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BIOENGINEERING

SAIEE THE OFFICIAL PUBLICATION OF THE SOUTH AFRICAN INSTITUTE OF ELECTRICAL ENGINEERS | **JANUARY 2016**

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GENERAL

REGULARS

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It's a new year. A fresh start. A new chapter in life, waiting to be written. New questions to be asked, new goals to be set and new things to try. Answers to be discovered and then to live in this transformative year of self-discovery.

We kick this year off with an absolutely informative and lip-smacking bumper issue on Bioengineering, with not 2 or 3, but a total of 4 feature articles!

Our first feature article, on page 22 features our BSc Student Project Competition winner, Josh Perry's presentation on the TAYObot – where robotics takes a leap!

With the current energy crisis we are experiencing in South Africa, smelters have to improve their efficiency. Ruan Murray and Prof Jan de Kock wrote a brilliant article on the potential in utilising furnace off-gas in South Africa (pg 26).

Bioengineering is so diverse that I will not have done it any justice without giving it a medical spin. Prof Johan Hanekom and Prof Tania Hanekom penned a brilliant article on Cochlear implants on page 34.

On page 40 you will find an article on bioengineering milestones in the last 50 years. This is one of the engineering disciplines that has saw the light only after WWII – which is truly remarkable.

Our SAIEE President mentions in his letter (pg 6) about a Neurosurgeon who operated on himself in order to find out how the brain works. I decided to publish this piece, which you will find on page 48.

Dudley Basson wrote an article on how sugarcane can be put to good use by harvesting the energy when it gets burnt. Read more on page 54.

Bioengineering has lengthened the lifespan of the human race with new inventions, mostly unheard of, being used to enhance our lives. To all the bioengineers out there – I salute you.

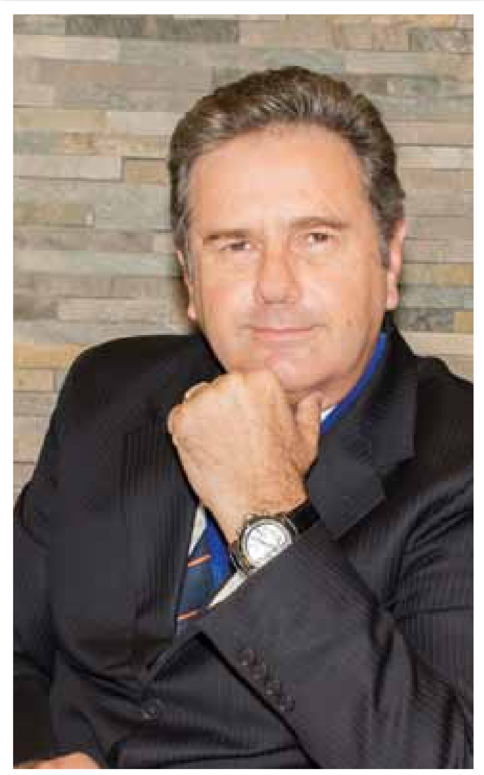
Herewith the January issue.

Enjoy a fruitful and joyous 2016!

Minx

Earn CPD Credits

Visit www.saiee.org.za to answer the questions related to these articles to earn your CPD points.



André Leo Hoffmann
2015 SAIEE President

I came across an article recently from the MIT Technology Review which piqued my interest.

The article covers the story of a Doctor who puts himself under the knife in order to better understand the brain. As one of the inventors of the brain-computer interfaces, he ended up getting one himself.

Phil Kennedy, a 67 year old Irish born neurologist and inventor, took the risky decision to go under the surgeon's knife himself, and to implant electrodes into his brain in order to establish a connection between a computer and his cerebral-cortex, and in particular the motor-cortex; that the part of the brain which originates the nerve impulses that initiate voluntary muscular activity. Kennedy was part of a team in the late 1980s which proposed invasive human brain interfaces, and he is widely accredited with allowing severely paralysed patients to be able to move a computer cursor just using their brain.

His aim was to build a speech decoder that would translate neural signals into words from a speech synthesiser, but he ran out of subjects and ultimately also funding. So in June 2014 he had to 'step-up' and 'walk-the-talk', and proceed with the research himself, or else 29 years of research would die. This spring, Kennedy presented the research of his own brain at the Society for Neuroscience in Chicago, provoking both awe and concern among his colleagues.

Read the full story on page 48.

Dr. Kennedy is either a humanitarian pioneer, or a modern day Dr. Frankenstein, maybe both. Some might say Dr. Kennedy is 'old school' as the future is probably a non-intrusive wireless interface. The danger may be that the wave of the future could be more sinister, such as the remote mind control of civilian populations. Of course we don't need to go to such lengths to manipulate people, the media seems to have that base pretty well covered already.

I look forward with anticipation as we challenge the frontiers of bioengineering and biomedical technologies.

Thank you for your support as we #Payitforward

André Hoffmann
Pr. (Tech.) Eng | FSAIEE

WATTSUP

SAIEE Annual Student Project Competition

Hosted by Central University of Technology (CUT) in Bloemfontein, the annual SAIEE Student Project Competition did not disappoint.

Final year students representing Universities (BSc) and Universities of Technology (B Tech) came together to showcase their final year projects for a bid to walk away with the coveted awards and prize money.

Dr Ben Kotze, Senior Lecturer: Department of Electrical, Electronic and Computer Engineering, CUT welcomed the participants and visitors to a sweltering Bloemfontein. *"This is the first time in the 27-year history of the National Student Project Competition that the Central University plays host to this event, and we are very proud, thank you"* Ben said as he introduced Stan Bridgens.

"You are all Regional winners and should be proud of yourselves to have made it this far, well done", was Stan Bridgens, SAIEE CEO's opening remarks to the students.

THE WINNERS ARE:

- **Josh Perry** representing the University of Cape Town is the winner in the BSc Category with his project *"Bio-inspired Robotics"*. This project had everyone in awe. You can read more about this project on page 22.
- **Luke Rogers** from Central University of Technology won the first place in the B Tech Category. His project *"Reconfigurable Automated Maintenance Assistant"* was the opener at the event.

After the judges deliberated, they decided to add a discretionary prize in each category. The recipients are:

- The BSc recipient is **Robert Mawbey** from University of Kwa-Zulu Natal for his project *"Intelligent Electric Vehicle Platform"*.
- The B Tech recipient is **Sikhona Cele** from Vaal University of Technology for her project on *"Small Rural Field Water Absorption Controller"*.

Each participating student received a token from Ben Kotze, which symbolises the "thinker". He said: *"The thinker is the student, which is placed inside the world to support his/her surroundings, community or family by what he /she have learnt or being taught and as a person to look up to.*

The platform symbolizes the Project competition and the support by SAIEE, which forms the base on which their knowledge stands and a benchmark to others and other institutions.

The hands symbolize the support with which the SAIEE reaches out to assist the world, communities as well as learners."

This token was sponsored by the Product Development and Technology Station (PDTS) and the Centre for Rapid Prototyping and Manufacturing (CRPM).

We would like to thank the Central University for their hospitality as well as PPS for their sponsorship of prizes and goodies - *ED*

From left: Josh Perry (UCT), winner in the BSc Category with George Debbo (SAIEE).

From left: Luke Rogers (CUT), winner in the BTech Category with Dr Ben Kotze (Project Supervisor).

Discretionary Prize Winners. From left: Robert Mawbey (UKZN) and Sikhona Cele (VUT).

I've requested the participating students to send me their project papers for publishing in the ***wattnow*** *magazine. Watch this space - ED*

Judges, from left: Wayne Fisher, Mpho Tabane, Stan Bridgens, Joseph George, George Mashee and George Debbo.

From left: Stan Bridgens (SAIEE), Ben Kotze (CUT), George Debbo (SAIEE) and Selma Kruger (PPS).

Timothy de Vos (NMMU) with George Debbo.

Tinus Green (UP) with George Debbo.

Sikhona Cele (VUT) with Project Supervisor Ruaan Schoeman.

Franscois Tolmie (NWU) with George Debbo.

Pieter Erasmus (UJ) with George Debbo.

Shiven Naicker (Wits) with George Debbo.

Cyndhu Sriram (Wits) with George Debbo.

DEHN AFRICA AWARDS LOCAL PARTNERS

From left: Andrew Economou (Pontins), Matthew Shuttleworth (ULPS), Trevor Manas (Pontins), Alexis Barwise (MD of DEHN AFRICA), Paul van As (Surgetek), Kirk Risch (Sales and Marketing Director, DEHN AFRICA), Richard Nobbs (EM), Don Perumal (DTE) and Helmut Pusch (Sales and Marketing Director, DEHN + SÖHNE GmbH + Co.KG.).

DEHN AFRICA (PTY) LTD, the local subsidiary of Germany-based lightning and surge protection, earthing components and safety equipment manufacturer, DEHN + SÖHNE, recently lauded local partners in its second official South African partner awards event.

Kirk Risch, Sales and Marketing Director of DEHN AFRICA, presented five awards to attending partners, with Surgetek being named for the second year as the best overall achiever. Universal Lightning Protection Services (ULPS) received the award for the "Most Innovative Design", ElectroMechanica (EM) was identified as the "Fastest Growing Partner", Down to Earth (DTE) won the title of "Most Up and Coming Partner", and Pontins was named as the partner with the best marketing strategy.

Said Risch: *"DEHN AFRICA is growing from strength to strength and we would like to thank our partners for their hard work over the past year. There is so much scope for us across the African continent and we look forward to engaging with our partners into the future to broaden our horizons further."*

Mind the gap at Schneider Electric's software customer conference





The much anticipated Schneider Electric Software Customer Conference was held recently at the upmarket Royal Elephant Hotel in Centurion, Gauteng, and focused on the implementation of software solutions, whilst addressing the disconnect between software potential and realising its purpose.

With the correct implementation, uptake and use, the company says, software will help manage variability and add flexibility in production, whilst translating into economic value and other benefits.

After the welcome and opening from Eric Léger, country president at Schneider Electric Southern Africa, Daniel Silke, one of the country's leading political analysts, as well as being a futurist and author, took to the stage to deliver the keynote address.

Following on from Silke's passionate and insightful address, Yong The, Global Strategic Alliance Manager at Schneider Electric in Australia, presented on operational excellence.

Two separate breakout streams followed, during which the topics covered included Schneider Electric's digitisation journey, software implementation best practices and change management, industrial energy management and utilities optimisation, a practical guide to ROI and justification for MES, and energy management through digital services, supply and demand optimisation.

Schneider Electric also used the conference as a platform to launch its "Customer FIRST" programme for Vijeo Citect, Vijeo Historian and Ampla.

It will be commercially available from January 2016 and replaces the SCADA & MES Software Global Support programme, in order to provide a common framework for support and services throughout the Schneider Electric Software business.

Speaking of the event, Quintin McCutcheon, Software Business Lead for southern Africa at Schneider Electric, said: *"The Schneider Electric software conference is, without a doubt, the industry's top thought-leadership event, where delegates learn more about solving some of the most complex implementation challenges through our game-changing products, solutions, and services."*

Actum builds on its reputation in the local electronics sector

From left: Actum Group Directors Greg Barron and Kevin Klaff

As a niche importer and distributor of quality components and instrumentation products, the Actum Group has built up a solid reputation in the local electronics sector, by embarking on a diversification and expansion strategy that recently saw it acquire Dowson & Dobson Industrial.

The Actum Group comprises two main divisions. Actum Electronics focuses on electronic components, while Actum Industrial encompasses industrial products, pneumatics and professional tooling. *"All these businesses have been well-established brands in their respective markets,"* Kevin Klaff, director of the Actum Group, explains.

"When we acquired Actum Electronics in 2004, we took over what was a relatively niche importer of electronic components. At that time it had already been established in the market for 35 years, with an excellent reputation in the local electronics sector," Klaff notes.

In 2006, Actum acquired Altico Static Control, a specialist in static control solutions for the electronic manufacturing, telecoms and military markets. In 2007, Actum acquired Connecta, a connectivity components supplier to the electronics, military, mining and industrial markets.

The Actum Group is striving to take all of its brands to the next level through improved customer relations, better stockholding and faster response times. *"Our vision is to provide our clients with the best quality industrial and electronic products,"* Klaff emphasises.

"Quality is a given across our entire product range, as all of our principals are global leaders in their respective markets. It is this focus on quality, together with our enhanced customer communications, that will continue to differentiate us in the marketplace," Klaff elaborates.

Looking to the future, Barron concludes that the Actum Group will continue to focus on expanding its dedicated technical sales team, offering customised product and solutions packages to its extensive customer base.

SENSING MADE EASY WITH ESI SMART SENSOR

Developing fit-for-purpose products that utilise sensors requires an in-depth knowledge of sensing technology as well as the ability to identify the correct sensor and integrate it with the electronics and intelligence enabling the desired final product in terms of information, automation and most importantly, increased safety.

Booyco Electronics has established itself as a provider of sensors that not only meet these exacting requirements but are also designed to operate in the often harsh operating conditions found in Africa on both underground and surface mines.

Accurate measurement of gases is made simple with the South African manufactured ESI Smart Sensor. Significantly, this compact sensing unit, weighing only 1.8 kg, has the ability to measure one of 15 different gases from a single controller. This feature sets the instrument apart from other such units currently in the market.

The ESI Smart Sensor

Lynne Pretorius appointed as CESA President

At its Annual General Meeting held during the Infrastructure Indaba during November 2015, Consulting Engineers South Africa (CESA) appointed Lynne Pretorius from ITS Engineers as President of the organisation for the next two years. She holds a BSc Engineering (Civil) and M. Engineering (Transportation) from the University of Cape Town and has worked in the Engineering industry for 22 years after graduating in 1993.

In her inaugural speech, Pretorius indicated that South Africa is on a dynamic trajectory that requires visionary leadership and flexibility from all stakeholders and role players to adapt to the changing and challenging environment currently prevailing. She stated that her key objectives are to get the CESA house in order, encourage members to submit quality bids and to be open and honest about corruption.

"Concerted effort is required from all of us to address the imbalances of the past thus creating a South Africa that everyone is proud of. Government requires us to transform our industry. We realise that this is a long-term process but we have to align ourselves to leverage business opportunities."

She has worked for both the Private sector and Public sector (including four years with the City of Cape Town). Pretorius specialises in transportation engineering with a focus on sustainable transport modes and integration between transport and land use.

Lynne Pretorius
CESA PRESIDENT

WEC Projects to deliver Wastewater Treatment Technology in SA

International engineering and project management consultancy Royal HaskoningDHV and WEC Projects Pty (Ltd) have signed an Agreement for Nereda® wastewater treatment technology in South Africa. The agreement was signed in Johannesburg in the presence of the Prime Minister of the Netherlands, Mr Mark Rutte as well as a number of South African Government Ministers and dignitaries including the Minister of Public Enterprises, Lynne Brown and the Minister of Water and Sanitation, Nomvula Mokonyane.

Nereda is an innovative wastewater treatment technology that has proved to be more efficient, sustainable, kinder to the environment and with lower operating costs than conventional methods of waste water treatment. The plant requires a four times smaller footprint and the process consumes half the energy compared to conventional installations. It is entirely based on natural processes, requiring no chemicals and features aerobic granular biomass with faster settling times than conventional aerobic systems

Royal HaskoningDHV and WEC are currently cooperating in the implementation of Nereda technology at the Hartebeestfontein Wastewater Treatment Works aimed at improving the capacity of the plant by 5Mℓ/day using existing infrastructure. The Hartebeestfontein plant is currently under construction for ERWAT (East Rand Water Care Association) in Gauteng. This will be the third Nereda plant in South Africa and the first in Gauteng Province – the other two – also 5Mℓ/day each - are at Wemmershoek and Gansbaai in the Western Province.

Salani Sithole, Managing Director, Royal HaskoningDHV South Africa, states, *"Since its commissioning the innovative wastewater treatment works at Wemmershoek, in South Africa's Western Cape, has been performing above expectations, providing final effluent quality in excess of "General Limit" standards set by the Department of Water and Sanitation."*

The Cooperation Agreement was signed on 17 November 2015 by Mr Karl Juncker, Managing Director WEC and Mr. René Noppeney, Global Director Water Products & Innovation Royal HaskoningDHV in the presence of the Prime Minister of the Netherlands, Mr. Mark Rutte and the South African Minister of Small Business Development Lindiwe Zulu

SAIEE Smart Grid Conference 2016

The South African Institute of Electrical Engineers will be hosting a Smart Grid Conference on 23rd to 25th February 2016, at the Eskom Academy of Learning in Midrand Johannesburg. The Conference will provide a platform for industry to discuss cutting edge innovations in smart grid and it's associated technologies; including addressing how the current electricity network can be converted into a smart grid. It is strongly believed that the adoption of smart grid technology within Sub Saharan Africa will provide immense benefit to the delivery of electrical energy in this Region.

The Conference will include keynote addresses, plenary presentations and panel discussions, as well as paper presentations in two simultaneous tracks.

An impressive list of international experts in the area of smart grids have been lined up for the Conference, and include the following:

PROFESSOR MASSOUD AMIN

Professor Amin is regarded as the "father of smart grids", and leads a number of extensive projects in smart grid research. Since 2003 he has served as Director of the Technological Leadership Institute at the University of Minnesota, and occupies the Honeywell/H.W. Sweatt Chair in Technology Leadership at the same University. He is also Professor of Electrical and Computer Engineering.

Prior to joining the University of Minnesota in 2003, Professor Amin held senior positions within the Electric Power Research Institute (EPRI) in Palo Alto. It was during this period that he conceived and articulated the vision of a smart self-healing grid. This is where the use of computer, communication, sensing and control technologies operate in parallel with an electric power grid to enhance reliability, increase resilience and reduce the cost of energy to consumers.

In addition to his technical leadership activities, Professor Amin maintains an active research program and has made significant contributions in predictive system identification methods, coupled with analytical and multi-domain modelling, fast simulation optimization and testing methodologies. All of these he applies to complex and large dynamical systems. Since 2003, he has given four briefings at the White House and nine Congressional briefings on smart grids. He has also served on numerous occasions as the USA delegation representative to several world engineering

SAIEE SmartGrid

ENABLING INTELLIGENT ELECTRICAL POWER SUPPLY AND DEMAND BALANCING

CONFERENCE

and scientific congresses. He is regularly interviewed by the media including the New York Times, CNN, BBC, Washington Post and Wall Street Journal to name a few. One of Professor Amin's key area of interest is how to revitalize ageing grids and he has delivered a number of talks in this regard, including a TED presentation.

Professor Amin currently serves as Chairman of the IEEE Smart Grid Committee and also serves on the IEEE Control Systems Technical Committee on Smart Grids. He is the founding chairman of the IEEE Smart Grid Newsletter.

MR KURT E. YEAGER

Mr. Yeager, who has over 30 years of experience in the energy industry, was previously President and Chief Executive Officer of the Electric Power Research Institute (EPRI). Currently Mr. Yeager is Vice Chairman of the Galvin Electricity Initiative, which is a non-profit organization that he co-founded with Robert Galvin, after retiring from the EPRI. Mr. Yeager is also Vice Chairman of the Galvin Electricity Initiatives Perfect Power Institute which is focused on transforming the reliability and value of the USA's electricity services.

Mr. Yeager has authored over 200 technical papers and publications on energy and environmental topics, including a book entitled Perfect Power which he co-authored with Robert Galvin. He was also a convening lead author for the International Institute of Applied Systems Analysis (IIASA) "Global Energy Assessment" report to the United Nations and World Bank.

MR LEE STOGNER

Mr. Stogner is the President of the Vincula Group, a consultancy in the USA that specializes in the Internet of Things. He has over 30 years of design, consulting, project management and business development experience across a range of industries, including companies such as Digital Equipment, Fluor Corporation and Rockwell international.

Today Mr. Stogner is active in promoting the development of the Internet of Things through his participation in the IEEE Smart Grid Initiative, the IEEE Transportation Electrification Committee and as a member of the IEEE Internet of Things Initiative. wn

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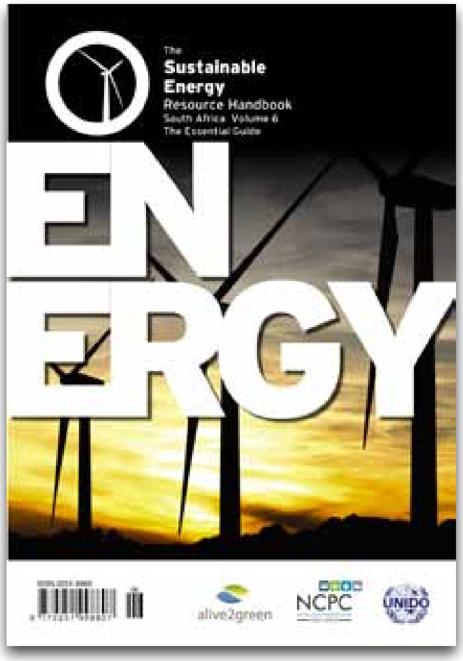


The Sustainable Energy Reading

As South African energy consumers scramble to find energy solutions in reaction to load shedding, crises at Eskom, and rapidly increasing electricity pricing, the market for alternatives is burgeoning!

Many of these alternative solutions are also sustainable solutions, but these are also typified by high capital expenditure and low operation costs, and thus must form part of a longer term strategy in order to be considered economically viable.

In cases where consumers have invested in diesel generators, sustainable solutions like energy efficiency are even more important, and the opportunity to hybridise diesel generators with roof top PV, also reduces diesel consumption and enables a larger PV installation.

The Sustainable Energy Resource Handbook explores the idea of this converging field of energy efficiency and renewable energy as genuine integrated solution for energy consumers.

Editorially the Handbook begins by evaluating the cost of load shedding on the economy, looks at developments in centralised energy generation, and moves quickly to addressing the energy reality of the end user. As such the publication is relevant to all energy sector stakeholders.

The idea of a convergence between the fields of energy efficiency and renewable energy are explored in the publication, emphasising the need to achieve efficiency first, and to then tackle onsite generation. By doing this the generation challenge is reduced, and the technological foundation is laid for the measuring and metering often required by the onsite generation solution. Combining these pursuits in an optimised and automated manner begins to enable energy users to imagine real independence from Eskom, even if only when required.

With contributions from leading researchers and practitioners, government, industry representative bodies, and non-governmental organisations, the publication offers multiple perspectives and insights.

Available in print and digital copy on www.alive2green.com, seeks to provide public and private energy stakeholders in South Africa and regionally, with the latest thinking, research, insights, and related case studies. Edited by Gordon Brown of alive2green in consultation with the late Russell Brown of Ruach Consulting R.I.P.

A copy of the Sustainable Energy Resource Handbook is included at no cost by the SAIEE, may it serve as a valuable reference for your business.

Should you wish to contribute to Vol 7, or comment on Vol 6 please email the publisher on gordon.brown@alive2green.com. wn

Farming project in Ugie growing in strength and size

A flagship Eastern Cape farming project is set to quadruple in size – and significantly increase its employment potential – after its patron, leading SA diversified timber company PG Bison, committed to extend land provided to the project by 6.5 hectares.

Plans are also already afoot to formalise the 13 employees of the Ugie Agricultural Social Project (UASP) into a co-operative business, placing the ownership and decision making power firmly in local hands.

PG Bison started the farming project in 2014 in partnership with the Joe Gqabi District Municipality, to both create employment and provide food security for local townships.

This was part of a broader collaboration between the company and the provincial and local governments, that has seen a total investment of more than R2.1 billion injected into the Elundini Local Municipality (Ugie / Maclear) since 2013. This amount includes the cost of PG Bison's new board plant (constructed at R1.3 billion), occupying 36 hectares of the 64-hectare site, as well as other surrounding infrastructure and services.

The initial 1.5 hectare section made available for the farming project is part of a larger piece of disused farmland found not to be suitable for forestry. This is now to be enlarged to 8 hectares.

COMMITTED TO SUSTAINABLE RURAL DEVELOPMENT

Mr Gerhard Victor, PG Bison's CEO, emphasised that the farming project is one of an array of corporate social investment initiatives whereby the company uses its footprint to economically empower locals.

To provide support services for the Ugie plant alone, 2 000 job opportunities have been created among 30 local, black-owned businesses. More than 80% of the labour and ownership in these businesses is local.

"What a joy to see locals literally dig in and come up with a farming venture that has the promise of creating significant employment and addressing food security. This is locally driven, sustainable empowerment. And we are committed to play our part to make this work. That is why we have decided to enlarge the tract of land provided to the project."

Victor says timber plants and plantations are ideally situated to contribute to economic development as they are by definition situated in rural areas.

"It goes without saying that these areas face significant challenges in education, healthcare and employment. Many forestry companies – including PG Bison – are making investments in ways that stimulate locally owned small enterprise development," he explains.

FLAGSHIP FARM IS "EVERYBODY'S PROJECT"

Working with his hands in the soil that his ancestors used to cultivate, is a spiritual process for Mr Julius Toli, ward committee member and member of the farming project.

The fact that the small farm has turned into a veritable Garden of Eden within only one year, supplying the local hospitality industry with roughly 50 000 heads of cabbage, 5 000 spinach plants and hundreds of heads of broccoli, cabbage and other veggies, is a bonus.

Toli was tasked to help find the initial employees to get the farming venture off the ground. He made sure that he invited participants from all areas of the local township, "because it is everybody's project."

Of the current thirteen employees, only three have some level of schooling and only Toli has matriculated.

The farm has not only provided salaries for its employees but has also been able to generate enough savings that this year's seeds and fertilizer could be bought in cash. Self-sustainability is, therefore, within reach.

"This project is really working. In this first year they really tested us, but we have passed.

"This farm has a place in people's hearts. They enjoy it and it has made a change in our community already. And the feedback we get is that our veg is of a better quality than anything in town."

YEARNING FOR GROWTH

Toli yearns for more than vegetables, though. He wants to see the farm extended so more people can be employed. This, he says, will not just put food on tables, but restore the community's dignity.

"It is huge for us to be working the land. If we can get more land, we will surprise you."

Mr Tony Tegg, PG Bison's nursery manager, who doubles up as supervisor and trainer for the farming initiative, is currently engaging with the project's team to determine how many full-time employment oportunities the farm can sustain.

"It may not be as easy as saying that each hectare can sustain 13 people. But we will definitely be able to sustain more jobs; especially when it comes to harvesting seasonal crops." wn

HellermannTyton and Renewable Energy

Even though the concept of renewable energy is known to us all, most of us still do not grasp the actual reality of this miracle of light and heat offered to us from the sun.

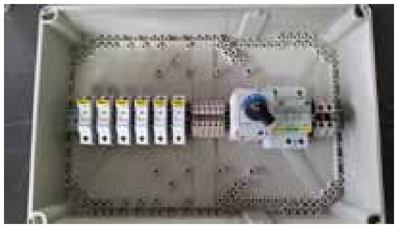
The solar radiation in South Africa is some of the highest recorded in the world, and even if we had the ability to responsibly harness only one percent of the sun's energy reaching the earth's surface, we would be able to open doors to a world of endless opportunities previously wiped from the table only as fictitious science fiction.

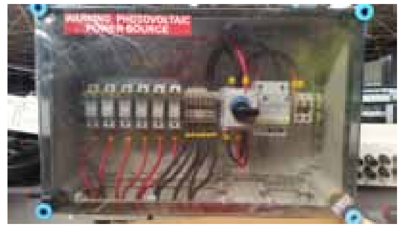
The sun is approximately 150 million km's from the earth, and it takes only eight minutes for the sun rays to cover that distance. We can measure its energy and calculate overwhelming possibilities, but even with all the latest technology available to us, we are able to control only a fraction of the energy entering our atmosphere.

Even though the technology of solar energy was born almost two hundred and fifty years ago, a strong evolution in technology through many lifetimes was necessary to school us in harnessing energy from the sun in a safe manner. Renewable energy might indeed be the future of electricity and also mankind's gift back to earth in protecting its resources and the very air we breathe, but also extremely dangerous if not understood and respected. HellermannTyton South Africa got involved in renewable energy for this very reason. Not only did we recognise the need for safe- and clean energy, but also the importance of investing in our planet for many future generations to enjoy clean and healthy living.

HellermannTyton's involvement in all industries including renewable energy reaches far beyond a supply chain of products currently being used all over the world. In the renewable energy sector, and in specific the String Combiner Boxes (SCB) needed for solar energy, we offer a service, tailor-made to perfection to suit the customer's energy needs. The customer is assisted from the initial enquiry through to the commissioning stage of the solar plant.

On receipt of a new enquiry, HellermannTyton does the full design of the SCB, the General Assembly and also the Single Line Diagram. After approval, a prototype is built by using only the highest class- and approved safety products, electronic controllers, switchgear and specially designed photovoltaic items all populated and prepared for





final installation in a class II double insulated enclosure system. Production of these boxes takes place at a state of the art assembly plant at the HellermannTyton premises in Johannesburg. Both production and assembly are subject to strict safety- and quality control schedules throughout the process and after completion, each SCB is thoroughly re-checked and electronically tested. The completed SCB is then labelled with a barcoded ID for future reference and packed for shipment.

HellermannTyton is currently in the final stages of a 90MW solar farm, which is one of the biggest ever built in South Africa. The complete plant covers an area of approximately twelve square kilometres. We were responsible for designing and managing the full production process of more than six hundred SCB's and also final delivery to site. In light of our experience, we were requested to further assist through supplies of hundreds of thousands of products needed on site for general installation. Through our strong international support, we are also able to offer an excellent percentage local content further adding positive value to the South African economy. HellermannTyton currently also offers our assistance in a growing rooftop solar market, belong to various corporate bodies and thrive to stay abreast with the ever growing technology in Renewable Energy.

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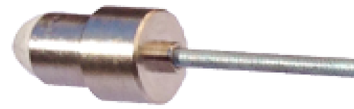
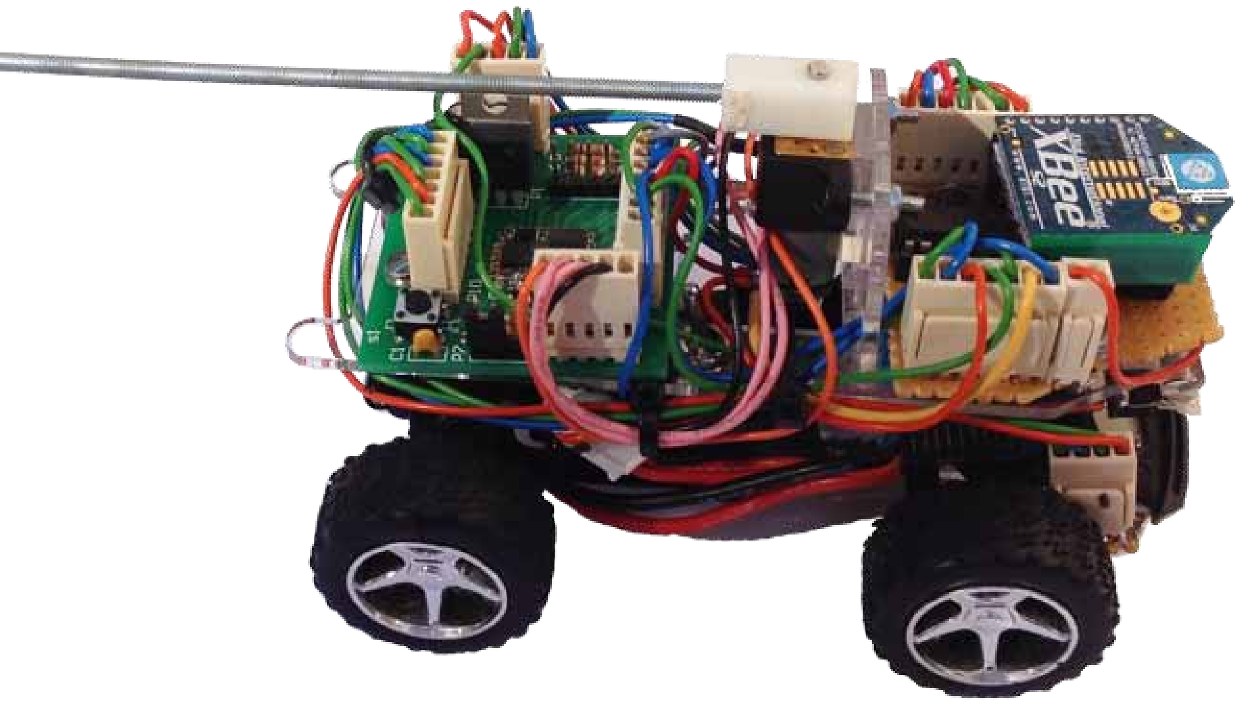


TAYObot

ROBOTICS TAKES A 'LEAP'

It has been shown that some flightless animals use their tails to achieve attitude control while airborne; this orientation technique inspired the robotic concept of the project. The aim of the project was to model, design and build a robot that was capable of using a tail to perform a 360-degree yaw stunt. The electro-mechanical systems required by the robot were modelled to aid in optimal robot design. Hardware, software, a mechanical structure and a control system were designed for the robot. The robot was then tested on a ramp platform; both the video footage and data collected illustrated the success of the system in performing the 360-degree yaw rotation, as the robot landed in the stunt three times. Unsuccessful jumps were seldom a consequence of poor controller performance, but rather resultant of the robot pitching forward before landing; in order to resolve this, an investigation into a two degrees of freedom tail is recommended.

BY JOSH PERRY & AMIR PATEL I UNIVERSITY OF CAPE TOWN



Modern robots have become increasingly versatile in the 21st century, and as such, more utility is expected from them. In important applications such as search and research as well as space exploration, robots are required to be exceptionally robust, and handle unforeseen circumstances.

To this end, this research investigated aerial orientation methods applicable to robots, not primarily designed for flight, and the implications this may have for such robots. The validity of looking to natural phenomena for solutions to engineering challenges has been well established [1].

Many flightless animals have been observed using their tails to achieve aerial orientation and attitude control while airborne [2]. Robots have been designed and have successfully emulated this methodology; the Tailbot used a tail to reject pitch perturbations [2], and the Flipbot used a tail to perform a barrel roll stunt [3].

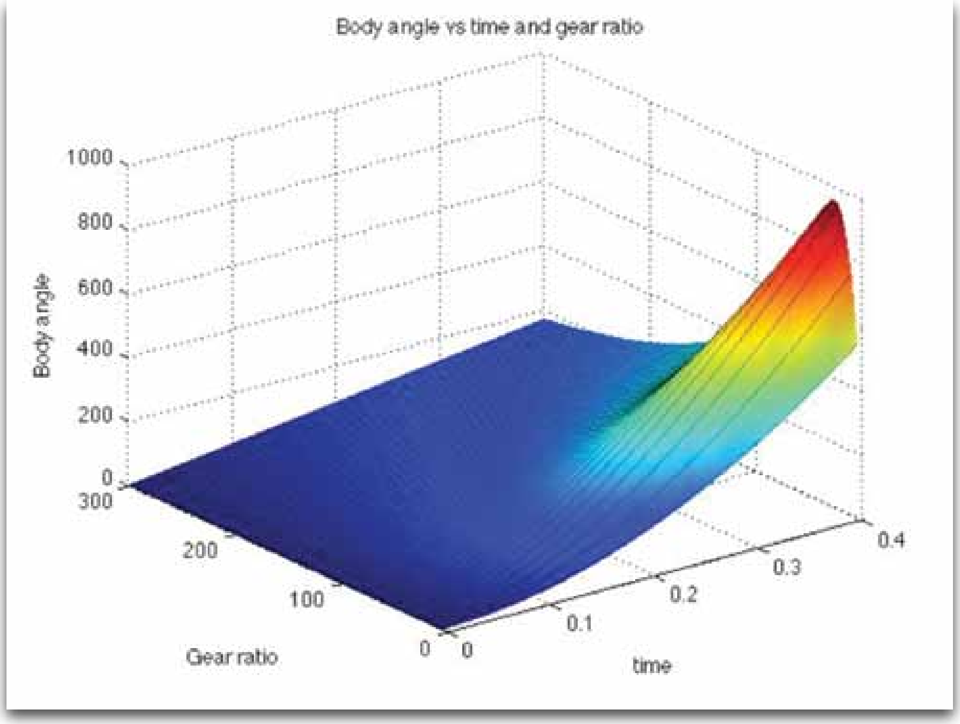
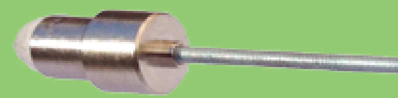


Fig. 1: Body Position vs Gear Ratio and Time

We aimed to extend the work done in this area by designing, building and testing a robot, which uses a tail to perform a 360-degree yaw stunt. The robot concept was based on the kangaroo rat, which uses its tail to orientate its body in the yaw plane whilst hopping [4].



TAYOBOT

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MODELLING, SIMULATION AND DESIGN

Modelling

The body and tail system was modelled using Lagrange dynamics, while the tail motor was modelled using its electrical and mechanical differential equations. The outcome of the modelling process was a set of four differential equations that were formulated in a state space model.

Simulation

The model's uncontrolled response to a voltage step input (to the tail motor) was simulated using MATLAB Simulink. These simulations were conducted for various tail lengths, gear ratios and body structures to give insight into the optimal robot design. A graph of the temporal body yaw position response against gear ratio is shown below; this data, in conjunction with similar graphs, was used to design the robot.

Design

The robot designed and constructed for the application is shown in Figure 2, and it was named the TAYObot (Tail Actuated Yaw Orientation robot), inspired by the UC Berkeley TAYLRoACH [5].

Fig. 2. The TAYObot – the tail actuated stunt robot

CONTROLLER DESIGN AND PERFORMANCE

The control system designed for the robot included two controllers, an integrated state feedback position controller for the dynamic body and tail system, and a predictive torque controller for the motor system. The control input commanded by the first controller (a torque) supplied the setpoint to the second, and the output of the second controller drove the input of the body and tail system. Figure 3 shows the control system in operation during an actuated jump test.

DISCUSSION AND CONCLUSIONS

The video footage and data collected during testing confirmed the success of the stunt, as the robot was able to complete the 360-degree yaw rotation on many occasions. The modelling was shown to be accurate by the dynamics exhibited by the physical system. The controller was also judged to have performed well; the empirical data very closely matched the control system simulation – as is illustrated by Figure 4.

It was observed during testing that the robot almost always performed the required rotation in the yaw plane, but would frequently crash upon landing as a consequence of pitching forward during the last quarter of the stunt. This pitching effect was resultant of unbalanced forces that arose due to the tail not being positioned perfectly at the robot's centre of mass. In order to compensate for these effects, the recommendation was made to investigate a system with a two degree of freedom tail. This research again confirmed that tails can be used effectively to aerially orientate a robotic platform and provide rapid attitude control. wn

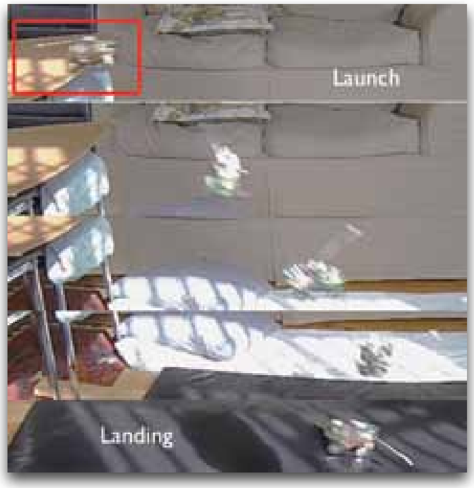

Fig. 3. An actuated jump sequence, which resulted in a successful landing. Five frames are shown, with the robot at launch, 90, 180, 270 and 360 degrees.

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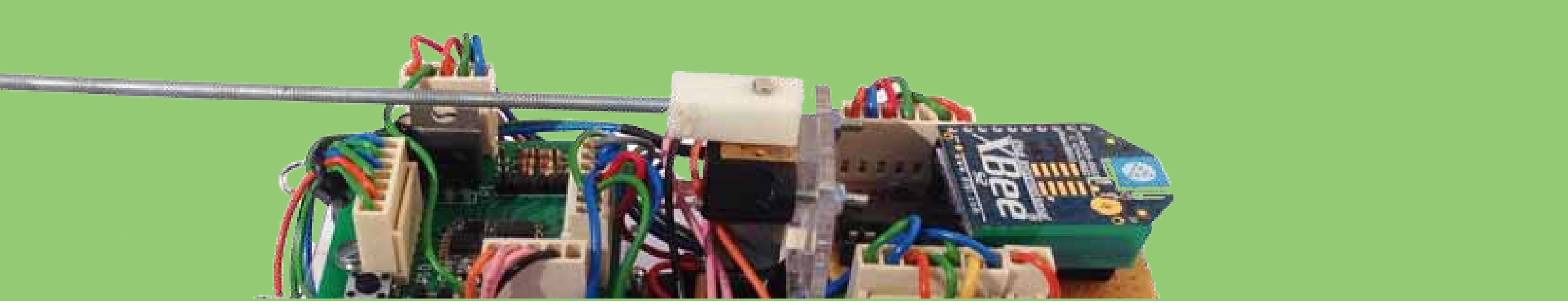

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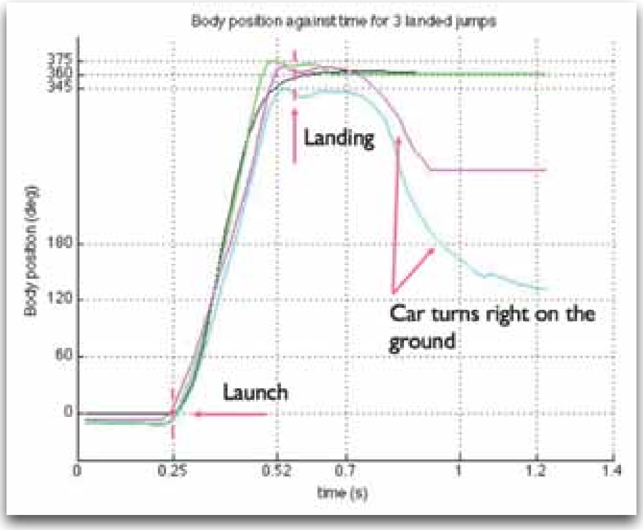
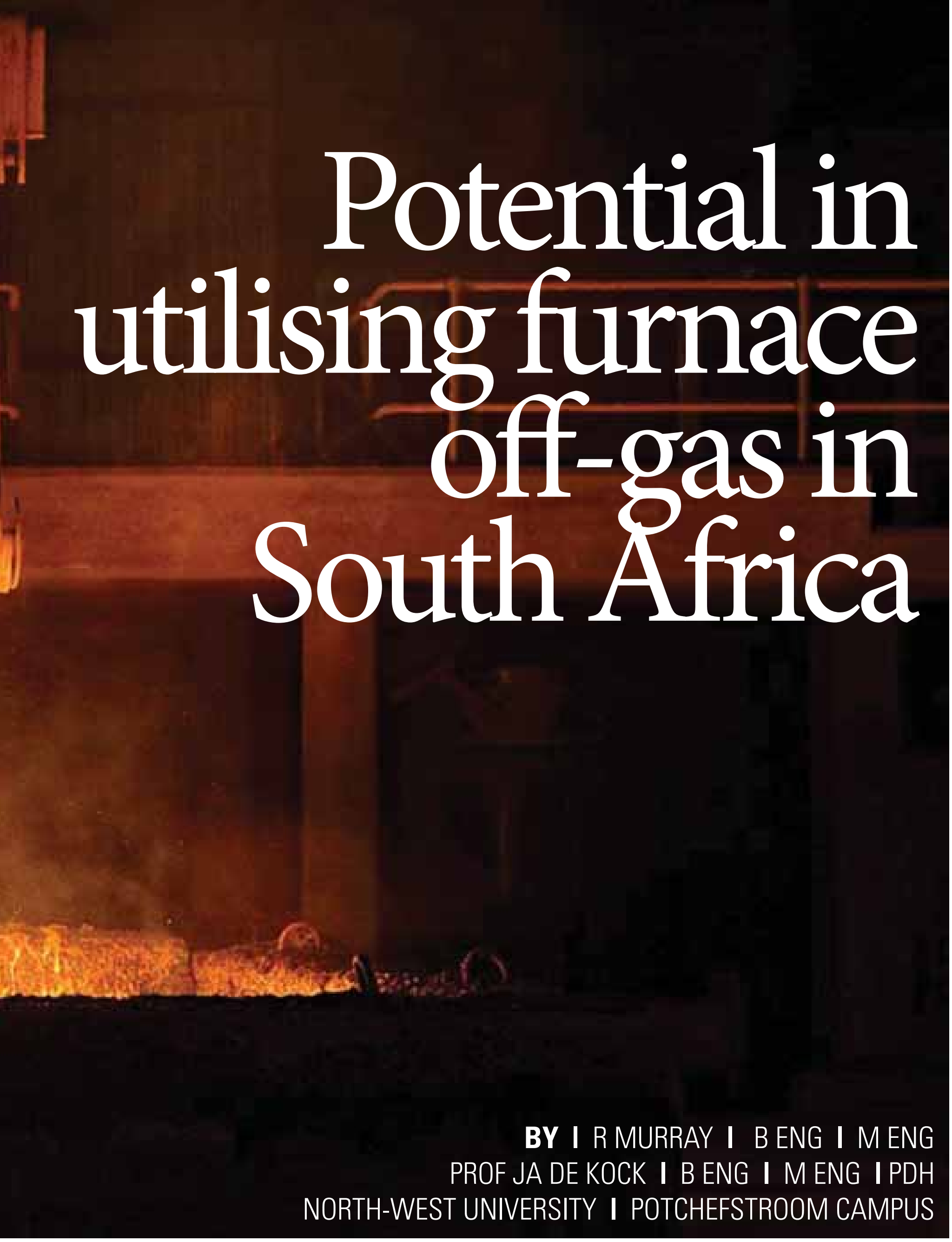


Fig. 4. Graph of yaw position against time for three successful jumps (in colour) and the simulated controller response (black). It should be noted that the robot's steering was not controlled, and it often turned right after landing.

This article presents a techno-economic evaluation of the utilisation of furnace off-gas, rich in carbon monoxide (CO), by using available technologies to convert waste off-gas energy into electrical energy – referred to as co-generation in this article. A FeCr smelter in South Africa is considered as the reference plant and the off-gas it produces analysed. The results, both the energy available in the FeCr furnace off-gas and the considered co-generation plants (gas engines, gas-fired boiler and gas turbines) efficiency, are used to determine the potential of the various systems to generate electrical energy.

Using the established potential an economic evaluation is conducted. In this article the potential of co-generation plants are evaluated for implementation at a ferrochrome smelter. The most feasible system is identified using the results from the techno-economic analysis.

Carbon dioxide (CO_2) emissions contribute about 80% of the total Green-House Gas (GHG) emissions in South Africa [1], which has one of the most carbon-intensive economies in the world [2]. It was announced that carbon tax would be introduced as from January 2016, at a rate of R120/t on 20% to 40% of the carbon emissions



Potential in utilising furnace off-gas in South Africa

BY | R MURRAY | B ENG | M ENG
PROF JA DE KOCK | B ENG | M ENG | PDH
NORTH-WEST UNIVERSITY | POTCHEFSTROOM CAMPUS

In South Africa the current electrical energy crises and the possibility of carbon tax forces Ferrochrome (FeCr) smelters to improve the efficiency of the plant and reduce carbon emissions at the same time. This can be done by utilising the waste energy available at the plant.

– which equates to an estimated rate of between R24/t and R48/t [3][4].

With the introduction of carbon tax, and the electrical energy supply from Eskom being regarded by some as unreliable, a ferrochrome smelter plant needs to look at ways to reduce electrical energy consumption, and with that carbon emissions.

One option for doing this is to use waste energy (off-gas) to generate electrical energy.

FERROCHROME SMELTER

A Ferrochrome (FeCr) smelter plant in South Africa, with two 55 MVA submerged AC-arc furnaces, is considered.

In the process of producing FeCr, a by-product in the form of CO-rich off-gas is formed. The off-gas, produced by the two furnaces, is supplied to the both a sinter plant (1,200 Nm^3/h) and furnace pre-heaters (1,000 Nm^3/h per pre-heater). The pre-heaters are installed at each furnace, and the off-gas used to supply thermal energy to the furnace feed, before it is fed to the furnace. This results in a reduction in electrical energy consumption.

Fig. 1 shows the flow of the produced off-gas.From the furnace, the off-gas is cleaned by venturi scrubbers and then supplied to the users (sinter plant and pre-heaters) or flared.

Plant and off-gas data

Data gathered regarding the electrical energy consumption of the entire smelter plant, produced off-gas characteristics, and carbon dioxide emissions are given in

Off gas in South Africa

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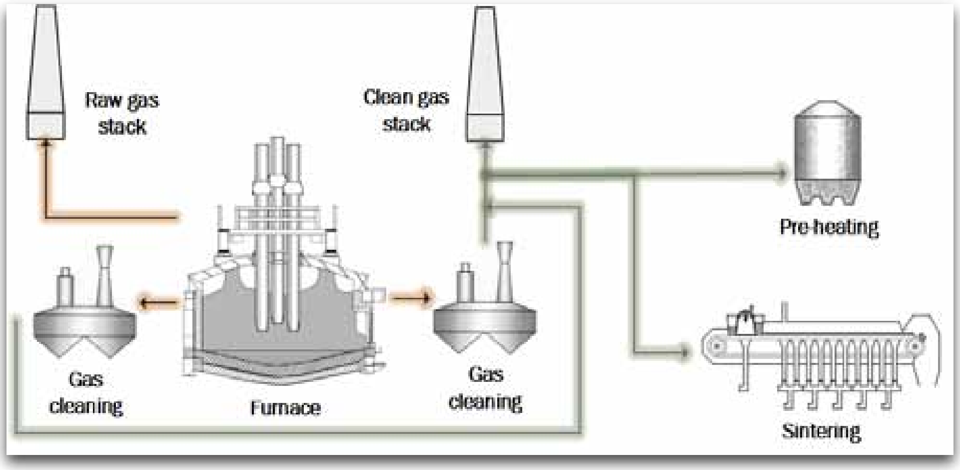

Fig. 1 Ferrochrome smelter off-gas flow diagram.

Tab. 1. The off-gas composition, calorific value (CV) and density were determining determined using independent off-gas measurements. The remaining values were calculated using annual plant measurements.

It was established that the smelter plant consumes around 707 GWh (81 MW) per annum. The months of June, July and August are used for furnace shut-downs (maintenance) and only one furnace operates during these months.

As mentioned, CO-rich off-gas is produced by the FeCr furnaces. This off-gas contains 59% CO-gas, 5% H_2-gas and 0.85% CH_4-gas. CO_2 and N_2 are noble gases that are also present in the off-gas, resulting in a density of 1.2 kg/Nm³. Using the off-gas composition (Tab. 1) and the lower heating values of CO (2.81 kWh/kg), H_2 (33.33 kWh/kg) and CH_4 (13.83 kWh/kg)[5], the CV (Calorific Value) of the off-gas is calculated as 1.78 kWh/kg. This gravimetric value is equal to a volumetric value of 2.14 kWh/Nm³.

On an annual basis 194.3 MNm³ of off-gas is produced by the furnaces, of which 9.6 MNm³ and 15.3 MNm³ is used by the sinter plant and pre-heaters, respectively. This means that an annual volume of 169.4 MNm³ is flared, and also available for utilisation.
(See Table 1)

The off-gas energy is determined using the off-gas volume produced and the off-gas CV value. The energy produced per annum equates to a total of 408 GWh (47 MW). Of this total, 53 GWh (6 MW) is used by the plant and 355 GWh (41 MW) flared at the furnaces. Showing that 355 GWh of off-gas energy is available for electrical energy generation.

The FeCr smelter plant is also responsible for carbon emissions. These carbon emissions are either directly emitted by the plant or indirectly caused by the electrical energy consumption of the plant (CO_2 emissions occur at the point of Eskom generation). The annual emission forecast is given in Fig. 2.

In this figure two forms of emissions are shown. This includes the plant emissions, caused by the flaring of the produced off-gas, and the indirect emissions due to electrical energy consumption ("EE emissions"). The latter is calculated using the established smelter plant electrical energy consumption and a carbon emission factor of 1.09 kg of carbon dioxide per kWh generated by Eskom [6].

The annual plant emissions (direct) equates to 287 kt of CO_2 and the indirect emissions add up to 771 kt. This means that the plant is responsible for 1 058 kt of CO_2 emissions per annum. Fig. 2 shows that if both

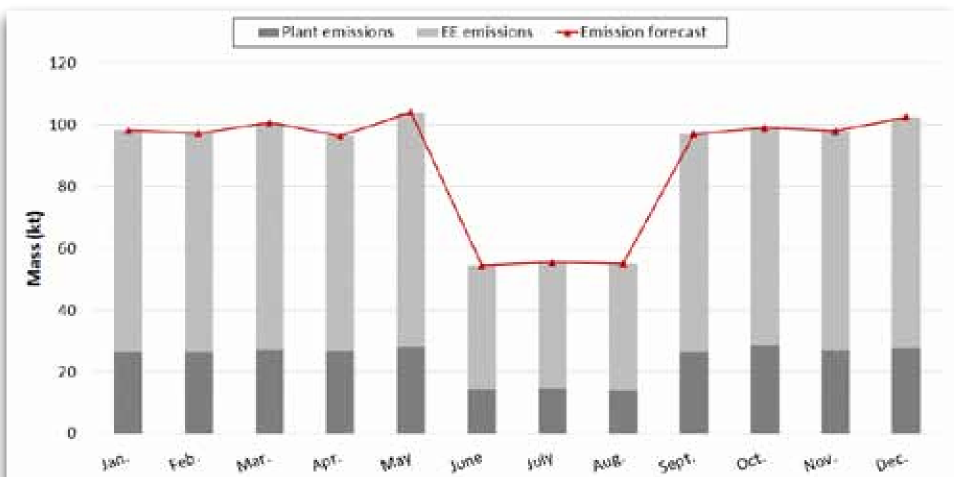

Fig. 2: Carbon dioxide emission estimation by the FeCr smelter.

	Unit	Value
Electrical energy consumption	GWh	707
	MW	81
Off-gas characteristics		
CO	Vol. (%)	59
H2	Vol. (%)	5
CO2	Vol. (%)	16
N2	Vol. (%)	19
CH4	Vol. (%)	0.85
CV	kWh/Nm3	2.14
Density	kg/Nm3	1.2
Volume		
Produced	MNm3	194.3
Utilised	MNm3	24.9
	%	13
Available (flared)	MNm3	169.4
	%	87
Energy		
Produced	GWh	408
	MW	47
Utilised	GWh	53
	MW	6
Available (flared)	GWh	355
	MW	41
CO2 emissions		
Plant emissions (direct)	kt	287
Indirect emissions (electricity consumed)	kt	771

Table 1: Ferrochrome smelter and off-gas data summary

furnaces are operating in a specific month that an average of 100 kt of CO2 is emitted.

CO-GENERATION PLANTS

Three co-generation plants are considered for implementation at this FeCr smelter. Two of which are similar to plants already in operation at certain smelters (gas engines and a gas-fired boiler). The third is a gas turbine plant, which has not yet been implemented in South Africa, but some details were gathered regarding turbines that could be used for this purpose.

Layout

The first considered plant is a gas-engine co-generation plant with 12 units (estimated units for the available off-gas). Fig. 3 shows a simple layout of this plant, which is similar to the layout of an already operating plant. The only difference is the addition of a larger gas holder, more engines and around four gas trains (depending on the design and flow rate of each). The gas holder is installed after the gas cleaning plants (GCP) of each furnace.

The second plant (Fig. 4) is also similar to a gas-fired boiler plant, installed at a smelter with four furnaces, already in operation. The only difference is that a smaller steam-turbine generator and boiler will be required, because the FeCr smelter only has two furnaces. This means that less off-gas is produced and that smaller units will be adequate. With this option no additional off-gas conditioning is required, because the boiler is not as sensitive to particulates in the off-gas.

As mentioned, a third plant (turbines) is also considered for implementation at the FeCr smelter. A turbine designed to operate on low calorific value fuels was identified. It was established that this specific turbine would require additional high CV fuel, like propane or diesel. This additional fuel will be required during the whole time of operation, and not only at start-up. The required fuel would be around 1 025 Nm3/h of off-gas and additional 440 ℓ/h of diesel or 178 m3/h of propane. This equates to 31.2 Mℓ of diesel or 12.6 Mm3 of propane per annum.

With all of this taken into account a similar layout, as the gas engine plant, is shown in Fig. 5.

Potential

Table 2 shows the potential of the considered co-generation plants. Of the three plants, the gas turbine plant would

Off gas in South Africa

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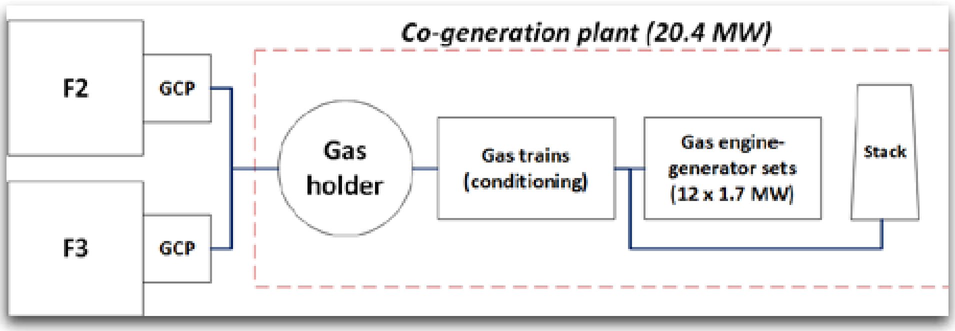

Fig. 3: Basic layout of a possible gas engine co-generation plant at the FeCr smelter

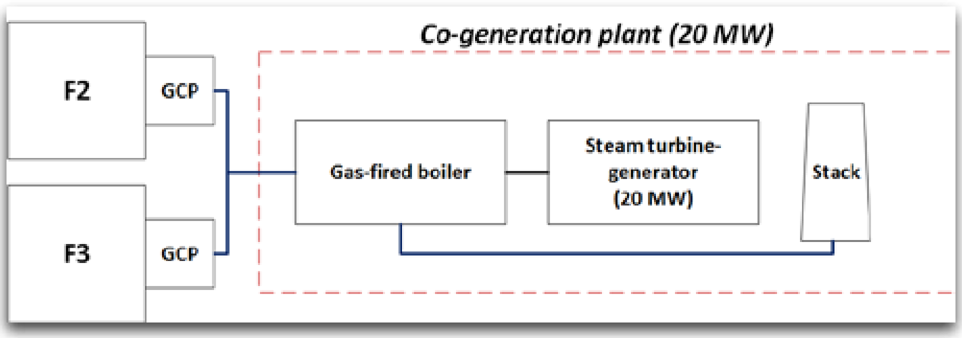

Fig. 4: Basic layout of a possible gas-fired boiler co-generation plant at the FeCr smelter

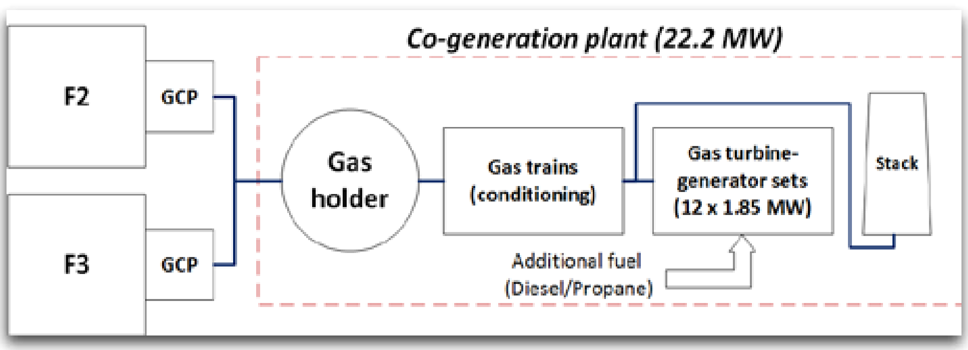

Fig. 5: Basic layout of a possible gas turbine co-generation plant at the FeCr smelter

	UNIT	ENGINES	BOILER	TURBINES
Plant size	MW	20.4	20	22.2
System efficiency	%	28	23	19
Electrical energy generation	GWh	99	81	124
	MW	11.3	9.2	14
Electrical saving	%	14	12	19
CO2 emission reduction	kt	108	88	135
	%	10	8	13

Table 2: Potential of each co-generation plant at the FeCr smelter plant

generate the most electrical energy. This is because of the additional high CV fuel, and with that additional energy, that is fed to the plant.

All of the plants have an installed capacity of around 20 MW, and would save the FeCr smelter between 12% and 19% on electrical energy purchases.

The system efficiency shown in this table, takes into account a reduced plant and off-gas utilisation. This is also the reason why the turbine plant has a lower efficiency, because the turbines would not be able to utilise all of the available off-gas, and additional turbines (also additional propane/diesel) would be required. The system efficiencies of the engine and boiler plants were established from the results of case studies conducted on similar plants.

It is also worth mentioning that the gas engine plant has the potential to have an improved efficiency. This is because the gas engine-generators have an efficiency of 37% and the 12 engines would be able to use all of the available off-gas. This means that the system efficiency could be increased to at least 32%, if the minimum volume of off-gas is flared at the co-generation plant. This would result in electrical energy generation of 113 GWh (12.9 MW), resulting in a 16% saving and additional CO_2 emissions reduction.

In the following section the results shown in Tab. 2 are used to conduct an economic evaluation on the considered co-generation plants.

ECONOMIC EVALUATION

In the economic evaluation calculations a discount rate of 10% was used for each

project and a project lifespan of 15 years. All the capital costs were converted to a present value (2015) and the operating and generating costs to a future value (2016). In these results no carbon tax was considered.

Evaluation results

Tab. 3 shows the economic evaluation results for each project. From these results the gas turbine plant has the highest capital cost and operating cost (includes capital for additional propane). In the evaluation of the turbine-plant propane was chosen as the additional fuel, due to the lower capital required to do so.

The boiler plant has the lowest capital cost and the gas engine plant the lowest operating cost per annum. The gas turbine plant is shown to be least feasible (uneconomical). This is mainly because of the additional fuel required and the added capital, because of that. The gas engine plant is seen to be the most feasible option.

In the following sections the gas turbine plant is disregarded, because of the results shown in Table 3.

Cash flow

The cash flow for each project, over the considered 15 years, is given in this section. These cash flows were considered in the economic evaluation of the projects. Major maintenance and services required for each project, werealso taken into account.

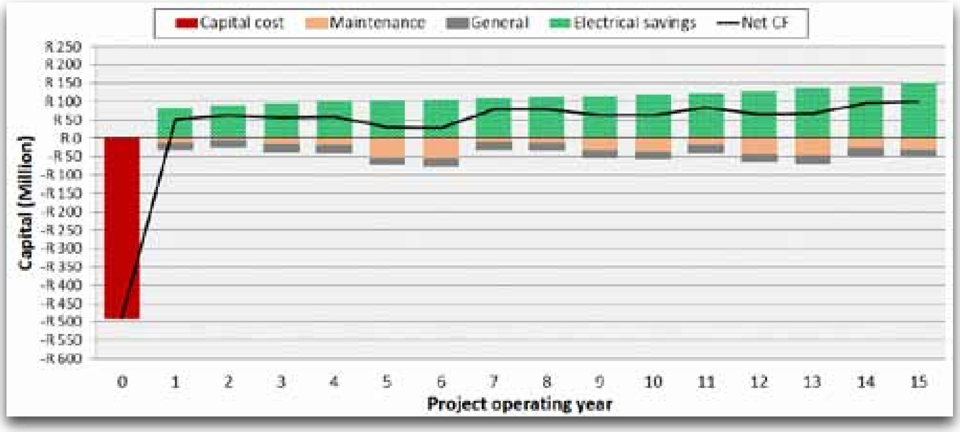

Fig. 6: Gas engine co-generation project cash flow projection

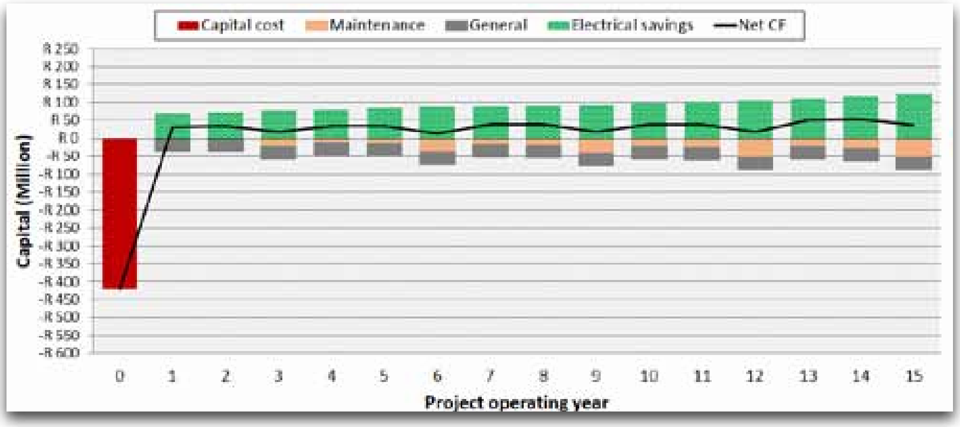

Fig. 7: Gas-fired boiler co-generation project cash flow projection

Fig. 6 and Fig. 7 shows the cash flows of both the gas engine and gas-fired boiler plants. With the gas engine plant major services occur during years 5, 6, 11, and 12. While the boiler plant has a boiler inspection every two and a half years, during which the plant has a two month shut-down.

In both of the cash flow graphs the annual operating expenses are divided into general expenses and maintenance costs. And the only cash flow income considered is the electrical savings, where the same cost per kWh is used for each year of each project. The net cash flow (CF) for both projects is positive for the 15 years, which means that both plants have a positive annual revenue. Of the two projects, the gas engine plant has a more positive cash flow, resulting in a greater net present value (NPV) and internal rate of return (IRR).

	Unit	Engines	Boiler	Turbines
Capital cost	R (million)	491	421	550
Operating cost	R(million)	31.3	36.8	304
Generating cost	R/kWh	0.32	0.46	2.48
NPV	R(million)	-25	-180	-1 957
IRR	%	9.2	2.0	-
SPP	Years	8.65	14.25	-
DPP	Years	16.51	63	-

Table 3: Economic evaluation results for the considered co-generation projects at the FeCr smelter

Off gas in South Africa

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Generating costs

Using the established cash flows, the annual generating cost per kWh is shown in Fig. 8. In this figure both of the other co-generation plants can be seen to generate electrical energy at a cheaper rate, if compared to the average estimated Eskom Megaflex tariff forecast. Of the two, the gas engine plant generates electrical energy at a cheaper rate.

RESULTS AND DISCUSSION

Three co-generation plants were identified for implementation at the FeCr smelter and a gas engine plant identified to be the most feasible option. This is mainly because of the greater efficiency of the system, which results in more electrical energy generation. This gas engine plant could generate 99 GWh of electrical energy per year, at R0.32/kWh (2016), with a project cost of around R421 million in 2015. With a 28% system efficiency the NPV is equal to -R25 million and the IRR 9.2%. The project also has a discounted payback period of 16.51 years. An improved efficiency (32%) would result in a NPV of R90 million, an IRR of 12.8% and a DPP of 11.76 years.

In all of the economic evaluations no carbon tax was taken into account. If carbon tax is implemented at a rate of R48/t (R120/t on 40% of emissions) in 2016, the FeCr smelter plant could save a further 5-10% (R1.8 million to R3.4 million) per annum on carbon tax. This is calculated on the 287 kt direct emissions at the FeCr smelter.

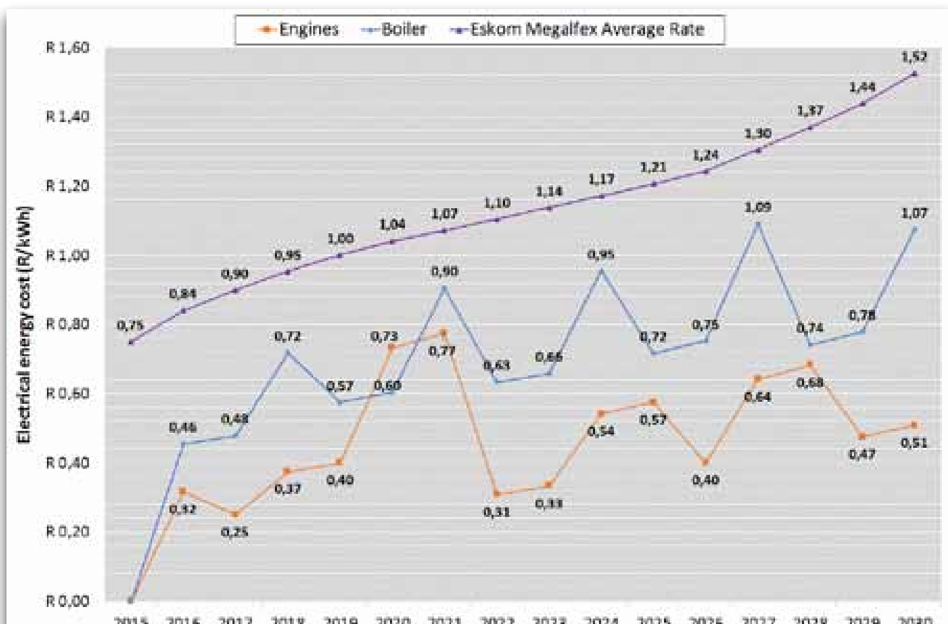

Fig. 8: Electrical energy generating cost for co-generation plants at the FeCr smelter

CONCLUSION

This article shows that there is a lot of potential in using ferrochrome furnace off-gas to generate electrical energy. By doing this the FeCr smelter plant will reduce the electrical energy bought from Eskom by a considerable amount. This will also result in a reduction in CO_2 emissions.

A gas engine co-generation plant is the most feasible option for doing this, at the considered smelter plant. The economic performance of this investment could be improved if carbon tax is implemented. A good plant design would also result in an improved efficiency and with that an improved feasibility.

Only certain technologies, and units within them, were considered in this study. Other options do exist for utilising the furnace off-gas energy and can also be evaluated. Some additions can also be made to the systems considered. For example, the engine flue gas can also be used for heating purposes or for additional power generation. Further studies will be required to determine the feasibility of such options.

This study shows that energy is available for utilisation at smelter plants and that well-established technologies exist for doing so. A FeCr smelter plant was considered in this study, but the results can be adapted and used for other smelter plants.

It is clear that co-generation plants can improve the overall efficiency and probability of a smelter plant in South Africa. wn

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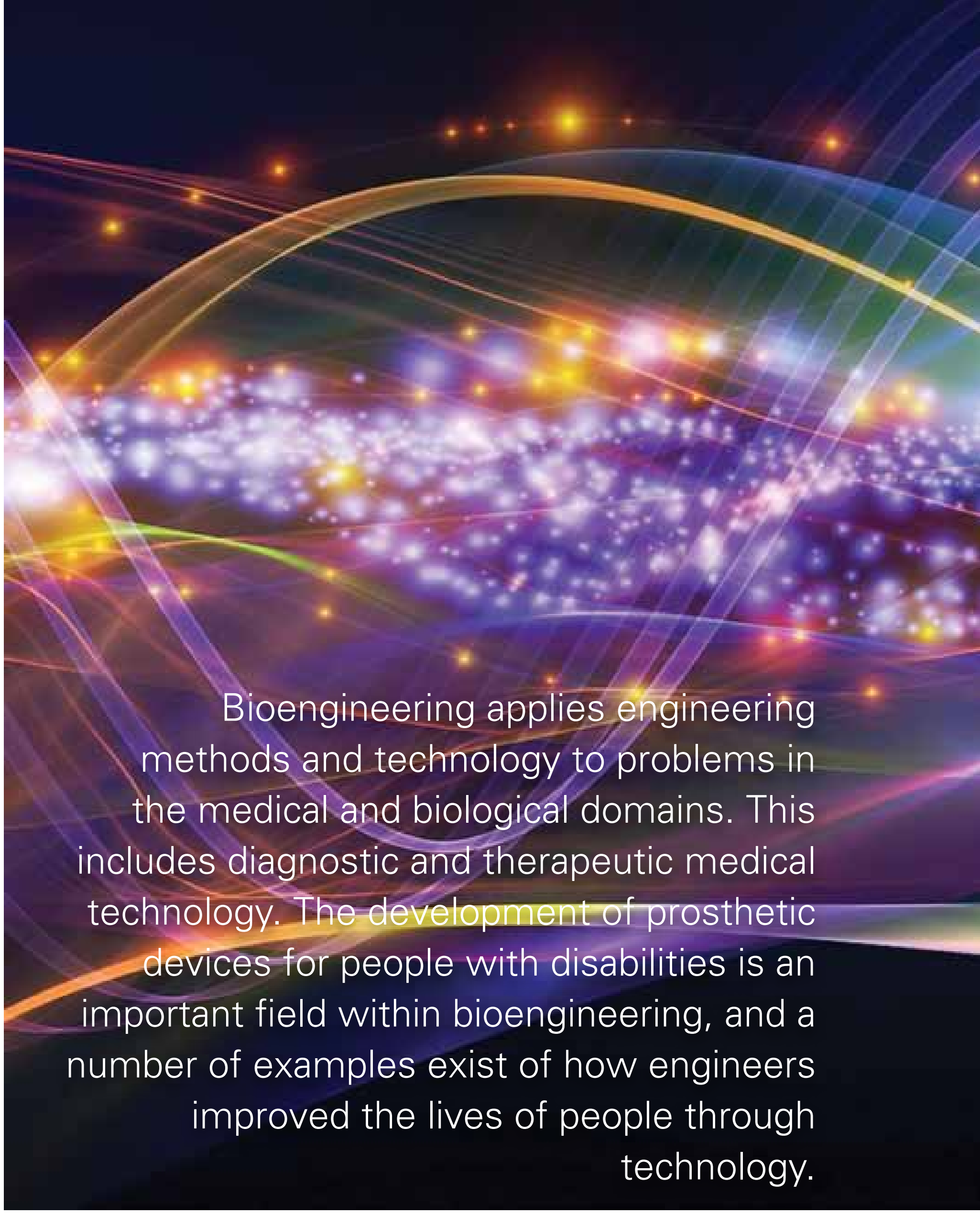
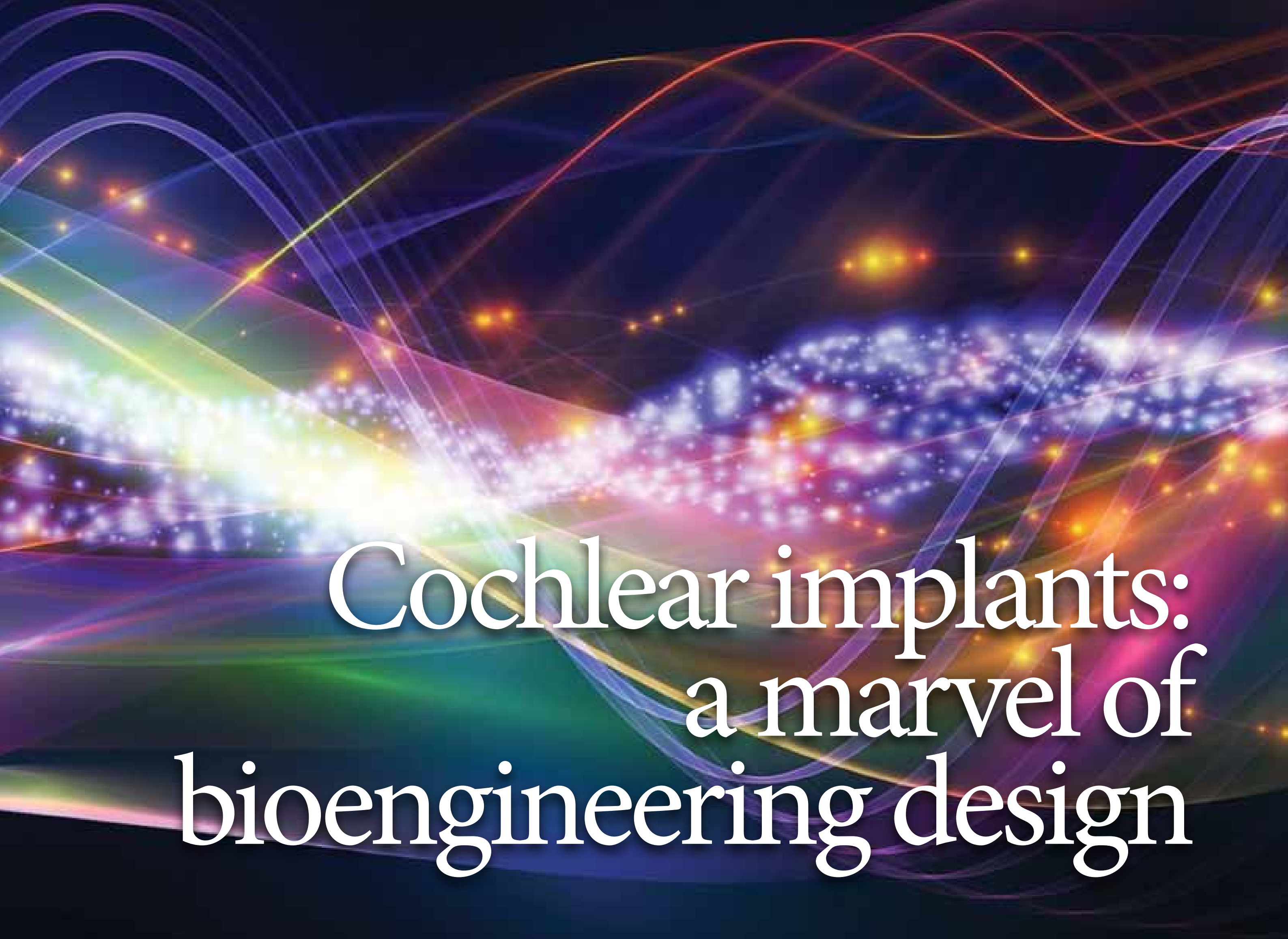


Bioengineering applies engineering methods and technology to problems in the medical and biological domains. This includes diagnostic and therapeutic medical technology. The development of prosthetic devices for people with disabilities is an important field within bioengineering, and a number of examples exist of how engineers improved the lives of people through technology.

Perhaps the most familiar examples would be hearing aids for the hard of hearing, and pacemakers for some heart conditions. The cochlear implant for deaf individuals is probably the pinnacle of bioengineering design and the most successful prosthetic device on the market. With this device, many profoundly deaf people can hear today.

Research and development in cochlear implants provide a good example of how engineering methods may be applied to solve problems in the medical domain. This article focuses on the engineering methods that are foundational to this medical device. In normal hearing, sounds entering the ear canal reach the inner ear (the cochlea) via a mechanical transduction process in the middle ear. Issues with mechanical transduction can often be solved by a hearing aid, which is in essence just an amplification device, although these can apply sophisticated signal processing to the incoming acoustic signal. However, a large percentage of profoundly deaf people are deaf because of hair cell loss in the cochlea, and hearing aids are of no value in these cases. Hair cells may be lost because of head trauma, noise exposure, some antibiotics, or disease (e.g. meningitis).

Information in the brain is encoded by nerve spike train patterns (i.e. electrical impulses that are conducted on nerve fibres). Hair cells are attached to nerve fibres that form the auditory nerve, which carries sound information to the sound processing centres of the brain. Hair cells provide a mechanical to electrical transduction from the incoming



Cochlear implants: a marvel of bioengineering design

BY | PROF JOHAN HANEKOM | GROUP HEAD: BIOENGINEERING | UNIVERSITY OF PRETORIA | SMSAIEE
PROF TANIA HANEKOM | UNIVERSITY OF PRETORIA | SMSAIEE

acoustic signal to an encoding in electrical nerve impulses. Large scale hair cell loss results in profound deafness, but usually many of the cochlear nerve fibres remain intact. These can be stimulated electrically by a cochlear implant.

A cochlear implant consists of a microphone, an external speech processor that converts the sound input from the microphone to a set of stimulation parameters, a transcutaneous radio-link that transmits data and power to the implanted electronics, an implanted electrical stimulus generator and a multi-contact electrode array that is surgically inserted into the cochlea. The cochlea is a tiny spiralling structure that vaguely resembles a snail's shell.

Auditory information is electrically transmitted to surviving auditory neurons via current injection through appropriate electrode combinations.

Outcomes are impressive. A previously deaf individual can achieve speech perception scores in quiet of around 80%, irrespective of the specific implant device. Despite the success of the device, the outcome is highly user-specific with benefits ranging from basic rhythm perception without much tonal content to being able to appreciate music and conversing via telephone.

Age of implantation (Hassanzadeh et al., 2002), duration of hearing loss (Blamey et al., 1996), design of the implanted electrodes (Rebscher et al., 2007), electrode insertion depth (Finley et al., 2008) and pre-operative variables (Gantz et al., 1993) are some of the factors that influence outcomes. The way in which these user-specific factors interact to produce a user-specific perceptual outcome is still relatively unclear and warrants further investigation. A computational modelling approach to tease out the factors that underlie inter-person variability is ideal since the development of a model in itself provides information about the structure of the system as well as the parameters that dictate its operation.

Cochlear implants

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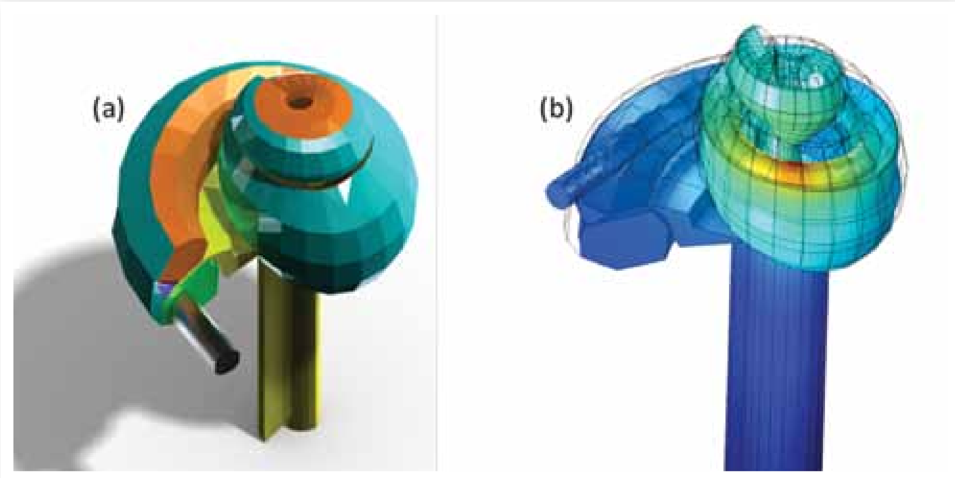

Figure 1. (a) User-specific computational model of a cochlea showing the electrode array (gray cylinder) protruding from the scala tympani (lower duct of the cochlea shown in green). (b) Finite element solution of the electric potential field inside the cochlea as a result of stimulation with one of the electrodes. The red area indicates the location of the stimulating electrode and has the highest electric potential. The extent to which nerve fibres in the vicinity of this electrode will be excited, depends on the specific spatial distribution of the potential field.

Cochlear implants function on two main principles: (i) nerve fibres can be excited by a current that passes through them, and (ii) the auditory nerve fibres that innervate the cochlea are tonotopically organised, i.e. fibres that are more sensitive for high frequency sounds are located towards the base of the cochlea while fibres that respond to lower frequency components in the sound signal are located towards the apex of the cochlea. This creates an ideal biophysical interface site since complex sounds, such as speech, may be synthesized from its Fourier components.

By processing the incoming acoustic sound signal by breaking it down into its constituent frequency components, basic generator signal component parameters may be transmitted to the implanted electronics. The implanted electronics generate appropriate electrical stimuli that are applied to a number of electrode contacts that are distributed along the length of the scala tympani (one of the cochlear canals). Since each electrode contact theoretically targets a different neural population, each of them elicits a different pitch percept, thereby creating the orthogonal signal components that are required to synthesize speech and other complex sound signals.

Unfortunately the components that are created are not necessarily completely orthogonal, since the fluid medium in which the electrode array is installed within the cochlea causes current to spread over a wide region in the cochlea. This results in overlap of neural populations elicited by different electrodes. This channel interaction is generally assumed to degrade auditory performance with a CI and much research is aimed at designing electrode arrays and electrical stimulation strategies to limit channel interaction, i.e. to focus currents on a limited neural population. The exact manner in which currents distribute throughout the cochlea and peripheral auditory neural structures depends on the specific morphology of a user's cochlea as well as the exact location of the electrode array inside the cochlea. A further important factor is the pattern of neural survival, which is also user-dependent.

Computational models provide a simulated invasive view of the interaction between the cochlear implant technology and the peripheral auditory system, consisting of the cochlea's anatomy and its neurophysiological environment. This enables researchers to investigate the neurophysiological mechanisms that underlie the functioning of cochlear implants (Malherbe et al., 2013). These models provide a computer-generated cochlear environment where neural responses to stimulation via the implant may be controlled through several interdependent parameters and subsequently analysed. They also provide a means to simulate an experimental environment that might not be feasible in reality, e.g. to "measure" (i.e., predict by the model) single nerve fibre thresholds in the auditory periphery of live human users.

Professors Johan and Tania Hanekom, a husband and wife team, have been working in the field of cochlear implant modelling for more than two decades. Recent work on the development of user-specific models for cochlear implantees has been driven through the PhD research of Dr Tiaan Malherbe (Malherbe et al., 2015b, Malherbe et al., 2015a) and a number of other postgraduate students in Bioengineering at the University of Pretoria. The work

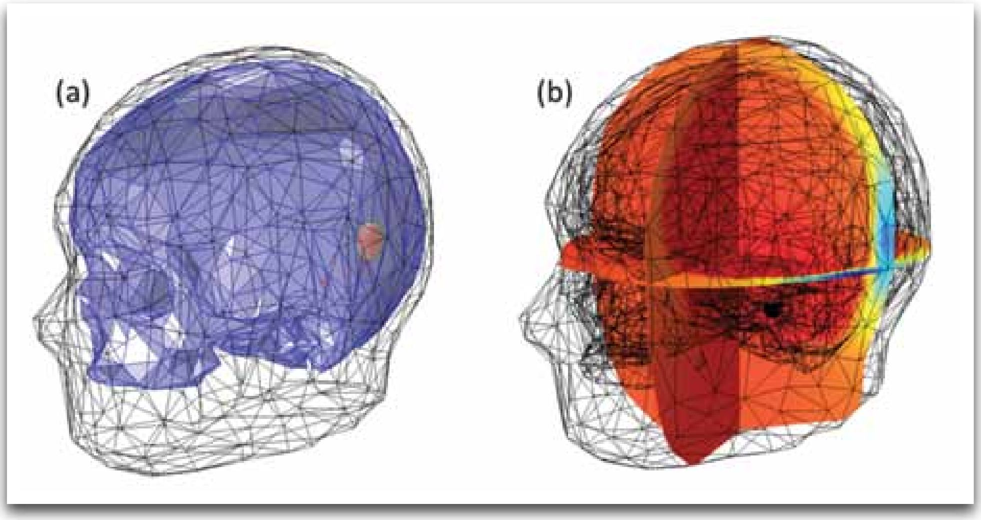

Figure 2. (a) Visual representation of the finite element mesh of the full head model showing the external return electrodes in red. (b) Predicted potential fields as a result of intracochlear stimulation on two planes through the model. The cochlea can be seen as a dark area behind the vertical plane and below the horizontal plane.

focuses on the construction of user-specific models for which the geometric parameters are extracted from Computed Tomography (CT) images of the cochleae of these users. The models incorporate skull and brain volumes to provide an accurate description of current pathways among the intra-cochlear stimulation electrodes and the extra-cochlear return electrodes.

Model generation starts with landmark assessment of the most lateral spiral trajectory of the cochlear canals from a CT scan of a cochlear implant user. CT scans have very low resolution compared to the size of the cochlea, limiting landmark assessment to regions of the cochlea where the boundaries of structures are clearly discernable. Since the measured cochlear spiral is a noisy representation of the actual cochlear boundary, and it is difficult to follow the spiral through to the helicotrema (the most apical point of the cochlea), a procrustes approach is used to determine the best fit to a library of spiral templates that were obtained from literature. This allows the spiral to be approximated from the round window at the basal-most end of the cochlea to the helicotrema at the apical-most end of the cochlea. Next, an inner structure template that contains structural details that are not discernible on the CT scans, is fused with the user-specific spiral trajectory to produce a user-specific cochlear structure.

Once the three-dimensional geometric framework that describes the cochlear geometry is created, a generic head model is morphed onto the user's head shape using skull size parameters measured from the user's CT images. The head model allows the extra-cochlear environment to be more accurately described than using an infinite volume or a head-sized homogeneous ellipsoid. It also allows the correct size and location of the extra-cochlear return electrodes to be modelled. The different 3D structures are then meshed and assigned appropriate electrical material properties. The tissues are assumed to be purely conductive, based on a study that showed that this is a good approximation for biological tissues at lower frequencies (Spelman et al., 1982).

The next step in the modelling workflow is simulation of electrical stimulation of the surviving auditory nerve fibres. This is done by solving the volume conduction problem through finite element analysis methods. The electrical potential field that is elicited by current injection through a specific electrode or set of electrodes is assessed at the location of neural elements in the 3D model. An impedance transfer matrix is created as output from the volume conduction model. This is then applied to calculate the stimulus field on the nodes of Ranvier of a nerve fibre model array.

The nodes of Ranvier are sites on a nerve fibre that are sensitive to electrical stimulation. Applying a search algorithm, the stimulus current at which each nerve fibre in the nerve fibre array fires (the term used for being activated)can be calculated, or alternatively the spatial distribution of the neural population that is activated can be assessed at a specific stimulus intensity. The neural excitation profiles that are the results of this procedure reveal a number of characteristics of the neural response. These include the amount of channel interaction at specific stimulus intensities, the threshold currents that may elicit an auditory percept and the pitch at which stimulation with a specific electrode may be perceived.

While these steps in the workflow may seem rather uncomplicated, there are a number of factors that poses which pose a significant challenge. The first is the low

Cochlear implants

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resolution of the imaging data from which the landmarks have to be quantified. Since the internal structural details of the cochlea are at best vague and mostly absent on clinical CT images, much effort is currently focused within the research group to develop a workflow that will optimise the level of detail and accuracy of the geometric assessment. A second challenge is the labour-intensive nature of model generation that requires a significant time investment in the development of each user's models.

Work is currently undertaken to automate a significant portion of the workflow to expedite the development of models. The reasons for creating an accelerated model generation workflow are two-fold: (i) to support research by creating a significant model repository to support investigations into the factors that underlie user-specific performance with cochlear implants, and (ii) the objective of translating the models into a set of clinical tools that may find standard application in all implant cases. It is thus necessary to develop the capacity to create intricate computer models in a relatively short period of time.

The end result of biomedical engineering research should be to drive the development of medical devices, or to provide clinical tools to assist medical professionals. The sophisticated computational models discussed here are intended to do the latter. It supports a level of customisation of the implant device for an individual that would be impossible without the detailed insight that person-specific models provide. In addition, it provides diagnostic tools through a detailed description of the biophysical interface between the cochlear implant device and a specific user's peripheral auditory system that provide the ability to probe complications that may arise after cochlear implantation. For example, facial nerve stimulation is a common side-effect of intra-cochlear stimulation.

Through models of an individual's cochlea and implanted electrode array we gain understanding of the electrical current pathways that could cause electrical stimuli to reach the facial nerve, and we can then customise the implant stimulation parameters or the electrode design to solve this type of problem. In an example like this, a computer model of an individual cochlear implant is the next level up from normal imaging (MRI or CT). The example of cochlear implants and computer modelling demonstrates how engineering skills and tools may directly impact the lives of people that who live with disabilities.

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Milestones of Innovation

The field of bioengineering is in its infancy – it is the only engineering discipline that developed post WWII. There is much room for growth and advancement within the field, which poses exciting opportunities for students looking toward bioengineering careers.

COMPILED BY | MINX AVRABOS

Medical and biological engineers today are carving-out their own path and are working to solve society's most vexing issues. As never before, advances in bioengineering hold tremendous promise in tackling some of the grand challenges facing the world. A look back at the development of the field of bioengineering reveals astounding achievements and remarkable advances.

The second half of the 20th century paved the way for the modern era of bioengineering yet to come. Major strides in medical devices were seen. Willem Kolff, Ph.D. conducted research and experiments that led to the advent of kidney dialysis in the late 1940's. Charles A. Hufnagel, M.D. invented the first artificial heart valve, which was successfully implanted in 1952. In 1953, Philadelphia surgeon John H. Gibbon, Jr. performed the first successful human heart surgery assisted by a heart-lung machine. Then in 1958, the first external cardiac pacemaker was successfully used. By the late 1960's, the first biomedical engineering departments were formed at the University of Virginia, Case Western Reserve University, Johns Hopkins University, and Duke University. These institutions have remained active in educating students and conducting cutting-edge research today.

At the same time, advances in what we knew about the building blocks of life were rapidly developing, spurring a 'biological revolution.' Cell culture, or the way cells are grown in the lab, became critical in the development of polio vaccines in the 1940's and 1950's. The discovery that DNA is a double helix in

the 1950's was invaluable to the medical and biological sciences. The beginning of the modern era of bioengineering was marked by the introduction of recombinant DNA technology (DNA produced artificially in the lab) in the 1970's. Towards the end of the 20th century, significant advances in technology spurred the development of the Human Genome Project and a revolution in biotechnology innovation around the world.

The past three decades continued to solidify bioengineering as a discipline uniquely positioned to advance human health at the cutting edge of medical technology. Medical imaging technology soared. Stem cell technology emerged. Biological and tissue engineered skin substitutes were developed. Major trends in public health including rising health care costs, re-emerging diseases, and an aging population demanded a field equipped with tools to tackle these problems. For the future, individuals educated with an integration of engineering with biology will be able to contribute not only to advances in medicine, but also to other society problems such as energy, the environment, and food.

The following remarkable milestones saw the light in the last 50 years and needs to be mentioned:

ARTIFICIAL KIDNEY

Once, kidney failure meant certain death. The advent of dialysis treatment to remove deadly impurities from the blood meant patients' lives could be saved. For some, dialysis has become a way-station to the long-term solution of a kidney transplant.

X-RAY

Among the first major "high tech" devices used in medicine, X-Rays have been in common use for almost a century as a diagnostic tool. In radiotherapy, X-Rays are used to treat certain diseases, notably cancer, by destroying malignant tumour cells with X radiation.

FEATURE

Milestones of Innovation

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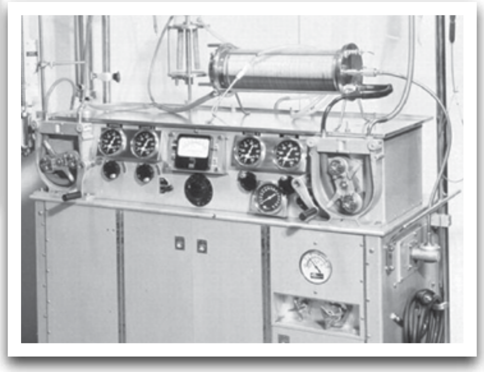
ELECTROCARDIOGRAM

The EKG is used to measure the rate and regularity of heartbeats as well as the size and function of the heart chambers, the presence of any damage to the heart, and the effects of drugs or devices used to regulate the heart (such as a pacemaker). EKG screenings have been instrumental in helping physicians reduce rates of death and debilitation from heart disease.

CARDIAC PACEMAKER

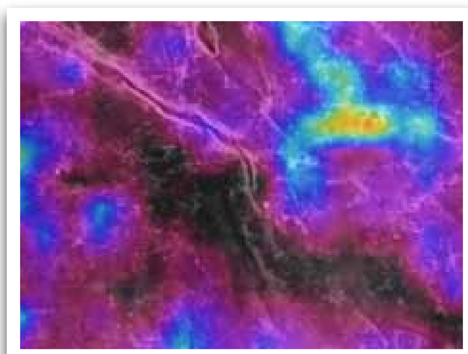
Many people who have an abnormal heart rhythm run the risk of sudden death if the heart rhythm gets out of control. A cardiac pacemaker can significantly reduce the risk of sudden death by providing a small, controlled electric current when needed to maintain steady rhythm.

November 2015 saw Scientists developed a miniature, wireless pacemakers. The mini pacemaker is the size of a large pill and can be placed without surgery and attached to the right side of the heart.



CARDIOPULMONARY BYPASS

Surgery to bypass congested coronary arteries (using sections of undamaged arteries or veins from other parts of the body) extends lives and improves the quality of life. This procedure was made possible with the development of the heart-lung machine which allows the heart to be stopped during surgery – with the machine taking over the job of providing oxygen to the blood and moving blood through the body.



ANTIBIOTIC PRODUCTION TECHNOLOGY

During and after World War II, there was explosive growth in the number of antibiotics being discovered and found useful to treat various conditions. However, it was the development of engineering technologies to mass produce those antibiotics that allowed them to come into general use.

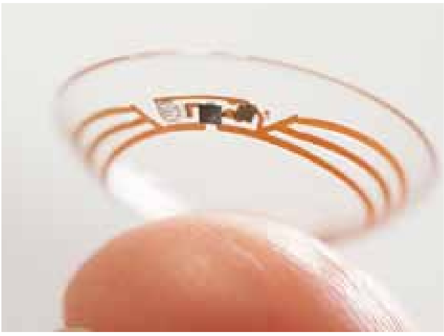
DEFIBRILLATOR

When a patient goes into cardiac arrest, the defibrillator is used to shock the heart back into action. Since the original engineering achievement to design the device, a series of additional engineering enhancements to make it smaller has allowed the defibrillator to move out of the hospital operating room or emergency room and into the hands of emergency response personnel treating patients in offices, shopping centers, airports and even homes and schools.

HEART VALVE REPLACEMENT

Replacement heart valves were an early example of engineers and clinicians

working together to restore cardiac function for patients facing incapacitation because their own valves were failing. Over the years, engineers have developed new designs and materials that allow valves made with synthetic and natural materials to replace damaged or diseased valves.



INTRAOCULAR/CONTACT LENS

The plastic Intraocular Lens (IOL) has helped restore full vision to those whose sight had grown cloudy due to cataracts (the leading cause of blindness worldwide) or other diseases. Collaboration among bio-materials engineers, mechanical engineers, optical engineers and surgeons has led to a variety of IOLs to fit different patient needs. These artificial lenses are inserted in an outpatient procedure taking only a few hours.

While the intraocular lens has restored normal vision to people with cataracts, the contact lens – which preceded it in general use – has proven critical for the functioning of numerous people with keratoconus and other maladies and psychologically important for those who have problems with eyeglasses. Having evolved from an expensive, uncomfortable glass device in the 1930s to an affordable, easy-to-use (and, in many cases, disposable) item today, contact lenses are used by tens of millions of people worldwide.

ULTRASOUND

For many parents, ultrasound has provided their first "picture" of their unborn child. Through creative engineering, ultrasound also is used to examine many other internal organs, including the heart, carotid arteries, kidneys and bladder. Ultrasound technology uses high-frequency sound waves to get its images – in the same way that submarines use sonar to detect other vessels.

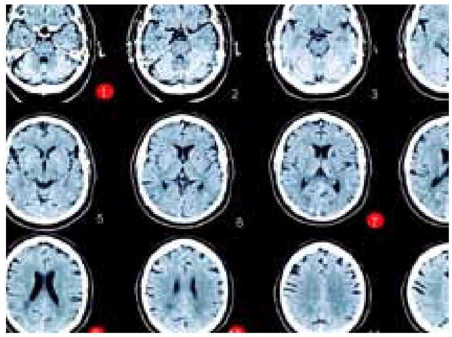
VASCULAR GRAFTS

Vascular grafts made with biologic or synthetic materials are used to repair or replace diseased blood vessels. Two common applications are the use of the internal mammary artery in coronary bypass surgery and the use of bypasses to treat peripheral arterial disease.

Engineers made these life-saving procedures possible through the design and use of innovative materials.

BLOOD ANALYSIS & PROCESSING

The field of clinical laboratory medicine was revolutionized by the Coulter Principle, which established the reference method for counting and sizing particles. This led to instrumentation that automated the complete blood count or CBC. Today, it is the most commonly utilized diagnostic test worldwide.



COMPUTER ASSISTED TOMOGRAPHY (CT)

The integration of computer and X-ray imaging technologies was a landmark engineering feat, allowing radiologists to achieve great breakthroughs in the diagnosis and treatment of certain diseases. CT technology provided an unprecedented cross-sectional picture of the body. In cancer for example, CT is used to detect a tumor, provide information about the extent of the disease, help plan treatment, and determine whether the cancer is responding to treatment.

Milestones of Innovation

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ARTIFICIAL HIP & KNEE REPLACEMENT

Before the advent of artificial hip and knee joints, millions of people – particularly the aged – lived with considerable pain and very limited mobility. Engineers developed designs that can be customized to meet patients' various needs. Famed golfers Arnold Palmer and Jack Nicklaus are among the millions who still lead active lives thanks to their artificial hips.

BALLOON CATHETER

The balloon catheter is like a ship in a bottle, symbolizing the engineering finesse and determination required to reach remote body locations through tiny holes. This less invasive technology allows for a fantastic voyage of exploration and treatment for a wide range of conditions, with reduced risk, cost and recovery time.

ENDOSCOPY

Before the endoscope, exploratory surgery often was needed to diagnose and treat patients. The engineering achievement of combining a miniature camera with a flexible tube provided a minimally invasive way to perform a broad range of diagnoses and treatments, with considerably lower risk and cost.

BIOLOGICAL PLANT & FOOD ENGINEERING

In addition to many medical achievements, biological engineering achievements have increased the quantity and safety of food and have benefited people in life-sustaining ways around the world. New packaging materials and techniques are being developed to provide more protection to foods, and novel preservation technology is emerging.

COCHLEAR IMPLANTS AND STIMULATORS

Cochlear implants and stimulators have provided functional hearing to more than 100,000 patients with profound or severe deafness, and millions more potentially could benefit from the technology. The devices allow people of all ages – whether they were born without functional hearing, or lost their hearing later in life – to participate more or less normally in a society in which both social and business interactions often depend on acoustic speech and hearing.

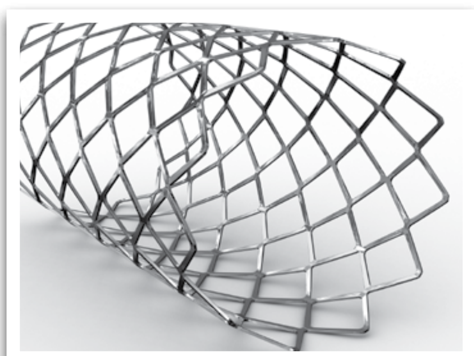
MAGNETIC RESONANCE IMAGING (MRI)

MRI imaging employs radio frequency waves and a strong magnetic field to produce remarkably clear and detailed pictures of internal organs and tissues. Through a combination of engineering

technology and clinical know-how, it provides physicians with exceptional resolution for cross-sectional images of the body. It has facilitated many breakthroughs in neuroscience, cancer treatment and orthopedic surgery.

LASER SURGERY

Laser surgery is an interesting example of engineers' ability to successfully apply an industrial technology for a wide range of medical uses. The pulsed dye laser was the first laser designed for a specific medical application, unsightly birthmarks. Some of the innovative applications include cancer treatment, aesthetic surgery and vision enhancement surgery.



VASCULAR STENTS

Vascular stents are an interesting example of how engineers continuously refine a concept over several product generations. The technology has evolved from a wire mesh tube to hold open an artery to more sophisticated devices – including the drug-eluting stents that have emerged over the past decade.

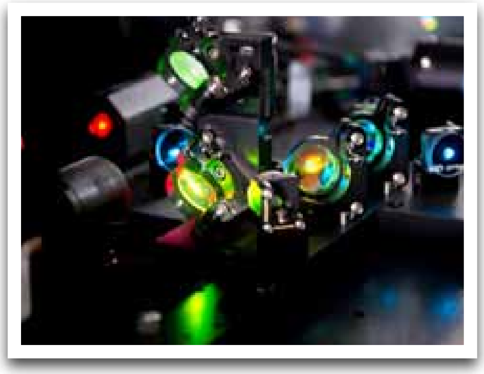
RECOMBINANT THERAPEUTICS

Engineers developed the enabling technologies to manufacture products of biological origin – or to treat biological activity – that are now a key component of the bio-pharmaceutical industry. For example, cells that manufacture therapeutic protein molecules form the basis for innovative and important drugs that could not be generated any other way.

Recombinant technologies were first introduced in the 1970's and by the following decade they were applied on an industrial scale, yielding proteins to treat diabetes, heart attacks, and cancer and to moderate the impact of immune deficiencies.

FLOW CYTOMETER AND CELL SORTER

The flow cytometer and cell sorter are devices used today in every major university, medical school, hospital, research institute, and pharmaceutical company in the world. The technology has revolutionized the study of the immune system and cancer, and today is driving emerging areas of



biomedical research such as proteomics and systems biology. Flow cytometry and cell sorting has emerged as the analytical method of choice for the diagnosis and monitoring of treatment for blood-based diseases ranging from leukemia to HIV/AIDS.

In fact, the maturation of flow cytometry technology in the early 1980's coincided with the emergence of HIV/AIDS as a major public health problem.

PULSE OXIMETER

With the introduction of Pulse oximetry, a non-invasive, continuous measure of patient's oxygenation was possible, revolutionizing the practice of anesthesia and greatly improving patient safety. Prior to its introduction, an estimated 2,000-10,000 Americans died each year from anesthesia-related complications, and many more were made ill.

Milestones of Innovation

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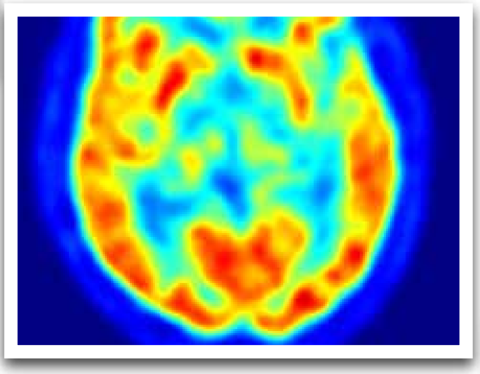
DIGITAL HEARING AID

The digital hearing aid – small enough to be positioned virtually out of sight in the inner ear – has improved the quality of life for millions of people. The device allows a wearer not only to talk to friends and family, but also to enjoy music, theater, television and other activities.

Primitive electronic hearing aids with vacuum tubes began to appear in the 1920s; transistors revolutionized analog hearing aids in the 1960s and digital hearing aids came about in the 1980s. Advances in microphone design, speech processing, molding techniques, zinc-air batteries and instrumentation for the audiologist all contributed and continue to evolve improved performance.

GENOMIC SEQUENCING & MICRO-ARRAYS

While the Human Genome Project has dominated the headlines in recent years, it would not have been possible without engineering achievements in DNA sequencing and micro-arrays. These tools have allowed researchers to identify the genes within human DNA. In time, this is expected to lead to fundamental breakthroughs in the practice of medicine.



POSITRON EMISSION TOMOGRAPHY

The PET Scan is the latest engineering breakthrough in imaging technology and an important supplement to CT Scanning and MRI. PET technology allows doctors to observe cellular-level metabolic changes with powerful cross-section images of the body. PET Scans are now used to detect some cancers, coronary heart disease and brain disorders.

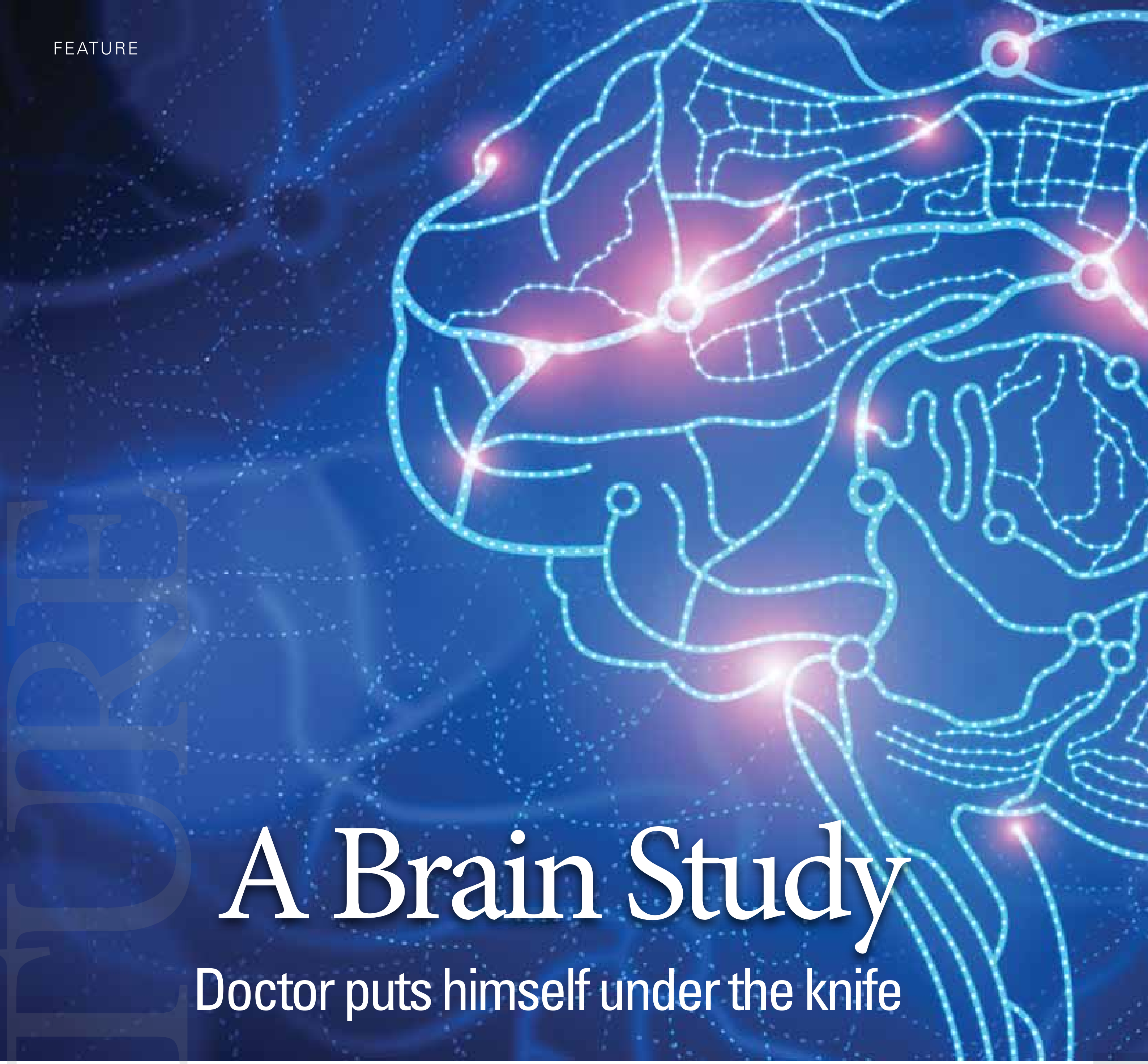
IMAGE-GUIDED SURGERY

Image-guided surgery allows the surgeon to use imaging technology to precisely identify where an incision or repair is needed. It helps minimize damage to surrounding tissue and promotes faster patient recovery and reduced patient morbidity. Image-guided surgery is the general term used for any surgical procedure where the surgeon

employs tracked surgical instruments in conjunction with preoperative or intra-operative images in order to indirectly guide the procedure. Similar to a car or mobile Global Positioning System (GPS), image guided surgery systems use cameras or electromagnetic fields to capture and relay the patient's anatomy and the surgeon's precise movements in relation to the patient, to computer monitors.

OPTICAL COHERENCE TOMOGRAPHY

Optical Coherence Tomography (OCT) is a technique for obtaining sub-surface images of translucent or opaque materials at a resolution equivalent to a low-power microscope. It is effectively 'optical ultrasound', imaging reflections from within tissue to provide cross-sectional images. OCT is attracting interest among the medical community, because it provides tissue morphology imagery at much higher resolution than other imaging modalities. wn



A Brain Study

Doctor puts himself under the knife

How one of the inventors of brain-computer interfaces ended up getting one himself.

BY | ADAM PIORE

Phil Kennedy no longer saw any other way to get the data. That was how one day he came to lie blissfully unconscious on an operating table in Belize while a neurosurgeon sawed off the top of his skull.

Last year, Kennedy, a 67-year-old neurologist and inventor, did something unprecedented in the annals of self-experimentation. He paid a surgeon in Central America $25,000 to implant electrodes into his brain in order to establish a connection between his motor cortex and a computer.

Along with a small group of pioneers, Kennedy had in the late 1980s developed "invasive" human brain-computer interfaces—literally wires inside the brain attached to a computer, and he is widely credited as the first to allow a severely paralyzed "locked-in" patient to move a computer cursor using her brain. "The father of cyborgs," one magazine called him.

Kennedy's scientific aim has been to build a speech decoder—software that can translate the neuronal signals produced by imagined speech into words coming out of a speech synthesizer. But this work, carried out by his small Georgia company Neural Signals, had stalled, Kennedy says. He could no longer find research subjects, had little funding, and had lost the support of the U.S. Food and Drug Administration.

That is why in June 2014, he found himself sitting in a distant hospital contemplating the image of his own shaved scalp in a mirror. *"This whole research effort of 29 years so far was going to die if I didn't do something,"* he says. *"I didn't want it to die on the vine. That is why I took the risk."*

During autumn, Kennedy presented studies of his own brain at the Society for Neuroscience in Chicago, where his actions provoked both awe and concern among colleagues. By arranging for surgery on a healthy person—even himself, even in the name of science—he'd likely violated his doctor's oath. *"I'm glad he's fine now,"* says Eddie Chang, a University of California, San Francisco, neurosurgeon whose recent work mapping the areas of the motor cortex that control speech helped guide Kennedy's calculations. *"I hope he gets some precious, precious data."*

FDA TROUBLE

Kennedy, who was born in Ireland, says his self-experiment was driven by frustration and by scientific questions. He was so intrigued by the brain as a young physician that he returned to school to earn a Ph.D. in neuroscience. While running a lab at the Georgia Institute of Technology in the 1980s, he developed and patented an innovative type of electrode consisting of a pair of gold wires encased in a tiny glass cone. Filled with a proprietary blend of growth factors, the electrode induced nearby neurons to grow into the device.

A Brain Study

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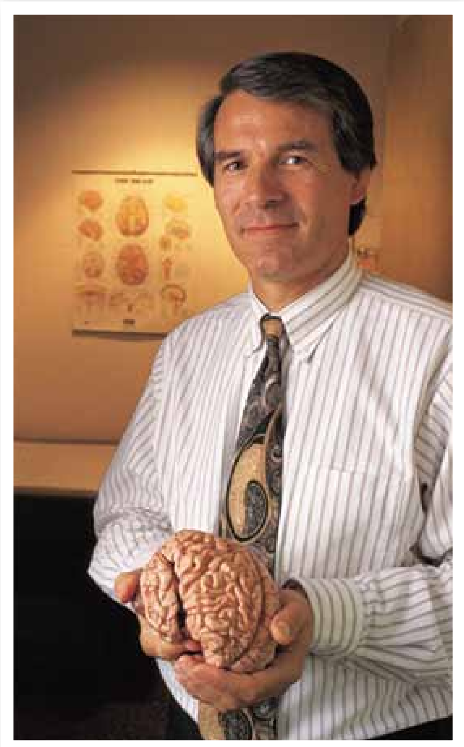


Phil Kennedy

In 1996, after tests in animals, the Food & Drug Administration (FDA) agreed to allow Kennedy to implant his electrodes into locked-in patients with paralysis so severe they could no longer speak or move. His first volunteer was a special education teacher and mother of two named Marjory, or "MH," who agreed to undergo the procedure at the very end of her life.

Marjory had ALS *(Amyotrophic Lateral Sclerosis - is a progressive neurodegenerative disease that affects nerve cells in the brain and the spinal cord)* but demonstrated she could turn a switch on and off just by thinking. But she was so sick that only 76 days later, she died. Next, in 1998, came Johnny Ray, a 53-year-old Vietnam veteran and drywall contractor who awoke from a coma with his mind fully intact but unable to move anything except his eyelids.

Kennedy personally oversaw the implantation of the electrodes in at least five subjects, and his team began showing that if it recorded from just a few neurons, patients could move a cursor on a computer screen and communicate by picking words or letters from a menu.

By 2004, Kennedy had implanted his electrodes in the brain of Erik Ramsey, a volunteer who suffered a catastrophic brain stem stroke in a car accident that left him locked in at the age of 16. Thanks to the data collected from Ramsey, Kennedy and his collaborators continued to publish high-profile papers on the results in journals like PLOS One and Frontiers in Neuroscience as recently as 2009 and 2011. One paper described how software could pick out the sounds Ramsey was imagining and allow him to very roughly pronounce a few simple words. Eventually, Ramsey became too ill to keep participating in the research.

By then, the FDA had also withdrawn permission to use the devices in any more patients. Kennedy says the agency began asking him for more safety data, including on the neurotrophic factors he was using to induce neuronal growth. When Kennedy couldn't provide the data, the FDA refused to approve any more implants.

Kennedy never fully accepted the FDA decision (he took at least one other patient to Belize for an implant). There were also scientific frustrations working with disabled people. Locked-in people can't communicate, except at times with grunts or their eyes, something that added a confounding variable to his experiments. When a given neuron fired off, he could never be sure what the patient had been thinking.

Kennedy became convinced that the way to take his research to the next level was to find a volunteer who could still speak. For almost a year he searched for a volunteer with ALS who still retained some vocal abilities, hoping to take the patient offshore for surgery. *"I couldn't get one. So after much thinking and pondering I decided to do it on myself,"* he says. *"I tried to talk myself out of it for years."*

The surgery took place in June 2014 at a 13-bed Belize City hospital a thousand miles south of his Georgia-based neurology practice and also far from the reach of the FDA. Prior to boarding his flight, Kennedy did all he could to prepare. At his small company, Neural Signals, he fabricated the electrodes the neurosurgeon would implant into his motor cortex—even chose the spot where he wanted them buried. He put aside enough money to support himself for a few months if the surgery went wrong. He had made sure his living will was in order and that his older son knew where he was.

WALKING THE WALK

Down in Belize, the procedure did not go smoothly, pointing to the dangers of brain-computer interface science to volunteers. There is a small but real chance of death anytime the skull is opened. After waking up from his first surgery, Kennedy says, he could not reply when the surgeons spoke to him. He had lost the ability to speak. The doctors later explained that his blood pressure had spiked during the 12-hour surgery, causing the brain to swell and leading to temporary paralysis. *"I wasn't the least bit scared,"* says Kennedy. *"I knew what was going on. I invented the surgery."*

The side effects were very serious, but Kennedy says he recovered and returned

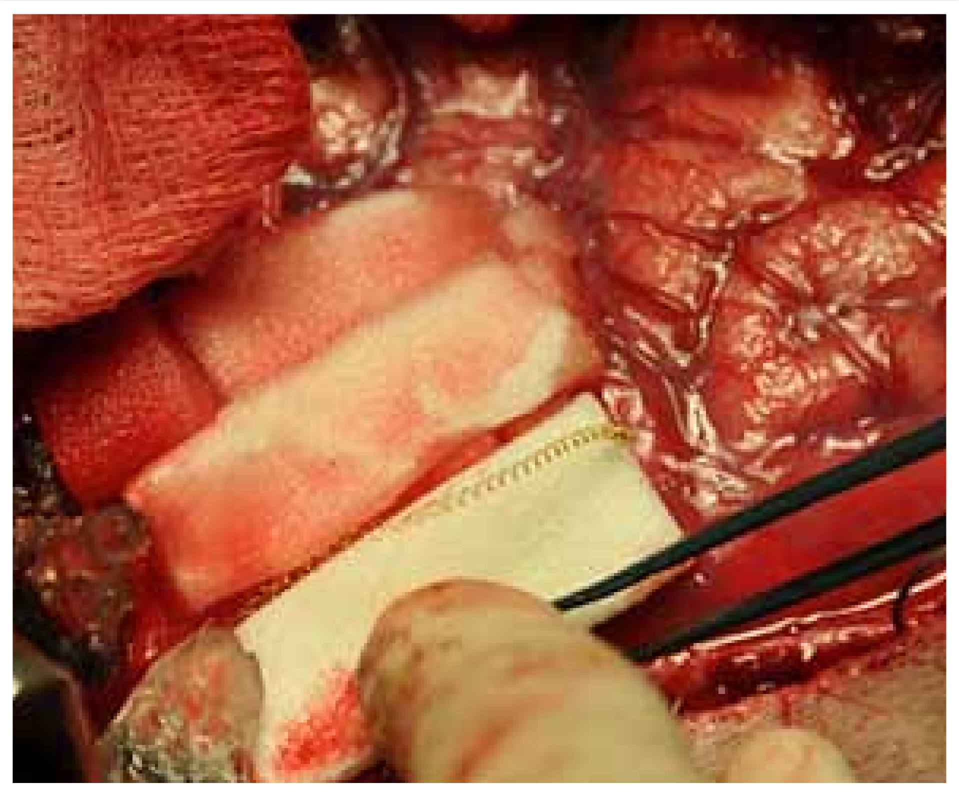
for a second 10-hour procedure in Belize City several months later so the surgeon could implant electronics that would let him collect signals from his own brain.

Kennedy's heroics impress some of his former patients. *"Talk about walking the walk!"* David Jayne, an ALS patient implanted by Kennedy's team in the early 2000s, said in an e-mail. *"I admire the hell out of Phil."*

To some researchers, Kennedy's decisions could be seen as unwise, even unethical. Yet, there are cases where self-experiments have paid off. In 1984, an Australian doctor named Barry Marshall drank a beaker filled with bacteria in order to prove they caused stomach ulcers. He later won the Nobel Prize. *"There's been a long tradition of medical scientists experimenting on themselves, sometimes with good results and sometimes without such good results,"* says Jonathan Wolpaw, a brain-computer interface researcher at the Wadsworth Center in New York. *"It's in that tradition. That's probably all I should say without more information."*

After returning home to Duluth, Georgia, Kennedy began to toil largely alone in his speech lab, recording his neurons as he repeated 29 phonemes (such as e, eh, a, o, u, and consonants like ch and j) out loud, and then silently imagined saying them. He did the same with about 290 short words such as "Dale" and "plum." There were also phrases to speak: "Hello, world," "Which private firm," and "The joy of a jog makes a boy say wow."

Kennedy says his early findings are "extremely encouraging." He says he determined that different combinations



The brain of Phil Kennedy during surgery to install a neuron-recording implant.

of the 65 neurons he was recording from consistently fired every time he spoke certain sounds aloud, and also fired when he imagined speaking them—a relationship that is potentially key to developing a thought decoder for speech. At The University of California, San Francisco (UCSF), Chang says that Kennedy may have learned something new. His own research uses different electrodes placed outside the brain, which he says are able to collect only a *"relatively rough"* signal (see "A Speech Synthesizer Direct to the Brain"). *"I think what he might have access to there is something a lot more detailed,"* says Chang.

There was one major disappointment. Kennedy had hoped to live with the implants in his brain for years, collecting data, improving his control, and publishing papers. But the incision in his skull never closed entirely, creating a dangerous situation. After a few weeks of collecting data, last January Kennedy was forced to ask doctors at a local Georgia hospital to remove the implants. The bill came to $94,000. Kennedy submitted the claim to his insurance company (he says it paid $15,000).

Kennedy attributes this setback to his decision to build the electrodes extra large and install them at an unusual angle so they would be easier to work with—a decision he now believes was a mistake.

"I got away with it, so I'm happy," he says. *"I had a few bumps and bruises after the surgery, but I did get four weeks of good data. I will be working on these data for a long time."* wn

Top 10 threats for websites

The cyber-world can be a dark and daunting place, especially if you are building and running your own websites or have an online business.

Cyber-crime in the form of hacking could result in your website being blacklisted by Google, equating to a drop in search rankings, a damaged reputation, and a loss of revenue as you try to get your site back up.

"But there is no need to panic," says Myron Salant, web services product manager at Webafrica. *"Many website owners only think about security after their site gets hacked, but knowledge is power: if you know what the threats are you can arm yourself appropriately and get one step ahead of the hackers."*

Myron has identified the top 10 threats to your website that you should be aware of:

INJECTION

Injection happens when hostile data is sent to an interpreter as part of a query or command. This data tricks the interpreter, resulting in unintended commands and corrupt data. It's a common problem in web applications, particularly with SQL injection.

CROSS-SITE SCRIPTING

When an application sends user-supplied data to a web browser without first validating or encoding it, cross-site scripting (XSS) can occur. This lets hackers execute scripts in the victim's browser that hijack user sessions or vandalize websites.

INSECURE DIRECT OBJECT REFERENCES

Web applications don't always verify that the user is authorized for the target object. Without an access control check or similar protection, supposedly secure data can be accessed and stolen by attackers.

CROSS-SITE REQUEST FORGERY

CSRF tricks a victim into submitting fake HTTP requests via cross-site scripting or image tags. It's an issue for web applications that inadvertently allows hackers to predict the details of a transaction – for example, automatically-generated session cookies. Attackers create hostile web pages which generate forged requests indistinguishable from real ones.

INSECURE CRYPTOGRAPHIC STORAGE

It's hard to believe but many web applications still do not properly protect sensitive data such as credit card numbers and personal details. Attackers can easily access poorly encrypted data and use it to commit credit card fraud, identity theft and other data-related crimes.

FAILURE TO RESTRICT URL ACCESS

An application may protect sensitive functionality only by not displaying relevant URLs to unauthorized users. By accessing those ULRs directly, attackers can exploit this weakness to perform unauthorized operations.

INVALIDATED RE-DIRECTS

Web applications may re-direct and forward visitors to other pages and websites without proper validation. Attackers can then re-direct victims to phishing or malware sites or use forwards to access unauthorized pages.

BROKEN AUTHENTICATION

Account credentials and session tokens are sometimes not properly protected. Attackers simply use stolen passwords, keys and authentication tokens to steal other users' identities and commit crimes.

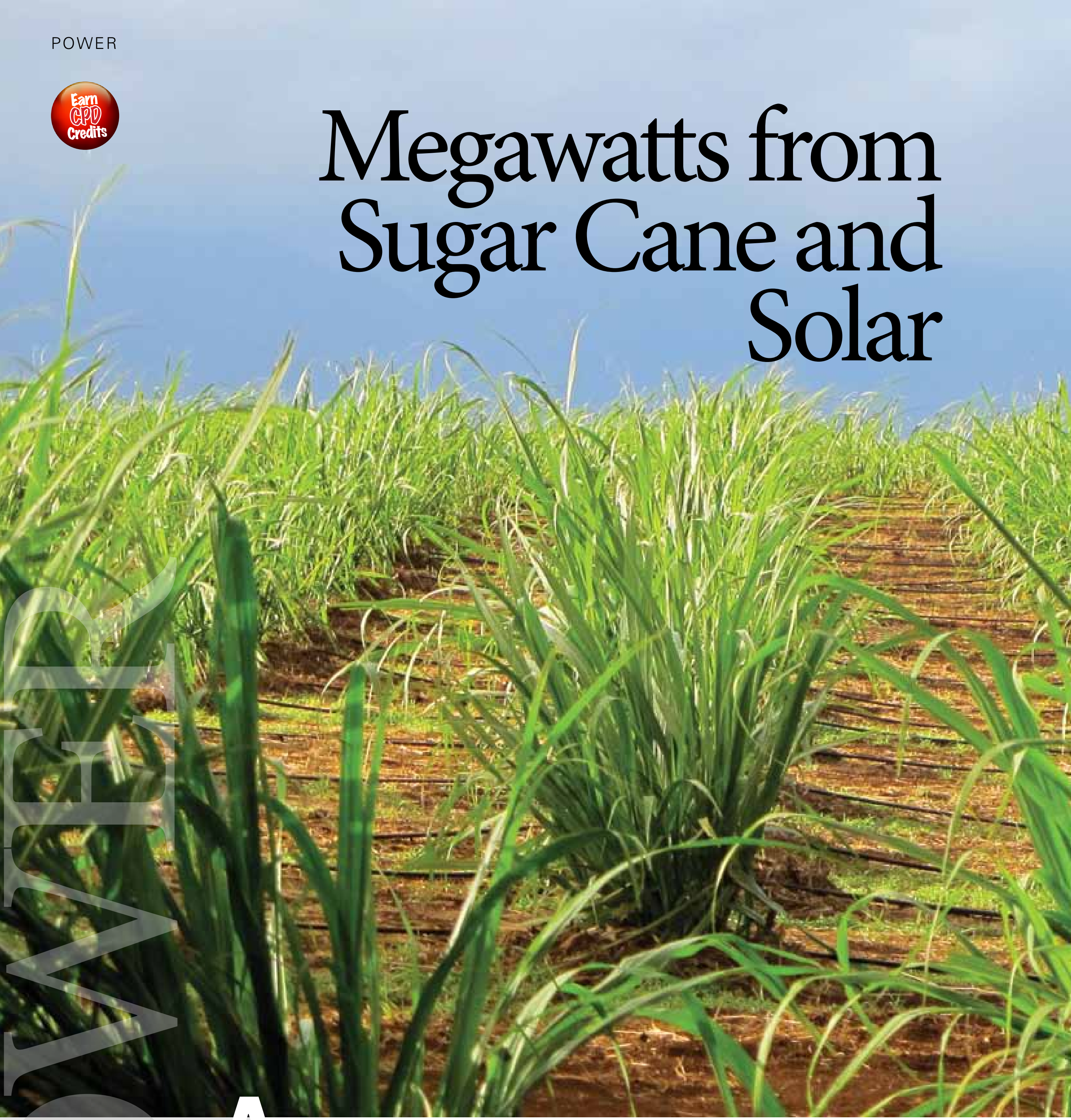
SECURITY MISCONFIGURATION

Attackers exploit security configuration weaknesses at any level whether it's the platform, web server, application server, framework or custom code. These flaws give attackers unauthorized access to default accounts, unused pages, un-patched flaws, unprotected files and system data.

INSUFFICIENT PROTECTION

When applications fail to authenticate, encrypt and protect sensitive network traffic, they may support weak algorithms, use expired or invalid certificates, or execute commands incorrectly.

"The above threats can simply be avoided by implementing an online security system, such as SiteLock, for example," says Myron. *"If you are unsure about the right security solution for your website, speak to your web developer – as the cliché goes, prevention is better than cure!"* wn



Megawatts from Sugar Cane and Solar

A feasibility study done for a very large South African cane farm showed that by harvesting the cane mechanically, and stripping the leaves and tops, it would be possible to keep a 16,5MW steam driven power station running for eleven months of the year. This would be more than enough to power the farm's irrigation systems and leave power to spare, which could be sold to further improve the farming profitability. Power for the irrigation systems costs about R30 000 per day. The farm's annual quota of 42 million tons of water is pumped from a floating barge in the dam by two 800kW variable speed driven pumps to a holding dam. The water is

A field of sugar cane on fire is an awesome sight. It is traditional practice to burn off the sugar cane leaves before harvesting but this vast source of energy can be put to good use.

BY I DUDLEY BASSON

pumped at 3000 litres per second through a 1400 mm fibre glass pipeline. The entire irrigation system has been retrofitted with soft starters and sophisticated computer control. The power generation could potentially add R300 per ton to the cane yield of R400 per ton. The power yield would be R9000 per hectare per annum. It is estimated that in KwaZulu Natal, 391 square kilometres (39 100 hectares) are under sugar cane cultivation.

The average sugar yield is about 60 tons per hectare per annum. The leaves and tops power station represents the first major biomass power project in South Africa.

At the sugar mill the cane juice is commonly extracted by crushing in heavy mills. The residue, known as bagasse, is used to fuel the boilers which provide steam for the

Megawatts from sugar cane & solar

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refining processes as well as the mill's entire electrical power requirement. Surplus bagasse is sold for various uses such as animal feed, paper making etc. Producing refined sugar requires a complex series of processes which also produce molasses as a by-product.

The largest sugar producing countries of the world are: Brazil, India, the European Union, China and Thailand. In cold climates sugar is obtained from sugar beets. Sugar cane is by volume the world's largest agricultural crop. World sugar production is at present about 1,83 billion tons.

Sugar cane converts sunlight into chemical energy which it stores in three roughly equal forms:

1. Juice - containing sucrose which can be used to produce sugar and ethanol. In 2004 Brazil produced 15 billion litres of ethanol from sugar cane.
2. Bagasse - the fibrous residue after crushing. In 2014 Brazil produced 19 000 GWh by burning bagasse, representing 4% of Brazil's electricity requirement. This is expected to rise to 20% by 2020.
3. Straw – leaves and tops constituting a huge source of energy which in the past was usually burned to waste.

Utilising the energy available from the straw presents a great opportunity as well as some challenges. Generating the power on the farm would be convenient as this eliminates transporting the straw and the power can be directly used on the farm. Surplus power could be sold by means of a link to the grid or alternatively directly to local communities. Generating the power at the sugar mill or other site could utilise straw from a number of farms, and a larger power station operating more economically could be used. In this case the farmer would sell the straw and continue purchasing his entire electrical power requirement. The total cost of implementing the biomass power station project is estimated at R1 billion. The generation and sale of electrical power is subject to approval by NERSA and ESKOM. A 10MW solar photovoltaic power plant is also under consideration.

The South African Department of Energy has assigned to Building Energy (through its SPC - Navosync (Pty) Ltd, the qualification of Preferred Bidder for the construction and operation of a 16 MW biomass fired power plant. Building Energy is involved in the development of significant photovoltaic, wind and biomass renewable projects in Sub Saharan Africa, North and Central America, Middle East, North Africa, Eastern Europe and Japan. Projects include Africa's largest photovoltaic plant using single-axis tracking technology with 75 MW capacity in Kathu.

Another exciting biomass power project is SAPPI's Ngodwana 25 MW project which will utilise biomass supplied from local plantations. SAPPI has been selected as preferred bidder of the Ngodwana energy biomass project in the fourth window of the South African government's REIPPP programme. Project partners are Sappi Southern Africa, KC Africa and Fusion Energy. There will be broad-based empowerment participation through the Ngodwana Energy Employees Trust and the Ngodwana Energy Community Trust, with each trust holding a 5% stake in the project.

Globally, SAPPI has already developed and constructed five hydro, two gas and 31 steam turbine plants, which generated about 800MW of renewable power on 14 sites in seven countries.

An interesting development in concentrated solar power (CSP), by Sener and Acciona is taking place at Quarzazate, Morocco. CSP has the advantage of utilising solar energy of all wavelengths and can even function for a while after sunset. The first phase of the Morocco plant, Noor1, will cover 2500 hectares and deliver a peak power of 160MW. This has been planned for availability by December 2015. The final configuration will deliver a peak power of 580 MW. The energy is stored as heat in huge insulated tanks of molten salt which will generate steam to drive the turbines for up to 8 hours after dark. The salt commonly used is a eutectic mixture of sodium nitrate, potassium nitrate and calcium nitrate which melts at 131°C. These salts are non toxic and safe to handle. Ordinary table salt has a melting point of 800°C which makes it unsuitable for solar power heat storage.

Ammonium nitrate is a salt commonly used as an agricultural fertilizer and if properly handled is non hazardous. In the past there have been several cases of catastrophic explosions of ammonium nitrate due to mishandling or criminal action. The salt is kept liquid at 288°C and passed through the focused solar parabolic trough heaters which heat it to 566°C. The heat is then available, when required, for producing superheated steam for power generation. The salt is well below its boiling point so there is no need for keeping it under pressure. The quantity of salt required for a solar power storage plant is huge. The Noor2 plant will have an output of 100MW. The Noor3 plant is to be a heliostat array CSP solar tower installation with an output of 200MW.

The largest solar project yet proposed was China's Ordos 2000MW photovoltaic solar plant in Inner Mongolia. This has, however been cancelled, and the magnificent modern city of Ordos remains largely uninhabited. Many designs of CSP tower plant are in use using large arrays of either flat or curved mirror heliostats.

Fluids used can be water for direct steam raising, molten sodium for indirect, possibly supercritical, steam raising or molten salt mixtures if heat storage is to be used. Using large arrays of mirrors for a CSP tower plant on a flat surface can be problematic requiring a very tall tower to give all the mirrors line of sight access. This can conveniently be overcome by using a disused open pit mine giving stadium type seating for the mirrors. Solar towers can also be used to obtain extremely high temperatures for experimental work.

Solar power is widely used in Spain. The Andasol 150MW parabolic trough plant uses molten salt energy storage to give 7,5 hours of energy storage . Another project by Sener and Acciona will be at Kathu, Northern Cape. This is a 100 MW CSP plant utilising the Sener parabolic trough reflectors and molten salt heat storage.

Power is planned for usage up to 4,5 hours after dark. Completion is expected by 2018. This project is led by GDF SUEZ with South African partners and has been selected by the South African Department of Energy (DoE) to form part of the country's renewable development program REIPPPP (Renewable Energy Independent Power Producer Procurement Program). This IPP Procurement Program has been designed so as to contribute towards the target of 3725 MW and towards socio-economic and environmentally sustainable growth, and to start and stimulate the renewable industry in South Africa. Renewable power includes: Onshore Wind, Photovoltaic, Concentrated Solar Power, Biomass, Biogas, Landfill Gas and Small Hydroelectric.

A similar parabolic trough project plant by Sener and Acciona is the 50MW CSP plant at Bokpoort near Upington. Other plants by Acciona are the Sishen PV farm and the Gouda 138MW wind farm.

Kathu is not far from the KaXu Solar One CSP 100MW plant near Pofadder. The power generated by the KaXu plant is sold to ESKOM under a long-term power purchase agreement. The project created 4,500 jobs during the construction phase and 80 permanent jobs during operation. KaXu Solar One is one of the 28 renewable energy projects announced by the South African Department of Energy (DoE) in 2011. Total investment in KaXu, the largest parabolic trough project in the southern hemisphere, was R10,7 billion.

Wheat and maize stalks and leaves are not usually used as fuel as these can rather be used as cattle feed. On travelling through northern France by TGV one cannot help but notice the extensive maize farms and numerous wind turbines. Mieliepap does not feature on the haute cuisine menu. The maize is mechanically harvested, stalks, tops, cobs, leaves and all and cut up as cattle feed. A nicely prepared chateaubriand fillet steak, with bread castle and béarnaise sauce, for two, is worth more than the cattle feed required to produce it, and the energy for cooking. A good vintage full bodied red completes the picture.

Megawatts from sugar cane & solar

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RENEWABLE POWER PLANT – FULLY OR PARTIALLY OPERATIONAL				
Site	**Type**	**MW**	**Closest town**	**REIPPPP WINDOW**
Aries Solar	PV	9,7	Kenhardt	1
Aurora	PV	10,35	Aurora	2
Boshoff Solar Park	PV	60	Boshoff	2
Chaba	Wind	20,6	Komga	2
Cookhouse Wind Farm	Wind	135	Cookhouse	1
Darling Wind Farm	Wind	5,2	Yzerfontein	
Dassiesklip Wind Energy Facility	Wind	26,2	Caledon	1
De Aar Solar Power	PV	50	De Aar	1
Dorper Wind Farm	Wind	97	Molteno/Sterkstroom	1
Dreunberg	PV	75	Dreunberg	2
Droogfontein Solar Power	PV	50	Kimberley	1
Eskom Sere	Wind	100	Koeknaap	
Gouda Wind Facility	Wind	135,2	Gouda	2
Grassridge	Wind	59,8	Port Elizabeth	2
Greefspan Power Plant	PV	10	Douglas	1
Herbert Power Plant	PV	19,9	Douglas	1
Hopefield Wind Farm	Wind	65,4	Hopefield	1
Jasper Power Company	PV	75	Postmasburg	2
Jeffreys Bay Wind Farm	Wind	138	Jeffreys Bay	1
Johannesburg Landfill Gas	Landfill Gas	18	Johannesburg	3
Kalkbult	PV	72,5	De Aar	1
Kathu Solar Energy Facility	PV	75	Kathu	1
KaXu Solar	CSP	100	Pofadder	1
Konkoonsies Solar	PV	9,7	Pofadder	1
Lesedi Power Company	PV	64	Postmasburg	1
Letsatsi Power Company	PV	64	Bloemfontein	1
Linde	PV	36,8	Hanover	2
Metro Wind van Staden's Farm	Wind	27	Port Elizabeth	1
Red Cap Kouga – Oyster Bay	Wind	80	St. Francis Bay	1
Mulilo Renewable Energy de Aar	PV	9,7	De Aar	1
Mulilo Renewable Energy Prieska	PV	19,9	Prieska	1
Neusberg Hydro	Hydro	10	Kakemas	2
Noblesfontein	Wind	72,8	Noblefontein	1
Sishen Solar Facility	PV	74	Sishen	2
SlimSun Swartland Solar Park	PV	5	Swartland	1
Solar Capital de Aar	PV	75	De Aar	1
Solar Capital de Aar 3	PV	75	De Aar	1

RustMo 1 Solar Farm	PV	6,8	Rustenburg	1
Soutpan Solar Park	PV	28	Mokopane	1
Stortemelk Hydro	Hydro	4,3	Clarens	2
Touwsrivier Project	PV	36	Touwsrivier	1
Upington Solar	PV	8,9	Upington	2
Vredendal	PV	8,8	Vredendal	2
West Coast 1	Wind	90,8	Vredenburg	2
Witkop Solar Park	PV	30	Polokwane	1

RENEWABLE POWER PLANT – UNDER CONSTRUCTION				
Site	**Type**	**MW**	**Closest town**	**REIPPPP Window**
Adams Solar	PV	82,5	Hotazel	3
Amakhala Emoyeni	Wind	134,4	Bedford	2
Bokpoort CSP Project	CSP	50	Groblershoop	2
Electra Capital - Paleisheuwel	PV	75	Clanwilliam	3
Khi Solar One	CSP	50	Upington	1
Khobab Wind farm	Wind	138	Loeriesfontein	3
Ilanga CSP 1 (Karoshoek Cons.)	CSP	100	Kimberley	3
Loeriesfontein 2	Wind	138	Loeriefontein	3
Mulilo Prieska	PV	75	Prieska	3
Mulilo Sonnedix Prieska	PV	75	Prieska	3
Noupoort Mainstream Wind	Wind	79	Noupoort	3
Tom Burke Solar Park	PV	60	Lephalale	3
Tsitsikamma Community	Wind	94,8	Tsitsikamma	2
Waainek	Wind	23,4	Grahamstown	2
Xina CSP South Africa	CSP	100	Pofadder	3

RENEWABLE POWER PLANT AT PRE-CONSTRUCTION STAGE				
Site	**Type**	**MW**	**Closest town**	**REIPPPP Window**
Aggeneys Solar Project	PV	40	Aggeneys	4
Bokamoso	PV	68	Leeudoringstad	4
Copperton Wind Farm	Wind	102	Copperton	4
De Wildt	PV	50	Brits	4
Droogfontein 2	PV	75	Kimberley	4
Dyason's Klip 1	PV	75	Upington	4
Dyason's Klip 2	PV	75	Upington	4
Eskom CSP	CSP	100	Upington	

Megawatts from sugar cane & solar

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Excelsior Wind Energy Facility	Wind	32	Swellendam	4
Garob Wind Farm	Wind	136	Copperton	4
Golden Valley	Wind	120	Cookhouse	4
Greefspan PV 2	PV	55	Douglas	4
Kangnas Wind Farm	Wind	137	Springbok	4
Karusa Wind farm	Wind	140	Sutherland	4
Kathu Solar Park	CSP	100	Kuruman	3
Konkoonsies II Solar Facility	PV	75	Pofadder	4
Kruisvallei Hydro	Hydro	4,5	Bethlehem	4
Longyuan Mulilo De Aar 2	Wind	139	De Aar	3
Longyuan Mulilo Maanhaarberg	Wind	96	De Aar	3
Mkuze	Biomass	16	Mkuze	3
Mgodwana SAPPI Biomass	Biomass	25	Ngodwana	4
Nojoli Wind Farm	Wind	87	Cookhouse	3
Nxuba Wind farm	Wind	140	Cookhouse	4
Oyster Bay Wind farm	Wind	140	Oyster bay	4
Perdekraal East Wind Farm	Wind	108	Matjiesfontein	4
Pulida Solar Park	PV	75	Kimberley	3
Red Cap – Gibson Bay	Wind	111	St Francis Bay	3
Redstone CSP	CSP	100	Postmaburg	3
Roggeveld	Wind	140	Sutherland	4
Sirius Solar PV Project One	PV	75	Upington	4
Solar Capital Orange	PV	75	Loeriesfontein	4
The Soetwater Wind Farm	Wind	139	Laingsburg	4
Waterloo Solar Park	PV	75	Vryburg	4
Wesley-Ciskei	Wind	33	Peddie	4
Zeerust	PV	75	Zeerust	4

For power generation on a more modest scale, typically of up to 100kW, the Scottish dominee's remarkable and highly efficient air engine, developed by the Rev. Robert Stirling (1780-1878) in 1816, holds great promise. The engine is powered by applying heat externally to the hot cylinder and cooling the cold cylinder.

The engine can have either two cylinders with pistons or a single cylinder with two pistons. The engine has remarkably few moving parts. There are no valves and the hot displacer piston does not make direct contact with the cylinder so that it is only necessary to lubricate the cold piston.

The engine can run on a small difference between source and sink temperatures. Models have even been made that can run on the heat of one's hand. Hobbyists are able to construct Stirling engines from beverage cans and pieces of wire. Generating electrical power by means of a Stirling engine heated by concentrated solar power can actually be more efficient than photovoltaic power.

Concentrated solar power can conveniently be used to heat air which can then be used to heat the hot cylinder. This can also be done by combustion of waste material and the hot flue gases ducted to the engine. These processes can be used together, so that combustion can take over when the solar power becomes insufficient. Air or

flue gases, having heated the cylinder, will still be hotter than the cylinder, but this heat need not go to waste – it can be used to pre-heat the air supplied to the fire by means of a heat exchanger. If the engine is being driven only by solar power, the air or other fluid can be in a closed insulated circuit for improved thermal efficiency.

This can improve efficiency close to that of the Carnot cycle. A Stirling engine can also be powered by means of the hot exhaust gases from a stationary internal combustion engine.

The path ahead for leaves and tops power generation holds much promise for more profitable farming and reduction of electrical demand from the grid.

January

Movers, shakers and history-makers

COMPILED BY | JANE BUISSON-STREET
FSAIEE | PMIITPSA | FMIITSPA

1 JANUARY

1845 Samuel Morse opened a fifty-mile electric telegraph line between Washington D.C. and Baltimore, Maryland, USA. Morse code was used for transmitting the messages.

2 JANUARY

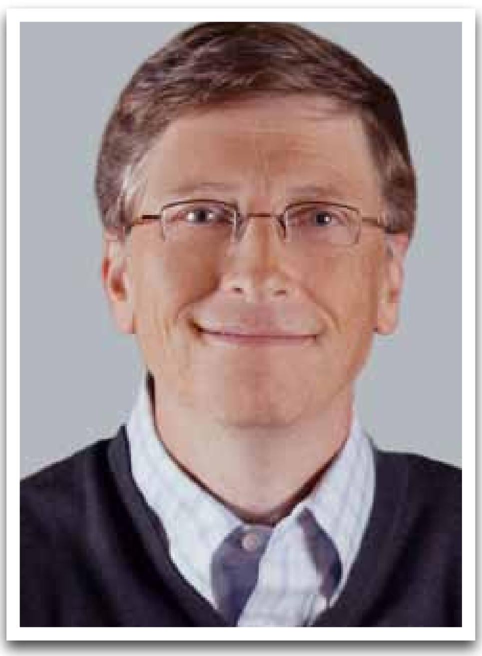
1984 Darryl Cullinan became the youngest South African to score a first-class cricket century at the age of 16.

3 JANUARY

1988 Margaret Thatcher became the longest-serving British Prime Minister of the 20th century.

4 JANUARY

1996 Bill Gates is quoted as saying "… an Internet browser is a trivial piece of software. There are at least 30 companies that have written very credible Internet browsers, so that's nothing… " in an article entitled 'The world according to Gates' by Don Tennant in InfoWorld Electric magazine.



5 JANUARY

1976 South Africa's television service was introduced. It was the first system in the world to provide colour transmission from the beginning.

6 JANUARY

1967 The Surveyor 1 spacecraft was reactivated after almost six months of lying dormant on the Moon's surface.

7 JANUARY

1927 The first commercial transatlantic telephone service (using radio) between London and New York City was inaugurated. The service will cost £40 a minute.

8 JANUARY

1940 Dr. George Stibitz, of Bell Laboratories, finished building a Complex Number Calculator, a full-scale relay calculator capable of performing the complex arithmetic calculations (involving complex numbers) necessary for circuit design.

9 JANUARY

2007 At the Macworld Conference & Expo, Jobs announced that Apple Computer, Inc. would become known as Apple, Inc.

10 JANUARY

2006 Apple Computer announced that its iTunes Music Store had sold 850 million songs and eight million videos since its launch on April 28, 2003.

11 JANUARY

1902 Popular Mechanics magazine was published for the first time. The magazine had five paying subscribers…

12 JANUARY

1984 The international panel charged with overseeing the restoration of the Great Pyramids in Egypt abandoned modern construction techniques. The use of mortar turned out to be destructive when water in modern cement damaged adjacent limestone. Once the ancient method of interlocking blocks that was "reintroduced" the project continued without complications.

13 JANUARY

1610 Galileo Galilei discovered, what would later be named Calisto, the fourth satellite of Jupiter.

14 JANUARY

1913 Henry Ford introduced the first modern assembly line for the Ford Model T. The existing assembly-line operation was improved with the addition of a chain to pull each chassis along. This continuous motion method reduced the time is taken to assemble a car from twelve and a half hours to ninety-three minutes.

15 JANUARY

2009 A U.S. Airways plane ditched into the Hudson River. All credit to the pilot as all 155 passengers survived.

16 JANUARY

1985 Playboy Magazine announced that they would no longer be stapling centrefolds.

17 JANUARY

2013 Japan announced plans to reduce its dependency on nuclear power by building the world's largest offshore wind farm in the Fukushima Prefecture, near the site of the Fukushima Daiichi Nuclear Power Plant.

18 JANUARY

2014 Lewis Clarke (UK) became the youngest person to reach the South Pole at the age of 16.

19 JANUARY

2013 Calcium deposits were found on Mars by NASA's Curiosity rover; the deposits are similar to deposits formed on Earth when water circulates in cracks and rock fractures.

20 JANUARY

2011 Scientists claimed that 2010 was the warmest year ever recorded, and the last decade the warmest ever recorded, in 200 years. (What will they say about 2015?)

21 JANUARY

2004 The NASA Mars Exploration Rover – A (MER-A) lost contact with mission control due to a malfunction in the probe's Flash Memory Management, it was repaired, from earth, on 6th February.

22 JANUARY

1997 Lottie Williams, Oklahoma USA, became the first human to be struck by space debris re-entering the Earth's atmosphere. At 3am, in a Tulsa, Oklahoma park, she was hit on the shoulder by a 10 x 13cm chunk of charred, woven metal that would later be authenticated as a piece of the fuel tank from a Delta II rocket that had been used to launch a U.S. Air Force satellite in 1996. She was uninjured.

23 JANUARY

1959 Robert Noyce of Texas Instruments conceived the idea of an integrated circuit. In 1968, he founded Intel with Gordon Moore and Andy Grove.

24 JANUARY

1984 The 3.5" stiffy disc was released by Apple Computer.

25 JANUARY

1881 Thomas Edison and Alexander Graham Bell form the Oriental Telephone Company.

26 JANUARY

2015 Libby Lane became the first female bishop of the Church of England.

27 JANUARY

2010 Steve Jobs, CEO of Apple, unveiled a new invention, a tablet PC called the iPad, at a press conference in San Francisco.

28 JANUARY

2014 Apple released earnings for the fourth quarter of 2013; its stock price drops eight percent because they sold 51 million iPhones, falling short of analyst expectations that they would sell 55 million iPhones.

29 JANUARY

1848 Greenwich Mean Time was adopted by Scotland.

1996 Johannes Jacobus Uys, more popularly known as Jamie Uys, internationally acclaimed South African film director who made 24 films, passed away. His work includes 'The Gods Must be Crazy' and 'Beautiful People'.

30 JANUARY

2010 On January 30, 1948, Indian independence leader Mahatma Gandhi was assassinated. He was cremated, per Hindu custom. Under normal circumstances, Hindus inter the ashes of their dead in a river as an offering to the gods. However, due to Gandhi's fame, his ashes were split up, some given to friends and family, and some sent all over India for use in ceremonies. On 30 January 2010, some of his ashes that had been kept by a friend of the Gandhi family were scattered off the coast of South Africa in a ceremony of some 200 people, including Gandhi's great-grandson and granddaughter Ela.

31 JANUARY

1964 The University of Port Elizabeth was founded. wn

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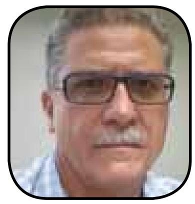

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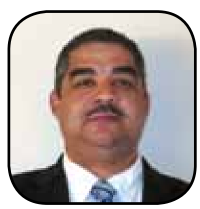

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