afforded this Committee to undertake this project of national importance, and for the guidance and direction we have received from her. The importance of this work is reflected, perhaps, in the willingness and commitment of the various informants and specialist writers that we have approached in the course of this project, and we are grateful to them for their generous time and considered insights. I would like to thank the Committee for their participation in producing this report, and the investment they made among their many other pressing commitments. In particular, I would like to express our appreciation to the report writers, Professors Wieland Gevers, Michael Kahn and Robin Moore, and to Ms Rita Sikhondze and Professor Robin Moore for the management of the project. We acknowledge with thanks the efforts of the DST Secretariat that was allocated to support the work of the Committee, in particular Mr Mlungisi Cele, Ms Miyelani Mashimbye and Ms Zoleka Ndlovu.

The Committee thus presents this report for the Minister's consideration.

Professor Loyiso Nongxa
Chairperson: Ministerial Review Committee on the National System of Innovation

March 2012

BACKGROUND

REMIT OF THE COMMITTEE

In July 2010, the Minister of Science and Technology, Minister GNM Pandor commissioned a Ministerial Committee to review the current science, technology and innovation (STI) landscape in South Africa, proposing a two-phase study that would both appraise the present as well as provide considerations for the future. The responsibilities of the Committee, and the purposes of the respective phases, are outlined below.

The **purpose** of the Ministerial Committee was to:

- Review the science, technology and innovation landscape and its readiness to meet the needs of the country
- Appraise the degree to which the country is making optimal use of its existing strengths
- Assess the degree to which the country is well positioned to respond rapidly to a changing global context and meet the needs of the country in the coming ten to thirty years.

The study must provide the nation with an understanding of what is being achieved in and by the National System of Innovation (NSI).

It must identify what is required from the state in order to ensure an adequate and growing investment in enhancing innovation that:

- Will deliver a sustained and durable knowledge-based economy
- Is geared to advance the national objectives of economic growth, jobs, better health, quality education and responsiveness to the needs of the most marginalised
- Facilitates the increased involvement of other key stakeholders.

According to the **terms of reference**, the work of the Ministerial Committee was to be undertaken in two phases.

Phase One: The Contemporary NSI Landscape

In the first phase, the Committee conducted a desktop study of the contemporary NSI landscape and, in particular, an assessment of:

- The OECD Review and its recommendations
- Key policies, strategies and reports of the DST and its public entities including the science councils and the national facilities (particularly in the period 2004 – 2009)
- The role of the private sector in science, technology and innovation

From this preliminary work, the Committee produced advice to the Minister on:

- The degree to which the recommendations of the OECD Review had been acted upon
- The adequacy of existing documentary data to inform an assessment of the strengths, shortcomings and responsiveness of the system in addressing the purpose above.

The work of the Committee during Phase One formed the basis for the continuation of Phase Two of the investigation.

Phase Two: Recommendations for the future of the NSI

During Phase Two, the Ministerial Committee was tasked to implement the scope of work developed in Phase One, as approved by the Minister. Based on the analysis of Phase One, and the further work undertaken in Phase Two, the Committee was to:

- Report on the performance of the system of science, technology and innovation, with particular reference to the following aspects of the system:
    - Size and shape
    - Governance and structure
    - Resourcing and financing (including human resource development)
    - Capacity to monitor and evaluate the impact of the system on the growth of a knowledge-based economy and in meeting the priorities of national development
    - Readiness of the system to adapt to changing circumstances.
- Make recommendations to the Minister on the steps that should be taken to strengthen the national system of science, technology and innovation, and to enhance the country's innovation capabilities, with particular reference to:
- Structure and governance of the system, including roles and responsibilities of different actors within the STI system
- Roles and responsibilities of the DST, including its relationship with other government departments
- Human resource and infrastructure capabilities
- Recapitalisation and funding requirements.

In particular, Phase Two was expected to make recommendations regarding:

- The framework conditions to achieve coordination and coherence of the components of the NSI to ensure a functional and effective system that will deliver innovation-driven national economic and social development
- The appropriate institutional arrangements and structures (existing, or to be established) that will direct the NSI, and will highlight and prioritise future challenges and research needs, and set out a suitable timeframe for addressing them

- The location and levels of investment responsibility for the NSI, including government, business, foreign support and other sources of funding and specifically to propose an investment plan for the NSI.

Process

In addition to desktop studies, the Committee was expected to engage with key stakeholders within and outside the national system of science, technology and innovation.

The Committee submitted its Phase One report to the Minister in November 2010. This report was presented to Cabinet and to the Parliamentary Portfolio Committee on Science and Technology.

In January 2011, the Minister advised the Committee to proceed with Phase Two of the exercise. The report on Phase Two was delivered to the Minister in November 2011.

This Final Report comprises the reports of both Phase One and Phase Two, and an overarching Executive Summary. Appendix 2 contains two diagrams illustrating the structure of the proposed institutional government research and innovation funding system.

COMPOSITION OF THE MINISTERIAL COMMITTEE

The Committee was constituted as follows:

Professor Loyiso Nongxa (Chair)
Professor Wieland Gevers (Deputy Chair)
Professor Cheryl de la Rey
Professor Brian Figaji
Professor Michael Kahn
Professor Thokozani Majozi (appointed 1 September 2011)
Professor Phuti Ngoepe
Professor Mmamokgethi Setati
Mr Michael Spicer
Dr Alysson Lawless (a member during Phase One)

The Committee was assisted by a **Secretariat** provided by the Department of Science and Technology:

Mr Mlungisi Cele
Ms Miyelani Mashimbye
Ms Zoleka Ndlovu

The report writing was undertaken by:

Professor Wieland Gevers
Professor Michael Kahn
Professor Robin Moore

The following were responsible for project management:

Professor Robin Moore
Ms Rita Sikhondze

APPROACH AND ACKNOWLEDGEMENTS

During Phase One, the Committee requested a number of **briefings**, and would like to express its appreciation to the following, many of whom were accompanied to the briefing sessions by members of their respective senior executive teams:

Ms Marjorie Pyoos	Department of Science and Technology
Dr Albert van Jaarsveld	National Research Foundation
Dr Sibusiso Sibisi	Council for Scientific & Industrial Research
Dr Steve Lennon	National Advisory Council on Innovation
Dr Phil Mjwara	Department of Science and Technology
Dr Molapo Qhobela	Department of Science and Technology
Dr Olive Shisana	Human Sciences Research Council

The Committee also commissioned a number of **briefing papers** that contributed seminal content to this report:

Professor Wieland Gevers (2 papers)
Professor Michael Kahn (2 papers and 1 presentation)

Mr Michael Spicer (2 papers and 1 presentation)
Professor Phuti Ngoepe (1 paper)

In its Phase Two deliberations, the Committee conducted a number of **interviews with expert informants**, and would like to express its appreciation to the following:

Ms Luci Abrahams	Learning Information Networking Knowledge Centre (LINK), University of the Witwatersrand
Ms Ferrial Adam	Gauteng City Region Observatory (GCRO)
Professor Erik Arnold	Technopolis
Emeritus Professor Martin Bell	University of Sussex
Professor Haroon Bhorat	Development Policy Research Unit (DPRU), University of Cape Town
Professor Ben Cousins	University of the Western Cape
Professor Owen Dean	Spoor and Fisher
Mr Simphiwe Duma	Technology Innovation Agency
Professor David Everatt	Gauteng City Region Observatory
Mr Mahesh Fakir	The Presidency
Mr Roger Jardine	CEO, Aveng (Pty) Ltd
Ms Rhoda Kadalie	Impumelelo
Professor David Kaplan	University of Cape Town
Professor Mohamed Karaan	Stellenbosch University
Ms Geci Karuri-Sebina	South African Cities Networks
Professor Murray Leibbrandt	Southern Africa Labour and Development Research Unit (SALDRU), University of Cape Town
Ms Bridget Letty	Institute of Natural Resources
Professor Rasigan Maharajh	Institute for Economic Research on Innovation (IERI)
Mr Mabhule Makhine	Greenhouse Project
Professor Gillian Marcelle	University of the Witwatersrand
Dr Phil Mjwara	Department of Science and Technology
Dr Shadrack Moephuli	Agricultural Research Council (ARC)
Professor Seeraj Mohammed	University of the Witwatersrand
Mr Sam Morotaba	Department of Labour
Dr Kuben Naidoo	National Planning Commission Secretariat
Ms Jayshree Naidoo	Development Bank of Southern Africa (DBSA)
Dr Thiambi Netshiluvhi	National Advisory Council on Innovation (NACI)
Dr Siyabulela Ntutela	Technology Innovation Agency
Mr Hermann Oelsner	Darling Wind Farm
Professor Francis Petersen	University of Cape Town
Mr Nkahloleng Phasha	Department of Labour
Dr Nicolas Pons-Vignon	University of the Witwatersrand
Mr Stephen Porter	University of the Witwatersrand
Professor Anastassios Pouris	University of Pretoria
Dr Nick Segal	Independent Consultant
Dr Sibusiso Sibisi	Council for Scientific & Industrial Research
Mr Garth Strachan	Department of Trade and Industry
Professor Mark Swilling	Stellenbosch University
Professor Alex van den Heever	University of the Witwatersrand
Professor Servaas van der Berg	Stellenbosch University
Professor Karl von Holdt	University of the Witwatersrand
Professor Eddie Webster	University of the Witwatersrand
Mr Nimrod Zalk	Department of Trade and Industry

The Committee also commissioned a number of **specialist reports** that provided seminal contributions to this report:

Professor Ben Cousins
Professor Michael Kahn
Professor David Kaplan
Ms Geci Karuri-Sabina
Professor Rasigan Maharajh
Professor Gillian Marcelle
Professor Francis Petersen
Dr Nick Segal
Dr Rolf Stumpf
Professor Alex van den Heever
Dr Gerhard von Gruenewaldt and Dr Anthon Botha

The Committee's deliberations were strongly informed by these various contributions, and this report has drawn extensively from the insights provided in this way. A full list of the documents and references accessed by the Committee is available in the bibliography of this report.

EXECUTIVE SUMMARY

FRAMEWORK FOR THE SOUTH AFRICAN NSI

In July 2010, the Minister of Science and Technology, Minister GNM Pandor, MP, commissioned a Ministerial Review Committee to review the South African science, technology and innovation landscape with respect to its readiness to meet the needs of the country, the extent to which the country was making optimal use of its existing strengths, and the degree to which the country was well positioned to respond rapidly to a changing global context and to meet the needs of the country in the coming ten to thirty years.

The Committee was also required to identify what would be required from the state, as well as from other key stakeholders, in order to ensure an adequate and growing investment in innovation that would deliver a sustained and durable knowledge-based economy geared to advancing the national objectives of economic growth, job creation, better health, quality education and responsiveness to the needs of the most marginalised.

In particular, the Committee was required to make recommendations on the future structure and governance of the system, including the roles and responsibilities of different actors within the system; the roles and responsibilities of the Department of Science and Technology (DST) including the relationship with other government departments; human resource and other capabilities; and the recapitalisation and funding requirements.

The focus of the Committee's work was the relevant policy framework established since the adoption of the White Paper on Science and Technology in 1996, while the point of departure was the last systematic review of the South African National System of Innovation (NSI) conducted by the Organisation for Economic Cooperation and Development (OECD) in 2006/2007. The Ministerial Review Committee was in essence tasked to provide the nation with an understanding of what was really being achieved by the NSI as the key driver of knowledge-based economic growth and associated inclusive national development, and to recommend ways in which the system could be made more effective.

In order to fulfil its task the Committee submitted draft reports in two phases: firstly to provide an appraisal of the existing NSI landscape and secondly to provide recommendations for the future system. This executive summary distils the insights of both of these reports, the fuller versions of which constitute the main text of the full report that follows this summary.

Conceptual framework for innovation

Innovation is the capacity to generate, acquire and apply knowledge to advance economic and social purposes. It includes both the search for frontier technologies driven by research and development (R&D), as well as the forms of learning and adaptation that might be market led or socially driven. Innovation is fundamentally uncertain, highly contextual and path dependent, but it is at the heart of moving the country from its present mix of resource- and efficiency-driven economic activity to one that is driven by the generation and application of knowledge. It is about doing new things in new ways.

Every country has a national system of innovation, which is the sum total of activities that contribute to innovations of any kind, whether as improved practices or as new products. When a deliberate, concerted and sustained effort is made to enhance the effectiveness and efficacy of the system through focused support and improvements in system design, based on the acceleration made possible in learning organisation mode, the otherwise inchoate system becomes a national system of innovation (NSI). The adoption as policy of the White Paper on

Science and Technology in 1996 signified that South Africa would follow this approach; the explicit intention was to improve the lives of all the country's people in this way. Innovation would achieve this in two ways: indispensably, through progressively increasing economic growth and enhanced participation in the economy, but, just as importantly, by innovative and pervasive personal and social development of the nation's people.

The achievement of focus and coherence in a national system of innovation is often brought about through an acute sense of crisis that galvanises the commitment and priorities of the key social partners. The South African system is currently sensing powerful demand signals of this kind, collectively constituting a call for the country, with all its profound creative and productive potential, to unite in the hunt for innovative answers to, not least, the crises of joblessness, inequality and poverty.

Government is embarking on a New Growth Path, a long-term project that argues for concerted interventions in the economy to construct a developmental state that "authoritatively, credibly, legitimately and in a binding manner is able to formulate and implement its policies and programmes". Innovation, and the national innovation system that nurtures it, will be pivotal in realising the New Growth Path.

Policy framework 1997–2007

The policy blueprint of the 1996 White Paper found effect in the establishment by statute of the National Research Foundation (NRF) in 1998, the National Advisory Council on Innovation (NACI) also in 1998, and the formation of the Department of Science and Technology (DST) in 2002. A Ministers Committee on Science and Technology (MCOST), with oversight of the NSI as a whole, had operated for several years from 1994 but then fell away. A major development was the creation of two sources of competitive funds for R&D, the Innovation Fund (1997) and the Biotechnology Regional Innovation Centres (2001). The 2002 National R&D Strategy then specified that an Annual Science Budget document would be prepared from data drawn from departmental budgets, to reflect all government R&D expenditure, including all agencies (and including in particular the support offered by the Department of Education to institutions in the higher education sector).

Key organisational arrangements for government-managed research were elaborated in the promulgation of the New Strategic Management Model for South Africa's public S&T system in 2004. The newly established DST then had line responsibility only for the public research organisations (PROs, also called science, engineering and technology institutions or SETIs) that were considered to be multi-sectoral (CSIR and HSRC), as well as for the systemic funding agency, the National Research Foundation (NRF). The other SETIs reported to, and were funded by, their respective sectoral departments, together with assigned scientific and technological service laboratories.

The governance role of the DST in this New Strategic Management Model was firstly to be the development of policy on standards for science, engineering and technology institutions (SETIs) (which took the form of a regimen of new governing board appointments and five-yearly external reviews). Secondly, the DST was responsible for the development of a prospective National Science and Technology Expenditure Plan, which in practice has thus far been limited to the annual production of a retrospective report on direct government expenditure on science and technology activities (STAs). Compilation of an annual retrospective National Survey of Research and Experimental Development (National R&D Survey) is also a significant DST role.

Summary of the findings of the review of the South African NSI by the OECD

The Organisation for Economic Cooperation and Development (OECD) was commissioned by the DST to conduct a review of South Africa's innovation policy (effectively the NSI). This review was the most comprehensive overview of the NSI since the SETI System-wide Review of 1998.

Published in 2007, the OECD Review constituted one of a series of highly regarded OECD country reviews of innovation policy conducted according to a well-developed methodology. The distinguished OECD experts concluded that:

- The NSI insufficiently supported a transition from strong reliance on a resource-and commodity-based economy to one that would be characterised by value-adding and knowledge-intensive activities.
- There seemed to be only limited horizontal coherence and integration between agencies in the NSI, and no Cabinet-level coordinating body had yet been successful in devising and monitoring national level strategies for innovation, and marshalling the resources needed for these.
- NACI's mandate was hamstrung by the fact that it reported to the DST and thus had no structural location that would afford it the authority needed for effective coordination of a national system.
- Business was insufficiently involved in building the National System of Innovation (NSI), at the levels of both large and small firms.
- The concept of a national system of innovation had as yet gained limited currency, both in the extent to which it was understood as something wider than the sum of traditional research and development (R&D) activities, and in the extent to which it had been fully absorbed into the strategies of key actors (including government departments and higher education institutions).
- The notion of innovation – in all its dimensions, including technical, economic and social – was poorly understood, especially on the demand side.
- The functioning of the NSI was seriously impeded by the deficit in high-order skills, particularly in the area of design, engineering, entrepreneurship and management;
- Institutionalisation of science, technology and innovation measurement capacity was inadequate.
- The NSI was making an inadequate contribution to poverty reduction and wider inclusion in the mainstream economy.
- The levels of innovation required in the economy would only be possible if there was a considerable expansion of university research, especially to provide the necessary research-capable human resources at all levels of qualification.
- South Africa would need to compete for high-end skills in the global talent pool where advanced economies were implementing immigration measures to attract high-level scientific and technological competencies (not least from South Africa).

No formal response to the OECD Review of the NSI was ever made public. Shortly thereafter, the DST's Ten-Year Innovation Plan (TYIP) appeared, but some of the most central recommendations

of the OECD Review were not addressed in the plan, especially bringing the private sector more centrally into the NSI, and resolving the considerable vertical and horizontal coordination difficulties arising from the current governance and institutional architecture of the NSI. This was especially problematic because the TYIP's new 'Grand Challenges', to be spear-headed by the DST and designed to steer the resource-based economy towards a knowledge-based economy, were spread across the operating domains of many government departments, and represented priority areas of government such as energy generation, climate change, the bio-economy, and human and social dynamics. The fundamental need for a platform authoritative enough to coordinate and steer both state and other sectoral innovation remained unresolved.

Since the OECD Review, significant public policy initiatives within the NSI have been the establishment by statute of the Technology Innovation Agency (TIA), the passage of the IPR from Publicly Financed Research law (Act No. 51 of 2008), and the establishment of the associated National Intellectual Property Management Office (NIPMO), in alignment with an evolving industrial policy framework. These initiatives were first flagged in the 2002 National R&D Strategy.

SUMMARY OF THE FINDINGS OF PHASE ONE: THE CONTEMPORARY NSI LANDSCAPE

The Phase One report, concluded in November 2010, made a number of findings and observations that informed the priority lines of enquiry pursued in the Phase Two exercise, concluded at the end of 2011. The Phase One findings are summarised as follows:

- Although the 1996 White Paper on Science and Technology articulated a compelling vision for a national system of innovation that would drive national economic and social development, this vision has not been adopted widely enough across the range of government departments to achieve the intended pervasive impact. The goal of a common understanding of the role of research and innovation in achieving the priority goals of the country, and the need for more closely coordinated activities to achieve these ends, remain elusive.

- The measures that government has taken (especially related to the roles and powers of the DST and NACI, as designated coordinators of an otherwise fragmented and diverse NSI) have yet to find sufficient effect. A consequence of this is that South Africa has achieved only very limited horizontal and vertical coherence and integration of purpose and effort between the various agencies of the NSI.

- This limited level of coherence and coordination is reflected in the fact that, in or under sectoral government departments, R&D activities appear to be highly fragmented, with the risk or even the reality of duplicated or contradictory effort, and the erosion of attention to R&D generally within these sectors.

- Another aspect of the limited level of coherence and coordination is that the role of business (both established and emerging enterprises) has been inadequately included in the conception and coordination of the NSI. In particular, the growth of small and medium enterprises (SMEs) needs greater attention, but the country's efforts as a whole

are insufficiently supporting a transition from strong reliance on a resource- and commodity-based economy to one that is characterised by value-adding and knowledge-intensive activities. This has implications for government's priorities in relation to employment creation and poverty alleviation.

- Innovation activities should be seen as involving more than just formal R&D, so that innovation in pervasive public service delivery systems is seen as equally urgent, legitimate and mutually supportive of parts of the NSI as are the more conventional design and engineering activities.

- The practical emphasis of the state's investment in innovation has historically focused on 'big science', rather than sufficiently supporting the technological requirements of the business economy and social development priorities. Demand-pull approaches to the development of the NSI should be given as much attention as science supply-push approaches.

- The shortfall in human capital development is the key weakness of the NSI. While the inadequacies of the schooling and training systems are widely acknowledged, with consequent shortages of well-equipped school-leavers, artisans and technicians, deeper insights are also needed into the throughput of postgraduates, and the production and retention of public sector academics, researchers and science council staff. Measures to optimise the availability of highly skilled individuals remain a vital framework condition.

- There are clearly distorted and/or inadequate resource flows in the NSI, both in quantity and nature, between its actors and in the system as a whole, whether this is for formal R&D or venture capital for start-ups and innovative enterprises.

- Adequate knowledge infrastructure is a crucial condition for a well-functioning NSI. This refers to the set of universities, vocational colleges and state laboratories with equipment for research and utilities such as reliable energy supply, communications and transport, and especially ICTs such as broadband and computing power. The earlier National Research and Technology Audit and its later NACI-commissioned update concluded that the public research system was seriously under-capitalised, and that inputs of around R700 million at current prices would be needed annually over six to seven years for its renewal, around double what is currently being invested.

- South Africa's NSI must be conceived as an internationally open system, with in-flows and outflows of all kinds, including skilled people.

- Provision must be made to strengthen the capacity of the NSI to operate as a distributed learning organisation that is responsive to signals from within the system and to the wider environment.

- This responsiveness of the NSI with respect to meeting its intrinsic mandate is most critically dependent on effective and participatory joint policy-making, planning and coordination at the central NSI policy-making platform. It is essential that this platform is well-defined in its composition, so that a clear-sighted regulatory environment is achieved, keeping in mind the distinctive capabilities and contributions of the various participants. It is certain that the exclusion from the NSI central policy platform of some actors (such as the private sector), or the persistence of insulated silos (e.g. in some government agencies) contributes to the weakness of the current system. Instead, the NSI central policy matrix should be reflected in clearly articulated and shared purposes, custom-designed organisational structures and dedicated resource flows. Clearly exercised political will is a paramount condition needed to achieve this coordination.

- This systemic responsiveness depends on the availability and analysis of the science, technology and innovation indicators, both quantitative and qualitative, needed for monitoring and evaluation, and for planning and management. System-level information as well as enterprise-level insights are needed to understand what underpins strength and responsiveness – or their absence. Although the NSI of the future will continue to require visionary leadership, it crucially requires systems of oversight and analysis to inform implementation and strategic intervention where necessary, and to inform the purposes and modalities of the NSI.

The Committee's critique of the current shortcomings in the functioning of the NSI is not a destructive one but rather a 'critically constructive' one.

STRUCTURE OF THE DISCUSSION AND RECOMMENDATIONS

In its discussion of the issues noted above, the Committee structured its deliberations for the purposes of this executive summary along the following lines:

i. Mechanisms for prioritisation and agenda-setting in the NSI, as well as oversight of the system

ii. Provision of an enabling environment for innovation in the private sector and social spheres, through appropriate policy and regulations and the promotion of knowledge transfer and exchange

iii. Strengthening of relevant human capital development and other components of knowledge infrastructure

iv. Policy learning, resting upon monitoring, measurement and evaluation

v. The use of funding as a key lever for steering the system.

This is reflected in each of the following five sections of the executive summary.

In each case, the discussion firstly sums up the Committee's assessment of the current situation before laying out the Committee's recommendations for how the system could be strengthened into the future.

SECTION 1: GOVERNANCE OF THE NATIONAL SYSTEM OF INNOVATION

Assessment

The compelling vision for innovation-driven national economic and social development articulated in the 1996 White Paper has not been adopted widely enough by the Cabinet or within the range of government departments to achieve the intended pervasive impact. The mechanisms for relevant priority- and agenda-setting that government has adopted are not very effective, especially those affected by the intrinsic constraints on the scope-of-function of the DST (the designated policy coordinator of the NSI as a whole) that have mostly been imposed, explicitly or implicitly, by the 2004 New Strategic Management Model. A clear focus in public policy on business as the largest NSI actor is still absent nearly five years after the OECD review.

Department of Science and Technology

Despite the above shortcomings of the NSI, the Committee considers the public recognition of the DST as a 'good government department' to be well-deserved. Pioneering initiatives and successes have included:

- The launch of the Innovation Fund and Biotechnology Regional Innovation Centres;
- The setting up of National Centres of (Research) Excellence and the more recently introduced Centres of Competence, as well as the South African Research Chairs Initiative (SARChI)
- A very successful programme of international liaison for research exchanges, collaboration and the general enhancement of available resources
- The currently aggregating and further evolving major components of the National Space Programme
- The key departmental contributions in the Industrial Policy Action Plan, such as the tax incentive scheme for company R&D, the setting up of TIA, NIPMO and university technology transfer offices, and support towards the costs of patenting
- The operation of a spectrum of schemes to enhance R&D cooperation between business and higher education
- Fostering the growth of the Academy of Science of South Africa (ASSAf)
- Many on-going interventions in the technical and knowledge-using capacitation of small and medium firms (through technology stations) and other enterprises featuring prominently in the Minister's current performance agreement with the President.

Balanced against these achievements are the reservations expressed by the OECD Review panel five years ago about the functioning of the NSI as a society-wide system, which is largely congruent with the assessment of the current situation in the present review:

- There is still no common understanding of the NSI and its purposes across government departments and beyond, and there is uneven support for it, even where it appears to be understood.

- The New Strategic Management Model (NSMM), established in 2004, emphasised a cross-cutting role for the DST in setting common governance standards and quality assurance mechanisms in place for each SETI. In the case of sector-specific science councils, the function of the DST would be to develop interventions in the case of market failure, under-subscription or where there were technology gaps of a strategic nature. The NSMM provided for sector-specific research agencies to remain in the domain of their respective line departments – the Medical Research Council (MRC) with the Department of Health; the Agricultural Research Council (ARC) with the Department of Agriculture, Forestry and Fisheries etc. The DST, largely as a result of the NSMM organisational model set up in 2004, has not been in a position to create a coherent, truly systemic policy framework to promote and coordinate the NSI, and has been obliged instead to throw its energies into activities that it seems to have undertaken in the manner of a 'line department', rather than as a system-wide facilitator.

- The trust placed in voluntary inter-departmental cooperation across the system has not, perhaps predictably, been vindicated. For example, even a very promising and well-formulated collaboration agreement between the DST and the Department of Higher Education and Training (DHET), already drafted in August 2010, had not been signed by the beginning of 2012, while the Knowledge Economy Forum activities and structures initiated by the DST in order to mobilise joint action across departments have petered away.

- Virtually no prospective NSI planning as envisaged in the White Paper has been possible (although the Committee understands that a funding cluster on Research, Development and Innovation will be adopted in the next Medium-Term Expenditure Framework), and the retrospective annual STA Report on government expenditure in these areas does not enjoy wide distribution or exposure.

- NACI has been effectively constrained to 'advise' only in the same limited NSI domains in which the DST can operate.

- Supply-side thinking remains pervasive (with continued emphasis on the linear model of innovation), leading to a continuing poor response to market and social demand.

- There is still too little systemic coherence and sense of common purpose between the private sector, government, higher education and civil society in NSI functioning in its broader sense (including governance, decision-making and allocation) or in the agenda for national development.

The key performers of research, development and innovation are private-sector business and state-owned enterprises (SOEs), on the one hand, and public higher education institutions and science councils, on the other. A degree of systemic agenda-setting and prioritisation can be achieved in the private sector itself, especially if it is effectively drawn into the overall governance and delivery vehicles of the NSI, while SOEs are in principle directly amenable to systemic approaches and interventions designed to enhance innovation (see Section 2 of the Executive Summary: The enabling environment for innovation in the private and social sectors).

An example of enhanced systematisation would be wider stakeholder participation in public-sector funding processes than is currently the case, where for practical purposes only portions of water and energy research are informed in this way. The generally successful introduction in other countries of sectoral funds, administered by boards drawn from a variety of stakeholders, suggests that the benefits already generated by the existing public researcher industry incentive

schemes could be extended if some public R&D funds were granted by sectoral boards rather than by the traditional panels of the NRF (this would have to be 'new money', as the existing agency provision is wholly inadequate).

The state itself is potentially a powerful site of innovation, both in how it delivers on its mandate and how it forges common purposes with other social partners. Civil society also provides a platform for innovative initiatives and brokerage potential between social actors, while having only limited capacity to take innovation to scale.

The overall conception of the NSI must thus take the full range of social actors into account, and work to marshal their distinctive capacities towards addressing the socio-economic development imperatives of the era. These large and complex challenges will mostly not be resolved in the short term, but the means must be constructed now for systemic collaboration between the various sectors in the longer term.

Structure of the public sector NSI

The current structure of the public sector actors that contribute to the NSI was well described in the 2007 OECD Review, and in summary this operates at four levels:

i. High-level institutions statutorily mandated to provide policy advice to government on innovation, or innovation-related functions, including the National Advisory Council on Innovation (NACI), the Council on Higher Education (CHE) and the National Science and Technology Forum (NSTF)

ii. Government ministries and departments

iii. Research and innovation agencies, including the National Research Foundation and the Medical Research Council

iv. Research-performers, including universities and science councils, along with providers of scientific and technical services (STS).

The systemic challenge contained in the idea of the NSI is the need for these agencies, at their various levels, to achieve a collective coherence in the complementarity of their functions, and a coordinated impact that makes the best of the resources invested in these entities. The challenges of coherence and coordination run both vertically up and down the levels of authority in the system as well as horizontally between the agencies. As the evaluations provided by the OECD and numerous other reviews have suggested, and as this Committee has noted in its comments above, there is much that must still be done to optimise the functioning of the system.

In particular, a greater clarification of roles between various agencies is needed in order to sharpen mandates and rein in mission creep; greater effects can be achieved if the efforts of specialist capacities in addressing complex challenges are well coordinated; and the best-informed intelligence from all quarters of the system must be gathered in setting priorities and deploying resources. There is a need for stronger reciprocal channels of communication, including

more strategically configured evaluations of the performance of the system and its constituent agencies.

The need for greater coherence and coordination has long been understood, and a variety of statutory and voluntary mechanisms have arisen to these ends. In addition to the organisations already noted above, and various government-driven efforts to achieve coherence across clusters of departments or across priority outcomes, there are numerous sectoral bodies such as Higher Education South Africa (HESA, for higher education institutions) and the Committee of Heads of Organisations of Research and Technology (COHORT, mainly for science councils). The contribution of these devices to the strengthening of the NSI varies, but there is little doubt that much more can be achieved than is presently the case.

The problem of coherence and coordination is perhaps best illustrated in the case of the science councils. With mandates periodically renewed by national legislation in the form of amendments to their respective statutes, these agencies follow a quality assurance system elaborated by the DST and based on five-yearly 'fitness-for-purpose' external and partly international reviews. These reviews of the SETIs have in many ways been less positive about these organisations than their own annual reports, citing duplication and overlaps, a lack of cooperation, and in some cases, mission drift or uncertainty.

A key issue in the research-performing science councils is the governance arrangement introduced in 2004 with the New Strategic Management Model (NSMM) for public research organisations; fragmentation and a distinct lack of systemic coherence are but two of the symptoms of dysfunction associated with the NSMM. The tension between strategic autonomy and a government laboratory service role is mostly only weakly resolved. The SETI review system is unpopular, because it revives and recycles the unresolved problems, and is tending to run down because of lack of support. There appear now to be no systematic, well-founded criteria for the establishment, re-mandating or disestablishment of science councils. Mission drift is rife, and direct competition with higher education institutions for resources, staff and contracts is prevalent.

The public perception of the scientific and technological service laboratories operated by sectoral departments has deservedly not been good, particularly those associated with the justice system. It is typical to hear of six-month delays in measuring blood alcohol levels or DNA-based identifications holding up trials and impairing the administration of justice. The notion of a service organisation, that must necessarily keep pace with advancing knowledge, doing its job in the environment of an administratively preoccupied government department seems to be strange and highly at odds with the vision for a knowledge economy in any case; every instinct suggests that agencification, public–private partnerships or relocation to an appropriate science council would in some, or even many, of these cases be a far better solution.

There is an absolute requirement for coherent information-gathering and analysis for effective agenda-setting and prioritisation in the NSI, and for the achievement of clearer and better-aligned institutional missions and functioning among the agencies of the system. Analysis of indicators and other information to inform the workings of high-level policy debate has necessarily to be

supplemented by the systematic, multi-perspective generation of evidence-based advice on complex issues. A role along these lines is now being built for and by the Academy of Science of South Africa (ASSAf), an arm's-length statutory body.

Recommendations

In general terms, the Ministerial Review Committee recommends that the clear and inspirational White Paper conception of the NSI be publicly re-endorsed by government as a potentially decisive driver of national economic and social development, indicating clearly that the NSI must be pervasive and truly systemic in its design and functioning, and that its functionality is core to any systematic national approach to creating jobs, addressing poverty and providing fulfilling life opportunities to all South Africa's people and communities. What is needed more than ever is a high-level expert body that will offer guidance to the NSI as a whole, a role that neither the defunct MCOST nor NACI has been able to fulfil.

Recommendation 1: The Committee recommends the establishment of a compact (15–20 person) statutory National Council on Research and Innovation (NCRI) to carry out the task of prioritisation and agenda-setting for the NSI, oversight of the system and high-level monitoring of its evolution, outcomes and developmental impact. The Council should be chaired by the Deputy President to emphasise its seniority and its pervasive systemic functions across government and society. The Minister of Science and Technology should be Deputy Chair and Implementation Coordinator because of the key facilitation role of the Department of Science and Technology in the NSI as a whole. The membership of the NCRI should include the ministers from key departments, and influential figures from the private sector, higher education and civil society best positioned to advise on issues of development and innovation. The NCRI must ensure that optimal framework conditions prevail and that financial resources are adequate and must receive system-wide evaluations. It must act to build trust through promoting a culture of responsiveness and administrative fairness. The Council must be equipped to make the hard calls to meet demand and to create supply.

The Committee is of the opinion that failure to establish such a high-level steerage mechanism for the NSI will mean no coherent strategy and no real progress for many years to come. The 2008 review of NACI pointed out the urgent need for the creation of such a body; NACI itself, as currently constituted, is not equipped to perform its proposed roles.

A first task for the Council must be to map out the demands on the research and innovation system for the next decade, and then to advise on broad measures needed to galvanise system actors to these ends, including advising on the mix of public research organisations needed to take up system or market failure.

The Council would make recommendations on future Grand Challenges, major allocations, major equipment needs and new sources of funds. The Council should receive and comment upon all system-wide evaluations, as well as maintain a watching brief on large projects with annual budgets in excess of an amount to be determined by the DST from time to time.

The Council must ensure consistency of efforts to address the supply of high-level resources, from schooling and from further and higher education and training, from other sites of training and across government, the private sector and civil society as a whole. It would be expected to identify policy inconsistencies and recommend appropriate changes.

Recommendation 2: A unitary Research and Innovation Vote should be established, designed to extend beyond the original version that operated until 2005, to function as a macro-coordinating mechanism to ensure that the country's public researchers in all public research-performing institutions (i.e. both higher education institutions and science councils), are adequately supported to perform their work. The NCRI, in consultation with cognate advisory bodies, should provide the oversight of the broad size and shape of this allocation. The NCRI should not be responsible for making specific budget allocation decisions, however.

Particular attention needs to be given to the adequacy of public funds awarded to research performers throughout the system as grants (to higher education institutions) or budgets (to science councils). There has been clear recognition for some time (in successive NRF and MRC SETI reviews, for example) that the average amounts of funding made available in agency mode have been inadequate for their multiple purposes of generating new knowledge and human capital as well as innovations. The total amounts allocated by the NRF and MRC, as well as the incentive schemes for industry for public researcher collaboration, must accordingly be increased to about twice their current levels as soon as possible.

In this context, the Committee is of the opinion that the public grant-making agency function should be consolidated within the NRF, so that a common policy framework and better-coordinated delivery model can be built, incorporating and generalising the successful instruments of promotion (Centres of Excellence, Centres of Competence, Research Chairs and major equipment provision) that have been introduced with such significant impact in recent years. This would incidentally also facilitate re-considering the mandate of the MRC as a science council.

Recommendation 3: The present NACI should be transformed into a new statutory Office for Research and Innovation Policy (ORIP). This arms-length body should compile evidence regarding both success and failure across the system in order to inform policy and planning by the NCRI and the DST, and associated policy nexus platforms. Among other things, ORIP should monitor the research investment climate, to determine and advise on any inhibiting factors and the performance of the system in responding to priority needs identified by the NCRI. The ORIP should, for example, be responsible for the National R&D and Innovation Surveys, and for designing information and indicator systems, technology foresight and social fabric studies; and the development of a researcher database (see Section 4 of the Executive Summary: Monitoring and evaluation, for details). ASSAf should work closely with the proposed ORIP to ensure that sound, multi-perspective, evidence-based reviews of key issues in the NSI are conducted.

Recommendation 4: The Ministry and Department of Science and Technology should henceforth primarily function as a pervasive, systemic formulator and coordinator of NSI-related policy and strategy, consistent with the decisions of the NCRI, allocating macro-resources, promoting system

learning through the oversight of effective and integrated monitoring and evaluation, maximising international cooperation and resources, systemically overseeing public research organisations, and providing best-possible knowledge infrastructure (people, equipment and facilities, and cyber-infrastructure) within the public sector.

Recommendation 5: In order for the NSI to be systemic in the fullest sense, the Committee recommends that the NSI needs at least three well-functioning 'core' policy nexuses, each structured through a written collaboration agreement spelling out how policy harmonisation and the coordination of implementation action plans would be ensured:

- One focused on post-school education and training involving the Department of Higher Education and Training (DHET) and the DST
- One focused on business and enterprise development, involving at least the departments of Trade and Industry (the dti), the Economic Development (EDD), Public Enterprises (DPE) and the DST
- One focused on social development and social innovation, involving the DST and departments concerned with social and rural development, and the social security, health and education complex.

The Committee states that failure to create well-functioning policy nexuses as described will very likely be associated with serious and continuing stasis at the very core of the NSI.

Recommendation 6: Because grant-making is not only a question of the amount of funding but also of its efficacy, the Committee recommends the purposeful elaboration of a new, additional mode of public grant-making based on the principle of cooperatively allocated sectoral funds. The priority sectors for such a mode would be identified by the NCRI from time to time (e.g. based on the Grand Challenges' of the TYIP). Boards would be established, involving all NSI stakeholders, to articulate the precise demands and to develop translational solutions. While in principle the funding could be drawn from the levies already raised against the depletion of some natural resources (minerals), as is done in Brazil and Norway, it would be easier to apply to this purpose some of the urgently required increase in total agency funding (see Recommendation 2). The sectoral funds could address both technological and social innovation dimensions of a focus area; one of them could, for example, be a Social Innovation Fund (perhaps in partnership with private sector philanthropy) to address social innovation needs identified by the NCRI.

The new funds should be structured so that they constitute well-informed consultative forums, including industry and government actors, for the identification of sector-specific strategic priorities and the development of corresponding research and innovation agendas. Reports and recommendations from the funds should inform the deliberations of the NCRI, and vice versa, investing the funds with both systemic alignment and gravitas.

Recommendation 7: The present organisational model for government research (the DST-run science councils, the sectoral science councils and the in-house S&T technical service organisations) needs to be revised to permit coherent, integrated and optimised mandates to be designed in each case within common policy frameworks, so that strategically directed funding flows can be applied across all these significant components of, and contributors to, the NSI. The Committee recommends that the NCRI should commission a review of the science councils and all other public research organisations (PRO)s, including, but not limited to the National Health Laboratory Service (NHLS), the scientific sections of museums, and Onderstepoort Biological Products.

The review must enable Government to make hard choices. It should review the reporting lines, missions, future functions and resource requirements of the science councils and PROs (including whether to terminate them, modify their mandates or establish new ones). It should take careful account of international practice and of variations in the role of such organisations over time and at different levels of development. The review should also consider how science councils, other SETIs and the private sector could become more fully involved in postgraduate supervision and human capital development generally.

The establishment principles and mandates of research-performing science councils should be redefined and used to review each of these organisations in a 'fitness of purpose' exercise, along with the periodic 'fitness for purpose' SETI reviews.

Efficiency, effectiveness and funding considerations would attend a decision to move into the science councils many of the scientific and technical services that are currently housed in government departments, which are likely to be both more functional and innovative if they were incorporated into a relevant science council or another body. This would also apply if most or all of the national facilities currently operated by the NRF were relocated to other bodies.

The science councils and public research organisations (PROs) would be asked to engage with the review by providing:

- An analysis of their offerings, broken down as essential services (including extension services), public goods research and client-oriented research, with associated revenue, outputs and impact
- A plan, including financial and staff requirements of how they would (i) address poverty and under-development, and (ii) simultaneously develop mechanisms to meet client demand and effect technology transfer.

SECTION 2: THE ENABLING ENVIRONMENT FOR INNOVATION IN THE PRIVATE AND SOCIAL SECTORS

Assessment

South Africa is currently trapped in a low growth trajectory. In the 1960s, the country's GDP per capita was higher than that of Mexico, Malaysia and Korea; since then, these nations have surged, while South Africa has stalled. The reasons for this hiatus are manifold and contested. South Africa has been free of armed conflict for almost two decades, yet has still to find a common vision that will take the country forward, rapidly, fairly and decisively. The work of the National Planning Commission (NPC) and its Vision 2030 represents a salutary concerted effort to build a common future. The Committee for its part attributes a substantial part of the failure to grow to the absence of systemic innovation that senses and creates innovations in the social and market spheres.

In getting to grips with the reasons for this, one can identify a continuing deep-seated gap between business and government with respect to the NSI that undoubtedly has its roots in a multiplicity of historical, political, philosophical and social factors, which will require careful and sustained attention to resolve. The recommendations made in Section 1 of the Executive Summary: Governance of the National System of Innovation are designed to bridge real or imagined gulfs through increased participation, joint decision-making, and benefit-sharing. Such an approach must be accompanied, however, by a policy framework that recognises that business in South Africa must be a large-scale funder and performer of R&D, and therefore a key strategic partner for government to engage with. Since government exerts controls on this extensive activity only indirectly, the aim should be substantially to enhance the conditions under which innovation is achieved in the business sector.

Performance-promoting framework conditions will also need to be developed to support innovation in civil society and in the public service itself.

The most ambitious recent interventions in the NSI have been the statutory establishment of the Technology Innovation Agency (TIA) and the companion National Intellectual Property Management Office (NIPMO). The transmutation of the 'Foundation for Technological Innovation', as proposed in the 2002 National R&D Strategy, into TIA some eight years later suggests that bringing about such an agency was not easy in terms of winning the support of National Treasury, as well as finalising the concept and design. The impression gained by the Ministerial Review Committee is that both TIA and NIPMO need an early function-promoting 'fitness of purpose' review, especially in the light of the high expectations, perhaps apprehensions, of many NSI stakeholders. The incorporation into TIA of the Innovation Fund, the four Biotechnology Regional Innovation Centres (BRICs), the Tshumisano incubators and the Advanced Manufacturing Technology Strategy (AMTS), with their varied histories and organisational forms, to become a single coherent organisation is surely not something that could have been achieved overnight.

This report considers below the two priority areas of business and social innovation.

Business enterprise

The business sector has to be a prime participant in addressing some of the larger structural factors that condition the shape of the economy. This will include diversifying away from the country's traditional reliance on the minerals and energy complex, reconfiguring the manufacturing base (and indeed all human activities) towards a green economy and more labour-absorptive production methods, opening access to markets to a greater diversity of players in the economy, especially new entrants, and ensuring that productive assets (new businesses, successful farms, etc.) bring prosperity to a widening proportion of the population.

The tax incentive scheme offered by the DST for R&D conducted by firms is still appreciably under-subscribed, apparently largely due to process obstacles associated with bureaucratic requirements, but perhaps also for other reasons.

The high rate of reporting of innovative activity in the last two national Innovation Surveys contrasts with the almost static rate of patents awards at the US Patent Office – it seems there is innovation, but few internationally patentable products and processes. While the low rate of patenting in part reflects the high proportion of commodities and original equipment manufacturer (OEM) products in South Africa's exports, it is obvious that a three-decade stasis points to a failure to diversify or capitalise on local knowledge generation, despite considerable expertise in sectoral systems of innovation such as mining, pulp and paper, viticulture, chemicals and telemetry. Structural constraints, recognised in a number of studies over the years, point to the need for a constructive dialogue between business and public research organisations on how to focus the country's limited resources towards the major issues of the day – growth, employment and equity.

In seeking explanations for this, one could point to the alarming fact that the contribution of local business to R&D conducted in higher education institutions and public research organisations has actually fallen over the last decade, from about 17% in 1997 to about 10% in 2007, which is odd when the NSI is based on the notion that these repositories of extensive intellectual and knowledge resources should be readily available to innovative firms in external or collaborative R&D mode. Such a view is confirmed by the repeated finding in innovation surveys, both in South Africa and internationally, that innovative businesses have a low regard for the local public research sector in terms of where they obtain their information. This picture is rather different from that in the USA, where the research universities provide a significant proportion of the ideas that lead to industrial innovation. There is evidence that much world-class innovation is not translated into intellectual property because of a culture that undervalues the importance of doing so. Unique low-grade heat recovery systems developed in South Africa's power stations are a good example of where patents have not appeared.

In this context, the accuracy of the official figures for technology balance of payments must also be queried. The level of outflows is comparable with a number of countries whose technological development is similar (e.g. Portugal, Norway and Hungary), but South Africa's receipts are many orders of magnitude smaller. While part of this discrepancy may be definitional, it could also

partly be due to behaviours inherited from the 'sanctions-busting' era of the past, and partly an indicator of an absence of local innovations in the market place. A thorough investigation of the data collection and interpretation is urgently needed (see Recommendation 32 below).

While the outcomes of the dti's Technology and Human Resources for Industry Programme (THRIP) (which provides both industrial funding and partnership to public researchers) and the smaller Support Programme for Industrial Innovation (SPII) have in general been positive, the slow development of productive triple-helix relationships between government, higher education institutions and business is a serious problem and a probable reflection of the same general phenomenon of a knowledge transfer gap between industry and public researchers (perhaps another manifestation of the innovation chasm much talked about in policy documentation). Another reflection of this issue is afforded by the Industrial Policy Action Plan (IPAP) of the dti, which, aside from mentioning the Council for Scientific and Industrial Research (CSIR), shows limited understanding of the importance of the science component of the research and innovation system.

It is possible that the public research system has not focused enough on fostering the kinds of critical-mass groups that are user-friendly to other NSI stakeholders or that readily fit into the helices of cooperative, innovative enterprises. To this end, the system should in future consider the way in which funding and incentive systems, as well as the intellectual property rights regime, actively encourage business and other social actors to collaborate for shared purposes.

An open National System of Innovation

A fundamental quality required of the enabling environment for innovation is the openness and permeability of the system. The capacity for learning, adaptation and novelty depends on the free flow of talent and ideas within and across organisations, national systems and globally. This has implications for the mobility of talented people, the availability of knowledge and lessons from elsewhere, and the freedom for new insights to arise across and between fields. Both immigration policies and intellectual property regimes need to be judiciously calculated to enable systemic openness for planned and fortuitous chemistries of innovation. Allowing foreigners to apply on equal terms for vacant posts in South African research institutions, business and industry acts as a competitive stimulus and a bench-marking tool in the system; it also permits the country to enlarge the pools in areas of talent shortfalls and to introduce fresh ideas into the relatively small and introspective research community. The legal framework and regulatory regimen for work permits and visas must be simplified and rendered as user-friendly as possible. The proposal of the National Planning Commission that foreign doctoral graduates be granted work permits for up to seven years reflects the kind of new thinking that is urgently needed.

The NSI requires active measures that will promote collaboration across boundaries within the national system and more broadly across the globe. This should include arrangements for the optimal utilisation of research infrastructure and the promotion of a culture of sharing and support for access to research facilities, including encouraging reciprocal access to equipment held by the private sector and state-owned enterprises.

International collaboration and linkages are indispensable components of healthy knowledge transfer and exchange. The DST, often using the NRF as its agent, has done a sterling job in promoting and managing cooperation schemes with selected countries in a variety of formats. A particularly significant achievement has been to make South Africa one of the principal beneficiaries of the European Union Framework Programmes. Less effective, perhaps, has been the use of the International Council for Science (ICSU) to leverage resources for the development of the individual disciplines represented by ICSU.

In this context, the benefits from South Africa's involvement in the African Union's S&T activities, including those related to the New Partnership for Africa's Development (NEPAD), have so far been less obvious, with some success stories (e.g. the African Science and Technology Indicators Initiative) and a number of less dynamic activities. They remain an essential part of the way in which the NSI can harness outside elements and create value for all participants.

An Enabling Public Sector

The state-owned business enterprises account for a substantial segment of business R&D conducted in the country. Government can obviously exert a reasonable measure of policy control over innovation in state-owned enterprises, several of which are major performers of R&D, both here and elsewhere, and account for the 20% of total business R&D expenditure that is sourced from government. State-owned enterprises also have considerable potential for energising innovation through their large-scale procurement activity and through international linkages; they are also extensively involved in technology transfer, with attendant opportunities for local adaptive innovation. The Industrial Development Corporation (IDC) and the Public Investment Corporation (PIC) are additional, potentially important levers for innovation.

An innovative public service stimulates innovative business enterprise and can energise the entire NSI. Examples of dramatic improvements in the public service efficiency include:

- The ease with which passports and ID books are now issued and renewed
- The massive transformation of the tax-collection system introduced by e-filing
- Much-simplified, online employer and worker registrations and payments by the Unemployment Insurance Fund.

These are examples of how government through innovative service delivery can create not only a sense of future possibilities, but can also develop processes that are core to business activity and make investment wheels more workable. This is vital for both established and emergent enterprises. There is, of course, still a great deal to be done in the many areas of public service delivery that must underpin a well-functioning NSI, especially in regard to the regulatory and science-technology services operated in line departments responsible for health, agriculture, the environment, police, etc.

The Committee noted the recent formation of TIA and that the agency has not yet had time to establish a track record of performance. The Committee noted, however, that the strategy for the

constitution of TIA involved the inclusion of a number of pre-existing agencies, and wondered about the fit between the capabilities provided by these residual bodies and the role that TIA should play in the future. Given the insight into the current and future NSI generated during the Ministerial Review process and the role TIA should play into the future, the Committee believes that TIA should benefit from formative evaluation sooner rather than later to ensure that the mandate and powers accorded to TIA are appropriate for the planned future trajectory of the NSI, and that TIA is appropriately equipped with the skills and capability to fulfil this role.

Social Innovation

Social innovation, or innovation for development, is concerned with the pre-eminent national priorities arising from poverty and joblessness. The responsibility for addressing the continuing legacy of poverty can no longer be seen as government's alone, but as a collective one, embracing all role-players including the private sector, civil society and poor communities themselves. Equally, the responsibility for achieving appropriate levels of employment cannot be confined to the formal economy alone. Although there is a distributed responsibility for these social purposes, there is a vital role to be fulfilled by government in constituting the social innovation dimensions of the broader NSI in a systemic fashion, and in orchestrating the contributions of the various social partners.

The thinking about development in poorer communities needs to ascribe a much greater potential for creative and active agency within communities, rather than seeing them only as recipients of service delivery. At the same time, however, the powerful structural conditions that operate to limit this agency must be acknowledged. The full range of societal actors is needed in order to mobilise their respective resources towards releasing the collective capacity for innovation.

There are outstanding examples in civil society of how individual non-government organisations (NGOs) have succeeded in crafting niche functions in the development arena, and now have the potential to provide models for innovative approaches on a larger scale. Among other things, a vital brokerage capacity to support partnerships for developmental purposes needs to be exercised. Other civil society partners for social innovation could include the media, labour unions and faith-based groupings.

Far-sighted elements in the corporate sector have increasingly acknowledged that business has a set of responsibilities beyond optimising shareholder returns, and corporate philanthropy has already made significant contributions to the public sphere; some estimates put the spend in 2010 at over R5 billion. The innovation challenge is to see whether this collective investment can be marshalled and directed in a sustained manner towards a small number of priority strategic purposes.

New approaches to philanthropy have emerged in the form of social venture capital, or impact investment. These represent an effort by private sector interests to achieve significant impact through targeted and sustained investment in strategic social projects, drawing on money from multiple corporate donor sources. This is informed by an inclination towards the collective action needed for any truly systemic character in an NSI. Social entrepreneurship has also appeared as a

means of advancing development goals; taking many forms, such social enterprises are businesses with primarily social objectives whose surpluses are principally re-invested for that purpose in the business or community. Both social entrepreneurship and impact investing are informed by the view that development activities should be, in one way or the other, sufficiently value-generating as to be inherently sustainable in their own terms. The social value of the innovation needs to be integrated into economic activity if it is to survive beyond the sponsorship of its initiators.

The challenge for government is to change the way that public services are delivered, for all citizens but especially the poor, rather than to see the solution in increased budget allocations. This involves easily informed policy development and strategy development, but also the capability of public delivery platforms. The intention is to institutionalise learning organisation capability, and the capacity for swifter adaptive behaviour, often informed by higher levels of citizen and civil society participation. Various examples exist of exciting and far-sighted innovations undertaken by government (including the Community Work Programme), characterised by a highly innovative partnership between government, NGOs and community-based organisations.

Although South Africa is confronted with urgent priorities in terms of socio-economic development, the role of social innovation in the NSI is currently under-conceptualised and under-developed. The activities associated with social innovation (in their varied and evolving forms) need to be clearly understood in the public mind as highly valued investments in the future, with implications for many fields of practice in the public and private sectors, and in personal lives.

Deliberate measures and incentives should thus be directed towards the field of social innovation, including areas of public service delivery, social development initiatives and the activities of the private sector and civil society. The incentives must induce business to contribute and participate, local and regional government to be innovative in what they do, and civil society to play its indispensable part. Strategies for addressing poverty and inequality are in fact as much a matter for concern in well-established sectors of industry as they are in community-level initiatives. Activities that constitute social innovation represent a sub-set of strategies by which the NSI as a whole addresses the developmental priorities of the country. Deliberate measures are needed to support and steer such activities in all sectors (public, private and civil society), in terms of the identification and dissemination of good exemplars, taking successful pilots to scale, improving funding opportunities, training to strengthen absorptive and adaptive capacity, and brokerage or facilitation of partnerships (e.g. between government and NGOs) in innovative projects.

The most important contribution of government to improving the innovation environment is an education and training system that provides large numbers of people with enough knowledge capital and knowledge-informed skills to equip them for lifelong learning within a spectrum of positive career trajectories; this is further elaborated in Section 3 of the Executive Summary: Human capital and knowledge infrastructure. What must be mentioned here is the lack of mobility caused by current immigration policy, meaning that catalytic effects on local training and capacity development cannot easily be achieved by imported high-level skills, or that enterprises

requiring a range of complementary skills may not be initiated because of critical gaps in the team.

Recommendations Related to Business Innovation

Recommendation 8: Systematic efforts should be made to bring industry and government closer together, and to strengthen the response of the system to demand signals from business and industry, on the one hand, and social spheres, on the other. The effective participation of the private sector should be structured into all levels of the system, including participation in the NCRI; strong establishment of the skills bases; encouraging reciprocal access to equipment held by the private sector and state-owned enterprises; and a repertoire of policy instruments within the respective three proposed nexuses of (i) the DST and DHET (focusing on higher education), (ii) the DST, the dti, EDD and DPE (focusing on industry and business in general) and (iii) the DST with the various departments whose portfolios have implications for social development and social innovation, and the linkage of social security measures with education, health, etc. These should be directed to the sustainable development of the economy through efforts to promote competitiveness, the establishment of firms and job creation, and poverty reduction (see Recommendation 5).

Recommendation 9: Government departments that form the key pillars of the research and innovation system and must draw to their ranks staff with direct experience of the business, civil and research environments so as to enable cross-sectoral collaboration and to boost the absorptive capacity of organisations for reciprocal learning and adaptation. A concerted effort must be made to bridge the knowledge transfer gap between local companies (big and small) and public-sector researchers and administrators, in order to ensure that the nation's considerable intellectual resources are utilised to a much greater extent. These capacities should become the subject of deliberate skills-building and case-study research to boost South Africa's collaborative abilities across all sectors within the NSI.

Recommendation 10: The research investment climate must be improved through a review of present and further possible incentive schemes for their accessibility, simplicity and effectiveness, with broadening as required. These measures should include:

- The Technology and Human Resources for Industry (THRIP) industry–public researchers linkage programme should be expanded further, to a target of double its present level.
- The excellent and thorough reporting system of the Support Programme for Innovation in Industry (SPII) should be adopted in other schemes (and perhaps in all public grant-making above a threshold level of award, together with the requirement of beneficiaries to participate fully in the annual National R&D Survey.
- Additional, specially tailored grants and concessions are required by small- and medium-sized enterprises to enable them to access advanced scientific and technological expertise.
- The regulatory environment for research permits should be streamlined to remove obstacles and speed up approvals, thereby reducing the need for burdensome appeals.

- Regulations and the approval processes for foreign researchers should be streamlined to speed up the issuing of work permits. Consideration could be given to including special treatment of R&D inputs of goods sourced under the local procurement mechanism.

- Overall, more imaginative and flexible sources of public capital support for innovation activities should be devised, including but not limited to low-cost loans, replacement of loans by grants, renunciation of state equity components, access to publicly owned buildings and land at zero cost, etc.

- The government system of company support and incentivisation should thus embrace a diversified approach that caters to size and sectoral distinctions; small companies generally cannot access incentives in the same way that large firms do, and different categories of firms, with different technological capabilities and potential for transitions to enhanced innovation capacity, should have tailor-made schemes. This implies that a sufficient number of well-informed and skilled intermediaries are available in government departments and their agencies to facilitate such transitions.

- Industry–public researcher links may be further strengthened through improved tax concessions on company grants, scholarships and bursaries deployed in public sector research institutions. Interfaces and the mobility of skills should be maintained between national disciplinary associations and related business sectors; research institutions and their funders should deliberately build groups that begin to bear some of the characteristics of the R&D divisions of companies.

Recommendation 11: The Technology Innovation Agency (TIA) should immediately be externally reviewed in terms of 'fitness for purpose', aimed mainly at promoting its success as a pivotal new element in the NSI. The National Intellectual Property Management Office (NIPMO) should likewise be formatively reviewed after a further period of initial functioning.

Recommendation 12: Immigration policies and intellectual property regimes need to enable the openness of the NSI.

Recommendations Related to Social Innovation

Recommendation 13: An explicit strategy should be developed for the advancement of social innovation within the National System of Innovation. This strategy should include:

- The launch of a multi-stakeholder forum, mandated by the National Council on Research and Innovation (NCRI), to advise government on a limited number of national social innovation priorities that should become iconic projects for the NSI and standing items on the agenda of the NCRI

- The establishment by the DST of policy instruments, and the necessary skills base, needed to foster the field of social innovation, including (but not confined to) initiatives aligned to the priority projects identified by the NCRI.

- The establishment within the proposed Office for Research and Innovation Policy (ORIP) of a strategy for monitoring and evaluation of social innovation activities, including social fabric studies, that draws on a range of methodologies and sources of data in the country,

in order to compile a synoptic view of this complex field of endeavour, sufficient to inform policy and action;

- The establishment, within the DST and/or other agencies, of the brokerage capacity and popularisation function needed to foster the multi-partner, cross-sectoral collaboration that is required to address complex social innovation issues such as those to be prioritised by the NCRI
- The establishment of a Social Innovation Fund (in partnership with private sector philanthropy), to be administered by the DST, intended to support the NCRI priority projects and other social innovation initiatives.

All the above incentivising and regulatory instruments will require appropriate levels of reportage into the sets of indicators to be developed or overseen by the proposed ORIP for the monitoring and steerage of the NSI (see Section 4 of the Executive Summary: Monitoring and Evaluation).

The Committee has observed that, in general, part of the enabling environment is the disposition of the population towards the notion of innovation and the capabilities that characterise an innovative society. The Committee believes that the 'appetite for innovation' of the whole population should be fostered by well-designed and well-executed interventions using broadcasting and other media, the systematic upgrading of public education including science centres, the award of medals and prizes, and through ASSAf hosting consensus conferences. In other words, achieving thorough commitment to innovation in all spheres of activity requires some attention to how this is understood and appreciated in the national psyche. This has implications beyond policy measures, and would require national leadership to play its role in this regard.

SECTION 3: HUMAN CAPITAL AND KNOWLEDGE INFRASTRUCTURE

Assessment

The achievement of an innovative and technology-rich economy and society depends on the depth, width and overall quality of the reservoir of human capital, meaning a sufficient complement of people who have expertise informed by knowledge and the experience of research, with the breadth of vision to provide leadership for innovation; inspiring teachers who have achieved mastery of their subjects; technical personnel at a variety of levels; entrepreneurial, driven business-people; competent managers and public servants; and a citizenry that can effectively participate in an economy in which knowledge is as important as exploitable mineral resources and a well-trained labour force.

Human capital development in modern science (broadly understood as empirical enquiry) and technology usually requires institutional infrastructure (including appropriate and adequate space, logistics, administration, strategic support, readily available consultative advice and collaboration, and research students), hardware in the form of equipment and related facilities and specialised services, and connectivity and information technology in general.

Visitors to South African higher education and public research institutions (science councils and similar) are usually impressed with the visible plant, the sense of good order and the apparent functionality, in general; they believe that the country has invested well in these mostly well-run institutions. The truth is that many problematic issues bedevil the main components of the public research sector.

The present human capital development system in South Africa is unfortunately locked into sets of interdependent 'pipeline jams', with piecemeal interventions having thus far served only to make the system more refractory to positive change. The interventions have actually produced a peculiar and rather general resistance to the idea of any further policy change in a supposedly 'fatigued' system. Higher (and further) education and training are the responsibility of the DHET, not the DST.

The NSI depends almost entirely on the effectiveness of the basic education and post-school systems. The NSI cannot work well if the available human capital is not adequate or equal to the task.

Beginning with schooling, South Africa's overall education system has many core fundamentals that are comparative positives in the fast-changing world, including a balance between prescribed content and choice in the processes of knowledge and skills acquisition, between formal and informal learning time, and between the exercise of the mind and the body. These features have made South Africans highly competitive when they have had the benefit of well-functioning institutions. Bringing all or most of the country's schools, colleges and higher education

institutions up to full functionality is thus something that does not require the re-setting of these fundamentals, but the inherently simpler challenge of 'making them work' in the ways that they should.

Most of the requirements for making the public education and training system work as the basic enabler of a knowledge economy are not yet in place, despite the best intentions:

- Access to effective pre-school education, a critical success factor, is limited to those who have the means.
- The social capital of parental and community involvement and support, at home and in school or college, is likewise strongly stratified in society or variable in quality or availability.
- A fully developed first-language competence is difficult to reach in the case of the vast majority whose first language is not English, impairing the general intellectual enskilling involved in reading, communication, subtle understandings, argumentation, and the capacity for personal and social growth based on useful knowledge.
- Whether one agrees with its dominance or not, proficiency in the use of English (the major language of instruction in the higher education institutions) in oral expression, writing and reading is still the preserve of a minority of learners and students.
- The continuous development of mathematical literacy (essentially the power of abstract and predictive thinking) is still seriously deficient, as is general numeracy.
- Direct experience of technological manipulation, in classrooms as well as outside, is yet another ingredient of 'brain-and-hands' capabilities that is denied to most, as is the ability to understand the application of physical and life science in everyday life.

The education and training (or re-education and re-training) of school teachers is a fundamental priority for the nation in terms of human capital development, yet the system is currently in considerable disarray. The current model for teacher and trainer production (in terms of qualification types and structures, as well as enrolment planning and bursary support, etc.) requires thorough re-examination – a knowledge economy is impossible without teachers who both understand their material and are skilled in transferring it to their charges. Extremely important, despite being controversial, is that teaching/training is not classified as an essential service, which it undoubtedly is, at all levels from basic to higher education – the nettle simply has to be grasped.

The parlous state of the vastly too small and flawed technical college system is associated directly with the problem of a massive waste of human potential through high rates of dropping out from schooling; failure in the national senior certificate examinations; or passes in this examination without higher education admission. The absence of a large number of competent middle- and lower-level artisans constitutes a crippling barrier to the economic survival of the nation, let alone its ability to earn its living as a knowledge economy. The Committee is in general support of the approach towards this issue adopted in the DHET's recent Green Paper on Post-School Education and Training (without prejudice to a more detailed examination of its proposals).

The Committee is painfully aware of the huge cultural challenge presented in the well-intentioned effort to re-orient school students toward vocational careers, and notes the long-standing debate on the vocational school fallacy.[1]

Higher Education

The present situation with respect to the pipeline performance in the higher education and training system can be summarised as follows:

- Despite sustained efforts to increase admission to higher education for academically deserving but financially disadvantaged students, the overall participation rate in higher education has remained at approximately 17–18% during the past five years; increased higher education participation rates constitute one of the defining features of countries that have made successful transitions from efficiency-driven economies to innovation-driven ones. (This conclusion does not detract from the immense achievement of the higher education system in shifting its demographic profile towards greater population representivity in a very short time.)

- An increasing emphasis on efficiency and effectiveness in higher education has not been translated into a corresponding increase in undergraduate graduation rates; low graduation rates and high drop-out rates at all levels of study continue to characterise South Africa's higher education system.

- Innovation-driven economies tend to have strongly differentiated higher education systems in which universities of applied science or technology play an important role in human capacity provision; during the past decade, it has proved extremely difficult to strengthen universities of technology by increasing their share of student enrolments.

- During the past decade, it has also proved difficult to increase enrolments for advanced postgraduate study; particularly disconcerting is the very slow progress being made in achieving greater levels of race and gender equity in enrolments at this level of study. The survival of many postgraduate programmes is contingent on the enrolment of foreign students.

- Graduation rates for masters and doctoral degree study have not improved significantly during the past decade, and signs exist of longer completion times for these levels of study which are hampering the provision of an adequate supply of highly skilled R&D personnel for improving the country's science, technology and innovation performance.

- There has been an upward creep in the average age of completion of doctoral degrees, due partly to the long time taken for completion, as well as late commencement of study.

- Disciplinary ageing due to failure to reproduce the existing researcher cadre.

- Significant barriers to the expansion of the postdoctoral sector (a particularly important component of the supply of person power in research and development in advanced countries) exist in South Africa in the form of inappropriate tax regimens and academic staff progression structures.

[1] The vocational school fallacy refers to the belief among education policy-makers that school students would be inclined to enter vocational schools rather than staying with the academic orientation of schooling. Student expectations were often at variance with what education planners and education ministers believed what was good for them, and for the economy. http://education.stateuniversity.com/pages/2537/Vocational-School-Fallacy.html

The above conclusions are the basis of the characterisation of South Africa's higher education and training system as being essentially locked in stasis, incapable of increased or better performance because of inter-locking constraints and a vast inertia (policy fatigue) in terms of change-directed policy and practice. This is the case despite the restructuring of institutions, the application of numerous new regulatory policies and the introduction of institutional audits, the dedication of a new ministry and department to this sector, and the successful intervention of the DST in establishing Centres of Excellence and Research Chairs distributed through the sector, supported by limited major equipment provision (see below). (It should be noted that some institutions have obtained outside support for the establishment of large-scale research institutes (with multiple principal investigators), which will require state support to continue to operate at their initial impressive levels, perhaps through the extension of the concept of Centres of Excellence and Research Chairs concept to Research Institutes).

An important example of continued stasis is afforded by the recent Consensus Report on the PhD degree by the Academy of Science of South Africa (ASSAf), which has provided the most complete and evidence-based set of proposals available to date to address pipeline difficulties in postgraduate education in South Africa. The study has confirmed the fact that the current system, already comparatively unproductive in terms of annual numbers of doctoral graduates (about 1000 per year), is severely stretched, and that asking it to increase doctoral graduates five-fold without the concerted implementation of a number of proposals is not realistic. The total numbers of research-active academic staff capable of postgraduate supervision remains static, and their capacity to reproduce themselves is limited by the pressures on their professional lives arising through the necessary but under-resourced simultaneous expansion of the higher education system.

The attainment of post-qualification job-competence is a much-neglected segment of the human capacity development pipeline. The fast-changing globalised world requires, in general, a framework of undifferentiated education and training that permits ready follow-through adaptation to specific professional or vocational requirements through a period of structured experiential learning. Wastage at this level is particularly damaging after the extensive earlier investment in the people concerned. Competence in the public service has been assured in countries such as the UK and India through a well-run public service examination system; post-appointment training is essential but cannot compensate for effective pre-appointment preparation and rigorous selection.

Engineering is a good, but not the only example of extensive wastage due to incomplete training and delayed or discontinued professionalisation; conversely, there are many degree qualifiers for whom no appropriate job-adaptation pathways are available, for example, the higher education institutions have not concentrated enough on offering high-quality postgraduate diplomas in 'job readiness' mode.

The pervasive lack of capacity in the public service is another symptom of 'failed pre-job training, and a major hindrance to the achievement of innovation in public administration and service delivery. There is still no system of public service examinations in this country, despite the extensive and successful use of such systems in countries closely linked to South Africa, such as the United Kingdom and India.

Postdoctoral fellowships have become perhaps the most important route for the adequate preparation of academics and researchers who can work independently and innovatively, acquire and productively utilise grants, effectively supervise postgraduate students, and generally catalyse growth in the knowledge economy. Apart from the present counter-productive taxation policy for such fellows, their entry into full academic service is impeded by the antiquated structure and organisation of the academic employment system at higher education institutions. The impressive scale of recent salary improvements for academic staff – partly fuelled by competition between higher education institutions (HEIs) and science councils and partly by general corporatisation of the operating model for HEIs – coupled with liberal application of the ad hominem promotion system and the virtual elimination of probation, has made the creation of every new post a matter of serious long-term budgetary concern.

The steering and orientation mechanisms that are aimed at addressing specified policy priorities through the generation of appropriate numbers and types of trained and skilled people, mainly the Programme and Qualification Mix policy of steering offerings at different public institutions, has so far worked mainly as an efficiency measure, rather than as a potentially valuable tool for preferentially growing a workforce to meet needs in a particular strategic area or for implementation of a particular plan. There are in fact quite astonishing contrasts at graduation ceremonies – hundreds of business science students, and only a handful of plant virologists, for example.

The cultivation of a cadre of young astrophysicists through a concerted medium-term recruitment and resourcing plan has thus far been an outstanding success, including its success in terms of the desired transformation results. The specification of the broad areas in which new DST/NRF Research Chairs are to be situated looks set to be another useful and effective focusing device. The largely unplanned (because it is mainly foreign-funded) proliferation of a large pool of postgraduate and postdoctoral workers of high quality in the molecular biosciences, related to the twin pandemics of HIV and TB infection, is an example of how human capital can be built up quite quickly in a national priority area. (This phenomenon warrants a thorough and urgent case study of how world-class activity can be rapidly developed in a particular priority field.)

Physical and Cyber-infrastructure

There have been repeated attempts to gauge the situation regarding physical infrastructure in public research institutions, and to obtain an idea of the shortfalls and future needs. The summary position is that a credible roadmap for medium-cost and major equipment is urgently needed; there are many problems with the adequate servicing of major equipment due partly to shortages of appropriately trained personnel; and the principle of sharing special equipment and facilities is a necessary and even beneficial aspect.

The national facilities currently operated by the NRF are an essential component of the NSI; these are uniquely expensive and complex machines or instrument aggregations that are affordable in only one place but are calculated to produce many benefits and spin-offs. The national facilities have caused a number of serious management problems in recent years, distracting and detracting from the core business of the NRF as the national agency for public research grants; some of the present national facilities are perhaps also ill-conceived in terms of any set of criteria for the establishment and maintenance of such facilities. The recent creation of a statutory

National Space Agency may provide a stimulus to the reconsideration of the national facility system within the NRF, associated as it is with the probable transfer of two of the biggest facilities to the new body.

Information technology for research and development has received considerable attention in recent years as cyber-mediated activities have mushroomed in research practice. Movement towards a national broadband-provision system (SANReN) has been vexed and slow, despite its potential of making a huge difference eventually to virtually all public researchers in the country. The rapid march of technological progress in this field indicates that a professionally and consultatively developed cyber-infrastructure roadmap for the NSI is urgently required.

Related to this is the requirement for researchers to have ready and affordable access to the current scientific literature, much of it still provided within the high-inflation commercial model of 'pay to read', based in most institutions on costly bundled subscriptions that dominate library budgets. By contrast, the local scholarly journals, which are important modes of dissemination in certain disciplinary areas and essential vehicles for the maturation of young scholars and scientists, are poorly visible (in either print subscriptions or commercial e-access) beyond a small traditional readership. The setting up by ASSAf of the state-subsidised SCiELO-South Africa, an internationally connected free-online e-publication platform equipped with full indexing capability, soon to be linked to the dominant Thomson-Reuters Web of Knowledge system, is a necessary adjunct to the peer review-based quality assurance model also being applied by ASSAf to all South African scholarly journals. A report on the possible advantages of the kind of national licensing model for commercial journals already deployed in Brazil, Chile and Pakistan is under preparation by ASSAf – the Committee supports such a licence in principle if it is genuinely cost effective and generally advantageous.

The coverage of innovation in the public media is currently fitful and generally mediocre. How many 'people in the street', or even school teachers or university lecturers, would know the concept of the NSI? The credible job done by the South African Agency for Science and Technology Advancement (SAASTA) does not mean that more could not be done, on a much broader terrain of public involvement. This is yet another of the under-developed systemic aspects of the NSI, and in its own way one of the most important ones.

Recommendations Related to Human Capacity Development

Recommendation 14: In order to meet the human resource development requirements of a knowledge economy, a planned, concerted, well-resourced and sustained programme of action in all areas of human capital development should be undertaken by all the relevant policy-makers and performers.

Recommendation 15: Teaching at all levels should be declared an essential public service within labour and other legislation and relevant regulations.

Recommendation 16: The technical colleges must urgently be revitalised, doubled, trebled or quadrupled in number, and organised through appropriate policy into a manageable system analogous to that already in place for higher education, with a similar level of autonomy (essentially the implementation, after full debate and consultation, of the DHET Green Paper on Post-School Education and Training).

Recommendation 17: The present stasis in higher education could be addressed through open-minded consideration of reforms. These might include revising the basic bachelors qualification model at universities, curriculum reform in the direction of greater breadth and versatility , and creating a clear differentiation of masters degree programmes into those that represent a strong focus on research training, those that are concerned with applied science and technology, those that involve advanced or multidisciplinary course-work and theory including subject teaching, and those that are professional specialisations including the performing arts.

Recommendation 18: The Programme and Qualification Mix policy of steering offerings at different public institutions should be used in conjunction with special preferential funding schemes for the development of scarce skills, in order to grow a workforce to meet the needs in a particular strategic area or for implementation of a particular plan.

Recommendation 19: Careful attention should be given to the improved functioning and throughput of compulsory post-qualification training programmes, and consideration given to the introduction of public service examinations linked to appropriate courses and qualifications offered by higher education institutions.

Recommendation 20: Public resourcing (both from outside and inside institutions) should be focused on departments or research enterprises that are demonstratively capable of attracting and hosting large numbers of successful postgraduates.

Recommendation 21: Opportunities in the academic job market should be widened to increase the population of productive academics. This would entail restructuring the present standard model of academic employment to increase the entry of talented younger scholars and scientists

and open up opportunities generally. Specific attention is needed to address the remuneration of postdoctoral fellows.

Recommendation 22: The average value of grants made to researchers by the agency services of the NRF and MRC should be increased to levels that are commensurate with the outputs that are desired, while the number of DST/NRF Research Chairs and Centres of Excellence should be judiciously increased (with the emphasis on 'brain gain'). A new category of DST/NRF Research Institutes is needed for multi-focus, high-level research concentrations with critical mass and a clear long-term trajectory.