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areas, the rural sector in general) cannot be a source of dynamic economic activity; that for the poor, development means primarily the delivery of services; and that development is something you 'get' not something you 'do'. A key constraint on self-employment is South Africa's wage culture, evident in the priority given to employment above all else by poor people, and the way that many projects and self-help initiatives are structured". Instead, Cousins argues, much **greater potential for creative and active agency should be ascribed to communities,** and development processes are (or should be) "a process of continuous adaptation, problem-solving and opportunity-exploiting under pressure [with] continuous adaptation to maximise well-being in changing conditions" (Chambers 1989: 10).

Indeed, Cousins confirms observations made more widely that there is strong evidence of **creative and hybrid livelihood strategies** undertaken by individuals who operate across the traditional binaries of 'formal' and 'informal', or 'rural' and 'urban'. Complex patterns of social economy have been forged that have enabled people to sustain themselves in the most precarious of situations, and a proportion has found the means to prosper. The potential for innovative agency at community level must be accepted as a foundational principle that should govern future approaches to social innovation; at the same time, however, it should be acknowledges, as does Karuri-Sebina (2011) does, that "the supply of innovation solutions emanating from within townships is questionable ... Townships no doubt have their own local livelihood strategies that have evolved over time; however, how this potential gets identified and valorised has not been significantly explored. The relatively weak human capital base in townships, and the nature of their co-dependence with their 'host towns' (to which they serve as dormitories), has largely led them to being centres of reproduction rather than production, hampering much of the local creativity and potential".

Cousins (2011) points out that there are **powerful structural conditions that operate to limit the exercise of individual agency,** and the challenge is to address the complex historical maldistribution of economic, physical, educational and spatial goods that still sustains South Africa's deep polarisation of wealth and poverty. To do so, the project of social innovation must recruit the full range of societal actors who are able to mobilise the social and economic resources at their disposal, and do so in ways different from before.

Each of the sectors noted below has distinctive and evolving roles to play, and each must confront the challenge of how they will integrate innovation as part of the modus operandi of fulfilling these roles into the future. The project of achieving sustainable social and economic futures is unlikely to be resolved through one tumultuous wave of innovations that delivers a new and sustainable equilibrium, but rather entails a state of continuous readiness for innovation in the uncertainty of changing futures.

4.2.2 Actors in Social Innovation

This section of the report will make observations about the changing roles of some sectors, before providing recommendations about systemic and other measures that should be taken within the NSI.

Civil society

South African society does not lack the inherent ability to innovate novel ways of organising itself. This is reflected in the creation of *stokvels* as community savings systems, or in the variety of methods used by those outside the banking system to effect financial transactions and funds transmissions to rural and even cross-border families and networks. Some of the most effective reclamation and recycling systems have arisen in the informal sector (and are of considerable benefit to the formal sector recycling industry). There is a rich array of **creative strategies** devised by those outside the reach of 'formal' systems in order to secure their livelihoods.

Similarly, for decades before 1994, South African **community-based organisations (CBOs), NGOs and unions** provided the organisational and skills base for much of the resistance activity that eventually became the mass democratic movement and paved the way for a globally unique transition to democracy and the adoption of a widely admired constitution. It should not be forgotten that both apartheid and social democracy are social technologies, each with their intended and unintended consequences. Innovation in any one direction is not inherently benign and virtuous and indeed will always be normatively inflected. South Africans have demonstrated their capacity to be innovators and leaders in achieving an extraordinary political transition, but now need to do the same with the fundamental social and economic order of the country, in the face of the formidable path dependencies set up in the old order.

Organisations from the non-profit sector have obviously long been key players in the field of development and will always continue to be vital actors because of their variety, capacity for specialisation, agility of response and proximity to the contexts of development. As the country seeks to achieve increasingly systemic effects, the role of NGOs and CBOs can only grow in salience, especially when multi-partner initiatives need agents with contextually specific intelligence, established access to communities and specialised forms of expertise.

There are outstanding examples of individual NGOs that have succeeded in crafting niche functions in the development arena, and now have the potential to provide the platform (or at least a template) for system-wide functions that, the Committee argues, are essential for the vitality of the future NSI. Very briefly, these include the following.

- **Impumelelo** Social Innovations Centre: This NGO offers a system of awards for leading examples especially of social innovation, not least in the service-delivery systems of government. The award system is a successful device for attracting information about – and thus enabling a mapping of – innovation activity across the countryside. The local awards are linked to counterpart international award systems, enabling both comparative benchmarking and dissemination of innovation. The role of these kinds of recognition-systems in growing a network and community of innovators, and advancing a culture of innovation, cannot be under-estimated.

- **Inyathelo** is the South African Institute for Advancement: This NGO brokers the development of fundraising skills across a wide range of non-profit organisations, strengthening their capacity for endogenous development, and has consistently sought to make national development priorities visible and available to grant-makers and beneficiaries alike. Again, Inyathelo seeks to raise the profile and influence of philanthropy, and thus encourages greater (and more strategic) investment in

philanthropy from a widening circle of donors and investors. The South African Private Philanthropy Circle is an Inyathelo initiative.

- The **Green House Project** is based in the Johannesburg inner city and seeks to create and recreate the city ecologically, socially and economically in sustainable ways. The project provides practical demonstrations of how to build, cultivate and recycle resources (materials, energy and water) in ways that bring sustainable benefit to people and the environment. With the City of Johannesburg as its key partner, the project disseminates to both organisations and communities the practical strategies that are available to promote 'green livelihoods' and enhanced quality of life in an urban setting. The project disseminates innovative approaches to green building design, sustainable energy systems, sustainable water and sanitation management, zero-waste culture and organic food, medicinal plants and landscaping.

- **Prolinnova** (Promoting Local Innovations) is a global organisation supporting agricultural research and development through identifying, supporting and disseminating farmer innovation capacities. In South Africa, the programme involves partnerships between several NGOs, university-based research institutes, provincial departments of agriculture and the ARC.

In each of the four examples noted above, we see a **vital brokerage capacity** emerging that assists in the development of networks and partnerships, the emergence of shared perspectives and the possibility of collective investment in common developmental purposes, which are important pre-conditions for systemic approaches to social innovation.

In considering collective action, we need also to draw on other distinctive capacities in civil society whose traditional institutional strengths position them to play complementary roles in innovative social projects. The media is a natural partner, and unions and faith-based groupings have this potential too.

Private sector

Far-sighted leaders in the corporate sector have long acknowledged that **business has a role and set of responsibilities in society that extend beyond optimising shareholder value.** Although the extent of this role in supporting social development and ensuring environmental sustainability is still strongly contested, there are powerful examples where corporate philanthropy has made significant contributions to the public sphere (in higher education, for example) and to social development through corporate social investment (CSI) and broad-based black economic empowerment (BBBEE) schemes. Indeed Henry (2011) estimates that corporate South Africa's CSI expenditure in 2010 amounted to over R5 billion. In one of the most significant investments in the promotion of innovation, the Business Trust earmarked R35 million in 2009 for the Shared Growth Challenge Fund, which was designed to incentivise private sector innovation aimed at growing the inclusion of the poor in the formal economy. The pressure on the private sector to expand the scope of accountability is reflected in the growing sustainability reportage required in contemporary governance codes such as King III, sector charters and enterprise development codes.

In many cases, however, the return on **CSI budgets** has had to be justified to shareholders in terms of its marketing, human resources and/or political equity value, and has had to demonstrate relatively short-term benefit to firms. This had had the effect of scattering a large amount of investment across a multitude of projects, with varying results. This variability has seen a sharply escalating interest in monitoring and evaluation of the impact of CSI expenditure, not always with the complexity of social development purposes being kept clearly in view. The issue of securing confidence in the likelihood of deferred returns, and ways of measuring developmental progress along the way, is a concern for all actors committed to sustainable development.

"CSI is an investment in human and social capital. By investing in creating opportunities for all South Africans, we are not only tackling poverty, but getting to the root of inequality. Being poor in the midst of plenty enrages people who know that they have not enjoyed the same opportunities as others. On the other hand, social justice leads to social stability, which leads to people who are committed to the future. When we have social justice, we have an alignment between the interests of the private sector, the public sector and individuals – everyone will win.

The private sector has far to go in realising its opportunities to transform this country. We're the only country in the world where corporate social investment is mandated, yet we are under-performing when it comes to the impact of CSI on our society. A birds-eye view of the CSI sector shows a fragmented landscape of once-off projects. The private sector knows all about strategic planning, so why is business falling short here? I believe it is because CSI is driven by a compliance culture, not by a vision of a sustainable investment in the country we all passionately want to live in." Mamphela Ramphele (2010: 20).

The innovation challenge facing the CSI sector will be to see whether this collective investment can be marshalled and directed to combined effect towards a small number of strategic purposes, so that **sustained investment** is made over time to address the complex conditions associated with such purposes, trusting that greater impact and lasting effect will be achieved in this way. Further, the growing insight into the complexity of these goals suggests that collaboration with other social partners will strengthen the likelihood of success.

It has been have seen that the emergence in developed economies of a new generation of **philanthropists**, as a variation away from the venerable foundations (such as Carnegie, Mellon, Rockefeller, Ford, etc.) that have supported charity and development work over the past half-century and longer. The new breed includes the likes of the Bill and Melinda Gates Foundation, the largest donor to development research (another synonym for social innovation), and an innovation in donor funding practising what has been called social venture capital, or what the *Economist* (2010) has dubbed 'philanthrocapitalism'). Organisations such as the Acumen Fund, New Philanthropy Capital, Venture Philanthropy Partners and New Profit are involved, investing money in non-profit ventures on behalf of corporate donors, but bringing business-minded approaches to evaluating the impact of the investment. The significance of these developments is that they 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. It is this impulse towards collective action that is necessary for the achievement of any truly systemic character in an NSI.

Ultimately, however, 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 shifts at the level of diversifying away from the traditional reliance on the minerals and energy complex, reconfiguring the manufacturing base (and indeed all human activities) towards the 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.[8]

A new phenomenon in recent years has been the emergence of **social entrepreneurship** as a means of advancing development goals. Representing a range of hybrids between business enterprises and socially committed initiatives, and taking many forms, social enterprises "are businesses with primarily social objectives whose surpluses are principally re-invested for that purpose in the business or community. They are not driven by the need to maximise profit for shareholders and owners" (EU 2010).

Although this form of enterprise is more strongly present in developed economies, and some BRIC countries, than seems apparent in South Africa, this may well be a modality that gains salience as our capacity grows for collaboration between sectors, and as our national appetite for development-focused entrepreneurialism takes hold. One of the functions of South Africa's future NSI will be to have agencies that are able to profile and popularise initiatives of this nature. Although the examples of cooperatives and networks are sometimes cited as instances of social enterprise, a sober view is that any such enterprise should be, in one way or another, substantively value-generating so as to be inherently sustainable in its 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 (NACI 2010).

Public sector

In the South African development context, the state remains the player chiefly mandated, and most resourced in financial terms, to leverage change in the lived experience of the poor. But, as the NPC Diagnostic Report points out (NPC 2011), the backlog is immense. The challenge for government is to change the way that public services are delivered, rather than to see the solution in increased budget allocations.

The shift is underpinned by a number of realisations already alluded to above; firstly, there is a recognition that the capacity for comprehensive social services afforded by post-war social democracies in northern Europe is not an option given the scale of South Africa's need and the size of the fiscus. Resources of all kinds need to be recruited from other societal partners, and communities themselves are powerful agents of change and development. Secondly, there is a realisation that delivery contexts for the provision of services are widely diverse and subject to rapid change. Thirdly, current levels of organisational capacity in the public service (especially at local level) remain constrained (Von Holdt 2010).

[8] A promising related development in South Africa is the recent establishment of the South African Private Philanthropy Circle which, among other things, will seek to encourage partnerships between private donors, government and the corporate sector.

The strategy is thus to focus predominantly on institutional restructuring directed at transforming the responsive capacity of public service provision, in terms of achieving optimally informed policy- and strategy-development, but also at the level of the capability of public delivery platforms. In each case, the intention is to institutionalise learning organisation capability, and the capacity for swifter adaptive behaviour.

At the level of policy- and strategy-development, the state has long sought to achieve integrated planning and oversight of the various functional areas that contribute to complex fields of activity. The current system of **twelve priority outcomes and the related performance contracts overseen by the Presidency** are intended to achieve this top-level coherence in government planning, and this system will be supported and informed by the activities of the Department of Performance Monitoring and Evaluation. In the case of services that together add up to the system of social security, five separate government departments administer one or another function in the multi-dimensional array of provisions (not counting education-related departments, whose functions could be seen as potentially collateral).

As Van den Heever (2011) notes, there are opportunities to link these various forms of provision in order to achieve complementary and multiplier effects. These include:

- **Social security and labour activation:** South Africa has to date implemented very few programmes which tie social security interventions, such as unemployment insurance or social grants, to labour activation strategies, including reintegration strategies for people who are disabled regardless of the cause. Although historically unemployment insurance and labour activation have fallen within the policy authority of the Department of Labour, very limited use has been made of combined strategies, and limited investment seems to have been made in the development of the possibilities of the delivery platform.

- **Social security, education and health:** Significant opportunities exist for various social security benefits to be tied to education and health interventions. Social grant registries contain information on around 17 million or more past beneficiaries, who for one reason or another were severely disadvantaged. Their locations are known as well as their income and asset status. Whether by way of conditions or incentives, health and education programmes can be tied to the needs of known grant recipients. Similarly, information contained in the registries for unemployment insurance and the South African Revenue Service (SARS) can be used. However, such linkages are limited by the narrow implicit mandate of all the departments concerned and the delivery platforms. There are significant examples internationally where conditional payment criteria are associated with various grants, intended to prompt complementary and optimal use of the services provided by the state. Brazil's 'Borsa Familia' is frequently cited, as is the counterpart example in Mexico.

In other areas of development, similar challenges exist in coordinating the efforts of multiple departments, including (importantly for social innovation purposes) **rural development** where separate programmes have been developed for rural development, land reform, agricultural development and water reform. In such cases, the need is for a compelling shared vision that is translated into a programme of coordinated mandates overseen by the forms of strong authority needed to bring about the adaptations and responsiveness required for innovative public service delivery.

Furthermore, public service departments that have strong implications for social innovation need to ensure that their policy- and strategy-development processes are appropriately participatory at the outset to include other societal partners needed to achieve the systemic effect intended. Effective partnerships require significant investment in achieving shared vision, a clear sense of division of responsibilities as well as the resilient mechanisms for the kinds of learning, revision and conflict management that inevitably accompany partnerships for innovation.

It is vital to the development of effective regulatory measures, and subsequent effective delivery capacity, that these be sufficiently evidence-based, from the systematic analysis of current contexts, to the regulatory impact assessment and to the *ex ante* evaluations. The activities of the state, and the partnerships with other social actors, will have a much greater chance of success when properly informed with good research and evaluation.

Essentially, innovation in modalities of public service delivery rest on the realignment of the responsive relationship between the platforms of delivery and the citizenry being served. Various examples exist of exciting and far-sighted innovations undertaken by government, including the Community Work Programme that has already provided employment opportunities for over 100 000 individuals, and has been characterised by a highly innovative partnership between government, NGOs and community-based organisations. The Working for Water programme reflects another successful partnership between government, a university and communities. Further, Impumelelo has documented many municipal-level sites of significant innovation, very notably from eThekwini.

Although significant further research is needed to understand the conditions that make for responsive and adaptive public service provision in South Africa, current insights suggest that **innovative sites of delivery** are characterised by being:

- Well-informed and strongly motivated by central vision and purposes articulated in state public policies
- Contextually sensitive to the distinctive social and economic conditions at that site, and capable of adapting to these conditions
- Alert to larger developmental dynamics in that context (including other public service initiatives or purposes being driven by other sectors) that could provide additive and mutually-reinforcing opportunities
- Information-rich, and able to read and respond to information with agility
- Granted a degree of independence and discretion – and the high-level capabilities – needed to formulate context-specific responses that serve to advance central strategic purposes
- Possessed of an institutional culture that is sufficiently learning-oriented to seek demand signals from the immediate context, to seek alternative models of practice suitable for local adaptation, and to sustain a judicious level of risk-appetite
- Able to enlist and sustain resilient relationships with other social partners.

To conclude, 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.

Although social innovation activities are under-represented in strategic, planning and budgeting frameworks, there is nevertheless a rich (if limited) field of existing practices and organisations that can be referenced as exemplars and informants for a much fuller set of public policy initiatives that can stimulate and scale-up social innovation to the levels needed in South Africa today.

4.2.3 Recommendations

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 incentivising and regulatory instruments proposed in order to provide an enabling environment for innovation 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 6 of the Phase Two report: Monitoring and evaluation).

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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 5: HUMAN CAPITAL AND KNOWLEDGE INFRASTRUCTURE

5.1 Human Capital

This section argues that meeting the human resource development requirements for the NSI, as a first-priority essential ingredient of an evolving **'knowledge economy'**, will require a planned, concerted, well-resourced and sustained programme of action by all the relevant policy-makers and performers.

This is because the present human capital development (HCD) system is locked into sets of inter-dependent 'pipeline jams', with piecemeal interventions having so far served only to make the system more refractory to positive change. In fact, the interventions have produced a peculiar and rather general resistance to the idea of any further policy change in a 'fatigued' system.

Simply throwing money at the problem will not solve it, in the Committee's view. Each proposed intervention, as policy or as practice, has to be weighed not as a microcosm of much-talked about pros and cons in each case, but in the context of the 'big picture and the big push' to a new and much-improved situation, where every enterprise in both the public and private sectors can readily assemble its complement of appropriately skilled and knowledgeable people, and where skills and knowledge are themselves the key starting assets of many such enterprises.

The objective of a 'big push' in HCD should be to create a **significantly expanded 'pyramid' of skilled people** who can develop, run and service an innovative knowledge economy. The concerted approach that the Committee regards as essential will require re-examination of some current shibboleths in the collective mind of many participants, integration of public policy-making and purposeful resourcing by the state, innovation of practice within academia, the active involvement of business and industry, and general support from civil society.

In essence, what is required is the following:

- The optimal development of the country's talent through much more effective schooling, post-schooling education and training, and the general promotion both of job competences and adaptive versatility
- Meeting the knowledge and skills requirements needed to address the economic and developmental challenges confronting society, and achieving the priority outcomes identified by government
- Investing in the national capacity for research, deep understandings and knowledge transfer
- Taking a long-term view of the development of knowledge fields and applications
- Promoting free circulation of talent

- Developing the skills base within government necessary for efficiency, effectiveness and innovation in its functions
- Promoting within the 'national psyche' a respect for knowledge and skill, and an appetite for innovation as a way of life.

The achievement of an innovative and technology-rich economy and society will thus depend on the depth, width and overall quality of the country's **reservoir of 'human capital'**, meaning people who have knowledge-informed, research-experienced expertise with the breadth of vision to provide leadership for innovation, as well as inspiring teachers who have achieved mastery of their subjects, technical personnel at a variety of levels, 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.

The Committee looked for examples of countries that may provide lessons for South Africa in situations that are, of have been, similar. Ireland may come closest in its two-decade trajectory from peripheral backwater nation to something approximating an 'EU tiger' (before the recent global recession, the occurrence of which in itself is a different lesson for South Africa). Ireland concentrated in its HCD approach on first degrees, including language skills, then on massively bolstering the activity of the higher education system in masters degrees, especially in applied fields, and then on enhanced R&D at doctoral and postdoctoral levels in both basic and applied fields. The country did not hesitate to bring in foreign group leaders and to invest heavily in strong teams. Foreign investment in industrial plants and skills-intensive enterprises became a torrent as the local people needed for the purpose became readily available.

From this and other examples, it can be seen that adequate and sustainable pipeline flows in HCD require bottom-up growth of national skills, free recruitment of outside talent, and an early emphasis on applied fields which are adequately backed by a basic- knowledge pool.

5.1.1 Education System

Schooling

South Africa's overall education system has many fundamentals at the core 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 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 they should.

Access to **effective pre-school education** is another fundamental positive for any child, as is the 'personal capital' of parental and community involvement and support, at home and in school or college. Yet another positive is a **fully developed role of the 'first-language subject'** in the general intellectual enskilling involved in reading, communication, subtle understandings, argumentation

and the capacity for personal and social growth, besides the core subject content of the grammar and literature of the language concerned. Proficiency in the **use of English** in oral expression, writing and reading is equally important.

The continuous development of **mathematical literacy** (essentially the power of abstract and predictive thinking) plays an equally important and parallel role at all levels of education, as does general **numeracy**. Direct experience of **technological manipulation**, in classrooms as well as outside, is yet another ingredient of 'brain-and-hands' capabilities, 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 HCD. Organisations such as the Centre for Development Enterprise (CDE) and the Joint Education Trust (JET) have contributed much of real value to the menu of what needs to be done by those who run and those who work in the schooling system. The current model for teacher/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 and training must be re-classified as an essential service**, which it undoubtedly is. The nettle simply must finally be grasped.

The Committee wishes to emphasise here the need to focus on the process fundamentals in a concerted approach to schools improvement, knowing that this is the area where the most significant positive impacts on national HCD will be achieved. Every school that is added to the present much-too-small complement of functional institutions represents a 'catalysis' of hundreds of high-potential minds for the system, over long time periods. The Committee thus argues strongly for **practical policy-making and enhanced practice**, since without this happening, it is doubtful that the downstream 'supply chain' of post-school education and training will actually be able to provide the quality and numbers of capable and skilled people required for a knowledge economy.

Technical colleges

The Committee is in no doubt about the need to attain a **much-expanded technical college system** in South Africa. The massive waste of human potential currently associated with 'dropping out' from schooling, as well as with failures in the national senior certificate examinations or passes without higher education admission, is a crippling barrier to the economic survival of the nation, let alone its ability to earn its living in knowledge economy mode.

Programmes promoting **adult literacy and education** outside the formal institutional framework, but drawing strength from it, must be greatly expanded and rendered more effective and user-friendly.

The **technical colleges** (now about 50 in number, with about 300 000 students) should urgently be re-vitalised, doubled, trebled or quadrupled in number, with a commensurate increase in student numbers, and organised through appropriate policy into a manageable system analogous to that already in place for higher education. They should be adequately resourced in terms of staff, equipment and facilities, and their geographical scope widened to promote accessibility and to lower user costs. They should be productively partnered and diversified with relevant industrial sectors. The National Qualifications Framework (NQF), through upgrading of the system of qualifications and unit standards, should be effectively harnessed to increase access, promote transferability and ensure quality in this system. **Enhanced articulation** possibilities should be provided for learner movement between schools and different types of post-basic institutions, through better combinations of school subject options and facilitated access arrangements.

The **curriculum content** of technical college programmes should be such as to ensure that mainstream applied/technical skills are acquired along with prescribed minimum levels of mathematical/numeracy and language/communication skills.

Every effort should be made to render technical colleges essentially tuition-free to all, or at least most, students in the form of loans convertible to bursaries on qualifying with the certificates concerned. For this, the National Student Financial Aid Scheme (NSFAS) should be expanded and/or, if necessary, relevant legislation amended to deploy the huge resource of the National Skills Fund (NSF) in the technical college sector.

Technical colleges should effectively be used to ensure that no young person is left behind before reaching their early twenties. Setting them up literally requires a 'Marshall Plan' (just as the schooling system does.) While the Committee is not in a position to cost its recommendations for technical colleges, it is mindful of the more than R7 billion annual income of the NSF, and believes that reconsideration of the related legislation may be a good start to finding the means for reforms that would address a large number of the most serious challenges that the country now faces, while bringing in returns of immeasurable economic and social value.

Higher education

Stumpf (2011), in his background paper to this report, summarised the present situation with respect to the 'pipeline performance' in the higher education and training (HET) system:

- 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.
- 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**. The very slow progress in achieving greater levels of race and gender equity in enrolments at this level of study is particularly disconcerting.

- **Graduation rates for masters and doctoral degree study** have not improved significantly during the past decade, and there are signs of longer completion times for these levels of study, which are hampering the provision of an adequate supply of highly skilled research and development 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,** which is in part consistent with the long time taken for completion, as well as late commencement of study.

- 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.

These conclusions are the basis of the characterisation of South Africa's HET 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, the introduction of institutional audits, and the dedication of a new Ministry and department to this sector. It could be argued that what appears to be stasis is really a period of consolidation after much policy and system turmoil, but the Committee fears that this is not the case, as shown by the repetitively depressing conclusions of the analysis summarised above.

An important example of continued stasis is afforded by the recent consensus report on the PhD degree by ASSAf (2010), 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 1400 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.

A concerted, innovative approach must be adopted to allow the higher education system to overcome the constraints that still shackle it despite the structural interventions of recent times. There must be preparedness to examine all of the assumptions that have underpinned the thinking up to the present. Much-improved functionality in the universities and universities of

technology simply has to be achieved in order to increase access, and to raise participation and completion rates.

The Committee believes that **applied disciplines** should represent the major part of qualifier output, supported through service course provision by **basic disciplines.** The latter must, however, be well maintained, at a level that will permit them to make their own contributions to knowledge and innovation, and especially for the reflectiveness that their approach can bring to innovation and inspiration.

The Committee does not advocate a simple division of higher education fields into science, technology, engineering and mathematics (STEM) and 'the rest', but a **more useful division into the 'more applied' and 'more basic' sides of each group of fields.**

In line with strong advocacy of a concerted, 'big picture-based' approach to achieving these objectives, the Committee urges careful and 'zero-based' consideration of measures that seem to have great potential:

- **Reform of the basic bachelors qualification structure** at universities, possibly involving the adoption in a number of fields of four instead of three years of study, with serious consideration given to a generic 'two-plus-two' model of four-year study in which the mid-period break-articulation point in many degree courses is sufficiently well designed to permit high-performing entrants from parts of the technical college system to 'transfer in' without having to re-start at the beginning of the four-year programme. (Such a system has been very successful in Florida, where public higher education is based on a central university offering the four-year bachelors degree and a large number of well-distributed community colleges offering two-year diplomas with exit value as well as articulation with the university degree.)

- Additional **curriculum reforms** at universities to require greater breadth of the main bachelors-degree programmes in terms of enriching course options taken from outside the degree specialisation of each programme, as well as other, more designed-in features. (Such reforms can increase the efficiency of higher educational programmes by achieving economies of scale for smaller departments.)

- Greater use of the 'summer term' concept to enable students who fail courses to repeat them in a different learning mode, yielding better 'diagnostic' insights as to the real causes of failure and better outcomes. (This approach can be very cost-effective if well designed and managed.)

- Operational **differentiation of the profession of 'higher education academic'** in terms of teaching, research and professional specialisation, to permit capable but specialised exponents of each modality to make their contributions at the highest level.

- Similar **differentiation of institutions**, with different mandates with respect to educational level, disciplinary or professional areas, research intensity, size and/or geographic focus.

- In a departure from present policy, it may be necessary to carefully examine the implications of 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 performing arts. (The Committee appreciates the 'long fight' that has given rise to the present emphasis on minimum content of original research in masters programmes, but suggest that the attainment of a knowledge economy and society will require a re-think of this approach in favour of regarding reflective and integrative knowledge as also having value.)

- Again as a departure from present thinking, one might carefully look at the idea of enhancing research-focused **doctoral programmes** with required course-work and skills acquisition, and the acceptance and introduction of doctoral programmes based on advanced theory, technological innovation and/or the highest levels of professional practice (see note to previous recommendation).

- Greatly extending aid and incentives offered to **full-time postgraduate students**, in the form variously of adequate bursaries, convertible loans, 'in kind' support in respect for example of teaching assistantships, subsidised ICT equipment, facilitated accommodation and transport, and generally improved working conditions, coordinated if possible through an effective postgraduate centre or research office.

- Encouraging continuous self-reflection and **skills planning** by postgraduates, aligned with the periodic progress reviews conducted by teaching departments, and providing effective career advice and job facilitation, including in-study internships in the public service and/or industry wherever and whenever this is possible.

- **Focusing public resourcing** (both from outside and inside institutions) on departments or research enterprises that are demonstratively capable of attracting and hosting large numbers of successful postgraduates (in other words, concentrating on the 'rating' of such productive 'units' in addition to, or instead of, that of individual scholars, as at present).

- Fostering and sustaining **local scholarly journals** that simultaneously provide opportunities for 'first publications' of postgraduates and young scholars generally (which should be virtually compulsory achievements for all postgraduates), as well as experience of peer reviewing and editing of research articles, in addition to growing a local 'sense of community' in the disciplines or focus areas concerned.

The Performance Agreement between the President and the Minister of Science and Technology for 2010–2014 stipulates her involvement, together with that of the Minister of Higher Education and Training, in reaching the following **targets by 2014**: 20 000 honours degree graduates; 4500 masters degree graduates; and 1350 doctoral graduates. According to the latest HEMIS data for 2010 from the DHET, reaching these targets by 2014 should not prove to be insurmountable, and in some cases they were already exceeded in 2010. The Committee is not supporting these figures or suggesting others in this report (although the Committee is disturbed by the large discrepancy between the doctoral graduate targets in the ministerial agreement and in the Ten-Year Innovation Plan of 2008 – see Section 3 of the Phase Two report: Governance of the NSI), as the Committee believes that the advocated changes in common degree structures (as listed above), if implemented, would necessitate a thorough revision of these targets, including postgraduate diplomas in the set (see below), adding new four-year bachelors degrees pitched, as are honours degrees, at Level 8 on the NQF, at least three kinds of masters degrees at Level 9, and an expansion of the possibilities of the doctoral degree at Level 10. The Diplomas and

Advanced Diplomas in the revised HEQF (previously National Diplomas and BTech degrees) should be included in these targets.

5.1.2 Becoming Job-competent

The Committee regards the attainment of post-qualification job competence as a much-neglected segment of the HCD pipeline. In a sense, 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.

Engineering affords a good example. There is a specific need for large numbers of engineering professionals to take care of much of the delivery end of an innovative, knowledge-based society. The proper education and training of engineering professionals is a **two-stage process**, the first being a tertiary qualification and the second a comprehensive workplace-based period leading towards professional registration, which requires that applicants reach a level of competence that allows them to take full responsibility for projects. Guided, structured experience in the workplace is essential to achieve this level of competence, and requires long hours from experienced staff to ensure that adequate skills transfer takes place. Sadly, current investment in enhancing the skills of graduates and ensuring that they are adequately integrated into the workplace is lacking, so that whereas it was normal until a few years ago for an engineering to become registerable within four or five years of graduation, few are now ready to register in under seven years, and the majority only register well into their thirties.

The Committee suggests inter alia the following measures and approaches:

- Fast-track intensive training in general organisation and management, public administration, human resource management, and other selected areas of **broad job enablement**
- Review all **post-qualification prescriptions required for professional registration**, in order to assess how appropriate and effective they are, and how accessible to all eligible persons, in partnership with the relevant professional bodies, industry and the public service
- Specifically review the role of **postdoctoral fellowships** in the preparation of academics/researchers who can work independently and innovatively, acquire and productively utilise grants, effectively supervise postgraduate students, and generally catalyse growth in the knowledge economy. This would entail revising the present counter-productive taxation policy for such fellows, drastically increasing the availability and adequacy of such awards, and linking their service with a restructured academic employment system at higher education institutions (see below)
- Expanding **work placements** such as are built into the TIPTOP sub-programme of the dti's THRIP incentive scheme (see Section 7 of the Phase Two report: Financing the system).

5.1.3 Professional Academics

To develop a much larger cohort of professional academics and researchers in South Africa, among whom there would be a much greater proportion of black people and more women than at present, the Committee recommends:

- Widening opportunities in the **academic job market** to recruit and retain a much larger complement of outstanding scholars and scientists who can in turn attract, inspire and effectively supervise increasing numbers of postgraduates, by a systemic investigation of the possible advantages of restructuring the present standard model of academic employment in favour of a system of professorships that starts with a large number of non-tenured, mid-career or emerging researcher positions of assistant professor (with a five- to six-year employment cap) and smaller numbers of tenured associate, full and distinguished professorships acquired by direct competitive appointment or ad hominem promotion. (This proposal is meant to involve the employment of more people than is now the case, through a combination of lower average salaries and more posts established, some of them by converting 'soft money'-funded posts into substantive appointments)

- Creating a grant system specifically designed for the **mid-career, non-tenured emerging researchers** to enable them to productively establish their projects and groups

- **Doubling (at least) the value of grants** currently being made to established researchers by the agency services of the NRF and MRC, based on the ratings of the groups rather than the individuals concerned (see above), and aimed at increasing both the quality and the number of researches thus supported

- Recognising (usually mostly anonymous) **voluntary scholarly work** such as peer-reviewing research articles or grant applications, as well as examining dissertations, by promoting a system of recording and accumulating task ratings that can become part of normal evidence of performance quality, in CVs for example

- Enlarging the **circle of research excellence** by expanding the number of DST/NRF Research Chairs (with an emphasis on 'brain gain') and DST/NRF Centres of Excellence, and creating a **new category of DST/NRF Research Institutes** for multi-focus, high-level research concentrations with the kind of critical mass and long-term trajectory that characterised the national institutes of the 'old' CSIR

- Aligning the **agency operations** of the MRC with those of the NRF in terms of the policy instruments available (possibly by incorporating the former into the latter), and addressing the present overall inadequacies of research support in health, agriculture and the broadly conceived humanities and education, by specific measures designed to produce coordinated growth of research activity and researcher numbers across the entire public sector (see Section 3 of the Phase Two report: Governance of the NSI, and Section 7: Financing the system of this report, dealing respectively with governance and public funding of R&D in South Africa)

- **Improving infrastructure** in (and for) the entire HEI sector, as proposed in Section 5 of the Phase Two report: Human capital and knowledge infrastructure.

- **Opening up posts in South Africa** to competitive entry of highly qualified and productive scholars and scientists from other countries in Africa and further afield

- Strengthening the roles of the **Academy of Science of South Africa (ASSAf)** and of the newly established **South African Young Academy of Science (SAYAS)** as authentic 'voices' of the leading scholars and scientists in the country.

The Committee considers the estimates of the **resource requirements** for a greatly increased supply of high-level human capital for the NSI prepared by the DST in its July, 2010 submission to the National Treasury (2011–2013 Medium-Term Expenditure Framework) to be the approximate minimum of what would be required for the full implementation of the above recommendations (which the Committee has not been able to cost due to the many uncertainties). The proposals made by the DST require new investment of the order of R1.5 billion annually by 2015; implementing this concerted set of additional recommendations for higher education institutions would increase this cost, perhaps up to R2 billion per annum, but the Committee's view is that the overall objective of creating a balanced skills pyramid, drawn from the whole population, will require a large number of refinements of the core investment model, as well as factoring in the proposed massive expansion of the technical colleges and the 'rescue' of the schooling system.

5.1.4 Public Service

The Committee believes that a skilled and knowledgeable public service is absolutely essential in a well-functioning NSI. It needs to be stocked with **qualified and competent people** able to work creatively and effectively together, within and across departments and ministries and at the different levels of government. The demands that will be made on such people will be above the ordinary, and both qualifications and curricula, on the one hand and in a more general sense, and the recommended public service entrance examination system, on the other, will need tailoring to ensure that both appropriate content knowledge and an open mind-set are inculcated in all or most of the candidates involved. The Committee has found (without going into detail in this report) that written communication and decision documentation is deficient in the NSI-related policy arena generally, with concerns about transparency and effective actioning of plans and decisions, and adequate monitoring and evaluation.

The current reliance on post-appointment training through the Public Administration Leadership and Management Academy (PALAMA) cannot compensate for thorough pre-appointment education and rigorous selection, which in countries such as the UK and India are promoted by a well-run system of 'public service examinations'.

5.1.5 An Adaptive Mix of Skills and Knowledge

Within the general framework of human capital development dealt with so far, the steering and orientation mechanisms aimed at addressing specified policy priorities through appropriate numbers and types of trained and skilled people need to be discussed, at both the system (cabinet-authorised) and local (within departments and ministries) levels.

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.

The cultivation of a cadre of young astrophysicists through a concerted medium-term recruitment and resourcing plan has been an outstanding success, including in terms of its desired transformation results. The specification of the broad areas in which new DST/NRF Research Chairs are to be awarded is another useful and effective device. The largely unplanned (because it is mainly foreign-funded) proliferation of a large surplus of postgraduate and postdoctoral workers of high quality in the molecular biosciences related to the twin pandemics of HIV and TB infection, is another example of how human capital can be built up quite quickly in a national priority area.

Essentially, the policy tools for a focused expansion of the highly skilled workforce exist already; they just need to be applied in a planned, coordinated and well-resourced manner.

5.1.6 A Systemic Approach to Productive Human Capital

The sociology of successful science has taught that teams are usually built around the inspiration and drive of individuals with the gift of leadership. This widely shared view is no longer adequate.

The completely different modern understanding of metabolic control in living cells is that all system components help to determine the overall performance of a metabolic process, and to different extents under different conditions. This means that the support of particular groups must be designed to bring together component individuals with appropriate skills to enhance the overall performance of the whole group. As mentioned above, moving the current NRF rating system towards one that makes provision for the rating of **highly productive groups** rather than individuals would greatly help to multiply the distributive effects of resource provision. The early identification and targeted support of natural or evolving leaders in the system is another important priority.

Different forms of **support should be coordinated and customised** to meet the needs of particular groups, rather than making periodic general competitive calls for a particular kind of resource, like expensive equipment, for example.

The Committee suggests that the **national associations of the different established disciplines** should undertake critical reviews of all aspects of their fields, including student recruitment at all levels, curricula, new developments and potential interdisciplinary 'gold mines', and their service role to society and the economy.

Monitoring the evolution of new and significant study fields is important, and is currently based in the NRF. The powerful **international unions of the International Council for Science (ICSU)**, with their under-utilised national committees, operated by the NRF as South Africa's adhering body, can surely assist in providing international context and support for such endeavours. The recent renaissance of physics in South Africa can be ascribed in no small measure to the intensive DST-supported self-review of that discipline.

5.1.7 Free Circulation of Talent

The importance for a knowledge economy of the **unrestricted movement of talent and skills** across national boundaries cannot be over-emphasised.

Allowing foreigners to apply on equal terms for vacant posts in South African research institutions and business/industry acts as a competitive stimulus and a bench-marking tool in the system; it also permits enlarging the pools in areas of talent shortfalls and introducing fresh ideas into the relatively small and introspective South African research community. This free circulation is enshrined in the SADC Protocol on Education and Training, but South Africa's immigration regulations appear to be implemented in ways that frustrate the intent of the protocol.

There is in any case no valid argument for excluding foreign scholars and scientists from local ranks, whether from other African countries or further abroad; each entrant will generate more work for locals than the jobs that will be taken away. The legal framework and regulatory regimen for work permits and visas must be simplified and rendered as user-friendly as possible. The recognition system for foreign qualifications must also be efficient and fair.

5.1.8 The Wider Public: Attitudes and Values

The citizens of a country that has become a knowledge society must necessarily accept the ethos of knowledge and skills as high-value assets, and must support innovation as the (main, if not only) lifeline to future prosperity and national self-regard.

The Committee is convinced that the **'appetite for innovation'** of the whole population can be fostered by well-designed and well-executed interventions at the grass-roots level, as well as through the systematic upgrading of public education, as advocated in this section.

The **public broadcaster** should be involved in presenting a mix of entertainment and excitement about innovation in all spheres of life and society.

The system of **science centres** is an extremely important part of public engagement with science, technology and innovation. The country unfortunately still lacks a prestigious National Science Centre to act as the core of a distributed national system; such an investment would have many beneficial consequences.

Innovation should be positively presented in the media and government, and followed up publicly to demonstrate its benefits. Schools should celebrate innovation in ways that leave a permanent impression of its value and interest. Much else can be done.

Lastly, the need for effective partnership and a 'big-picture-based' policy-and-practice debate that could be fostered through **consensus conferences** that bring scientists and the public into open debate concerning topics of pressing interest. The tensions between environmental conservation and the desire for access to land for farming or mineral exploitation is an example of a matter that lends itself to such debate. Consensus conferences are different from public hearings; they attempt to reach a scientifically informed consensus, and as such are an important learning process for scientists and the public alike. The Academy of Science of South Africa would be the natural convenor of such consensus conferences.

It will be evident that the enhancement of human capital development advocated in this report absolutely requires close cooperation and common purpose between many government departments, but especially those overseeing basic education, higher education and training, and science and technology. Public institutions such as schools, technical colleges and higher education institutions will be the targets of policy change and altered practice. Business and industry can make major contributions all along the way, as can non-government organisations and many other players and stakeholders. Inspirational leadership will be indispensable from top to bottom.

This Committee has no doubt that the agenda of people development is more central than any other to the aspiration for South Africa to become an innovative winning nation.

5.1.9 Recommendations

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** such as 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, possibly by **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.

5.2 Knowledge Infrastructure for Innovation

Knowledge infrastructure is defined as the specific requirements for building and sustaining an innovative society based on the value chain of knowledge generation, transfer, storage and assimilation.

In essence, this definition could (and probably should) be extended to include higher education institutions and science councils, as well as the totality of their staff and students, but this is not usually done, despite their importance in the system. (**Strong knowledge institutions** are actually the best indication of sound infrastructure in innovation systems.) Similarly, national infrastructure such as government, cities and towns, transportation and communication networks, banks and financial institutions, etc. are not included.

The focus in this section of the report is thus on the specific enablement of knowledge value chains in the NSI by built-for-purpose **spaces, equipment (large and small), scholarly information**

services and cyber-infrastructure, as well as the staff and organisational systems required to operate and maintain these entities.

Adequate, appropriate and up-to-date knowledge infrastructure for innovation is essential in all fields of activity within the NSI, and in all sectors involved in it, including innovation for social development.

This section of the report is based in large measure on the specialist report by Von Gruenewaldt and Botha (2011) commissioned for the Ministerial Review Committee.

It should be noted at the outset that knowledge infrastructure is peculiarly subject to a number of special phenomena:

- There is a strong gradient in extent to which much of the equipment and many of the facilities are at the **cutting edge** (since quality and capability inflation are marked in the laboratory instrumentation field). Many scientists will take much trouble to acquire new equipment, preferably at the leading edge, and lose interest in it once newer and more powerful versions have been acquired (many laboratories are replete with equipment that has lost its charm despite still being serviceable).
- The obvious measure of **sharing expensive equipment** is fraught with the issues of who will maintain and service the instrument, as well as psychological questions related to ownership and competitive advantage.
- Institutions tend to be parsimonious when it comes to **technical servicing and maintenance** of equipment that their researchers have acquired, while suppliers tend to over-price service contracts. Much available equipment is therefore not used to full capacity.
- **Surveys of equipment infrastructure needs** are notoriously unreliable for the above and other reasons; much interpretative skill is needed to understand the real situation.
- **Cyber-infrastructure** is even more subject to extremely rapid technological change.

Two guiding interventions by government have addressed backlogs and planned (non-cyber) infrastructure for the future: the **National Research and Technology Infrastructure Strategy** developed by the NRF in 2004, and the **study commissioned by NACI** in 2006, which is in current use as a baseline for funding research infrastructure applications. More recent commissioned studies have reviewed progress in rolling out the **National Equipment Programme (NEP)** and the **National Nanotechnology Equipment Programme (NNEP)**, including an emphasis on shared or joint use of equipment items at national and regional levels.

The DST has recently invested substantially in large science projects and in the creation of national cyber-infrastructure. This has contributed significantly to the current high-end knowledge infrastructure base.

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To address the growth planned in national R&D (GERD) in relation to GDP up to the target of 1.5% set by government, driven to a very significant extent by increased public sector investment (see Section 7 of the Phase Two report: Financing the system), the existing infrastructure needs not only to be expanded on a continuous basis, but restructured in terms of its elements, to ensure a higher degree of effectiveness and efficiency in its deployment.

This section summarises and reviews the various components, initiatives and interventions that constitute the present status of knowledge infrastructure for innovation in South Africa. In addition, it also highlights several shortcomings that require attention in order to optimise this infrastructure within the NSI.

5.2.1 General Research Infrastructure

As mentioned above, several programmes have been initiated by government to address the state of specialised research equipment and facilities over the last five years. Some facilities have been upgraded, and there has been large emphasis on acquiring and managing high-cost, multi-user research equipment at universities, science councils and national facilities.

South Africa has also attracted attention as a partner and host in some large **international astronomy programmes** such as the Southern African Large Telescope (SALT) and MeerKAT, possibly hosting the future Square Kilometre Array (SKA) and as a partner in the Cherenkov Telescope Array (which is under development). Its role in the Southern Oceans and Antarctica has been recognised. Renewal of the research base on Marion Island and the replacement of the research vessels have been funded in recent times.

A suite of programmes addressing expensive research equipment and equipment required for implementing the **Nanotechnology Strategy** has been devised. Some other strategic imperatives such as hydrogen technology and fuel-cell development are being supported by applying the **Centre of Competence** model, which brings a spectrum of specialised research equipment together.

The status of the system with respect to smaller, still expensive but more routine equipment that that is no less essential is much less satisfactory. Government has regarded this segment of infrastructure as a part of the overall 'block subsidy' system in which it is assumed that the overheads for teaching and research are adequately covered; in this case, the overhead is the general, non-unique equipment base.

Agencies such the NRF and the MRC as have tended to limit expensive, entry-level middle-range equipment awards and/or to put them in (usually unsuccessful) competition with operating costs or people in block grant utilisation. HEI managements also have the general tendency to under-value this kind of middle-range equipment in setting-up plans for young staff or new appointments, despite the once-off nature of the associated expenditure.

The result of these trends is that expensive, entry-level or middle-range equipment (often the key to progress in solid, laboratory-based, multi-student research programmes) is in many respects the weakest link in infrastructure at HEIs and, to a lesser extent, at science councils (see below).

National (research) facilities

National (research) facilities are the expression of a set of selected and specialised aspirations that can each be satisfied only once in the country because of high cost and great complexity (but not all of the current national facilities meet this description). A new and innovative approach to proclaiming national facilities and providing strategic mobility to existing ones is urgently needed in the light of national needs and priorities. Decisions must be made in each case as to whether individual national facilities should be further developed within their current framework; whether operational control should be devolved to another sector-specific entity in the NSI; or whether they should be decommissioned (see Section 3 of the Phase Two report: Governance of the NSI).

It is clear that national facilities as a range of unique, focused 'big science' facilities with large equipment and operating budgets are potentially huge assets to the NSI, or considerable liabilities in terms of opportunity cost.

Research platforms

The development of centralised or distributed **research platforms** for enhanced competitiveness in research and innovation may be an important enabling tool for optimal use of expensive new infrastructure. This may be achieved through the Centre of Competence approach with a specific focus on bridging the innovation chasm; through new technology clusters; or by way of mission-driven implementation of programmes linked to sector-specific national strategies.

Much of the infrastructure investment may have to be made at the interfaces of triple- or quadruple-helix enterprises, where life-cycle approaches to equipment procurement will help to manage the risks and distribute the benefits to the participants.

International facilities

The DST is apparently in the process of developing a framework and guidelines regarding membership of and access to **large global research infrastructure facilities.** The membership and access to facilities such as CERN, JINR and various synchrotrons are presently governed by separate agreements with a substantial annual investment, and the purpose of developing a new framework is among others to consolidate and streamline processes and procedures, assess the return on investment, and design criteria for assessing the need and the benefit. This review process will look at both outbound access and usage of facilities and inbound access and usage of local mega-facilities. The Committee recommends that this work be brought to early completion.

5.2.2 Technological Infrastructure in Specific Service Domains

The role of innovation in high-level technical service delivery cannot be over-estimated. Several government line departments currently manage services where old technology is used and where no or weak links with the general field-specific 'march of science' exist (e.g. police and health department forensic laboratories). Other services are in fact embedded in knowledge organisations, but may not be regarded as priority components, such as national agricultural public assets with the ARC and biodiversity facilities within the South African National Biodiversity Institute (SANBI).

All these services need to be accorded priority in reviewing organisational arrangements and upgrading infrastructure so that world-class services can be rendered to a plethora of users.

Expensive entry level research equipment

As mentioned above, expensive entry-level **research equipment** is a common requirement in the setting-up or consolidation phase of new research groups in higher education institutions, creating so-called 'well-found' laboratories suitable for scaled-up postgraduate training and research. A funding scheme separate from that for major equipment is needed to provide matching support to HEIs for this purpose, bearing in mind the basic public subsidisation model of these institutions (see Section 7 of the Phase Two report: Financing the system).

Scientific and technical support staff

The dearth of appropriately **qualified technical support staff** has already been mentioned. These are often instrument-focused scientists who are researchers in their own right, but also experts in the use of a particular facility, capable of promoting the facility among researchers in various disciplines, facilitating the necessary training in its use, devising innovative uses in different disciplines, and staying abreast with the newest developments in the field. The availability of such technology specialists should be planned into all purchases of such facilities.

The second need is for properly trained technical support and maintenance staff with specialised skills in electronics, optics, vacuum systems, operational software and mechanics. A concerted national effort should be made to train such **technical specialists** through the mobilisation of existing skills in science councils and national facilities together with the universities of technology and/or technical colleges.

User forums for planning

There is a lack of facilitation to involve users of specific types of equipment, or clusters of equipment using specific technologies, to plan future equipment acquisitions through programmes such as the National Equipment Programme (NEP), the National Nanotechnology Equipment Programme (NNEP) and the Strategic Research Infrastructure Programme (SRIP). Such **user forums** should discuss strategically what they as a community require, where the technology

is going, where to focus the efforts when money is made available, and what should be priorities in equipping the community on a regional and national basis.

It is important to do **life-cycle planning** for each item of major equipment or high-level facility, and to assign the responsibility for sustainable operation.

Sharing and access

As mentioned above, optimal utilisation of much research infrastructure is seriously hampered by the lack of a culture of sharing and support to access research facilities. Sharing schemes need to be built into all grants for major instrumentation, with appropriate resourcing arrangements, which can simultaneously address service and maintenance issues.

Remote access

A new generation of equipment is emerging that allows for **networking and linking** researchers to equipment through broadband links. Virtual use of equipment (from remote stations) must become a strong consideration in future.

A research infrastructure roadmap

Funding and the development of research infrastructure has to date not been guided by any particular process that has interrogated the infrastructure needs in a holistic and synergistic fashion. Even where research infrastructure has been created in accordance with sector-specific strategies, this has been done on an ad hoc basis without any overarching guidelines and synergies. There is a strong case for the establishment and step-wise roll-out of an **infrastructure roadmap for South Africa**, probably best driven by the new NSI governance structures proposed in this report (see Section 3 of the Phase Two report: Governance of the NSI).

5.2.3 Capacity of Knowledge Repositories to Support Innovation

The state of **special knowledge collections** in South Africa requires immediate and significant attention. A recent audit has pointed out the state of these collections and has made some remedial recommendations, including the establishment of a National Collections Facility for the four national natural science collections in the museum environment and a number of other collections of importance. A similar approach could be adopted for historically significant and culturally valuable knowledge repositories presently curated and digitised at great expense by universities and other institutions. A policy framework would be needed whereby such collections could be classified to be of national importance and significance and become freely accessible for research in order to qualify for incorporation, and hence also for support from the proposed National Collections Facility.

5.2.4 Cyber-infrastructure

Significant public investment in **high-performance computing, fast broadband networks** and **very large database storage** has been made in the last few years, much of it through the Meraka

Institute at the CSIR. The capacity of our local cyber-infrastructure to support leading-edge innovation will always be challenged by the fast overall development of ICT, and it is likely that this environment will require a constant stream of funding to remain on par with global standards.

5.2.5 A National and International Responsibility

South Africa's responsibility towards international partners and scientists from around the world to maintain and expand the cyber-infrastructure is further underlined by the setting up of **international facilities.** The community responsible for developing and using this cyber-infrastructure is at the beginning of a learning curve, and planning for data-stream transfer and processing will have to be done carefully, so that close synergy between the users and providers of the facilities and services can be established. Use of grid computing, and cloud computing and storage will increase.

5.2.6 Decision-support Tools

All these developments will require close cooperation between government and the expert community involved. Decision-support tools such as various types of science, technology and innovation (STI) **observatories** must be developed in order to provide policy-makers with evidence-based information and strategic analysis, both for designing and implementing effective socio-economic development-oriented policies and action plans, and for assessing the efficacy and impact of existing STI policies.

Organisations such as the **Centre for Science, Technology and Innovation Indicators (CeSTII),** officially designated by the DST to fulfil such one such observatory role, constitutes a key infrastructural component within the NSI. The demographic and bibliographic **SA Knowledgebase** system held by Stellenbosch University at CREST is another unique resource.

Soon-to-be-available decision-support tools, such as the **Research Information Management System (RIMS)** could be considerably enriched and expanded through appropriate linkages and collaborative initiatives with the above-mentioned players as well as the Higher Education Management System (HEMIS), NEXUS in the NRF, and others.

These key information repositories would naturally feed into the system-integrative and virtual observatory work of the proposed Office of Research and Innovation Policy (ORIP).

5.2.7 Access to Information

ASSAf has made much progress in setting up the DST-subsidised, free-online, fully indexed e-publication platform, **SciELO-South Africa,** designed to render a large part of the content of South Africa's scholarly journals visible worldwide, to increase its impact and to enhance collaboration. This should be expanded and sustained, linked as it is to quality assurance through the Academy's discipline-grouped peer review programme.

The Committee also strongly recommend the **subsidised national licensing** of e-access to high-impact, international core commercial journals, following the release of the current ASSAf advisory study on this topic.

Both these interventions are likely to be highly cost-effective in terms of their impact on national research productivity and human capacity development generally.

5.2.8 Dedicated Human Resources

South Africa has to build the human capacity to specify and use the evolving cyber-infrastructure. The local demand for high-end computing provides a nucleus for creating a local South African industry, which would be an emerging one in the global context as well. South Africa should be able to operate and host advanced high-end computers and to build parts of its own computer infrastructure, including software development and computer engineering capability.

5.2.9 National Research and Education Networks (NRENS)

Without affordable broadband internet access available to all contributors and participants, no knowledge economy can be established.

The problematic current situation with the separately conceived and operated public-sector networks **SANReN (South African National Research Network)** and **TENET** (the **Tertiary Education and Research Network of South Africa**) must urgently be resolved so that these can co-exist productively or merge into a single system. Users should have a strong role in advising on the future of a South African National Research and Education Network (NREN) as part of the strategic national infrastructure.

Although SANReN is increasingly addressing much of the national connectivity demands, it does not have a fast link internationally, limiting its usefulness. This linkage is currently a high priority.

Special needs

It is estimated that there are at least 14 000 **remote and distributed sensing and measuring** devices around South Africa. Currently the data collection and storage methodologies used for these are in the main archaic and ineffective, and intelligent use of the NREN would make a big difference in permitting standardisation and a common access mechanism.

The bandwidth, speed and storage needs of the national and global astronomy communities for the **MeerKAT and SKA** projects are genuinely formidable, and planning for this has helped to accelerate the pace of national cyber-infrastructure provision, as well smooth the growth path of SANReN.

5.2.10 A National Roadmap for Cyber-Infrastructure

A system of national cyber-infrastructure encompasses local, regional and international relationships for which a coherent strategy is required. No formal roadmap for cyber-infrastructure in South Africa exists, although some of the components are in place. Well-considered projections of the applications for cyber-infrastructure are needed. While some South African researchers already utilise the tools of the existing cyber-infrastructure, there are many more who could benefit, including the benefit of significant enhancement of their research impact.

It is necessary to advocate interventions in especially the higher education system so as to produce a differently trained cyber-ready cohort of researchers. The social sciences and humanities domains present many opportunities. The imperative in the South African situation is therefore both respond to those pushing the boundaries as well as to reach those whose work could benefit from these tools. A cyber-infrastructure road-map has to address different levels and cater for different datasets.

An appropriately constituted **National Advisory Panel on Cyber-infrastructure**, reporting to the proposed National Council for Research and Innovation (NCRI) (see Section 3: Governance of the NSI), would be a suitable body to deal with cyber-infrastructure at strategic and policy levels, and to draw up a roadmap for integrated implementation over time.

5.2.11 Connecting Business to the Public Cyber-Infrastructure

The question arises as to whether, and when, business should be connected to the evolving public cyber-infrastructure. It is desirable that when business does become connected to national cyber-infrastructure developed to support the public research and innovation environment, the focus should be on research, just as the SANReN licence is specific for R&D and education. NRENS everywhere in the world are very different from commercial networks and operate on different principles.

5.2.12 New Ways of Collaboration for Innovation

Not only are high connectivity, broad bandwidth, ultra-high speed of transfer and vast data-processing capacity important in South Africa's cyber-infrastructure, but also the software and user interfaces that become available for real-time individual and group collaboration.

Social networking and professional networking are causing a revolution in how people, interest groups and communities of practice make contact and connect. This has not been optimised yet for research collaboration, and it is foreseen that virtual teams and instant communication will increasingly become the norm, as a new generation of scientists and researchers that has grown up in the fast-changing mobile, connected and collaborative environments start entering the mainstream of research and innovation.

5.2.13 Organisational Change Related to Infrastructure in Leading Knowledge-focused Institutions

Universities, science councils and national facilities will have to consider major changes in how they organise themselves as they face changing demands for different kinds of infrastructure in an evolving NSI. This will require visionary leadership and adaptive capacity in these institutions, and willingness to be part of a learning collective.

The mobilisation of separate disciplines to address complex challenges and national priorities has become an essential way of managing research. Several vehicles have been created by government (in particular the DST and the dti) to provide environments where knowledge can be shared and combined better among researchers, frequently across sectoral lines. The Centres of Excellence and Centres of Competence have proved that such new approaches to focus research can be extremely successful in creating and using advanced forms of infrastructure.

Creating **open networks of collaboration**, having access to knowledge repositories, and enhancing the mobility of data, ideas and people in the virtual (remote user) context will greatly benefit an evolving and competitive NSI.

5.2.14 Knowledge Infrastructure in the Private Sector and State-owned Enterprises

No survey or evaluation has to the knowledge of the Committee conducted, to assess the extent and status of the knowledge infrastructure in the private sector and state-owned enterprises (SOEs), nor have the linkages between, and inter-dependence of this R&D-active sector and the universities and science councils been evaluated. This is a major gap in the total understanding of knowledge infrastructure in the NSI, given the important role that the private sector and SOEs play in making the NSI competitive. The gap should be filled by a comprehensive study, not only to gain a full understanding of the contribution of business and industry to the knowledge economy, but also to conceptualise ways in which this capacity, in conjunction with that vested in the public sector, can be mobilised to explore opportunities for innovation that have not previously been evident.

5.2.15 Recommendations

Recommendation 23: To address the growth targeted by government in national R&D (GERD) in relation to GDP, driven to a very significant extent by increased public sector investment, the Committee recommends that **the existing infrastructure needs not only to be expanded in a** commensurate manner, **but restructured** in terms of its elements to ensure a higher degree of effectiveness and efficiency in its deployment.

Recommendation 24: To this end, there is a strong case for the **establishment and step-wise roll-out of an Infrastructure Roadmap for South Africa**, probably best driven by the new NSI governance structures proposed in this report.

Recommendation 25: An appropriately constituted National Advisory Panel on Cyber-infrastructure, reporting to the proposed National Council for Research and Innovation (NCRI), would be a suitable body to deal with cyber-infrastructure at strategic and policy levels, including fast broadband, and to draw up a roadmap for integrated implementation over time.

Recommendation 26: The extent and status of **the knowledge infrastructure in the private sector and state-owned enterprises (SOEs) should be surveyed**, and the linkages evaluated between this highly R&D-active sector and the universities and science councils.

Recommendation 27: The DST-subsidised, free-online, fully indexed e-publication platform, SciELO-South Africa, set up by the Academy of Science of South Africa (ASSAf) in order to render a large part of the content of South Africa's scholarly journals visible worldwide, should be expanded and sustained.

Recommendation 28: The subsidised national licensing of e-access to high-impact, international core commercial journals should be effected following the release of the current ASSAf advisory study on this topic.

SECTION 6: MONITORING AND EVALUATION

Arising as it did from the post-apartheid policy landscape, the notion of the NSI that was introduced in the 1996 White Paper on Science and Technology was intended to be fundamentally transformative in its purpose. As argued earlier in this report, this renewal is intended to reach all dimensions of business, scientific and socio-economic activity. South Africa is a society predicated on change, and the NSI is a pre-eminent policy device geared to this end. However, the achievement of intended change is more difficult, and takes longer, than expected. Change need not always be for the good, and the world is wrestling today with the effects of perverse innovations, such as, for example, the novel financial instruments that paved the way for the current global financial crisis. Achieving virtuous patterns of change depends on the availability of top-quality information, the ability to access and interpret it, and the capacity to use the information to achieve adaptation in performance.

The Committee has already noted in the Phase One section of this Report that, "the absence of an assigned responsibility for ensuring the availability, collation, maintenance (and even analysis) of the science, technology and innovation indicators, both quantitative and qualitative, needed for monitoring and evaluation, and for planning and management" for the NSI as a whole. Although evidence is available from a number of sources for some dimensions of discreet activity in the system, there is no comprehensive synopsis available, even in conception, that reflects the desire to be able to 'see' the system in its totality, and how it might be fulfilling its function. If South Africa is to invest in the system as a fundamental strategy to advance its national purposes, then the country must have the means to review its performance.

There are some excellent windows on to selected parts of the system. For example, the 2008 **Innovation Survey** provides vital and intriguing insight into business sector innovation. This survey identifies important continuing trends, such as the relatively high innovative activity in firms but at the same time (and following international trends) the low national propensity for the acquisition of knowledge from external sources, including higher education and research councils, as noted earlier in this report. Similarly, the survey reports that investment in innovation is constrained by a lack of funds, while at the same time only a small proportion of innovating companies are accessing, or are able to access, public funds for these purposes.

The Innovation Survey notes that the pattern suggests that "it is more important for Government to create an enabling environment for innovation" than to work only through funding programmes (HSRC/DST 2011: 64). These appear to be continuing trends, reflected in earlier surveys. However, we have no sense of what further research and intervention might have been directed at these phenomena between the surveys and thus what we might have learned about the operation of the system, especially the interaction between the key players reflected in these data. **There seems as yet to be no provision for sustained research into the dynamics of the system in order to inform steerage.** As the Innovation Survey notes, "countries are still learning to understand the determinants and processes of innovation" (HSRC/DST 2011: 62). In the case of South Africa, the platform for such systemic learning has not yet been provided, and it seems South Africa is not alone in this (OECD 2009a).

Monitoring information on social innovation is also available, but from disparate sources. Intriguing survey information is available in the regular editions of Trialogue's *CSI Handbook* (its most recent 13th edition reflects 2009/2010 activity), which among other things confirms the 'scatter-shot' effect of the very considerable R5.4 billion in CSI expenditure, distributed across 12 development focus areas analysed in the report. The *Handbook* also points, however, to increasing incidences of working partnerships between corporates and non-profit and public sector collaborators, and increasing determination that CSI investment be aligned with stakeholder interests. The information provided in this resource, however, is a reflection of private sector funding of development projects, and provides little insight into the levels and destinations of social innovation funding made available through the philanthropic community.

Equally valuable insight into social development activity can be obtained from **Non-Profit Organisation (NPO)** sources. The Impumelelo Social Innovations Centre, for example, has rich information about particular projects (or portfolios of projects in some cases), often assembled into regional maps of innovation activity. These **'innovation landscapes'** have potentially powerful value for the planning and brokerage of collaborative approaches to larger innovation priorities, and provide a model for how this information (with its detailed case-study material) could be made available through a more comprehensive centre for innovation system intelligence. As it stands, South Africa does not appear to have a comprehensive or synoptic database or the analytic capacity needed to provide insight into social innovation funding or the spread of activities that it supports, despite the priority that this issue commands in the national discourse. There is a similarly fragmented picture of public service innovation, with valuable but only partial insights available from several sources (including CPSI and Impumelelo).

6.1 The Synoptic Gaze

In this chapter, the Committee make the case for a **system of specialised monitoring and evaluation (M&E)** that is structured to serve the purposes of the NSI and thus advance the broader goals intended for the system of innovation.

In arguing for a conception that brings monitoring and evaluation closer to planning, the Committee is following the observation of Miles et al. (2006: 3) that "evaluation has moved on beyond being a simple auditing of performance and is becoming an integral part of a learning-based approach to policy-making and programme formation". *Ex ante* impact assessment is increasingly *de rigueur* now for the formulation of policy instruments, as is the requirement for the up-front design of subsequent *ex post* evaluation. Similarly, contemporary notions of open innovation insist on the interactive, non-linear nature of these dynamics, where learning and adaptation are conditioned by multiple, accumulative inputs, both intentional and fortuitous. The approach to gathering and distributing intelligence about the system thus needs to understand and design these information flows in as integrated and inclusive a fashion as possible.

From the appraisal conducted in the Phase One section of this Report, and also from the discussions conducted by the Committee in Phase Two, it is apparent that the NSI does not yet occupy a firm conceptual and practical space in the critical fields of endeavour necessary for the achievement of national purposes. Given the necessary connection between policy intent and associated evaluation methodologies, it is clear that the functions of the M&E system should serve to enable both ***system-building*** **and** ***system-steerage***. The system-building function of M&E

provision needs to address existing system failures, while the capacity at the same time informs an emerging appreciation of the shape the system must take into the future.

There are a number of key respects in which the NSI still requires deliberate and well-informed attention (in the form of research and planning, policy and programmatic interventions, and monitoring and evaluation) in order to strengthen its systemic character.

6.2 System-building Priorities

The priorities for system building include:

- The achievement of broadly-shared and widely-distributed **understanding** within government, and beyond, of the nature of the NSI, its purposes, and the supportive measures that it affords
- The establishment of a **governance** architecture that reflects the systemic nature of the NSI and the imperative to achieve common vision and coordinated activities among the full range of stakeholders who are key players in the system
- The development of specific system-level **strategies** for innovation that address and strengthen the role of innovation in growing and diversifying sustainable business and industry, in strengthening the provision of public services, and in addressing poverty and exclusion (acknowledging that these spheres of activity are related and inter-connected)
- The establishment of **funding** measures suited to each of these fields of activity (such as venture capital of various kinds, tax incentives, innovation funds, etc.)
- The provision of **brokerage** services and **partnering skills** needed for cross-boundary collaboration and technology transfer between actors in the system
- The development of strategies designed to promote the **dissemination** of innovation, including the capacity in organisations to identify technologies and good practice elsewhere for adaptation into local contexts
- The launch of a sustained campaign to **popularise innovation** across the country as a whole, cultivating it as an admired national disposition and personal aspiration, and an imperative for a sustainable future

Each of these activities has proved persistent areas of need and, in some cases, persistent areas of system failure in spite of repeated efforts to the contrary. It is clear that dedicated measures, supported by top-quality research and evaluation, are needed to achieve this systemic character.

It is for this reason that special provision should now be made for the establishment of a specialist research and evaluation capacity directed at NSI system-building. The Committee believes that this capacity should be distinct from the existing central planning and evaluation capabilities, such as the National Planning Commission and the Department of Performance

Monitoring and Evaluation,[9] whose responsibilities – although importantly linked – are more comprehensively deployed across government activities and are thus less able to drive specialist sub-system development, as is clearly needed in the case of the NSI. In this regard, the Committee is following various **successful models overseas** (e.g. Sweden, Finland, Ireland and the UK), where specialist capacities have been assembled for monitoring the trajectory of national innovation systems (OECD 2009a: 76–77). Having said this, approaching the goal of "a unified national evaluation system as a way to understand the overall progress of the innovation system" (OECD 2009a: 75) must be done with South Africa's distinct purposes and contextual conditions in mind.

6.3 M&E System Purposes

In sketching out the dimensions and qualities that an M&E system should adopt, the considerable complexity should be acknowledged of trying to achieve a **mapping of innovation activity** and **understanding the determinants** that might encourage it in causal, or even associative, terms. While *ex ante* methodologies seek to lower the risks inherent in policy-making choices and to inform judgement more clearly in priority-setting exercises, experience shows that the directions that the future takes tend to resist close prediction.

> Maharajh (2011) cites a note from John Kay, a visiting professor at the London School of Economics and a columnist for the *Financial Times*, that provides a cautionary note about the boundaries of possibility inherent in a foresight exercise: "If you were in a government department pondering the future of the computer industry in the 1970s, you would naturally have turned to IBM for thoughtful experts and presentations. You would not have consulted Bill Gates or Steve Jobs, who were barely out of school, or Michael Dell, who was barely in it. But IBM did not know the future of the industry. If it had known, it would – sensibly – have tried to prevent it. The interests of the industry and of consumers were not only different from those of the dominant business: they were diametrically opposed" (Kay 2011: 10–11).

Nevertheless, this behoves us all the more to be better equipped to read the trends in the South African environment and to be alert to the surprises that the future presents. In many cases here in South Africa, however, the trends of the future look to be unsurprising and wearingly familiar, and intelligence capacities are needed to equip the country more effectively to change these for the better.

The Committee therefore proposes that a **strong and system-wide monitoring and evaluation capacity** geared to advancing the purposes and functioning of the NSI be established. This capacity should be state-funded, and be located within the institutional architecture of state, but with an independent organisational identity that enables it to engage with the full range of sectors and actors within the NSI. The M&E facility should include the following purposes in its admittedly medium- to long-term mandate:

- **System-mapping:** What innovation activity is occurring across the various sectors, with a particular interest in those areas of activity currently under-reflected in existing measures? Private sector activity and formal R&D are best represented at present,

[9] The Committee notes with appreciation the current system of delivery agreements and implementation forums associated with the government's 12 priority outcomes, and the way the Department of Performance Monitoring and Evaluation has structured its internal functions to align with these outcomes.

although as yet inadequately understood. Innovative reforms in the public sector are more difficulty to track, although several existing avenues provide rich windows into this activity. Much more elusive are the wide variety of innovations and adaptations in communities, both urban and rural, that arise spontaneously or are supported by non-profit organisation (NPO) or CSI activity.

- **System-analysis:** What is known about the state of the enabling conditions that the Committee believes are required to release the innovative potential within the system, and how are the various actors in the system responding to these conditions? What can be learnt about how bottlenecks and constraints work to limit this potential, and how incentives are able to release it? How robust are existing theories about system dynamics, and about South Africa's contextual specificities?

- **System-building:** What intelligence can be made available to inform and equip each of the system-building measures noted earlier in this section? In addition, periodic capability reviews of key agencies in the NSI should be commissioned, and the progress in fulfilling the recommendations needs to be monitored.

- **System-steerage**: What measures are best advised to produce deliberate, desired system effects? Our national goals around sustainable, labour-absorptive growth and poverty alleviation require that we make policy and investment decisions in the directions that we believe will best prompt adaptive behaviour. How can our research and evaluation capacity best guide these planning decisions? The system-steering work will probably involve at least three levels of activity, including those producing ***projections*** (such as foresight exercises and scenario-building techniques), those informing ***policies*** (both *ex ante* and *ex post* impact assessment studies) and those informing ***programmes*** (contextual and project-specific intelligence geared to optimise a particular intervention).

- **System-evaluation:** What trends are discernible, and what is the impact of the investments in innovative and adaptive behaviour? There is wide acknowledgement of the difficulties associated with estimating systemic impact accumulating over a period of sustained investment in targeted measures, especially in elusive quality-of-life measures. The monitoring and evaluation (M&E) capacity must enable the derivation of compelling indicators and analytically powerful qualitative insights. Ultimately, the capacity is require to assemble a synoptic view of emergent patterns across the system, and the relationships that might be at work among them.

- **System-learning:** One of the founding conceptions of the system is that it is an interactive, relational system of mutually reinforcing learning and adaptation. One of the functions of the M&E capacity must be to provide a knowledge base and a communicative nexus for cognitive exchange and accumulation within the system, both within sectors and across them. This has to be done deliberately and inclusively, so as to draw on local and distributed knowledges arising from the sites of innovative activity, and to ensure the widest possible distribution of the questions, the debates and the insights that must inform the growing vitality of the system.

- **System-foresight:** The extensive investment made in Research and Technology Foresight in 1998 has not been followed up with further exercises of this kind.