2016/17
ANNUAL REPORT

CSIR

our future through science

OUR MANDATE

The Council for Scientific and Industrial Research (CSIR) was established on 5 October 1945. The CSIR's mandate is as stipulated in the Scientific Research Council Act, 1988 (Act 46 of 1988, as amended by Act 71 of 1990), section 3: Objects of CSIR:

"The objects of the CSIR are, through directed and particularly multidisciplinary research and technological innovation, to foster, in the national interest and in fields which in its opinion should receive preference, industrial and scientific development, either by itself or in co-operation with principals from the private or public sectors, and thereby to contribute to the improvement of the quality of life of the people of the Republic, and to perform any other functions that may be assigned to the CSIR by or under this Act."

The CSIR's Executive Authority is the Minister of the Department of Science and Technology.

science
& technology
Department:
Science and Technology
REPUBLIC OF SOUTH AFRICA

CONTENTS

ENGLISH

Foreword

by the Minister of Science and Technology

There is overwhelming global evidence to support the link between a country's investment in research and development (R&D) and its social and economic development and prosperity. Science and technology is a sector that most developed nations promote to foster their development. As a result of an understanding of these links, South Africa too has promoted science, technology and innovation through investment in R&D. This has been an important part of government's economic development strategy over the last two decades.

Science, technology and innovation are directly linked to providing South Africans with jobs through strengthening the competitiveness of our various industrial sectors and by creating new industries. Science and technology must ensure that the established parts of our economy continue to innovate in an increasingly competitive world so that we can derive the greatest benefit from our geographic advantages and resources. Improved support for innovation is therefore fundamental to sustainable economic growth, employment creation, improved service delivery and social development.

A key focus of the Department of Science and Technology (DST) and all its entities, is the implementation of the National Development Plan (NDP) and associated government strategies. The breadth of the research addressing the majority of the focus areas outlined in the NDP is encouraging. We have established a solid foundation in research on the economy and employment; a capable state; economic and social infrastructure; transitioning to a low-carbon economy; building safer communities; and improving health. These position us well for expanded R&D and implementation work to be done both here and in other parts of Africa.

Entrenched in the CSIR's mandate is using science and technology to improve the quality of life of South Africans. The organisation's imperative is to identify key determinants of poverty, inequality and unemployment and to draw the link between the research conducted and addressing these determining factors.

The CSIR plays a significant role in the National System of Innovation. Its skilled and multidisciplinary teams of scientists, engineers and researchers play a valuable role in addressing our country's most pressing needs and positioning South Africa as a prospering nation.

It is evident in this report that making a difference in our country and in Africa as a whole, remains a priority for the CSIR. As the largest research organisation on the continent, the CSIR subscribes to the African Union vision of an integrated, prosperous and peaceful Africa. Contribution to Africa's growth and development can be enhanced greatly through the CSIR's intentional and coordinated efforts with similar partners in the Southern African Development Community region and other parts of Africa.

Government has an important role in creating an enabling environment – policy and regulatory – for business and industry, and thus society, to thrive. Partnerships and collaborations between departments, the private sector and with civil society should invariably create opportunities to provide scientific and technical support to enhance service delivery, create new industries and resuscitate declining ones and share complementary technologies, all with the aim of contributing to the improvement of the quality of life of South Africans.

In response to the national imperative of advancing science and technology, my department is committed to investing in human capital development (HCD) and infrastructure. The DST has recently launched its inter-bursary support programme, aimed at supporting capacity development in strategic and priority areas identified in key departmental strategies. The CSIR is supporting the DST in the development of skills in these areas. To date, 330 students have been funded.

The department's contribution to infrastructure support is reflected in the Nanomaterials Industrial Development Facility, launched in December 2015; the Biomanufacturing Industry Development Centre, launched in May 2016; and the soon to be launched Biorefinery and Photonics facilities.

Besides these examples, significant investment is being made in promoting cooperation between the CSIR, government, state-owned entities, higher education institutions, research and technology organisations and the private sector through collaborative research to advance science and technology and provide tangible solutions, nationally and in other parts of Africa.

I wish to commend the CSIR Board, executive leadership and all staff for their contribution in advancing innovation in science, engineering and technology in our country. I am confident that the new CEO, Dr Thulani Dlamini, will propel the organisation to even greater heights, making an indelible mark in improving the quality of life of our people.

Naledi Pandor

Mrs Naledi Pandor
Minister of Science and Technology

ISIZULU

Isandulelo sika Ngqongqoshe weSayensi nobuChwepheshe

Kunobufakazi obuqanda ikhanda emhlabeni ngokuxhumana phakathi kokuhlwanyela kwezwe kwezocwaningo nentuthuko ngokwenhlalo nomnotho nokudlondlobala kwalo. Isayensi nobuchwepheshe wumkhakha zonke izizwe ezithuthukile eziwugqugquzelayo ukufukula intuthuko yazo. Ngenxa yokuqonda lokhu kuxhumana, neNingizimu igqugquzela isayensi, ubuchwepheshe nokusungula izinto ezintsha ngokutshala ocwaningweni nasentuthukweni. Lokhu kube yingxenye ebalulekile yomshikashika wohlelo lukahulumeni lwentuthuko yomnotho eminyakeni engamashumi amabili edlule.

Isayensi, ubuchwepheshe nokusungula kuthinta ngqo indaba yokudala imisebenzi ngokuphakamisa izinga lokuqhudelana neminye imikhakha yethu yezimboni nokwakha izimboni ezintsha. Isayensi nobuchwepheshe kufanele kuqinisekise ukuthi iminxa yomnotho wethu esimeme iyaqhubeka nokusungula izinto ezintsha ukuze sihlomule ngokwezwe lethu nomcebo ombiwayo. Ngakho-ke ukweseka kangcono umsebenzi wokusungula izinto ezintsha kuyisisekelo sokudlondlobala komnotho, ukwakha umsebenzi, ukuletha izidingo kangcono nentuthuko ngokwenhlalo.

UmNyango weSayensi nobuChwepheshe nazo zonke izikhungo zawo ugxile empumelelweni yoHlelo lweNtuthuko lukaZwelonke nezinye izinhlelo ezihambisana nalo zikahulumeni. Ukujula kocwaningo lokubhekana nemsebenzi wethu omningi luqinisa idolo. Sibeke isisekelo esiqinile ocwaningweni ngomnotho nokuqasha, uhulumeni osebenza kahle, ingqalasizinda yomnotho neyenhlalo, ukushintshela emnothweni onciphisa ukungcolisa imvelo, ukwakha imiphakathi ephephile nokuphucula ezempilo. Lokhu kusibeka endaweni ekahle yocwaningo nentuthuko nomsebenzi osihlalele kuleli nakwamanye amazwe ase-Afrika.

Into enkulu emsebenzini weCSIR wukusebenzisa isayensi nobuchwepheshe ukuphucula izinga lempilo yabantu baseNingizimu Afrika. Umsebenzi omkhulu wale nhlangano wukubheka izimbangela ezinkulu zobubha, ukungalingani nokusweleka kwemisebenzi bese sibona ukuthi ucwaningo olwenziwe lusiza kanjani ukuxazulula lezi zinkinga.

I-CSIR ineqhaza elikhulu oHlelweni lokuQamba lukaZwelonke. Amathimba ososayensi, onjiniyela nabacwaningi anamakhono ehlukene nobuchule aneqhaza elikhulu ekubhekaneni nezinkinga ezinkulu zezwe nokwenza iNingizimu Afrika ibe yizwe elisimamayo.

Kuyacaca kulo mbiko ukuthi ukuletha ushintsho ezweni lethu nase-Afrika yonke kumqoka kwiCSIR. Njengenhlangano yocwaningo enkulu ezwenikazini, iCSIR ivumelana nombono we-African Union we-Afrika ebumbene, esimeme nenokuthula. Ukuphosa esivivaneni sokudlondlobala nentuthuko ye-Afrika kungaphunyeleliswa yimizamo ehlelekile efanayo yabalingani besifunda esiseningizimu ye-Afrika nezinye izindawo zase-Afrika.

Uhulumeni uneqhaza elibalulekile ukwenza izinto zenzeke – ngokwenqubo nemithetho – emabhizinisini nezimboni ukuze umphakathi uchume. Ukubambisana eminyangweni ehlukene, amabhizinisi azimele nezinhlangano zomphakathi nakanjani kufanele kudale amathuba osizo lwezesayensi nolwamakhono ukuphucula ukulethwa kwezidingo emphakathini, ukusungula izimboni ezintsha nokuvuselela lezo eziwayo nokwabelana ngobuchwepheshe obuwusizo kuwo wonke umuntu ngenhloso yokuphosa esivivaneni sokuthuthukisa izinga lempilo labantu baseNingizimu Afrika.

Enjongweni kahulumeni yokugxilisa isayensi nobuchwepheshe, umnyango wami uzibophezele ekutshaleni ekuthuthukiseni igugu eliyizisebenzi nengqalasizinda. UmNyango weSayensi nobuChwepheshe usanda kwethula uhlelo lwemifundaze emikhakheni ehlonzwe njengemqoka ngokwezinhlelo ezibalulekile zeminyango ehlukene. I-CSIR ilekelela umNyango weSayensi nobuChwepheshe ukuthuthukisa amakhono kule mikhakha. Kumanje bangama-330 abafundi asebethole le mifundaze.

Iqhaza lomnyango ekwesekeni ingqalasizinda libonakala kwi-Nanomaterials Industrial Development Facility, ethulwe ngoZibandlela wa-2015; iBiomanufacturing Industry Development Centre, ethulwe ngoNhlaba wama-2016 nezikhungo ezizokwethulwa maduze zesayensi yokukhiqiza amandla nokushisa, phecelezi i-Biorefinery; umkhakha wokukhiqiza nokudlulisa ngokukhanya, phecelezi i-Photonics.

Ngale kwalezi zibonelo, kukhulu okutshalwa ekuthuthukiseni ukubambisana phakathi kweCSIR, uhulumeni, izinkampani zikahulumeni, izinhlangano zocwaningo nobuchwepheshe nezinkimpani ezizimele ngokubambisana ocwaningweni ukusimamisa isayensi nobuchwepheshe nokuxazulula izinkinga ezweni nakwezinye izindawo ze-Afrika.

Ngifisa ukuncoma ibhodi laseCSIR, abaphathi abakhulu nazo zonke izisebenzi ngeqhaza labo ekuthuthukiseni isayensi, ubunjiniyela nobuchwepheshe ezweni lethu. Ngineqholo lokuthi isikhulu esiphezulu esisha, uDkt Thulani Dlamini, uzoqhuba umkhankaso wokubeka iCSIR esicongweni, abe negalelo elikhulu ekuthuthukiseni izinga lempilo yabantu bakithi.

Naledi Pandor

Nkk. Naledi Pandor
uNgqongqoshe weSayensi nobuChwepheshe

SEPEDI

Ketapele ka Tona ya Saense le Theknolotši

Go na le bohlatse bjo bogolo bja lefase ka kakaretšo go thekga kgokagano gare ga peeletšo ya naga ka dinyakišišo le tšweletšopele (R&D) le tšweletšopele ya leago le ekonomi le lehumo. Mahlale le theknolotši ke karolo yeo dinaga tše dintši tšeo di gotšego di e thekgago go hlokomela tšweletšopele ya tšona. Ka lebaka la kwešišo ya dikgokagano tše, Afrika Borwa le yona e thekgile mahlale le theknolotši le mpshafatšo ka peeletšo ka go R&D. Se e bile karolo ye bohlokwa ya mokgwa wa mmušo wa tšweletšopele ya ekonomi mo dipakeng tše pedi tša go feta.

Mahlale, theknolotši le mpshafatšo di kgokagane thwii go fa Afrika Borwa mešomo ka go matlafatša phenkgišano ya dikarolo tša intasteri tša go fapana le ka go hlola diintasteri tše difsa. Mahlale le theknolotši di swanetše go kgonthiša gore dikarolo tše di hlotšwego tša ekonomi ya rena di tšwela pele go kaonafala mo lefaseng la phenkgišano ye e oketšegago gore re kgone go godiša dikholego tše dikgolo go tšwa go mehola ya lefase la rena le methopo. Thekgo ye e kaonafaditšwego ya mpshafatšo ka gona e bohlokwa go kgolo ya ekonomi ye e swarelelago, tlholo ya mešomo, kabo ya ditirelo ye e kaonafaditšwego le tšwelotšopele ya leago.

Nepo ye kgolo ya Kgoro ya Saense le Theknolotši (DST) le makala ka moka a yona, ke phethagatšo ya Leano la Tlhabollo ya Setšhaba (NDP) le dipeakanyo tša mmušo tše di amanago le lona. Bogolo bja dinyakišišo bjo bo šoganago le dikarolo tša nepišo tše dikgolo bjo bo hlalošitšwego ka go NDP bo a hlohleletša. Re hlomile motheo wa go tia ka dinyakišišong tša ekonomi le mešomo; mmušo wa bokgoni; ekonomi le infrastraktša ya leago; phetogo go ya go ekonomi ya khapone ya fase; go aga ditšhaba tše di bolokegilego, le go kaonafatša maphelo. Se se re bea maemong a makaone go R&D ye e katološitšwego le phethagatšo ya mošomo wo o swanetšwego go dirwa bobedi mo gae le dikarolong tše dingwe tša Afrika.

E thekgwa go tšwa taolelong ya CSIR e šomiša mahlale le theknolotši go kaonafatša boleng bja bophelo bja Maafrika Borwa. Bohlokwa bja mokgatlo ke go utolla dilo tša motheo tšeo di hlolago bohloki, go se lekalekane le go hloka mešomo le go hwetša kgokagano gare ga dinyakišišo tše di dirilwego le go šogana le dilo tšeo di hlolago tše.

CSIR e kgatha tema ye bohlokwa mo Mokgweng wa Setšhaba wa Mpshafatšo. Sehlopha sa bokgoni le dikarolontši sa boramahlale, baentšenere le banyakišiši se kgatha tema ye bohlokwa go šogana le dilo tšeo go hlokegago gore di fiwe šedi ya tšhoganetšo gomme sa bea Afrika Borwa maemong a go ba naga ye e golago.

Go hlatsetšwe ka mo pegong ye gore go dira phapano mo nageng ya rena le ka Afrika ka bophara, ke selo sa pele go CSIR. Bjalo ka mokgatlo wa dinyakišišo wo mogolo

go feta ka moka mo kontinenteng, CSIR e ngwadiša go pono ya Kopano ya Afrika ye e kopanego, ya go huma gape ya khutšo. Khuetšo go kgolo le tšweletšopele tša Afrika di ka kaonafatšwa kudu ka maitapišo ao a nago le maikemišetšo gape a beakantšwego le badirišani ba go swana mo seleteng sa Ditšhaba tša Tšweletšopele ya Borwa bja Afrika le dikarolo tše dingwe tša Afrika.

Mmušo o na le karolo ye bohlokwa ya go hlola tikologo ya go matlafatša – pholisi le go laola – ya kgwebo le intasteri, ke moka setšhaba, go tšwelela. Ditirišano le dikamano gare ga dikgoro, lekala la praebete le ditšhaba tša segae di swanetše go dula di hlola dibaka tša go fa thekgo ya mahlale le ya thekniki go kaonafatša kabo ya ditirelo, go hlola diintasteri tše mpsha le go boloka tše di wago le go abelana ditheknolotši tša go tlaleletša, ka moka ka maikemišetšo a go thekga kaonafatšo ya boleng bja bophelo bja Maafrika Borwa.

Go arabela bohlokwa bja naga bja go godiša mahlale le theknolotši, kgoro ya ka e ikgafile go beeletša go tšweletšopele ya matlotlo a batho (HCD) le infrastraktša. DST e thakgotše lenaneo la yona la thekgo ya dipasari tša tirišano, leo maikemišetšo a lona e lego go thekga tšweletšopele ya bokgoni ka dikarolong tša thulaganyo le tše bohlokwa tše di utollotšwego ka dithulaganyong tša kgoro tša motheo. CSIR e thekga DST ka tšweletšopele ya mabokgoni mo dikaralong tše. Go fihla lehono, baithuti ba 330 ba thekgilwe ka ditšhelete.

Go kgatha tema ga kgoro mo thekgong ya infrastraktša go tšweleditšwe ka Senolafatšing sa Tšwelotšopele ya Intasteri ya Dimateriale tša Nano, seo se thakgotšwego ka Manthole 2015; Senthara ya Tšweletšopele ya Intasteri ya Tšweletšo ya thutaphedi, yeo e thakgotšwego ka Mopitlo 2016; le dinolofatši tša Difotoniki le Payorefaenari tše di tlogo thakgolwa kgauswanyana.

Ntle le mehlala ye, peeletšo ye bohlokwa e dirilwe go thekga tirišano gare ga CSIR, mmušo, makala a mmušo, diinstitušene tša thuto ya godimo, mekgatlo ya theknolotši le dinyakišišo le lekala la praebete ka dinyakišišo tša tirišano go phagamiša mahlale le theknolotši gomme ya fa ditharollo tša nnete, mo gae le dikarolong tše dingwe tša Afrika.

Ke rata go leboga Boto ya CSIR, boetapelephethiši le badirišani ka moka ka tema ye ba e kgathilego ka go phagamiša mpshafatšo mo go mahlale, boentšenere le theknolotši mo nageng ya rena. Ke na le nnete gore Mohlankedimogolophethiši yo mofsa, Mdi. Thulani Dlamini, o tla nameletša mokgatlo le go feta, a bea leswao le le ka se lebalwego ka go kaonafatša boleng bja maphelo a batho ba rena.

Mdi. Naledi Pandor
Tona ya Saense le Theknolotši

ENGLISH

Chairman's overview

The CSIR is an exceptional organisation and our unique multidisciplinary capability in research and the focus on making an impact in improving the quality of lives of South Africans should now, more than ever, be an entrenched pursuit.

We operate in a dynamic environment and as an organisation, we have had to navigate through a maze of economic, political, regulatory and other environmental changes to remain relevant and a major contributor within the science, engineering and technology space, nationally and internationally, particularly in Africa.

Research, development and innovation are widely recognised as being pivotal for industrial development and are listed in the National Development Plan 2030, as being essential in ensuring that South Africa remains competitive. Therefore, we respond to national priorities in line with our mandate by undertaking research aimed at supporting industrial development, as well as enhancing the capabilities of government in the areas of service delivery, policy development and information management.

We know that our long-term mission is to contribute to the redress of unemployment, inequality and poverty. Although the current economic climate is not favourable, we still need to focus our efforts on the immediate interventions that will support our country's economic development. We have made significant strides in growing our technical base. We need to maintain this capability and without compromising on scientific quality and rigour, transform that considerable investment into technologies that support employment creation.

As the Board, we want to see the CSIR's increasing role in the development and transfer of manufacturing technologies that improve the competitiveness of existing South African industries and creating new manufacturing opportunities. We will offer the requisite support in accomplishing this task.

Our ability to contribute, over the long term, to national development through innovation and our scientific and technological work, would be severely compromised without sound governance. I am pleased with the leadership's achievement of maintaining a track record of an unqualified audit status. This is commendable and demonstrates that the systems and controls set in place to maintain good governance are adhered to and monitored. Maintaining this discipline will ensure that the organisation continues to operate in a sustainable manner.

Our success in achieving our mandate would not be possible without the contributions of our diverse stakeholders. Our partners

and collaborators in government, industry, higher education institutions and research organisations play a pivotal role in shaping the outcome of our research.

Another major challenge we face is the ongoing demographic transformation of the CSIR. This organisation has made significant strides with respect to transformation over the past 10 years, but we have to ensure that this transformation occurs at all levels of the organisation. Our deliberate interventions at transformation must also place focus on the higher echelons of our scientific ladder. To this end, indicators have been identified that will track our transformation efforts at all levels.

In September 2016, we bade farewell to Dr Sibusiso Sibisi, who had led the CSIR for almost 15 years as the Chief Executive Officer (CEO). We thank Dr Sibisi for his able and skillful leadership of the organisation and we wish him well in his future endeavours. I also wish to thank Dr Molefi Motuku, who acted as CEO for the period 1 October 2016 to 31 January 2017.

I wish to welcome the new CEO, Dr Thulani Dlamini, whose appointment became effective on 1 February 2017. The Board is confident that his skills, experience and qualifications will contribute towards placing the organisation on a rewarding and innovative trajectory during the critical years ahead.

I acknowledge my fellow board members and thank them for their outstanding contributions over the past year. Thank you to the executive leadership of the CSIR and staff for their hard work during the past year and the Minister of Science and Technology, Mrs Naledi Pandor, for her guidance and oversight. The Board is looking forward to working with all our stakeholders to continue to deliver value to our country.

Prof. Thokozani Majozi
CSIR Board Chairperson

ISIZULU

Elijikayo likaSihlalo

I-CSIR iyinhlangano engumangaliso kanti amakhono ethu amaningi angefaniswe nalutho ekucwaningeni nokugxila ekuletheni ushintsho ezingeni lempilo yabantu baseNingizimu Afrika kufanele kube yimpokophelo enkulu manje kunakuqala.

Sisemkhakheni oshintshashintshayo kanti njengenhlangano kudingeke ukuthi sichushe esijwini sezinguquko ngokomnotho, ngokwepolitiki, ngokwemigomo nangokwemvelo ukuze siqhubeke nokuba nesidingo emphakathini futhi sibe neqhaza elikhulu endimeni yesayensi, ubunjiniyela nobuchwepheshe ezweni lonke nasemhlabeni, ikakhulu e-Afrika.

Ucwaningo, intuthuko nokuqamba kabusha kuthathwa njengokumqoka entuthukweni yezimboni kanti kubalwa oHlelweni lweNtuthuko lukaZwelonke lwango-2030 njengento emqoka ekuqinisekiseni ukuthi iNingizimu Afrika ikwazi ukuqhudelana namanye amazwe ezingeni lomhlaba. Yingakho sisabela ezidingweni zezwe ezihambisana nomsebenzi wethu ngokwenza ucwaningo oluhlose ukweseka intuthuko yezimboni nokwandisa amandla kahulumeni emikhakheni yokuletha izidingo emphakathini, intuthuko yenqubo nokulawula ulwazi.

Siyazi ukuthi injongo yethu enkulu wukuphosa esivivaneni ukulwa nokusweleka kwemisebenzi, ukungalingani nobubha. Nakuba isimo somnotho samanje singavumi kodwa kudingeka ukuthi siphokophele ukuqhamuka nezixazululo ezizolekelela izwe lethu lithuthuke ngokomnotho. Makhulu amagalelo ethu ekukhuliseni inqolobane yobuchwepheshe. Kufanele siqhubeke nalo msebenzi, sishintshe ubuchwepheshe obudala amathuba emisebenzi kodwa sibe singalehlisi izinga nomfutho kwesayensi.

NjengeBhodi, sifisa ukubona iqhaza leCSIR likhula ekuthuthukiseni nasekudluliseni ubuchwepheshe bokukhiqiza obuphucula izinga lokuqhudelana kwezimboni ezivele zikhona zaseNingizimu Afrika nokudala amathuba amasha okukhiqiza. Sizoweseka ngendlela efanele lo msebenzi.

Ikhono lethu lokukwazi ukuphosa esivivaneni sentuthuko yezwe lonke ngokuqamba kabusha nomsebenzi wethu wesayensi nobuchwepheshe kungaphazamiseka uma kungekho ukulawulwa ngendlela efanele. Ngithokozile ngomsebenzi omuhle wabaholi wokuthi baqhubeke nokungabi nasici ekucwaningweni kwamabhuku. Kuyancomeka lokhu futhi kukhombisa ukuthi izindlela ezikhona zokuphatha zilandelwa ngendlela efanele. Ukuqhubeka nokuyibamba ngale ndlela kuzoqinisekisa ukuthi le nhlangano iyaqhubeka nokusebenza ngendlela.

Ngeke siphumelele ekwenzeni umsebenzi wethu ngaphandle kweqhaza labalingani bethu abehlukene. Abalingani bethu kuhulumeni, emabhizinisi, ezikhungweni zemfundo ephakeme nezinhlangano zocwaningo zineqhaza elimqoka emphumeleni wocwaningo lwethu.

Enye inselelo esibhekene nayo woshintsho ngokobuzwe kwezisebenzi zaseCSIR. Le nhlangano isiyenze umsebenzi omkhulu ngokoguquko eminyakeni eyishumi edlule kodwa kufanele siqikelele ukuthi lolu shintsho lwenzeka kuwo wonke amazinga enhlangano. Imizamo yethu ehlose ukuletha uguquko kufanele ibheke nasemazingeni aphezulu ohlaka lwethu lwesayensi. Ukwenza lokhu kunezinsiza ezizobheka ukuthi uguquko lwenzeka kuwo wonke amazinga.

NgoMandulo ngonyaka odlule sivalelise uDkt Sibusiso Sibisi, obese eneminyaka engama-15 ehola iCSIR eyisiKhulu esiPhezulu. Siyambonga uDkt Sibisi ngobuchule bakhe bokuhola le nhlangano kanti simfisela okuhle kodwa lapho eya khona. Ngifisa ukubonga noDkt Molefi Motuku, obambe izintambo zokuba yisikhulu esiPhezulu kusukela ekuqaleni kukaMfumfu wango-2016 kuya ekupheleni kukaMasingana wango-2017.

Ngifisa ukwamukela isiKhulu esiPhezulu esisha uDkt Thulani Dlamini, oqashwe mhla ka 1 kuNhlolanja wango-2017. IBhodi ayingabazi ukuthi ikhono, isipiliyoni neziqu zakhe kuzobeka le nhlangano esicongweni sempumelelo kule minyaka ezayo.

Ngifisa ukubonga abalingani bami kwiBhodi, ngibabonge ngeqhaza labo elikhulu ngonyaka odlule. Siyabonga kubaphathi abakhulu baseCSIR nezisebenzi ngokuzikhandla kwabo ngonyaka odlule, sibonga noNgqongqoshe wezeSayensi nezobuChwepheshe uNkk Naledi Pandor ngobuholi bakhe neso lakhe. Ibhodi ikubheke ngabomvu ukusebenzisana nabo bonke abalingani bethu ukuba wusizo ezweni lethu.

uSol. Thokozani Majozi
uSihlalo weBhodi yaseCSIR

SEPEDI

Kakaretšo ya Modulasetulo

CSIR ke mokgatlo wa bokgoni gomme bokgoni bja rena bja dikarolontši bja moswananoši mo dinyakišišong le nepišo ye e dirago khuetšo mo kaonafatšong ya boleng bja maphelo a Maafrika Borwa e swanetše gore gonabjale go feta le peleng, e be mošomo wo o sa šikinyegego.

Re šoma tikologong ya mafolofolo bjalo ka mokgatlo, re ile ra swanela ke go ba ka gare ga ekonomi ye e šarakanego, polotiki, molao le diphetogo tše dingwe tša tikologo gore re dule re le maleba le go ba mothekgi wo mogolo wa sekgoba sa mahlale, boentšenere le theknolotši, mo gae le ditšhabatšhabeng, kudu ka Afrika.

Dinyakišišo, tšweletšopele le mpshafatšo di lemogwa ka bophara bjalo ka ge di le bohlokwa mo tšwelotšopeleng ya diintaseteri gomme di beilwe lenaneong la Leano la Tlhabollo ya Setšhaba la 2030, ka ge di le bohlokwa go kgonthiša gore Afrika Borwa e dula e na le mohola. Ka gona, re arabela go dilo tše bohlokwa tša naga go nyalelana le taolelo ya rena ka go thoma dinyakišišo tšeo di ikemišeditšego go thekga tšweletšopele ya diintasteri, gammogo le go kaonafatša mabokgoni a mmušo mo dikarolong tša kabo ya ditirelo, tšweletšopele ya dipholisi le taolo ya tshedimošo.

Re a tseba gore maikemišetšo a rena a nako ye telele ke go kgatha tema go kaonafatša tlhokego ya mešomo, go se lekalekane le bohloki. Le ge klaemete ya ekonomi ya gonabjale e se ye kaone, re sa hloka go nepiša maitekelo a rena go tsenogare ya ka pela yeo e tla thekgago tšweletšopele ya ekonomi ya naga ya rena. Re dirile dikaonafatšo tše bohlokwa ka go godiša motheo wa rena wa theknolotši. Re hloka go thekga bokgoni bjo ntle le go senya boleng bja mahlale a rena le nepagalo, go fetolela peeletšo yela ye bohlokwa go ditheknolotši tše di thekgago go hlola mešomo.

Bjalo ka Boto, re rata go bona karolo ye e golago ya CSIR mo tšwelotšopeleng le phitišetšong ya ditheknolotši tša go dira tšeo di kaonafatšago bokgoni bja diintasteri tše di lego gona tša Afrika Borwa le go hlola dibaka tša go dira tše difsa. Re tla aba thekgo ye e hlokegago go fihlelela mošomo wo.

Bokgoni bja rena go kgatha tema, mo nakong ye telele, go tšweletšopele ya setšhaba ka mpshafatšo le mošomo wa rena wa mahlale le theknolotši, bo tla senywa kudu ntle le taolo ya go kwagala. Ke thabile ka dikatlego tša bolaodi tša go tšwela pele ka dikatlego tša nako ye e fetilego tša maemo a tlhakišo ye botse. Se se a retega gomme se bontšha gore mekgwa le ditaolo tše di beakantšwego go thekga taolo ye botse di a latelwa gape di a lekolwa. Go swarelela thupišo ye ye botse go tla kgonthiša gore mokgatlo o tšwela pele go šoma ka mokgwa wa go swarelela.

Katlego ya rena ya go fihlelela taolelo ya rena e be e ka se kgonagale ntle le go kgatha tema ga batšeakarolo ba rena ba go fapana. Badirišani le bašomišani ka mmušong, diintasteri, diinstitušene tša thuto ya godimo le mekgatlo ya dinyakišišo di kgatha tema ye bohlokwa go bopa dipoelo tša dinyakišišo tša rena.

Tlhohlo ye nngwe ye kgolo ye re lebanego le yona ke phetogo ye e tšwelago pele ya temokrafi ya CSIR. Mokgatlo wo o dirile dikaonafatšo tše bohlokwa malebana le phetogo mo mengwageng ye 10 ya go feta, eupša re swanetše go kgonthiša gore phetogo ye e direga magatong ka moka a mokgatlo. Ditsenogare tša rena tša maikemišetšo mo go phetogo di swanetše go nepiša go magato a godimo a llere ya rena ya mahlale. Go fihla mo, maswao ao a lemogwago ao a tla latišišago maitikelo a rena magatong ka moka.

Ka Lewedi 2016, re laelane le Ngaka Sibusiso Sibisi, yoo a etilego CSIR mengwaga ye e ka bago 15 bjalo ka Mohlankedimogolophethiši. Re leboga Ngaka Sibisi ka boetapele bja gagwe bja go kgona le bokgoni bja mokgatlo gomme re mo lakaletša tše dibotse leetong la gagwe le lefsa. Ke rata gape go leboga Ngaka Molefi Motuku, yoo e bilego moswarela Mohlankedimogolophethiši go tloga ka la 1 Diphalane go fihla ka la 31 Pherekgong 2017.

Ke rata go amogela Mohlankedimogolophethiši yo mofsa, Ngaka Thulani Dlamini, yoo a thomilego go šoma ka la 1 Dibokwane 2017. Boto e na le nnete gore mabokgoni a gagwe, boitemogelo le dithuto di tla kgatha tema go tlišetša mokgatlo tše dibotse nakong ya mengwaga ye bohlokwa ye e tlago.

Ke amogela badirišani ba ka e lego maloko a boto gomme ke ba leboga mo go kgatheng tema ga bona ga bokgoni mo mengwageng ya go feta. Ke leboga boetapelephethiši bja CSIR le badirišani ka go šoma ka maatla mo ngwageng wa go feta le Tona ya Saense le Theknolotši, Mdi Naledi Pandor, ka tlhahlo ya gagwe le taolo. Boto e lebeletše go šoma le batšeakarolo ka moka go tšwela pele go tliša boleng mo nageng.

Prof Thokozani Majozi
Modulasetulo wa Boto ya CSIR

ENGLISH

CEO's introduction

The CSIR is built on a heritage of research excellence. Through our work, we have demonstrated a commitment to pushing boundaries in our quest for excellent research and technological innovation leading to industrial and scientific development. Ultimately, all this should contribute to improving the quality of lives of the people of South Africa, our main stakeholder. This is the essence of our mandate.

There are many examples in this annual report that demonstrate how the CSIR has delivered on its mandate and in so doing, touched the lives of many South Africans.

We are subjected to an environment that is becoming increasingly more competitive and unpredictable; this will have an impact on our organisation. Navigating this environment will require coherency in strategy and leadership that will ensure that the organisation is nimble and adaptable, whilst safeguarding our pillars of research excellence and ethics. This will require that we compliment the strong research capability that we have built in the organisation, with equally important strong business acumen.

Our scientific development research agenda is aligned with most of the national priorities contained in the National Development Plan. Our work in smart spectrum management led to the gazetting of a position paper by the Independent Communications Authority of South Africa, a milestone in the commercial use of Television White Spaces that will help address the rising demand for connectivity. Various healthcare technologies with significant potential impact for healthcare provision were piloted and tested. Approximately 6.3 million registrations have been captured on the CSIR-developed system to electronically store patient records, while a portable, wireless blood analyser that allows for two-way communication between the clinic and a central laboratory performed well in tests.

Working with the Department of Science and Technology, The Jobs Fund and our partners from the private sector, the CSIR is implementing a number of industry development programmes under the umbrella of the Industry Innovation Partnership Programme. This programme has supported the development of new enterprises and innovations in key sectors and future technology areas such as Biomanufacturing, Nanotechnology, Photonics and Biorefinery. To date, over 25 SMMEs have been supported, 113 interns trained and 181 jobs created by this programme.

Our teams have made significant progress in the development of 3D printing technology for the manufacture of aircraft components. This technology offers a complimentary strategic capability for the beneficiation of indigenous mineral resources, in particular

titanium. In a separate project, the CSIR is developing a process for the production of titanium metal powder. With the success of this innovation, South Africa will be well-positioned to develop an entire new industry across the full titanium value chain, unlocking substantial new industrial opportunities in the use of titanium powder.

A world class research organisation requires world-class infrastructure. The CSIR is over 72 years old and despite having invested in excess of R100 m per annum in infrastructure, we have not kept up with developments in the rest of the world. In this regard, a 10-year master plan for the renewal of the CSIR campus has been developed. The implementation of this programme will require a capital investment in excess of R5 bn. This investment will ensure that the CSIR innovatively continues to address the challenges facing South Africa.

The CSIR believes that it can contribute to innovation in Africa and jointly tackle continental societal challenges through cooperation in science, engineering and technology. We continue to work with our partners in countries such as Mozambique, Namibia, Rwanda, Tanzania and Zambia, just to name a few. The projects include point-of-care diagnostics to speed up the control of infectious diseases in livestock, adaptation strategies to ensure that road systems are more resilient in the face of climate change and the use of laser technology in a multitude of fields.

People are at the heart of the CSIR. I am committed to ensuring that we have a comprehensive employee value proposition for all our staff. Despite our progress in the past, we need to decisively drive employment equity and diversity across the organisation. Specific initiatives aimed at the recruitment, development and retention of staff are being reviewed and I believe once measures are put in place, they will enhance our competitiveness and stature as an employer of choice.

Our success as an organisation is attributed to the brilliant minds of our staff. I would like to congratulate many of our colleagues for the various notable achievements and recognition awards that they received in the year under review.

We cooperate with various local and international stakeholders in industry, government, universities and state-owned entities to provide integrated solutions and interventions to contribute to economic growth and development. I look forward to engaging our diverse partners on ways to strengthen our partnerships and provide value-adding solutions to some of our pressing challenges.

The CSIR is financially sustainable, despite poor prevailing micro-economic conditions and heavy reliance on contract research income. Once again, we have received a clean audit, which is testimony to the discipline that has been inculcated into the organisation.

Looking ahead, our effort will be directed towards ensuring that we amplify the 'I' in 'CSIR' through our contribution to industrial development, addressing challenges of transformation especially in the middle management layers, making progress with the implementation of the campus master plan and continuing to embed a culture of operational efficiency and disciplined execution.

I am taking over a well-functioning organisation from my predecessor, Dr Sibusiso Sibisi. I wish to thank him for his excellent service to the CSIR for almost 15 years.

Of course the achievements of the past year were only possible through the hard work and dedication of the CSIR leadership, our staff in the science, engineering and technology base and the invaluable support staff that ensure that the environment in which we work is conducive to excellence and innovation. I would like to acknowledge the ongoing support of the CSIR Board and the Department of Science and Technology, under the leadership of Minister Naledi Pandor.

Dr Thulani Dlamini
CSIR CEO

ISIZULU

Isingeniso seSikhulu esiPhezulu

I-CSIR yakhelwe esisekelweni socwaningo olusezingeni eliphezulu. Ngomsebenzi wethu sikhombise ilaka lokubeka kwelinye izinga umsebenzi wocwaningo nowokuqamba izinto kabusha ukuthuthukisa ezezimboni nesayensi. Ekugcineni, konke lokhu kufanele kuphose esivivaneni sokuphucula izinga lempilo yabantu baseNingizimu Afrika, okungabalingani bethu abamqoka. Yilo umnyombo womsebenzi wethu.

Kulo mbiko wonyaka ziningi izibonelo eziveza ukuthi iCSIR iwenze kanjani umsebenzi wayo, kwathi ngomsebenzi wayo yaguqula izimpilo zabantu abaningi baseNingizimu Afrika.

Sibhekene nesimo esidinga ukuqhudelana nesinokungaqondakali; kanti lokhu kuzoba nomthelela enhlanganweni yethu. Ukubhekana nalesi simo kuzodinga ukuzwana phakathi kwezinhlelo zethu nobuholi benhlangano okuzoqinisekisa ukuthi le nhlangano ibe bukhali, ikwazi ukushintsha ukwenza kodwa ibe ivikela izinsika zocwaningo nezindlela zokuziphatha okusezingeni eliphezulu. Lokhu kuzodinga ukuthi ikhono elinzulu lokucwaninga esilitshale enhlanganweni silenze lihambisane nekhono lokuphatha ibhizinisi.

Uhlelo lwethu lokuthuthukisa ucwaningo kwezesayensi luhambisana nezinto eziseqhulwini oHlelweni lweNtuthuko kaZwelonke. Umsebenzi wethu wokulawula ubuchwepheshe bokuxhumana obungenazintambo uholele ekutheni i-Independent Communications Authority of South Africa ishicilele iphepha, ngqophamlando emkhakheni wokuxhumana ngamaza eVHS ne-UHS, okuzosiza ukubhekana nezinselelo ezikhona ezidingweni kwezokuxhumana ngobuchwepheshe. Kuhlolwe ubuchwepheshe obehlukene kwezempilo noma kwezokwelapha. Cishe kubhaliswe amarekhodi eziguli acela ezigidini eziwu-6.3 agcinwa ngendlela yobuchwepheshe kanti kuhambe kahle ukuhlolwa komshini ohlaziya igazi oyiwayilense okwazi ukuxhumanisa imitholampilo negumbi lokucwaninga elilodwa.

I-CSIR, ibambisene nomNyango weSayensi nobuChwepheshe, i-Jobs Fund (isikhwama semisebenzi) nabalingani bethu kwezamabhizinisi azimele, yenza izinhlelo ezehlukene zokuthuthukisa izimboni ngaphansi koHlelo lokuBambisana ukuQamba kaBusha eziMbonini. Lolu hlelo lweseke ukuthuthukiswa kwemikhakha enjengokukhiqizwa kwezinto ezingayicekeli phansi imvelo; phecelezi i-biomanufacturing, ubuchwepheshe noma ubunjiniyela bezakhi ezincanekazi, phecelezi iNanotechnology; umkhakha wokukhiqiza nokudlulisa ngokukhanya, phecelezi i-Photonics; nesayensi yokukhiqiza amandla nokushisa, phecelezi iBiorefinery. Kuze kube manje lolu hlelo selweseke izinkampani ezincane ezingaphezu kwama-25, lwaqeqesha amathwasa angama-113, lwadala imisebenzi engama-181.

Amathimba ethu enze umsebenzi oncomekayo ekuphuculeni ubuchwepheshe besimanje bokushutha nokugaya izithombe ekukhiqizeni izinsimbi zamabhanoyi. Lobu buchwepheshe busiza kakhulu ekukhiqizeni izimpahla ezintsha ngezinto ezimbiwa phansi zezwe, ikakhulu i-titanium (isakhi sensimbi engagqwaliswa ngamanzi olwandle). Komunye umsebenzi, iCSIR iphezu kombhidlango wokukhiqiza impuphu ye-titanium. Uma uphumelela lo msebenzi, iNingizimu Afrika iyobe

isisemweni esikahle semboni yawo wonke umkhiqizo we-titanium kusuka ekuqaleni kuze kufinyelele ekugcineni, kwakheke namathuba amasha.

Inhlangano yocwaningo esezingeni lomhlaba idinga ingqalasizinda esisezingeni lomhlaba ukusebenza. I-CSIR ineminyaka engaphezu kwama-72 kanti nakuba sitshale imali eyevile ezigidini zamarandi ayikhulu kwingqalasizinda kodwa sisilele kontanga yethu emhlabeni. Yingakho kunohlelo lweminyaka eyishumi yokuvuselela ikhempasi CSIR. Lo msebenzi uzodinga imali engaphezu kwezigidigidi zamarandi ezinhlanu. Lo msebenzi uzokwenza iCSIR ikwazi ukuqhubeka nokuxazulula izinkinga ezibhekene neNingizimu Afrika.

I-CSIR ikholwa wukuthi ingakwazi ukuphosa esivivaneni ukuvuselela i-Afrika ngokubambisana nabanye abalingani ukubhekana nezinselelo kwezesayensi, ezobunjiniyela nezobuchwepheshe. Siyaqhubeka ukubambisana nabanye abalingani bethu njengeMozambique, Namibia, Tanzania neZambia. Emisebenzini esiyenzayo kukhona indawo lapho kuhlonzwa khona izinkinga ukuze kunqandeke izifo zemfuyo, imigwaqo ikwazi ukumelana noguquguquko lwesimo sezulu nobuchwepheshe bokuthwebula ngombani emikhakheni ehlukene.

Abantu bamqoka kwiCSIR. Ngizimisele ukuqinisekisa ukuthi sinohlelo olubanzi lokuhlomulisa nokukhulisa izisebenzi zethu. Kumele sikhohlwe yimuva lethu, siqhube izinhlelo zokunika amathuba labo ababencishiwe wona, silethe uguquko enhlanganweni yonke. Imikhankaso yokuqasha, ukuthuthukisa nokugcina izisebenzi iyabuyekezwa kanti ngikholwa wukuthi uma isilandelwa izosenza sibe ngcono, kukhule negama lethu njengomqashi oyinyama kubantu.

Kungenxa yemiqondo ebukhali yezisebenzi zethu ukuthi siyinhlangano ephumelelayo. Ngifisa ukuhalalisela izisebenzi zethu eziningi ngemisebenzi yayo emihle ehlukene nemiklomelo eziyithole ngonyaka odlule.

Sibambisene nabalingani abehlukene bakuleli nabaphesheya ezimbonini, kohulumeni, emanyuvesi nasezinkampanini zohulumeni ukuqhamuka namasu okukhulisa umnotho, silethe nentuthuko. Ngimagange ukusebenzisana nabalingani bethu abehlukene ngokuqinisa amaxhama obudlelwano, siqhamuke nezixazululo zezinselelo esibhekene nazo.

I-CSIR imi kahle kwezomnotho nakuba isimo somnotho sintenga kanti futhi ithembele kakhulu emalini yezinkontileka zocwaningo. Siphinde sathola umbiko wezimali ongenasici, okufakazela ubuqotho obukhona enhlanganweni yethu.

Uma sisinga phambili sibona ukuthi umsebenzi wethu uzogxila ekukhuliseni ingxenye yezimboni, ukubhekana nezinselelo zoguquko ezingeni eliphakathi labaphathi noma lezimenenja, ukuqhubeka nohlelo olukhulu lwekhempasi nokugxilisa isiko lokushaya into ecokeme emsebenzini wethu.

Ngithatha izintambo kuDkt Sibusiso Sibisi. Ngifisa ukumbonga ngomsebenzi wakhe osezingeni eliphezulu weminyaka ecela kweyishumi nanhlanu eyibambile eCSIR.

Yebo, impumelelo yangonyaka odlule ibe ngenxa yokuzikhandla nokuzinikela kwabaholi baseCSIR; izisebenzi zethu kwezesayensi, ezobunjiniyela nezobuchwepheshe nokuqinisekisa kwezisebenzi zethu ukuthi indawo esisebenza kuyo yenza umsebenzi weqophelo eliphezulu nokuqamba kabusha. Ngifisa ukubonga ukwesekwa yiBhodi yaseCSIR ngezikhathi zonke nomNyango weSayensi nobuChwepheshe, oholwa wuNgqongqoshe uNaledi Pandor.

Dkt Thulani Dlamini
ISikhulu esiPhezulu kwaCSIR

SEPEDI

Matseno a Mohlankedimogolophethiši Ketapelekakanywa

CSIR e agilwe mo bohweng bja dinyakišišo tša bokgoni. Mošomong wa rena, re laeditše boikgafo go šoma ka maatla maikemišetšong a rena a dinyakišišo tša bokgoni le mpshafatšo ya theknolotši ao a išago tšwelotšopeleng ya mahlale le intasteri. Mafelelong, ka moka tšeo di swanetše go kgatha tema go kaonafatšeng boleng bja maphelo a batho ba Afrika Borwa, batšeakarolo ba rena ba bagolo. Se ke moya wa taolelo ya rena.

Go na le mehlala ye mentši ka mo pegong ye ya ngwaga le ngwaga yeo e laetšago ka moo CSIR e tšweleditšego mo taolelong ya yona gomme ka go dira bjalo, e kgwathile maphelo a Maafrika Borwa a mantši.

Re lebane le tikologo yeo go nago le koketšego ye kgolo ya phadišano gape ya go se akanyege; se se tla ba le khuetšo mo mokgatlong wa rena. Go sepediša tikologo ye go tla nyaka kopanyo ya mekgwa le boetapele tšeo di tla kgonthišago gore mokgatlo o a kgahliša le go amantšhega, mola re šireletša baetapele ba dinyakišišo tša bokgoni le maitshwaro. Se se tla nyaka gore re rete bokgoni bjo maatla bja dinyakišišo bjo re bo agilego mo mokgatlong, go sa lebalwe bohlale bjo maatla bja kgwebo.

Lenaneo la rena la dinyakišišo tša tšweletšopele ya mahlale le amanywa le dilo tše bohlokwa tša setšhaba ka mo go Leano la Tlhabollo ya Setšhaba. Mošomo wa rena ke go laola mohlwaela wa dikgopolo tša go amana tšeo di išago go phatlalatšweng ga pego ya go ngwalwa ka Taolo ya Dikgokagano tše di Ikemelago tša Afrika Borwa, legato le bohlokwa mo tšhomišong ya Dikgoba tše di sa Šomišwego tša Thelebišene tšeo di tla thušago go šogana le nyakego ye e golago ya kgokagano. Ditheknolotši tša mehutahuta tša tlhokomelo ya maphelo ka khuetšo ya bokgoni ye bohlokwa ya maemo a tlhokomelo ya maphelo e dirilwe le go lekwa. Dingwadišo tše e ka bago tše 6.3 milione di tsentšwe mo mekgweng ya CSIR ye e kaonafaditšwego go ya go direkoto tša molwetši tše di bolokilwego ka elektroniki, mola sesakaseki sa madi sa seyalemoya se senyenyane seo se dumelelago kgokagano ya tsela tše pedi gare ga kliniki le laporotori ya gare se šomile gabotse mo ditekong.

Go šoma le Kgoro ya Saense le Theknolotši, Thekgo ya Mešomo le badirišani ba rena go tšwa lekaleng la praebete, CSIR e phethagatša mananeo a mmalwa a tšwelotšopele ya diintaseteri ka fase ga taolo ya Lenaneo la Tirišano la Mpshafatšo ya Diintasteri. Lenaneo le le thekgile tšweletšopele ya dikgwebo tše difsa le mpshafatšo mo makaleng a motheo le mafelong a theknolotši ya kamoso go swana le Tšweletšo ya thutaphedi, Dimateriale tša Nano, Difotoniki le Payorefaenari. Go fihla lehono, diSMME tša go feta 25 di thekgilwe, baithutelamošomo ba 113 ba hlahlilwe gomme mešomo ye 181 e hlotšwe ke lenaneo le.

Dihlopha tša rena di tšwetše pele kudu mo tšweletšopeleng ya theknolotši ya kgatišo ya 3D ya go dira dikarolo tša sefofane. Theknolotši ye e aba bokgoni bja mokgwa wa tlaleletšo wa go hola methopo ya diminerale tša setala, kudu lerojana la metale wa titaniamo. Mo protšekeng ya go fapana, CSIR e godiša tshepetšo ya tšweletšo ya lerojana la titaniamo. Ka katlego ya mpshafatšo ye, Afrika Borwa e tla ba maemong a mabotse go dira diintasteri tše difsa go phatlalala le go oketša mohola mo titaniamong ka botlalo, go bula dibaka tše bohlokwa tša diintasteri tše difsa mo tšhomišong ya lerojana la titaniamo.

Mokgatlo wa dinyakišišo tša maemo a godimo o nyaka infrastraktša. CSIR e na le mengwaga ya go feta 72 gomme le ge e beeleditše go feta ka R100 milione ka ngwaga mo infrastraktšheng, ga se ra fihlelela tšwelotšopele ya lefaseng ka moka. Ka moo, leano le legolo la mengwaga ye 10 la mpshafatšo ya khamphase ya CSIR le dirilwe. Phethagatšo ya leano le e tla nyaka peeletšo ya tšhelete ya tlaleletšo ya R5 bilione. Peeletšo e tla kgonthiša gore CSIR mo mpshafatšong e tšwela pele go šogana le ditlhohlo tše di lebanego le Afrika Borwa.

CSIR e kgolwa gore e ka kgatha tema go mpshafatšo ka Afrika gomme ya hlohla ditlhohlo tša setšhaba ka tirišano ka mahlale, boentšenere le theknolotši. Re tšwela pele go šoma le badirišani mo dinageng tša go swana le Mozambique, Namibia, Rwanda, Tanzania le Zambia, go bolela tše mmalwa. Diprotšeke di akaretša diphekolo tša ntlha ya tlhokomelo go potlakiša taolo ya malwetši a go fetela mo diruiweng, mekgwa ya kamantšho go kgonthiša gore dipeakanyo tša tseleng di na le maatla mo phetogong ya klaemete le tšhomišo ya theknolotši ya leisara mo dikarolong tše dintši.

Batho ba dipelong tša CSIR. Ke ikgafile go kgonthiša gore re na le leano la bohlokwa le legolo la bašomi go badirišani ba rena ka moka. Ntle le katlego ya rena mo nakong ya go feta, re hloka go hlohleletša go gapeletša tekatekano ya mošomo le phapano go phatlalala le mokgatlo. Mananeo ao a itšego ao a ikemišeditšego go kalatša, go tšweletšapele le go swara badirišani a sekasekilwe gomme ke tshepa gore ditshepedišo di beakantšwe, a tla kaonafatša bokgoni le maemo bjalo ka mothwadi wa kgetho.

Katlego ya rena bjalo ka mokgatlo e lemogwa go menagano ya maphefo ya badirišani ba rena. Ke rata go lebogiša badirišani ba rena ba bantši ka dikatlego tša bona tša bokgoni bja go fapana le difoka tša temogo tšeo ba di amogetšego mo ngwageng wa tshekatsheko.

Re somišana le batšeakarolo ba mo gae le ba ditšhabatšhaba mo diintastering, mmušong, diyunibesithing le makaleng a mmušo go fa ditharollo tša go kopanelwa le ditsenogare mo go kgatheng tema kgolong ya ekonomi le tšweletšopele. Ke lebeletše go amana le badirišani ba rena ba mehutahuta mo mekgweng ya go matlafatša badirišani ba rena le go fa ditharollo tša mohola go ditlhohlo tše dikgolo.

CSIR e a swarelela ka ditšhelete, ntle le maemo ao a lego gona a ekonomi ye nyenyane ya go fokola. Gape, re amogetše tlhakišo ye botse, seo e lego bohlatse bja thupišo ye e hlohleleditšwego ka mokgatlong.

Go iša pele, maatla a rena a tla lebiša go kgonthišeng gore re matlafatša 'Nna' mo 'CSIR' ka go kgatha tema ga rena tšweletšopeleng ya diintasteri, go šogana le ditlhohlo tša phetogo kudu mo magatong a taolo a gare, go tšwela pele ka phethagatšo ya leano le legolo la khamphase le go tšwela pele go bjala setšo sa bokgoni bja tirišo le phethagatšo ye e thupišitšwego.

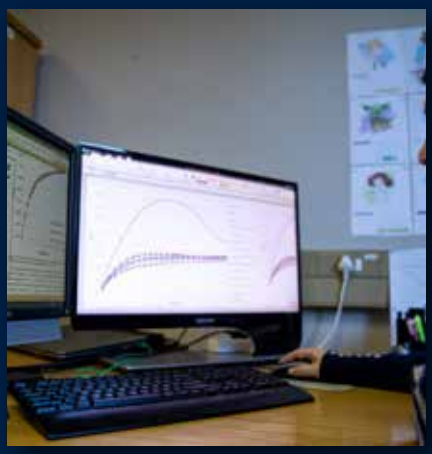
Ke tsena mokgatlong wa go šoma gabotse go tšwa go yo ke mo hlatlamago, Ngaka Sibusiso Sibisi, ke rata go mo leboga ka mošomo wa gagwe wo mobotse go CSIR mengwaga ye e ka bago 15.

Ka nnete dikatlego tša ngwaga wa go feta di kgonagetše ka go šoma ka maatla le boikgafo bja boetapele bja CSIR, badirišani ba rena ka motheong wa mahlale, boentšenere le theknolotši le badirišani ba thekgo ba bohlokwa bao ba kgonthišitšego gore tikologo yeo re šomago go yona e na le mohola go bokgoni le mpshafatšo. Ke rata go lemoga thekgo ye e tšwelago pele ya Boto ya CSIR le Kgoro ya Saense le Theknolotši, ka fase ga boetapele ba Tona Naledi Pandor.

Ngaka Thulani Dlamini
Mohlankedimogolophethiši wa CSIR

PROJECT HIGHLIGHTS

RESEARCH, DEVELOPMENT AND IMPLEMENTATION



The CSIR is mandated to contribute to the improvement of the quality of life of people in South Africa.

Meeting this mandate requires that the organisation responds to unemployment, inequality and poverty in South Africa. National government addresses these challenges through a broad range of programmes, guided by the National Development Plan (NDP) and further articulated through Government's 9-Point Plan and sector-specific initiatives. The CSIR heeds and responds to these national priorities, in line with its mandate.

The CSIR's research and development programme speaks to seven of the 11 focus areas outlined in the NDP. This section features a selection of the work undertaken in this regard.

The CSIR's Dr Mike Masukume (right) and Jan Mentz of Greenfield Additives in the Nanomaterials Industrial Development Facility at the CSIR, where they are using nanotechnology to make stabilisers for the production of plastics.

Research, development and implementation for

ECONOMY AND EMPLOYMENT

The CSIR supports national re-industrialisation initiatives by directing its multidisciplinary skills at the beneficiation of key strategic minerals and the strengthening of sectors such as aerospace and defence. The organisation contributes by improving production processes, supporting local economic development and developing automation solutions for industrial processes. The CSIR helps develop new – and support existing – small, medium and micro enterprises by providing access to its specialised infrastructure as well as scientific, engineering, technology and enterprise-related skills.

Research, development and implementation for

ECONOMY AND EMPLOYMENT

Supporting industry with specialised infrastructure and skills

IN BRIEF

The CSIR is helping local industry improve its competitiveness by providing access to specialised facilities and skills as part of the Industry Innovation Partnership Fund, supported by the Department of Science and Technology. Participants have access to large-scale prototyping and pre-commercial manufacturing infrastructure, equipment, expertise and access to business and technical networks.

The Photonics Prototyping Facility provides infrastructure, world-class equipment and skilled manpower to assist technology concept providers in fast-tracking the prototyping process.

The challenge: Translating concept technologies to competitive products and new enterprises

The South African manufacturing industry creates jobs and drives economic growth in the country, but faces development challenges in the competitive and knowledge-intensive global market. Challenges include a skills deficit and limited access to sophisticated infrastructure, especially for smaller enterprises.

Launching a biomanufacturing industry development centre

Despite excellent biosciences research and development in South Africa, the conversion of outputs into commercialised products and technologies has been limited. In response to this challenge, the CSIR established the Biomanufacturing Industry Development Centre (BIDC), which was officially launched by the Minister of Science and Technology, Mrs Naledi Pandor, in 2016.

The BIDC provides laboratory and pilot-scale infrastructure and skills to catalyse the growth of natural products and the biomanufacturing industry.

To date it has supported 23 small, medium and micro enterprises (SMMEs), of which 78% are black-owned. The support has led to the creation of 177 permanent and 201 temporary jobs, with a further 73 graduates trained in relevant industrial skills through an internship programme. With the transfer of 79 new products into the market, it is projected that the CSIR's initial support will lead to an estimated R250 million contribution to the bioeconomy sector.

The BIDC has also supported established companies with product and process development, including BioDx, NemaBio, Chemical Process Technologies, Teubes, Puris Natural Aromas, BGM Pharmaceuticals, Onderstepoort Biological Products and Agchem.

Establishing a photonics prototyping facility

Photonics is a research field that aims to generate, manipulate and detect particles of light. It is an essential component of everyday technologies in lighting sources such as lasers and light-emitting diodes, telecommunications and information processing, and medical instruments. Currently, South Africa has a very small market share of the global photonics industry due to a lack of infrastructure and skills to industrialise new technology.

The Photonics Prototyping Facility at the CSIR provides skills in optical engineering, industrial design, product integration and facilities such as equipment and clean room space to support prototype development.

The new facility has to date been used to support work on a CSIR-developed new-generation fingerprinting sensing technology using high-speed, large-volume optical coherence tomography. The technology makes it possible to acquire latent fingerprints without destroying potential useful DNA material for forensics. The facility provides access to optical design, assembly and software development to advance the technology to a portable device. The technology has been tested in a local mortuary for the extraction of fingerprints of various states of decomposing human tissue and a contract for commercialisation is in the pipeline. In addition, commercial and partnership opportunities are being explored.

Biorefinery: More competitive pulp and paper mills

The CSIR collaborates with industry, universities and other research and technology organisations to develop and test biorefinery technologies that are used to convert biomass into chemicals, biomaterials and fuels; this is in addition to traditional wood, pulp and paper products. A new facility with cutting-edge analytical and pilot-scale equipment for biorefinery technology development is set to become functional in 2017.

Currently, forest processing industries are inefficient and extract only about 47% of value from trees, with the rest being lost as waste such as sawdust and mill sludge. The biorefinery programme is developing new value chains from the waste to produce high-value products such as xylitol (a low-calorie sweetener) and nanocrystalline cellulose. This will enable increased extraction of value from trees and reduce or eliminate waste production.

The CSIR was contracted by an industrial client to develop technologies for improving industrial competitiveness. In one project, CSIR research ascertained that the presence of fines material (very small fibre particles) in pulps affects the final product quality, causes operational problems and leads to increased consumption of expensive bleaching chemicals. The CSIR developed a technology for removing the fines material and indications are that this technology will save the industry about 50% of bleaching costs per annum for each mill that implements the technology.

Research, development and implementation for

ECONOMY AND EMPLOYMENT

Supporting industry with specialised infrastructure and skills (continued)

Developing the nanomaterials industry

The CSIR and the Department of Science and Technology have launched a production facility that provides small and large South African enterprises, universities and research institutions with access to facilities and expertise to scale-up nano-based innovations to industrial and commercial levels.

The facility is supporting Greenfield Additives in its development and scale-up of nanomaterials used as a stabiliser in the production of plastics such as polyvinyl chloride. CSIR researchers also helped develop cosmetic products based on the Greenfield materials, further supporting the competitiveness of this SMME.

The facility is enabling Sappi to develop cosmetics and polymeric composites applications based on their cellulose nanofibres.

The Nanomaterials Industrial Development Facility provides access to a versatile scale-up plant with sophisticated equipment and a skilled workforce with technological expertise in process development and scale-up. Researchers at the CSIR are knowledgeable about what happens to materials at the nano-scale and how the special properties such as surface-to-volume ratio and reactivity can be utilised. They also have a sound understanding of how engineering properties such as heat and mass transfer, as well as flow properties, must be considered during the scale-up of materials. A total of 34 interns have been trained at the facility. Of these, 16 are now employed in industry, six are continuing with their studies and eight are still at the facility.

The CSIR's Mbongeni Mahlangu preparing organically modified nano-clay for drying.

Research, development and implementation for

ECONOMY AND EMPLOYMENT

Supporting SMMEs through research, development and implementation

IN BRIEF

Small, medium and micro enterprises (SMMEs) are important contributors to the economy as they create employment opportunities that reduce poverty and improve quality of life. The CSIR has developed new SMMEs and supported several existing enterprises by providing access to its specialised infrastructure as well as scientific, engineering, technology and enterprise-related skills.

Kgalalelo Sekgetho, an intern of the Department of Rural Development and Land Reform, holds a container with essential oil produced by the Temothuo cooperative in Driekop in Limpopo's Sekhukhune district. Temothuo is establishing an agro-processing enterprise that aims to produce essential oils for manufacturers to make perfumes, cosmetics, aroma-therapeutic products and natural remedies. The department contracted the CSIR as an implementation agent for the production facility.

Research, development and implementation for

ECONOMY AND EMPLOYMENT

CSIR supports SMMEs through research, development and implementation (continued)

The challenge: Creating an enabling environment for SMMEs

There are more than two million formal and informal small, medium and micro enterprises (SMMEs) in South Africa. Many new enterprises fail within the first few years of their establishment, often due to insufficient feasibility projections, poor business planning, lack of skills and poor access to funding, expertise, technology and infrastructure.

CSIR support for small enterprises

The CSIR provides SMMEs with access to specialised infrastructure and multidisciplinary skills, helps optimise processes and products as part of localisation and supplier development initiatives, provides training and skills development, and licenses CSIR-developed technologies to SMMEs. The organisation develops new enterprises through feasibility studies and incubation support and creates and incubates spin-out companies from technology development.

OptimusBio: Empowering SMMEs through licensing

OptimusBio, a CSIR spin-out company, manufactures biological products for sanitation, water treatment, aquaculture and agriculture products that contain active, beneficial bacteria from the genus *Bacillus*. Launched in 2014, OptimusBio is a small enterprise that operates from the CSIR premises and is incubated as part of the Biomanufacturing Industry Development Centre. The development of the technology was partly funded by the Department of Science and Technology (DST), Biopad, The Jobs Fund and the Innovation Hub.

In 2016, the CSIR successfully implemented the use of these eco-friendly biological cleaning products across most of its campuses. The CSIR has also supported the South African National Defence Force to test the OptimusBio products for personal care, cleaning, as well as water and waste treatment during remote deployments in the Kruger National Park.

OptimusBio manufactures eco-friendly biological products that contain active, beneficial bacteria from the genus Bacillus.

Helping to optimise a water bottling enterprise

The CSIR is supporting a local community cooperative in rural Mpumalanga in upgrading its water bottling factory and to market its products in local towns. The Donkerhoek Water Bottling factory is situated on a farm near Ermelo, Volksrust and eMkhondo.

Funded by the Department of Rural Development and Land Reform (DRDLR), the CSIR conducted a due-diligence study of the built-up factory, developed a business plan and helped with the setting up and commissioning of operations at the plant. The next steps include pilot production and scaling up to full production towards the end of 2017.

Expanding the essential oils sector

In 2010, the CSIR received funding from the DST to develop a new range of essential oil projects to diversify and expand the South African essential oil sector. Two sites were established, one in Brits (North West) and the other in Ficksburg (Free State), for conducting the agronomic experiments to determine which crops would be commercially viable in stimulating the essential oil sector in South Africa.

The information gathered at the Brits site led to the development of an agronomic and processing guide for emerging essential oil farmers and entrepreneurs. The guide encompasses information on soil types, agricultural methods, processing, income potential and marketing.

Also funded by the DRDLR, the CSIR is helping the Temothuo cooperative in Driekop (Limpopo) to exploit the natural properties of indigenous plants such as the lemon bush and rose geranium. It has completed a feasibility study that included future projections, investment requirements and what the return on investment would be. The CSIR will support Temothuo with the chemical analysis of the oils and has introduced the cooperative to potential buyers. The cooperative is also supported with applications for regulatory approvals such as an integrated biotrade and bioprospecting permit and a water-use licence. The cooperative has started to harvest and distil crops, which will be sold to manufacturers of natural aromatic and therapeutic products.

New bakery for North West community

The small rural village of Mokgalwangeng, in the Moses Kotane Local Municipality in the North West Province, now has a bakery that supplies 32 spaza shops in the area with baked products. Enterprise

(From the top) Vivian Radebe, a CSIR enterprise development practitioner and Thobile Nkosi (right), a supervisor at the Donkerhoek Water Bottling factory at the plant's water purification infrastructure.

Rose geranium is one of two plants cultivated by the Temothuo Cooperative. The CSIR's Dr Luke Mehlo and Oupa Mphogo inspect the seeds of the Lippia javanica plant, also featured above.

Research, development and implementation for

ECONOMY AND EMPLOYMENT

CSIR supports SMMEs through research, development and implementation (continued)

creation experts at the CSIR had conducted a feasibility study for the North West Department of Economy and Enterprise Development after which a cooperative was formed with 13 members of the community. During the incubation period, the CSIR assisted in setting up the necessary infrastructure where the bakery would operate, ensured that the facility complied with relevant regulations and trained cooperative members.

Helping the Tshivhase Tea Estate to improve its competitiveness

The CSIR used science and technological solutions to help the Tshivhase Tea Estate in Limpopo investigate diversification of its product range to improve its competitiveness.

CSIR enterprise development experts conducted a pre-feasibility study to assess the market, technical and financial aspects in which the business operated. Thereafter an in-depth feasibility study was conducted to assess the commercial viability of botanical extracts as an additional product line. This included the establishment of a pilot production facility to test technical viability and gather accurate production data.

The feasibility study led to the drafting of a business plan that could be sent to potential funders.

Developing small-scale farmers with business savvy

The CSIR implemented an educational rural development programme that teaches learners and the community how to run a successful farming business.

The Technology for Rural Innovation and Economic Development Programme, initially funded by the DST and with follow-up funding by the Department of Trade and Industry, was created to enable

(From the top) Elias Matumba, agricultural management practice teacher at the Tshipakoni High School provides guidance to the next generation of small-scale farmers, Lutendo Matumba and Nyandano RaMulongo. A project nursery at the school provides quality seedlings. Tea plantations at the Tshivhase Tea Estate.

agri-entrepreneurship at high schools to introduce black rural learners to the farming industry.

After successfully implementing the programme in the Eastern Cape, researchers implemented the programme at the Tshipakoni High School in Limpopo's Vhembe district. The school has been able to supply maize and other produce to the local markets and has created farming-related jobs for community members who partake in the course.

Helping entrepreneurs meet environmental obligations

The CSIR helps small business owners meet environmental regulations when growing their businesses by rendering support to the Special Needs and Development Programme of the Department of Environmental Affairs.

The organisation has helped a small-scale poultry farmer in Onderstepoort, outside of Pretoria, to expand his business by assisting him in identifying and contracting experts in geology, water, ecology and heritage. The researchers assisted with the reports and findings from the experts and completion of the required documentation to receive the necessary permits to open an abattoir.

To date, the CSIR has received 30 applications and completed approximately 15 environmental assessment reports. Most of the beneficiaries have been in agriculture, mining and tourism.

Developing local suppliers for the aerospace industry

The main objective of the Aerospace Industry Support Initiative (AISI), an initiative of the Department of Trade and Industry that is hosted by the CSIR, is to assist the aerospace and defence industry to improve its competitiveness, productivity and quality management systems. In doing so, the AISI optimises operations to ensure the integration of the South African industry into global supply chains. In the 2016/17 financial year, 12 AISI projects benefitted 23 organisations of which 15 are SMMEs.

Enabling local firms to supply goods to state-owned enterprises

The DST Technology Localisation Programme, which is managed and hosted by the CSIR, provides funding and technology support to enable more local firms to supply goods to state-owned enterprises. Minimum local content thresholds have been set for 16 designated products. Since the launch of this programme, a number of original equipment manufacturers have started buying locally-produced equipment that was previously imported.

Two local companies, T&T Engineering, a fabrication company based in KwaZulu-Natal and Daliff Precision Engineering, an aerospace supplier based in the Western Cape, are examples of local businesses that have benefitted from the programme.

Access to specialised infrastructure

The CSIR supports new enterprises by providing them with access to the organisation's specialised facilities and multidisciplinary skills as part of the Industry Innovation Partnership Fund, which is supported by the DST. This means that SMMEs that would otherwise not be able to afford it, have access to large-scale prototyping and pre-commercial manufacturing infrastructure, equipment, expertise and access to business and technical networks. The SMMEs can put their innovations through a process of laboratory-scale validation to technology prototyping and pilot manufacturing. See article on page 25.

Michael Molenke, a worker on the Tolane farm north-west of Rustenburg, holds fibre produced on-site from sisal plants.

A delivery pump housing manufactured by local aerospace components supplier, Daliff Precision Engineering, a beneficiary of the supplier development programmes of the Aerospace Industry Support Initiative and the Technology Localisation Implementation Unit.

Research, development and implementation for

ECONOMY AND EMPLOYMENT

An ocean information management system to protect South Africa's oceans economy

IN BRIEF

The CSIR has developed and is implementing the national Oceans and Coastal Information Management System under contract to the Department of Environmental Affairs to provide access to interactive spatial and temporal information as a tool for improved decision-making and predictive modelling.

The CSIR-developed harmful algal bloom notification system indicates areas on a map at high risk due to the formation of large concentrations of algae in the ocean.

The challenge: Reaching a vast coastal area

South Africa is straddled by two oceans and has 3 900 kilometres of coastline. Its coastal areas support thousands of jobs with goods and services estimated to contribute significantly to the national economy. It is estimated that the oceans have the potential to contribute up to R177 billion to the gross domestic product (GDP) and create just over one million jobs by 2033.

Operation Phakisa: Oceans Economy is a national government programme, led by the Department of Environmental Affairs (DEA), to realise the potential of the country's oceans economy. It aims to protect and grow South Africa's oceans economy. This requires the monitoring and governance of the country's oceans and coastal areas, which is challenging due to their size and previously disparate monitoring systems.

The protection and governance of the country's oceans is crucial to unlocking the potential of the oceans economy. However, challenges include the size of the coastline and ocean regions, the number of departments, institutions and national acts involved, as well as the different socio-economic contexts, development goals and habitats of coastal provinces.

Research and development: A user-friendly national oceans information management system

The CSIR has developed the Oceans and Coastal Information Management System (OCIMS) that integrates systems, information and expertise into one cost-effective and user-friendly national system, providing access to interactive spatial information as a tool for improved decision-making and predictive modelling.

OCIMS has been released to its first users, including the DEA, the South African Navy, Defence Intelligence and the fisheries compliance unit at the Department of Agriculture, Forestry and Fisheries.

This first version provided access to over 190 ocean and coastal related datasets from the Transnet National Port Authority, the DEA, the Wildlife and Environment Society for South Africa and the South African National Botanical Institute. It also provided access to the beta versions of modules that detect harmful algal blooms, track vessels in our seas and provide an integrated view of the country's coastal zone. Proofs of concept for SeaState forecasts and coastal inundation decision-support tools were also demonstrated.

Outcomes

Detecting harmful algal blooms

Harmful algal blooms happen when large concentrations of aquatic micro-organisms form in the ocean, producing natural toxins and depleting oxygen in the water. These red tides sporadically cause large rock lobster walkouts, also killing other aquatic animals.

The rock lobster industry contributes approximately R200 million per annum to South Africa's GDP and a red tide event in 2015 caused a walk-out of lobster stock worth R114 million. In February 2017, another harmful bloom formed and was pumped into on-shore abalone farms, causing stock losses of R50 million. Using its capabilities in satellite monitoring and information systems, the CSIR developed a harmful algal bloom notification system that is now in operational use.

Tracking seafaring vessels

South Africa's exclusive economic zone is 1 535 538 km² and its diverse and rich marine ecology is an easy target for illegal fishing due to the difficulty in policing such an immense expanse.

In 2016, CSIR-developed technology helped the authorities to track foreign vessels that had entered South Africa's exclusive economic zone without permits and without declaring 600 tonnes of squid on board. The operators were apprehended, appeared in court and were fined. The CSIR technology is called SeaFAR and is one of the decision-support tools integrated into OCIMS. It uses satellite-based synthetic aperture radars, optical satellites and satellite automatic identification system data as well as satellite vessel management system data, coupled with machine learning algorithms, to detect and identify vessels displaying suspicious behaviour.

The CSIR continues to improve and enrich the functions of OCIMS.

Going forward

In other work in support of Operation Phakisa: Oceans Economy, the CSIR is in the process of developing decision-support tools for sea search and rescue missions, monitoring oil bilge spills and pollution, providing sea state forecasts to small-scale fishing communities, supporting tourism with map stories of coastal highlight areas and for marine spatial planning.

CSIR researchers are also contributing to a strategic environmental assessment on the aquaculture industry, developing a sensor that measures carbon dioxide in the ocean, and refining a system that monitors fish stock levels.

Research, development and implementation for

ECONOMY AND EMPLOYMENT

Titanium powders produced at the CSIR explored for downstream processing

The CSIR has overcome significant technical challenges to produce titanium metal powder for various applications at its semi-batch pilot processing plant. The CSIR produced high purity Ti-6Al-4V alloy powders (Grade 5) suitable for the aerospace industry and large aircraft manufacturers.

The titanium pilot plant was constructed following the development of a novel, CSIR-patented process to produce primary titanium metal. While South Africa has large reserves of titanium-bearing minerals, the ability to economically extract the mineral from the mineral concentrate, using the CSIR process, will help create a new downstream industry. A Titanium Centre of Competence (TiCoC), funded by the Department of Science and Technology (DST) and hosted at the CSIR, had been established in 2009, pooling local skills in this domain, including those at six local tertiary education institutions.

TiCoC is in the process of securing ISO/IEC 17025 accreditation for its powder characterisation laboratory to qualify the powder and to ensure that it meets international standards.

The titanium powders produced at the CSIR are being explored for use in various downstream manufacturing processes such as additive manufacturing, powder metallurgy and investment casting. All these manufacturing processes and the advanced facilities at the CSIR are used to design, develop, manufacture and test metallic materials, mill products and components.

The DST has committed R105 million over three years to enable TiCoC to implement its titanium powder acceleration plan with the Industrial Development Corporation as partner.

The TiCoC team has recently been awarded the prestigious National Science and Technology Forum (NSTF)-South 32 Award in the category for research leading to innovation.

The CSIR's Ntokozo Shabalala with titanium metal powder produced at the CSIR titanium pilot plant.

Research, development and implementation for

ECONOMY AND EMPLOYMENT

First aerospace parts produced in local additive manufacturing collaboration

The CSIR and the Aerosud Innovation Centre, an aeronautical engineering and manufacturing company, have developed an advanced 3D printer for metal components as part of project Aeroswift. Three titanium parts, namely a pilot's throttle lever, a condition lever grip and a fuel tank pylon bracket, have been successfully produced using the 3D printing system. The project is funded by the Department of Science and Technology, and forms part of South Africa's national titanium beneficiation strategy, which aims to transform the country from an exporter of raw materials to an exporter of semi-finished or finished goods.

The metal additive manufacturing system uses a laser to melt titanium powder to produce metal parts for the commercial aerospace manufacturing sector. The system has the ability to produce geometrically complex parts according to a customer's specification, minimising material wastage while processing difficult-to-machine materials. The system can also be used to produce parts for the power generation, automotive tooling, defence and manufacturing sectors.

During proof-of-concept trials, the machine achieved production speeds up to 10 times faster than currently available commercial laser melting machines.

Compared to conventional manufacturing technologies which often rely on the removal of material through a machining process to produce a final component, additive manufacturing relies on various energy-depositing technologies to fuse powdered or wire-based materials into 3D functional near-net-shape parts.

The Aeroswift team produced two different flight grips (the condition lever grip and throttle grip) for the South African developed AHRLAC aircraft. The titanium metal part on the far right of the top image is a fuel pylon bracket developed for a commercial aircraft. The bottom image shows the parts from a different angle.

Research, development and implementation for

ECONOMY AND EMPLOYMENT

New mining hub to advance South African mining

A new mining research and development hub that will host researchers and mining staff from four organisations is being established at the CSIR in Johannesburg. The hub is coordinating research activities directed towards the revitalisation of mining through the development of next-generation mechanised mining systems.

The establishment of the hub follows the development of a mining research and development strategy that focuses on extraction. Developed by the CSIR in consultation with public and private stakeholders in the mining sector, the South African Mining Extraction Research, Development and Innovation (SAMERDI) strategy focuses on establishing global leadership in narrow-reef, hard rock mining systems through partnerships in research and development and creating a competitive local manufacturing capability. The Department of Science and Technology (DST) allocated R150 million in support of the implementation of the SAMERDI strategy and contracted the CSIR as the lead implementer.

Statistics South Africa reports had indicated a decline in mining and manufacturing production negatively impacting economic growth and employment in the country. To curb the decline in the contribution of mining to the gross domestic product, a government-led Phakisa process was applied to the mining sector, involving stakeholders from organised labour, government departments and research organisations.

The strategy provides a roadmap on how to work collectively towards technological solutions that will increase safety and productivity, and reduce costs to ultimately extend the life of mines. It has the buy-in from stakeholders in government, mining companies, local equipment manufacturers and the research community to ensure the longevity of the South African mining industry.

Initiatives to revitalise South African mining through the development of next-generation mechanised mining systems are underway with a new mining research and development hub established at the CSIR in Johannesburg.

Research, development and implementation for

ECONOMY AND EMPLOYMENT

CSIR technology creates jobs in the media and broadcast industry

The CSIR has issued pilot licenses of its technology for the streaming of mobile videos without buffering to three small, medium and micro enterprises (SMMEs) and has issued an expression of interest to SMMEs to license the technology. The three active pilot licenses are with Sky Rink Studios, eMbizo and Psybergate.

The micro enterprise media engine-broadcast is one component of the technology that, in addition to allowing for the streaming of mobile videos without buffering, makes it possible to broadcast scheduled content in both low- and high-bandwidth environments. The technology empowers entrepreneurs to operate their own Internet-based television stations over mobile networks.

To deliver content to audiences, a broadcast station must be able to commission, upload and schedule content. A second component, micro enterprise media engine-workflow enables a broadcast manager to commission work from other media professionals and to upload, schedule and broadcast to audiences, while also connecting audiences to advertisers.

The solution has been patented in China, Russia, Nigeria, Africa, the United States of America and the United Kingdom. Since its inception, it has created 39 direct and indirect employment opportunities.

CSIR technology has been integrated into the curriculum of local film school, Bigfish School of Digital Filmmaking. CSIR researcher Thabang Sono and Bigfish student Phelisa Mgudlwa test aspects of the technology.

Research, development and implementation for

ECONOMY AND EMPLOYMENT

Developing a better alternative for the nonwoven fabric industry

The CSIR has developed a sample of nonwoven filter fabric that can be used in the filtration market in South Africa. Researchers have found that the new product performs better than the current filter fabrics which are imported. The fabrics can be used for disposable products such as wipes and diapers, or for products with longer-term usage such as geotextiles, insulators and interlinings.

Nonwoven fabric is material made from long fibres, bonded together by chemical, mechanical, heat or solvent treatment using different bonding techniques. Globally, nonwoven fabrics is one of the fastest growing segments in the textile sector. The industry is relatively small in South Africa, however studies by the CSIR show that the market is ready for locally produced material.

The development of the new fabric resulted from a pilot project in which the CSIR, the Department of Trade and Industry and the Eastern Cape local government collaborated with a view to develop an alternative method of creating these fabrics to boost local production and create employment.

The sample is lightweight and provides better efficiency than those currently on the market. It also saves 30 percent of the material used in production, which makes it affordable to be produced locally. Results show that an affordable option for the filter fabric can help smaller enterprises who are competing in the textile sector.

Researchers now have to produce 120 bags from their new filter fabric, which will be tested by companies to see how the product performs under operational standards.

The CSIR's Dr Sunshine Blouw (left) and Dr Mlando Mvubu with a sample of the fabric used in manufacturing filter bags for power-stations.

Polyacrylonitrile used to manufacture fabric for filter bags.

Research, development and implementation for

ECONOMY AND EMPLOYMENT

CSIR-hosted programmes play key role in government's localisation strategy

The CSIR is playing a pivotal role in the implementation of government's localisation strategy. A key part of this strategy is creating an environment in which state-owned entities buy locally manufactured goods.

The CSIR-hosted Technology Localisation Implementation Unit (TLIU), an initiative of the Department of Science and Technology, and the National Foundry Technology Network (NFTN), an initiative of the Department of Trade and Industry, are programmes that offer support to the local manufacturing sector. Interventions led by these programmes – ranging from product development and tooling support, to technical and management training – have resulted in local suppliers increasing their share in local and global supply chains.

The TLIU worked with ABB South Africa to identify potential manufacturers of components required for traction transformers. Traction transformers direct power at safe voltages to support train functions such as traction, braking, lighting, heating and ventilation, as well as signalling and communication. The specially designed transformers will be supplied to Bombardier, the chosen supplier to build new locomotives for Transnet's freight trains, and eight local companies will benefit by supplying components.

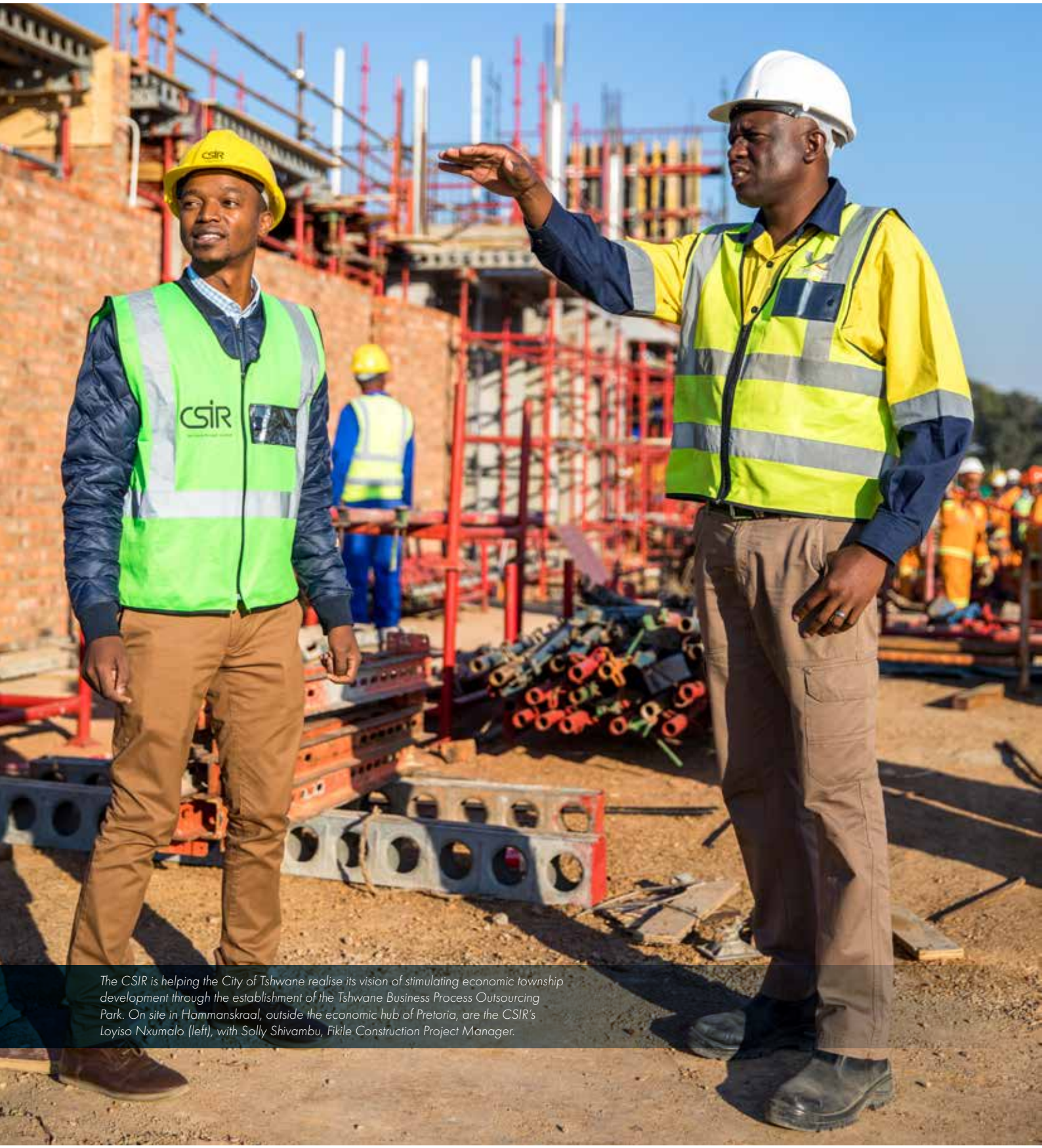
Alloy Magnetic Cores (AMC), a local company that received technology and knowledge transfer from ABB, secured an order from South America for 40 tonnes of cores through ABB's intervention. The technology transferred to AMC through a TLIU intervention has enhanced the capability at the company and has resulted in the company's ability to compete globally in this segment. Cores are the bundles of ferrous material that form the inner portion in electromagnets and transformers.

In the foundry industry, the NFTN, in collaboration with the TLIU, provided Microcast Foundry, a 100% black-owned and managed foundry, based in Durban, with access to simulation and 3D modelling technology that has enabled the company to efficiently design and manufacture prototype patterns for valve bodies used in the marine industry. This has resulted in a 50% reduction in the time spent and associated cost to develop prototype patterns.

The NFTN is also assisting a cluster of rural foundries in Limpopo with technology interventions and process improvements. With limited resources and support, these small foundries produce indigenous aluminium castings such as three-legged pots and art casting products. The rural foundries use low-energy-efficient furnaces that are coal fed in steel drums, which are not economically viable and emit toxic pollutants to the surroundings.

Through the NFTN intervention, productivity has improved and production costs have reduced at these foundries through process optimisation and installation of solar energy panels. Pollution has also been minimised through the introduction of renewable materials, while the employees have benefitted from health and safety improvements.

A CSIR intervention and collaboration with a local company, Paltechnologies (Pty) Ltd (Paltech), has resulted in the successful development of a standard 80 mm diameter butterfly valve installed on electrical power transformers.



The CSIR is helping the City of Tshwane realise its vision of stimulating economic township development through the establishment of the Tshwane Business Process Outsourcing Park. On site in Hammanskraal, outside the economic hub of Pretoria, are the CSIR's Loyiso Nxumalo (left), with Solly Shivambu, Fikile Construction Project Manager.

Research, development and implementation for a

CAPABLE STATE

A capable state relies on efficient service delivery processes to support its citizens. The CSIR addresses various challenges related to this, including a shortage of skills, lack of organisational capacity and poor uptake of potential technology-based service-delivery solutions. The CSIR provides decision-support services to government departments, local government and state-owned enterprises to enable more coherent and better-informed decisions.

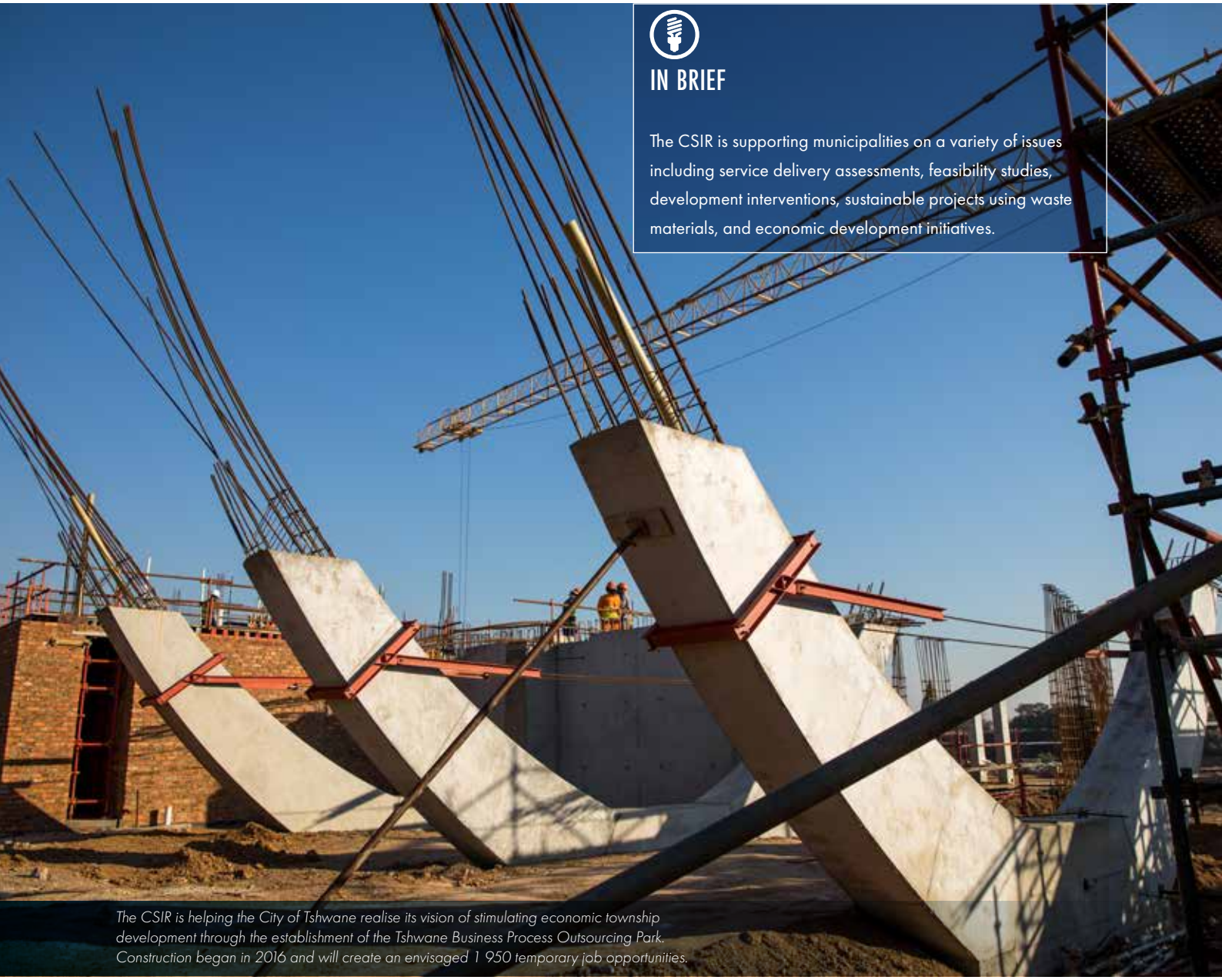
Research, development and implementation for a

CAPABLE STATE

Supporting municipalities with service delivery, economic development and a green economy

IN BRIEF

The CSIR is supporting municipalities on a variety of issues including service delivery assessments, feasibility studies, development interventions, sustainable projects using waste materials, and economic development initiatives.



The CSIR is helping the City of Tshwane realise its vision of stimulating economic township development through the establishment of the Tshwane Business Process Outsourcing Park. Construction began in 2016 and will create an envisaged 1 950 temporary job opportunities.

The challenge: Issues in municipal service delivery

Efficient municipal service delivery has a direct impact on the wellbeing of South Africans. Challenges facing municipalities include rapid urbanisation, the need to boost local economic growth, as well as climate change, pollution, land degradation and the associated strain on natural resources.

Assessing service delivery infrastructure for the Municipal Infrastructure Management Agency

The CSIR was commissioned by the Municipal Infrastructure Management Agency (MISA) to collate infrastructure service delivery data collected by MISA from 10 distressed municipal districts into one assessment tool. The tool will assist to determine the extent and causes of service delivery backlogs in municipalities. The analysis focuses on waste management, electricity as well as road and storm water infrastructure. The CSIR has completed the first phase of the project, which includes the development of questionnaires for MISA's data collectors and a comprehensive report template for each sector. Following the completion of the assessment tool, the CSIR will assist with assessment reports and subsequent support plans for the 10 districts.

Researching the use of waste to support a green economy for the City of Johannesburg

The CSIR conducted feasibility studies for potential projects that could develop sustainable green economy solutions for the City of Johannesburg (CoJ). These are projects that aim for economic development that supports social equity without degrading the environment.

Biogas production

Researchers conducted a feasibility study to assess the implementation of biogas production plants that would provide renewable fuel for the city's mass transit system (Rea Vaya Bus Rapid Transport and Metrobus). Biogas is a biofuel that is produced by converting biomass such as waste and agricultural crop residues into a methane-rich fuel.

The study identified organic waste resources that normally are a burden and carry a disposal fee, as the lowest cost option for the production of biofuel. Reducing the disposal of waste to landfill avoids carbon-emissions, the pollution of groundwater and soil, and the degradation of urban land. Using municipal organic waste for biogas can also help to mitigate greenhouse gas emissions through the displacement of fossil fuels and by avoiding methane emissions that would occur if left in the environment to decay.

The CSIR assessed the economies of scale of biogas production and found that large-scale facilities will be needed to achieve low production costs that can compete with fossil fuel alternatives (petrol, diesel and natural gas). Ideally, two facilities serving the northern and southern parts of Johannesburg would be optimal to capture the organic waste and produce biogas for upgrading to transport fuel. A pilot study at a site near Olifantsvlei showed that it is possible to produce biomethane fuel for 150-200 buses using existing household and garden waste.

Using builders' rubble for stone paper

The CSIR investigated the feasibility of using rock waste from mining and builders' rubble for the production of stone paper, a durable and water resistant paper-like product that could reduce the need for the import or local production of packaging paper. The researchers found that there are sufficient resources of waste rock in the CoJ, but that the cost of removing radioactive uranium in the mine tailings might be a financial barrier. They concluded that builders' rubble, which is currently sent to landfill or illegally dumped, is a better option and could create new enterprises at landfill sites. Stone paper is currently made from marble dust and high-density polyethylene using established technology. This type of plastic forms 1-1,5% of the city's waste stream and could be used together with builder's rubble that is dumped at municipal landfill sites. The CSIR found that the establishment of stone paper production facilities at municipal landfills using builders' rubble and this plastic is financially feasible, but development will require licensing from the patent holder, or the development of a product with novelty that will not be covered by the patent.

A business process outsourcing park for the City of Tshwane

The CSIR is helping the City of Tshwane realise its vision of stimulating economic township development through the establishment of the Tshwane Business Process Outsourcing (BPO) Park in Hammanskraal, outside the economic hub of Pretoria.

The first phase of the project includes the construction of two purpose-designed buildings to house BPO operations, complete with IT infrastructure. The implementation work includes the appointment of a professional team to supervise construction, as well as an IT designer and project manager. Construction of the BPO Park, estimated to cost in excess of R300 million, began in 2016 and will create an envisaged 1 950 temporary job opportunities. Small, medium and micro enterprises (SMMEs) will be able to supply products and services associated with the construction phase of the BPO Park. Once complete, the BPO Park will employ 1 100 young people full time. SMMEs providing BPO services will also have access to an incubator and training centre located in the BPO Park.

Research, development and implementation for a

CAPABLE STATE

CSIR successfully implements algae-based wastewater treatment solution

IN BRIEF

The CSIR has successfully implemented an algae-based wastewater treatment solution at the Motetema wastewater treatment works in the Sekhukhune District Municipality in Limpopo. The treatment facilitated the removal of nutrients and pathogens in wastewater treatment works.

A total of 5 000 litres of algal species were added to the five reactor tanks installed at the wastewater treatment works in Motetema. The algae is designed to remove nutrients and increase the pH level of the water.

The challenge: Wastewater quality management in small municipalities

The outcomes of the Green Drop assessments – which measure the performance of South Africa's wastewater treatment works (WWTWs) as part of wastewater quality management – confirm that WWTWs in the country in general, and the Sekhukhune District in particular, are facing significant challenges. Through engagements with the Sekhukhune District Municipality it was established that this is mainly as a result of aging infrastructure, insufficient technical capacity and limited financial resources. The municipality urgently needed long-term sustainable solutions to address the issue.

Smaller municipalities throughout South Africa face the challenge of improving their green drop status. The Green Drop Report (DWA, 2012) noted that all 17 of the WWTWs in the Greater Sekhukhune District Municipality are in high and critical risk positions, which means that effluent discharged from these WWTWs pollutes receiving water bodies and presents a high risk to public health.

Research and development: Algae-based treatments for wastewater

Due to the lack of proper WWTW infrastructure and electricity, a series of ponds at the Motetema treatment works were used to treat the municipal sewage. The algae-based treatment developed uses a specific community of algal species, which have been isolated and cultured in the laboratory. Five reactor tanks were installed at the WWTW and 5 000 litres of the algal species were added to each tank. The two species of algae that are cultured at a mass scale and used for the phycoremediation of the pond systems are *Chlorella vulgaris* and *Chlorella protothecoides*. The algae remove nutrients and create suitable conditions for effective solar disinfection to reduce pathogen and *E.coli* bacteria by increasing the pH level of the water.

To create further value, fish were introduced in the ponds to consume algae and residual pathogens, resulting in the creation of a fish farming venture. One of the major considerations was to implement a self-sustaining system that is independent of electricity or expensive chemicals and that can be effectively operated within the current financial and capacity constraints of the Sekhukhune District Municipality.

Output: A wastewater treatment system suitable for a rural community

The algae-based treatment developed was successful and reduced the nutrients that cause eutrophication. The solution is ideal for a rural community because it does not require electricity or highly qualified engineers to function.

The implementation of this low-cost intervention contributes to improved human health and the ecosystems downstream from the Motetema wastewater treatment works.

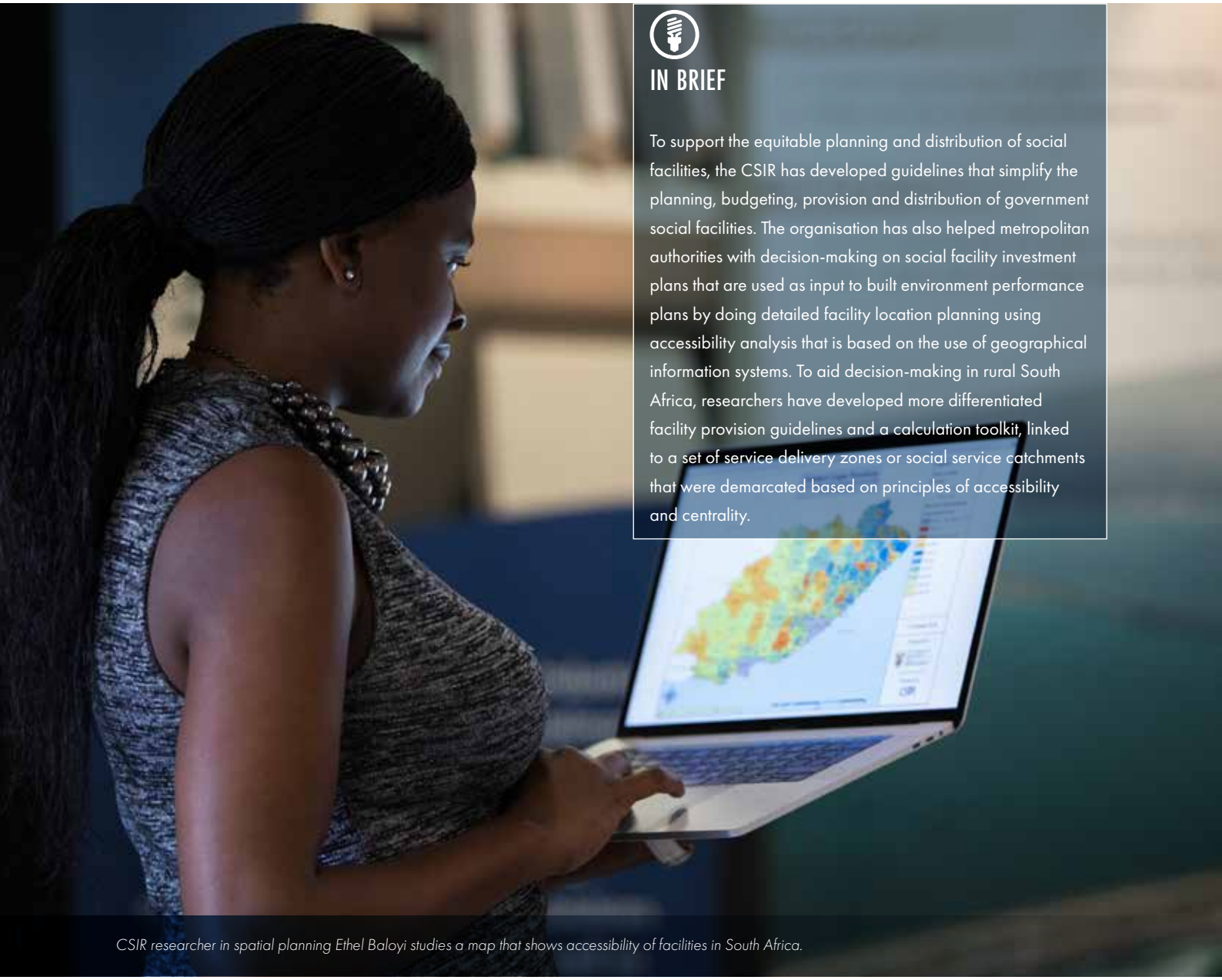
CSIR researchers have trained the operators of the ponds and have developed a manual with operational and maintenance guidelines which can be used by municipalities to manage algae-based wastewater treatment systems.

The wastewater treatment technology applied at Motetema does not require electricity or special skills, making it ideal for use in a rural setting.

Research, development and implementation for a

CAPABLE STATE

Spatial planning of social facilities



IN BRIEF

To support the equitable planning and distribution of social facilities, the CSIR has developed guidelines that simplify the planning, budgeting, provision and distribution of government social facilities. The organisation has also helped metropolitan authorities with decision-making on social facility investment plans that are used as input to built environment performance plans by doing detailed facility location planning using accessibility analysis that is based on the use of geographical information systems. To aid decision-making in rural South Africa, researchers have developed more differentiated facility provision guidelines and a calculation toolkit, linked to a set of service delivery zones or social service catchments that were demarcated based on principles of accessibility and centrality.

CSIR researcher in spatial planning Ethel Baloyi studies a map that shows accessibility of facilities in South Africa.

The challenge: Sufficient and equitably distributed social facilities

While all South Africans have the right to access basic services such as health and education, it is important that all citizens in time, have access to a wide range of social facilities that can improve their quality of life. Many local authorities strive to make facilities such as parks, sports fields and community halls accessible to their communities and to do this in a way that is equitable and socially just. This means that provision should be both sufficient and equitably distributed. The reality is that some geographical areas in South Africa have an over-supply of facilities, with an associated maintenance burden on the municipalities, while other areas lack even the most basic facilities. Guidance is often lacking on what is to be provided, where, for whom, and in what quantities.

Research and development

Quantitative standards to redress inequalities in rural service provision

To achieve greater equity, measurement, modelling and monitoring are required. When the research was initiated, no reliable methodology had been applied to spatially test sufficiency of facility provision across the country, neither were there any consolidated provision standards against which to benchmark this provision.

The CSIR consolidated, verified and adapted the provision standards for providing social facilities using interactive research, as well as status quo analysis and measurement. Researchers also consulted with numerous government stakeholders. This resulted in *CSIR Guidelines for the Provision of Social Facilities in South African Settlements*, published in 2012 and reprinted in 2015, and more recently, in 2016, *Guidelines for the Differentiated Provision of Social Services in Rural Areas* for the Department of Rural Development and Land Reform. The 2016 guidelines provide greater differentiation of standards for use in a range of lower-density rural contexts. The guidelines apply across many public service sectors, including health, education, sports, emergency services and citizen registration services.

Tools to help address service delivery: GIS-based accessibility analysis

To support government in addressing the equitable distribution of social services, the CSIR delivers facility location planning support to all tiers of government. Applying detailed GIS-based accessibility analysis, the organisation provides metropolitan authorities with detailed input into social facility investment and built environment performance plans. Such plans enable efficient and socially just spatial planning to support longer term city and regional development.

In a recent project for the City of Tshwane, CSIR researchers used the UrbanSim model to develop a future population projection that was then applied to develop a detailed spatially disaggregated long-term social facility investment plan for the city.

Results and recommendations for the Cities of Tshwane, eThekwini and Cape Town are directly influencing the location, number and distribution of social facilities that support long-term city growth and provide evidence for the capital budget process. The research, to date, has had an impact on social facility investment planning that affects more than 10 million citizens in four metropolitan areas.

At a provincial level, the tools and techniques have supported the Department of Justice as it re-aligns service delivery areas of courts, while a detailed analysis of school capacity sufficiency and location for Limpopo was also undertaken.

At a national level, support has been provided to the Department of Social Development for decision-making on its early childhood development centres and programmes.

Access-related service delivery zones in rural areas

In finding a cost-effective way to support facility location planning in mainly rural South Africa, the CSIR made use of GIS accessibility tools to develop a set of access-related service delivery zones or social service catchments around all towns and villages. The effective use of services is highly dependent on the affordability and distance of travel of users. Therefore, catchments are based on all citizens being allocated to their closest place of local service delivery. Researchers developed a spatial framework to equitably allocate specified services within a spatial service hierarchy. This will enable a first-level assessment of facility backlog without the need for detailed accessibility analysis as used in metros. The latter approach is cost effective in low-density rural environments with poor data availability. The profiling and classification of some 1 328 service catchments was linked to the definition of differentiated facility service packages for different catchment sizes. The profiling of settlement contexts is important in understanding how much, where and how facilities should be distributed within catchments. The profiles of the catchments cover a range of factors including population size, density, area, administrative role, economic production, settlement morphology and topography, and information on travel distances to other settlements.

As an outcome of this work, the Department of Rural Development and Land Reform in 2016 launched the first web-based toolkit that can support the differentiated application of social facility provision standards in non-metropolitan areas through the calculation of the maximum number of schools, clinics, hospitals and libraries that each service catchment can support. The toolkit is freely available at www.socialfacilityprovisiontoolkit.co.za.

Research, development and implementation for a

CAPABLE STATE

Integrated assessments support responsible planning for the Central Karoo

IN BRIEF

The Central Karoo is an arid, extensive landscape admired for its pristine natural beauty. However, the region is also characterised by poverty, high levels of unemployment and inequality. Government asked the CSIR to lead a multidisciplinary assessment process to guide decisions in the region regarding both shale gas development and the construction of the Square Kilometre Array.

A CSIR team doing fieldwork at the SKA site in the Karoo.

The challenge: Obtaining reliable evidence about fracking

South Africa is investigating the opportunities for introducing more natural gas into the coal-dominated energy mix. One potential option is to exploit naturally occurring methane from deep shale layers in the Central Karoo through horizontal drilling and hydraulic fracturing ('fracking'). Very little is known about the distribution and magnitude of the gas resource, or whether it can be extracted at economically viable rates. If shale gas were found at economically viable flow rates, the economic and energy security opportunities could be substantial; however, there may be socio-economic and environmental risks associated with the lifecycle of a domestic gas industry.

Questions relating to shale gas development have been presented to the public and decision-makers as a trade-off between economic opportunity on the one hand and environmental protection on the other. It has become a highly divisive topic, but one which has been, up to now, poorly informed by publicly-available and trusted evidence.

Research: An independent scientific assessment for shale gas development

To address this lack of critically-evaluated information, the CSIR led an independent scientific assessment with its partners, the South African National Biodiversity Institute and the Council for Geosciences. The assessment was completed in November 2016 following 12 months of intense investigation. It is the largest and most comprehensive scientific assessment ever undertaken in South Africa. The process included detailed inputs from 146 expert authors covering 18 topic chapters, 75 independent peer reviewers, multiple governance groups representing a diversity of sectors and hundreds of stakeholders who participated in the process through various communication and outreach forums. The outcomes of the scientific assessment presented the risks and opportunities associated with a range of plausible development scenarios. The results have been published as a peer-reviewed e-book and are freely available at http://seasgd.csir.co.za/scientific-assessment-chapters/.

Key outcomes: Development scenarios, risk assessment, monitoring requirements and best-practice guidelines

The first outcome from the study was a set of plausible development scenarios for shale gas in the Karoo, based on a synthesis of best available information. The study assessed the potential risk and opportunities for various issues, including biophysical aspects such as seismicity, water and biodiversity, as well as socio-economic aspects. The CSIR prepared a set of best-practice guidelines and ongoing monitoring requirements that should be satisfied.

Key findings relating to water are that current potable water resources in the Karoo are already fully allocated. Any additional water requirements for shale gas development would need to make use of water from non-potable sources, such as the treatment and transport of seawater from the coast, or sourcing deep saline groundwater when undertaking drilling activities. The risk assessment also identified the need for treatment of groundwater from deep drilling, the need for a centralised waste facility as well as requirements for wastewater treatment and recycling. The study also found that one of the highest risks is that the fracking fluid leaks into the surface water and shallow aquifers used by people and the ecosystem due to inadequate sealing of the upper parts of the borehole, or the surface-stored fracking fluid spills during a storm, for instance. These risks can be mitigated, but not eliminated, by good engineering.

In terms of biodiversity risks, the actual spatial impact of the wellpads and connecting roads and pipelines is small.

The biggest and least tractable impacts are likely to be social: the introduction of noise, traffic, lights, workers, work-seekers and their dependents into a formerly tranquil environment.

The challenge: Building a telescope array with the environment and economy in mind

The Square Kilometre Array (SKA) project is an international effort to build the world's largest radio telescope, which will be co-located in Africa and Australia. With its dishes collectively covering a square kilometre in area, it will generate unprecedented scientific information which will substantially improve our understanding of the universe.

The MeerKAT telescope array is being constructed near Carnarvon in the Northern Cape in the first phase of the South African SKA project and as a precursor to the full SKA telescope. MeerKAT will consist of 64 complete antenna structures, each comprising a 13.5-metre diameter dish antenna, cryogenic coolers, receivers, digitiser and other electronics. Another 112 dishes will be erected in close proximity to the MeerKAT telescope array and 21 more dishes within an 80 km radius.

Research, development and implementation for a

CAPABLE STATE

Integrated assessments support responsible planning for the Central Karoo (continued)

This technology needs to be located far from electronic devices or machines that emit radio waves that will interfere with faint radio signals coming from the distant universe. The climate also needs to be dry to avoid radio waves being absorbed by moisture in the atmosphere. Researchers needed to conduct reliable assessments of the impact of the SKA on the environment and vice versa.

Research: An environmental assessment for a SKA setting in the Karoo

The Department of Environmental Affairs in partnership with the Department of Science and Technology commissioned the CSIR to undertake a strategic environmental assessment for the first phase of the South African SKA project in a Karoo central astronomy advantage area. In 2014, the DST declared several areas in the Karoo as astronomy advantage areas to be protected from radio frequency and other interference.

The goal of the assessment was to guide sustainable development, balancing human development goals with the ability of natural systems to continue to provide the resources and ecosystem services upon which the economy and society depend. Independent and multidisciplinary researchers conducted assessments of agriculture, the area's cultural and archaeological heritage, ecology, biodiversity and water sources. Other factors included the influence of aviation and defence activities, use of telecommunication devices and services, mining and waste management.

Outcome: An integrated environmental management plan for the SKA

During the assessment, the CSIR prepared an integrated environmental management plan that established the geographical and activity scope of the first phase of the SKA project, the minimum requirements for the construction and operation phases, environmental principles, environmental management outcomes and mitigation measures, as well as long-term research monitoring programmes to be implemented on the SKA site. The plan has been submitted to the Minister of Environmental Affairs for consideration for adoption as an environmental management instrument in terms of section 24(2)(e) of South Africa's National Environmental Management Act. The adoption of this instrument will enable the identified activities associated with the development of the SKA project to be managed in a responsible and efficient manner.

Citizen scientists participating in the bioblitz component of the shale gas scientific assessment, a rapid biodiversity 'groundtruthing' exercise led by the South African National Biodiversity Institute. Multiple forms of public outreach and participation were developed, designed to enhance the transparency, fairness and balance of the assessment.

An aerial view of the MeerKAT core at the SKA project's Losberg site in the Karoo, in the Northern Cape. The MeerKAT radio telescope array will consist of 64 antennas which will be integrated into the first phase of the SKA project. ***Image courtesy SKA South Africa***

Research, development and implementation for

ECONOMIC AND SOCIAL INFRASTRUCTURE

To achieve sustainable and inclusive growth by 2030, South Africa needs to maintain and upgrade existing infrastructure and develop technologies to support future infrastructure. This includes maintaining and building transport, water, energy, as well as information and communications technology infrastructure. The CSIR's interventions in support of economic and social infrastructure take two forms – the design of technological solutions and the development of policies.

Research, development and implementation for

ECONOMIC AND SOCIAL INFRASTRUCTURE

Cyber infrastructure

Milestone reached in commercial use of TV Whitespaces in South Africa

The Independent Communications Authority of South Africa (ICASA) has gazetted a position paper to open up TV Whitespaces (TVWS) for commercial use, as well as regulations for commercial use of TVWS. This milestone in the potential commercial use of TV Whitespaces in South Africa was made possible by the CSIR's earlier development of a smart spectrum management tool, the geo-location spectrum database.

Spectrum is the airwaves over which all wireless communication devices communicate. It is an important national resource needed for the increasing demand for connectivity. While under-utilised spectrum is available in TV broadcasting frequency ranges, the CSIR's tool makes it possible, for the first time, to determine what frequencies are available at a particular location and time. Dynamic spectrum assignment therefore enables authorities to assign unused spectrum to other parties, on a secondary basis, while ensuring that there is no interference with the primary licensee.

The CSIR's work in this domain illustrates its ability to support government departments with technology evaluation and regulatory framework formulations. The organisation is in the process of analysing stakeholder inputs that will inform the final TVWS regulations for South Africa. The final regulations will accelerate the emergence of new commercial TVWS broadband network technologies and increase the creation of Internet service industries.

ICASA's Bomkazi Somdyala (centre), flanked by the CSIR's Drs Fisseha Mekuria and Luzango Mfupe (left) and Seani Rananga and Dr Moshe Masonto (right).

Research, development and implementation for

ECONOMIC AND SOCIAL INFRASTRUCTURE

Cyber infrastructure

Building capacity in the growing field of data science

The CSIR is implementing a programme to strengthen the national capability in data visualisation and analytics. The programme targets third-year, final-year and postgraduate students in the fields of engineering, computer science, business informatics, mathematics as well as statistics, and has been running since 2014. In 2016/17, the programme trained 52 students from 18 universities over a 12-week period.

Examples of project outcomes include tools that assess the state of infrastructure within the public education system and monitor the country's coastline for illegal fishing hotspots, as well as an information system that visualises drought-related data and the drought status in the country. Students showcased their work to stakeholders and potential clients such as Trackmatic, Transnet, SAP, Deloitte and Microsoft.

The Data Science for Impact and Decision Enablement programme is funded by the Department of Science and Technology and stems from the exponential growth in the volume of data that has become available from sensors, satellites and other sources. One of the challenges associated with this growth in data is how to draw insights from, forecast and act on these massive datasets. Data science has been identified as an area of innovation that could assist in the creation of entrepreneurial businesses.

Students spend a total of 12 weeks at the CSIR where mentors introduce the students to machine-learning topics, tools, theories and provide them with datasets on which to apply these techniques. The students are then required to present their understanding of the dataset with new insights acquired through interactive visual exploration, analytics and model development.

Since 2014, four of the DSIDE students have been employed by the CSIR, two by Deloitte and one by Nedbank.

A CSIR-managed programme introduces students in the fields of engineering, computer science, business informatics, mathematics and statistics to machine learning topics. From left, are participants Perseverance Mbewe, Thompho Rambuda, Dhiren Seetharam, Nkonsinathi Ndlovu, Ndamulelo Netshiavha, Antonius Mamphishwana and (seated) Anathi Mafuna.

Research, development and implementation for

ECONOMIC AND SOCIAL INFRASTRUCTURE

Cyber infrastructure

South Africa launches Africa's fastest supercomputer

Mrs Naledi Pandor launched Africa's fastest supercomputer, the Lengau, in June 2016 at the Centre for High Performance Computing (CHPC). The CHPC now provides 700 registered users with access to high-performance computing. High performance computing is the use of parallel processing to run advanced application programmes quickly and efficiently and has become a key enabling technology for a growing number of sectors.

Statistics from the CHPC indicate that utilisation of its systems is at about 80%. Some 75% of users are from South African academic institutions, 14% from the local public sector, 7% from local industry and 4% from African academic institutions. Users of the system include Mintek, PetroSA, Eskom, Transnet, De Beers Marine, Johnson Matthey, Hatch, Roche, Inqaba Biotech, MTech and eScience.

At 22%, the system's number one use is for chemistry, followed by bio-informatics (17%), materials science (14%), engineering (13%), earth sciences (9%), astronomy (7%), health sciences (5%), applied mathematics (5%), computer science (2%), physics (2%) and other areas (4%).

Subsequent to the launch of this peta-scale system, it received two international awards on the Top500 List, a supercomputing body that lists the top performing computers in the world and announces them bi-annually. In June 2016, Lengau was placed at 121 on the list and in November of the same year it was placed at 161, keeping South African computing resources on par with international standards.

Lengau (Cheetah), South Africa's peta-flop supercomputer.

Research, development and implementation for

ECONOMIC AND SOCIAL INFRASTRUCTURE

Cyber infrastructure

New software-defined networking laboratory to strengthen the competitiveness of SA networking products

The CSIR is building a laboratory that will support research and development in software-defined networking (SDN) and network function virtualisation (NFV) as well as accreditation of emerging SDN standard equipment.

SDN separates the network's control and forwarding plane functions and provides a centralised view of the distributed network for more efficient arrangement and automation of network services. NFV focuses on enhancing the network services themselves. It decouples the network functions from proprietary hardware appliances, so they can run in software to accelerate service innovation and provisioning, particularly within service provider environments.

Together, these standards increase programmability of the telecommunication network and increase flexibility in sharing of networks. The lab will offer professional services and issue certification for conformance of network switches to OpenFlow, a protocol that allows for centralised management and control of network switches. It will be the first OpenFlow Conformance testing facility in the southern hemisphere and in Africa and will strengthen the global competitiveness of South African networking products.

The laboratory is funded by the Department of Science and Technology.

The CSIR's Lawrence Mboweni in the new software-defined networking laboratory.

Research, development and implementation for

ECONOMIC AND SOCIAL INFRASTRUCTURE

Cyber infrastructure

CSIR's computer for the blind commercialised

The CSIR, in partnership with the South African National Council for the Blind, has made the SAnote commercially available under a non-exclusive licence. The SANote is a talking computer for the visually impaired. Currently, the sole distributor of the SAnote is the South African National Council for the Blind.

The SAnote is a fully functional portable talking computer for the blind. It is designed, developed, manufactured and distributed in South Africa. It is multilingual, user-friendly and affordable. The computer is ready-to-use, but its software is customisable to individual needs.

The computer has a standard English-language keyboard layout (QWERTY). However, it provides the user with feedback through synthesised speech. Its user interface is an easy-to-use menu navigation system that allows you to browse the web, use the scientific calculator and post to Twitter – to name but a few of its applications. The system offers braille support for external braille displays through brltty – a background process that provides access to the Linux console for a blind person, using a refreshable braille display. It also has enhanced audio functionality that enables audio recording and playback.

The SAnote is available in English, Sepedi, Setswana and Afrikaans. A user has the ability to switch between languages without leaving the programme currently running.

The CSIR's Willem van der Walt uses the SAnote, a portable talking computer for the blind.

Research, development and implementation for

ECONOMIC AND SOCIAL INFRASTRUCTURE

Transport infrastructure

Unique algorithm developed to optimise train operation

The CSIR has developed a train energy optimisation model with the aim of incorporating it into a real-time driver-assist programme. This optimisation algorithm has the potential to significantly reduce the energy usage and therefore the cost of train operation.

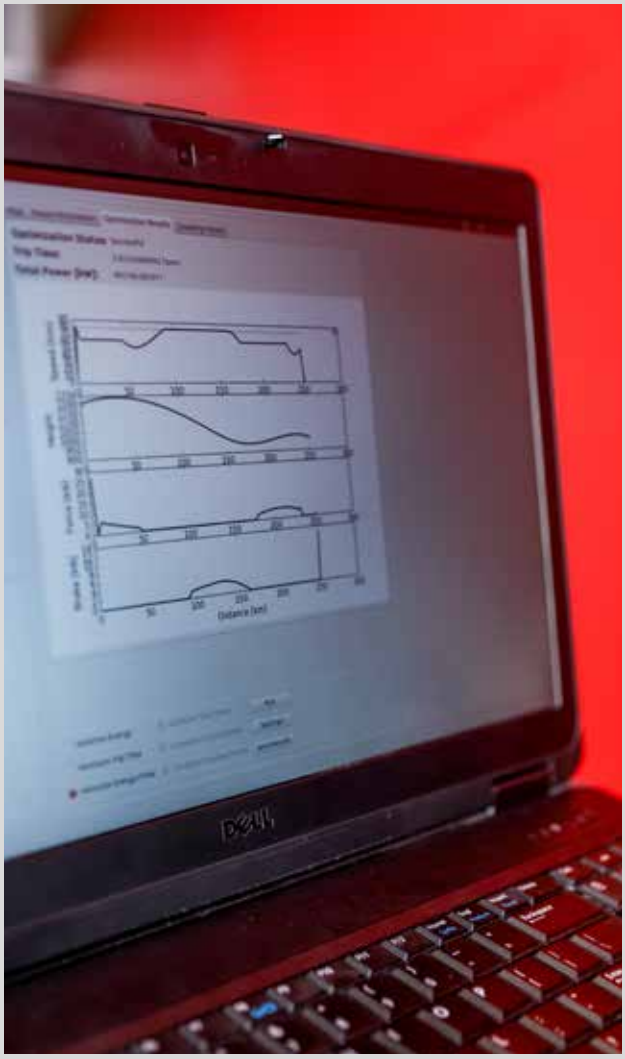
South Africa's extensive mining industry relies on the transport of mined raw material via freight rail over large distances, typically from the mines to central distribution or processing centres. These trains transport heavy tonnage over long distances, with enormous associated energy requirements.

In traditional models, a train is described as a lumped mass – the locomotive and wagons are considered one entity. The CSIR model describes the train as a distributed mass, which allows for the coupling forces between wagons and locomotives to be computed.

CSIR researchers developed a novel mathematical formulation, which allows for the formal optimisation of power distribution between the locomotives and wagons in a long train. This allows for indirect control of the coupling forces to be either globally minimised or predominately in tension, reducing the risk of train derailment in addition to globally minimising energy usage.

The model takes into account the effect of the curvature of the track, prescribed speed limits due to track configuration and surrounding landscape, the critical velocity on super-elevated tracks, as well as natural limitations such as the total travel time, the maximum available tractive power and available braking force.

The next phase will require calibrating and testing the model on a real train and train network before it can be rolled out as a real-time driver assist programme.



The graphical output of the train energy optimisation model which includes the prescribed train velocity, track height relative to sea level, locomotive traction force and the braking force versus distance.

Research, development and implementation for

ECONOMIC AND SOCIAL INFRASTRUCTURE

An unmanned survey and inspection device to improve rail safety

IN BRIEF

Defects and obstacles on and around train tracks cause delays and deadly accidents and cost the railway industry millions every year. The CSIR has developed a rail inspection device that travels ahead of locomotives and warns train drivers of dangers ahead, allowing them sufficient time to stop the train.

In inspection mode, the railway inspection device continuously monitors the condition of railway tracks, looking for defects while measuring the track gauge (the distance between the tracks).

The challenge: Deadly and costly accidents difficult to avoid

According to the Rail Safety Regulator's State of Safety Report 2013/14, 400 people died and 800 were injured per year as a result of collisions, derailments, level crossing incidents and people struck by trains on South Africa's railway tracks between 2008 and 2014. The financial impact on Transnet Freight Rail is approximately R434 million per year. The average stopping distance of a freight train can be as much as 1 – 2 km and the driver can only see a few hundred metres ahead of the locomotive. In many cases, it is almost impossible to avoid these accidents.

Research and development: A rail inspection device that warns

CSIR engineers developed a survey and inspection device that travels ahead of the locomotive alerting the driver of obstacles and potential hazards at level crossings. The device is also designed to inspect and report on the condition of the rail infrastructure.

Fitted with sensors that detect obstacles

The device is fitted with sensors such as cameras and laser scanners and travels 1 – 2 km ahead of the locomotive surveying the track for obstacles such as animals, vehicles or missing tracks. Once an obstacle is detected, the unit notifies the train driver via live video feedback. This information can also be sent wirelessly to a server where it can be accessed afterwards.

Acting as a pointsman

At level crossings, the device acts as a pointsman, warning motor vehicle drivers of the approaching train, thereby preventing them from crossing the track. The device waits in the middle of the railroad crossing until the train is in sight of the motor vehicle driver and then speeds off. Visual recording systems on board record all activity outside the device while its highly visible warning lights and voice communication systems allow communication to the vehicle drivers.

Inspecting infrastructure

In inspection mode, the device continuously monitors the condition of the track, looking for defects while measuring the track gauge (the distance between the tracks). This includes the ballasts and surrounding civil works. The device also uses a multispectral camera to monitor the condition of the electrical overheads. When a defect is found, the nature of the defect and its GPS location is stored and digitally communicated to a command centre.

Outcome: A prototype launched

The first prototype version was unveiled at Africa Rail 2016, the continent's leading infrastructure and transport show. Testing of the system commenced in April 2016 and it is continuously being upgraded.

Field trials of a rail inspection device that travels ahead of locomotives and warns train drivers of dangers ahead.

Research, development and implementation for

ECONOMIC AND SOCIAL INFRASTRUCTURE

Transport infrastructure

An intelligent vehicle monitoring system for efficient transport operations

CSIR researchers have developed vehicle condition monitoring systems for the rail and bus transport industry that collect and analyse vehicle, driver and passenger data to optimise the operation of buses and locomotives.

A healthy transport system for people and goods in South Africa is the backbone of social and economic development. Vehicles such as trains and buses need to operate reliably and cost-effectively. They also need preventative maintenance to avoid costly breakdowns.

The CSIR is working on prototype condition monitoring systems designed for Busmark's fleet of buses and Transnet's locomotives. These systems collect data from on-board sensors, cameras, engine control units, computers and networks and also provide information such as global positioning data. This is communicated to drivers, supervisors and fleet operators. The data are transmitted to a central server and analysed with computer algorithms to detect journey and vehicle anomalies but also negative trends in sensor data. The system can determine the location of the vehicle at any part of the journey; detect driver and commuter behaviour, capture incidents and monitor fuel consumption, emissions and even re-route in case of obstructions.

All of this data are generated and analysed in real time and the system can generate early warnings, for example when there are signs of potential engine failure. The focus is to do preventative maintenance and to keep the fleet available while reducing total operational cost.

The researchers are finalising a prototype of the bus condition monitoring system. Such a system would also use cameras to count passengers embarking and disembarking or to detect any unusual behaviour. A prototype for the locomotive condition monitoring system is expected to enter field trials in 2017.

The Busmark production facility. The CSIR has developed a condition monitoring system (top) for the company's fleet of buses.

The technology can be tailored for any vehicle application, including driverless vehicles and for vehicles in mining. It houses sufficient intelligence to eradicate the need for additional computers, thereby limiting third-party involvement in manufacturing and operations. It also creates local expertise, jobs and faster turnaround times in maintenance and repairs.

Research, development and implementation for

ECONOMIC AND SOCIAL INFRASTRUCTURE

Transport infrastructure

CSIR supports Gauteng's road asset management system

The CSIR has assisted the Gauteng Department of Roads and Transport with its road asset management system. The data collected have been used to prepare an annual road asset management plan for the department for the last three years.

The CSIR updated the department's geographic information systems-based road centreline map and road classifications, which form the basis of the road asset management system. The CSIR also assisted with the appointment and management of professional service providers to inspect the entire Gauteng provincial road network, all provincial bridges and major culverts, and to conduct pavement surveillance measurements on the paved provincial road network. To optimise access to the information, researchers developed a web-based geospatial decision-support system.

Provincial road asset management systems with current data on the condition of the assets are a prerequisite for provincial roads departments to qualify for National Treasury's Provincial Roads Maintenance Grant. The grant was instituted by National Treasury to ensure proper road maintenance in the country.

The CSIR is assisting the Gauteng Department of Roads and Transport to update inventory data and condition data for roads and bridges, as well as software applications that are used to store and analyse the data. This is done through a road asset management system, as shown above.

Research, development and implementation for

ECONOMIC AND SOCIAL INFRASTRUCTURE

Transport infrastructure

A new methodology to calculate the cost of road crashes in South Africa

The CSIR has developed a user-friendly methodology to more accurately account for the social and indirect cost of road traffic crashes in the country. The crash cost analyses made use of the validated 2015 fatal road traffic crash dataset of the Road Traffic Management Corporation (RTMC). The new methodology is referred to as *Cost of Crashes 2016*.

In September 2015, the CSIR was commissioned by the RTMC to conduct an evaluation and review of the last cost estimation of road traffic crashes, the Department of Transport's Cost of Crashes, 2004. Even though this was useful for benefit/cost evaluation of road safety programmes and projects targeting specific types of road traffic crashes and victim groups, the methodology was not user-friendly and difficult to apply. In addition, the social costs elements of road traffic crashes needed to be accounted for more comprehensively.

The cost of road traffic crashes to the economy is significant, specifically in the context of efforts to eradicate poverty. Cost categories include human casualty costs, vehicle repair costs and incident costs. The total cost of road traffic crashes on South Africa's road network for 2015 amounted to approximately R142.95 billion, which is equivalent to 3.4 per cent of gross domestic product.

A variety of stakeholders benefit from the results of the cost analysis by understanding the impact of road traffic crashes on the economy and South African society, and to benchmark South Africa's road traffic safety performance internationally. In addition, it serves as an input into policy and strategy development to improve coordination and allocation of funds and other resources aimed at curbing road traffic safety challenges and to monitor and evaluate the cost-effectiveness of road traffic safety interventions at all levels.

The total annual cost of road traffic crashes in South Africa is equivalent to 3.4 per cent of gross domestic product. ***Image courtesy Adv. Johan Jonck, Arrive Alive.***

Research, development and implementation for

ECONOMIC AND SOCIAL INFRASTRUCTURE

Transport infrastructure

Cost-effective road construction materials for long-life roads validated

The CSIR has completed a five-year monitoring programme following the construction of a long-life road using cost-effective road construction materials. The test was conducted along a part of the South Coast Road in Durban, and demonstrated that the test road was able to withstand heavy traffic.

Engineers used Enrobé à Module Elevé (EME) technology, a high modulus asphalt (HiMA) technology. EME is a mixture of very hard paving-grade bitumen and good quality fully-crushed aggregates, customised to South African conditions. The outcomes of the monitoring programme will feed into the future revision of the EME performance specifications in South Africa. The test, conducted on behalf of the Southern African Bitumen Association, commenced in 2011 with the construction of the base layers.

Field assessments were performed at six-month intervals over the first two years, followed by tests at yearly intervals for a further three years. The assessments consisted of visual condition survey, profilometer survey (rutting, roughness and texture) and deflection measurements. Researchers also analysed the traffic carried by the section of road over a period of five years.

Further research will focus on the development of alternative criteria for the evaluation of rutting performance of EME as well as practical characteristics for the structural design of roads containing EME layers.

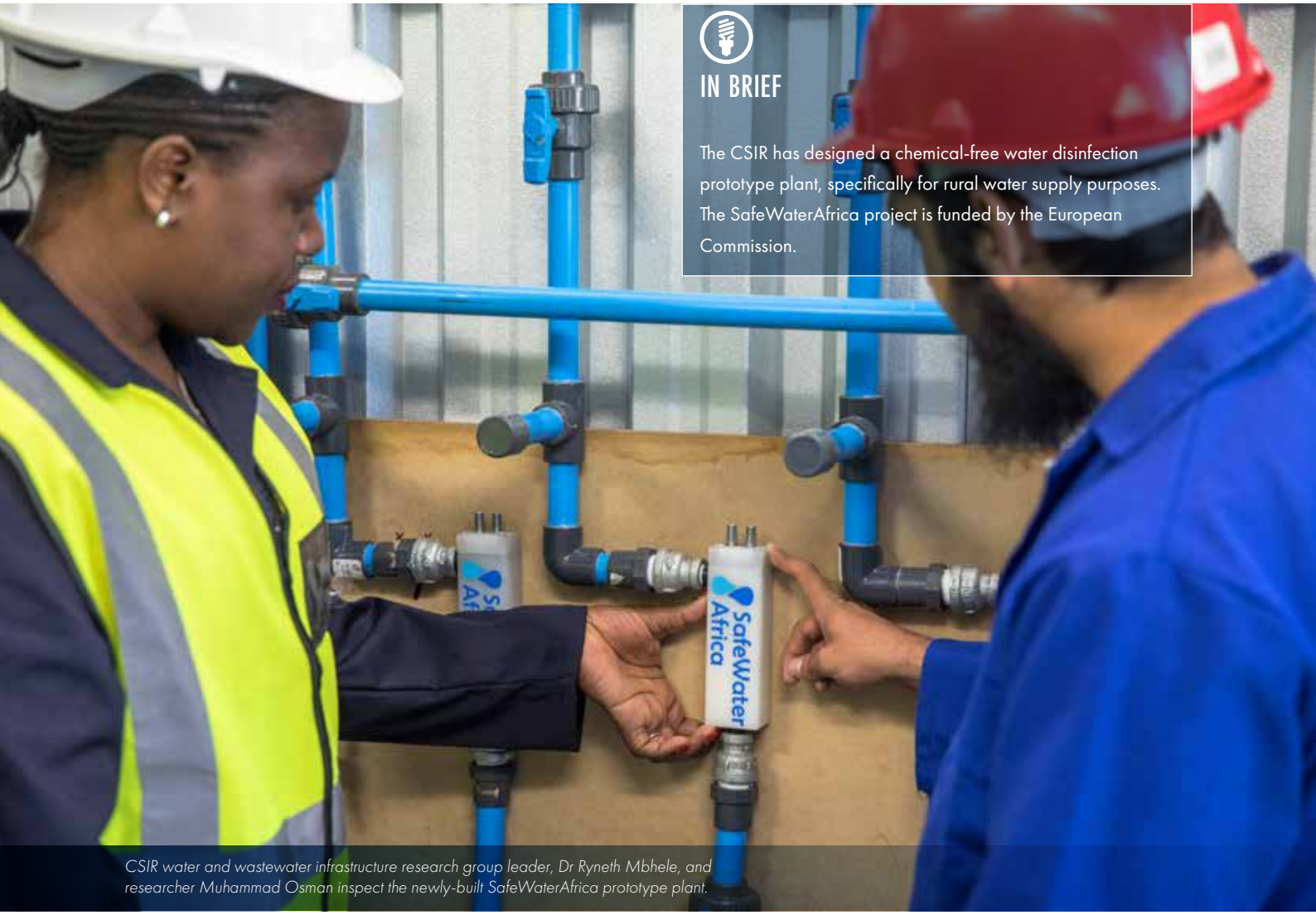
Measuring the temperature of asphalt.

Research, development and implementation for

ECONOMIC AND SOCIAL INFRASTRUCTURE

Water infrastructure

Prototype of new water disinfection plant bodes well for clean rural water supply



IN BRIEF

The CSIR has designed a chemical-free water disinfection prototype plant, specifically for rural water supply purposes. The SafeWaterAfrica project is funded by the European Commission.

CSIR water and wastewater infrastructure research group leader, Dr Ryneth Mbhele, and researcher Muhammad Osman inspect the newly-built SafeWaterAfrica prototype plant.

The challenge: Access to clean water

Approximately 108 million people in 15 sub-Saharan African countries have limited or no access to clean water. The world faces formidable challenges in meeting society's rising demand for clean water. The available sources of fresh water are decreasing because of extended and worsening droughts, continued population growth and competing demands for water from a variety of users. This water crisis has been worsened by water pollution with millions of people in the developing world for whom contaminated water is the only source of water.

In South Africa, some 10 million people depend on water sources with no or very limited and unreliable water treatment. An estimated 3.5 million people have no reliable access to safe drinking water at all. The nation's water supply is expected to become even further stretched in the coming years, moving from a situation of water stress to one of water scarcity. If the country continues to use the remaining water resources at its present consumption rate, South Africa could run out of drinking water by 2025.

Research and development: A prototype water treatment platform

The CSIR and 11 partners from Europe and Africa are developing an autonomous water purification system using low-energy treatment technology.

The researchers have designed and built a prototype water treatment platform at the CSIR in Pretoria and are conducting experimental tests using the platform. The results from these tests will provide design input for the two demonstration systems to be built in 2018. The two demonstrators will be implemented at selected rural sites.

Unlike conventional methods that use chemicals and require extensive energy, the technology is based on a chemical-free water purification process that uses energy from renewable sources. The treatment plant uses a carbon-based electrode, which can be operated using solar energy to remove organic and microbial pollutants from the drinking water sources.

The water treatment prototype consists of conventional pre-treatment modules, a remote monitoring and control system and a solar power supply.

The system uses a number of commercially available sensors together with innovative algorithms to derive a multitude of water quality measures from the combined readings of these sensors.

Uptake of the technology

Upon the completion of the technology demonstration, the research findings will be extensively communicated. In addition, the CSIR, the Tshwane University of Technology and the Energy and Water Sector Education and Training Authority are promoting spin-off businesses based on the system to help create jobs. The system relies on local solutions and all components will be produced, installed, operated and maintained locally.

(From the top) A group of students from the Tshwane University of Technology placed at the CSIR by the Energy and Water Sector Education and Training Authority to gain experience, work inside the SafeWaterAfrica water disinfection prototype plant. Students Alex Kasilembo (left) and Tshepo Lebang inspect the water treatment manifold which mixes water with liquid coagulants. The CSIR's Phuti Ledwaba (left) and Dr Vhahangwele Masindi discuss the water treatment process.

Research, development and implementation for

ECONOMIC AND SOCIAL INFRASTRUCTURE

Water infrastructure

CSIR study puts a price tag on the impact of algae on irrigation costs

IN BRIEF

The CSIR estimates that commercial farmers in the Dwars River area of the Western Cape spend approximately R600 000 per farm ridding their irrigation systems of filamentous algae. The CSIR has taken the first step in formulating a tradable permit system as a tool to help manage pollution in the river, which serves as an important water source to the citizens of Cape Town.

Nutrient enrichment from raw or partially treated sewage, agricultural effluent and other forms of phosphorus-rich pollutants stimulates the growth of filamentous algae. The CSIR is proposing a tradable permit system to discourage pollution.

The challenge: Placing a price on the impact of algae on irrigation

Algae is a water-based plant that attaches itself to rocks and other plants. Nutrient enrichment from raw or partially treated sewage, agricultural effluent and other forms of phosphorus-rich pollutants stimulate the growth of filamentous algae. This, in turn, clogs farmers' irrigation systems. The standard practice to manage the impact of filamentous algae is the frequent cleaning of irrigation systems, which provides the basis to establish a cost estimate on the impact of algae.

Research and development

The cost of eutrophication

Taking into account typical irrigation maintenance protocol, as well as the cost of labour and other consumables in a low and high algae load scenario, the CSIR estimates the cost of eutrophication at R1 887.92 per hectare per year. The figure not only provides a management budget for filamentous green algae mitigation strategies specific to the area, but enabled the calculation of a reserve price for filamentous green algae pollution permits, which is estimated at between R2.25 and R111.00 per gram of filamentous green algae.

Attaching a value to ecosystem services

In a separate study, CSIR researchers undertook an assessment of the value of aquatic ecosystem services and found that a causal loop diagram has the potential to facilitate an alternative value chain analysis where traditional approaches to value chain analysis are unsuitable. A causal loop diagram attempts to explain the behaviour of a system by showing a collection of connected nodes and the feedback loops created by these connections.

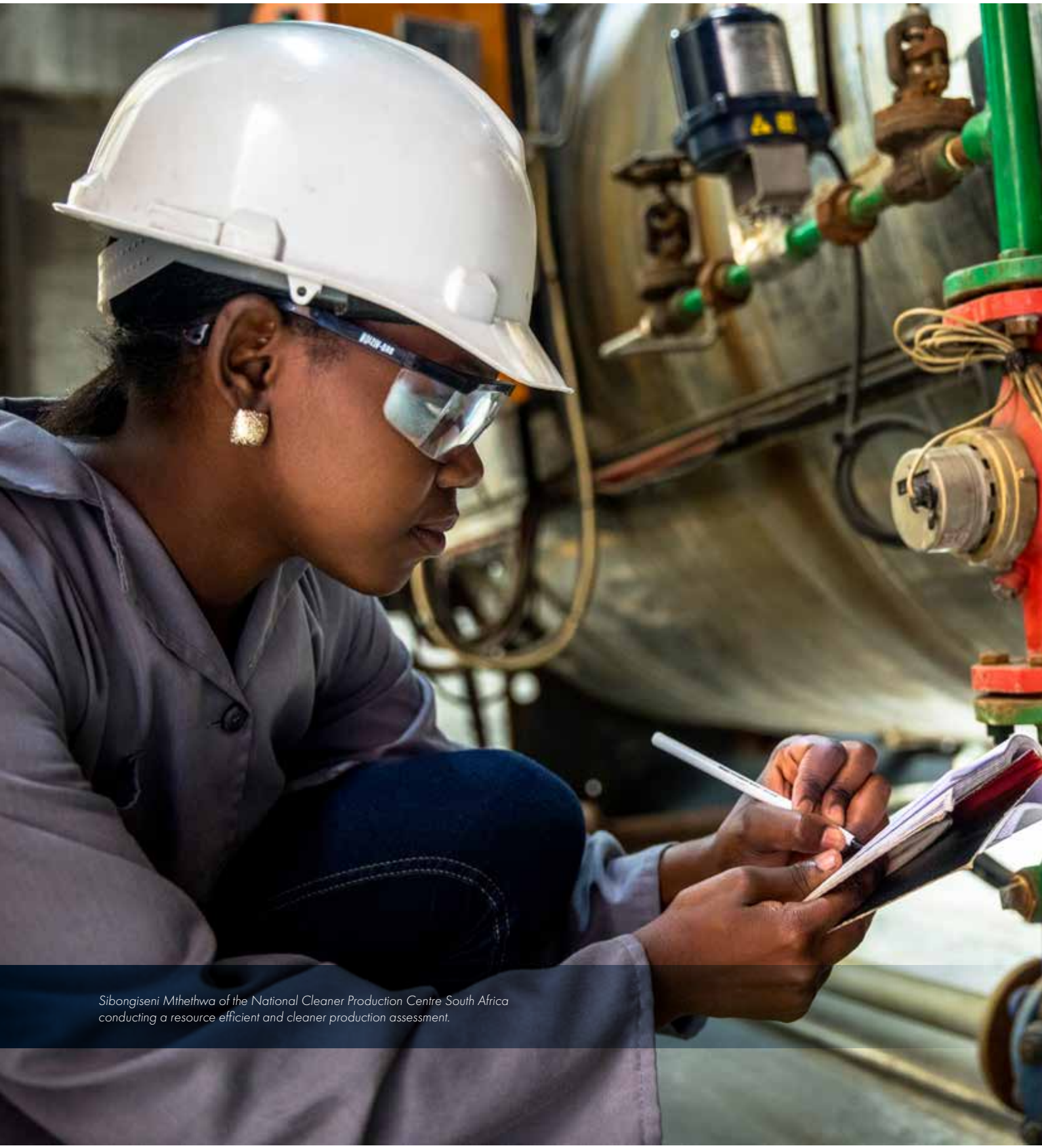
The study focused on identifying key ecosystem services, their forward linkages, understanding how to improve market access to such services and create or improve the value chains in the South African context. The outcomes are intended to help identify more broadly the opportunities for improvements that would benefit society. The research is useful to land-use planners, the designers of infrastructure and town planners.

The causal loop diagram enabled easier identification of the transactional route for each value chain, which in turn enables the identification of potential inefficiencies in the chain. The consequent assessment of these inefficiencies formed the basis for recommending improvements to a market-making process for aquatic ecosystem services, such as the treatment of algae.

Tradable permits seek to limit pollution at an optimal cost to the polluter and create an incentive for companies to further reduce pollution, relative to their entitlement, since it is possible to sell the difference to willing buyers. Pollution in effect becomes a tradable commodity. This mechanism uses the marketplace to distribute pollution impacts more evenly to support the self-cleansing capability of rivers.

Therefore, taking aquatic ecosystem services to market as a way of incentivising increased private sector investment to improve the service seems possible in theory and could be done in several ways. Although a tradable permit system is, due to its nature, a complex instrument in terms of implementation, it has potential to effectively mitigate pollution. The freedom to trade pollution 'entitlements' provides an incentive for polluters to consider abatement while others face the cost of having to purchase permits. For society, the existence of tradeable permits enables pollution abatement to be achieved cost effectively. Over time, pollution standards can be tightened, increasing the value of the permits and the pressure on market participants to reduce their pollution.

The Dwars River area of the Western Cape is the pilot study site for a CSIR-proposed tradable permit system aimed at halting pollution in the river.



Sibongiseni Mthethwa of the National Cleaner Production Centre South Africa conducting a resource efficient and cleaner production assessment.

Research, development and implementation to

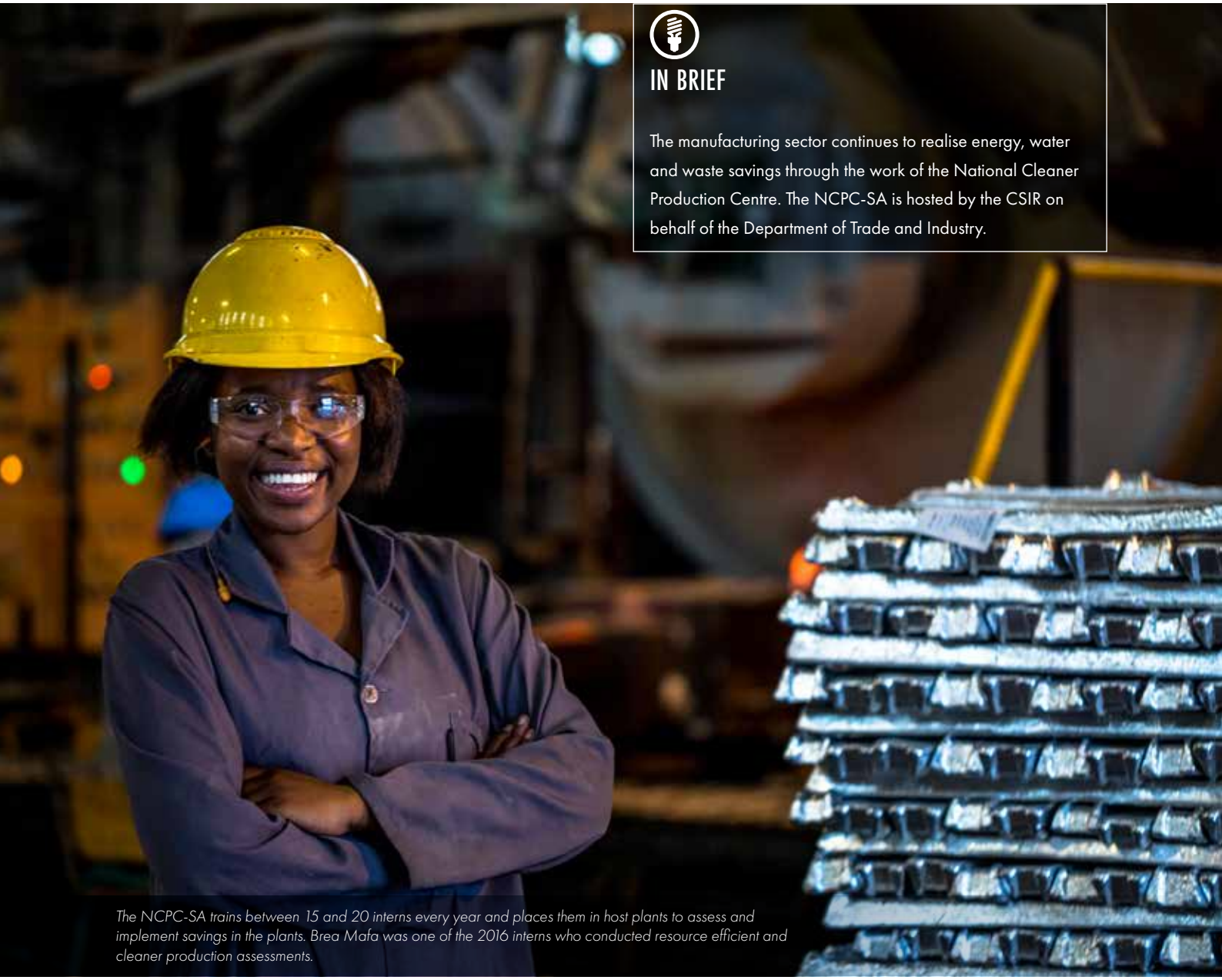
TRANSITION TO A LOW-CARBON ECONOMY

The CSIR supports South Africa's transition to a low-carbon, resilient economy. The organisation works on improving the measurement and management of our natural resources and improving our ability to understand the long-term effects of climate change to support government's mitigation and adaptation strategies. The CSIR supports the development of a green economy by addressing the shortage of effective tools for embedding sustainability into development planning and developing new knowledge and technologies to unlock the opportunities in, for example, waste and biomass.

Research, development and implementation to

TRANSITION TO A LOW-CARBON ECONOMY

Resource efficient and cleaner production holds the key to significant savings



IN BRIEF

The manufacturing sector continues to realise energy, water and waste savings through the work of the National Cleaner Production Centre. The NCPC-SA is hosted by the CSIR on behalf of the Department of Trade and Industry.

The NCPC-SA trains between 15 and 20 interns every year and places them in host plants to assess and implement savings in the plants. Brea Mafa was one of the 2016 interns who conducted resource efficient and cleaner production assessments.

The challenge: Positioning resource efficient and cleaner production for improved profitability

While water and energy conservation is increasingly recognised by businesses and industries as key for sustainability, few regard resource saving as a business tool or a financial incentive. Resource efficient and cleaner production (RECP) remains a largely untapped avenue for improved profitability and addressing increasing production costs, while also saving jobs, improving working conditions and addressing environmental concerns.

Implementation: Energy, water and materials interventions identified that could save R383 million per year

The National Cleaner Production Centre South Africa (NCPC-SA) conducts annual assessments in companies to identify potential savings opportunities in energy, water, input materials and waste. The funds to undertake these assessments are provided by the Department of Trade and Industry, on whose behalf the CSIR implements the programme.

During the 2016/17 financial year, the NCPC-SA identified energy, water and materials interventions that could potentially save industrial and commercial companies R383 million per annum. This essentially means that if the 128 companies assess and adopt these recommendations and implement the interventions, they could save a combined R1.9 billion over the next five years, even with a moderate escalation in resource prices.

In addition, the NCPC-SA measured implemented resource savings in 33 companies previously assessed. These companies had implemented interventions that saved resources worth R73 million. This included savings of the following resources: 308 000 Kl of water (R3.6 million); 64.2 GWh of energy (R67 million); 1.1 million tonnes of input materials (R2 million); and 6 160 tonnes of waste. The energy and waste savings translate into CO_2e emissions mitigation of 77 000 tonnes.

The R383 million in potential savings identified between 1 April 2016 and 31 March 2017 translates into an average company saving of R3 million per annum. When compared to the average of R850 000 per company in 2013, it is clear that the potential value in resource efficient and cleaner production is on the increase.

The value of resource efficient and cleaner production becomes evident when these savings are projected, sustained over the long term as a buffer against resource price increases. If the companies that received assessment reports identifying potential savings this year adopt the recommendations, implement the interventions and sustain the activities, then 128 companies could save a combined R3.1 billion over the next five years, even with a moderate escalation in resource prices. Include the assessment results of the past five years, and the number increases to R12.4 billion for 800 companies.

Skills development

The NCPC-SA implemented a number of projects that contributed to the mentioned savings, including the Industrial Energy Efficiency (IEE) Project, the Industrial Symbiosis Programmes in Gauteng and KwaZulu-Natal, the RECP Internship Programme and the Industrial Water Efficiency Project. The savings achieved through implementation by interns have been significant.

The NCPC-SA trains between 15 and 20 interns every year and places them in host plants to assess and implement savings in the plants. During 2016, interns and their mentors implemented resource savings worth R7.4 million in 18 host plants.

The NCPC-SA places a significant emphasis on skills development, offering training on various levels in all areas of RECP. Some of the most significant savings in energy have been made through the expert level candidates training through the IEE Project. These training courses have been integrated into the National Qualifications Framework (NQF) to allow increased training in energy efficiency across the country. In partnership with the Energy and Water Sectoral Education and Training Authority, the NCPC-SA finalised a process during this year to register two energy efficiency occupational qualifications on the NQF. The Energy Efficiency Technician qualification has been registered by the South African Qualifications Authority on the NQF at level six and the Energy Management Advisor qualification will be registered by mid-2017 at level 8 on the NQF.

The NCPC-SA training courses were also acknowledged during the year when the Centre won the "Best training provider in the public sector award" at the Achiever Skills Development Awards in August 2016.

Research, development and implementation to

TRANSITION TO A LOW-CARBON ECONOMY

Research and development to add value to the waste sector

IN BRIEF

The waste sector provides opportunities for value recovery, job creation and economic development. The Department of Science and Technology has tasked the CSIR with implementing the Waste Research, Development and Innovation Roadmap to stimulate waste innovation, research and development and human capital development through investment in science and technology. The CSIR is undertaking research to maximise the diversion of waste from landfill sites towards value-adding opportunities, including waste prevention and value extraction to create significant economic, social and environmental benefit.

While households are encouraged to separate their waste, the implementation of a separate waste collection system is costly for municipalities, resulting in all the different bags being placed into the same truck upon collection. The CSIR has developed and is testing a decision-support tool that can be used by municipalities to assess and compare the costs and benefits of collecting source-separated recyclables.

The challenge: Understanding the waste landscape to enable recovery and reuse

Waste generated differs from one household to the next; and from one suburb to the next. While households are encouraged to separate their waste, the different bags are often placed into the same truck upon collection, making the recovery and reuse of waste challenging. Additionally, while information is available on the potential benefits of waste separation at source in terms of space savings, reduced disposal costs, and potential income from the sale of recyclable materials, limited information exists on the costs of implementing waste separation at source at the municipal level.

Similarly, not enough information was available on the e-waste recycling landscape in South Africa for optimal decision-making on how to retain a secondary resource, such as e-waste, in the local value chain.

Research and development

South Africa's e-waste recycling economy

To identify new opportunities for research and innovation in waste, Mintek, the Department of Science and Technology and the CSIR, as part of the Waste Research, Development and Innovation Roadmap, did a study to understand the e-waste dismantling, pre-processing and processing recycling technology landscape in South Africa, the various role players and the flow of e-waste within and beyond the borders of the country.

The study found that at least 90% of printed circuit boards and 80% of plastic recovered from electronic waste (e-waste) in South Africa are exported for reprocessing. In doing so, the country loses access to valuable metals, as well as the opportunity to create jobs. The study concluded that the biggest constraint to growing South Africa's e-waste recycling economy is access to the waste, rather than the availability of technology or skills. The last official statistics for South Africa (2011) showed that only 11% of the e-waste generated in the country was recycled. Much of the country's e-waste is locked up in offices, homes and storerooms. By increasing the collection, sorting and recycling of waste in South Africa, more opportunities will be created to recover valuable resources that can feed into downstream manufacturing, and as a result, more opportunities for jobs and enterprise development will be generated. The research has shown that the waste sector currently generates around 25 jobs per 1 000 tonnes of handled e-waste.

Waste characterisation for Ekurhuleni Metropolitan Municipality

A waste characterisation study is typically done to determine the composition of the waste stream and the relative contribution of each component, such as paper, plastic, glass and organic waste to the overall waste stream. The results help inform local governments on how to manage their waste more effectively. Currently, most waste is disposed of at landfills despite national strategies and goals to divert it away from such sites.

CSIR researchers conducted a waste characterisation study for the Ekurhuleni Metropolitan Municipality that will influence its decision-making on waste. The study entailed sampling of municipal waste collected over a four-month period in 2016. During this period, the team gathered data on waste composition, types and quantities collected and potentially recoverable waste, as well as volumes of waste from households, businesses and institutions.

A decision-support tool for municipal waste separation at source

Municipalities are under increasing pressure to implement separation-at-source recycling programmes, in which households and businesses separate recyclable waste from their other waste, to allow for separate collection and recycling. However, implementation of a separate collection system is costly for municipalities.

The CSIR has developed a decision-support tool that can be used by municipalities to assess and compare the costs and benefits of different options for the collection of source-separated recyclables, based on each municipality's unique context. The separation-at-source costing model can assist municipalities in identifying the most cost-effective option for implementing separation at source, evaluating tenders for kerbside collections and for materials recovery facilities, and in motivating for funding for implementation (e.g. through tariffs or subsidies). This will facilitate the implementation of separation at source, thereby enabling growth of the recycling industry, job creation and reducing waste going to landfill. The model has been tested by a number of municipalities.

Research, development and implementation to

TRANSITION TO A LOW-CARBON ECONOMY

Contributing towards a sustainable energy future for South Africa

IN BRIEF

The global energy transition towards more distributed energy systems with higher shares of renewable energy calls for a research agenda along the entire energy value chain. The CSIR has embarked on a number of research projects to measure the energy output of renewable energy sources, to model energy systems, to give inputs into government planning processes and to develop future energy plans for its Pretoria campus and external clients.

One of three solar photovoltaic plants that were installed on the CSIR's campus in Pretoria from 2015 to 2017. They have a 1008 kW power output and marked the start of a journey to an autonomous CSIR campus.

The challenge: Incorporating renewables in energy systems

The shift to renewable energy is a gradual process and to minimise the risk of costs and grid instability, the incorporation of sources such as solar photovoltaic (PV), wind and biogas needs to be carefully planned. An integrated system will require cost-effective components and an optimal regime to dispatch different sources at different times.

Formal comments on government's Integrated Resource Plan

The CSIR made a formal written submission to the Department of Energy as part of the public consultation processes to inform government's Integrated Resource Plan. Based on power system simulations, this plan is meant to provide the electricity generation mix for the country until the year 2050. The department published the draft plan in the Government Gazette for public consultation on 25 November 2016. The CSIR participated in public hearings and its submission indicates that the country can provide cost-effective and reliable electricity supply via solar photovoltaic, wind and flexible generation sources, such as natural gas, up to the year 2050.

Developing solar PV plants in Pretoria

Several research projects flowed from three solar PV plants that were installed on the CSIR's campus in Pretoria from 2015 to 2017. The three solar PV plants have a 1 008 kW power output and marked the start of a journey to an energy-autonomous CSIR campus.

Researchers developed a model of the CSIR's campus grid using power system analyses software, creating a real-time digital simulator that models the solar output of the PV plant. It allows them to study the behaviour of the campus energy grid, to detect and mitigate potential risks to power supply and to proactively plan future grid developments, such as determining the impact of installing new PV plants on campus buildings.

Modelling for best performance

The researchers also developed a mathematical model that can be used to analyse energy demand and energy generation from different sources to inform the best way to dispatch the sources at hourly and sub-hourly resolutions. This type of modelling helps to determine the best technically possible performance from an energy system. The next step is to integrate this model with the real-time digital simulator.

Developing a campus energy plan

Another CSIR study aims to create an integrated energy resource plan for the campus, similar to what was done for government. It takes into account all possible energy generation sources such as PV, wind and biogas to determine the least-cost generation mix, while taking into account demand-side options like flexible load, battery storage and electric vehicles. This model serves as a blueprint of what can be applied to other campuses, institutions and municipalities to assess future energy systems of different sizes. Initial results have been generated and the model was used as a basis for drafting a CSIR Pretoria campus integrated resource plan for the next five years.

Sharing lessons learnt

The CSIR engaged with various municipalities to share knowledge gained from establishing the solar PV plant and trying to become energy-autonomous. The organisation provided training on its procurement approach to the City of Cape Town and Ekurhuleni. Ekurhuleni used this methodology to procure some of its own solar PV assets. The CSIR has also engaged with the City of Tshwane regarding its sustainable energy plans.

The South African Local Government Association took note of these engagements and has requested that this training be adapted and made available to all interested municipalities. The Deutsche Gesellschaft für Internationale Zusammenarbeit has expressed interest in funding training programmes underpinned by CSIR expertise. Engagements with Transnet, which is also looking to procure solar PV assets, provide a suitable pilot opportunity for the CSIR to see how the training service could be rolled out.

Helping others with long-term planning

The CSIR was commissioned by the eThekwini municipality to develop a long-term sustainable energy plan in line with the municipality's climate change goals. eThekwini has since also requested two studies that investigate the use of bioenergy and the feasibility of developing a regulatory incentive for small-scale embedded solar PV systems for the residential housing sector. The CSIR is also assisting the City of Cape Town with its long-term energy planning.

Research, development and implementation to

TRANSITION TO A LOW-CARBON ECONOMY

Contributing towards a sustainable energy future for South Africa (continued)

A bioenergy plan for KwaZulu-Natal

The KwaZulu-Natal Department for Economic Development, Tourism and Environmental Affairs commissioned the CSIR to develop a long-term strategy to grow the bioenergy sector in the province, thereby boosting the creation of new industries, jobs and offtake markets for the biomass resource in the province.

Photovoltaic testing facility

Incorporating solar power into an energy system requires a good understanding of the electrical output that the latest panel technology and weather conditions allow. CSIR researchers completed a study to scope an outdoor and indoor solar photovoltaic testing facility, in collaboration with the South African Bureau of Standards. The technology will comprise a set of test bits mounted on panels to measure the electrical output of panels over time. It will be used to do verification testing for imported and locally manufactured modules. This will support local energy providers and solar photovoltaic manufacturing industries. The facility is expected to be operational within a year.

CSIR principal engineer Crescent Mushwana, who leads research into the planning and operation of energy systems and Dominic Milazi, who heads CSIR research into energy policy, at the solar photovoltaic plant on the CSIR's Pretoria campus.

Research, development and implementation to

TRANSITION TO A LOW-CARBON ECONOMY

Developing wind forecasting techniques

The ability to forecast wind speed is becoming more important as South Africa adds renewables to its future power system. CSIR researchers are building local capacity to incorporate wind speed forecasts that rely on mathematical algorithms.

An earlier study in which the CSIR partnered with Germany's Fraunhofer Institute for Wind Energy and Energy System Technology managed to quantify the combined effect of solar and wind energy sources in South Africa and concluded that it is a viable source of renewable electricity.

South Africa has abundant wind and solar resources, but these fluctuate naturally and continuously. It is important to understand this variability in the context of a stable power system for the country.

Wind patterns are fairly consistent from year to year, but over shorter time scales, such as days and hours, it is difficult to predict. Predicting wind speed a few hours ahead of time would enable better estimates of potential wind electricity production and allow for better planning to balance energy production from different sources.

One of the renewable energy projects of the South African National Energy Development Institute is to map wind resources in the country to produce the Wind Atlas for South Africa (WASA). The atlas contains a large quantity of data that researchers in mathematical modelling can use to find trends in wind patterns.

CSIR researchers used machine learning techniques on wind data from Alexander Bay in the Northern Cape to see if they could forecast wind 1 to 24 hours ahead in hourly intervals. They tested several machine-learning regression algorithms and all algorithms improved on a benchmark forecast previously set. The researchers are adding atmospheric readings from the WASA, for example, air temperature, relative humidity and wind speed direction.

In this graph, the errors in the forecasted wind speed (1 to 24 hours ahead) that were obtained from different models, are compared to the benchmark.

Research, development and implementation to

TRANSITION TO A LOW-CARBON ECONOMY

Recovery and reuse of water and caustic soda at pulp mills

CSIR researchers have developed processes and made recommendations to recover caustic soda and water at pulp mills.

Pulp mills that produce bleached pulps consume relatively large amounts of water and chemicals that are eventually released into rivers and the sea, or used for land irrigation. Stringent environmental regulations and the increasing costs for chemicals used in bleach plants have created the need for novel technologies to recover water and chemicals from the effluent streams of these pulp mills. Water resources are increasingly becoming scarce and for industry, the effective implementation of water system closures will lead to a meaningful contribution to the national goal of water efficiency.

Researchers used ultrafiltration and reverse osmosis membrane processes to recover caustic soda while simultaneously recovering water from the end-of-pipe effluent, where caustic soda, oxygen, and peroxide are applied as pulp bleaching chemicals. This reduced the volume of wastewater discharged into the environment.

In their preliminary techno-economic analysis, the researchers proposed that the recovered caustic soda be used in the make-up of the weak white liquor traditionally used in the production of green liquor in kraft pulp mills. Due to the high quality of the recovered water, it is proposed that this water be used as boiler feed water. The researchers have found that, depending on the flow rates of caustic soda, oxygen and peroxide, an investment of up to R25 million would be required, with a return expected in three to four years.

CSIR researchers recommend that the water recovered at pulp mills be used as boiler feed water.

Research, development and implementation to

TRANSITION TO A LOW-CARBON ECONOMY

Options for cheaper and greener cement

The CSIR has developed a low-cost process with a reduced carbon footprint for the production of a cement extender and replacement material.

For centuries, Ordinary Portland Cement (OPC) has been used as the binder for concrete. However, the production of OPC is an energy-intensive process that releases large amounts of greenhouse gases, mainly carbon dioxide.

The CSIR has developed a replacement for OPC called metakaolin, based on the clay mineral kaolinite. Metakaolin can be used to make concrete, blocks, bricks and pavers. The potential benefits of metakaolin over OPC include its lower carbon footprint, enhanced strength, higher durability and lower production and product cost. Metakaolin has the potential to replace traditional cement extenders such as fly-ash, ground granulated blast furnace slag and silica fume and can be used in OPC-free geopolymers. The metakaolin was successfully produced using a coal-fired vertical shaft kiln. These kilns are of simpler design and operation and have a lower associated capital cost than other kilns.

The next developmental milestone is the setting up of an industrial-scale pilot plant to produce metakaolin and cement blends. If successful, low-cost metakaolin production and cement blending plants can be set up in areas with deposits of kaolinitic clays such as in Grahamstown in the Eastern Cape, Hammanskraal outside Pretoria in Gauteng, Zebediela in Limpopo, as well as towns in the Northern and Western Cape.

CSIR researcher Zonke Dumani tests kaolinitic clays used to produce metakaolin in a vertical shaft kiln at the Roedtan Leo Mine in Limpopo. The CSIR is in the process of setting up an industrial-scale pilot plant to produce metakaolin.

One of the long-range, dual camera optronic subsystems used as part of the Meerkat wide-area surveillance system. It is directed at an object detected and tracked by a ground-moving target indication radar to discriminate between human and animal targets in counter rhino poaching operations.

Research, development and implementation to

BUILD SAFER COMMUNITIES

CSIR interventions in support of national security include supporting technology integration by the security forces, as well as developing systems for information sharing, national surveillance and protection against cybersecurity threats.

Research, development and implementation to

BUILD SAFER COMMUNITIES

Remaining protected in an ever-changing cyberworld

IN BRIEF

The integration of cyberspace with almost every part of daily life has led to security threats to citizens and the state. CSIR cybersecurity experts have contributed to the development of systems, technologies and skilled teams to protect against cybercrime.

The CSIR's Kgwadi Matenche and Sophia Moganedi (front) in the process of developing new methods to defend against cyber threats.

The challenge: Proactive efforts needed to prevent cybercrime

South Africa's critical infrastructure can be exposed through the integration of the Internet of Things and Smart Cities – two concepts which have advanced the integration of cyberspace into the physical world. The protection of personal information through passwords and fingerprint technology is crucial to prevent cybercrime. However, existing technology has not been able to secure and store fingerprint data efficiently and safely. The introduction of new technology in cyberspace requires experts from various domains to develop technical standards and response teams that are ready to proactively detect and neutralise threats to the entire cybersystem.

Research and development

A security testing laboratory

The CSIR has developed a network emulation and simulation laboratory that provides a platform for the design, development and deployment of cybersecurity processes and tools that resemble a real-world production environment. It allows for the replication of existing or planned networks through a combination of physical and virtual devices.

These processes and tools test concepts with the emulation and simulation of real-world, legitimate traffic. This includes malware and therefore helps to identify security vulnerabilities and ineffectiveness in computer networks. The laboratory provides cybersecurity researchers with the ability to perform network bandwidth modelling, cybersecurity training, device research and advanced analytics to study cyber risks in an environment that mirrors reality. It also enables the delivery of tested, proven, effective and practical security solutions. The platform is ideal for use by researchers, including postgraduate students in cybersecurity as well as companies developing cybersecurity products.

Matching and securing fingerprints in an irreversible form

The protection of large fingerprint databases in cyberspace is an important security requirement to prevent identity theft and fraud.

The CSIR has found a mathematical way of hashing fingerprints. Hashing is the multiplying of unique fingerprint points (minutia points) by numbers into a complex code that is stored into a database.

When an authorised person logs into a server, he uses a password that is fixed and it will be matched the same way every time. However, when a person puts a finger on a fingerprint scanner, the device captures a picture of the finger. The CSIR software extracts those features as mathematical numbers, hashes the data and secures it. It correctly matches the data despite the fact that fingerprints are never scanned in a fixed position. For example, pressure applied means the position of the minutia points are never stable.

The technology can match fingerprints in the hashed form and secure it in such a way that no one will be able to reverse the process.

This technology could secure data on small devices such as smart cards and cellphones and be used by the Department of Home Affairs and South African security services to secure their databases.

Contributing to protect the national payment system

CSIR experts in the field of biometrics were part of a project working committee of the Payment Association of South Africa (PASA) to develop a technical standard to specify how to use biometrics as a bank card holder verification method in South Africa's national payment system.

PASA is the payment system management body recognised by the South African Reserve Bank to organise, manage and regulate the participation of its members (mostly banks) in the payment system. This system encompasses the total payment process, for example between individuals, businesses and banks. The management of this system is crucial for the stability of the country's financial sector.

CSIR experts contributed to the requirements that informed the technical standard, which was developed by MasterCard and VISA at the request of the South African Social Security Agency (SASSA). SASSA requires social grant recipients to use biometrics as a bank card holder verification method when accessing social grant funds at ATMs. This is to confirm that all grants are being validly accessed and fraud is being avoided. The project started in 2015 and was completed early in 2017. MasterCard is conducting trials with Pick n Pay and ABSA on bank cards that use biometrics for card holder verification.

Launching a computer security incident response team

The South African National Research Network (SANReN) is a high-speed information technology (IT) network dedicated to

Research, development and implementation to

BUILD SAFER COMMUNITIES

Remaining protected in an ever-changing cyberworld (continued)

science, research, education and innovation traffic. It is part of the Department of Science and Technology's National Integrated Cyber Infrastructure System, hosted by the CSIR.

In March 2016, the SANReN computer security incident response team that comprises CSIR experts, and is based at the CSIR, was launched to provide proactive IT security services to SANReN beneficiaries such as universities, science councils and research institutions in South Africa.

The team focuses on preventing the occurrence of IT security incidents within the constituency. Activities to date include conducting vulnerability assessments for 11 beneficiary institutions. The team has also been working on the early detection of malicious activity within the research and education community as well as a cybersecurity challenge for students to be hosted at the annual conference of the Centre for High Performance Computing.

Proactive cybersecurity using home-grown technologies

The CSIR has developed two home-grown cybersecurity technologies in its response to local and global cybersecurity challenges.

One is a solution that seeks to promote compliance to South Africa's Protection of Personal Information Act and the National Cybersecurity Policy Framework through the monitoring of threats and the safeguarding of the country's digital borders. The system focuses on the national cyberattack entry points for hardware, software and people. It consists of a visualisation component, a hardware and software infrastructure information sensor and a personal information sensor. The function of these components is to proactively visualise the potential cyberattack entry points related to hardware, software and personal information. The system is also capable of detecting vulnerabilities within devices connected to the Internet. This innovation has been tested and preliminarily deployed for testing purposes in the cybersecurity hub managed by the Department of Telecommunications and Postal Services.

The CSIR also developed a unique local software capability to assist with the evaluation and vetting of mobile applications and physical mobile devices. The evaluation/vetting process ensures that both mobile applications and mobile devices behave as expected and do not contain any malicious activities or vulnerabilities that can be compromised.

The technology has received national attention, and CSIR experts are collaborating at various levels with the Institute of Maritime Technology and Nanoteq to further expand this capability for different environments.

Research, development and implementation to

BUILD SAFER COMMUNITIES

Technology interventions for improved surveillance and situation awareness help stem wildlife crime

IN BRIEF

Technology interventions for combating wildlife crime, such as improved surveillance (through the new Meerkat system) and interventions to improve collaboration (through the technology platform Cmore) have contributed to the impact of counter-poaching operations in South Africa. In February 2017, the Department of Environmental Affairs released poaching statistics for 2016, showing a 10.3% decline in rhino poaching compared to the previous year. Local and international research organisations, technology developers, philanthropists, non-profit organisations and governments continue to pool their resources to stem rhino poaching.

The unmanned remote radar and optronics sensor subsystem of the Meerkat wide area surveillance system can be transported by offroad vehicle and deployed by helicopter on difficult-to-reach, high sites overlooking areas that require safeguarding.

Research, development and implementation to

BUILD SAFER COMMUNITIES

Technology interventions for improved surveillance and situation awareness help stem wildlife crime (continued)

The challenge: Improving the response to wildlife crime

The intensity of the campaign against poaching in South Africa has necessitated the establishment of joint operations centres and command and control rooms in reserves and parks. These centres house ranger and security forces, as well as, in the case of the Kruger National Park, members of the South African Police Service and the South African National Defence Force. Many of these centres deal with poaching incidents on a daily basis. Foot, vehicle and air patrols are executed 24 hours a day, seven days a week with multiple ground actions occurring at any one time and are supported by helicopter, while fixed-wing aircraft sorties are conducted over vast areas of land. Coordinating these efforts is critical to mission success and has been the focus of CSIR interventions and support for several years. An area such as the Kruger National Park with its changing landscape and extreme temperatures also present several challenges in terms of surveillance as traditional optic, radar and infrared technologies have proven ineffective.

Research and development: Enhanced situation awareness

The CSIR-developed Cmore system is an innovative platform for situation awareness and decision support. It addresses the need for shared awareness amongst users through the consolidation of information from various sensors and external systems, real-time analytics and the collaboration between multiple parties from various domains. It provides an integrated view of an entire environment, enabling the user to go from sensing, to data, to insight, to action and thereafter, being able to form a complete picture of how events unfolded and how operations can be improved. It uses current and historic data to do predictive analysis.

A system such as Cmore requires input from sensors such as the Meerkat surveillance system, a wide area persistent surveillance system that was launched in the Kruger National Park in December 2016. The system combines the detection, localisation and tracking capabilities of radar with the visual target classification that an electro-optical system provides. It is able to detect and identify potential intruders, supplying reaction forces with early warning information on location, speed and direction as required to intercept suspects. Meerkat employs a radar sensor that was produced and is supported by Reutech Radar Systems as the main wide area surveillance sensor. The radar is integrated with a dual camera optronic sensor which was custom-developed by the CSIR for both day and night operations.

Within the first three months of deployment in early 2017, Meerkat detected and identified 20 poaching groups (more than 50 poachers). This enabled SANParks rangers to intercept, arrest and deter many poachers and stabilise a developing hotspot. As poaching groups typically hunt more than one rhino per infiltration, it is safe to say that many rhino lives were saved as a result, while reducing the risk to the safety of security personnel working in the park.

The Cmore system, initially funded by Armscor, has now been in operational use for three years and has been rolled out to over 80 national, provincial and private parks and reserves across South Africa. Its footprint has been extended to Mozambique and Namibia, servicing its users as an effective data gathering, situation awareness, analytics and collaboration platform. Cross-border collaboration is a key success factor in curbing wildlife crime.

Research, development and implementation to

BUILD SAFER COMMUNITIES

Developing local synthetic aperture radar technology

IN BRIEF

The CSIR has conducted extensive research in the field of synthetic aperture radar. Data collected using this technology are being used in a range of areas, including maritime domain awareness, monitoring surface subsidence in mining areas and sink holes in urban areas, as well as national assessments of woody biomass.

The CSIR developed a synthetic aperture radar technology demonstrator that was installed on an Atlas Angel aircraft during flight trials.

Research, development and implementation to

BUILD SAFER COMMUNITIES

Developing local synthetic aperture radar technology (continued)

The challenge: Local capabilities in synthetic aperture radar

Synthetic aperture radar (SAR) is a proven remote sensing technology for both civil and military applications. It complements and offers substantial advantages over passive sensors, such as cameras or telescopes. The technology employs radio waves that are emitted from an antenna placed on a moving platform to form an image of the illuminated area. SAR systems are able to detect relatively small (typically a few centimetres) changes between images, and are thus able to detect newly formed tyre tracks in sand or the cutting of vegetation in an area. Areas in which SAR may potentially be applied include mapping, disaster management, precision agriculture and military and security applications.

Synthetic aperture radar put to work

In the marine environment, the CSIR is using SAR data to derive high-resolution ocean wind, wave and surface current information to investigate physical processes in coastal and shelf regions, while in the urban environment SAR is being used to monitor key planning parameters.

One of the best-known applications of synthetic aperture radar is land-cover and land-use classification. This provides a description of the physical material that covers the surface of a particular area, for example, grasslands, forest, water or bare soil.

SAR images can also be used to generate digital terrain models by comparing the information from two images of the same scene recorded at different heights. If repeated over time, it is possible to detect small, centimetre-scale height changes in the areas of interest. This capability becomes extremely useful in applications concerned with monitoring subsidence, for instance in areas of mining activity.

Research and development: Developing airborne synthetic aperture radar sensor technology

To unlock lower-cost exploitation of synthetic aperture radar imagery, the CSIR, with funding from the Department of Science and Technology, is developing airborne synthetic aperture radar sensor technology aimed at manned and unmanned aerial vehicles and ultimately, satellites. This local sensor, image formation and application capability will benefit local industry, academic institutions and various government departments, as well as the South African National Defence Force.

A major milestone of the initiative was achieved in November 2016 when the first technology demonstrator developed was successfully manufactured and was tested during a flight on board an Atlas Angel aircraft.

The data recorded during this measurement campaign enable further application development at the CSIR.

Researchers assess the data received during the testing of locally developed SAR technology.

Research, development and implementation to

BUILD SAFER COMMUNITIES

Locally developed military vehicle to address local needs

The CSIR, Denel Vehicle Systems, Armscor and the South African National Defence Force (SANDF) are developing a versatile, protected vehicle that can withstand the challenges of terrain, the destructive forces of guns, missiles and other explosive devices, and other operational demands of the armed forces on the African continent.

A capability demonstrator of the Africa Truck was unveiled by the Chief of the SANDF, Gen. Solly Shoke, at the biennial Africa Aerospace and Defence Expo in September 2016.

The intent is to create a family of vehicles with modular, interchangeable attributes to offer a range of modes of transport, limiting the environmental footprint of a military logistics support capability, and opening opportunities for new enterprises, jobs and skills.

The Africa Truck is similar to the RG31, a South African-developed mine protected vehicle that is sold internationally and that has a proven track record of saving lives in conflict environments.

The truck has a roll-on-off load carriage that enables it to transport different cargoes – personnel, fuel, water, medical supplies or a full field hospital. Other enhancements include integrated armaments and protection against landmines and improvised explosive devices, which are increasingly being used.

Aside from having contributed to the component design and various structural, mobility and protection analyses, the CSIR will develop a strategy to manage the vehicles throughout their life cycle.

An important benefit of the partnership that is making this integrated, local military vehicle development possible, is the ready access to operational feedback from the armed forces to ensure that the vehicle is optimally suited to its operating environment.

Local companies and entities Armscor, Ergotech, Gerotek, Denel Vehicle Systems and the CSIR joined forces to develop a versatile protected vehicle suitable for African conditions.

Armscor is assisting with requirements analysis and developing the overall vehicle specifications, with contributors Ergotech, for ergonomic design and evaluation, and Gerotek, for development and qualification test support. As the original equipment manufacturer and primary design authority, Denel Vehicle Systems will manufacture the vehicle at its facility in Benoni and provide after-sales support to clients.

Sibongile Mtimka, a student researcher in molecular biology at the CSIR, loosens the soil to collect samples at the Kogelberg Biosphere Reserve in the Western Cape. This reserve is known for its high plant biodiversity, which researchers believe could translate to microbial diversity in its soil.

Research, development and implementation to

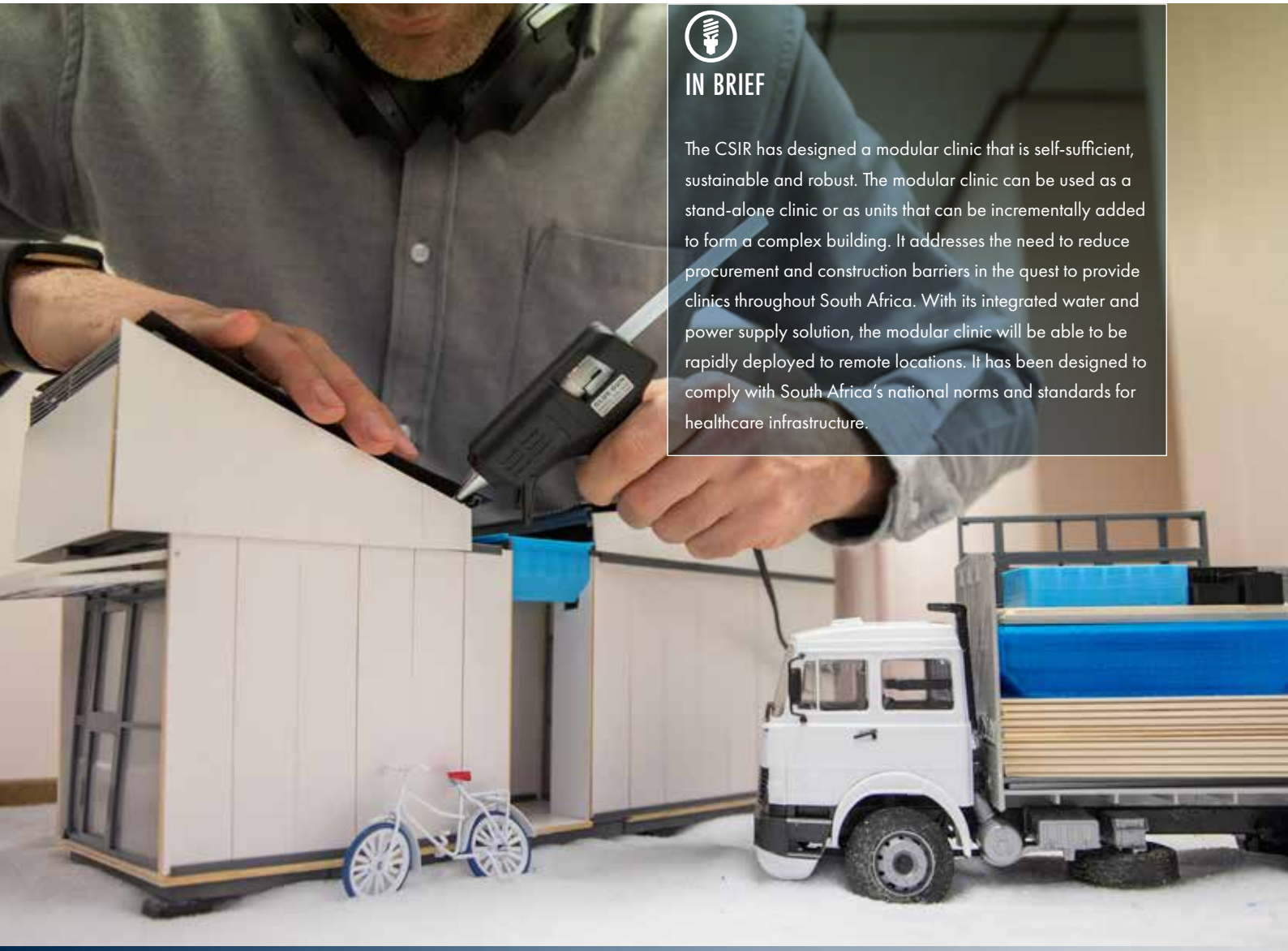
IMPROVE HEALTH

The CSIR uses its vast expertise to help improve the health of all South Africans. Scientific and technological interventions include the development of interconnected and inter-operable point-of-care devices, technology for diagnostics, vaccine development and new methods to understand disease mechanisms at cellular and molecular level. The CSIR also provides technical support to the National Health Insurance initiative.

Research, development and implementation to

IMPROVE HEALTH

New smart modular design to help address the need for clinics



IN BRIEF

The CSIR has designed a modular clinic that is self-sufficient, sustainable and robust. The modular clinic can be used as a stand-alone clinic or as units that can be incrementally added to form a complex building. It addresses the need to reduce procurement and construction barriers in the quest to provide clinics throughout South Africa. With its integrated water and power supply solution, the modular clinic will be able to be rapidly deployed to remote locations. It has been designed to comply with South Africa's national norms and standards for healthcare infrastructure.

Primary healthcare service delivery is severely hampered by lack of, and poor quality infrastructure. The CSIR has conceptualised a modular clinic that is self-sufficient, sustainable, robust, fully equipped and can be used as a stand-alone or as multiple units.

The challenge: Addressing the backlog in infrastructure for service delivery

South Africa suffers from a backlog in service-related infrastructure, including basic healthcare infrastructure. Addressing this need is not trivial, as it requires bulk water, electricity and sanitation services and involves issuing of tenders for construction, procurement of fixtures and equipment, and securing connectivity, while adhering to standards for quality management.

CSIR research and development: A new modular building technology

The CSIR has conceptualised a modular building technology for a variety of applications. The technology is resource-efficient as it results in less construction waste and has a lower impact on the environment than conventional techniques. Its benefits in terms of time, lifecycle cost and quality, make it particularly suitable for social infrastructure.

Social infrastructure refers to the built environment and supporting technologies that are necessary for the rendering of public services such as education, health, sport and recreation, early childhood development and social services.

One of South Africa's most critical needs is for primary healthcare and the CSIR therefore opted to apply the building technology to a clinic. In addition, the organisation has a number of technologies, which, when applied in combination, provide practical and innovative solutions for addressing clinic infrastructure needs.

The design has been applied to a scaled model of 1:24 and the next step is to build a full-scale prototype. The design will be readily customisable to other applications in the social services sector and includes planning for the industrialisation of innovative components as well as national roll-out and scale-up.

The design is currently being lodged as a registered design and is producible at the end of the project under licence.

Design considerations

It is foreseen that building materials, including novel high-performance lightweight construction materials, will be manufactured in an industrialised setting. Technologies that address requirements for energy, connectivity as well as water and sanitation are part of the modular design, and will be manufactured with the building envelope. These will be assembled with equipment, furniture and fixtures, which will be deployed to site in a single-truck solution.

Climate-responsive design strategies – appropriate for South Africa – have been incorporated into the design detail. An example is the ventilation design, which addresses the need for comfort and mitigates risk against airborne disease transmission.

From an energy and water perspective, modules are intended to be self-sufficient in order to be deployed to rural settings or urban settings without piped water or bulk electricity supply. This will be achieved with renewable solar energy collection as well as rainwater storage and harvesting and greywater reuse. The approach minimises the burden on municipal infrastructure and makes it less vulnerable to central supply uncertainty. It also simplifies procurement. Such a solution is currently not available on the market.

Clinic modules can be added incrementally, as the community need grows. Should the clinic module no longer be required, modules can be dismantled and redeployed, again reducing waste.

Placement and roll-out of modular clinics

CSIR tools in geospatial planning will enable decision makers to rapidly deploy the infrastructure as and when it is needed. These tools can aid decisions on social infrastructure sizing, placement and prioritisation, based on features of need such as demographics, epidemiology and migrancy trends. This will reduce extended planning times, and allow for more responsive service delivery. The building materials and utilities will be assembled in factory settings at central locations. This means that there is less need for coordination at remote sites which will lead to improved working conditions and consistency in quality.

While the project focuses on the South African public healthcare sector, the technologies will be readily adaptable to other sectors of government, to private developers and to regional markets. Provision of off-grid utilities with renewables are more environmentally sound than conventional technologies. Improved efficiency of infrastructure delivery will benefit taxpayers through rapid delivery and reduced operational cost, and patients by providing safe environments.

The construction industry tends to apply tried and tested technologies and is slow to modernise. Industrialising the production and delivery process of built infrastructure has the potential to support service delivery, unlock quality and value in investment, improve working conditions and reduce environmental impact.

Research, development and implementation to

IMPROVE HEALTH

Promising molecular biology reagents from microbes in biodiverse Cape soil

IN BRIEF

The Kogelberg Biosphere Reserve in the Western Cape is one of the world's most recognised biodiversity hotspots. Researchers from the CSIR have identified microbes from the reserve's soil that are used to produce protein molecular biology reagents used in genome engineering.

Sibongile Mtimka, a student researcher in molecular biology at the CSIR, collects a soil sample at the Kogelberg Biosphere Reserve in the Western Cape. These samples are taken to the CSIR's laboratories in Pretoria to investigate techniques to extract microbial genes for use as novel protein molecular biology agents.

Dr Tsepo Tsekoa, a CSIR principal researcher in protein biochemistry, leads research into biomanufacturing technology demonstration.

The challenge: Better reagents for the large and growing protein and enzyme reagent market

Biotechnology research and development (R&D) activities rely heavily on the use of proteins and enzymes as reagents. Access to newly developed research reagents with novel activities is a major driver of improved competitiveness and productivity in the biotechnology research and innovation sector.

The global molecular biology reagents market is growing fast and end-users have a desire to conduct their R&D better and faster through novel reagents with improved functionality.

Research and development: Developing reagent product prototypes and processes for market testing

The Kogelberg Biosphere Reserve in the Western Cape boasts the world's highest plant species biodiversity per unit area. Realising that the high plant biodiversity could translate to microbial diversity, CSIR researchers collected soil samples from the reserve to investigate techniques to extract microbial genes for use as novel protein molecular biology reagents.

They specifically targeted molecular biology enzymes that are used to cut DNA to amplify, multiply or join DNA molecules. The use of these reagents in molecular biology techniques is a crucial component of synthetic biology and genome editing. As a result, the annual market for these enzymes exceeds $5 billion globally.

Extracting gene sequences and testing prototypes

CSIR researchers successfully sequenced the metagenome and metavirome from the soil and identified novel reagent enzyme genes. The next step in the work forms the basis of a project funded by the Department of Science and Technology in which the aim is to develop a pipeline of prototypes to translate into market-ready processes and products.

The CSIR is developing a production process based on the fermentation of recombinant microorganisms and chromatography purification. Several of these protein reagents have been formulated for entry into a phase of end-user testing (beta testing) where end-users and potential customers are testing them for use in their own laboratory applications. End-user testing of one product prototype has already been completed. The expanded and fully branded and packaged beta testing of other advanced prototypes has been initiated. These include DNA polymerase and DNA ligase products.

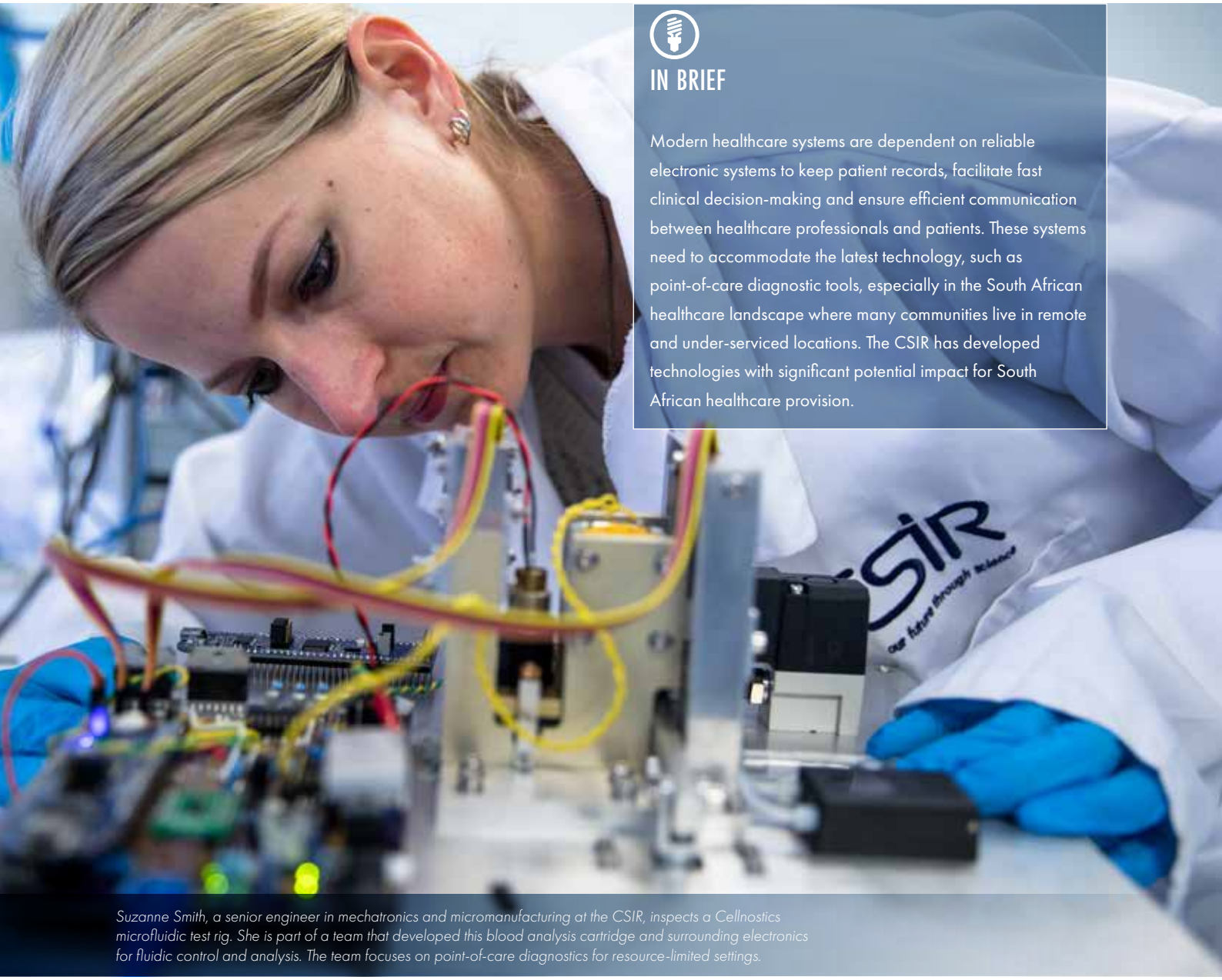
Supporting the national bioeconomy strategy

The R&D undertaken – and the project's potential for commercialisation – is in alignment with government's national bioeconomy strategy. The work has contributed significantly to the development of human capital in biosciences, with one post-doctoral researcher, two PhD students and one MSc student focusing their studies on the research project.

Research, development and implementation to

IMPROVE HEALTH

Technology for better healthcare



IN BRIEF

Modern healthcare systems are dependent on reliable electronic systems to keep patient records, facilitate fast clinical decision-making and ensure efficient communication between healthcare professionals and patients. These systems need to accommodate the latest technology, such as point-of-care diagnostic tools, especially in the South African healthcare landscape where many communities live in remote and under-serviced locations. The CSIR has developed technologies with significant potential impact for South African healthcare provision.

Suzanne Smith, a senior engineer in mechatronics and micromanufacturing at the CSIR, inspects a Cellnostics microfluidic test rig. She is part of a team that developed this blood analysis cartridge and surrounding electronics for fluidic control and analysis. The team focuses on point-of-care diagnostics for resource-limited settings.

The challenge: Suboptimal healthcare

As a result of resource constraints, many marginalised communities receive suboptimal health services. Challenges include insufficient record keeping of patient data leading to delays, duplication or incomplete patient history profiles as well as limited access to specialised services such as prenatal screening and pathology tests.

Other health challenges relate to efficient primary healthcare delivery, which requires a proactive approach to prevent medical complications that require specialist interventions, such as complications related to chronic conditions and pregnancy.

Research and development: Technology for better care

The CSIR has applied its multidisciplinary expertise to strengthen primary healthcare in the country. This includes the strengthening of information and communications technology systems and the development of point-of-care diagnostic devices.

Efficient electronic systems

Knowledge of patient demographics and a record of patient movement through health facilities are fundamental in delivering integrated healthcare services and are required for planning aspects of the national health system. The CSIR and the National Department of Health have partnered to develop the National Health Patient Registration System, which allows for the registration and identity verification of patients at public health facilities. The system has thus far been deployed in 1 859 facilities and 6 355 759 registrations have been captured on a central database.

A point-of-care ultrasound device

One of the challenges with reducing South Africa's infant mortality rate is improving access to specialist obstetric care for those that need it while reducing unnecessary referrals. In trials undertaken in the Tshwane district it was shown that a CSIR-developed Doppler ultrasound device has the potential to significantly reduce the perinatal mortality rate.

The Tshwane clinical trial started on 4 May 2015 and is in its second year in multiple clinics. To date more than 2 640 women have participated in the trial of which 324 were classified as high risk and referred to the Mamelodi Hospital.

Of a group of 1 096 women who have given birth, 10% showed abnormal results with the Umbiflow screening. It is estimated that about 10% of the group showing abnormal results would reasonably have been expected to have a stillbirth if the abnormal reading had not been detected by Umbiflow.

The perinatal mortality rate for women who had access to Umbiflow testing was 11.3/1 000 deliveries, and among those who were not Umbiflow-screened, the mortality rate was 21/1 000. This indicates that Umbiflow has the potential to reduce the perinatal mortality rate by up to 50%. Umbiflow is also highly cost-effective – each screening costs less than R500. This trial will be extended to nine sites across all provinces to validate Umbiflow in different settings.

Pathology training support

The CSIR joined forces with the National Health Laboratory Service (NHLS) to develop a national digital pathology database containing 104 medical case studies focusing on South Africa's unique disease burden. For each case study, clinical history, blood counts and digital morphology images were captured. More than 1 200 digital images with detailed annotations have been captured. The NHLS is using this database to provide annual haematology morphology training courses.

On-site blood test device

The majority of South Africans receive their medical care at primary healthcare facilities, such as clinics and community centres. If the healthcare centres are located far from centralised laboratories, the delays caused by the transport of blood samples and test results may detrimentally affect the quality of patient care. In another partnership with the NHLS, CSIR researchers have developed a device, called Cellnostics, to perform quick and effective on-site blood tests to reduce the time between tests and diagnosis and subsequent treatment.

The portable wireless blood analyser allows for two-way communication between the clinic and a central laboratory. Medical professionals can also access the information with cell phones and tablets.

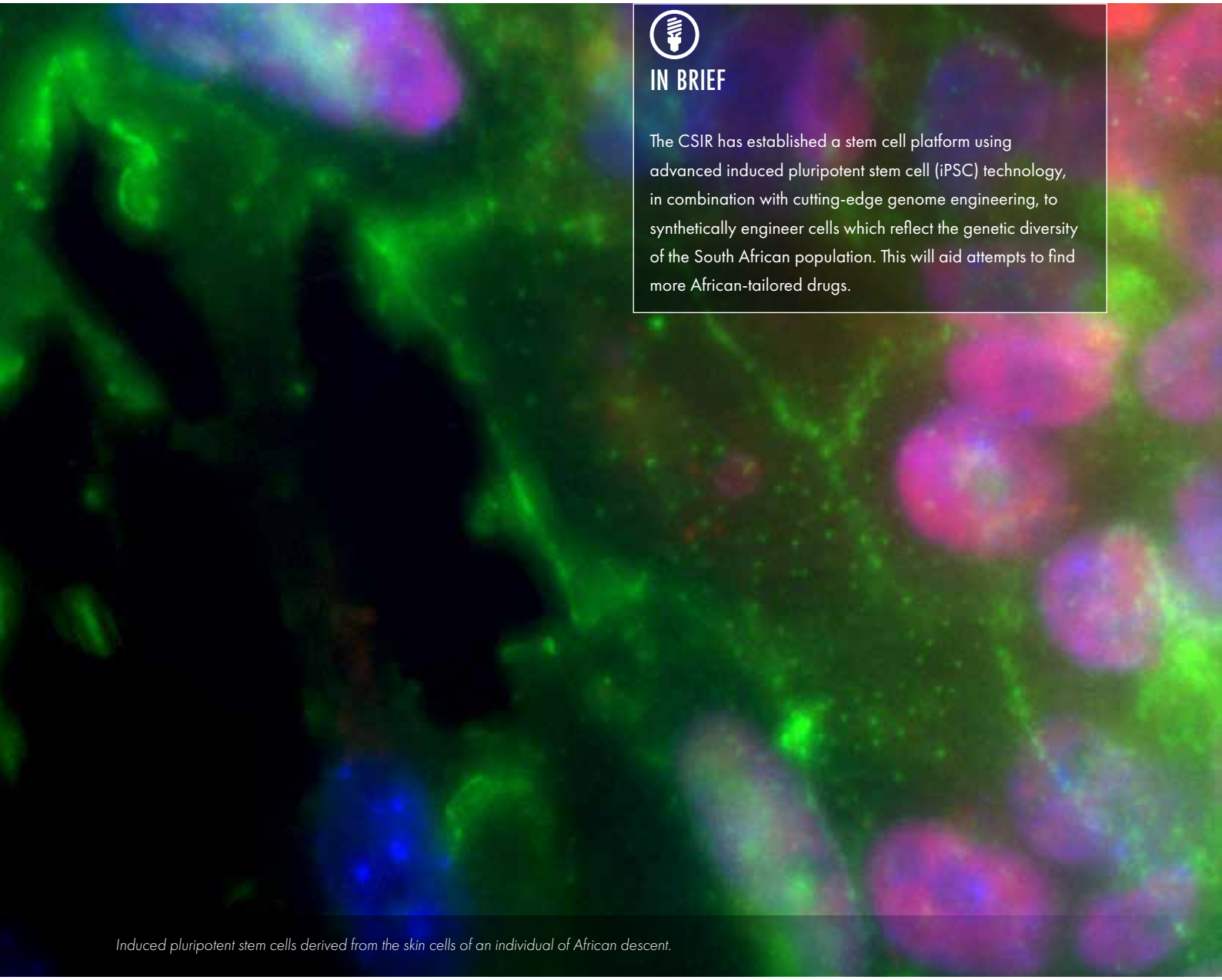
Cellnostics uses microfluidic technology to prepare blood samples for analysis. Microfluidics involves the manipulation of very small volumes of fluid, typically at the nano- to femto-litre levels. Holography and other novel optical techniques record physical information from the blood samples prepared by the microfluidic cartridge.

During 2016/17, two design versions of the microfluidic cartridge were tested and evaluated in CSIR laboratories and their performance was found to be comparable to gold standard tests in a pathologist's laboratory. The next step is to conduct clinical assessments with the device in partnership with the NHLS. Two patents related to the device, a 4D light field microscope and an analysis system, method and device have been registered.

Research, development and implementation to

IMPROVE HEALTH

Research and development to help minimise adverse drug-reactions for populations in southern Africa



IN BRIEF

The CSIR has established a stem cell platform using advanced induced pluripotent stem cell (iPSC) technology, in combination with cutting-edge genome engineering, to synthetically engineer cells which reflect the genetic diversity of the South African population. This will aid attempts to find more African-tailored drugs.

Induced pluripotent stem cells derived from the skin cells of an individual of African descent.

The challenge: Finding novel testing models to assess adverse drug reactions in sub-Saharan Africa

It is becoming increasingly important for South Africa to exploit advanced scientific technologies to address some of the unique and complex issues with which we are faced. This is no less critical in the health sector, where the extraordinary genetic diversity of the South African population, in combination with the country's heavy infectious disease burden, creates health issues unique to our country.

Although drugs designed to target particular diseases may be effective, they potentially lead to severe side effects due to the changes in the genetic-basis of our metabolism. Such adverse reactions can lead to non-compliance – a game changer in the fight against diseases like tuberculosis and HIV/Aids.

It is well established that the genetic diversity of African population groups is not accounted for in the largely Caucasian clinical trials established in developed nations, resulting in severe adverse drug reactions, estimated to cause as many as 1 in 12 hospital admissions. This leads to a decline in compliance which can be fatal in many scenarios, but is of particular concern within the context of South Africa's high HIV burden, where lifelong antiretroviral therapy regimens are required to avoid disease progression and death. Therefore, established drugs need to be retested across southern African populations. However, the time and cost associated with these potential retrials make this an unattractive prospect for large international pharmaceutical companies. There is a need, therefore, to bridge the gap between expensive and time-consuming clinical trials on the sub-Saharan population and finding novel testing models to minimise adverse drug reactions.

Research and development

Establishing iPSC technology to generate a vast number of cells affected by adverse drug reactions

The development of appropriate cellular models which are representative of the genotypes and haplotypes endemic to southern Africa may negate the requirement for clinical retrials and help to predict, based on simple polymerase chain reaction or sequencing tests, which drugs will be best tolerated in vivo. Such cellular models need to retain basic characteristics, for example, comparisons between proficient and poor drug metabolism phenotypes must be made with the knowledge of the exact contributing genetic change. These can then be used to characterise accurate indicators of drug metabolism. Therefore it is critical to investigate the development of advanced physiologically relevent cellular models that can be used in a high-throughput format.

The CSIR has established cutting-edge induced pluripotent stem cell (iPSC) technology which would allow the organisation to generate vast amounts of liver cells – the cell type most affected in, and indicative of, adverse drug reactions. In addition, researchers have established genome engineering technology which allows them to precisely and discretely introduce variations known to exist in the southern African population with which to re-evaluate drug toxicity. The CSIR is currently engineering stem cells to incorporate a highly prevalent African genetic variant which leads to the poor metabolism of the anti-retroviral Efavirenz – considered a standard drug in the fight against HIV in South Africa. With these engineered and physiologically relevant cells, which are highly superior to currently available testing models, this research can propel the reassessment of drug screening into an African-centric domain.

The goal of the research is to not only create genetically valuable cells for the pharmaceutical community at large, with which to perform their own high content screens, but also, due to the cutting-edge nature of this work, to push the boundaries of modelling African-relevant genetic factors.

The CSIR's Dr Janine Scholefield is part of a team that has established genome engineering technology that may change drug screening in the African context.

The CSIR's Tshepo Makgoba, Karabo Setlhapelo, Phiyani Lebea, Frank Banda and Simone Hammersley during field trials for an African-focused diagnostic for foot-and-mouth disease in Lesotho.

Partnering for

AFRICAN RESEARCH, DEVELOPMENT AND IMPLEMENTATION

The CSIR subscribes to the African Union vision of an integrated and prosperous and peaceful Africa, driven by its own citizens and representing a dynamic force in the global arena. The organisation believes that it can contribute to innovation in Africa, tackling continental societal challenges through continental and global cooperation in science, engineering and technology.

Partnering for

AFRICAN RESEARCH, DEVELOPMENT AND IMPLEMENTATION

Designing resilient roads to withstand the effects of climate change in Africa

IN BRIEF

It is estimated that, during this century, it may cost Africa in excess of $150 billion to repair and maintain roads damaged by events related to projected climate change. The cost excludes critically needed new roads and the indirect socio-economic effects generated from dislocated communities and loss of rural access. The CSIR assessed parts of the road system in Ethiopia, Ghana and Mozambique to determine their vulnerability to climate change and to identify interventions to improve their resilience. The organisation presented recommendations and adaptation strategies to 12 countries associated with the Africa Community Access Partnership, a programme of UKAid.

The effects of climate change impact negatively on infrastructure.

The challenge: Climate change impacting road infrastructure

Climate change exacerbates the frequency of rural areas being cut off when roads and bridges are damaged. It is anticipated that climate change, in the form of more extreme events, will lead to increased incidences of this sort.

For low-volume rural road networks, the environment plays a much larger role in contributing to deterioration than traffic does. Greater climate variability in the future is likely to stress present road infrastructure beyond the range of the impacts that it is currently able to resist, impinging on rural accessibility and the delivery of essential services with significant socio-economic consequences for rural communities.

The backlogs of damages resulting from extreme weather events are growing because of insufficient knowledge, methodologies and funding to address issues.

CSIR research and development: Current climate threats, vulnerabilities and trends

The CSIR and its partners, Paige-Green Consulting and St Helens Consulting, assessed parts of the road infrastructure in Ethiopia, Ghana and Mozambique for climate adaptation, looking into risk management and resilience optimisation for vulnerable road access. The project is funded by the Africa Community Access Partnership, a programme of applied research and knowledge dissemination funded by the Department for International Development of the United Kingdom.

In the first phase of the project, researchers studied data on weather patterns and climate from 1961 to 1990 as well as projected changes in climate over the periods 2021-2050 and 2071-2100. High-resolution (8x8km) maps for the identified priority countries, namely, Ethiopia, Ghana and Mozambique, were produced for climate metrics such as maximum temperature, number of very hot days, rainfall and extreme rainfall days. From this data, maps on wind velocity, a drought index, fire-hazard days and other climate-derived metrics can be produced. Engineers focused on three demonstration roads, namely, the Tullo Bollo to Kela road in Addis Ababa, Ethiopia; the R448 road from Chokwe to Macarretane in Gaza Province, Mozambique; and the Tampion-Tibognaayili-Tidjo road in Tamale, Ghana.

The CSIR made recommendations and formulated adaptation strategies relating to the upgrading of earth roads, improved material selection, construction practices, maintenance practice, and use of innovative compaction techniques and water drainage solutions.

Stakeholders have requested comprehensive guidelines on all aspects of climate adaptation, from incorporating climate change considerations in management goals and policies, to the identification of risks and vulnerabilities and the prioritisation of actions, to the adoption of adaptation measures and to monitor and evaluate their effectiveness.

CSIR helps Tanzania design asphalt design guidelines for high-volume roads

The CSIR has developed guidelines for the design and use of asphalt concrete in road pavements for the Tanzania National Roads Agency. Use of these guidelines will contribute to the roads being able to better withstand the increase in volumes of heavy traffic on trunk roads and highways, preventing premature failures on asphalt concrete pavements.

The guidelines were developed following an earlier forensic study by the CSIR into high incidences of recurrent premature rutting failures on a number of trunk roads and highways in Tanzania. CSIR engineers identified a need for more robust asphalt mix design procedures to allow for the selection of asphalt materials that are appropriate for heavy traffic loading conditions over the service life of the asphalt concrete pavement.

The guidelines describe the methodology and procedures to assist in the selection of asphalt materials and provide guidance on quality management considerations during mix design and construction.

The guidelines are a precursor to a more comprehensive asphalt concrete design manual and performance-related specifications for the design of asphalt mixes.

Partnering for

AFRICAN RESEARCH, DEVELOPMENT AND IMPLEMENTATION

African collaboration in laser research provides answers in multidisciplinary fields

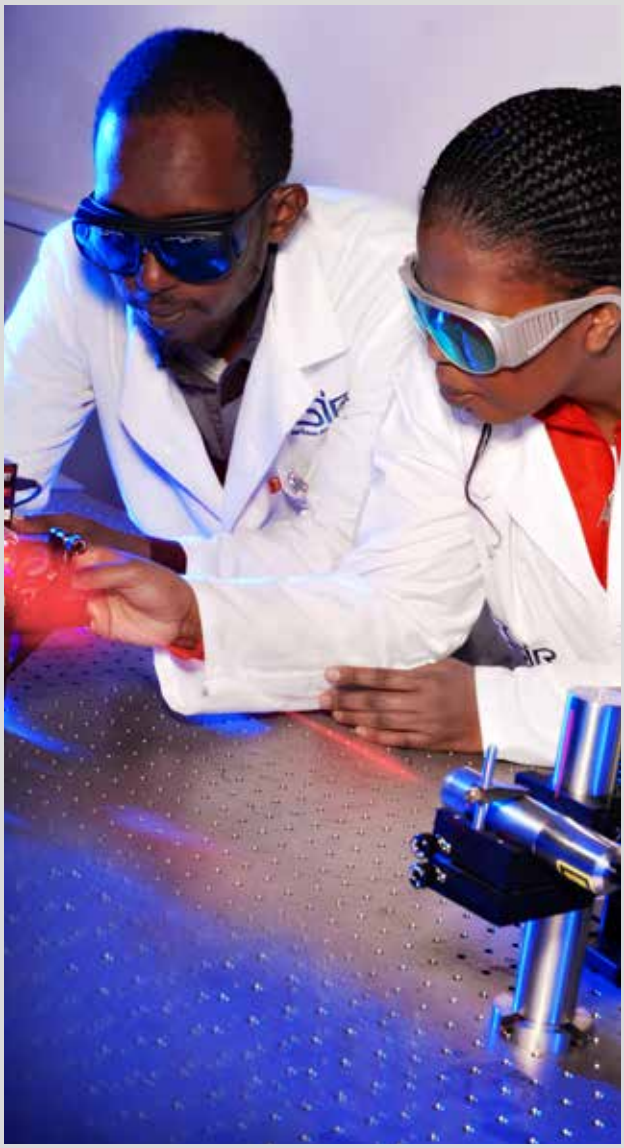
In 2016/17, the African Laser Centre (ALC) supported 12 research collaboration projects between South African researchers and their counterparts from Algeria, Senegal, Nigeria, Mozambique, Tunisia, Kenya, Uganda, Botswana, Sudan, Egypt and Zimbabwe. These projects covered process development for titanium metal oxides for fuel cell research, improving the luminescence of phosphors, laser-based manufacturing, advanced fibre-based optical communication technologies, the evaluation of the medicinal properties of African plants and work on short-pulse laser applications for sensing and diagnostic applications.

The ALC is managed by the CSIR on behalf of the Department of Science and Technology. It is a virtual centre of excellence aimed at stimulating research and technology development in the field of lasers and laser applications between African countries. A total of 59 researchers (34 from South Africa and 25 from 11 other African countries), as well as 68 postgraduate students (22 South African and 46 from other African countries) participated in these projects.

The ALC also supported 20 students from the Democratic Republic of the Congo, Zimbabwe, Kenya, Zambia, Uganda, Gabon, Morocco, Cameroon and Nigeria to study in various laser-related research fields at South African universities. Three of them were at Master's level and 17 at PhD level.

The centre conducted six training events on topics covering laser-based imaging techniques, quantum communication technologies and quantum effects in biological systems.

South African institutions that participated in the initiatives include the Universities of Johannesburg, Cape Town, Pretoria, the Witwatersrand and the Free State, the Nelson Mandela University and Stellenbosch University.



A CSIR researcher assists a student supported by the African Laser Centre with alignment in a laser experiment.

Partnering for

AFRICAN RESEARCH, DEVELOPMENT AND IMPLEMENTATION

Diagnostic for African strains of foot-and-mouth disease progresses to commercial development

The CSIR, in collaboration with a commercial life sciences company, the Zambian Central Veterinary Research Institute and Mozambique's Agricultural Research Institute, is developing an African-focused diagnostic for foot-and-mouth disease (FMD). The diagnostic will be in the form of an enzyme-linked immunosorbent assay to supplement other technologies already developed for the disease at the CSIR.

Foot-and-mouth disease is the single most important livestock disease worldwide in terms of negative socio-economic impact. The consequences of the disease on the affected countries include the creation of food insecurity, which contributes to malnutrition; production losses due to reduced conception and live calving rates; significant drops in milk production; restrictions on local livestock movement hampering local trade; as well as restrictions on export to other African and global markets. Furthermore, once such an outbreak occurs, there are costs linked to animal vaccination, movement control, vaccine monitoring and overall management control of the disease.

Enzyme-linked immunosorbent assays are the recommended surveillance methodology of the World Organisation for Animal Health and are widely used for foot-and-mouth disease control. While there are commercial kits available for several strains of the virus, no commercial kits exist for the three foot-and-mouth strains prevalent in Africa, especially in the southern African territories.

For the efficient management of the disease, the determination of the foot-and-mouth disease serotype for a given outbreak is necessary to determine adequate vaccine. The availability of a kit with the capacity to identify African strains, in conjunction with already-available kits for the other strains, will allow for specific identification and significantly improved management of foot-and-mouth disease. The CSIR and its partners are at a stage where the development of the kit is nearing field testing for the kit under development in Zambia and Mozambique. The full kit, including field proficiency testing, is expected to be fully developed and ready for commercialisation by December 2018.

The CSIR's Tshepo Makgoba (left) and Karabo Setlhapelo during field trials of a kit that focuses on strains of foot-and-mouth disease that are prevalent in Africa.

Partnering for

AFRICAN RESEARCH, DEVELOPMENT AND IMPLEMENTATION

Social and environmental assessments for the Cameroon petroleum industry

The CSIR completed two environmental and social impact assessments for the petroleum industry in Cameroon in collaboration with a local environmental consultancy firm, CIME consulting.

For oil and gas projects to be developed and operated, the law in Cameroon requires that companies submit environmental and social assessment reports compiled by independent consultants. These reports inform best practice management and mitigation actions that will contribute to environmentally responsible development of petroleum resources. Based on the findings of the assessments, Cameroon's Ministry of Mines, Industry and Technological Development decides on whether a project should go ahead.

EurOil, an oil and gas exploration company, commissioned assessments for its Bomono explorations near Douala, a project that aims to bring two onshore gas wells back into production. Golar LNG, an international company specialising in vessels that carry liquefied natural gas, also commissioned an assessment for its Hilli Episeyo carrier that will operate from Cameroon's offshore Kribi field to liquefy natural gas from a sub-sea pipeline.

The researchers considered environmental, social and economic factors and used their data to recommend impact mitigation measures for these projects. The final recommendation by the CSIR was that both projects could proceed without significant impact to the environment.

Artisanal fishermen at work (above) and boasting with their catch on Kribi beach (below) in Cameroon. These fishermen fish for subsistence and small markets using traditional means and are vital for food security in their communities. CSIR researchers considered the risk of impacts on artisanal fisheries in Cameroon when conducting the environmental and social impact assessments for the exploitation of an offshore natural gas field.

Partnering for

AFRICAN RESEARCH, DEVELOPMENT AND IMPLEMENTATION

Farming for a green future

The CSIR participated in a European-Union funded programme to facilitate the transition to a green economy in the agri-food sector in South Africa. Sustainability experts identified factors to be addressed for small-scale vegetable farmers to align their farming activities to green-economy principles. The project is part of a broader Switch Africa Green programme in Burkina Faso, Kenya, Ghana, Mauritius, Uganda and South Africa.

The capacity of small-scale farmers and relevant stakeholders in the sector needs to be expanded to support and implement vegetable production and marketing compatible with South Africa's green economy aspirations.

Small-scale farmers in three districts in Limpopo, namely Mopani, Waterberg and Capricorn participated in the project. They all use conventional or industrial farming methods which are characterised by the intensive use of resources with a heavy reliance on chemical inputs such as synthetic fertilisers and pesticides, as opposed to organic or green production practices.

The researchers investigated different types of crops, irrigation practices and methods, water sources and rotations. They found production and marketing constraints that included climate change and changing rainfall patterns, water shortages, a lack of transport and inconsistent production.

CSIR researchers worked with a diverse set of stakeholders representing government, the private sector, farmers' organisations, policymakers and farmers to achieve the project's objectives.

Farmers can enhance their sustainability by employing techniques for producing with less water as the climate becomes warmer, including adapting their buildings and infrastructure. A core part of water conservation during irrigation is management through irrigation scheduling – something few small-scale farmers employ. Irrigation scheduling leads to efficient water use and can enhance the efficiency of drip irrigation systems.

In line with South Africa's green economy aspirations, it is necessary for small-scale farmers to implement green production processes. CSIR sustainability experts have worked with a number of small-scale farmers to assist them in the implementation of green production practices.

CORPORATE GOVERNANCE

Corporate governance

Framework

Corporate governance is formally concerned with the organisational arrangements that have been put in place to provide an appropriate set of checks and balances within which the stewards of the organisation operate. The objective is to ensure that those to whom the stakeholders entrust the direction and success of the organisation act in the best interest of these stakeholders. It is about leading with integrity, responsibility, accountability and transparency.

The CSIR is committed to principles and practices that provide its stakeholders with the assurance that the organisation is soundly and ethically managed. A management model that governs and provides guidance for the way that all employees interact with various stakeholder groups has been established to provide this assurance.

The underpinning principles of the Group's corporate governance rest on the three cornerstones of an effective and efficient organisation namely: a long-term strategic planning process; day-to-day management processes and effective change management processes. These processes are supported by people and systems that plan, execute, monitor and control the strategic and operational domains of the organisation. The supporting infrastructure and its evolution are documented in the management model, which is reviewed and updated to align with organisational changes.

In accordance with the Scientific Research Council Act 1988 (Act 46 of 1988), as amended by Act 71 of 1990, the appointment of the CSIR Board is by the Executive Authority (the Minister of Science and Technology). The Board provides oversight strategic direction and leadership, determines goals and objectives of the CSIR and approves key policies. The Board has adopted formal Terms of Reference that are in line with the Scientific Research Council Act, the Public Finance Management Act (PFMA), 1999 (Act 1 of 1999), as amended by Act 29 of 1999 and best practice.

The CSIR Board and its Executive Management Committee believe that the organisation has complied with the relevant principles incorporated in the Code of Corporate Practices and Conduct, as set out in the King Report.

Shareholder's Compact

In terms of Treasury Regulations issued in accordance with the PFMA, the CSIR must, in consultation with the Executive Authority, annually agree on its key performance objectives, measures and indicators. These are included in the shareholder's performance agreement (Shareholder's Compact) concluded between the CSIR Board and the Executive Authority.

The Shareholder's Compact promotes good governance practices in the CSIR by clarifying the roles and responsibilities of the Board and the Executive Authority, as well as ensuring agreement on the CSIR's mandate and key objectives. The chairperson of the Board and the Executive Management Committee hold bilateral meetings with the Executive Authority to ensure performance is in line with the Shareholder's Compact.

Financial statements

The Board and the CSIR Executive Management Committee confirm that they are responsible for preparing financial statements that fairly present the state of affairs of the Group as at the end of the financial year and the results and cash flows for that period. The financial statements are prepared in accordance with International Financial Reporting Standards (IFRS). In addition, the Board is satisfied that adequate accounting records have been maintained.

The Auditor-General independently audits and reports on whether or not the financial statements are fairly presented in conformity with IFRS. The Auditor-General's Terms of Reference do not allow for any non-audit work to be performed.

Enterprise risk management

The Board is responsible for ensuring that a comprehensive and effective risk management process is in place.

Enterprise risk management in the CSIR is an ongoing process, focused on identifying, assessing, managing and monitoring all known forms of significant risks across all operations and Group

Corporate governance

companies. This has been in place for the year under review and up to the date of approval of the annual financial statements.

A structured process of enterprise risk management ensures that the goals and objectives of the CSIR are attained. This takes cognisance of the fact that the risks identified are often inter-linked and cannot be managed in isolation. CSIR systems review aspects of economy, efficiency and effectiveness. The management of risk is assigned at appropriate levels to ensure adequate responses.

Documented and tested processes allow the CSIR to continue its critical business operations, in the event of interruptions that could possibly impact on its activities. Based on the internal audit, the organisational results achieved, the audit report on the annual financial statements and the management report of the Auditor-General, the Board is satisfied that the system of risk management has been effective during the year under review.

The CSIR has defined three broad risk categories, namely: systemic risks, strategic risks and operational risks.

Systemic risks

Systemic risks originate from macro-economic and national challenges affecting the National System of Innovation and National Government Business Enterprise space in which the CSIR operates.

Continued evaluation of macro-economic influences, ongoing assessment and engagement with stakeholders remain key in directing research activities towards achieving the CSIR's mandate.

Strategic risks

The organisation has effective mechanisms in place for identifying and monitoring strategic risks that impact the CSIR's ability to deliver on its mandate. The procedures for implementing a risk management process include a focus on areas such as: human capital assessment and development, research impact areas, technological development and business continuity.

Operational risks

The CSIR endeavours to minimise operating risk by ensuring that the appropriate infrastructure, controls, systems and people are in place throughout the Group. Key processes employed in managing operating risk include research ethics and good research practices, segregation of duties, transaction approval frameworks, financial and management reporting and the monitoring of metrics that are designed to highlight positive and/or negative performance across a broad range of Key Results Areas. The Operations Committee, which comprises members of the Executive Management Committee, Operating Unit Executive Directors, Centre Managers and Group Managers, oversee operational matters.

Sustainability

The Board has reviewed the Group's financial budgets for the period 1 April 2017 to 31 March 2018 and is satisfied that adequate resources exist to continue as a going concern for the foreseeable future. The Board confirms that it has assessed key sustainability risks and there is no reason to believe the business will not be a going concern in the year ahead.

The income streams of the CSIR are detailed in the notes to the annual financial statements.

Internal audit

The Group has an internal audit function that reviews its operations. The Audit and Risk Committee approves the internal audit charter, the annual audit plan and budget of the CSIR internal audit to maintain its independence.

The annual audit plan is based on the key risks to the organisation and outcome of enterprise risk assessment conducted by management, as well as specific areas highlighted by internal audit and the Audit and Risk Committee. In addition, areas highlighted by internal control reviews by the external auditors are incorporated into the internal audit plan.

Corporate governance

The annual audit plan is flexible in ensuring it is responsive to changes in the business and emerging risks. A comprehensive report on internal audit findings is regularly presented to management and quarterly presented to the Audit and Risk Committee.

The internal audit function operates in conformance with International Standards of the Professional Practice of Internal Auditing (The Standards) of the Institute of Internal Auditors. In accordance with The Standards, an external quality assurance review of internal audit has been concluded for the 2016/17 financial year. The results are satisfactory, reflecting general conformance with The Standards.

Internal control and combined assurance

The Board has ultimate responsibility for the system of internal control designed to mitigate risks, identify, evaluate, manage and provide reasonable assurance against misstatements and losses.

The system comprises self-monitoring mechanisms to allow for actions to be taken to correct deficiencies as they are identified.

A combined assurance approach is in place to assist in addressing key enterprise risks.

Management and the Risk Office identify controls that are necessary to mitigate risks. Internal Audit is the third line of defence and provides assurance on the effectiveness of risk management and the system of internal control.

For the year under review, the internal financial controls have been assessed as adequate and effective.

Audit

External auditors are responsible for the independent audit and to report on the annual financial statements. The statements comply with International Financial Reporting Standards.

In line with the requirements of the PFMA and good governance, the internal audit function provides assurance to the Audit and Risk Committee and management on the adequacy and effectiveness of internal controls. Information is derived from an independent evaluation of risk management, governance processes and internal controls. Corrective action is identified and improved controls are recommended.

Approval framework and policies

The approval framework governs the authorisation processes in the CSIR. It deals with, among others, the construction of strategic plans, development of operational plans and budgets, appointment of staff, approval of salaries, intellectual property management and investment in and disposal of property, plant and equipment. It also defines authority levels in relation to organisational positions.

Appropriate controls are in place to ensure the compliance with the above framework. A comprehensive set of procedures exists to provide the necessary checks and balances for the economical, efficient and effective use of resources. The essence of this framework is that it is comprehensive, clear and unambiguous, as well as easy to assimilate and internalise.

Other policies that are in support of the CSIR mandate and strategic priorities cover the following key areas: building and transforming human capital, governance and financial sustainability, transferring technology and human capital, strengthening the science and technology base, and performing relevant research and development (R&D).

All subsidiary companies are under the control of a duly appointed Board of Directors.

The Board reserves all matters with the potential to have material impact on the operations and reputation of the CSIR to itself.

Code of business ethics and organisational values

The Board and CSIR Executive Management Committee have approved and adopted a code of ethics that reflects their commitment to a policy of fair dealing and integrity in conducting their operations. The code aligns closely to the CSIR set of values, compliance to laws and regulations and requires all employees

Corporate governance

to maintain the highest ethical standards, ensuring that business practices are conducted in a manner that is beyond reproach. Monitoring ethical behaviour is devolved to operating unit level and transgressions are addressed by means of procedures detailed in the CSIR Conditions of Service and the PFMA.

Employee participation

The CSIR strongly encourages effective and modern workplace practices and relationships to foster employee participation and work process involvement as a key practice at all levels in the organisation. Employee participation happens, for example, through the Transformation and Employment Equity Committee, formal induction programmes, technical and strategic focus groups and task teams.

As part of the induction of the new CEO, organisational-wide roadshows were conducted. The CEO engaged staff at all levels to share his vision and understand functions of the various operating units and portfolios.

Governance structure

The CSIR Board

The responsibilities of the Board are governed by the Scientific Research Council Act and the PFMA. The Board approves the strategy, goals, operating policies and priorities for the organisation and monitors compliance with policies, applicable legislation and achievement against objectives.

With the exception of the CEO of the CSIR, all members of the Board are non-executive. Board members are actively involved in and bring independent judgement to bear on the Board's deliberations and decisions.

The Board, of which the current number of members adheres to the statutory minimum requirements, meets quarterly. For the year under review, the Board met eight times. Four of these meetings were normal Board meetings held on 30 June 2016, 22 September 2016, 10 November 2016 and 21 February 2017. Three of these were special Board meetings held on 4 April 2016, 6 May 2016 and 19 July 2016. A Board strategic session was held from 26 to 27 October 2016. The annual financial statements for the 2016/17 financial year were approved on 29 June 2017.

The Board has the following sub-committees: The Audit and Risk Committee, the Human Resources and Remuneration Committee and the Research, Development and Innovation Committee (see page 117). These committees are selected according to the skills sets required for the committees to fulfil their functions.

The Audit and Risk Committee held three of its four scheduled meetings. A meeting scheduled for 6 September 2016 was cancelled due to unforeseen circumstances. However the substantive issues that were supposed to have been deliberated at the cancelled meeting were tabled and dealt with at the 10 November 2016 meeting. The other Board committees complied with their respective Terms of Reference.

The Board has adopted formal Terms of Reference reflected in the Board Charter.

Governance structure

CSIR Board members (1 April 2016 to 31 March 2017)

Prof. Thokozani Majozi
Chairperson of the CSIR Board
NRF/DST Chair: Sustainable Process Engineering, University of the Witwatersrand

Dr Sibusiso Sibisi*
Chief Executive Officer, CSIR

Dr Thulani Dlamini**
Chief Executive Officer, CSIR

Adv. Ghandi Badela
Advocate, Duma Nokwe Group

Ms Phindile Baleni
Director General, Gauteng Premier's Office

Dr Philip Goyns
Senior Climate Change Advisor, Promethium Carbon

Dr Antonio Llobell
Chief Executive Officer, BioGold International

Dr Ramatsemela Masango
Executive Director, Mzansi Energy Solutions and Innovations (Pty) Ltd

Ms Mokgadi Maseko
Director, Leruo Corporate Consulting

Mr Joel Netshitenzhe
Executive Director and Board Vice-Chairperson, Mapungubwe Institute for Strategic Reflection

Ms Ayanda Noah
Group Executive: Distribution, Eskom

Prof. Mamokgethi Phakeng
Vice-Chancellor (Research and Internationalisation), University of Cape Town

* Dr Sibusiso Sibisi's contract of employment ended on 30 September 2016. He attended Board meetings in his capacity as CEO.
** Dr Thulani Dlamini was appointed CEO effective 1 February 2017. He attends Board meetings in his capacity as CEO.

Governance structure

Schedule of attendance of the CSIR Board and CSIR committee meetings (1 April 2016 to 31 March 2017)

Board member	Board meetings	Audit and Risk Committee	Human Resources and Remuneration Committee	Research, Development and Innovation Committee
T Majozi	7			
S Sibisi*	3	1	2	1
M Motuku**	1	1		1
T Dlamini***	1	1	1	1
G Badela	5	2	2	
P Baleni	4	2	1	
P Goyns	6		3	4
A Llobell	4			1
R Masango	7			3
M Maseko	5	2		
J Netshitenzhe	6			4
A Noah	3	3		
M Phakeng	6		2	3

* Dr S Sibisi's contract of employment ended on 30 September 2016. He attended Board meetings in his capacity as CEO.
** Dr M Motuku was appointed Acting CEO from 1 October 2016 to 31 January 2017. He attended Board meetings in his capacity as Acting CEO.
*** Dr T Dlamini was appointed CEO effective 1 February 2017. He attends Board meetings in his capacity as CEO.

Governance structure

Executive Management Committee

The Executive Management Committee has executive responsibility for the CSIR and consists of the following Executive members:

1. CEO: Dr Sibusiso Sibisi (Contract ended on 30 September 2016)
2. CEO: Dr Thulani Dlamini (Appointed 1 February 2017)
3. Chief Financial Officer: Mr Chris Sturdy
4. Group Executive, Research and Development: Dr Molefi Motuku (Acting CEO from 1 October 2016 to 31 January 2017)
5. Group Executive, Strategic Alliances and Communication: Dr Rachel Chikwamba
6. Group Executive, Operations: Mr Laurens Cloete
7. Group Executive, Shared Services: Mr Raynold Zondo

The position for Group Executive, Human Capital is vacant. All Executives are employed on a five-year contract basis.

Governance structure

CSIR leadership team

The CSIR management is responsible for strategy implementation and managing the day-to-day affairs of the CSIR and its operating units in accordance with the policies and objectives approved by the CSIR Board.

This leadership team comprises the members of the CSIR Executive Management Committee, Operating Unit Executive Directors and Centre Managers.

Other internal structures that contribute to governance at the CSIR include the Executive, Operations and Strategic Committees, the Strategic Research and the Research Advisory Panels.

Board of Directors and Group companies

The CSIR Executive appoints the boards of the various subsidiary companies.

Board and Executive Management remuneration

Details of the Board are set out on pages 112 to 113 of the Corporate Governance Report. The membership and Terms of Reference of each Board Committee are further described on page 117.

Remuneration of Board members and the Executive Management is set out in Note 18 of the annual financial statements.

Remuneration of Executive Management is in accordance with the remuneration policy that has been approved by the Board.

General

The CSIR acknowledges that systems of corporate governance should be reviewed continuously to ensure that these are sound and consistent with world-class standards relevant to the operations of the Group.

The CSIR will continue to comply with all major recommendations of the Code of Corporate Practices and Conduct as set out in the King Report on Corporate Governance.

Public Finance Management Act

The PFMA came into effect on 1 April 2000 and has had an impact on governance matters regarding the regulation of financial management in the public sector. For the financial period reported, the CSIR has complied with the PFMA requirements.

Materiality framework

The materiality framework for reporting losses through criminal conduct and irregular, fruitless and wasteful expenditure, as well as for significant transactions envisaged per section 52 of the PFMA, has been finalised and incorporated into the Shareholder's Compact. No material losses through criminal conduct and irregular, fruitless and wasteful expenditure were incurred during the year.

CSIR Board committees

Audit and Risk Committee

1 April 2016 to 31 March 2017

Chairperson:	Ms A Noah
Members:	Adv. G Badela
	Ms P Baleni
	Ms M Maseko
Meetings:	27 June 2016
	10 November 2016
	7 February 2017

Purpose:

- To deal with all matters prescribed by the regulations issued regarding the PFMA and the Scientific Research Council Act;
- To perform the final review of the key risk matters affecting the organisation;
- To agree on the scope and review the annual external audit plan and the work of the CSIR internal auditors (including the internal audit charter); and
- To act in an unfettered way to understand the dynamics and performance of the organisation without restrictions.

The Audit and Risk Committee has adopted formal Terms of Reference and is satisfied that it has complied with its responsibilities as set out therein.

Human Resources and Remuneration Committee

1 April 2016 to 31 March 2017

Chairperson:	Adv. G Badela
Members:	Ms P Baleni
	Dr P Goyns
	Prof. M Phakeng
Meetings:	23 June 2016
	6 September 2016
	7 February 2017

Purpose:

- To influence and advise on human resources and remuneration matters in the organisation; and
- To approve remuneration changes and bonus payments and review the remuneration of the Executive Management.

The Human Resources and Remuneration Committee has adopted formal Terms of Reference and is satisfied that it has complied with its responsibilities as set out therein.

Research, Development and Innovation Committee

1 April 2016 to 31 March 2017

Chairperson:	Prof. M Phakeng
Members:	Dr P Goyns
	Dr A Llobell
	Dr R Masango
	Mr J Netshitenzhe
Co-opted members appointed on 22 September 2016	
	Mr R Heydenrich
	Mr T Mtshali
Meetings:	9 June 2016
	1 September 2016
	3 November 2016
	2 February 2017

Purpose:

- To provide guidance and advice on the long-term trajectory and composition of the CSIR's science and technology portfolio in the context of the needs of the country; and
- To ensure that key innovation and research processes are conducted effectively and benchmarked against international best practice, and that research outputs, organisational climate and credibility remain congruent with the role and objectives of the institution.

The Research, Development and Innovation Committee has adopted formal Terms of Reference and is satisfied that it has complied with its responsibilities as set out therein.

At its meeting on 22 September 2016, the Board appointed Mr Thami Mtshali and Mr Rudi Heydenrich as co-opted members of the RD&I Committee. Mr Mtshali, a businessman and Mr Heydenrich, from industry, bring a wealth of experience and their contribution will be invaluable to the RD&I Committee and to the CSIR as a whole.

Board and committee meeting attendance (1 April 2016 to 31 March 2017)

Board meetings

Board members	04/04/16*	06/05/16*	30/06/16	19/07/16*	22/09/16	10/11/16	21/02/17
T Majozi (Chair)	Present	Present	Present	Present	Present	Present	Present
S Sibisi	Apology	Apology	Present	Present	Present	n/a	n/a
M Motuku	n/a	n/a	n/a	n/a	n/a	Present	n/a
T Dlamini	n/a	n/a	n/a	n/a	n/a	n/a	Present
G Badela	Present	Present	Apology	Apology	Present	Present	Present
P Baleni	Present	Present	Apology	Present	Apology	Present	Apology
P Goyns	Present	Apology	Present	Present	Present	Present	Present
A Llobell	Present	Apology	Apology	Present	Apology	Present	Present
R Masango	Present	Present	Present	Present	Present	Present	Present
M Maseko	Present	Apology	Present	Apology	Present	Present	Present
J Netshitenzhe	Present	Present	Present	Present	Present	Apology	Present
A Noah	Present	Apology	Present	Apology	Apology	Present	Apology
M Phakeng	Apology	Present	Present	Present	Present	Present	Present

* Special Board meeting held

Board strategic session held from 26 to 27 October 2016

Board members	Attendance
T Majozi (Chair)	Present
S Sibisi	n/a
M Motuku	Present
T Dlamini	n/a
G Badela	Present
P Baleni	Present
P Goyns	Present
R Heydenrich*	Apology
A Llobell	Present
R Masango	Present
M Maseko	Present
T Mtshali*	Present
J Netshitenzhe	Present
A Noah	Apology
M Phakeng	Present

* Co-opted member of the RD&I committee. Board attendance by invitation.

Board and committee meeting attendance (1 April 2016 to 31 March 2017)

Audit and Risk Committee meetings

Committee members	27/06/16	10/11/16	07/02/17
A Noah (Chair)	Present	Present	Present
G Badela	Apology	Present	Present
P Baleni	Present	Present	Apology
M Maseko	Present	Present	Apology

The meeting scheduled for 6 September 2016 was cancelled.

Human Resources and Remuneration Committee meetings

Committee members	23/06/16	06/09/16	07/02/17
G Badela (Chair)	Apology	Present	Present
P Baleni	Present	Apology	Apology
P Goyns	Present (Acting chair)	Present	Present
M Phakeng	Present	Apology	Present

Research, Development and Innovation Committee meetings

Committee members	09/06/16	01/09/16	03/11/16	02/02/17
M Phakeng (Chair)	Apology	Present	Present	Present
P Goyns	Present	Present	Present	Present
R Heydenrich	n/a	n/a	Present	Apology
A Llobell	Present (Acting chair)	Apology	Apology	Apology
R Masango	Present	Present	Present	Apology
T Mtshali	n/a	n/a	Present	Present
J Netshitenzhe	Present	Present	Present	Present

Committee meetings are open to all Board members.

Report of the Audit and Risk Committee for the year ended 31 March 2017

The committee is pleased to present its report for the financial year ended on 31 March 2017.

The committee's responsibility

The committee has adopted formal Terms of Reference approved by the Board. Accordingly, the committee has conducted its affairs in compliance with its Terms of Reference and has discharged its responsibilities contained therein.

Committee members and attendance

The committee consists of the members as stated on page 117 of this report. The committee met on 27 June 2016, 10 November 2016 and 7 February 2017. The schedule of attendance is shown on page 119 of this report.

The effectiveness of internal control

The system of internal control applied by the CSIR over financial risk management is effective, efficient and transparent. In line with the PFMA and the code of best practice, the internal audit provides the committee and management with assurance that the internal controls are appropriate and effective. This is achieved by means of the risk management process, as well as the identification of mitigating measures and on-going assessment thereof.

From the quarterly reports of the internal audit, the audit report on the annual financial statements and the management report of the Auditor-General of South Africa, it was noted that no matters were reported that include any material deficiencies in the system of internal control or any deviations therefrom. Accordingly, the committee can report that the system of risk management and internal control over financial reporting for the period under review was efficient and effective.

Internal audit

The Group has an internal audit function that has a direct line of reporting to the committee. Its charter and audit plans are approved by the committee to ensure it operates independently. The committee is satisfied that the internal audit function is operating effectively and has addressed the risks pertinent to the CSIR through its audits.

Risk management

The committee is satisfied that the CSIR has a risk management process focused on identifying, assessing, managing and monitoring significant risks across all operations and Group companies. This has been in place for the year under review and up to the date of approval of the annual financial statements.

Evaluation of financial statements

The committee has evaluated the annual financial statements of the CSIR Group for the year ended on 31 March 2017, and based on the information provided, the committee considers that it complies, in all material respects, with the requirements of the various acts governing disclosure and reporting on the annual financial statements.

The committee concurs with the Executive Management that the adoption of the going concern premise in the preparation of the annual financial statements is appropriate. Therefore, the committee has, at its meeting on 26 June 2017, recommended the adoption of the annual financial statements by the CSIR Board.

Ayanda Noah
Chairperson of the Audit and Risk Committee
26 June 2017

Report of the Auditor-General for the year ended 31 March 2017

Report of the Auditor-General to Parliament on the Council for Scientific and Industrial Research

Report on the audit of the consolidated and separate financial statements

Opinion

I have audited the consolidated and separate financial statements of the Council for Scientific and Industrial Research and its subsidiaries (the Group) set out on pages 136 to 177, which comprise the consolidated and separate statements of financial position as at 31 March 2017 and the consolidated and separate statements of profit or loss and other comprehensive income, statements of changes in equity and statements of cash flows for the year then ended, as well as the notes to the consolidated and separate financial statements, including a summary of significant accounting policies.

In my opinion, the consolidated and separate financial statements present fairly, in all material respects, the consolidated and separate financial position of the Group as at 31 March 2017, and their financial performance and cash flows for the year then ended in accordance with International Financial Reporting Standards (IFRS) and the requirements of the Public Finance Management Act of South Africa, 1999 (Act No. 1 of 1999) (PFMA).

Basis for opinion

I conducted my audit in accordance with the International Standards on Auditing (ISAs). My responsibilities under those standards are further described in the Auditor-General's responsibilities for the audit of the consolidated and separate financial statements section of my report.

I am independent of the Group in accordance with the International Ethics Standards Board for Accountants' Code of ethics for professional accountants (IESBA code) together with the ethical requirements that are relevant to my audit in South Africa. I have fulfilled my other ethical responsibilities in accordance with these requirements and the IESBA code.

I believe that the audit evidence I have obtained is sufficient and appropriate to provide a basis for my opinion.

Responsibilities of the accounting authority for the financial statements

The Board of Directors, which constitutes the accounting authority is responsible for the preparation and fair presentation of the consolidated and separate financial statements in accordance with IFRS and the requirements of the PFMA and for such internal control as the accounting authority determines is necessary to enable the preparation of consolidated and separate financial statements that are free from material misstatement, whether due to fraud or error.

In preparing the financial statements, the accounting authority is responsible for assessing the entity's ability to continue as a going concern, disclosing, as applicable, matters relating to going concern and using the going concern basis of accounting unless there is an intention to either liquidate the entity or to cease operations, or there is no realistic alternative but to do so.

Auditor-General's responsibilities for the audit of the consolidated and separate financial statements

My objectives are to obtain reasonable assurance about whether the consolidated and separate financial statements as a whole are free from material misstatement, whether due to fraud or error, and to issue an auditor's report that includes my opinion. Reasonable assurance is a high level of assurance, but is not a guarantee that an audit conducted in accordance with ISAs will always detect a material misstatement when it exists. Misstatements can arise from fraud or error and are considered material if, individually or in the aggregate, they could reasonably be expected to influence the economic decisions of users taken on the basis of these consolidated and separate financial statements.

A further description of my responsibilities for the audit of the consolidated and separate financial statements is included in the annexure to the auditor's report.

Report on the audit of the annual performance report

Introduction and scope

In accordance with the Public Audit Act of South Africa, 2004 (Act No. 25 of 2004) (PAA) and the general notice issued in terms

Report of the Auditor-General for the year ended 31 March 2017

thereof I have a responsibility to report material findings on the reported performance information against predetermined objectives for selected objectives presented in the annual performance report. I performed procedures to identify findings but not to gather evidence to express assurance.

My procedures address the reported performance information, which must be based on the approved performance planning documents of the entity. I have not evaluated the completeness and appropriateness of the performance indicators included in the planning documents. My procedures also did not extend to any disclosures or assertions relating to planned performance strategies and information in respect of future periods that may be included as part of the reported performance information. Accordingly, my findings do not extend to these matters.

I evaluated the usefulness and reliability of the reported performance information in accordance with the criteria developed from the performance management and reporting framework, as defined in the general notice, for the following selected objectives presented in the annual performance report of the entity for the year ended 31 March 2017:

Objectives	Pages in the annual performance report
Objective 1 – Scientific and technical	129
Objective 2 – Learning and growth	130

I performed procedures to determine whether the reported performance information was properly presented and whether performance was consistent with the approved performance planning documents. I performed further procedures to determine whether the indicators and related targets were measurable and relevant, and assessed the reliability of the reported performance information to determine whether it was valid, accurate and complete.

I did not identify any material findings on the usefulness and reliability of the reported performance information for the following objectives:

- Scientific and technical
- Learning and growth

Other matter

I draw attention to the matter below:

Achievement of planned targets

Refer to the annual performance report on pages 129 to 130 for information on the achievement of planned targets for the year and explanations provided for the under/overachievement of a number of targets.

Report on audit of compliance with legislation

Introduction and scope

In accordance with the PAA and the general notice issued in terms thereof I have a responsibility to report material findings on the compliance of the entity with specific matters in key legislation. I performed procedures to identify findings but not to gather evidence to express assurance.

I did not identify any instances of material non-compliance with selected specific requirements of applicable legislation, as set out in the general notice issued in terms of the PAA.

Other information

The entity's accounting authority is responsible for the other information. The other information does not include the consolidated and separate financial statements, the auditor's report thereon and those selected objectives presented in the annual performance report that have been specifically reported on in the auditor's report.

My opinion on the financial statements and findings on the reported performance information and compliance with legislation do not cover the other information and I do not express an audit opinion or any form of assurance conclusion thereon.

In connection with my audit, my responsibility is to read the other information and, in doing so, consider whether the other information is materially inconsistent with the consolidated and separate financial statements and the selected objectives presented in the annual performance report, or my knowledge obtained in the audit, or otherwise appears to be materially misstated. If, based on the work I have performed on the other information obtained prior to the date of this auditor's report, I conclude that there is a material misstatement of

Report of the Auditor-General for the year ended 31 March 2017

this other information, I am required to report that fact. I have nothing to report in this regard.

Internal control deficiencies

I considered internal control relevant to my audit of the consolidated and separate financial statements, reported performance information and compliance with applicable legislation; however, my objective was not to express any form of assurance thereon. I did not identify any significant deficiencies in internal control.

Auditor-General

Pretoria
29 July 2017

AUDITOR-GENERAL
SOUTH AFRICA

Auditing to build public confidence

Annexure – Auditor-General's responsibility for the audit

As part of an audit in accordance with the ISAs, I exercise professional judgement and maintain professional scepticism throughout my audit of the consolidated and separate financial statements, and the procedures performed on reported performance information for selected objectives and on the entity's compliance with respect to the selected subject matters.

Financial statements

In addition to my responsibility for the audit of the consolidated and separate financial statements as described in the auditor's report, I also:

- Identify and assess the risks of material misstatement of the consolidated and separate financial statements whether due to fraud or error, design and perform audit procedures responsive to those risks, and obtain audit evidence that is sufficient and appropriate to provide a basis for my opinion. The risk of not detecting a material misstatement resulting from fraud is higher than for one resulting from error, as fraud may involve collusion, forgery, intentional omissions, misrepresentations, or the override of internal control.
- Obtain an understanding of internal control relevant to the audit in order to design audit procedures that are appropriate in the circumstances, but not for the purpose of expressing an opinion on the effectiveness of the entity's internal control.
- Evaluate the appropriateness of accounting policies used and the reasonableness of accounting estimates and related disclosures made by the Board of Directors, which constitutes the accounting authority.
- Conclude on the appropriateness of the Board of Directors, which constitutes the accounting authority entity's use of the going concern basis of accounting in the preparation of the financial statements. I also conclude, based on the audit evidence obtained, whether a material uncertainty exists related to events or conditions that may cast significant doubt on the entity's and its subsidiaries ability to continue as a going concern. If I conclude that a material uncertainty exists, I am required to draw attention in my auditor's report to the related disclosures in the financial statements about the material uncertainty or, if such disclosures are inadequate, to modify the opinion on the financial statements. My conclusions are based on the information available to me at the date of the auditor's report. However, future events or conditions may cause an entity to cease to continue as a going concern.
- Evaluate the overall presentation, structure and content of the financial statements, including the disclosures, and whether the financial statements represent the underlying transactions and events in a manner that achieves fair presentation.
- Obtain sufficient appropriate audit evidence regarding the financial information of the entities or business activities within the Group to express an opinion on the consolidated financial statements. I am responsible for the direction, supervision and performance of the Group audit. I remain solely responsible for my audit opinion.

Communication with those charged with governance

I communicate with the accounting authority regarding, among other matters, the planned scope and timing of the audit and significant audit findings, including any significant deficiencies in internal control that I identify during my audit.

I also confirm to the accounting authority that I have complied with relevant ethical requirements regarding independence, and communicate all relationships and other matters that may reasonably be thought to have a bearing on my independence and where applicable, related safeguards.

EXECUTIVE REPORT

Executive report

INTRODUCTION

On behalf of the CSIR Board, we take pleasure in submitting to Parliament, through the Minister of Science and Technology, our Annual Report and the audited annual financial statements of the CSIR Group for the financial year ended 31 March 2017.

In the opinion of the CSIR Board, the financial statements fairly present the financial position of the CSIR Group as at 31 March 2017 and the results of its operations for that year.

Statutory basis

As a statutory research council established by government, the CSIR is governed by the Scientific Research Council Act, 1988 (Act 46 of 1988). The organisation is listed as a Public Business Enterprise in terms of the Public Finance Management Act (PFMA), 1999 (Act 1 of 1999).

The CSIR mandate

The CSIR's mandate is as stipulated in the Scientific Research Council Act, 1988 (Act 46 of 1988):

The objects of the CSIR are, through directed and particularly multidisciplinary research and technological innovation, to foster, in the national interest and in fields which in its opinion should receive preference, industrial and scientific development, either by itself or in co-operation with principals from the private or public sectors, and thereby to contribute to the improvement of the quality of life of the people of the Republic, and to perform any other functions that may be assigned to the CSIR by or under this Act.

– Extract from Scientific Research Council Act 46 of 1988

The existence of a vibrant economy and a capable state is a pre-requisite for any sustainable solution to South Africa's developmental priorities. The work of the CSIR is therefore aimed at supporting industrial development as well as enhancing the capabilities of government in the areas of service delivery, policy development and information management.

Scientific Research and Development (R&D) will play a critical role in supporting the short-, medium- and long-term growth of the economy. In the short term we need to develop and deploy technologies that improve the efficiency and competitiveness of our existing enterprises; while in the medium to long term we need to develop the industries and sectors (based for example on the use of new technologies or the beneficiation of local resources) that will grow the economy, as well as understanding and mitigating the risks to long-term growth due to climate change and the mismanagement of our natural resources.

While sustained economic growth will almost certainly address the issues of unemployment and poverty, dealing with the threat of inequality will require a strong and capable state. The CSIR sees its role as providing the scientific and technological innovations that will improve the ability of the state to efficiently deliver basic services (such as health, education, social security, access to energy and shelter) to all South Africans, hence combating material inequality, as well as the inequality of access to basic services remains crucial.

Income sources

The CSIR is funded through a combination of baseline and ring-fenced grants from the Department of Science and Technology (DST) (our Parliamentary Grant), and earns contract research and development income from both the public and private sectors; locally and internationally.

Grant funding is invested in research programmes, research infrastructure as well as in R&D skills development. There are a number of policies and guidelines that underpin the effective utilisation of grant funding.

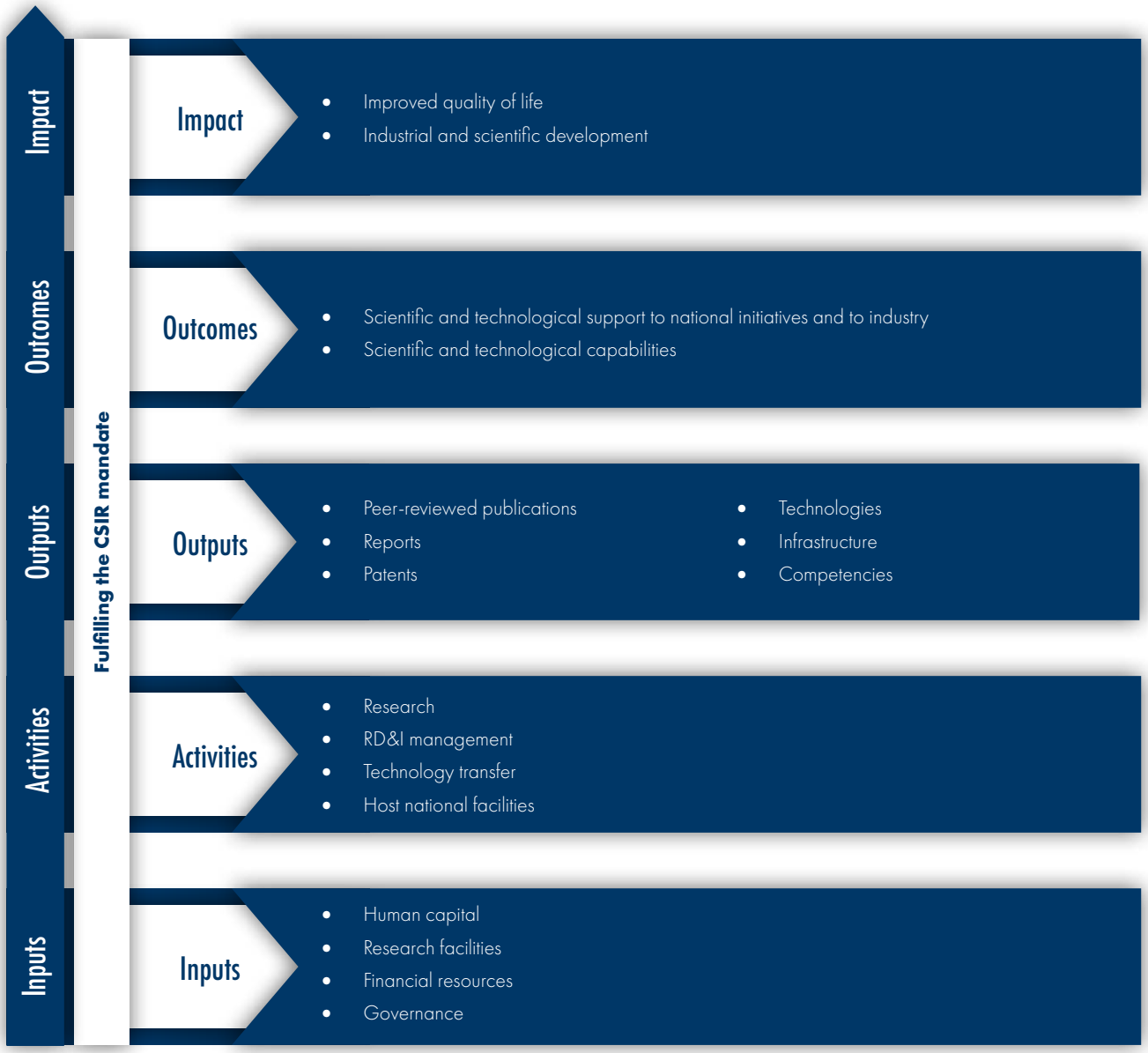
Executive report

Strategic overview

The CSIR is mandated to contribute to the improved quality of life of people in South Africa. Meeting this mandate requires that the CSIR responds to the triple challenge of unemployment, inequality and poverty that faces South Africa. The national government intends to address these challenges through a broad range of programmes, guided by the National Development Plan (NDP) and further articulated through Government's Programme of Action (including the 9-Point Plan and sector-specific initiatives).

The CSIR's strategy is structured around a framework aligning organisational inputs, activities and outputs with this role and the mandate (Figure 1). The CSIR's role is further defined by organisational competences and capabilities, reinforced through an effective network of local and international research partnerships.

Figure 1: *The CSIR framework for fulfilling its mandate*



Executive report

The CSIR Strategic Framework sets out the logical steps through which we take our inputs (people, processes and facilities) and undertake a set of activities (research and research management) to produce outputs (academic publications, reports and technologies). These outputs will then lead to a series of outcomes (scientific and technological development) that will ultimately result in an improved quality of life for all South Africans.

The CSIR has set the following three high-level strategic objectives in order to meet its mandate:

Strategic objective 1: Conduct high-quality and relevant research and technological innovation to foster industrial and scientific development.
This strategic objective is achieved through the selection and implementation of a range of R&D programmes.

Strategic objective 2: Build and transform human capital.
The CSIR's scientific and technical contributions are only possible through the skills and capabilities of our scientific staff (which we refer to as our Science, Engineering and Technology (SET) base). The ongoing development, renewal and transformation of the SET base is therefore of critical importance for the organisation. In addition, the CSIR is an important part of the national system of innovation, and through the development and training of our scientific base contributes to the national imperative to develop human capital and to the ongoing transformation of our society.

Strategic objective 3: Maintain a sustainable and well-governed organisation.
Without a financially sustainable and well-governed organisation our ability to, over the long term, contribute to national development through our scientific and technological work would be severely compromised. The CSIR is therefore committed to maintaining our record of good governance and to continue to operate in a sustainable manner.

The CSIR's R&D programme speaks to seven of the 11 focus areas identified in the NDP:

- Economy and employment
- Building a capable state
- Economic and social infrastructure
- Transition to a low-carbon economy
- Building safer communities
- Improving health
- Transforming human settlements

Economy and employment

The CSIR is well-positioned to play a significant role in the national effort at re-industrialisation through a range of key capabilities that are aligned to national priorities, ranging from the beneficiation of strategic minerals, through to the aerospace and defence sectors. The CSIR's responses range from the immediate (improving the efficiency of production processes, supporting local economic development through localisation programmes and so forth) to the medium-term (the development of automation solutions for industrial processes, technologies for the beneficiation of local mineral resources, nano-manufacturing and agro-processing technologies) as well as interventions that may only pay off in the longer term (the development of large-scale engineering capabilities, industries based on bio-therapeutic manufacture and the development of enterprises using digital media technologies).

Building a capable state

Our interventions in this area have focused on service delivery and its associated issues. The main problems we are attempting to address are:

- A lack of organisational capacity to support service delivery. This lack of capacity may take various forms, including the absence of co-ordinating or implementing agencies, or the shortage of specific technical or programme management skills.
- The absence of an integrated decision support capability at all levels of government responsible for service delivery. This absence may lead to poor decisions with respect to the planning in service delivery interventions.
- The poor diffusion/uptake of potential technology-based service-delivery solutions. There are instances where potentially appropriate and effective technical solutions to service delivery problems have been developed by CSIR but are not being implemented.

Executive report

Economic and social infrastructure

To achieve sustainable and inclusive growth by 2030, South Africa needs to invest in a strong network of economic infrastructure designed to support the country's medium- and long-term objectives. There is a clear need to maintain and upgrade our existing infrastructure, and to develop the technologies that will form the basis for the infrastructure of the future. South Africa's economic growth and its ability to provide basic services to its people will be undermined if there is no concerted effort to maintain and re-build our transport, water, energy and Information and Communication Technology (ICT) infrastructure.

Our interventions in support of economic and social infrastructure take two forms - the development of policies and the design of technological solutions.

Transition to a low-carbon economy

Our long-term goal is to support South Africa's transition to a low-carbon and resilient economy. The CSIR is working on improving the measurement and management of our natural resources, our ability to understand the long-term effects of climate change, therefore, assisting the government with the formulation of mitigation and adaptation strategies. The CSIR is also supporting the development of a green economy and the development of renewable energy technologies and their integration into the national energy system.

Building safer communities

The CSIR interventions focus on supporting the acquisition and integration of technology by our security forces, the development of systems for the effective sharing of information across different components of the security forces, the continuous improvement of South African Air Force air capability, the protection of air and naval assets against guided weapons, the support of specialised, highly mobile and combat-ready forces, the development of national surveillance capabilities, and protection against cyber-security threats.

Improving health

The CSIR's work in support of health ranges from technical support to the National Health Insurance initiative (particularly with respect to the security, use and transfer of health-related data), the development of interconnected and inter-operable point-of-care devices, the use of technology in support of diagnostic functions, the development of vaccines using biotherapeutic manufacturing methods, and the development of new methods to understand, manage and diagnose disease mechanisms at the cellular and molecular level.

Transforming human settlements

The CSIR is supporting metropolitan areas and municipalities with spatial planning, the management of infrastructure and the long-term transition to greener and smarter economies.

Fast-growing cities are not performing optimally, often due to ineffective spatial layout and management. In addition, there is a lack of capability and tools in government as well as evidence-based decision-making support, resulting in poor planning, design and management, decision making and spatial prioritisation of interventions (i.e. housing, infrastructure investment, risk mitigation, social support, economic development interventions, and so forth). A major need exists to timeously plan and prioritise infrastructure investment with an understanding of impact on development priorities and long-term implications. In addition, the performance of the built environment system in South Africa is suboptimal due to a number of factors including the legacy of apartheid.

The R&D work of the CSIR is supported by a number of enabling conditions and processes. These include support for technology transfer, strategic partnerships with state-owned entities, developmental agencies, the private sector and other research and technology organisations.

Executive report

OVERVIEW OF 2016/17 PERFORMANCE

Key performance indicators and performance reporting

The CSIR enters into a Shareholder's Compact agreement with the DST on an annual basis. The Compact contains both a long-term strategic plan and a detailed operational plan with specific Key Performance Indicators (KPIs). Setting of KPI targets is supported by ongoing benchmarking against similar research organisations and trend analysis. Quarterly reports to the DST are the main forms by which the performance against these indicators is monitored.

The CSIR's KPIs provide a high-level basket of measures that reflect the strategic objectives of the organisation. These strategic objectives can be summarised as follows:

1. **Scientific and technical:** These KPIs are a measure of the extent to which we conduct research and technological innovation to foster industrial and scientific development. The KPIs that are linked to this strategic objective measure the annual aggregated outputs that are produced by these research programmes. These are research publications, patents, technology demonstrators, the income earned from R&D performed on behalf of other parties and the income earned from royalties or the licensing of CSIR technologies.

2. **Learning and growth:** These KPIs measure the extent to which we are able to build and transform human capital. The CSIR's scientific and technical contributions are only possible through the skills and capabilities of our scientific staff (our science, engineering and technology (SET) base). Therefore, the ongoing development, renewal and transformation of the SET base is of critical importance for the organisation. The KPIs that are linked to this strategic objective include the overall size of the SET base, the number and percentage of that base with doctoral level qualifications and the number and percentage of the SET base that are black and female South Africans respectively.

3. **Finance and governance:** Without a well-run and financially sustainable organisation, our ability to contribute to national development through our scientific and technological work would be severely compromised. The KPIs linked to this strategic objective include the total income earned by the organisation and the net profit that we are able to generate, the level of investment we make to maintain our infrastructure, our Broad-Based Black Economic Empowerment (B-BBEE) status and our safety record.

Once again, the organisation has delivered high-quality scientific outputs while growing and transforming our scientific base, as well as maintaining our already high standards regarding financial and corporate governance.

Scientific and technical

The CSIR has met or exceeded the annual targets for each of the six indicators in this category.

Table 1: *CSIR performance: scientific and technical*

Indicator	2016/17 Target	2016/17 Actual
Publication equivalents	≥490	491
Journal articles	≥300	286
New technology demonstrators	≥30	56
New patents granted	≥15	15
Contract income	≥R1 914m	R1 952m
Royalty and licence income	≥R2.9m	R5.4m

The CSIR continues to place emphasis on the quality and quantity of our research outputs in the form of peer-reviewed publications (journal articles and conference papers), technology demonstrators and patents. The CSIR produced 491 publication equivalents (including 286 journal articles) meeting our target of 490 publication equivalents. The number of journal articles is within the 5% allowable variation for this indicator.

Technology demonstrators are a lead indicator of technology transfer and the excellent performance in exceeding this target further illustrates the greater efforts the CSIR is making in this area. Contract income amounting to R1 952 million exceeded the budget by R38 million. Income from royalties and licensing amounted to R5.4 million, R2.5 million greater than our target of R2.9 million.

Executive report

Learning and growth

The CSIR has met or exceeded the annual targets for three of the seven indicators in this category, and has missed the targets for the number of SET staff, the number of black SET staff, the number of female SET staff, and the number of SET staff with PhDs.

Table 2: *CSIR performance: learning and growth*

Indicator	2016/17 Target	2016/17 Actual
Total size of SET base	2 100	1 966
Number of black South Africans in SET base	1 260	1 190
% of SET base who are black South Africans	≥60	61
Number of female South Africans in SET base	755	702
% of SET base who are female South Africans	≥37	36
Number of SET base with Doctorates	375	351
% of SET base with Doctorates	≥18	18

At the end of the 2016/17 financial year the CSIR employed 1 966 SET staff (the comparative 2015/16 figure is 1 969 staff) missing our target of 2 100 SET staff by 134 (6.4%). This exceeds the 5% variation allowed for in the definition of this indicator.

The CSIR took a conservative stance with regards to increasing its employee fixed costs through the appointment of additional staff to the SET base. This was informed by poor prevailing macro-economic conditions and the late securing of contract income during the 2016/17 financial year. Furthermore, the CSIR is facing increasing competition for scarce technical skills (and particularly at PhD level) in South Africa, particularly from both local and international Higher Education Institutions, making it harder to both attract and retain SET staff with specialised skills. This is evident with the staff turnover of the SET base of 9.8% which required the recruitment of 192 additional staff to maintain the current size of the SET base.

During the financial year, the CSIR also transferred SET staff to the purchaser of the CSIR Food & Beverage Laboratories who acquired the operations as a going concern.

The lack of growth in SET staff in turn negatively affected our ability to meet our numerical targets for the number of black and female South African SET staff, as well as for the number of SET staff with PhDs. In spite of these challenges the CSIR increased the number of black and female South African SET staff (from 1 164 to 1 190 for black South Africans, and from 692 to 702 for female South Africans), and also increased the number of SET staff with PhDs (from 345 to 351).

Financial and governance

The CSIR met or exceeded its targets for four of the five indicators in this category. The only indicator for which the target was not achieved was that of our B-BBEE status, which stood at Level 3 against a target Level 2. The target was missed due to the impact the new codes have had on the B-BBEE status of our suppliers and challenges in meeting the CSIR's employment equity targets.

Table 3: *CSIR performance: financial and governance*

Indicator	2016/17 Target	2016/17 Actual
Total income	≥ R2 611m	R2 712m
Investment in property, plant and equipment	≥R103m	R144m
Net profit	≥ R58m	R95.5m
B-BBEE rating	Level 2 contributor	Level 3 contributor
Disabling injury frequency rate	< 0.3	0

The CSIR continued to demonstrate its financial sustainability despite the current difficult economic climate. The solid performance in achieving corporate governance and citizenship targets was maintained.

HUMAN RESOURCES OVERVIEW

At the end of the 2016/17 financial year, the CSIR had a staff complement of 2 740 employees[1]. Table 4 gives the distribution of employees across the different occupational levels.

1 Employees include permanent and contract employees and excludes vacation students

Executive report

Table 4: *CSIR employees by occupational level: March 2017*

Occupational level	Total
A. Top	12
B. Senior	103
C. Professional	1 238
D. Skilled	1 042
E. Semi-skilled	325
F. Unskilled	20
Total	**2 740**

The majority (83%) of CSIR employees are employed in the Professional and Skilled categories. The CSIR is committed to the demographic transformation of its workforce. The composition of our workforce by gender, race and nationality is given in Table 5.

Approximately 5% (146 employees) of our workforce are non-South Africans, with the majority being employed as technical professionals. Black South Africans account for 66% (1 814 employees) of all employees, with black male South Africans accounting for 34% and black female South Africans accounting for 32% of all employees.

Table 5: *CSIR employee demographics by gender, race and nationality: March 2017*

Occupational level	Male					Female				
	A	C	I	W	N-SA	A	C	I	W	N-SA
A. Top	4	0	0	3	1	1	1	0	0	2
B. Senior	21	5	13	34	10	6	1	2	10	1
C. Professional	224	32	71	376	89	148	20	49	198	31
D. Skilled	326	16	39	47	4	430	28	40	104	8
E. Semi-skilled	143	14	2	0	0	133	22	3	8	0
F. Unskilled	15	3	0	0	0	2	0	0	0	0
Total	**733**	**70**	**125**	**460**	**104**	**720**	**72**	**94**	**320**	**42**

A=African, C=Coloured, I=Indian, W=White, N-SA=Non South-African

Staff qualification profile

Three-hundred and fifty-nine (359) CSIR employees have a doctoral qualification[2] and 637 employees have masters-level qualifications. In 2015/16 the corresponding values were 355 and 594 respectively.

Table 6 shows the distribution of these qualifications by some key demographic groups. The proportion of doctorates that are black or female South Africans is relatively low (34% and 24% respectively) and the CSIR is committed to the long-term efforts needed to improve this situation. The corresponding figures for masters-level qualification are more positive – 40% of employees at this level are female South Africans, and 53% are black South Africans (the comparative 2015/16 figures are 37% and 52% respectively).

Table 6: *CSIR staff qualification: March 2017*

Qualification	Doctorate	Masters	Masters/ Doctorate
Total	**359**	**637**	**996**
SA female	87	254	341
% of all	24%	40%	34%
SA male	192	338	530
% of all	53%	53%	53%
SA black	122	343	465
% of all	34%	53%	47%

Ongoing qualifications

The CSIR is committed to supporting the academic development and transformation of its staff. Table 7 shows the number and distribution

2 This is higher than the 351 reported in Table 2 since that statistic refers only to SET staff.

Executive report

of staff studying for higher (doctoral or masters) degrees. At the end of the 2016/17 financial year 438 employees were enrolled for higher degrees (2015/16: 416) – 48% of these were female South Africans (2015/16: 46%) and 72% were black South Africans (2015/16: 65%).

Table 7: *CSIR staff studying for higher degrees: 2017*

Staff enrolled for	Doctorate	Masters	Masters/ Doctorate
Total	189	249	438
SA female	98	112	210
% of all enrolled	52%	45%	48%
SA male	85	133	218
% of all enrolled	45%	53%	50%
SA black	125	189	314
% of all enrolled	66%	76%	72%

FINANCIAL PERFORMANCE OVERVIEW

The CSIR remains financially sustainable and has exceeded its financial targets.

The total operating income of the CSIR amounted to R2.71 billion (2015/16: R2.70 billion). The Parliamentary Grant recognised as income in 2016/17 amounted to R714.1 million, an increase of 4.9% from the prior year amount of R680.5 million.

The CSIR's total contract income amounted to R1.95 billion (2015/16: R1.97 billion). This includes a R70.9 million (2015/16: R68.1 million) ring-fenced allocation from the DST. Significant investments were made in grant funded property, plant and equipment in the 2015/16 financial year. The revenue for these investments is included in the CSIR's contract income. The growth in contract income, excluding the revenue for investments in grant funded property, plant and equipment of R71.8 million (2015/16: R207.5 million), amounts to 6.9%.

The continued investment in scientific infrastructure and equipment remains a priority to ensure that world-class facilities and equipment are acquired and maintained. Over the past five financial years R926.3 million has been invested in property, plant and equipment with R143.8 million invested in the 2016/17 financial year.

The net profit of the CSIR amounts to R95.5 million (2015/16: R59.2 million). The profit for the 2016/17 financial year includes the profit on the sale of the CSIR Port Elizabeth site to Nelson Mandela Metropolitan University. These funds will be retained as part of the CSIR reserves to be invested in scientific equipment and infrastructure.

The cash and cash equivalent holdings of the CSIR stood at R1.1 billion (2015/16: R1.0 billion). The current ratio is marginally higher than the previous financial year at 1.2 (2015/16: 1.1).

Executive report

Five-year review of income and expense indicators

	2017 R'000	2016 R'000	2015 R'000	2014 R'000	2013 R'000
Total income	**2 755 665**	**2 736 550**	**2 442 590**	**2 202 595**	**2 069 221**
Parliamentary Grant recognised as income	714 105	680 485	675 340	618 849	594 478
Contract income, royalty income, other income and net finance income	**2 041 560**	**2 056 065**	**1 767 250**	**1 583 746**	**1 474 743**
Local private and international sectors	348 462	320 950	348 388	361 353	361 018
Local public sector	1 603 485	1 645 798	1 331 042	1 134 470	1 027 998
Royalties and other income	45 996	49 347	30 202	38 766	39 351
Net finance income	43 617	39 970	57 618	49 157	46 376
Total expenditure	**2 661 057**	**2 677 568**	**2 390 203**	**2 151 664**	**2 020 769**
Employees' remuneration	1 487 899	1 468 155	1 339 345	1 229 566	1 108 202
Operating expenses	1 111 414	1 154 910	1 002 234	874 885	867 680
Depreciation	61 744	54 503	48 624	47 213	44 887

Five-year ratio analysis

	2017	2016	2015	2014	2013
Operating expenses					
Remuneration as a percentage of total income (excluding finance income)	54.9%	54.4%	56.2%	57.1%	54.8%
Remuneration as percentage of total operating expenditure	55.9%	54.8%	56.0%	57.1%	54.8%
Asset management					
Investment in property, plant and equipment (Rm)	143.8	308.0	209.7	134.7	130.1
Investment in property, plant and equipment as a percentage of revenue	5.4%	11.6%	8.9%	6.3%	6.5%
Net asset turn	2.7	2.9	2.8	2.7	3.2
Current ratio	1.2	1.1	1.1	1.1	1.1
Cash flow					
Net cash from operating activities (R'000)	96 642	138 869	41 407	137 626	130 385
Cash and cash equivalents at end of year (including long-term fixed deposits) (R'000)	1 099 124	1 005 241	975 952	1 043 427	983 511

Definitions

Net asset turn: Total revenue (including finance income) divided by net assets
Current ratio: Current assets divided by current liabilities

The post-retirement medical benefit expense and liability and the effects of the adoption of IFRS, IAS39: financial instruments – recognition and measurement have been excluded for the comparison of financial indicators.

ANNUAL FINANCIAL STATEMENTS

STATEMENTS OF

Profit or loss and other comprehensive income

FOR THE YEAR ENDED 31 MARCH 2017

	Notes	GROUP 2017 R'000	GROUP 2016 R'000	CSIR 2017 R'000	CSIR 2016 R'000
Revenue	2	**2 671 355**	2 650 741	**2 671 497**	2 652 482
Other income		**40 559**	45 961	**40 551**	44 098
Total operating income		**2 711 914**	2 696 702	**2 712 048**	2 696 580
Expenditure					
Employees' remuneration		**1 487 899**	1 468 201	**1 487 899**	1 468 155
Depreciation	6	**61 745**	54 514	**61 744**	54 503
Operating expenses		**1 109 944**	1 163 854	**1 111 414**	1 154 910
Total operating expenditure		**2 659 588**	2 686 569	**2 661 057**	2 677 568
Finance income	4	**53 166**	48 781	**52 578**	48 341
Finance expense	4	**(8 961)**	(8 371)	**(8 961)**	(8 371)
Share of (loss)/profit of joint ventures and associates	8	**(1 833)**	2 193	**-**	-
Profit before income tax	3	**94 698**	52 736	**94 608**	58 982
Income tax expense	5	**(41)**	(1 554)	**-**	-
Profit for the year		**94 657**	51 182	**94 608**	58 982
Other comprehensive income					
Not subsequently reclassified to profit or loss:					
Remeasurement of post-retirement medical benefit obligation	17.3	**926**	704	**926**	704
May be subsequently reclassified to profit or loss:					
Change in value of available-for-sale financial asset	10	**-**	(526)	**-**	(526)
Other comprehensive income for the year		**926**	178	**926**	178
Total comprehensive income for the year		**95 583**	51 360	**95 534**	59 160
Profit attributable to:					
Stakeholders of the parent		**94 657**	51 182	**94 608**	58 982
Total comprehensive income attributable to:					
Stakeholders of the parent		**95 583**	51 360	**95 534**	59 160

STATEMENTS OF

Financial position

AS AT 31 MARCH 2017

	Notes	GROUP 2017 R'000	GROUP 2016 R'000	CSIR 2017 R'000	CSIR 2016 R'000
ASSETS					
Non-current assets		**789 219**	763 102	**794 654**	777 379
Property, plant and equipment	6	**762 908**	753 737	**762 907**	753 725
Interest in joint ventures and associates	8	**20 216**	1 438	**20 216**	1 424
Interest in subsidiaries	9	**-**	-	**5 436**	16 053
Available-for-sale financial asset	10	**-**	6 177	**-**	6 177
Trade and other receivables	11	**6 095**	1 750	**6 095**	-
Current assets		**1 482 866**	1 397 100	**1 475 465**	1 381 123
Trade and other receivables	11	**275 828**	250 705	**275 777**	242 366
Inventory and contracts in progress	12	**100 564**	105 966	**100 564**	105 966
Cash and cash equivalents	23	**1 106 474**	1 012 879	**1 099 124**	1 005 241
Non-current assets held for sale	7	**-**	27 550	**-**	27 550
TOTAL ASSETS		**2 272 085**	2 160 202	**2 270 119**	2 158 502
EQUITY AND LIABILITIES					
Reserves		**1 026 090**	930 507	**1 024 166**	928 632
Retained earnings		**1 026 090**	930 507	**1 024 166**	928 632
Non-current liabilities		**10 764**	10 695	**10 764**	10 695
Post-retirement medical benefits	17.3	**10 764**	10 695	**10 764**	10 695
Current liabilities		**1 235 231**	1 219 000	**1 235 189**	1 219 175
Advances received	14	**786 620**	800 202	**786 620**	800 202
Trade and other payables	15	**448 611**	418 798	**448 569**	418 973
TOTAL EQUITY AND LIABILITIES		**2 272 085**	2 160 202	**2 270 119**	2 158 502

STATEMENTS OF

Changes in equity

FOR THE YEAR ENDED 31 MARCH 2017

	Retained earnings	Total
	R'000	R'000
GROUP		
Balance at 31 March 2015	879 147	**879 147**
Total comprehensive income	51 360	**51 360**
Profit for the year	51 182	**51 182**
Other comprehensive income for the year:		
Remeasurement of post-retirement medical benefit obligation	704	**704**
Change in value of available-for-sale financial asset	(526)	**(526)**
Balance at 31 March 2016	930 507	**930 507**
Total comprehensive income	95 583	**95 583**
Profit for the year	94 657	**94 657**
Other comprehensive income for the year:		
Remeasurement of post-retirement medical benefit obligation	926	**926**
Balance at 31 March 2017	**1 026 090**	**1 026 090**
CSIR		
Balance at 31 March 2015	869 472	**869 472**
Total comprehensive income	59 160	**59 160**
Profit for the year	58 982	**58 982**
Other comprehensive income for the year:		
Remeasurement of post-retirement medical benefit obligation	704	**704**
Change in value of available-for-sale financial asset	(526)	**(526)**
Balance at 31 March 2016	928 632	**928 632**
Total comprehensive income	95 534	**95 534**
Profit for the year	94 608	**94 608**
Other comprehensive income for the year:		
Remeasurement of post-retirement medical benefit obligation	926	**926**
Balance at 31 March 2017	**1 024 166**	**1 024 166**

STATEMENTS OF

Cash flows

FOR THE YEAR ENDED 31 MARCH 2017

	Notes	GROUP 2017 R'000	GROUP 2016 R'000	CSIR 2017 R'000	CSIR 2016 R'000
Cash flows from operating activities					
Cash receipts from external customers		**2 020 037**	2 035 880	**1 983 601**	2 034 269
Parliamentary Grant received		**694 827**	649 704	**694 827**	649 704
Cash paid to suppliers and employees		**(2 656 052)**	(2 586 888)	**(2 627 817)**	(2 584 844)
Cash generated from operating activities	22	**58 812**	98 696	**50 611**	99 129
Finance income received	4	**55 538**	48 551	**54 992**	48 111
Finance expense paid	4	**(8 961)**	(8 371)	**(8 961)**	(8 371)
Income taxes paid	5	**(45)**	(1 582)	**-**	-
Net cash from operating activities		**105 344**	137 294	**96 642**	138 869
Cash flows from investing activities					
Acquisition of property, plant and equipment	6	**(71 987)**	(100 543)	**(71 987)**	(100 543)
Proceeds on disposal of property, plant and equipment		**67 043**	2 233	**67 033**	2 233
Decrease in subsidiary loans		**-**	-	**9 000**	-
(Increase)/decrease in interest in joint ventures and associates		**(9 085)**	1 250	**(9 085)**	-
Increase in available-for-sale financial asset		**(4 861)**	(1 294)	**(4 861)**	(1 294)
Net cash utilised in investing activities		**(18 890)**	(98 354)	**(9 900)**	(99 604)
Cash flows from financing activities					
Net cash utilised in financing activities		**-**	-	**-**	-
Unrealised exchange gains/(losses) on foreign cash balances		**7 141**	(9 976)	**7 141**	(9 976)
Net increase in cash and cash equivalents		**93 595**	28 964	**93 883**	29 289
Cash and cash equivalents at beginning of the year		**1 012 879**	983 915	**1 005 241**	975 952
Cash and cash equivalents at end of the year	23	**1 106 474**	1 012 879	**1 099 124**	1 005 241

NOTES TO THE

Annual financial statements

FOR THE YEAR ENDED 31 MARCH 2017

1. PRINCIPAL ACCOUNTING POLICIES

The CSIR is a national government business enterprise (enacted by The Scientific Research Council Act, Act 46 of 1988) domiciled in the Republic of South Africa. The address of the CSIR's principal place of business is Meiring Naudé Road, Brummeria, Pretoria. The CSIR undertakes directed and particularly multi-disciplinary research and technological innovation, to foster, in the national interest and in fields which in its opinion should receive preference, industrial and scientific development, either by itself or in co-operation with principals from the private or public sectors, and thereby to contribute to the improvement of the quality of life of the people of the Republic.

The consolidated annual financial statements of the Group as at and for the year ended 31 March 2017 comprise the company and its subsidiaries (together referred to as the Group) and the Group's interest in associates and jointly controlled entities.

1.1 Basis of presentation

The consolidated annual financial statements have been prepared in accordance with International Financial Reporting Standards (IFRS) as issued by the International Accounting Standards Board (IASB) and the Public Finance Management Act, Act 1 of 1999 as amended by Act 29 of 1999.

The policies set out as follows have been consistently applied to all the years presented.

The preparation of financial statements requires management to make judgements, estimates and assumptions that affect the application of policies and reported amounts of assets and liabilities, income and expenses. The estimates and associated assumptions are based on historical experience and various other factors that are believed to be reasonable under the circumstances, the result of which forms the basis of making judgements about carrying values of assets and liabilities that are not readily apparent from other sources. Actual results may differ from these estimates.

Estimates and underlying assumptions are reviewed on an ongoing basis. Revisions to accounting estimates are recognised in the period in which the estimate is revised and in any future periods affected.

The consolidated annual financial statements are presented in South African rand (R), which is the CSIR's functional currency, and are rounded off to the nearest thousand.

1.2 Basis of consolidation

Subsidiaries

Subsidiaries are all entities (including structured entities) over which the Group has control. The Group controls an entity when the Group is exposed to, or has rights to, variable returns from its involvement with the entity and has the ability to affect those returns through its power over the entity. Subsidiaries are fully consolidated from the date on which control is transferred to the Group. They are deconsolidated from the date that control ceases.

The Group applies the acquisition method to account for business combinations. The consideration transferred for the acquisition of a subsidiary is the fair values of the assets transferred, the liabilities incurred to the former owners of the acquiree and the equity interests issued by the Group. The consideration transferred includes the fair value of any asset or liability resulting from a contingent consideration arrangement. Identifiable assets acquired and liabilities and contingent liabilities assumed in a business combination are measured initially at their fair values at the acquisition date. The Group recognises any non-controlling interest in the acquiree on an acquisition-by-acquisition basis, either at fair value or at the non-controlling interest's proportionate share of the recognised amounts of the acquiree's identifiable net assets.

Acquisition-related costs are expensed as incurred.

If the business combination is achieved in stages, the acquisition date carrying value of the acquirer's previously held equity interest in the acquiree is re-measured to fair value at the acquisition date; any gains or losses arising from such re-measurement are recognised in profit or loss.

Any contingent consideration to be transferred by the Group is recognised at fair value at the acquisition date. Subsequent changes to the fair value of the contingent consideration that is deemed to be an asset or liability is recognised in accordance with IAS 39 either in profit or loss or as a change to other comprehensive income. Contingent consideration that is classified as equity is not re-measured, and its subsequent settlement is accounted for within equity.

The excess of the consideration transferred, the amount of any non-controlling interest in the acquiree and the acquisition-date fair value of any previous equity interest in the acquiree over the fair value of the

1. PRINCIPAL ACCOUNTING POLICIES (CONTINUED)

identifiable net assets acquired is recorded as goodwill. If the total of consideration transferred, non-controlling interest recognised and previously held interest measured is less than the fair value of the net assets of the subsidiary acquired in the case of a bargain purchase, the difference is recognised directly in profit or loss.

Inter-company transactions, balances and unrealised gains on transactions between group companies are eliminated. Unrealised losses are also eliminated. When necessary, amounts reported by subsidiaries have been adjusted to conform with the Group's accounting policies.

Investments in subsidiaries are measured at cost less accumulated impairment losses in the CSIR's annual financial statements.

Changes in ownership interests in subsidiaries without change of control

Transactions with non-controlling interests that do not result in loss of control are accounted for as equity transactions – that is, as transactions with the owners in their capacity as owners. The difference between fair value of any consideration paid and the relevant share acquired of the carrying value of net assets of the subsidiary is recorded in equity. Gains or losses on disposals to non-controlling interests are also recorded in equity.

Disposal of subsidiaries

When the Group ceases to have control, any retained interest in the entity is remeasured to its fair value at the date when control is lost, with the change in carrying amount recognised in profit or loss. The fair value is the initial carrying amount for the purposes of subsequently accounting for the retained interest as an associate, joint venture or financial asset. In addition, any amounts previously recognised in other comprehensive income in respect of that entity are accounted for as if the Group had directly disposed of the related assets or liabilities. This may mean that amounts previously recognised in other comprehensive income are reclassified to profit or loss.

Associates

Associates are all entities over which the Group has significant influence but not control, generally accompanying a shareholding of between 20% and 50% of the voting rights. Investments in associates are accounted for using the equity method of accounting. Under the equity method, the investment is initially recognised at cost, and the carrying amount is increased or decreased to recognise the investor's share of the profit or loss of the investee after the date of acquisition. The Group's investment in associates includes goodwill identified on acquisition.

If the ownership interest in an associate is reduced but significant influence is retained, only a proportionate share of the amounts previously recognised in other comprehensive income is reclassified to profit or loss where appropriate.

The Group's share of post-acquisition profit or loss is recognised in profit or loss, and its share of post-acquisition movements in other comprehensive income is recognised in other comprehensive income with a corresponding adjustment to the carrying amount of the investment. When the Group's share of losses in an associate equals or exceeds its interest in the associate, including any other unsecured receivables, the Group does not recognise further losses, unless it has incurred legal or constructive obligations or made payments on behalf of the associate.

The Group determines at each reporting date whether there is any objective evidence that the investment in the associate is impaired. If this is the case, the Group calculates the amount of impairment as the difference between the recoverable amount of the associate and its carrying value and recognises the amount adjacent to share of profit/loss of associates in profit or loss.

Profits and losses resulting from upstream and downstream transactions between the Group and its associate are recognised in the Group's financial statements only to the extent of unrelated investor's interests in the associates. Unrealised losses are eliminated unless the transaction provides evidence of an impairment of the asset transferred. Accounting policies of associates have been changed where necessary to ensure consistency with the policies adopted by the Group.

Dilution gains and losses arising in investments in associates are recognised in profit or loss.

Investments in associates are measured at cost less accumulated impairment losses in the CSIR's annual financial statements.

Joint arrangements

Under IFRS 11 investments in joint arrangements are classified as either joint operations or joint ventures depending on the contractual rights and obligations of each investor. The CSIR Group has assessed

NOTES TO THE

Annual financial statements

FOR THE YEAR ENDED 31 MARCH 2017

1. PRINCIPAL ACCOUNTING POLICIES (CONTINUED)

the nature of its joint arrangements and determined them to be joint ventures. Joint ventures are accounted for using the equity method.

Under the equity method of accounting, interests in joint ventures are initially recognised at cost and adjusted thereafter to recognise the Group's share of the post-acquisition profits or losses and movements in other comprehensive income. When the Group's share of losses in a joint venture equals or exceeds its interests in the joint ventures (which includes any long-term interests that, in substance, form part of the Group's net investment in the joint ventures), the Group does not recognise further losses, unless it has incurred obligations or made payments on behalf of the joint ventures.

Unrealised gains on transactions between the Group and its joint ventures are eliminated to the extent of the Group's interest in the joint ventures. Unrealised losses are also eliminated unless the transaction provides evidence of an impairment of the asset transferred. Accounting policies of the joint ventures have been changed where necessary to ensure consistency with the policies adopted by the Group.

Investments in joint ventures are measured at cost less accumulated impairment losses in the CSIR's annual financial statements.

1.3 Foreign currencies

Foreign operations

All foreign subsidiaries of the CSIR are foreign operations. There are no foreign subsidiaries in the period covered by this set of annual financial statements.

The financial statements of foreign subsidiaries are translated into South African rand as follows:

- Assets and liabilities, including goodwill and fair value adjustments on acquisition, at rates of exchange ruling at the reporting date.
- Revenue, expenditure and cash flow items at the average rates of exchange during the relevant financial year (the average rates approximate exchange rates at the various dates).

Differences arising on translation are recognised in other comprehensive income and presented in equity as non-distributable reserves called a foreign currency translation reserve (FCTR). When a foreign operation is disposed of, in part or in full, the relevant amount in the FCTR is transferred to profit or loss.

Foreign exchange gains and losses arising from a monetary item receivable from or payable to a foreign operation, the settlement of which is neither planned nor likely in the foreseeable future, are considered to form part of a net investment in a foreign operation and are recognised directly in other comprehensive income and presented in equity in the FCTR.

Foreign currency transactions and balances

Transactions in foreign currencies are converted to South African rand at the rate of exchange ruling at the date of the transactions. Monetary assets and liabilities denominated in foreign currencies are translated into South African rand using the rates of exchange ruling at the reporting date. The resulting exchange differences are recognised in profit or loss. Non-monetary assets and liabilities measured at fair value are translated at foreign exchange rates ruling at the date the fair value was determined.

1.4 Property, plant and equipment

Owned assets

Land is stated at cost less accumulated impairment losses. Buildings, equipment and vehicles are stated at cost less accumulated depreciation and accumulated impairment losses. Cost includes expenditure directly attributable to acquisition.

The cost of self-constructed assets includes the cost of materials, direct labour, the initial estimate, where relevant, of the costs of dismantling and removing the items and restoring the site on which these are located and an appropriate proportion of production overheads.

Where parts of an item of property, plant and equipment have different useful lives, these are accounted for as separate items (major components) of property, plant and equipment.

Gains and losses on disposal of an item of property, plant and equipment are determined by comparing proceeds from disposal with the carrying amount of property, plant and equipment and are recognised in profit or loss.

Subsequent costs

The Group recognises in the carrying amount of an item of property, plant and equipment, the cost of replacing a part of such an item when that cost is incurred, if it is probable that the future economic benefits embodied in the item will flow to the Group and the cost of the item

1. PRINCIPAL ACCOUNTING POLICIES (CONTINUED)

can be measured reliably. The carrying amount of the replaced part is derecognised. The costs of the day-to-day servicing of property, plant and equipment are recognised in profit or loss as incurred.

Depreciation

Depreciation is based on cost less residual value and is calculated on the straight-line method from the day the assets are available for use, at rates considered appropriate to write off carrying values over the estimated useful lives of the assets, except for assets specifically acquired for a contract, which are depreciated over the life of the contract. Land is not depreciated.

The estimated lives of the main categories of property, plant and equipment for the current and comparative period are as follows:

- Land: Indefinite
- Buildings: 90 years
- Equipment: 3 to 10 years
- Vehicles: 10 years

Depreciation methods, useful lives and current residual values, if not insignificant, are reassessed annually.

1.5 Intangible assets

Research and development

Expenditure on research activities, undertaken with the prospect of gaining new scientific or technical knowledge and understanding, is recognised in profit or loss when incurred.

Development activities involve a plan or design for the production of new or substantially improved products and processes. Development expenditure is capitalised only if development costs can be measured reliably, the product or process is technically and commercially feasible, future economic benefits are probable, and the Group intends to and has sufficient resources to complete development and to use or sell the asset. The expenditure capitalised includes the cost of materials, direct labour and overhead costs that are directly attributable to preparing the asset for its intended use. Other development expenditure is recognised in profit or loss when incurred.

Capitalised development expenditure is measured at cost less accumulated amortisation and accumulated impairment losses.

Subsequent costs

Subsequent expenditure on capitalised intangible assets is capitalised only when it increases the future economic benefits embodied in the specific asset to which it relates. All other expenditure, including expenditure on internally generated goodwill and brands, is expensed as incurred.

Amortisation

Amortisation is based on cost and calculated on the straight-line method at rates considered appropriate to write off carrying values over the estimated useful lives of the intangible assets with definite useful lives. Intangible assets are amortised from the day they are available for use.

The estimated lives of intangible assets with definite useful lives are as follows:

- Investment in technology: 3 to 10 years

Amortisation methods, useful lives and residual values are reviewed at each reporting date and adjusted if appropriate.

1.6 Impairment

Financial assets

A financial asset not classified at fair value through profit or loss is assessed at each reporting date to determine whether there is any objective evidence that it is impaired. A financial asset is considered to be impaired if objective evidence indicates that one or more events have had a negative effect on the estimated future cash flows of that asset.

An impairment loss in respect of a financial asset measured at amortised cost is calculated as the difference between its carrying amount, and the present value of the estimated future cash flows discounted at the original effective interest rate.

Individually-significant financial assets and those that have been identified as impaired are tested for impairment on an individual basis. The remaining financial assets are assessed collectively in groups that share similar credit risk characteristics.

All impairment losses are recognised in profit or loss.

An impairment loss is reversed if the reversal can be related objectively to an event occurring after the impairment loss was recognised. For

NOTES TO THE

Annual financial statements

FOR THE YEAR ENDED 31 MARCH 2017

1. PRINCIPAL ACCOUNTING POLICIES (CONTINUED)

financial assets measured at amortised cost the reversal is recognised in profit or loss.

Non-financial assets

The carrying amounts of the Group's non-financial assets, other than inventories and deferred tax assets, are reviewed at each reporting date to determine whether there is any indication of impairment. If any such indication exists then the asset's recoverable amount is estimated. For goodwill arising from the acquisition of subsidiaries and intangible assets that have indefinite lives or that are not yet available for use, the recoverable amount is estimated at each reporting date.

An impairment loss is recognised if the carrying amount of an asset or its cash-generating unit exceeds its recoverable amount. A cash-generating unit is the smallest identifiable asset group that generates cash flows that are largely independent from other assets and groups. Impairment losses are recognised in profit or loss. Impairment losses recognised in respect of cash-generating units are allocated first to reduce the carrying amount of any goodwill allocated to the units and then to reduce the carrying amount of the other assets in the unit (group of units) on a pro rata basis.

The recoverable amount of an asset or cash-generating unit is the greater of its value in use and its fair value less costs of disposal. In assessing value in use, the estimated future cash flows are discounted to their present value using a pre-tax discount rate that reflects current market assessments of the time value of money and the risks specific to the asset.

An impairment loss in respect of goodwill is not reversed. In respect of other assets, impairment losses recognised in prior periods are assessed at each reporting date for any indications that the loss has decreased or no longer exists. An impairment loss is reversed if there has been a change in the estimates used to determine the recoverable amount. An impairment loss is reversed only to the extent that the asset's carrying amount does not exceed the carrying amount that would have been determined, net of depreciation or amortisation, if no impairment loss had been recognised.

1.7 Short-term employee benefits

Short-term employee benefit obligations are measured on an undiscounted basis and are expensed as the related service is provided. A liability is recognised for the amount expected to be paid under short-term cash bonus if the Group has a present legal or constructive obligation to pay this amount as a result of past service provided by the employee, and the obligation can be estimated reliably.

1.8 Retirement benefits

Pension fund

The Group operates a defined contribution plan, the assets of which are held in a separate trustee-administered fund. The benefits payable by the fund in the future, due to retirements and withdrawals from the fund, are contributions to the fund together with fund interest at a rate determined by the valuator with the consent of the trustees. The rate is so determined that the value of the total of the fund shall not exceed the value of the total assets of the fund.

Post-retirement benefits other than pensions

The Group provides post-retirement medical benefits to qualifying employees, which is deemed to be a defined benefit plan. The expected costs of these benefits are determined using the projected unit credit method, with actuarial valuations being carried out at each reporting date. Contributions are made to the relevant funds over the expected service lives of the employees entitled to those funds. The estimated cost of providing such benefits is charged to profit or loss on a systematic basis over the employees' working lives within the Group.

Actuarial gains and losses are recognised in other comprehensive income in the year when actuarially determined. The amount recognised in the statement of financial position represents the present value of the post-retirement medical fund benefit obligation. Any asset resulting from this calculation is limited to actuarial losses and the present value of available refunds and reductions in future contributions to the plan.

1.9 Inventory and contracts in progress

Inventory is measured at the lower of cost and net realisable value. Cost of inventory is determined by the weighted average method. In the case of work in progress, cost includes an appropriate share of production overheads based on normal operating capacity. Net realisable value represents the estimated selling price less all estimated costs to completion and costs to be incurred in selling.

Contracts in progress are stated as a percentage of the sales value of work completed, after provision for losses relating to the stage of completion and any foreseeable losses to completion of the contract, less progress billings.

1. PRINCIPAL ACCOUNTING POLICIES (CONTINUED)

1.10 Income tax

The CSIR is exempt from South African income tax. The income tax expense of subsidiary companies is reflected on Group level.

Income tax expense comprises current and deferred tax. The current tax charge is based on the profit or loss for the year as adjusted for items that are non-taxable or disallowed. It is calculated using tax rates that have been enacted or substantially enacted at the reporting date. Income tax expense is recognised in profit or loss except to the extent that it relates to items recognised directly in other comprehensive income or equity, in which case it is recognised in other comprehensive income or equity.

Deferred tax is recognised in respect of temporary differences arising from differences between the carrying amounts of assets and liabilities in the financial statements and the corresponding tax basis used in the computation of the taxable profit.

Where the tax effects of temporary differences, including those arising from tax losses, give rise to a deferred tax asset, the asset is recognised only if it is probable that future taxable profits will be sufficient to allow the tax benefit of the loss to be realised. Deferred tax assets are reviewed at each reporting date and are reduced to the extent that it is no longer probable that the related tax benefit will be realised. Deferred tax is not recognised for the following temporary differences: the initial recognition of assets or liabilities in a transaction that is not a business combination and that affects neither profit or loss, and differences relating to investments in subsidiaries, associates and jointly controlled entities to the extent that it is probable that they will not reverse in the foreseeable future.

Deferred tax assets and liabilities are offset when there is a legally enforceable right and when these relate to income taxes levied by the same taxation authority and the Group intends to settle its current tax assets and liabilities on a net basis.

1.11 Provisions

Provisions are recognised when the Group has a present legal or constructive obligation as a result of past events, for which it is probable that an outflow of economic benefits will be required to settle the obligation, and a reliable estimate can be made of the amount of the obligation. Provisions are measured at the present value of the expenditures expected to be required to settle the obligation using a pre-tax rate that reflects current market assessments of the time value of money and the risks specific to the obligation. The increase in the provision due to passage of time is recognised as interest expense.

A provision for onerous contracts is recognised when the expected benefits to be derived by the Group from a contract are lower than the unavoidable cost of meeting its obligations under the contract. The provision is measured at the present value of the lower of the expected cost of terminating the contract and the expected net cost of continuing with the contract. Before a provision is established, the Group recognises any impairment loss on the assets associated with that contract.

1.12 Government grants

Government grants that compensate the Group for expenses incurred are recognised as income on a systematic basis over periods necessary to match the assistance with the related expenses it is intended to compensate.

Grants that compensate the Group for the cost of an asset are deducted in arriving at the carrying amount of the acquired asset.

1.13 Revenue recognition

Revenue from the sale of goods is measured at the fair value of the consideration received or receivable, net of returns and allowances, trade discounts and volume rebates. Revenue is recognised when the significant risks and rewards of ownership have been transferred to the buyer, recovery of the consideration is probable, the associated costs and possible return of goods can be estimated reliably and there is no continuing management involvement with the goods, and the amount of revenue can be measured reliably.

Revenue from services rendered is recognised in profit or loss in proportion to the stage of completion of the transaction at the reporting date. The stage of completion is assessed by reference to work performed as at the reporting date.

Contract revenue includes the initial amount agreed in the contract plus any variations in contract work, claims and incentive payments to the extent that it is probable that these will result in revenue and can be measured reliably. As soon as the outcome of a contract can be

NOTES TO THE

Annual financial statements

FOR THE YEAR ENDED 31 MARCH 2017

1. PRINCIPAL ACCOUNTING POLICIES (CONTINUED)

estimated reliably, contract revenue and expenses are recognised in profit or loss in proportion to the stage of completion of the contract.

The stage of completion is assessed by reference to work performed as at reporting date. When the outcome of a contract cannot be estimated reliably, contract revenue is recognised only to the extent of contract costs incurred that are likely to be recoverable. An expected loss on a contract is recognised immediately in profit or loss.

Royalties are accrued based on the stipulations of the applicable contracts.

1.14 Finance income/expense

Finance income/expense comprises interest receivable on funds invested, interest receivable on trade and other receivables, fair value adjustments on investments and interest payable on borrowings. Interest income is recognised in profit or loss as it accrues, using the effective interest rate method. Interest payable on borrowings is calculated using the effective interest rate method.

1.15 Expenses

Operating lease payments

Leases in which a significant portion of the risks and rewards of ownership are retained by the lessor are classified as operating leases. Payments made under operating leases are recognised in profit or loss on a straight-line basis over the term of the lease. Lease incentives received are recognised in profit or loss as an integral part of the total lease expense, over the term of the lease.

Finance lease payments

Leases of property, plant and equipment where the Group has substantially all the risks and rewards of ownership are classified as finance leases. Minimum lease payments are apportioned between the finance charge and the reduction of the outstanding liability. The finance charge is allocated to each period during the lease term so as to produce a constant periodic rate of interest on the remaining balance of the liability.

1.16 Financial instruments

Financial instruments are initially measured at fair value plus, for instruments not at fair value through profit or loss, any directly attributable transaction costs, when the Group has become a party to contractual provision of the instrument. Subsequent to initial recognition, these instruments are measured as set out as follows:

Loans and receivables

Trade and other receivables

Trade receivables are subsequently measured at amortised cost using the effective interest method less any impairment losses, which approximate the fair value of these due to the short-term nature thereof.

Loans

Loans are measured at amortised cost using the effective interest method less any impairment losses if they have a fixed maturity, or at cost if there is no fixed maturity.

Cash and cash equivalents

Cash and cash equivalents are measured at amortised cost, which is their fair value. Cash and cash equivalents comprise fixed deposits, call deposits, bank balances, cash on hand and cash deposits.

Financial assets at fair value through profit or loss

Forward exchange contracts

Forward exchange contracts are fair valued and gains and losses are recognised in profit or loss. Hedge accounting is not applied.

Available-for-sale financial assets

Available-for-sale financial assets are subsequently carried at fair value. Changes in the fair value of available-for-sale financial assets are recognised in other comprehensive income. When available-for-sale financial assets are sold or impaired, the accumulated fair value adjustments recognised in equity are included in profit or loss.

Financial liabilities at amortised cost

Trade and other payables and advances received

Trade and other payables and advances received are stated at amortised cost, which approximates the fair value of these due to the short-term nature thereof.

1. PRINCIPAL ACCOUNTING POLICIES (CONTINUED)

De-recognition

Financial assets (or a portion thereof) are de-recognised when the Group realises the rights to the benefits specified in the contract, the rights expire or the Group surrenders or otherwise loses control and does not retain substantially all risks and rewards of the asset. On de-recognition, the difference between the carrying amount of the financial asset and proceeds receivable is included in profit or loss.

Financial liabilities (or a portion thereof) are de-recognised when the obligation specified in the contract is discharged, cancelled or expires. On de-recognition, the difference between the carrying amount of the financial liability and the amount paid for it is included in profit or loss.

1.17 Related parties

The Group operates in an economic environment currently dominated by entities directly or indirectly owned by the South African government. As a result of the constitutional independence of all three spheres of government in South Africa, only parties within the national sphere of government will be considered to be related parties.

Key management is defined as being individuals with the authority and responsibility for planning, directing and controlling the activities of the entity. All individuals from the level of Group Executive up to the Board of Directors are regarded as key management.

Close family members of key management are considered to be those family members who may be expected to influence, or be influenced by key management individuals or other parties related to the entity.

1.18 Standards and interpretations issued, not yet effective

At the date of authorisation of the financial statements of the Group for the year ended 31 March 2017, the following standards and interpretations were in issue but not yet effective:

Standard/Interpretation	Description	Effective date
Amendments to IAS 7, Statement of cash flows on disclosure initiative	These amendments to IAS 7 introduce an additional disclosure that will enable users of financial statements to evaluate changes in liabilities arising from financing activities. The amendment is part of the IASB's Disclosure Initiative, which continues to explore how financial statement disclosure can be improved. These amendments are not expected to affect the Group's results.	Annual periods beginning on or after 1 January 2017
Amendments to IAS 12 - 'Income taxes' on recognition of deferred tax assets for unrealised losses	These amendments on the recognition of deferred tax assets for unrealised losses clarify how to account for deferred tax assets related to debt instruments measured at fair value. These amendments are not expected to affect the Group's results.	Annual periods beginning on or after 1 January 2017
Amendments to IFRS 2, 'Share based payments', on clarifying how to account for certain types of share-based payment transactions	This amendment clarifies the measurement basis for cash-settled, share-based payments and the accounting for modifications that change an award from cash-settled to equity-settled. It also introduces an exception to the principles in IFRS 2 that will require an award to be treated as if it was wholly equity-settled, where an employer is obliged to withhold an amount for the employee's tax obligation associated with a share-based payment and pay that amount to the tax authority. This amendment is not expected to affect the Group's results.	Annual periods beginning on or after 1 January 2018

NOTES TO THE

Annual financial statements

FOR THE YEAR ENDED 31 MARCH 2017

1. PRINCIPAL ACCOUNTING POLICIES (CONTINUED)

Standard/Interpretation	Description	Effective date
IFRS 9 'Financial instruments'	This standard replaces the guidance in IAS 39. It includes requirements on the classification and measurement of financial assets and liabilities; it also includes an expected credit losses model that replaces the current incurred loss impairment model. The impact of this standard on the Group's results cannot be determined at this stage.	Annual periods beginning on or after 1 January 2018
IFRS 15 – 'Revenue from contracts with customers'	IFRS 15, 'Revenue from contracts with customers' is a converged standard from the IASB and FASB on revenue recognition. The standard will improve the financial reporting of revenue and improve comparability of the top line in financial statements globally. The impact of this standard on the Group's results cannot be determined at this stage.	Annual periods beginning on or after 1 January 2018
Amendment to IFRS 15, 'Revenue from contracts with customers'	These amendments comprise clarifications of the guidance on identifying performance obligations, accounting for licences of intellectual property and the principal versus agent assessment (gross versus net revenue presentation). New and amended illustrative examples have been added for each of those areas of guidance. The IASB has also included additional practical expedients related to transition to the new revenue standard. The impact of these amendments on the Group's results cannot be determined at this stage.	Annual periods beginning on or after 1 January 2018
IFRS 16 – 'Leases'	This standard replaces the current guidance in IAS 17. Under IAS 17, lessees were required to make a distinction between a finance lease and an operating lease. IFRS 16 now requires lessees to recognise a lease liability reflecting future lease payment and a 'right-of-use asset' for virtually all lease contracts. There is an optional exemption for certain short-term leases and leases of low-value assets which can be applied by lessees. Lessors will be affected by the new standard as the guidance on the definition of a lease has been updated. The impact of this standard on the Group's results cannot be determined at this stage.	Annual periods beginning on or after 1 January 2019 with earlier application permitted if IFRS 15, 'Revenue from Contracts with Customers', is also applied

1. PRINCIPAL ACCOUNTING POLICIES (CONTINUED)

Standard/Interpretation	Description	Effective date
Amendments to IFRS 4, 'Insurance contracts' regarding the implementation of IFRS 9, 'Financial instruments'	These amendments introduce two approaches: an overlay approach and a deferral approach. The amended standard will: • give all companies that issue insurance contracts the option to recognise in other comprehensive income, rather than profit or loss, the volatility that could arise when IFRS 9 is applied before the new insurance contracts standard is issued; and • give companies whose activities are predominantly connected with insurance an optional temporary exemption from applying IFRS 9 until 2021. The entities that defer the application of IFRS 9 will continue to apply the existing financial instruments standard - IAS 39. These amendments are not expected to affect the Group's results.	Annual periods beginning on or after 1 January 2018
Amendment to IAS 40, 'Investment property' relating to transfers of investment property	These amendments clarify that to transfer to, or from, investment properties there must be a change in use. To conclude if a property has changed use there should be an assessment of whether the property meets the definition. This change must be supported by evidence. These amendments are not expected to affect the Group's results.	Annual periods beginning on or after 1 January 2018
Annual improvements 2014–2016	These amendments impact 3 standards: • IFRS 1, 'First-time adoption of IFRS', regarding the deletion of short-term exemptions for first-time adopters regarding IFRS 7, IAS 19, and IFRS 10 effective 1 January 2018. • IFRS 12, 'Disclosure of interests in other entities' regarding clarification of the scope of the standard. These amendments should be applied retrospectively for annual periods beginning on or after 1 January 2017. • IAS 28, 'Investments in associates and joint ventures' regarding measuring an associate or joint venture at fair value effective 1 January 2018. The impact of these amendments on the Group's results cannot be determined at this stage.	Annual periods beginning on or after 1 January 2018
IFRIC 22, 'Foreign currency transactions and advance consideration'	This IFRIC addresses foreign currency transactions or parts of transactions where there is consideration that is denominated or priced in a foreign currency. The interpretation provides guidance for when a single payment/receipt is made as well as for situations where multiple payments/receipts are made. The guidance aims to reduce diversity in practice. The impact of this IFRIC on the Group's results cannot be determined at this stage.	Annual periods beginning on or after 1 January 2018

The Group has not early-adopted any of the above guidance.

NOTES TO THE

Annual financial statements

FOR THE YEAR ENDED 31 MARCH 2017

2. REVENUE

	GROUP				CSIR			
	2017		2016		2017		2016	
	R'000	%	R'000	%	R'000	%	R'000	%
Parliamentary Grant	**714 105**	**27**	680 485	25	**714 105**	**27**	680 485	25
Parliamentary Grant received	**694 827**	**26**	649 704	24	**694 827**	**26**	649 704	24
Less:								
Grant received for projects started before year-end but not completed	**(4 248)**	**-**	(23 526)	(1)	**(4 248)**	**-**	(23 526)	(1)
Add:								
Grant received in prior year for projects completed in this year	**23 526**	**1**	54 307	2	**23 526**	**1**	54 307	2
Contract income	**1 951 805**	**73**	1 965 007	75	**1 951 947**	**73**	1 966 748	75
Local private sector	**186 487**	**7**	172 348	7	**186 487**	**7**	172 154	6
Local public sector	**1 603 343**	**60**	1 643 863	62	**1 603 485**	**60**	1 645 798	63
International sector (including Africa)	**161 975**	**6**	148 796	6	**161 975**	**6**	148 796	6
Royalties	**5 445**	**-**	5 249	-	**5 445**	**-**	5 249	-
	2 671 355	**100**	2 650 741	100	**2 671 497**	**100**	2 652 482	100

Contract income is disclosed after taking into account the effect of the time value of money (the value of discounting) in terms of SAICA's Circular 9 of 2006: Transactions giving rise to adjustments to revenue/purchases. The value is R16,25 million (2016: R12,09 million) and is included in finance income (note 4).

Included in public sector contract income is R70,95 million (2016: R68,12 million) ring-fenced allocation from the Department of Science and Technology for specific initiatives managed through memorandums of agreement.

Included in contract income is rental income amounting to R46,57 million (2016: R44,80 million) and revenue of R39,27 million (2016: R32,14 million) earned by the CSIR International Convention Centre.

Estimates on Parliamentary Grant recognition are based on cost to completion, budgets and percentage of completion.

3. PROFIT BEFORE INCOME TAX

	GROUP		CSIR	
	2017 R'000	2016 R'000	2017 R'000	2016 R'000
Profit before income tax is arrived at after taking the following items into account:				
Audit fees	**5 099**	5 658	**5 099**	5 658
Fees for services	**12 225**	9 868	**12 096**	9 764
Patent costs	**11 507**	8 387	**11 378**	8 283
Legal costs	**718**	1 481	**718**	1 481
Operating leases	**6 891**	4 781	**6 891**	4 745
Buildings	**2 609**	1 685	**2 609**	1 649
Equipment	**2 982**	1 841	**2 982**	1 841
Vehicles	**1 300**	1 255	**1 300**	1 255
Net realised foreign exchange loss/(gain)	**13 165**	(55 544)	**13 165**	(55 544)
Net unrealised foreign exchange (gain)/loss	**(1 996)**	14 145	**(1 996)**	14 145
Board members' and Executive Management's remuneration (note 18)	**23 922**	25 663	**23 922**	25 663
(Reversals of impairments)/impairments	**(16 923)**	10 339	**(15 282)**	1 811
(Reversal of impairment)/impairment on subsidiaries, joint ventures and associates	**(489)**	63	**1 152**	(8 465)
(Reversal of impairment)/impairment on trade receivables	**(16 434)**	10 276	**(16 434)**	10 276
Profit on sale of associate*	**-**	(1 834)	**-**	-
Bad debt written off	**3 480**	2 278	**3 480**	2 278
Profit on disposal and write-off of property, plant and equipment**	**(38 422)**	(1 459)	**(38 422)**	(1 459)
Lost and/or stolen equipment and vehicles***	**1 028**	759	**1 028**	759
Losses incurred	**1 237**	767	**1 237**	767
Losses recovered	**(209)**	(8)	**(209)**	(8)

* Refer to note 26.2

** Refer to note 7

*** These are losses incurred in the normal course of the CSIR's business and are covered by the CSIR's insurance policy. The net losses incurred on these are included in the profit on disposal and write-off of property, plant and equipment amounts.

NOTES TO THE

Annual financial statements

FOR THE YEAR ENDED 31 MARCH 2017

4. FINANCE INCOME/EXPENSE

	GROUP		CSIR	
	2017 R'000	2016 R'000	2017 R'000	2016 R'000
Finance income	**53 166**	48 781	**52 578**	48 341
Interest on bank balances and investments	**36 454**	36 693	**35 866**	36 253
Interest on trade and other receivables	**461**	-	**461**	-
Adjustment on initial recognition of contract income*	**16 251**	12 088	**16 251**	12 088
Finance expense	**(8 961)**	(8 371)	**(8 961)**	(8 371)
Adjustment on initial recognition of operating expenses*	**(8 961)**	(8 371)	**(8 961)**	(8 371)
	44 205	40 410	**43 617**	39 970

* These adjustments are due to the effect of the time value of money (the value of discounting) in terms of SAICA's Circular 9 of 2006: Transactions giving rise to adjustments to revenue/purchases.

5. INCOME TAX EXPENSE

The CSIR is exempt from South African income tax in terms of section 10 (1) (t) (i) of the Income Tax Act, Act No 58 of 1962.

South African normal taxation due by subsidiaries	**41**	1 554
Current taxation	**41**	1 554
	41	1 554

	%	%
South African normal rate of taxation	**28%**	28%
Profit attributable to tax exempt entities	**(28%)**	(21%)
Assessed loss (refer note 13)	**0%**	(1%)
Share of profit of joint ventures and associates	**0%**	(1%)
Non-taxable portion of capital gain on sale of associate	**0%**	(2%)
Current and deferred taxation - effective rate	**0%**	3%

6. PROPERTY, PLANT AND EQUIPMENT

	2017			2016		
	Cost	Accumulated depreciation	Carrying value	Cost	Accumulated depreciation	Carrying value
	R'000	R'000	R'000	R'000	R'000	R'000
Group						
Land	125 435	-	125 435	125 435	-	125 435
Buildings	472 960	69 302	403 658	459 237	64 291	394 946
Equipment	478 145	313 643	164 502	449 576	288 689	160 887
ICT equipment	180 394	117 993	62 401	167 674	102 318	65 356
Furniture and fittings	14 950	10 084	4 866	14 356	9 184	5 172
Vehicles	8 014	5 968	2 046	7 825	5 884	1 941
	1 279 898	516 990	762 908	1 224 103	470 366	753 737
CSIR						
Land	125 435	-	125 435	125 435	-	125 435
Buildings	472 960	69 302	403 658	459 237	64 291	394 946
Equipment	478 145	313 643	164 502	449 576	288 689	160 887
ICT equipment	180 389	117 989	62 400	167 627	102 283	65 344
Furniture and fittings	14 950	10 084	4 866	14 356	9 184	5 172
Vehicles	8 014	5 968	2 046	7 825	5 884	1 941
	1 279 893	516 986	762 907	1 224 056	470 331	753 725

NOTES TO THE

Annual financial statements

FOR THE YEAR ENDED 31 MARCH 2017

6. PROPERTY, PLANT AND EQUIPMENT (CONTINUED)

	Land	Buildings	Equipment	ICT equipment	Furniture and fittings	Vehicles	Total
	R'000	R'000	R'000	R'000	R'000	R'000	R'000
Group							
Carrying value 31 March 2015	143 587	374 090	141 795	69 839	4 806	1 915	**736 032**
Additions	-	25 549	55 317	17 491	1 529	657	**100 543**
Disposals and write-offs	-	-	(178)	(585)	(11)	-	**(774)**
Depreciation	-	(219)	(31 295)	(21 341)	(1 152)	(507)	**(54 514)**
Transfer to non-current assets classified as held for sale	(18 152)	(4 474)	(4 752)	(48)	-	(124)	**(27 550)**
Carrying value 31 March 2016	125 435	394 946	160 887	65 356	5 172	1 941	**753 737**
Additions	-	13 730	36 877	19 876	826	678	**71 987**
Disposals and write-offs	-	(7)	(405)	(506)	(21)	(132)	**(1 071)**
Depreciation	-	(5 011)	(32 857)	(22 325)	(1 111)	(441)	**(61 745)**
Carrying value 31 March 2017	**125 435**	**403 658**	**164 502**	**62 401**	**4 866**	**2 046**	**762 908**
CSIR							
Carrying value 31 March 2015	143 587	374 090	141 795	69 816	4 806	1 915	**736 009**
Additions	-	25 549	55 317	17 491	1 529	657	**100 543**
Disposals and write-offs	-	-	(178)	(585)	(11)	-	**(774)**
Depreciation	-	(219)	(31 295)	(21 330)	(1 152)	(507)	**(54 503)**
Transfer to non-current assets classified as held for sale	(18 152)	(4 474)	(4 752)	(48)	-	(124)	**(27 550)**
Carrying value 31 March 2016	125 435	394 946	160 887	65 344	5 172	1 941	**753 725**
Additions	-	13 730	36 877	19 876	826	678	**71 987**
Disposals and write-offs	-	(7)	(405)	(496)	(21)	(132)	**(1 061)**
Depreciation	-	(5 011)	(32 857)	(22 324)	(1 111)	(441)	**(61 744)**
Carrying value 31 March 2017	**125 435**	**403 658**	**164 502**	**62 400**	**4 866**	**2 046**	**762 907**

Land and buildings are unencumbered and full details of the titles are available at the registered office of the CSIR.

A change in the depreciation estimate due to a change in the useful lives of equipment, ICT equipment, furniture and fittings and vehicles resulted in a R5 million (2016: R4,9 million) decrease in the depreciation amount for the current financial year. The useful life of buildings was re-assessed from 40 years to 90 years and resulted in an increase of R4,8 million in the depreciation amount for the current financial year.

During the current financial year, assets to the value of R71,8 million (2016: R207,5 million) were purchased with Government grant funds. At year-end the cumulative value of assets purchased with Government grant funds and shown at a nil cost is R732,3 million (2016: R664,6 million).

7. NON-CURRENT ASSETS HELD FOR SALE

In the previous financial year, property, plant and equipment transferred to non-current assets classified as held for sale amounted to R27,6 million (carrying value) and related to land, buildings, equipment, ICT equipment and vehicles. The property, plant and equipment was presented as held for sale following the events detailed below.

The CSIR and Nelson Mandela Metropolitan University (NMMU) were finalising an agreement to transfer Erf 1281 Summerstrand to NMMU. The transfer was finalised in the current financial year and the net profit of R36,8 million is included in other income.

The CSIR reached an agreement to sell certain laboratory assets in the previous financial year. The contract of sale was approved and concluded with the effective date being in the current financial year. The net profit of R1,9 million is included in other income.

8. INTEREST IN JOINT VENTURES AND ASSOCIATES

	GROUP		CSIR	
	2017 R'000	2016 R'000	2017 R'000	2016 R'000
Cost of investments less impairment losses	**19 580**	1	**20 650**	1
Loans to joint ventures and associates	**27 937**	27 937	**27 937**	27 937
Share of post-acquisition losses of joint ventures	**(23 362)**	(23 432)	**-**	-
Share of post-acquisition losses of associates	**(1 903)**	-	**-**	-
	22 252	4 506	**48 587**	27 938
Impairment of joint ventures and associates	**(2 036)**	(3 068)	**(28 371)**	(26 514)
	20 216	1 438	**20 216**	1 424

The loans to joint ventures and associates are interest free, unsecured and have no fixed terms of repayment. In substance, they form part of the Group's net investment in joint ventures and associates.

Agreements have been entered into between the CSIR and certain joint ventures and associates to subordinate the loans made to those joint ventures and associates. The subordination agreements will remain in force for as long as the liabilities of the relevant joint ventures or associates exceed their assets, fairly valued.

NOTES TO THE

Annual financial statements

FOR THE YEAR ENDED 31 MARCH 2017

8. INTEREST IN JOINT VENTURES AND ASSOCIATES (CONTINUED)

Details of the joint ventures and associate at 31 March 2017 are as follows:

Name of joint venture/associate	Place of incorporation	Portion of ownership interest	Portion of voting power held	Principal activity	Carrying value 2017 R'000	Carrying value 2016 R'000	Financial year-end
Joint ventures							
Sera (Pty) Ltd	South Africa	50%	50%	Commercialisation and licensing of patents	**3 062**	3 068	31 March
Ellipsoid Technology (Pty) Ltd	South Africa	50%	50%	Commercialisation of encapsulation technology	**1 514**	1 438	31 March
Associate							
Persomics AB*	Sweden	28.29%	28.29%	Commercialisation of novel printing technology	**17 676**	-	31 December
					22 252	4 506	

* Persomics AB was classified as an available-for-sale financial asset in the previous financial year. It became an associate in the current financial year. Refer to note 10.

The following are details of the significant joint ventures' and associates' assets, liabilities, income and expenses:

	Joint ventures Group 2017 R'000	Joint ventures Group 2016 R'000	Associates Group 2017 R'000	Associates Group 2016 R'000
Current assets	**7 785**	7 482	**4 578**	-
Non-current assets	**33 665**	33 665	**7 144**	-
Current liabilities	**53 597**	53 433	**1 256**	-
Non-current liabilities	**36 232**	36 232	**6 910**	-
Income	**432**	377	**5 346**	34 780
Expenses	**293**	130	**12 377**	30 180

9. INTEREST IN SUBSIDIARIES

	CSIR	
	2017 R'000	2016 R'000
Shares at cost less impairment losses	**4 650**	4 650
Indebtedness	**786**	11 403
- by subsidiaries	**8 703**	19 500
- impairment of loans	**(7 917)**	(8 097)
	5 436	16 053

Details disclosed in Addendum A.
The loans to subsidiaries are interest free, unsecured and have no fixed terms of repayment.
Agreements have been entered into between the CSIR and certain subsidiaries to subordinate the loans made to those subsidiaries. The subordination agreements will remain in force for as long as the liabilities of the relevant subsidiaries exceed their assets, fairly valued.

10. AVAILABLE-FOR-SALE FINANCIAL ASSET

	% held	Number of shares held		Class of shares	GROUP		CSIR	
		2017	2016		2017 R'000	2016 R'000	2017 R'000	2016 R'000
Unlisted shares								
Persomics AB**	*	*	9 497	Ordinary	-	6 177	-	6 177
					-	6 177	-	6 177

* The percentage held in Persomics AB as at 31 March 2016 was 12.53%. Persomics AB became an associate in the current financial year. Refer to note 8.
** Country of incorporation is Sweden

NOTES TO THE

Annual financial statements

FOR THE YEAR ENDED 31 MARCH 2017

	GROUP		CSIR	
	2017 R'000	2016 R'000	2017 R'000	2016 R'000

11. TRADE AND OTHER RECEIVABLES

Trade receivables	**234 207**	191 811	**234 202**	193 517
Prepaid expenditure	**38 023**	48 305	**38 011**	48 295
Other receivables*	**9 693**	12 339	**9 659**	554
	281 923	252 455	**281 872**	242 366
Less non current portion: other receivables*	**(6 095)**	(1 750)	**(6 095)**	-
Current portion	**275 828**	250 705	**275 777**	242 366

Trade receivables are shown net of impairment losses. Refer to note 21 for more detail on trade receivables.

* Included in other receivables is an amount of R1,75 million (2016: R11,75 million) for the sale of an associate (refer to note 26.2). The initial payment of R10 million was received in April 2016 with the balance of R1,75 million being payable by 30 June 2019. Also included in other receivables is an amount of R7,52 million for the sale of Erf 1281 Summerstrand (refer to note 7).

12. INVENTORY AND CONTRACTS IN PROGRESS

Contracts in progress less provision for losses	**99 141**	104 184	**99 141**	104 184
Raw materials and consumables	**1 423**	1 782	**1 423**	1 782
	100 564	105 966	**100 564**	105 966

Estimates on contract in progress recognition are based on cost to completion, budgets and percentage of completion.
The cost of inventories recognised as an expense amounted to R12,03 million (2016: R10,94 million).

13. DEFERRED TAX

A subsidiary in the Group is in an assessed loss position and no deferred tax asset was raised for the assessed loss due to the uncertainty of the recoverability in future periods in respect of the carry forward of unused tax losses.

Opening balance	**7 453**	7 966
Assessed tax loss utilised for the year	**(136)**	(513)
Assessed tax loss carried forward	**7 317**	7 453

14. ADVANCES RECEIVED

Advances on contracts received from clients and stakeholders	**786 620**	800 202	**786 620**	800 202

	GROUP		CSIR	
	2017 R'000	2016 R'000	2017 R'000	2016 R'000

15. TRADE AND OTHER PAYABLES

Accounts payable and accruals	**386 431**	259 356	**386 389**	259 531
Salary related accruals	**62 180**	159 384	**62 180**	159 384
Forward exchange contracts	**-**	58	**-**	58
	448 611	418 798	**448 569**	418 973

16. OPERATING LEASE COMMITMENTS

Financial commitments under non-cancellable operating leases will result in the following payments falling due:

Within one year:	**4 787**	1 874	**4 787**	1 874
Land and buildings	**3 939**	1 104	**3 939**	1 104
Vehicles	**848**	770	**848**	770
Within two to five years:	**12 786**	1 669	**12 786**	1 669
Land and buildings	**11 576**	858	**11 576**	858
Vehicles	**1 210**	811	**1 210**	811
More than 5 years:	**12 764**	-	**12 764**	-
Land and buildings	**12 764**	-	**12 764**	-

Agreements relating to operating lease payments for vehicles vary from three to four years and payments are fixed for the term of the agreements.

The CSIR leases buildings under operating leases. The lease periods vary from one to 10 years. The leases have varying terms, escalation clauses and renewal rights. On renewal, the terms of the leases are renegotiated. Not included in the above commitments are rental payment amounts which are contingent on market rates.

The CSIR leases a number of properties at nominal rental amounts. The lease periods vary from 25 to 99 years.

NOTES TO THE

Annual financial statements

FOR THE YEAR ENDED 31 MARCH 2017

17. RETIREMENT BENEFITS OF EMPLOYEES

17.1 CSIR Pension Fund

The fund is registered in terms of the Pension Funds Act, 1956, and is a defined contribution plan. The CSIR's liability to the fund was limited to paying the employer contributions up until 29 February 2016. The impact of the tax reform effective from 1 March 2016 is that the CSIR package structure was changed to reflect all retirement fund contributions as employee contributions. All the CSIR's permanent employees are members of the fund.

Employer contributions of R nil (2016: R92,3 million) and employee contributions of R180 million (2016: R68,4 million) were expensed during the year.

17.2 Associated Institutions Pension Fund (AIPF)

The fund is a defined benefit plan. The formula used to determine pensions is based on the pensionable earnings of the final year, and the aggregate period of uninterrupted membership.

The CSIR has one employee (2016: one employee) who is a member of the AIPF as at 31 March 2017. The fund is controlled by the state, which has assumed responsibility for the unfunded portions of these funds.

Employer contributions of R nil (2016: R6 460) and employee contributions of R12 201 (2016: R5 016) were expensed during the year.

17.3 Post-retirement medical benefits

The CSIR has a post-retirement medical benefit obligation to certain qualifying retired CSIR employees (pensioners) that joined the CSIR prior to 30 September 1996. An offer was made to qualifying pensioners in December 2005 to accept an annuity, payable from an independent source, equivalent to the value of their medical subsidy. The pensioners who accepted the offer are no longer entitled to a subsidy from the CSIR.

The accumulated benefit obligation and the annual cost of accrual of benefits are assessed by independent, qualified actuaries using the projected unit credit method. The estimated present value of the anticipated expenditure for the remaining 18 continuation members (2016: 18 continuation members) was recalculated by the actuaries as at 31 March 2017 and will be funded through cash and cash equivalents. These cash and cash equivalents have not been set aside specifically for this benefit.

17. RETIREMENT BENEFITS OF EMPLOYEES (CONTINUED)

The amount included in the statement of financial position arising from the CSIR's obligation in respect of post-retirement medical benefits is as follows:

	GROUP		CSIR	
	2017 R'000	2016 R'000	2017 R'000	2016 R'000
Present value of obligations	**10 764**	10 695	**10 764**	10 695
Net liability on statement of financial position	**10 764**	10 695	**10 764**	10 695

Amounts recognised in the statement of comprehensive income in respect of the scheme are as follows:

Interest cost	**995**	785	**995**	785
Actuarial gain recognised during the year	**(926)**	(704)	**(926)**	(704)
	69	81	**69**	81

Movement in the net liability recognised in the statement of financial position is as follows:

Net liability at the beginning of the year	**10 695**	10 614	**10 695**	10 614
Movement for the year	**69**	81	**69**	81
Net expense recognised in the statement of comprehensive income	**69**	81	**69**	81
Net liability at the end of the year	**10 764**	10 695	**10 764**	10 695

Principal actuarial assumptions at the reporting date:				
Discount rate at 31 March	**8.70%**	9.30%	**8.70%**	9.30%
Medical inflation costs	**7.20%**	8.30%	**7.20%**	8.30%

The above results are sensitive to changes in the assumed future rate of medical inflation.

The effect of a one percent increase in the assumed future rate of medical inflation would have the following effects:				
Effect on defined benefit obligation	**660**	689	**660**	689
The effect of a one percent decrease in the assumed future rate of medical inflation would have the following effects:				
Effect on defined benefit obligation	**(601)**	(626)	**(601)**	(626)

The above sensitivity analyses are based on a change in an assumption while all other assumptions are assumed to remain unchanged. This may not always be realistic as some of the assumptions tend to be correlated. When calculating the sensitivity of the defined benefit obligation to significant actuarial assumptions the same method (present value of the defined benefit obligation calculated with the projected unit credit method at the end of the reporting period) has been applied as when calculating the liability recognised within the statement of financial position.

NOTES TO THE

Annual financial statements

FOR THE YEAR ENDED 31 MARCH 2017

17. RETIREMENT BENEFITS OF EMPLOYEES (CONTINUED)

Historical information (R'000):	2017	2016	2015	2014	2013
Present value of the defined benefit obligation	**10 764**	10 695	10 614	9 772	10 347
Deficit in the plan	**10 764**	10 695	10 614	9 772	10 347

The average term (undiscounted) of the defined benefit obligation is 9.6 years (2016: 10.5 years) and the average duration (discounted) of the defined benefit obligation is 6.5 years (2016: 6.8 years).

18. BOARD MEMBERS, DIRECTORS AND EXECUTIVE MANAGEMENT'S REMUNERATION

2017							
			Managerial services				
	Entity	Fees for services as director	Basic salary	Bonuses and performance-related payments	Retirement fund and medical aid contributions*	Accrued leave	Total
		R'000	R'000	R'000	R'000	R'000	R'000
Board members and Executive Directors							
Dr TH Dlamini (from February 2017)	CSIR	-	728	-	-	-	**728**
Dr SP Sibisi (until September 2016) **	CSIR	-	2 459	1 752	-	254	**4 465**
Non-executive Board members							
Adv. G Badela	CSIR	115	-	-	-	-	**115**
Ms P Baleni	CSIR	-	-	-	-	-	**-**
Dr PH Goyns	CSIR	174	-	-	-	-	**174**
Dr A Llobell	CSIR	90	-	-	-	-	**90**
Professor T Majozi	CSIR	308	-	-	-	-	**308**
Dr R Masango	CSIR	128	-	-	-	-	**128**
Ms M Maseko	CSIR	92	-	-	-	-	**92**
Mr J Netshitenzhe	CSIR	131	-	-	-	-	**131**
Ms A Noah	CSIR	63	-	-	-	-	**63**
Professor M Phakeng	CSIR	150	-	-	-	-	**150**
Executive Management							
Dr RK Chikwamba	CSIR	-	2 534	788	-	-	**3 322**
Mr JPL Cloete	CSIR	-	2 696	835	-	-	**3 531**
Dr M Motuku ***	CSIR	-	2 815	835	-	-	**3 650**
Mr CR Sturdy	CSIR	-	2 750	867	-	-	**3 617**
Mr RM Zondo	CSIR	-	2 563	795	-	-	**3 358**
2017		**1 251**	**16 545**	**5 872**	**-**	**254**	**23 922**

18. BOARD MEMBERS, DIRECTORS AND EXECUTIVE MANAGEMENT'S REMUNERATION (CONTINUED)

2016							
			Managerial services				
	Entity	Fees for services as director	Basic salary	Bonuses and performance-related payments	Retirement fund and medical aid contributions*	Accrued leave	Total
		R'000	R'000	R'000	R'000	R'000	R'000
Board members and Executive Directors							
Dr SP Sibisi	CSIR	-	3 877	2 035	581	-	6 493
Non-executive Board members							
Adv. G Badela	CSIR	157	-	-	-	-	157
Ms P Baleni	CSIR	-	-	-	-	-	-
Dr PH Goyns	CSIR	153	-	-	-	-	153
Dr A Llobell	CSIR	61	-	-	-	-	61
Professor T Majozi	CSIR	135	-	-	-	-	135
Dr R Masango	CSIR	92	-	-	-	-	92
Ms M Maseko	CSIR	75	-	-	-	-	75
Mr J Netshitenzhe	CSIR	92	-	-	-	-	92
Ms A Noah	CSIR	51	-	-	-	-	51
Professor M Phakeng	CSIR	167	-	-	-	-	167
Executive Management							
Dr RK Chikwamba	CSIR	-	2 176	716	145	-	3 037
Mr JPL Cloete ****	CSIR	-	2 356	754	164	66	3 340
Ms GA Huma (from May 2015 to March 2016)	CSIR	-	1 904	-	154	-	2 058
Dr M Motuku	CSIR	-	2 325	554	184	-	3 063
Mr CR Sturdy	CSIR	-	2 249	1 007	360	-	3 616
Mr RM Zondo	CSIR	-	2 212	660	201	-	3 073
Subsidiaries							
Non-executive Board member:							
Mr M Sibanda (until October 2015)	Technifin SOC Ltd	-	-	-	-	-	-
2016		983	17 099	5 726	1 789	66	25 663

* The impact of the tax reform effective from 1 March 2016 is that the CSIR package structure was changed to reflect all retirement fund contributions as employee contributions. From 1 March 2016 all retirement fund contributions are thus included in the basic salary category for disclosure purposes.

** Accrued leave paid out at end of contract

*** Acting CEO for the period October 2016 to January 2017

**** The approved changes to the CSIR conditions of service, effective 1 April 2013, resulted in amendments to leave days and the accumulation of leave. Leave accrued as at 1 April 2013 had to be utilised or sold within 2 years.

NOTES TO THE

Annual financial statements

FOR THE YEAR ENDED 31 MARCH 2017

	GROUP		CSIR	
	2017 R'000	2016 R'000	2017 R'000	2016 R'000

19. CONTINGENT LIABILITIES AND FACILITIES

Local and foreign payment and performance guarantees issued as at 31 March	**26 416**	13 684	**26 416**	13 684

The CSIR has a borrowing plan approved by the Minister of Finance to issue performance bonds, local and foreign advance payment guarantees and carnets.

Legal costs and litigation

In the nature of the CSIR's business, agreements with complex deliverables may be entered into. All necessary steps are taken to manage the risks inherent to these transactions. If and when it is evident that there is a reasonable probability that a dispute on a transaction could lead to costs against the CSIR, such costs will be disclosed.

20. CAPITAL COMMITMENTS

Property, plant and equipment	**36 332**	37 608	**36 332**	37 608

This capital expenditure is to be financed from internal sources.

21. FINANCIAL INSTRUMENTS

The Group has exposure to the following risks from its use of financial instruments:

- market risk
- credit risk
- liquidity risk.

This note presents information about the Group's exposure to each of the above risks and the Group's objectives, policies and processes for measuring and managing risk. Further quantitative disclosures are included throughout these consolidated financial statements.

The Board has overall responsibility for the establishment and oversight of the Group's risk management framework.

The Group's risk management policies are established to identify and analyse the risks faced by the Group, to set appropriate risk limits and controls, and to monitor risks and adherence to limits. Risk management policies and systems are reviewed regularly to reflect changes in market conditions and the Group's activities. The Group, through its training and management standards and procedures, aims to develop a disciplined and constructive control environment in which all employees understand their roles and obligations.

The Audit and Risk Committee oversees how management monitors compliance with the Group's risk management policies and procedures and reviews the adequacy of the risk management framework in relation to the risks faced by the Group. The Group Audit and Risk Committee is assisted in its oversight role by Internal Audit. Internal Audit undertakes both regular and ad hoc reviews of risk management controls and procedures, the results of which are reported to the Audit and Risk Committee.

21. FINANCIAL INSTRUMENTS (CONTINUED)

21.1 Market risk

Market risk is the risk that changes in market prices, such as foreign exchange rates and interest rates will affect the Group's income or the value of its holdings of financial instruments. The objective of market risk management is to manage and control market risk exposures within acceptable parameters, while optimising the return.

Foreign currency risk

The Group is exposed to currency risk on sales and purchases that are denominated in a currency other than the respective functional currency of the Group entities.

The Group enters into forward exchange contracts to buy specified amounts of foreign currencies in the future at a predetermined exchange rate.

Forward exchange contracts are entered into mainly to cover import orders. The Group has no policy to enter into forward exchange contracts for anticipated foreign receipts. The Group does not use derivative financial instruments for speculative purposes.

The Group's exposure to foreign currency risk was as follows:

	31 March 2017					
	Total R'000	ZAR R'000	EURO R'000	USD R'000	GBP R'000	Other R'000
Trade receivables	**234 207**	195 472	1 716	32 851	2 831	1 337
Bank accounts	**205 736**	41 420	7 326	140 611	11 952	4 427
Trade and other payables	**(448 611)**	(445 404)	(119)	(1 721)	-	(1 367)
Gross statement of financial position exposure	**(8 668)**	(208 512)	8 923	171 741	14 783	4 397
Forward exchange contracts	**-**	-	-	-	-	-
Net exposure	**(8 668)**	**(208 512)**	**8 923**	**171 741**	**14 783**	**4 397**

	31 March 2016					
	Total R'000	ZAR R'000	EURO R'000	USD R'000	GBP R'000	Other R'000
Available-for-sale financial asset	6 177	-	-	-	-	6 177
Trade receivables	191 811	163 048	206	27 457	922	178
Bank accounts	187 442	49 525	17 788	100 287	9 676	10 166
Trade and other payables	(418 798)	(409 196)	(5 903)	(965)	(2 062)	(672)
Gross statement of financial position exposure	(33 368)	(196 623)	12 091	126 779	8 536	15 849
Forward exchange contracts	(6 941)	-	(6 941)	-	-	-
Net exposure	(40 309)	(196 623)	5 150	126 779	8 536	15 849

NOTES TO THE

Annual financial statements

FOR THE YEAR ENDED 31 MARCH 2017

21. FINANCIAL INSTRUMENTS (CONTINUED)

	GROUP	
	2017	2016
The following significant exchange rates applied during the year:		
	R	R
Average rate of forward exchange contracts: Euro	-	16.8579
Year-end spot rate:		
Euro	**14.3275**	16.8338
USD	**13.4123**	14.8208
GBP	**16.7489**	21.2941

Sensitivity analysis

A 10% strengthening of the rand against the following currencies at 31 March would have decreased profit or loss by the amounts shown below. This analysis assumes that all other variables remain constant. The analysis is performed on the same basis for 2016.

	R'000	R'000
Euro	**(892)**	(515)
USD	**(17 174)**	(12 678)
GBP	**(1 478)**	(854)
Other	**(440)**	(1 585)

A 10% weakening of the rand against the above currencies at 31 March would have had the equal but opposite effect on the above currencies to the amounts shown above, on the basis that all other variables remain constant.

Interest rate risk

Interest rate exposure and investment strategies are evaluated by management on a regular basis. Interest-bearing investments are held with several reputable banks in order to minimise exposure.

At the reporting date the interest rate profile of the Group's interest-bearing financial instruments was as follows:

	R'000	R'000
Fixed rate instruments: carrying amount		
Financial assets: Fixed deposits	**848 620**	764 940

The Group does not account for any fixed rate financial assets and liabilities at fair value through profit or loss, and the Group does not designate derivatives as hedging instruments under a fair value hedge accounting model. Therefore, a change in interest rates at the reporting date would not affect profit or loss.

21. FINANCIAL INSTRUMENTS (CONTINUED)

	GROUP	
	2017	2016
	R'000	R'000
Variable rate instruments: carrying amount		
Financial assets: Call deposits	**52 000**	58 000
Financial assets: Bank balances	**205 736**	187 442
	257 736	245 442

Sensitivity analysis

An increase of 100 basis points in interest rates at the reporting date would have increased equity and profit and loss by the amounts shown below. This analysis assumes that all other variables, in particular foreign currency rates, remain constant. The analysis is performed on the same basis for 2016.

Variable rate instruments	**2 577**	2 454

A decrease of 100 basis points would have had the equal but opposite effect to the amounts shown above.

21.2 Credit risk

Credit risk is the risk of financial loss to the Group if a customer or counterparty to a financial instrument fails to meet its contractual obligations, and arises principally from the Group's bank balances and deposits, trade and other receivables and loans to joint ventures, associates and subsidiaries.

Trade and other receivables and loans to joint ventures, associates and subsidiaries

Trade and other receivables and loans to joint ventures, associates and subsidiaries are presented net of impairment losses. Credit risk with respect to trade receivables is limited due to the large number of customers comprising the Group's customer base and their dispersion across different industries and geographical areas.

Bank balances and deposits

The Group's bank balances and cash are placed with high credit, quality financial institutions with no significant exposure to any one financial institution.

Guarantees

Refer to note 19 for details on bank guarantees issued with respect to facilities.

NOTES TO THE

Annual financial statements

FOR THE YEAR ENDED 31 MARCH 2017

21. FINANCIAL INSTRUMENTS (CONTINUED)

	GROUP	
	2017	2016
	R'000	R'000
Exposure to credit risk		
The carrying amount of financial assets represents the maximum credit exposure.		
The maximum exposure to credit risk at the reporting date was:		
Available-for-sale financial asset	-	6 177
Current fixed deposits	848 620	764 940
Call deposits	52 000	58 000
Bank balances	205 736	187 442
Cash on hand and cash deposits	118	2 497
Trade and other receivables	281 923	252 455
Contracts in progress less provision for losses	99 141	104 184
	1 487 538	1 375 695
The maximum exposure to credit risk for trade receivables at the reporting date by type of customer was:		
Local public sector	143 065	127 151
Local private sector	52 551	32 511
International sector	38 591	32 149
	234 207	191 811

The Group's most significant customers are various local public sector customers.

The ageing of the Group's trade receivables at the reporting date was:

	2017		2016	
	Gross	Impairment	Gross	Impairment
	R'000	R'000	R'000	R'000
Not past due	149 485	706	113 416	3 007
Past due 0 - 30 days	32 342	12	49 383	770
Past due 31 - 120 days	23 385	1 030	28 666	2 534
Past due more than 120 days	38 342	7 599	26 127	19 470
	243 554	9 347	217 592	25 781

21. FINANCIAL INSTRUMENTS (CONTINUED)

	GROUP	
	2017	2016
	R'000	R'000
The movement in the allowance for impairment in respect of trade receivables during the year was as follows:		
Balance at 1 April	**25 781**	15 505
Movement for the year	**(16 434)**	10 276
Recoveries	**(12 151)**	(4 403)
Utilisation	**(8 811)**	(3 805)
New impairment allowances	**4 528**	18 484
Balance at 31 March	**9 347**	25 781

The allowance account in respect of trade receivables is used to record impairment losses unless the Group is satisfied that no recovery of the amount owing is possible; at that point the amount considered irrecoverable is written off against the financial asset directly.

The fully performing trade receivables are considered to be of high credit quality.

21.3 Liquidity risk

Liquidity risk is the risk that the Group will not be able to meet its financial obligations as these fall due. The Group's approach to managing liquidity is to ensure, as far as possible, that it will always have sufficient liquidity to meet its liabilities when due, under both normal and stressed conditions, without incurring unacceptable losses or risking damage to the Group's reputation.

The Group monitors its cash flow on a daily basis. Typically, the Group ensures that it has sufficient cash on demand to meet expected operational expenses for a period of 60 days, including the servicing of financial obligations; this excludes the potential impact of extreme circumstances that cannot be predicted reasonably, such as natural disasters.

NOTES TO THE

Annual financial statements

FOR THE YEAR ENDED 31 MARCH 2017

21. FINANCIAL INSTRUMENTS (CONTINUED)

The following are the contractual maturities of financial liabilities, including interest payments and excluding the impact of netting agreements for the Group:

	2017			2016		
	Carrying amount	Contractual cash flows		Carrying amount	Contractual cash flows	
		6 months or less	6 - 12 months		6 months or less	6 - 12 months
	R'000	R'000	R'000	R'000	R'000	R'000
Non-derivative financial liabilities						
Trade and other payables	**(448 611)**	**(448 611)**	**-**	(418 740)	(418 740)	-
Derivative financial liabilities						
Forward exchange contracts	**-**	**-**	**-**	(58)	(6 999)	-
	(448 611)	**(448 611)**	**-**	(418 798)	(425 739)	-

	2017	2016
Rate of forward exchange contracts:	R	R
Euro	-	16.9994

21.4 Fair values

At 31 March 2017 the carrying amount of bank balances and cash, deposits, trade and other receivables, contracts in progress and trade and other payables approximated their fair values due to the short-term maturities of these assets and liabilities.

Basis for determining fair values

Trade and other receivables and trade and other payables

The fair value of trade and other receivables and trade and other payables is calculated based on the present value of future cash flows, discounted at the average return on investment rate at the reporting date.

Forward exchange contracts

The fair value of forward exchange contracts is determined using forward exchange rates at the Statement of Financial Position date, with the resulting value discounted back to present value.

21.5 Fair value hierarchy

The table below analyses financial instruments carried at fair value, by valuation method. The different levels have been defined as follows:

Level 1: quoted prices (unadjusted) in active markets for identical assets or liabilities.

Level 2: inputs other than quoted prices included within Level 1 that are observable for the asset or liability, either directly (as prices) or indirectly (derived from prices).

Level 3: inputs for the asset or liability that are not based on observable market data (unobservable inputs).

	Level 1	Level 2	Level 3	Total
31 March 2017				
Forward exchange contracts	**-**	**-**	**-**	**-**
31 March 2016				
Forward exchange contracts	-	(58)	-	(58)

	GROUP		CSIR	
	2017 R'000	2016 R'000	2017 R'000	2016 R'000

22. RECONCILIATION OF OPERATING PROFIT TO CASH GENERATED FROM OPERATING ACTIVITIES

Operating profit for the year before taxation	**94 698**	52 736	**94 608**	58 982
Adjusted for:				
Profit on disposal of interest in associate	**-**	(1 834)	**-**	-
Depreciation	**61 745**	54 514	**61 744**	54 503
Net unrealised foreign exchange (gain)/loss	**(1 996)**	14 145	**(1 996)**	14 145
Net finance income	**(44 205)**	(40 410)	**(43 617)**	(39 970)
Post-retirement medical benefits	**995**	785	**995**	785
Straight-lining adjustment of operating leases	**5**	(18)	**5**	(18)
Leave accrual	**14 111**	3 421	**14 111**	3 421
(Reversals of impairments)/impairments	**(16 923)**	10 339	**(15 282)**	1 811
Profit on disposal and write-off of property, plant and equipment	**(38 422)**	(1 459)	**(38 422)**	(1 459)
Share of loss/(profit) of joint ventures and associates	**1 833**	(2 193)	**-**	-
Bad debt written off	**3 645**	2 511	**3 645**	2 511
Operating profit before changes in working capital	**75 486**	92 537	**75 791**	94 711
(Increase)/decrease in trade and other receivables	**(19 247)**	9 075	**(27 535)**	7 276
Decrease/(increase) in inventory and contracts in progress	**3 379**	(509)	**3 379**	(509)
(Decrease)/increase in advances received	**(16 504)**	28 314	**(16 504)**	28 314
Increase/(decrease) in trade and other payables	**15 698**	(30 721)	**15 480**	(30 663)
Net working capital changes	**(16 674)**	6 159	**(25 180)**	4 418
Cash generated from operating activities	**58 812**	98 696	**50 611**	99 129

23. CASH AND CASH EQUIVALENTS

Fixed deposits	**848 620**	764 940	**844 394**	761 000
Call deposits	**52 000**	58 000	**50 000**	56 000
Bank balances	**205 736**	187 442	**204 612**	185 744
Cash on hand and cash deposits	**118**	2 497	**118**	2 497
	1 106 474	1 012 879	**1 099 124**	1 005 241

NOTES TO THE

Annual financial statements

FOR THE YEAR ENDED 31 MARCH 2017

24. RELATED PARTY TRANSACTIONS

The CSIR is a schedule 3B National Government Business Enterprise in terms of the Public Finance Management Act, Act 1 of 1999 as amended by Act 29 of 1999, and therefore falls within the national sphere of government. As a consequence, the CSIR has a significant number of related parties, being entities that fall within the national and provincial sphere of government. Amounts due from/to these entities are subject to the same terms and conditions as normal trade receivables and trade payables. For detail on individually significant transactions refer to notes 2 and 3.

In addition, the CSIR has a related party relationship with its subsidiaries (see Addendum A) and joint ventures and associates (see note 8). Unless specifically disclosed, these transactions are concluded at arm's length and the Group is able to transact with any entity.

24.1 Transactions with related parties

The following is a summary of transactions with related parties during the year and balances due at year-end:

	GROUP		CSIR	
	2017 R'000	2016 R'000	2017 R'000	2016 R'000
Constitutional institutions				
Services received	-	5	-	5
Major public entities				
Services rendered	369 041	369 137	369 041	369 137
Services received	32 604	192 269	32 604	192 269
Amount due from	37 009	19 806	37 009	19 806
National public entities				
Services rendered	118 209	135 517	118 209	135 517
Services received	7 537	15 340	7 537	15 340
Amount due from	22 095	13 065	22 095	13 065
National government business enterprises				
Services rendered	6 275	5 311	6 275	5 311
Services received	1 488	4 629	1 488	4 629
Amount due from	664	557	664	557
Provincial public entities				
Services rendered	4 800	1 136	4 800	1 136
Amount due from	1 457	-	1 457	-
Provincial government business enterprises				
Services rendered	-	2 886	-	2 886
Services received	22	30	22	30
Amount due (to)/from	(16)	2 538	(16)	2 538

	GROUP		CSIR	
	2017 R'000	2016 R'000	2017 R'000	2016 R'000

24. RELATED PARTY TRANSACTIONS (CONTINUED)

Government departments				
Services rendered	**1 791 895**	1 764 009	**1 791 895**	1 764 009
Services received	**256**	2 665	**256**	2 665
Amount due from	**74 993**	71 889	**74 993**	71 889
Subsidiaries				
Services rendered	**-**	-	**142**	1 997
Services received	**-**	-	**13**	92
Amount due (to)/from	**-**	-	**(13)**	1 454
Joint ventures and associates				
Services rendered	**205**	2 322	**197**	2 099
Services received	**-**	1 032	**-**	970
Amount due from	**3**	-	**-**	-

24.2 Transactions with key management

Total remuneration of key management is included in employees' remuneration (refer to note 18 for Executive Management's remuneration).

25. IRREGULAR AND FRUITLESS AND WASTEFUL EXPENDITURE

25.1 Irregular expenditure

Opening balance	**-**	117	**-**	117
Irregular expenditure relating to the 2015/16 financial year:				
- Payment prior to signing of contract *	**920**	-	**920**	-
Amounts condoned	**-**	(117)	**-**	(117)
Irregular expenditure awaiting condonation	**920**	-	**920**	-

* Contract was subsequently signed and no loss was incurred by the CSIR.

25.2 Fruitless and wasteful expenditure

Fruitless and wasteful expenditure of R6 997 was incurred due to a customs penalty levied.

NOTES TO THE

Annual financial statements

FOR THE YEAR ENDED 31 MARCH 2017

26. DEREGISTRATION OF SUBSIDIARIES AND DISPOSAL OF INTEREST IN ASSOCIATE

	GROUP 2017 R'000	GROUP 2016 R'000
26.1 Accredited Spatial Knowledge Network (Pty) Ltd		
The Group held 100% of the issued share capital in Accredited Spatial Knowledge Network (Pty) Ltd. The company was deregistered on 21 July 2016.		
The net assets of Accredited Spatial Knowledge Network (Pty) Ltd on deregistration were as follows:		
Net asset value disposed	-	-
Total consideration	-	-
Net cash outflow arising on deregistration of interest in subsidiary		
Bank balance and cash disposed	-	-
26.2 Uvirco Technologies (Pty) Ltd		
The Group held 45% of the issued share capital in Uvirco Technologies (Pty) Ltd. The shares held were sold effective 15 March 2016.		
Carrying amount of Uvirco Technologies (Pty) Ltd on date of disposal		9 916
Profit on disposal		1 834
Proceeds on disposal		11 750
26.3 Citizens Information Services (Pty) Ltd		
The Group held 100% of the issued share capital in Citizens Information Services (Pty) Ltd. The company was deregistered on 16 September 2015.		
The net assets of Citizens Information Services (Pty) Ltd on deregistration were as follows:		
Net asset value disposed		-
Total consideration		-
Net cash outflow arising on deregistration of interest in subsidiary		
Bank balance and cash disposed		-
26.4 Ulwazi Biotech (Pty) Ltd		
The Group held 100% of the issued share capital in Ulwazi Biotech (Pty) Ltd. The company was deregistered on 10 March 2016.		
The net assets of Ulwazi Biotech (Pty) Ltd on deregistration were as follows:		
Net asset value disposed		-
Total consideration		-
Net cash outflow arising on deregistration of interest in subsidiary		
Bank balance and cash disposed		-

27. AGRéMENT SOUTH AFRICA

Agrément South Africa has been established as a separate entity. The Department of Public Works has indicated to the CSIR that all activities of Agrément South Africa are to be transferred to the new entity in the 2017/18 financial year.

	GROUP 2017 R'000
Profit attributable to Agrément South Africa is as follows:	
Revenue	15 140
Employees' remuneration	(7 866)
Operating expenses	(6 699)
Profit for the year	575
Assets and liabilities attributable to Agrément South Africa are as follows:	
Assets	
Non-current assets	471
Property, plant and equipment	471
Current assets	4 959
Trade and other receivables	173
Inventory and contracts in progress	-
Bank balances and cash on hand	4 786
Total assets	5 430
Equity and liabilities	
Reserves	1 419
Retained earnings	1 419
Current liabilities	4 011
Advances received	3 131
Trade and other payables	880
Total equity and liabilities	5 430

ADDENDUM A

Interest in subsidiaries

31 MARCH 2017

Consolidated subsidiaries	Interests of the CSIR						
	Country of incorporation	Issued capital	Effective holding		Financial year-end	Shares at cost less accumulated impairment losses	
		R'000	2017 %	2016 %		2017 R'000	2016 R'000
Direct investments							
Technology Finance Corporation SOC Ltd (Technifin)	South Africa	**5 200**	**100**	100	31 March	**4 650**	4 650
Technovent SOC Ltd	South Africa	**5 000**	**100**	100	31 March	**-**	-
						4 650	4 650

The Group has an interest in one dormant company. Details of this interest is available at the CSIR's registered office.

Interests of the CSIR				
Net indebtedness less accumulated impairment losses by subsidiaries		Net investment		General nature of business
2017 R'000	2016 R'000	2017 R'000	2016 R'000	
-	-	**4 650**	4 650	The commercialisation of patents, which are being developed at the CSIR, and on which royalties are earned based on the utilisation of the rights by external companies, either local or international.
786	11 403	**786**	11 403	The provision of financial services to the CSIR subsidiaries and joint ventures.
786	11 403	**5 436**	16 053	

KNOWLEDGE DISSEMINATION

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New international patents granted

Patent title	Patent number	Country
A method of calibrating a camera and a system therefor	9,330,463	United States
A method of calibrating a camera and a system therefor	2 013 141 224	Russian Federation
Aileron actuation mechanism to eliminate control reversal (wing control)	2605962	EPO-European Patent Office
Aileron actuation mechanism to eliminate control reversal (wing control)	9,434,468	United States
Bio-based composite panels	2788409	EPO-European Patent Office
Compounds and extracts for use in the treatment of malaria (cycloguanil)	2464353	EPO-European Patent Office
Cross pavement carrier	9,321,474	United States
Dendrispheres - Protein binding to polymer	9,574,054	United States
Diagnosis of TB	AP3990	ARIPO
Emulsion-derived particles	2205662	EPO-European Patent Office
Inhibition of the activity of kinase and synthetase enzymes - Kinase inhibitors	2516668	EPO-European Patent Office
Method for converting aloeresin to aloesin	9,434,710	United States
Method of operating a laser and laser apparatus using intra-cavity digital holograms	9,588,488	United States
Titanium powder production process	113145	Ukraine
Treatment of erectile dysfunction and libido enhancement	2037913	EPO-European Patent Office

Abbreviations

3D	Three-dimensional
AHRLAC	South African-developed Advanced High-performance Reconnaissance Light Aircraft
AIPF	Associated Institutions Pension Fund
AISI	Aerospace Industry Support Initiative
ALC	African Laser Centre
B-BBEE	Broad-based Black Economic Empowerment
BIDC	Biomanufacturing Industry Development Centre
BPO	Business Process Outsourcing
CHPC	Centre for High Performance Computing
CoJ	City of Johannesburg
CSIR	Council for Scientific and Industrial Research
DEA	Department of Environmental Affairs
DRDLR	Department of Rural Development and Land Reform
DSIDE	Data Science for Impact and Decision Enhancement
DST	Department of Science and Technology
DWA	Department of Water Affairs
EME	Enrobé à Module Elevé
EPO	European Patent Office
FCTR	Foreign currency translation reserve
FMD	Foot-and-mouth disease
GBP	Great British Pound
GDP	Gross domestic product
GWh	Gigawatt hour
HCD	Human Capital Development
HiMA	High Modulus Asphalt
HIV	Human Immunodeficiency Virus
IAS	International Accounting Standards
IASB	International Accounting Standards Board
ICASA	Independent Communications Authority of South Africa
ICT	Information and Communications Technology
IEE	Industrial Energy Efficiency
IESBA	International Ethics Standards Board for Accountants
IFRS	International Financial Reporting Standards
IIPF	Industry Innovation Partnership Fund
IMT	Institute of Maritime Technology
iPSC	induced Pluripotent Stem Cell
IT	Information technology
KRA	Key results area
KPI	Key Performance Indicator
MISA	Municipal Infrastructure Management Agency
NCPC-SA	National Cleaner Production Centre of South Africa
NDP	National Development Plan
NFV	Network Function Virtualisation
NHLS	National Health Laboratory Service
NQF	National Qualifications Framework
NSTF	National Science and Technology Forum
OCIMS	Oceans Coastal Information Management System
OPC	Ordinary Portland Cement
PAA	Public Audit Act
PASA	Payment Association of South Africa
PFMA	Public Finance Management Act
PhD	Doctor of Philosophy
PV	Photovoltaic
R&D	Research and Development
RDI (also RD&I)	Research, Development and Innovation
RTMC	Road Traffic Management Corporation
SAICA	South African Institute of Chartered Accountants
SAMERDI	South African Mining Extraction Research, Development and Innovation
SANBio	Southern Africa Network for Biosciences
SANDF	South African National Defence Force
SANParks	South African National Parks
SANReN	South African National Research Network
SAQA	South African Qualifications Authority
SAR	Satellite Aperture Radar
SASSA	South African Social Security Agency
SDN	Software-defined networking
SET	Science, engineering and technology
SKA	Square Kilometre Array
SMME	Small, Medium and Micro Enterprise
SOE	State-owned entity
TiCoC	Titanium Centre of Competence
TV	Television
TVWS	Television Whitespaces
UK	United Kingdom
USD	United States Dollar
WASA	Wind Atlas for South Africa
WWTWs	Wastewater treatment works

Notes

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