

Research strengthens the Faculty's innovation capacity

Research is one of the core activities of the Faculty of Engineering, Built Environment and Information Technology at the University of Pretoria, and contributes to its positioning as one of the top faculties of its kind in the country. Several new research centres, institutes and units have been developed over the past few years to supplement the Faculty's vast research capacity. Some of these research entities and centres of excellence are featured in the following pages.

SARChI chairs

The South African Research Chairs Initiative (SARChI) forms part of the human and institutional capacity development programme of the National Research Foundation (NRF). Its main goal is to strengthen and improve the research and innovation capacity of public universities to produce high-quality postgraduate students, research and innovation outputs. The Faculty has been awarded four research chairs under SARChI.

SARChI Chair in Artificial Intelligence

The main research focus of this chair is computational intelligence, with a particular emphasis on computational swarm intelligence, learning from zero knowledge using competitive coevolution and evolutionary algorithms. The research team, under the leadership of A-rated researcher Prof Andries Engelbrecht, has developed an open-source library of computational intelligence algorithms, which is increasingly being used internationally.

SARChI Chair in Carbon Technology and Materials

The main research focus areas of this chair are nuclear graphite, the fabrication and characterisation of new carbon/graphite materials, composites and thermal materials, graphite

oxidation and nano-carbon, with the emphasis on graphene research, which includes synthesis and characterisation, as well as applications to photovoltaic and energy storage as super capacitors and graphene/ conducting polymer composites as gas sensors. This multidisciplinary research chair was awarded to the University of Pretoria in 2006, and is now in its second five-year term as part of SARChI.

SARChI Chair in Fluoro-materials Science and Process Integration

This chair was established in 2007 and has been functioning in the Institute of Applied Materials since 2010. Current research includes the development of a fluoro-polymer capability

in South Africa. The focus is on polytetrafluoroethylene (PTFE), polyvinylidene fluoride (PVDF), fluorinated ethylene propylene (FEP) and pulverised fuel ash (PFA). Other focus areas include the dry fluorination of inorganic materials, the modelling of fluorine electrolysis cells and various projects of interest to the Advanced Metals Initiative (AMI) relating to fluoride-based minerals processing, and high-temperature processes for the production of high-value products directly from fluorspar.

SARChI Chair in Advanced Sensor Networks

The main research focus of this chair, established in January 2015, is building research capacity in the area of advanced sensor networks, a modern and growing field, which is strategic to the economy. The first five years of the programme will target research on the mathematical aspects of wireless sensor networks (WSN), while the subsequent five-year programme will focus on hardware, test beds and implementation aspects. The applications to be considered will have major national interest, especially in the wildlife monitoring, soil and in-situ soil moisture analysis (for viticulture), home security, the monitoring of health infrastructure and human healthcare. (See article on page 33.)



The Faculty has been awarded four SARChI chairs.



The SARCHI Chair in Carbon Technology and Materials focuses on nuclear graphite, as well as the fabrication and characterisation of new carbon/graphite materials.

Industry-sponsored chairs

Support from industry enables the University to conduct cutting-edge research in specific fields, while providing postgraduate students the opportunity to be mentored by established researchers who are at the forefront of their research areas.

Electrical, electronic and computer engineering

In addition to the SARCHI Chair in Advanced Sensor Networks and the Sentech Chair in

Broadband Wireless Communications (featured in this issue), there are a number of other chairs in the Department of Electrical, Electronic and Computer Engineering that conduct research on a variety of aspects in this field, including power electronics, electronic defence research, microelectronics, electromagnetism, and telecommunications engineering for the information society.

CBI-electric: Low Voltage Chair in Power Electronics

The CBI-electric: Low Voltage Chair in Power

Electronics was launched in the Department in 2012. The chair is funded by CBI-electric: Low Voltage (previously known as Circuit Breaker Industries). It will initially support salaries, undergraduate and postgraduate bursaries and research project costs in the Department for a period of three years. Furthermore, CBI-electric: Low Voltage has sponsored power electronics and electrical equipment to the value of R140 000, which students will use for their design project work. It is envisaged that this partnership with CBI-electric will lead to further research and

product development, as well as human capital development.

Chair in Electronic Defence Research

The Chair in Electronic Defence Research was established with the support of the Council for Scientific and Industrial Research (CSIR) and undertakes research related to exploiting the electromagnetic spectrum to the maximum benefit of oneself and one's allies, and to the maximum detriment of one's adversaries. As such, it exploits all specialist fields within the general scope



→ *Prof Monuko du Plessis of the Carl and Emily Fuchs Institute for Microelectronics was nominated for the prestigious NSTF-BHB Billiton Awards for his work in 2015.*

of electrical, electronic and computer engineering. Current research topics include cross-eye jamming, automatic electronic warfare mission planning, sub-Nyquist sampling and low-cost training systems. Four webinars have been presented under the auspices of the Association of Old Crows (AOC), a major international association that focuses on electronic warfare and related fields. Furthermore, an international university has approached UP for information on establishing similar programmes there.

Carl and Emily Fuchs Institute for Microelectronics

The Carl and Emily Fuchs Institute for Microelectronics (CEFIM) has been active in the

field of microelectronics research and specialist training since 1981.

The research and postgraduate programme mainly covers integrated circuit design, especially the design of analogue signal processors, radio frequency circuits and optical receivers in complementary metal-oxide-semiconductor (CMOS) technology. The application of semiconductors as optoelectronic devices plays an important role in the institute's activities.

The injection-enhanced silicon in avalanche (INSiAVA) technology, which has been successfully commercialised by the University of Pretoria, was developed by a team led by CEFIM's Prof Monuko du Plessis. Prof Du Plessis

was nominated for the prestigious National Science and Technology Forum and Broken Hill Proprietary (NSTF-BHP) Billiton Awards for his work in 2015.

Centre for Electromagnetism

The Centre for Electromagnetism has comprehensive measurement facilities, and this research group, comprising a team of three researchers, has developed very strong computational abilities in various aspects of electromagnetism. The research of this centre is focused on achieving a high level of excellence in electromagnetic technology, particularly in the design, development and evaluation of microwave antennae, radar backscatter and antenna measurements.

Various novel antenna-radiating elements have been developed, as well as feeding and matching techniques with specific application in wireless and array technology. The Director of the Centre, Prof Wimpie Odendaal, has contributed to the practical implementation of polarisation optimisation for conformal antenna arrays.

Centre for Telecommunications Engineering in an Information Society

The Centre for Telecommunications Engineering in an Information Society (CeTEIS) brings together a team of researchers from electronic engineering and computer science. It was established in 1997 with the support of Telkom, but also receives support from

other industry partners. Its research focuses on realising the vision of a totally connected planet, in which humans and machines are seamlessly interconnected, and where new applications, such as Smart City applications, become a reality for a better living. The Centre has been awarded a Technology and Human Resources for Industry Programme (THRIP) grant for a project entitled FutureCloud, which considers the unification of cloud computing, cloud communication and technology convergence, moving towards a future internet network.

Maintenance engineering and asset integrity management

The Centre for Asset Integrity Management (C-AIM) in the Department of Mechanical and Aeronautical Engineering was established in 2014 as a result of the cumulative growth of knowledge and expertise in asset management conducted in a number of research chairs and institutes in the Department. It benefits from long-term industry partnerships with companies like Eskom, Exxaro, Weir Minerals and Rand Water.

The Centre developed from a Centre of Excellence in Maintenance Engineering that was established in 2008 with industry support from Sasol, Eskom, Exxaro and Anglo American. The Centre was established to conduct research on aspects such as structural fatigue testing, experimental modal analysis and vibration modelling. In 2012, Eskom established a Specialist

Centre for Plant Asset Management as part of the Eskom Power Plant Engineering Institute (EPPEI) initiative, with a research focus on asset integrity management. This was followed by the establishment in 2014 of the Rand Water Chair in Mechanical Engineering, as well as a collaboration agreement with Weir Minerals to establish a research focus on machine condition monitoring.

The consolidation of the activities of these research chairs and institutes into a single centre has created a very interesting research environment in which highly technical issues pertaining to structural and machine failures and remaining useful life are integrated into well-founded management decisions.

Energy research

The University has for some years recognised the need to conduct focused research in the field of energy in an effort to address the energy crisis that is facing South Africa. It has therefore established a number of strong multidisciplinary research groups led by acknowledged international leaders, as well as industry-sponsored chairs. Research is conducted across a number of departments, including Electrical, Electronic and Computer Engineering, Mechanical and Aeronautical Engineering, Chemical Engineering, and Engineering and Technology Management, as well as in the Institute for Technological Innovation.



FutureCloud,
a project
of CeTEIS,
considers the
unification
of cloud
computing,
cloud
communi-
cation and
technology
convergence,
moving
towards
a future
internet
network.

National Hub for Postgraduate Programme in Energy Efficiency and Demand-side Management

The South African National Energy Development Institute (SANEDI) selected the University of Pretoria to house the Energy Efficiency and Demand-side Management (EEDSM) Hub. SANEDI, a subsidiary of CEF (Pty) Ltd, is a joint initiative of the Department of Science and Technology and the Department of Energy. SANEDI identifies energy efficiency and demand-side management as key research and development themes for South Africa. The EEDSM five-year postgraduate programme was initiated as one of the targeted, government-funded programmes to generate high-quality master's and doctoral graduates who are specifically trained to meet the needs of an expanding and sustainable energy industry in South Africa.

Centre of New Energy Systems

The Centre of New Energy Systems (CNES) is a research centre in the Department of Electrical, Electronic and Computer Engineering. It has gained a reputation as a premier research institute in the area of energy management, both nationally and internationally. It is the only Centre of Excellence in energy optimisation and standardisation in South Africa to address the research, education, development and industrial applications of energy optimisation and management. The focus on energy management

includes both supply-side and demand-side management. It collaborates with research centres on energy management both locally and internationally.

Exxaro Chair in Energy Efficiency

This chair was established in June 2012 with the industry support of Exxaro. It is hosted by the Centre of New Energy Systems. The mission of this chair is to participate in forefront research activities in the field of energy efficiency and to deliver world-class research and educational outputs for the benefits of Exxaro, the University of Pretoria, and South Africa in general. This chair is specifically devoted to addressing energy-efficiency problems of

industrial processes by modelling, optimisation, control and management techniques. The chair also aims to train suitably qualified engineers to solve practical engineering problems and work for the industry.

Institute for Technological Innovation

The research of the Institute for Technological Innovation (ITI) is focused on quantitative studies of science, technology and innovation policy, including assessments, international benchmarking and scientometrics. The ITI is particularly interested in multidisciplinary fields like energy and water. The ITI's research has been informing and initiating a number of policy actions in the country. Examples

include the introduction of tax incentives for research and development in the country, the linking of financial support to researchers who are rated by the NRF and the current recommendation in the draft intellectual property policy for the introduction of an examining approach in the country's patent system.



Clean Energy Research Group

The Department of Mechanical and Aeronautical Engineering has been active in research on energy systems – including thermoflow systems – since the early

1980s. Research areas originally focused on heating, ventilation, and air-conditioning (HVAC) systems and engines. Since the early 1990s, there has been a growing emphasis on computational research in the thermoflow field, with applications like electronics cooling and industrial computational fluid dynamics (CFD) gaining ground. These activities are currently balanced by a growing group in experimental heat transfer and CFD research. The applications of these research areas have been consolidated into a broader focus on clean energy systems and components. The research of the Clean Energy Research Group is currently focused on energy systems, renewable energy (solar, fuel cells, wind and ocean

Centre of Excellence for Nuclear and Radiation Safety

The National Nuclear Regulator (NNR) has taken the initiative to establish a Centre of Excellence for Nuclear and Radiation Safety at the University of Pretoria. This is mainly motivated by government's envisaged nuclear expansion programme. One of the important questions that the NNR and government will have to answer is: "Is the NNR ready and does it have the necessary infrastructure and resources to regulate all the future use of nuclear technology in South Africa. On 20 February 2015, a one-day workshop was held on the Hatfield Campus as an

initial interaction to verify the University's capabilities to host such a Centre of Excellence. The workshop was attended by the heads of various departments and other researchers. Prof Stephanie Burton, Vice-Principal: Research and Postgraduate Studies, and Prof Sunil Maharaj, Dean of the Faculty of Engineering, Built Environment and Information Technology, welcomed the delegation and presented the achievements and growth statistics of the University. The University's other delegates then presented their departments' individual



capabilities. The day was concluded by a visit to the various laboratories, with specific attention being paid to those that could potentially be of interest to the NNR.

The NNR plans to select and appoint the host partner institution and to appoint the Director of the NNR Centre for Nuclear Safety and Security (CNSS) by the end of November 2015. ➔

engineering), nuclear energy, energy efficiency and optimisation, heat exchangers, nanofluids, gas turbines and aerodynamics.

Water resource management

Research into water resource management is a focus area of both the Department of Chemical Engineering and the Department of Civil Engineering. The Water Utilisation and Environmental Engineering Division in the Department of Chemical Engineering is supported in its research activities by the Sedibeng Water Research Chair in Water Utilisation Engineering (featured in this issue), while the Department of Civil Engineering enjoys

the support of Rand Water for research into water purification, supply and utilisation-related science and engineering.

Rand Water Chair in Civil Engineering

This research chair was established in the Department of Civil Engineering in 2014, and is engaged in research on determining a change in the hydraulic capacity of pipelines.

This research, under the leadership of Prof Fanie van Vuuren, examined the elements to be considered in the hydraulic design of pipelines. The research team considered the recorded hydraulic performance of pipelines, secondary energy loss associated with the

dimensional details of the couplings, the adaptation of the friction formula to include the influence of biofilm growth, and the provision of monitoring points for the continuous or intermittent hydraulic assessment of the pipeline.

The research found it to be imperative that a periodic review of the hydraulic performance of conveyance systems be undertaken, which would be simplified if the design of water systems included sufficient access points on the system to measure flow and pressure.

Chemical engineering

The Department of Chemical Engineering is active in a number of specialist research fields.

These include the activities of the Environmental Engineering Group (see articles on pages 125–132), the Sedibeng Water Research Chair in Water Utilisation Engineering, the SARCHI Chair in Carbon Technology and Materials, the SARCHI Chair in Fluoromaterials Science and Process Integration and the Institute of Applied Materials (IAM).

The IAM performs applied research for the industry. It pursues research and development targets in carbon materials and chemical product design, including modelling multicomponent mixture properties, layered solids as functional additives for polymers, green pyrotechnics and combatting malaria transmission. ➔

Innovative research into water security receives award

Marco van Dijk of the University's Department of Civil Engineering, who has conducted groundbreaking work in the development of South Africa's first conduit hydropower facility (see article on page 59), has been recognised by the Water Research Commission (WRC).

On 17 September 2015, Van Dijk received the prestigious Knowledge Tree Award in the category New Products and Services for Economic Development. The award was made in recognition of the impact of his research, as well as his significant

contribution to water science and technology.

Water is essential for local development, particularly for sectors such as health, agriculture, economic development, education and the environment. However, 768 million people in the world do not have access to clean drinking water.

Van Dijk's research is closely aligned to the post-2015 Agenda, in which integrating universal access to drinking water and basic sanitation is a priority for the water



➔ *Dr Limakatso Moorosi, Chief Executive of Bloemwater (left), Mr Marco van Dijk (centre) and Mr Dhesigen Naidoo, CEO of the Water Research Commission.*

and sanitation sector worldwide. His particular research interests include hydropower development for rural electrification in South Africa, energy generation using low-head hydropower technologies,

and conduit hydropower implementation. He has compiled numerous technical reports and journal articles in the field of pipelines, hydropower generation and water distribution systems. ➔