R&D and Innovation Capabilities in South African State-Owned Enterprises: The Case of the South African National Energy Development Institute

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EXECUTIVE SUMMARY

This case study research report, commissioned by the Department of Science and Innovation (DSI), analyses R&D and innovation capabilities in the South African state-owned enterprise, the South African National Energy Development Institute (SANEDI). It situates SANEDI within its unique innovation system, examining five key dimensions within the organisation: networks, technological capabilities, human capabilities, research infrastructure, and governance. The report also documents plans and strategies that SANEDI has set in place to develop its R&D and innovation capabilities. Where possible, the analysis is punctuated with examples of the SOE's R&D and innovation outputs as well as some of the available unit-level R&D Survey data reported by SANEDI.

Formed in 2011 as the joint successor to the South African Energy Research Institute (SANERI) and the National Energy Efficiency Agency (NEEA), SANEDI is a Schedule 3A state-owned entity under the executive authority of the Department of Mineral Resources and Energy (formerly the Department of Energy). SANEDI's mandate, as set out in the National Energy Act (Act No. 34 of 2008), comprises both energy efficiency, on the one hand, and energy research and development, on the other hand. This mandate encompasses a responsibility to optimise the "utilisation of finite energy resources" in South Africa, as well as a large range of R&D and innovation roles, including performer, promoter, adviser, funder, capacity builder, and transferor of technology. Reporting to the mineral resources and energy minister, SANEDI's mission encompasses the use of "applied and energy research and resource efficiency to develop innovative, integrated solutions that will catalyse growth and prosperity".

As a relatively small and new actor within a 'busy' national and global energy institutional landscape, characterised by both policy uncertainty and dynamism, collaboration and partnership is framed by SANEDI as central to its R&D and innovation capabilities and, by extension, its ability to deliver on its mandate. SANEDI works with a plethora of both local (i.e. national) partners as well as international partners. These partnerships cut across both public and private sectors and enable SANEDI to share the costs, risks and rewards of joint work, as well as to validate the implementation of new technological solutions within specific community or municipal contexts. The organisational capacity of SANEDI to manage its collaboration portfolio—its partnering function—is codified and includes a stakeholder engagement team and accompanying strategy and governance mechanisms to ensure the 'health' and appropriate management of inter-organisational relationships.

As a dedicated R&D performer, SANEDI has a well-established R&D programme focused on applied energy research and demonstration, with six sub-programmes: Cleaner Fossil Fuels; Smart Grids; Working for Energy; Data and Knowledge Management; Cleaner Transport; and Renewable Energy. Since its formation, SANEDI has built a substantial track record of technological capability within these areas, given expression through several ongoing and closed projects and initiatives. Notable examples include a carbon capture, utilisation and storage project, with a Pilot Carbon Dioxide Storage Project with substantial investment from the World Bank (transferred to the Council for Geoscience during 2020), a number of smart grid projects aimed at improving the capacity of municipalities to operate sustainable electricity distribution financial models, and an array of rural community-focused renewable energy initiatives targeting poor communities.

SANEDI retains a small core of R&D personnel, in addition to the corporate support services staffing component of the organisation, comprising key functions such as administration, finance, IT and human resources. Most of SANEDI's R&D personnel are trained engineers or scientists, which include a number of leading industry experts previously employed in private and public companies or government departments. As an organisation with

a concentration of energy R&D and innovation expertise, SANEDI is a vital site for the development and growth of energy R&D and innovation human capability within the South African National System of Innovation, as well as for the development of the field of energy studies within the global south.

Counter to larger-scale R&D-performing SOEs, SANEDI is in fact, rather 'thin on the ground' when it comes to research infrastructure that it owns or maintains. Its research infrastructure requirements, nevertheless, are substantial in some project instances. Where it does not own or commission the infrastructure itself, SANEDI accesses research infrastructure through collaboration with universities, non-profit organisations, other SOEs, and municipalities across the country and internationally. Limited financial support has necessitated it not accumulating a mass of research infrastructures, such as laboratory or demonstration equipment, or software programmes, a strategy that compels it to join forces to scale its efforts or experiment with new technological approaches.

At the level of governance of R&D and innovation, SANEDI's board comprises several senior-ranking officials across key line ministries, such as the Department of Science and Innovation. For nearly half a decade, various interim CEOs have held terms of office, reflecting an ongoing leadership sustainability challenge for SANEDI. This relates closely to the findings of the recent institutional review of SANEDI, recommending greater attention be paid to the organisation's capacity to sustain its activities financially and locate its value proposition within the energy R&D and innovation landscape. A further area where there is a paucity of information concerns the strategies to be adopted to commercialise SANEDI-owned technologies to ensure public value is derived from the suite of public investments made by SANEDI and its partners.

One critical question addressed in the research contributing to this case study report is which dimension(s) could be instrumental in gearing SANEDI's R&D and innovation performance. As a small SOE that performs vital applied R&D, and other innovation activities, in a transforming and dynamic energy sector, collaboration with universities and other organisations is critical to gearing the SOE to use its R&D and innovation outputs to achieve its mandate more efficiently and effectively. Clearly, it is through collaboration that SANEDI can acquire technological capability, resources, and infrastructure. But collaboration also helps SANEDI's R&D personnel acquire new knowledge and build capacity, and validate and quality assure its projects. Indeed, SANEDI's strong partnering function can, in part, be attributed to its robust R&D and innovation governance—that is, the generally effective and supportive management environment enabling the entity to secure the right collaborative partners and funding on an ongoing basis. Equally, a strategic approach, including the appointment of a new CEO beyond its interim appointments, is required to ensure the organisation selects the appropriate topics to co-invest or partner and does not 'spread itself too thin'.

SUMMARY FINDINGS AND PRELIMINARY RECOMMENDATIONS

Finding	Preliminary recommendations
Despite policy uncertainty and dynamism, SANEDI is extremely well-positioned, as a South African SOE, to take advantage of the convergence of interest and political will within the domain of clean energy more broadly to grow and sustain its applied R&D and innovation agenda.	Effectively linking local research needs to regional and global urgencies is vital to continue technological capability and energy R&D field-building.
To the extent that SANEDI has not yet fully established or sufficiently deepened its intellectual property management core competencies, it may remain constrained in its ability to deliver a financial return on R&D or innovation investment.	The growing domain of professional IP and technology transfer practice, given expression through forums and organisations such as the Southern African Research and Innovation Management Association and the Innovation Bridge, could further enable capability building within this domain.
The considerable accumulated knowledge and technological capability inherent in the SANEDI R&D and innovation personnel, and its portfolio of ongoing and closed projects, represents a strategic asset for both SANEDI and the broader South African government. The diversity of energy topics and partnerships into which SANEDI has invested resources reflects an impressive and contemporary range of initiatives with varying degrees of potential for scalability and impact, as well as substantial learning in the localisation of technology for social and economic impacts.	The opportunity to build from this technological capability, learning and stock of accumulated knowledge in future by SANEDI should not be overlooked, as part of the organisation's institutional alignment, following its institutional review in 2018/19.
SANEDI's focus on strong corporate governance of stakeholder relationships represents an important capability that allows the organisation to expand and deepen its suite of partnerships.	A strategic approach is required to ensure the organisation selects the appropriate topics to co-invest or partner and does not 'spread itself too thin'.

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ACRONYMS

CGS	Council for Geoscience
CO2	Carbon Dioxide
CSIR	Council for Scientific and Industrial Research
CeSTII	Centre for Science, Technology and Innovation Indicators
DST	Department of Science and Technology
DSI	Department of Science and Innovation
DoE	Department of Energy
DMRE	Department of Mineral Resources and Energy
EARTH	Equine Assisted Riding, Therapy and Healing
EDI	Electricity Distribution Industry
EPWP	Expanded Public Works Programme
ESI	Electricity Supply Industry
EWSETA	Energy, Water Education and Training Authority
HSRC	Human Sciences Research Council
RECORD	Renewable Energy Centre on Research Development
REEP	Renewable Energy and Energy Efficiency Partnership
R&D	Research and Experimental Development
TIA	Technology Innovation Agency
UNISA	University of South Africa
SANEDI	South African National Energy Development Institute
SANDF	South African National Defence Force
SARDA	South African Riding for the Disabled Association
SANCO	South African National Council of Chambers
SAYC	South African Youth Council
SOE	State-Owned Enterprises
PFMA	Public Finance Management Act
PetroSA	Petroleum Oil and Gas Corporation of South Africa
UNIDO	United Nations Industrial Development Organisation
UNFCCC	United Nations for Climate Change
NYDA	National Youth Development Agency
OECD	Organisation for Economic Co-operation and Development

1 | INTRODUCTION

Formed in 2011 as the successor to the South African Energy Research Institute (SANERI) that was established during 2006 that reported to the Department of Science and Technology and the National Energy Efficiency Agency (NEEA), SANEDI, established under Chapter 4 of the National Energy Act, 2008 (No 34 of 2008), is a state-owned entity under the executive authority of the Department of Mineral Resources and Energy (DMRE). SANEDI's mandate comprises both energy efficiency and energy research and development, a mandate that encompasses a responsibility to optimise the "utilisation of finite energy resources" in South Africa, as well as a large range of R&D and innovation roles, including performer, promoter, adviser, funder, capacity builder, and transferor of technology. Reporting to the mineral resources and energy minister, SANEDI's mission encompasses the use of "applied and energy research and resource efficiency to develop innovative, integrated solutions that will catalyse growth and prosperity".[1]

This case study research report, commissioned by the Department of Science and Innovation (DSI), describes and analyses SANEDI's R&D and innovation capabilities. It situates SANEDI within its unique innovation system, examining five key dimensions within the organisation: human capabilities, technological capabilities, networks, research infrastructure, and governance. The report also documents plans and strategies that SANEDI has set in place to develop its R&D and innovation capabilities. This includes most notably, a stakeholder engagement strategy encompassing SANEDI's efforts to pursue its strategic objectives through different forms of collaboration and partnership with a broad range of national and international actors.

In terms of structure: Section 2 describes the research methodology followed in the preparation of this report; Section 3 describes the study's analytical framework; Section 4 presents and discusses research data in relation to the study's analytical framework; and Section 5 discusses challenges and opportunities for SANEDI in respect of its R&D and innovation capabilities and plans.

Solar hot water technology, West Coast, 2019. [Image credit: Katharine McKenzie]

1 https://www.sanedi.org.za/About%20us.html, last accessed 14 May 2020.

2 | RESEARCH METHODOLOGY, IN BRIEF

Research questions

The research methodology adopted in the preparation of this case study is an exploratory, qualitative mixed-methods approach, which was applied in the context of a larger three-case study project, of which this report is one output.[2] This research aimed to answer the following question and sub-questions: **To what extent and how are South African SOEs geared—in terms of their human and technological capabilities, networks, research infrastructure and governance—to perform R&D and innovation?** Two stated sub-questions emphasise a present and future orientation studied in this research:

- **Sub-question 1**: What are the current human and technological capabilities, networks, research infrastructure and governance of SOEs to perform R&D and innovation?
- **Sub-question 2**: What strategies or plans do SOEs have in place to develop these dimensions?

Definitions of R&D and innovation

Research and experimental development (R&D) is defined, in this study, according to the OECD's Frascati Manual (2015), and innovation is defined according to the OECD's Oslo Manual (2018). These definitions are given as:

- **Research and experimental development (R&D)** comprise creative and systematic work undertaken in order to increase the stock of knowledge—including knowledge of humankind, culture and society—and to devise new applications of available knowledge.[3]
- **Innovation** is defined as a new or improved product, or process (or a combination thereof) that differs significantly from the unit's previous products and processes and that has been made available to potential users (product) or brought into use by the unit (process).[4]

It is important to note that, in studies of innovation, R&D is considered one 'innovation activity' among others.

Data collection and preparation

In terms of developing an in-depth understanding of SANEDI necessary for its preparation, the study team engaged primary sources, notably SANEDI's 2015/16, 2016/17, 2017/18 and 2018/19 integrated annual reports, as well as corporate brochures and other grey literature sources, such as presentations, magazines or news articles. Some of these materials were shared with the research team by SANEDI, while some were located through keyword web searches.

Five semi-structured interviews with key informants from SANEDI were administered at the organisation's Gauteng offices to supplement these information sources.[5] Key informants included a range of senior and assistant research management staff, senior scientists, and one executive-level staff member.[6] Interviews were semi-structured, which involved a clear list of questions (see *Synthesis Report* for full interview schedule) and the expectation of some flexibility around the sequence in which questions are asked. Respondents were offered space to elaborate more broadly about question topics and follow up with the research team telephonically, in-person, or by email.

2 A more detailed account of the research methodology is included in the annexures of the *Synthesis Report*, accompanying this report.

3 Organisation for Economic Co-operation and Development (OECD), Frascati Manual: Guidelines for Collecting and Reporting Data on Research and Experimental Development. OECD Publishing: Paris, 2015.

4 Organisation for Economic Co-operation and Development (OECD), Oslo Manual Guidelines for Collecting, Reporting and Using Data on Innovation, 4th Edition, OECD Publishing: Paris, 2018.

5 Interviews took place on 22 October 2018.

6 Cited in this report respectively as **INTERVIEW.ROLE DESCRIPTION. CASE STUDY NUMBER, DATE**: ITV.SPEC.CS1, 22 October 2018; ITV.SMAN1.CS1, 22 October 2018; ITV.SMAN2.CS1, 22 October 2018; ITV.AMAN.CS1, 22 October 2018; ITV.EXEC1.CS1, 22 October 2018.

In terms of data preparation, audio recordings of interviews were transcribed in full. Data was descriptively coded by grouping and categorising transcribed statements into the study's five dimensions.[7] Due to the limited number of key informant exchanges, no specialist coding software was required. Report writing, critical review, and improvement took place concurrently, commencing in April 2019 and concluding in final draft form in December 2020.

Ethical considerations and dissemination

The study's researchers produced and explained informed consent forms to key informants before each interview. In line with consent forms, key informants remain anonymous in the draft written reports and access to the original recordings and transcriptions is restricted to CeSTII researchers. It was expressly agreed with key informants at the time of interviews that draft reports would be shared with SANEDI key informants first to correct any inaccuracies and, as part of the validation of the research. This took place during 2020 and 2021. The validated reports will be shared widely with the relevant government departments, other researchers, and the general public, for further validation and to enhance the dissemination and uptake of the research findings.

7 R. Tesch, Qualitative Research, Types and Software Tools. Falmer Press: New York, 1990. Also: J. Saldana, 2016. The Coding Manual for Qualitative Researchers. Sage: London.

3 | ANALYTICAL FRAMEWORK

Concept of gearing

Unlike the concept of gearing in financial accounting, which reflects the proportion of debt to equity, 'gearing' from an automotive perspective refers to the engine and gears' capacity and action, working together to alter a vehicle's rate of acceleration. The study team chose this as a useful organising concept for the research—to help shape our assessment of the extent to which SOEs are prepared, ready, and capacitated through R&D and innovation to deliver public value to the South African people. The study team hypothesises that if an SOE is *gearing*—or indeed, *geared*—appropriately, then it is in a position to leverage R&D and innovation to achieve its mandate efficiently and effectively. If not, then a set of questions could be invited of SOE shareholders, leaders and managers as to what investment or organisational change is required—if at all—to facilitate the development of R&D and innovation capabilities in the future.

A caveat is in order: While there are indicators against which SOEs can report on their R&D and innovation activities to their shareholders, for example, within integrated annual reports, the findings of this case study research are not generalisable to the extent that they can provide a normative framework for 'gearing' (which is to say that if a given SOE meets certain pre-defined criteria, then it is geared 'correctly', and vice versa). Instead, the study team has aimed in preparing this report to develop a set of qualitative suggestions, based on the individual case study's research data, for consideration by national policymakers and SOE organisational leaders in determining future plans for R&D and innovation within the specific SOEs studied. Indeed, more SOE case study research could, in the future, contribute empirical evidence to allow for generalisability of findings, which could further enhance indicator development and evidence-based policymaking within this domain.

Systems approach

State-owned enterprises, like non-state firms, are actors within particular national policy and industrial systems that span a range of boundaries, both commercial, technological, political and geographical.[8] When it comes to R&D and innovation, SOEs are also nested within particular knowledge and technical systems (innovation systems) that can enable and/or circumscribe their capacity. The systemic nature of R&D and innovation, therefore, represents a conceptual starting point for this research, and **Figure 1** below illustrates the position of an SOE (black box) in relation to its regulatory forces, market demand (brown oval), global value chains, national and international framework conditions, as well as the knowledge flows (black lines) and interactive relationships (green lines).

8 BÅ Lundvall, *Product Innovation and User-Producer Interaction, Industrial Development.* Research Series 31, Aalborg University Press: Aalborg, 1985.

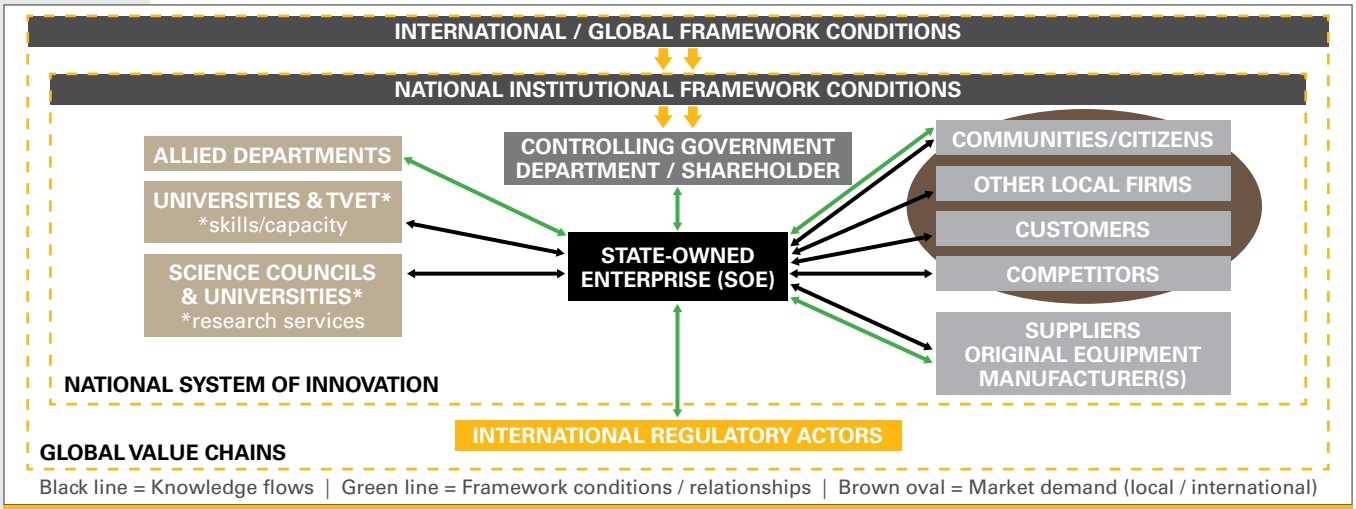

Figure 1: SOEs are nested within technical and knowledge systems as well as national policy and industrial systems [Source: CeSTII]

R&D and innovation capabilities of the SOE: Five study dimensions

Within this systems context, this case study focuses on five dimensions *within the organisation*—the unit of analysis—to assess SANEDI's readiness to perform R&D and innovation in line with its mandate. These dimensions, defined in more detail below and in no particular order, are human capabilities; technological capabilities; networks; research infrastructure; and governance. The particular dimensions were developed during stakeholder consultations held in 2017 with SOEs and government departments, which identified areas for investigation through case study research.[9] A critical assumption the study team has made is that the nature of how these dimensions are established (or nascent) can affect the way the organisation operates and, therefore, its ability to deliver goods and services to customers within the constraints of its resource base.

Human capabilities

The ability of people as a whole or as individuals to perform and manage their affairs successfully is how the OECD defined human capabilities in 2006.[10] In the specific context of this research, human capabilities refer to the abilities of R&D and innovation personnel within a given state-owned enterprise to generate R&D and innovation outputs and outcomes in line with their organisational mandates.

Technological capabilities

In this study, technological capabilities refer to the entity's ability, based on its accumulated knowledge, to perform R&D and innovation, which results in new technological knowledge development to achieve positive results.[11] Similarly, technological capabilities, as defined by Guerra and Carmago in 2016, refer to the ability of a firm to execute a technical function.[12] Following these definitions, technological capabilities within this research include technologies and knowledge of technologies.

Networks

Networks, as defined in this research, incorporates relationships enacted by and through SOE personnel and institutional processes and the form of formal partnership agreements and/or informal collaborative work undertaken in the conduct of R&D and innovation activities.[13] Partners or collaborators could be private firms, professional bodies, other SOEs, universities, or other actors. Networks have the potential to increase R&D and innovation productivity and performance through transferring skills and expertise through inter-organisational knowledge flows.[14]

Research infrastructure

The 2016 *South African Research Infrastructure Roadmap* (SARIR) defines research infrastructure as facilities, resources and services used by the scientific community across all disciplines for conducting cutting-edge research for the generation, exchange and preservation of knowledge.[15] According to the SARIR definition, this includes major facilities, equipment or sets of instruments, collaborative networks and knowledge-containing resources such as collections, archives, databanks and biobanks, and research infrastructures may be single-sited, distributed, or virtual. To all intents and purposes, SOEs require access to research infrastructure in order to conduct cutting-edge research, which in turn nurture and sustain the SOEs R&D and innovation capabilities.

Governance

Governance, read in a corporate context as opposed to a national or international context, according to Camay and Gordon refers to systems, processes, policies and structures available to direct, manage and control an organisation.[16] Governance also involves the effective and equitable allocation and management of resources for the common good.[17] Following these definitions, this research interprets governance of the SOE broadly, focussing on actors within the SOE (as opposed to external governance actors) and focussing specifically on R&D and innovation activities.

9 See Key Outcome 7.4 and 7.5 in ANNEXURE A: KEY OUTCOMES FROM THE CLUSTER WORKSHOP ON PUBLIC RESEARCH AND DEVELOPMENT (R&D) INVESTMENT TRENDS AND POLICY IMPLICATIONS DATE: 13 APRIL 2018, UNION BUILDINGS.

10 Organisation for Economic Cooperation and Development, Development Assistance Committee (OECD-DAC), *The Challenge of Capacity Development: Working Towards Good Practice*. OECD DAC, DAC Network on Governance (GOVNET), 2006.

11 PA Zawislak & FM Reichert, Technological Capability and Firm Performance. *Journal of Technology Management and Innovation*, 9 (4), 2006, p. 21.

12 Guston, D. A & Sarewitz, D, *Shaping Science and Technology Policy: The Next Generation of Research*. The University of Wisconsin Press: Madison, 2014.

13 R. Hamann & F. Boulogne, Partnerships and Cross-sector Collaboration. In: R. Hamann, R., Woolman, S. and Sprague, C., eds., *The Business of Sustainable Development in Africa: Human Rights, Partnerships, Alternative Business Models*. Pretoria: Unisa Press, 2008, pp. 54-82.

14 G. Kruss, *Creating Knowledge Networks: Working Partnerships in Higher Education, Industry and Innovation*. HSRC Press: Cape Town, 2006.

15 South African Research Infrastructure Roadmap (SARIR), 1st edition, Department of Science & Technology, 2016.

16 P. Camay & AJ Gordon, *Evolving Democratic Governance in South Africa*. The Co-operative for Research and Education (CORE): Johannesburg, 2004.

17 Ibid., p. 17.

4 | ANALYSIS: HOW IS SANEDI GEARED TO PERFORM R&D AND INNOVATION?

This section aims to provide a holistic description of the sectoral innovation system of which SANEDI may be considered to form part and a basis for more in-depth discussions using the study's key dimensions. The first important starting point for our analysis is a description of the SANEDI mandate, business model, and operating context. A second starting point is an illustration and a brief description of the SANEDI R&D and innovation system's key features. A third starting point is the analysis of a limited amount of SANEDI unit-level data from the SA R&D Survey to assess R&D expenditure trends.

SANEDI mandate, business model and operating context

Mandate

The South African Energy Research Institute (SANERI) and the National Energy Efficiency Agency (NEEA), both established in 2005 within the Central Energy Fund (CEF) where SANERI was established as a company within CEF and NEEA was established as a division of CEF but which reported via SANEDI, were the predecessor organisations prior to the establishment of SANEDI in 2011. Formed as a merger of these entities and effectively spun out of the CEF, SANEDI is an independent Schedule 3A state-owned entity.[18] Its formation took place in the context of Chapter 4 of the National Energy Act, 2008 (Act No. 34 of 2008).

A critical difference between SANEDI and its predecessors is the component of 'development' (rather than simply research). As set out in the National Energy Act (Act No. 34 of 2008), the mandate of SANEDI comprises both energy efficiency and energy research and experimental development (R&D). This mandate encompasses a dual responsibility to optimise the "utilisation of finite energy resources" in South Africa and a large range of R&D and innovation roles, including performer, promoter, adviser, funder, capacity builder, and transferor of technology. SANEDI is uniquely positioned to contribute to South African energy R&D capability in both its organisational history and its mandate.

Business model and strategy

A business model expresses the rationale of how an organisation delivers value to its customer(s).[19] In the case of SANEDI, its value proposition includes two 'core' programmes, namely Applied Energy, Research, Development, Demonstration and Deployment ('Applied R&D'), with its array of six sub-programmes (**Figure 2**), as well as Energy Efficiency, which is principally concerned with contributing to the efficient and effective management of the Section 12L tax incentive.[20]

These core programmes are flanked by a third core programme, Governance and Administration. Core programmatic services delivered by SANEDI are paid for through a combination of an annual Parliamentary appropriation as well as funding from national and international sources.[21] In terms of its recent financial performance, revenue in 2018/19 of R117.4 million, down from R142.6 million in 2017/18, exceeded expenses of R90.1 million, resulting in a surplus for the financial year ended March 2019. Revenue was made up of government grants and subsidies totalling R97.1 million in 2018/19, with the balance including consultancy income and accrued interest.[22]

18 A Schedule 3A state-owned entity is a particular sub-class of 155 National Public Entities (as at May 2019) contemplated in the Public Finance Management Act (No. 1 of 1999). See: http://www.treasury.gov.za/legislation/pfma/public%20entities/2019-05-24%20Public%20institutions%20Sch%201-3D.pdf

19 J. Magretta, Why Business Models Matter, *Harvard Business Review* (May 2002). Available at: https://hbr.org/2002/05/why-business-models-matter, last accessed 4 March 2019.

20 According to the SANEDI magazine, *Insights 2019/20*: "The energy efficiency savings allow for a tax deduction of 95c/kWh saved on energy consumption across all energy carriers, including gas, coal, liquid fuels or any energy carrier (excluding renewable energy)." Available at: https://www.sanedi.org.za/img/Events/Sanedi%20Insights2020FINALNW4singles.pdf

21 In the 2016/17 financial year, SANEDI raised six Rands for every one Rand allocated to it by Parliament. See SANEDI Annual Report 2017/18, p. 26.

22 SANEDI Annual Report 2018/19, pp. 94-136.

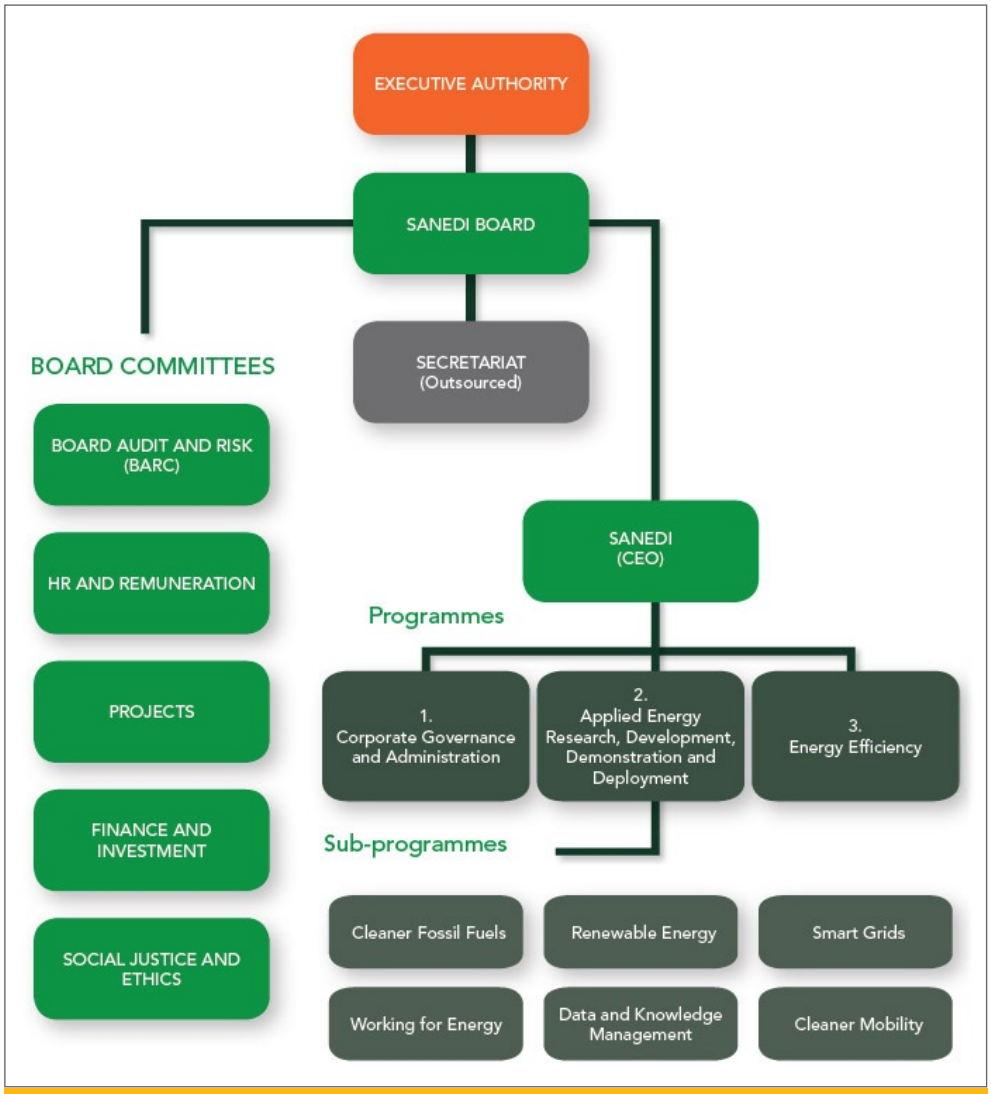

Figure 2: SANEDI corporate and board structure [Source: SANEDI Annual Report 2018/19]

In terms of strategy, the 2018/19 SANEDI annual report, themed "Innovation for Life", includes a "Strategy Map" with the vision statement "Leading responsive smart energy" and the mission statement "To provide energy knowledge-based solutions towards a sustainably responsive energy sector for improved quality of life for all in South Africa". The strategy's two goals include: "A resilient, efficient, effective and enabling delivery environment that is aligned to/complies with all statutory requirements"; and "Energy innovation, knowledge and skills for a less carbon-intensive, more environmentally sustainable, affordable and efficient energy system".[23]

Operating context

In 2022, the energy sector in South Africa continues to face a plethora of both immediate and long-term challenges, which have been widely reported on and discussed in the South African and international public sphere in recent years.[24] By all accounts, the most pressing is restoring public confidence in and financial health to Eskom, in the context of ageing coal-based generation and transmission infrastructure, the rapidly escalating cost of electricity for individual and commercial consumers, persistent load-shedding, and the legacies of state capture. Longer-term, climate change and the demands that this places on countries and industries to reduce emissions and adopt renewable energies represents wider risks and urgencies.[25] In current research and policy discourse, this is reflected in the relatively novel

23 Ibid., p. 18.

24 For one articulation of current challenges, see T. Hancock, 'Local energy not managed efficiently', *Engineering News* online. Available at: https://m.engineeringnews.co.za/article/local-energy-not-managed-efficiently-2020-05-08/rep_id:4433, last accessed on 14 May 2020.

25 See for an accessible data update, 'The state of the climate in 2021'. Available at: https://www.bbc.com/future/article/20210108-where-we-are-on-climate-change-in-five-charts

concept of the 'just transition'[26] in the context of South Africa's historic minerals-energy complex.[27] Policy uncertainty has been a feature of the South African energy sector, to the extent that subsequent administrations have placed different emphases on components of the country's 'energy mix' (for example, the relative weighting of nuclear to other sources, but also the opening of bid windows for the Independent Power Producers (IPPs)). Out of this uncertainty, arguably, has arisen a situation of policy dynamism, where policy options are also rapidly changed.

On the upside, as it were, the sector is also characterised by rapidly advancing technological development and substantial opportunities for existing and new actors to participate in the country's energy transition.[28] In his foreword to SANEDI's 2018/19 annual report, interim board chairperson, Nkululeko Buthelezi, elegantly describes a "glimpse" of a democratised energy system in South Africa and the potential of technological development in this context:

> *The past few years have seen accelerated technology development across a broad spectrum of platforms, including solar PV and wind power, micro grids, artificial intelligence, smart infrastructure, electric vehicles and battery storage. This revolution of technology and platforms allows us to glimpse a future of democratisation of electricity, a move away from bulk delivery systems to a community-, home-, and business-based energy system. It's an exciting time in the energy sector, with all these developments converging to enable an effective response to energy security, climate change challenges and ambitions for electricity for all as encapsulated in the Sustainable Development Goals (SDGs).*[29]

As shown above, the work of SANEDI takes place within a context of both policy uncertainty as well as dynamism. Usefully, the SANEDI 2018/19 annual report contains a detailed situational analysis covering its service delivery environment, organisational environment, and policy and legislative developments impacting the work of the organisation. Among the key issues raised in the situational analysis include:

- **Service delivery environment**: Increasing energy demand globally, rising CO2 emissions, the adoption of the Paris Agreement by South Africa committing to a low-carbon future; and South African-specific challenges related to the adoption of clean energies, including within the commercial sector, transportation, municipalities, and cities;
- **Organisational environment**: The organisational review of SANEDI, concluded in 2018/19, as part of refining its position within the landscape;
- **Policy and legislative developments**: Green Transport Strategy (2018-2050) and the introduction of the Carbon Tax Act (2019).

Situating SANEDI within an R&D and innovation systems context

An illustrative mapping of the sectoral R&D and innovation system of which SANEDI forms a part is provided in **Figure 3** below. This is not an exhaustive account of the system but serves to illuminate for the purposes of analysis the interconnections and linkages between the organisation and the systemic determinants of its performance. SANEDI operates within this context and is strategically positioned, within its sectoral system of innovation, to play a catalytic role in terms of R&D and innovation-driven change.

The illustrative mapping of this system in **Figure 3** illustrates the linkages with formal knowledge producers, such as universities (local and international) and science councils, which enable critical knowledge and information flows. It also showcases several linkages between SANEDI and local and international energy regulatory and funding organisations. Notably, the presence of a range of policy frameworks points to the strategic positioning of SANEDI within the South African energy policy environment, an environment it must

26 The International Trade Union Confederation defines a Just Transition as follows: "A Just Transition secures the future and livelihoods of workers and their communities in the transition to a low-carbon economy. It is based on social dialogue between workers and their unions, employers, government and communities. A plan for Just Transition provides and guarantees better and decent jobs, social protection, more training opportunities and greater job security for all workers affected by global warming and climate change policies."

27 See L. Baker, P. Newell & J. Phillips, The Political Economy of Energy Transitions: The Case of South Africa, *New Political Economy*, Vol. 19, Issue 6, pp. 791-818.

28 See for example, GreenCape's Market Intelligence Report (2020). Available at: https://www.greencape.co.za/assets/ENERGY_SERVICES_MARKET_INTELLIGENCE_REPORT_20_3_20_WEB.pdf, last accessed on 14 May 2020.

29 SANEDI Annual Report 2018/19, p. 11.

navigate in terms of its programming and its broader organisational strategy. Within the global environment, key framework conditions include climate change, as mentioned, and Industry 4.0, both of which already intersect in complex ways with existing policy, economic and governance frameworks. The substantial number of international funders with which SANEDI interacts is perhaps a reflection of an actor well-positioned, both in terms of its mandate, governance, and capabilities, to deliver value-added outputs in response to the requirements of these actors. These key aspects of the energy innovation system provide a context for the analysis of key informant data, presented below.

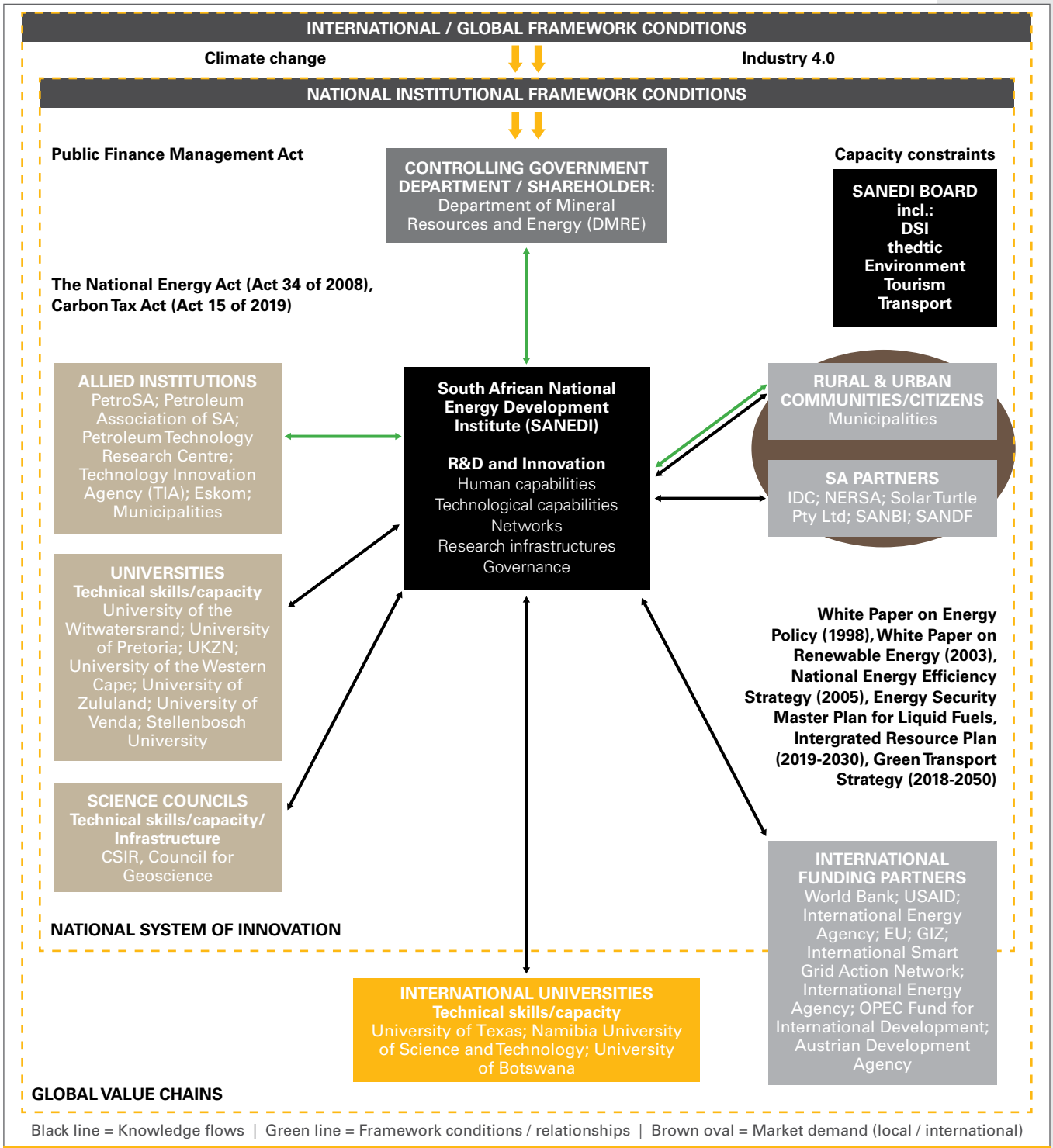

Figure 3: Mapping of SANEDI R&D and innovation system*

*Note: This mapping is indicative rather than exhaustive

R&D expenditure trends (2012/13 to 2017/18)

A perhaps unsurprising result of its variable funding model, SANEDI's R&D expenditure fluctuated substantially over the five years 2012/13 to 2017/18 (**Figure 4**). R&D expenditure, as shown, is the sum of both expenditures on labour and research infrastructure. Labour costs include researchers, research executives and managers, technicians directly supporting R&D, and other personnel directly supporting R&D. Research infrastructure includes land, vehicles, machinery and other equipment, and structures. The trends of gradual growth are noted between 2013/14 and 2014/15 financial years, with a sharp increase and decline between 2014/15 and 2015/16 and 2015/16 and 2016/17 respectively.

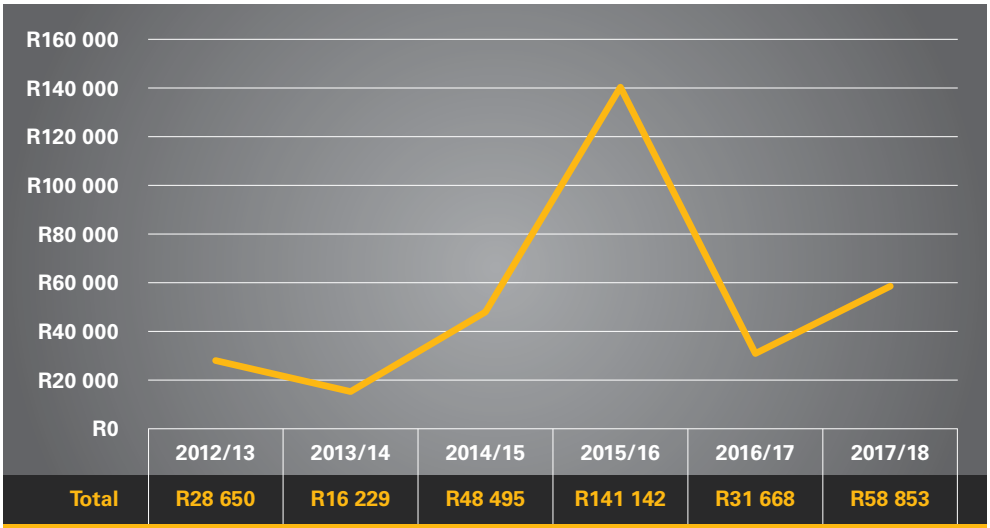

Figure 4: Total R&D expenditure (R'000) at SANEDI (2012/13 to 2017/18). [Source: SANEDI; CeSTII]

SANEDI has consistently reported spending about 90 percent of its R&D budget on applied research and about 10 percent on experimental development, a ratio that is in keeping with its mandate.[30] When benchmarked against total R&D expenditure in the SOE sector for the years where comparative data is available, SANEDI's contribution is marginal (**Table 1** and **Figure 5**). Importantly, the relative size of its expenditure to the SOE sector could be read as an indication of its limited capacity to absorb and manage financial resources relative to other SOEs, rather than an indication of the viability of energy R&D as a site for public R&D investment.

Table 1: Comparison of SANEDI R&D expenditure with SOE total R&D expenditure (2012/13 to 2017/18)

Year	Number of R&D performing SOEs	SOE total R&D expenditure (R'000)	SANEDI R&D expenditure (R'000)	Proportion of SANEDI to SOEs
2012/13	19	R1 512 021	R28 650	0.02
2013/14	19	R1 609 771	R16 229	0.01
2014/15	19	R2 019 919	R48 495	0.02
2015/16	18	R1 973 416	R141 142	0.07
2016/17	16	R2 621 883	R31 668	0.01
2017/18	16	R2 536 374	R58 853	0.02

30 SANEDI; CeSTII R&D Survey. See the section on human capabilities below for a critical discussion on the researcher: administrator ratio at SANEDI.

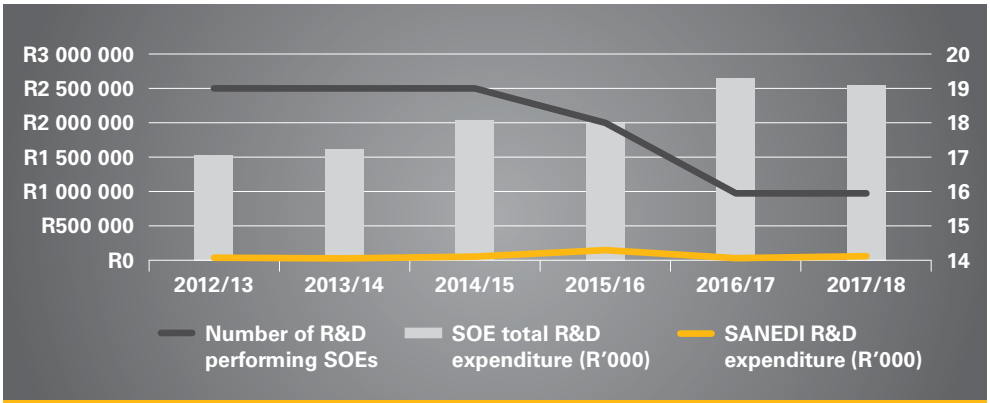

Figure 5: SANEDI benchmark against SOE R&D expenditure, including number of R&D performers (2012/13 to 2017/18) [Source: CeSTII]

Summary of system mapping and R&D data trends

As far as its annual budget is concerned, SANEDI is a comparatively small-scale organisational actor within one of the most important South African economy sectors: energy. Its R&D expenditure is marginal compared to the total R&D expenditure of SOEs, reinforcing its modest position within the national system of innovation, broadly, and R&D-performing SOEs, specifically. Despite its relative size and scale, SANEDI is strategically positioned within the energy R&D and innovation 'space' in South Africa to the extent that it works on a variety of topical issues, with a variety of key national and international actors—funders, companies, universities, communities, inter alia—in executing its mandate. While local exigencies such as South Africa's key socio-economic challenges of poverty and inequality persist, key global urgencies for SANEDI include climate change and Industry 4.0.

Analysis of five dimensions of R&D and innovation capability

This section assesses the extent and ways in which SANEDI is gearing to perform R&D and innovation by examining the data collected on each dimension outlined in the conceptual framework. By studying key informant interview data and information derived from desktop research, this section aims to provide an empirical basis for discussing challenges and opportunities for R&D and innovation capability building at SANEDI. The study team chose R&D and innovation networks as a logical starting point. As illustrated in the discussion and **Figure 3** above, it is principally through collaboration and partnership that SANEDI develops its R&D and innovation outputs accesses finance and expertise and leverages research infrastructure.

R&D and innovation networks

As a relatively new actor within a 'busy' national and global energy institutional landscape, collaboration and partnership is framed by SANEDI as central to its R&D and innovation capabilities and, by extension, its ability to deliver on its mandate. From the interviews and desktop research conducted, it was evident that SANEDI works with a plethora of both local (i.e. national) partners and international partners (summarised in Table 2). It was also evident that these partnerships cut across both public and private sectors and enable SANEDI to share costs, risks, and joint work rewards. Critically, stakeholder engagement is also often a vital pre-requisite for successfully implementing its project work, whether in terms of

localising a new technology or securing buy-in from community stakeholders for new experimentation.

The SANEDI 2018/19 annual report showcases the type of national and international/global actors with which SANEDI has established some form of relationship: from donor organisations, multi-lateral agencies, private companies, South African government departments, academic and research institutions, and communities (see **Figure 7** overleaf). The organisational capacity of SANEDI to manage its collaboration portfolio—its partnering function[31]—is codified and includes a stakeholder engagement team and its accompanying strategy and governance mechanisms to ensure the 'health' of partnerships (**Figure 8**).

> *The emphasis of the Stakeholder Engagement Strategy is on improving the quality and frequency of interactions with Stakeholders in order to create a supportive, collaborative environment within which SANEDI can fulfil its mandate and achieve its strategic priorities. There is an engagement plan for each Stakeholder. In addition, a scorecard, a risk Management process and a supporting budget to support the strategy.*[32]

It continues:

> *The approach taken is based on the International AA1000 Stakeholder Engagement Standard. The outputs are fully congruent with the Global Reporting Initiative (GRI) G4 Guidelines and International Integrated Reporting Council (IIRC) reporting requirements, even though this is not a requirement for a SoE.*[33]

Table 2: R&D and innovation collaboration between SANEDI and sectoral actors (national and international)*

PARTNER	SECTOR	COUNTRY	FOCUS OF COLLABORATION
GIZ	FUNDER	GERMANY	R&D
United Nations Industrial Development Organisation (UNIDO)	MULTI-LATERAL ORGANISATION - GLOBAL	GLOBAL	R&D
World Bank	FUNDER	GLOBAL	R&D
Anglo-American	BUSINESS SECTOR - SA	GLOBAL	R&D
Norwegian Embassy	FUNDER	NORWAY	R&D
University of Pretoria	HIGHER EDUCATION/ RESEARCH - SA	SOUTH AFRICA	Bursaries/Training
University of the Witwatersrand	HIGHER EDUCATION/ RESEARCH - SA	SOUTH AFRICA	R&D
University of the Western Cape	HIGHER EDUCATION/ RESEARCH - SA	SOUTH AFRICA	Bursaries/Training
University of KwaZulu-Natal	HIGHER EDUCATION/ RESEARCH - SA	SOUTH AFRICA	R&D

Continues overleaf...

31 G. Ralphs, Partnership and organisational capacity: An exploratory study of the partnering function in research organisations in Southern and East Africa. Research report prepared for the Donor Partnerships Division at the International Development Research Centre. 2012.

32 SANEDI Annual Report 2018/19, p. 68.

33 SANEDI Annual Report 2018/19, p. 68.

PARTNER	SECTOR	COUNTRY	FOCUS OF COLLABORATION
University of South Africa	HIGHER EDUCATION/ RESEARCH - SA	SOUTH AFRICA	Bursaries/Training
University of Venda	HIGHER EDUCATION/ RESEARCH - SA	SOUTH AFRICA	Bursaries/Training
University of Zululand	HIGHER EDUCATION/ RESEARCH - SA	SOUTH AFRICA	R&D
Council for Scientific and Industrial Research (CSIR)	SCIENCE COUNCILS - SA	SOUTH AFRICA	R&D
Council for Geoscience (CGS)	SCIENCE COUNCILS - SA	SOUTH AFRICA	R&D
Technology Innovation Agency (TIA)	SCIENCE COUNCILS - SA	SOUTH AFRICA	R&D
Eskom	BUSINESS SECTOR (SOCs) - SA	SOUTH AFRICA	Innovation
PetroSA	BUSINESS SECTOR (SOCs) - SA	SOUTH AFRICA	R&D
National Youth Development Agency	GOVERNMENT - SA	SOUTH AFRICA	R&D
National Development Agency	GOVERNMENT - SA	SOUTH AFRICA	R&D
University of Fort Hare	UNIVERSITY	SOUTH AFRICA	R&D
Walter Sisulu University	UNIVERSITY	SOUTH AFRICA	R&D
Stellenbosch University	UNIVERSITY	SOUTH AFRICA	R&D
University of Texas	HIGHER EDUCATION/ RESEARCH - US	USA	R&D
Bureau of Economic Geology	GOVERNMENT - US	USA	R&D
Batelle	NON-PROFIT COMPANY - GLOBAL	USA	R&D

*List is not exhaustive

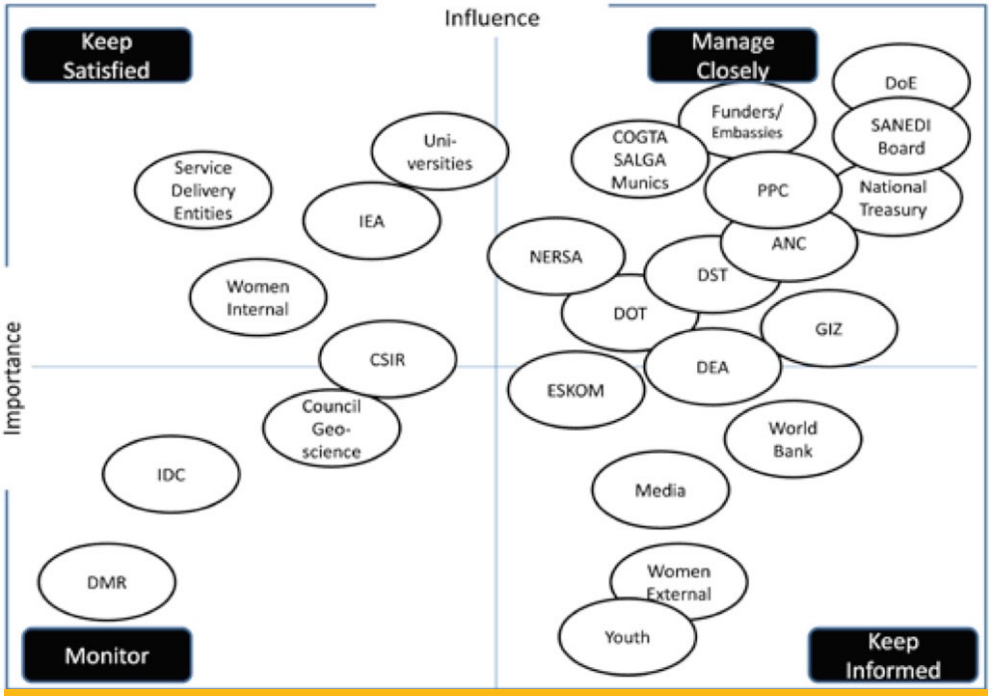

Figure 6: SANEDI stakeholders and management approach [Source: SANEDI Annual Report 2018/19]

		Stakeholder Influence on the Organisation			
		No Influence	Low Influence	Some Influence	High Influence
		Stakeholders' support for the organisation has lesser impact on success		Stakeholders' support for the organisation has greater impact on success	
Organisational Impact on SANEDI- [importance]	Stakeholder is highly dependent on SANEDI, they have no choice	**Keep Satisfied:** Treat them fairly, honour commitments: policy, regulations, industry norms		**Manage Closely**: Invest in engagement process to manage concerns and develop solutions	
	No direct impacts - stakeholders have broad range of choice	**Monitor:** Low priority - provide access and information		**Keep informed** Keep involved and informed	

Figure 7: Stakeholder management matrix [Source: SANEDI Annual Report 2018/19]

SANEDI personnel also participate in various research and policy action networks, such as the International Smart Grid Action Network, and the Southern African Solar Thermal Training & Demonstration Initiative (SOLTRAIN), to name just two.

Summary of networks dimension

SANEDI is a highly active collaborator, both with diverse organisations in South Africa, such as universities, companies, government institutions, and internationally, with multi-lateral organisations and funders. To all intents and purposes, these relationships enable SANEDI to leverage critical human, financial and knowledge resources and access infrastructure, work with communities, conduct scientific experimentation, diffuse technologies, and influence policy processes. SANEDI has codified its collaboration work in terms of the Stakeholder Engagement Strategy, which it manages in line with global best practices.

Technological capabilities

> *I can assure you, South African know-how, our technical capability is world-class. We have demonstrated on numerous occasions that we compare equally to anybody in the world.*[34]

This quote from a SANEDI executive, considered a field leader, suggests a positive outlook for South African technological capability development in the domain of energy research and development. How can SANEDI's technological capabilities be mapped at a high level?

Within its Energy Efficiency programme, SANEDI is responsible for overseeing the application process for the Section 12L tax incentive—an area of SANEDI's work not covered in detail in this report. SANEDI's 'core' R&D and innovation activities—and its accumulated technological capabilities—are largely concentrated within its Applied Research, Development, Demonstration and Deployment (thereafter, 'Applied R&D') programme. The Applied R&D programme comprises six sub-programmes (see **Figure 2** above), each of which contains a range of active and closed projects and dedicated centres focusing on particular issues or topics. Reflecting on the development of the SANEDI mandate and organisation in the late 2000s, a senior executive from SANEDI described the unique 'space' for the organisation in this way:

> *We negotiated that SANEDI should focus on applied research. We are not in the fundamental research space, and we focus on mainly taking our concepts out there and linking them to an industry problem and using technology as an enabler for change to achieve and solve industry problems.*[35]

This section describes in some detail four selected areas of SANEDI's applied R&D work, including, to the extent possible, specific project examples and histories. Our goal? To describe, at a high level, the extent and nature of SANEDI's accumulating technological capabilities within and across several key energy topics and highlighting key themes and cross-cutting issues. The four topical areas are Cleaner Fossil Fuels; Working for Energy; Smart Grids and Network Automation; and Renewable Energy.[36] It is this stock of knowledge and the accompanying capacity to leverage this knowledge base, that we refer to as technological capabilities.

34 ITV.EXEC1.CS1, 22 October 2018

35 ITV.EXEC1.CS1, 22 October 2018

36 The Data and Knowledge Management and Cleaner Mobility sub-programmes were not covered in sufficient depth in the interviews conducted to warrant discussion in this report. However, the study team were made aware of these sub-programmes and their contribution to the total stock of applied R&D performed by SANEDI on an annual basis.

Topic 1: Cleaner Fossil Fuels—Carbon Capture Utilisation and Storage (CCS)[37]

The South African government's interest in CCS—a technique to store large volumes of carbon dioxide (CO_2) in porous geological formations beneath the earth's surface (**Figure 8**)—predates the establishment of SANEDI to the early 2000s, when several countries signed the Carbon Sequestration Leadership Forum Charter, a country-level international climate change initiative.[38] Soon after, in 2004, the Department of Minerals and Energy[39] commissioned the CSIR to prepare a "report on the potential for carbon sequestration in South Africa".[40] This research paved the way for a workshop on the topic in 2006, and subsequently, the formation of the Centre for Carbon Capture and Storage, hosted by SANEDI, which was initially jointly supported by, inter alia, the South African government, South African Industry, Norwegian governments and international organisations.[41]

In 2013, five years after SANEDI's establishment, SANEDI initiated its Pilot CO_2 Storage Project (PSCP) as part of the Cleaner Fossil Fuels sub-programme. Partially funded by the International Bank for Reconstrustion and Development acting as Administrator of the Carbon Capture and Storage Trust Fund (the World Bank), the PSCP's first phase involved in-depth geological assessment and multi-stakeholder processes in determining possible conducive storage sites in South Africa (**Figure 8**).[42] [43] Initial prospecting gave rise to two potential onshore sites—the Algoa Basin in the Eastern Cape province and the KwaZulu-Natal Zululand Basin.[44] In terms of leveraging the country's accumulated technological capabilities from its early interest in CCS, SANEDI's 2017/18 annual report describes the substantial analytical work required to ensure the successful deployment of CCS in the South African context:

> *The CCS research and investigations have continued focusing on the broader requirements for the development of technology in South Africa. Two studies were completed during the 2017/18 year: Firstly, the Business Case for continued CCS in South Africa*

Figure 8: Illustration of depth level for CCS. [Source: SANEDI]

37 In late 2020, after the primary research for this case study had been performed, the SANEDI CCS initiative was migrated to the Council for GeoScience. Other initiatives within the Cleaner Fossil Fuels sub-programme include studies on shale gas performed on behalf of the Department of Energy, as well as work on the use of CO_2 to product synthetic fuels.

38 http://www.cslforum.org/

39 The Department of Minerals and Energy was split into separate line ministries in 2009. In 2019, the departments were merged again, to form the Department of Mineral Resources and Energy (DMRE).

40 S. Hietkamp, A. Engelbrecht, B. Scholes and A. Golding, 'The potential for sequestration of carbon dioxide in South Africa', CSIR. Available at: http://playpen.meraka.csir.co.za/~acdc/education/CSIR%20conference%202008/Proceedings/CPO-0027.pdf, last accessed 15 May 2020.

41 TITV.SPEC1.CS3, 22 October 2018

42 Sites at Zuluand and Algoa were among the initial sites scoped. SANEDI, *Prospectus: addressing climate change through CCS technology*: The South African Centre for Carbon Capture and Storage Programme, 21 February 2018, pp. 4-5.

43 ITV.SPEC1.CS3, 22 October 2018

44 Offshore sites were excluded owing to cost factors, according to a SANEDI manager interviewed for this study.

was completed. The aim of the project is to develop a business case for continued research into CCS activities in the country and to assist decision-makers with reasons why continued support of CCS is necessary. Secondly; an assessment of CO_2 utilisation technologies and their suitability for implementation in South Africa. Instead of storing carbon dioxide, it may be more appropriate to use the gas as a chemical feedstock, especially if one can use renewable energy in the process. The aim of the project is to assess all carbon utilisation technologies currently considered or employed internationally and recommend those that are appropriate for South Africa.[45]

By 2018/19, SANEDI's Interim CEO, Dr Thembakazi Mali, reported the conclusion of the PSCP second phase agreement of USD 23 million between SANEDI and the World Bank's CCS Trust Fund. As Mali explained in the 2018/19 SANEDI annual report:

The purpose of the PCSP is to test CO2 injection and sub-surface storage under South Africa geological conditions and build capacity and expertise for South African professionals to prepare for commercialisation. […] The ideal site for the pilot project has been identified in the Bhongwana Basin in KwaZulu-Natal (KZN) Province. A Memorandum of Agreement (MoA) was signed with the KZN Department of Economic Development, Tourism and Environmental Affairs (EDTEA) as a partner in the PCSP, thus creating capacity in KZN as well as developing KZN industry participation in the PCSP.[46]

This brief account of SANEDI's progress on CCS points to the value of long-term strategic STI investment by the South African government: from an initial or exploratory approach, in the early 2000s, to a more focussed international partnership. The key SANEDI expert, who has spearheaded South Africa's CCS work over two decades, participated in a research interview for the purposes of the current study. He explained:

So we started from a zero base in 2002 to where we are now. And at that stage, there was nobody interested, really. But we built it up slowly. So now we have a national-wide institutional capacity.

As a result, the scientist pointed out, CCS is mentioned three times in South Africa's National Development Plan.

Underpinning this example, of course, are lessons such as continuity in terms of the key industrial experts currently employed by SANEDI to drive the work in the South African institutional and scientific context. The SANEDI CCS team reported to the study team that a novel approach is to be explored within the CCS World Bank project, which encompassed cross-programme collaboration, includes exploring how renewable energy solutions can be harnessed within the context of the CCS plant in order to halve the cost of the energy required.[47] During 2020, on ministerial approval, the CCUS Programme was transferred from SANEDI to the Council for Geoscience.

Topic 2: Smart Grids and Network Automation

The SANEDI Smart Grids and Network Automation ('Smart Grids') sub-programme, located within the Applied R&D programme umbrella, was introduced in 2014.[48] This initiative includes various project types to test and deploy solutions within the South African Electricity Distribution Industry (EDI).[49] At a strategic level, SANEDI aims to provide a common vision for smart grids in South Africa; facilitate a smart grid knowledge-sharing forum for both the Electricity Supply Industry (ESI) and relevant government departments; implement applied research pilots within municipalities to introduce several Smart Grids concepts, and provide strategic policy inputs related to smart grids and the ESI.

45 SANEDI Annual Report 2017/18, p. 39.

46 SANEDI Annual Report 2018/19, p. 13.

47 ITV.SPEC1.CS3, 22 October 2018

48 A smart grid is an electricity network that integrates two infrastructures, electrical infrastructure and information and telecommunication infrastructure.

49 SANEDI Annual Performance Plan 2016.

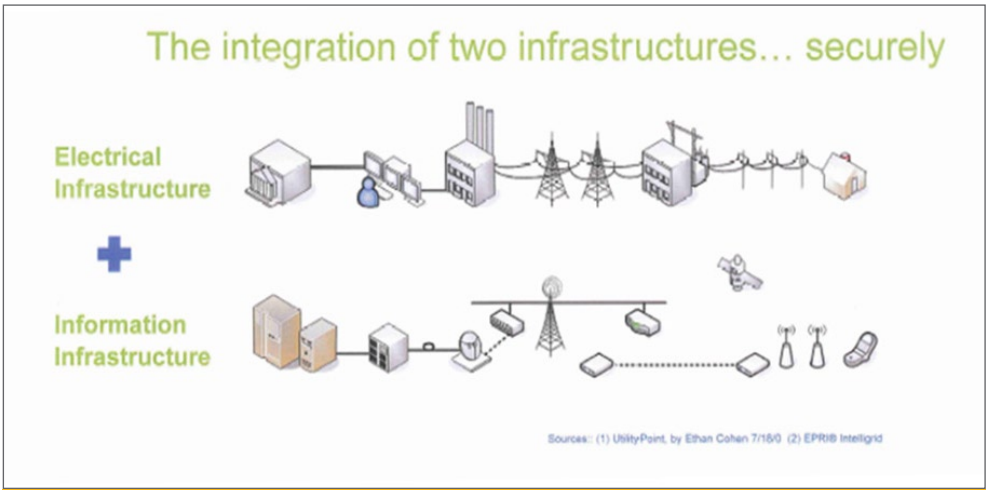

Figure 9: Smart Grids securely integrate electricity generation with information infrastructure. [Source: EPR]

By securely integrating electricity generation with information and data infrastructure, smart grid solutions have provided SANEDI with a means to support South African municipal electricity distributors to accommodate changing systems requirements and to work toward sustainable operational and financial models for the provision of electricity to end-users (**Figure 9**).[50] To improve service delivery, smart grid technology also enables the use of integrated systems and processes in the municipal environment, to enable efficiencies and effectiveness. **Box 1** includes brief accounts of two municipalities that have benefitted from the activities of this sub-programme.

A key issue noted by an executive of SANEDI in relation to intellectual property protection specifically, in relation to South African technological capability in the domain of smart grids was given expression in this frank vignette:

> *Eskom invented the pre-payment metering concept in early 1990 when it embarked on its electrification drive. It needed a cost-effective means to deliver electricity to the poor in areas where people did not have a formal street address and post boxes. This posed a problem to Eskom at the time concerning providing the customer with an electricity bill. Out of the need to give the customer an electricity bill, pre-payment metering was born. . The concept of a pre-payment meter has over the year evolved into what is known today as a smart meter. This original South African innovation is now imported into the country at a considerable cost, all because we did not protect our intellectual property.*

50 Ibid., p. 39.

Box 1: Building capacity at municipal level to implement smart grids

In the Dr Ruth Segomotsi Mompati district of South Africa's North West province, residents and business owners of the Naledi Local Municipality faced widespread electricity cuts in early 2017 owing to non-payment of accounts. In response, the implementation of a SANEDI Revenue Enhancement Project, encompassing smart grid principles, was implemented with the aim of assisting Naledi municipal authorities to better manage revenue. The project reportedly helped the Naledi municipal authorities to reduce revenue losses from 23 percent to 9 percent.

The Smart Grids programme in the Mogale City Municipality, within the West Rand District, Gauteng province, is another example of SANEDI work. During the 2016/17 financial year, the Mogale City Local Municipality completed the renovation of old kiosks with tamper-proof kiosks and the deployment of 600 fully functional smart meters that are integrated into the municipality's existing billing and the vending system as part of a revenue improvement project.

In 2018/19, SANEDI's smart grid collaboration with the University of Pretoria resulted in training sessions attended by officials from municipalities, government departments and relevant service providers. The goal? To introduce smart grid technologies and trends within power system control operations to South African municipalities. The training focused on smart metering, audits, and installation practices and advanced metering infrastructure for revenue improvement in South Africa.

SANEDI's work on smart grids reflects an impressive track record of experimentation—and impact—within municipal contexts. It has transferred technology, and in this process, contributed to public value goals of improved service delivery.

Topic 3: Renewable Energy

The Renewable Energy sub-programme of SANEDI's Applied R&D programme focuses on facilitating and coordinating renewable energy research, development and demonstration through collaboration with local and international organisations in the renewable energy domain. In particular, it focuses on technology transfer and information exchange to deploy and commercialise sustainable, efficient, reliable, cost-competitive and environmentally sound renewable energy technologies. Through programme activities and in collaboration with other organisations, SANEDI seeks to make the best use of local resources that expand energy production and create an environmentally sound energy sector. The Working for Energy (WfE) initiative, discussed in more detail below, falls within the broader ambit of the SANEDI Renewable Energy sub-programme.

Through this programme, SANEDI has established Centres of Research and Development (CORDs) that focus on research, development and innovation for the energy sector, promotion of technologies, skills development and collaboration. A manager reflected on the purpose of the CORDs as akin to technology platforms:

> *We facilitate renewable energy research within the country,through our various technology platforms. We bring people together that have an interest in a particular technology, could be PVs, which is one of our platforms, and it could be industry research institutions, government, anyone who has an interest in it. And so we form a platform with those various stakeholders. But before we do, we look into the research that has been done in that particular technology. So, we do a scan of—it's not very detailed, but it highlights the topics that the different institutions, especially research institutions, have covered in that technology. And from there, we identify*

the gaps in what exactly has not yet been done. So in that platform we formed, we look into collaborative funding of perhaps filling up the gaps that have been identified in the scan. So, SANEDI, our RECORD, facilitates this all, you know, we initiate it, and going forward, we nominate someone to run with it, especially from the research institutions.[51]

Box 2: Renewable Energy Centre of Research and Development (RECORD) and Southern African Solar Thermal Training & Demonstration Initiative

RECORD was established in 2011 as key initiative within its Renewable Energy sub-programme. As a research centre within SANEDI, it coordinates renewable energy R&D projects in South Africa with a focus on large-scale grid-connected renewable energy and domestic-scale initiatives. RECORD promotes collaboration among research organisations by forming research groups to avoid duplication and optimise the use of scarce resources. Its main partners are the Deutsche Gesellschaft Fur Internationale Zusammenarbeit (GIZ) GmbH, as funder; as well as the CSIR and various South African universities. RECORD focusses on three technological capabilities: waste-for-energy, biodiesel and biomass.

Waste-for-energy: generating electricity from landfill waste and pollution, including energy generation processes (electricity, heat) from incineration waste.

Biodiesel: vegetable oil or animal fat-based fuel consisting of long-chain alkyl (methyl, propyl or ethyl) as a renewable, clean-burning diesel replacement.

Biomass: biological material from plants and some animals that can be turned into fuel.

A second SANEDI initiative within its Renewable Energy sub-programme is the Southern African Solar Thermal Training and Demonstration Initiative (SOLTRAIN). SOLTRAIN supports SADC countries in transitioning from largely fossil fuel energy supply systems to more sustainable systems based on renewable energy in general, and on solar thermal energy in particular. The project is funded by the Australian Development Agency and OPEC Fund for International Development (OFID).

In 2018, RECORD entered into a five-year agreement with the South African National Defence Force (SANDF). The partnership, which encompasses the SOLTRAIN initiative, involves, inter alia, upgrading hot water supply for two bungalows at an SANDF base in Limpopo province. Solar Heating (SWH) systems are designed to reduce the use of electricity and/or backup diesel generators in bungalows with defunct hot water geysers. Through this project, SANEDI has been able to provide training programmes on renewable energy applications, energy efficiency, and SWH and presents clean energy awareness programmes at several military bases in the country.

A key component of SANEDI's applied R&D programming, as demonstrated briefly, is convening or mobilising actors around particular energy-related problems and technologies. This approach foregrounds the value of concentrating expertise to address specific practical problems at a larger scale than may be possible through individual action. Also part of its Renewable Energy sub-programme is the Working for Energy initiative, discussed in detail below.

51 ITV.AMAN.CS1, 22 October 2018

Topic 4: Working for Energy

The Working for Energy (WfE) initiative, located with the SANEDI Applied R&D programme under the Renewable Energy sub-programme, is a clean energy initiative of the Department of Mineral Resources and Energy (DMRE), implemented by SANEDI. Notably, the WfE also forms part of the Expanded Public Works Programme's (EPWP), and echoes the approach of similarly named programmes, such as Working for Water or Working on Fire.[52] The purpose of WfE is to develop clean energy access and solutions for rural and low-income communities across South Africa.[53] At the time of writing this report in 2020, WfE had nearly been in operation for a decade and had gained traction with the rollout of its project pipeline in the provinces of KwaZulu-Natal, Limpopo, Gauteng, Eastern Cape, Northern Cape and the North West (examples in **Box 2**).[54]

The WfE sub-programme focuses on applied research, demonstration and implementation of clean energy solutions, as well as energy use in communities, Early Childhood Development (ECD) organisations, and schools, including energy for cooking, lights and other energy usage.[55] Through a partnership with entities such as the National Development Agency, WfE has delivered a range of energy projects, emphasising the use of natural resources, appropriate technologies, cost-effectiveness, and the socio-economic benefits to the participating communities.

> *So, if there are residential spaces, there is a demand for catering, accommodations, cooling and so on, which would be the greatest. So, in that regard, you look at the whole energy utilisation for those facilities, right? So, in the kitchen, it will be electricity/energy for cooking and energy for cool storage and energy for water heating. It would be a lot for waste being produced. There would be issues of lighting, chances are 24-hours lighting. There will be, well, those kinds of issues. So, the question will be, what renewable energy intervention to institute to ensure that those facilities use as little energy as possible.*

Box 3: Biogas digester implementation stories

In 2016/17, SANEDI's Working for Energy sub-programme implemented several biogas projects: in Melani village in the Eastern Cape province; in Sharpeville in Gauteng province; Mpfuneko in Limpopo province's Greater Giyani local municipality; and Vryburg in the North West province.

The Melani biogas project was implemented in partnership with the University of South Africa and the University of Fort Hare. Sixteen balloon and dome digesters were installed.

A greening project in Sharpeville, in which schools in the area were provided with solar energy heating, efficient lighting, and biogas digesters.

In Mpfuneko village, biogas digesters were installed in 51 households, and out of 51 only 31 households have their biogas digesters fully operating. The project has a number of benefits, including production of bio-fertilisers, which are used in the household gardens to improve crop production and ensure food security; reduction of reliance on firewood for cooking; reduction of energy costs associated with fuel wood; and, education of community members about the use of alternative cleaner technologies.

In the North West's Vryburg area, the biogas project implemented 20 solar water heaters in all the dormitories on campus. This connected to a water purification system in the area since the water underground that was used was hard and obstructed the water reticulation systems of the facility.[56]

52 SANEDI Annual Report 2016/17, p. 37. Also: Human Sciences Research Council (HSRC), 2007. *Mid-term review of the EPWP. Synthesis report*. HSRC: Cape Town. Introduced in 2004/5, the EPWP is a nationwide programme aimed at providing poverty and income relief through temporary work for the unemployed South Africans. Due to its incorporation within the EPWP, WfE is also required to fulfil the mandate of EPWP, particularly in terms of skills development, job creation and environmental benefits through energy services delivery.

53 SANEDI Annual Report 2018/19, p. 36.

54 Ibid., p. 37.

55 One example is biogas digesters. Digesters use bio waste to produce energy as biogas used for different applications such as cooking.

56 SANEDI Annual Report 2016/17, p. 38.

During the 2018/9 financial year, WfE worked in partnership with UNISA through the EXXARO Chair for the advancement of micro-digester research and the South African Riding for the Disabled Association (SARDA) now known as Equine Assisted Riding, Therapy and Healing (EARTH), on a biogas project (also known as SARDA biogas project) in Ruimsig, Gauteng province.[57] The SARDA biogas project aimed to demonstrate the utility of horse manure as an alternative form of waste-to-energy available in the renewable energy mix. The outcome of the SARDA biogas project was that it was shown to be possible to use horse manure as feedstock.[58] During the 2018/19 financial year, WfE in collaboration with the National Youth Development Agency (NYDA), undertook a greening project in KwaZulu-Natal's Masisizane Early Childhood Development Centre in Kwa-Maphumulo. The project demonstrated the benefits of clean energy interventions on the operational efficiency of the Centre.[59] The same greening project took place at the Mhinga Early Childhood Development Centre in Vhembe district municipality in Limpopo, where the project demonstrated the possibility of creating small community enterprises. People received training through a collaboration between University of Venda, SANEDI and the United Nations Industrial Development Organisation (UNIDO).[60]

Recurrent challenges are encountered in the execution of these and other WfE projects. These concern what the sub-programmes leader, a senior SANEDI manager, referred to as "cultural issues" in the rural communities. Some pertinent examples included: difficulty in accepting the idea that human excrement can be treated and processed in such a way as to generate energy and fertiliser; vandalism and theft of public property; the relationship between cooking and the taste of food; as well as interpretations of new technology implementation as a rationale or basis for explaining broader changes in the weather. As the manager reflected:

> *So, you have those cultural issues and being a multicultural society, the reception of one of these technologies differ. Let me give you an example; you go to Limpopo, you say to people, bio-energy can work for you, instead of you cutting down trees, they say yes, we want technology, you provide everything from the beginning to the end. They say, 'By the way, it's cultural for us to have a smokey smell'. So whereas, on the other hand, we have similar cultural issues to the extent, and you say, by the way, you got a solar, this can work well for you. It will cut down electricity cost for you and chances are they say ever since we have put this it is no longer raining.*[61]

This brief discussion of the WfE initiative showcases some of the project instances but also substantive learning that SANEDI is engaged in with communities, in terms of the transfer and localisation of technologies within target communities.

Summary of technological capability dimension

SANEDI performs R&D and carries out innovation activities within a range of key energy topics. Its work on carbon capture and storage, smart grids, Working for Energy, and renewable energy, showcased in this section, points to a substantial accumulation of knowledge, learning, expertise and research output—technological capabilities. Owing to its funding relationships with a number of foreign government agencies or multi-lateral donors, continuity in programming once grant cycles are completed represents a potential strategic challenge in terms of how SANEDI consolidates its technological capabilities for social and economic impacts 'down the line'. Differently framed, the sustainability of SANEDI's R&D and innovation agenda is critical to the deepening of this capability.

57 SANEDI Annual Report 2018/19, p. 37.

58 Ibid.

59 Ibid.

60 Ibid.

61 ITV.SMAN2.CS1, 22 October 2018

In what ways is SANEDI geared to perform R&D and innovation in terms of its human capabilities? The study team found both strengths and challenges. On the side of strengths, SANEDI retains a 'core' of R&D personnel, in addition to its corporate support services staff comprising key functions such as administration, finance, IT and human resources. Most of SANEDI's R&D personnel are trained engineers or scientists, including leading industry experts with decades of experience in the sector. Due to the relative age of SANEDI, several research personnel were previously employed by multi-national corporations, such as SASOL and Anglo-American, the South African government, such as the energy ministry, and other state-owned enterprises, such as Eskom. A senior executive interviewed for this study reflected on the establishment of SANEDI's "research capability" as a coalescing of human capacities under one organisational umbrella:

> *To establish SANEDI, the then CEO, Mr Kadri Nassiep, was quite visionary in the way he approached it. He approached industry experts to come on board to build a research capability based on the guidance of people who have been in the industry doing this and could take this institution forward.*[62]

In terms of its composition, SANEDI's R&D team comprises a relatively modest in numbers team of researchers and technicians—26 such employees were reported in 2018/19—predominantly from the geoscience, IT and electrical engineering fields. Irrespective of its staff contingent's size, as an organisation with a concentration of energy R&D and innovation expertise, SANEDI is a vital site for the development and growth of energy R&D and human innovation capability within the South African NSI.

On the side of challenges, the issue of the skills gap was addressed by key informants. One respondent spoke about it in terms of bureaucratisation of research management procedures and protocols and an unbalanced technical to administrative and support staff ratio in relation to research personnel.

> *I think there are three admin people for every scientist here. It should be the other way around: it should be one admin person for every three scientist. […] You have a world of technical people who just want to get along and do the job. Planning: no problem. Reporting periodically: no problem. Then you have all the administration and compliance people, and they have different masters.*[63]

Similarly, another respondent noted that the organisation employed *"some highly skilled people, but a very concentrated few […] and you have a huge gap and a low level supporting that".*[64]

As pointed to in the earlier discussions, SANEDI R&D personnel gaps are augmented through partnerships and collaboration. In the case of a key SANEDI R&D project (described in more depth in the *Technological capabilities* section) focussed on carbon capture and storage, one programme management respondent explained the absolute necessity of collaboration with several national and international organisations to access the necessary skills but also software to ensure the execution of the initiative. The project's particular and specialised nature necessitated this reliance on diverse role-players for knowledge and infrastructural input. He explained:

> *Because we don't have a full team, we rely on external specialists because the project is very specialised. So, we have collaborations with the Council for Geosciences, who provide all the geoscientists we need, geophysicists, stratigraphers, and the engineers […] We work with the Petroleum Association of South Africa, who regulate the oil and gas industry, but they also have some very good people that do the seismic interpretation.*

62 ITV.EXEC1.CS1, 22 October 2018

63 ITV.SMAN1.CS1, 22 October 2018

64 ITV.EXEC1.CS1, 22 October 2018

Other examples of collaboration include an internship programme set up between SANEDI and the Technology Innovation Agency (TIA), which enables interns to gain experience in their chosen areas of interest.

Summary of human capability dimension

SANEDI has a very small R&D team. However, the team is supplemented by the collaborative partnerships the SOE established over the years. The partnerships benefit SANEDI in terms of expertise in the energy sector, research infrastructure, funding, and others.

Research infrastructure

Are South African SOEs sufficiently resourced in terms of access to research infrastructure to achieve their R&D and innovation goals? This question has served as a touchstone for the research team in exploring the issue of research infrastructure with SANEDI through the interviews and desktop research process. In contrast with larger-scale R&D-performing SOEs, such as the South African Forestry Company (SAFCOL), SANEDI is relatively 'thin on ground' when it comes to research infrastructure that it owns and/or maintains. As one senior manager explained:

> *We were at least supposed to have some of the basic research facilities, labs […] we have got very limited of that. Except […] through partnerships […] for instance […] in the Western Cape […] in which we have universities, institutions, donor organisations to entrench ourselves with research and development infrastructure. Right, but if we say, 'What does SANEDI own in terms of, you know, the labs and […] so on?', it is very limited but the ideal is to have a budget.*[65]

Its research infrastructure requirements, nevertheless, are substantial in some project instances. Much like in the case of skills gaps, SANEDI partners with actors in its external environment to mobilise access to vital research infrastructure in order to execute projects. One interviewee explained in more detail the nature of this approach, with reference to the CCS sub-programme.

> *And then we also have a collaboration with PetroSA. They're the only company, basically, that has got know-how in deep well oil and gas drilling. So, nobody else in South Africa drills two thousand metre holes with large diameter oil type using oil rigs […] So we have a good collaboration with them and we're also some of their know-how […] mainly drilling, seismic researchers and also geologists and stratigraphers […] And they also have very good in-house capability to do analytical work, because some of the requirements of this is that we need some of these large international programmes that can do these algorithms and build a three dimensional image […] They're used in the oil and gas industry, so most people buy them. They're very expensive, about three million dollars per package. So we at SANEDI can't go out and buy this thing.*[66]

As shown in the quote above, SANEDI's collaboration with universities and various organisations give the SOE access to crucial research infrastructure such as laboratories, equipment and other related facilities that are needed to conduct research. However, SANEDI has been deliberate or intentional about not over-capitalising on research infrastructures. As one SANEDI senior executive explained:

> *Now SANEDI as an entity does not have any laboratories. Currently we partner with the universities for that and our strategy is to collaborate, and we took a strategic decision not to re-create the laboratories and research centres.*[67]

65 ITV.SMAN2.CS1, 22 October 2018

66 ITV.SMAN1.CS1, 22 October 2018

67 ITV.EXEC1.CS1, 22 October 2018

This arguably reflects an intelligent approach, to the extent that large-scale research infrastructure of the type SANEDI may require for its R&D are prohibitive in terms of cost; but also that some of the applied research that SANEDI conducts uses existing municipal and/or other forms of physical or digital infrastructure as the 'laboratory' in which experimentation is carried out.

Summary of research infrastructures dimension

SANEDI accesses research infrastructure through collaboration with universities, non-profit organisations, other SOEs, and municipalities across the country as well as internationally. It has been intentional about not accumulating research infrastructure.

Governance

Governance is an increasingly critical concern for SOEs globally, and the OECD has published numerous guidelines on aspects thereof in recent decades.[68] In the South African context, iterations of the King Report in 1994 (I), 2002 (II), 2009 (III) and 2016 (IV), set an important foundation for the governance of SOEs, in tandem with the Public Finance Management Act and the Companies Act. In this context, South African SOEs are facing a crisis of public confidence, in the wake of recent state capture in entities such as Eskom, SAA and the SABC, but also the institutional memory of large-scale energy R&D investments by the state, such as the Pebble Bed Modular Reactor (PBMR), that have since been decommissioned.[69] But what is the state of governance at SANEDI, in so far as R&D and innovation are concerned?

In terms of the governance of R&D and innovation, the study team was interested at a high level in the systems, processes, policies and structures available to direct, manage and control the organisation's R&D and innovation activities. Principally, this concerns the role of executive management but also the board. Studying governance from this perspective can contribute to understanding how SOEs are supported through their institutional structures, including funding allocations and other mechanisms for new and improved ideas to flow through the organisation.

In terms of systems, processes, policies and structures for direction, management and control of SANEDI's R&D and innovation, there were at least four key issues that surfaced through the research process.

The first key governance issue concerns the leadership of SANEDI. The appointment of SANEDI Chief Financial Officer, Lethabo Manamela, to interim CEO position took effect on 1 May 2020.[70] Manamela's appointment followed several interim CEO appointments, including outgoing Dr Thembakazi Mali and Dr David Mahuma. The official reason for Mali's departure was that she had taken up a role in the private sector at SASOL. The lack of continuity in the top position of leadership at SANEDI is an issue only one interview respondent mentioned in passing, which is perhaps a signal of a relatively effective middle-management tier at the level of programming and corporate services.

A second key governance issue that has surfaced in recent years is the financial health of SANEDI and, linked to this, the viability of its overall value proposition. As one respondent said: *"You can't drive your country's technology innovation strategy on grant funding"*.[71] The institutional review of SANEDI performed in terms of its normal corporate governance points to this issue's particular nature. According to the SANEDI annual report for 2018/19, there were two main injunctions for SANEDI to be considered by the board:

68 Since the early 2000s, the OECD has homed in on SOE governance and governance reform. For example: Corporate Governance of State-Owned Enterprises: A Survey of OECD Countries, 2005; State-Owned Enterprise Governance Reform: An Inventory of Recent Change, 2011; Boards of Directors of State-Owned Enterprises: An Overview of National Practices, 2013; OECD Guidelines on Corporate Governance of State-Owned Enterprises, 2015; Broadening the Ownership of State-Owned Enterprises: A Comparison of Governance Practices, 2016; State-Owned Enterprises as Global Competitors: A Challenge or an Opportunity?, 2016.

69 The Pebble Bed Modular Reactor (PBMR), established in 1994 as a nuclear research and development company, employed approximately 700 personnel, who collaborated with over 600 personnel in universities and companies, before it was discontinued in 2010. Close to R10 billion was invested in the initiative, the bulk from the South African people.

70 M. Arnoldi, 'SANEDI appoints interim CEO'. 2 July 2020. Available at: https://www.engineeringnews.co.za/article/sanedi-appoints-interim-ceo-2020-07-02

71 ITV.EXEC1.CS1, 22 October 2018

Upon review of the findings, the board identified additional areas that needed to be covered in more depth, such as how the organisation can become more self-sustaining, and refocus its scope of work to create a niche market for itself within the industry.[72]

A third key governance issue concerns intellectual property capabilities. Even though SANEDI has a mandate and role as a transferor of technology, its strategic focus with respect to IP protection and its operational capability were not clearly visible to the study team. Despite this, several of the respondents reflected on key ongoing work that may require dedicated treatment.

A fourth key governance issue concerns what some commentators have referred to as "parachute"[73] science and technology. This refers to S&T solutions developed in one context and transplanted into another without considering the contextual factors that may inhibit, circumscribe, or constrain the solution's effectiveness. In almost all of SANEDI's experimental or developmental work reflected on in the interviews conducted for this study, this issue came to the fore. This was discussed in some detail in the section above in the context of the WfE programme. As one senior manager lamented:

So we have a situation with solar technologies where we were, lessons from the previous mistakes were not learnt properly. We are now sitting with a lot of solar heaters that are not implemented, therefore the capability to produce those, now the opportunity is stranded right. I am not going to venture into previous systems and other technologies and give you examples of those. It's a national issue because we have the capability of localising and also have the ability to frustrate all that we have created.

Summary of governance dimension

Four key governance-related aspects for SANEDI's R&D and innovation output surfaced through the interviews. These included, for example, continuity in terms of the leadership of the organisation; fiscal challenges in sustaining SANEDI R&D and the viability of its value proposition; intellectual property protection; and the issue of parachute science and technology. These issues point to broader governance challenges facing SOEs in South Africa more generally and SANEDI in particular, in the context of a highly dynamic energy institutional and political landscape.

72 SANEDI Annual Report 2018/19, p. 27.

73 See for example, L. Roldan-Hernandez, A. B. Boehm, and J. R. Mihelcic, 'Parachute Environmental Science and Engineering', in Environ. Sci. Technol. 2020, 54, 23: 14773-14774 https://doi.org/10.1021/acs.est.0c07462

5 | DISCUSSION: CHALLENGES AND OPPORTUNITIES FOR SANEDI R&D AND INNOVATION CAPABILITY BUILDING

The case study data is helpful to the extent that it contributes to a quantitative and qualitative snapshot of R&D and innovation at SANEDI at a point in time. What can we glean from this data about opportunities and challenges for capacity building in R&D and innovation at SANEDI? An equally important question is what factors might be crucial in gearing SANEDI to perform R&D and innovation effectively and efficiently in the future. The brief discussion that follows weaves together threads from the data described and analysed above.

A modest actor in the 'busy' energy R&D and innovation landscape

The energy R&D and innovation landscape can be characterised as 'busy' to the extent that South Africa faces substantial short-term energy-related challenges and challenges related to its longer-term transition from fossil fuel-based generation to renewable energy sources. In this context, there is significant policy uncertainty but also dynamism. A substantial number of national agencies and international and multi-lateral organisations remain intensely focused, on aspects of South Africa's energy challenges in their programming and investments. SANEDI is well-positioned, as a South African SOE, to take advantage of this convergence of interest to grow and sustain its R&D and innovation agenda, alongside the support it receives from the South African people.

The challenge of IP protection and commercialisation

Even though there are excellent examples of technology transfer by SANEDI, in public or municipal contexts, a substantial challenge faced by SANEDI is the challenge of ensuring not only the protection of the intellectual property emanating from its R&D and innovation activities but also commercialisation. Several respondents interviewed by the study team spoke to inadequate organisational capabilities in these areas. To the extent that SANEDI has not yet fully established or sufficiently deepened its competencies, it may remain constrained in its ability to deliver a financial return on R&D or innovation investment.

Accumulated knowledge and technological capability as a strategic asset

The considerable accumulated knowledge and technological capability inherent in the SANEDI R&D and innovation personnel, and its portfolio of ongoing and completed projects, represents a strategic asset for both SANEDI and the broader South African government. The diversity of energy topics and partnerships into which SANEDI has invested resources reflects an impressive and contemporary range of initiatives with varying degrees of potential for scalability and impact. The opportunity to build from this technological capability and stock of accumulated knowledge should not be overlooked.

The value of a stakeholder engagement strategy

SANEDI's focus on strong corporate governance of stakeholder relationships represents an important capability that allows the organisation to expand and deepen its suite of partnerships. Partnerships are vital to SANEDI in terms of gearing in the domain of human capabilities and infrastructure and ensuring that project requirements for stakeholder engagement are met.

CONCLUSION

This case study research describes, on the one hand, an organisation geared toward a robust foundational R&D and innovation capability, as well as a robust stakeholder engagement capability and capability to transfer technology in the public and municipal context. On the other hand, it is geared less toward IP protection and commercialisation to maximise return on R&D and innovation investments.

Due to its pivotal role in the country's future growth and development, the energy sector remains in national and international policymakers and business leaders' crosshairs. Energy R&D and innovation investments remain vital to the country's economic performance over the long-run, particularly as the sector transitions from its long-standing reliance on coal-fired power to diverse renewable energy sources, such as wind, solar, biofuels, and the like. In this context, SANEDI is uniquely positioned as a key contributor to the field of energy R&D and innovation studies and with the potential to showcase public value from the investments of South African taxpayers and those from foreign countries. SANEDI has built substantial capacity to conduct various applied R&D projects in its relatively short lifespan, from carbon capture and storage projects to projects focused on indigent South Africans in rural areas. This report has aimed to briefly showcase some of the challenges and opportunities associated with SANEDI's organisational performance as a whole, as well as specific aspects of its R&D and innovation performance more specifically.

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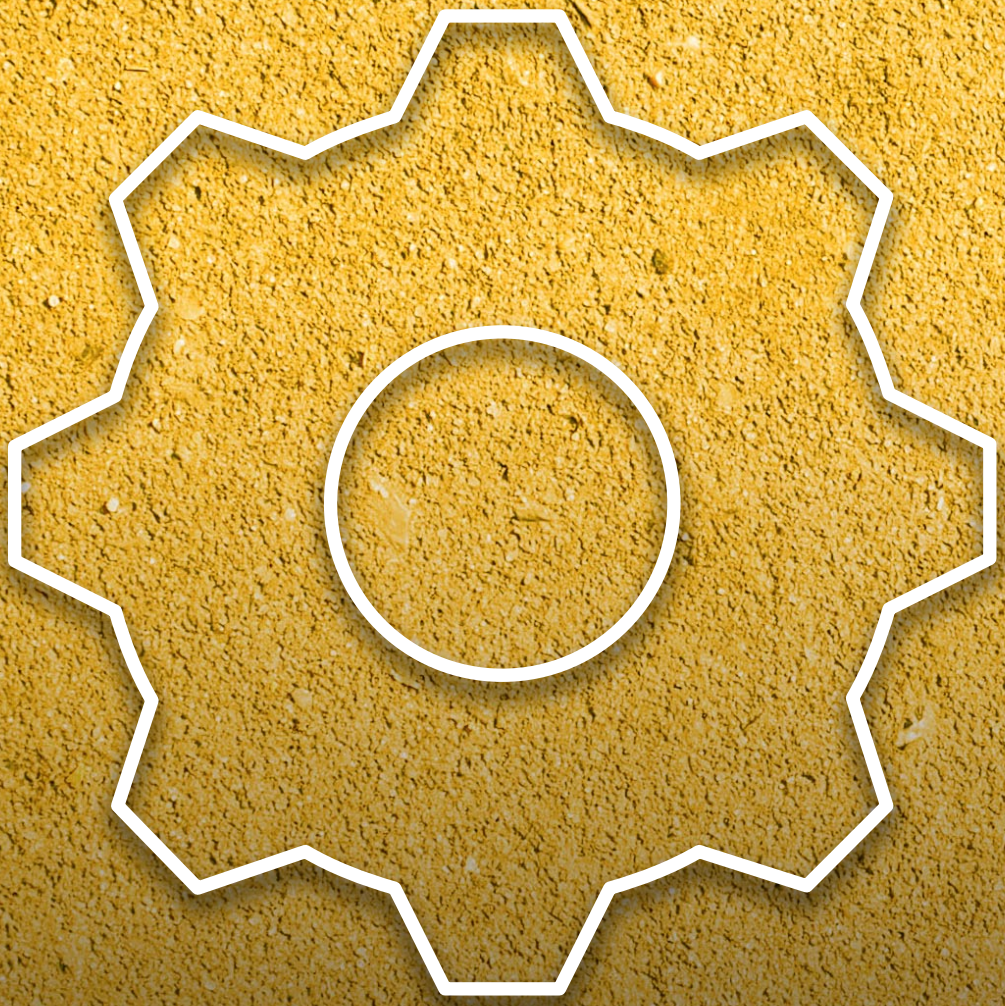

Working Paper Series on R&D and Innovation Capabilities in South African State-Owned Enterprises

State-owned enterprises (SOEs) are important national assets with a mandate to contribute to sustainable economic growth and South Africa's broad developmental goals. In March 2019, the Department of Science and Innovation (DSI), published the White Paper on Science, Technology and Innovation. This recognised the importance of SOEs in the South African economy and the need to revitalise them to play a meaningful role in South Africa's science, technology, innovation and economic development. As key institutions for human capital development and international and national knowledge sharing, the White Paper also aimed to position SOEs as innovation-driven for the knowledge economy. But to what extent and how are South African state-owned enterprises geared to perform R&D and innovation? Based on in-depth case study research with three SOEs—SANEDI, ATNS and SAFCOL—as well as analysis of the academic literature, the Human Sciences Research Council's Centre for Science Technology and Innovation Indicators (CeSTII) identified dimensions key to effective R&D and innovation 'gearing' by these SOEs, including: human capabilities; technological capabilities; networks; research infrastructure; and governance. Out of this research, indicators on R&D and innovation are also proposed to guide national policy discussion on the future of SOEs in South Africa.

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