

Background

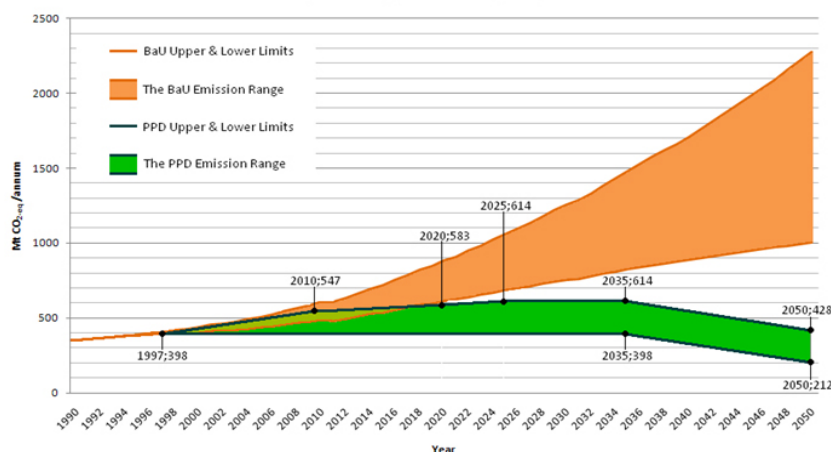
Until about 2006 South Africa was seen as a country with abundant and cheap energy resources. Coal was seen as an infinite resource for electricity generation and although the country has some hydro-electrical and the only nuclear power station on the African continent, there was little reason to move away from coal as the dominant energy source. In late 2007 this changed when Eskom suffered a number of unplanned plant outages and together with a then higher than expected economic growth rate, this created what one could argue was the “perfect energy storm”. During 2008 the country suffered rolling blackouts (somewhat diplomatically referred to as “load-shedding”) that even saw the key mining industry being totally cut off from electricity supply for a while. The effect on the economy was huge, and in some cases industries still have not fully recovered from the subsequent economic fallout, almost a decade later. These events, together with increased pressures to substantially reduce greenhouse gas releases, led to a fresh look at what the energy future of South Africa should look like.



During and after the blackouts of 2007 and 2008 a number of Government policy and strategy documents were released that were clearly aimed at taking the country towards a more secure energy future, notably the Nuclear Energy Policy (eventually approved by Cabinet during 2008), and Integrated Resource Plan (the first version, known as IRP1, was published in the Government Gazette during December 2008, the second version was published in draft form for public comment during October 2010, and is generally known as IRP2010; the latest version, IRP2013 is currently available for public comment). Others included the

Industrial Policy Action Plan (known as IPAP2 and in force since April 2008), the Energy Efficiency and Demand Side Management Policy (known as EEDSM and published in May 2010), and the Nuclear Research, Development and Innovation Strategy (known as NERDIS, currently stuck in draft form since 2011 awaiting review by the Department of Science and Technology; it is unknown when a final version will be released). All of these have in common the issue of energy security and its contribution to job creation, economic growth, research and human capacity/skills growth. These are also underpinned by the Department of Economic Development’s National Development Plan 2030 (better known as the “NDP”), a first version which was implemented during February 2013.

The desired South African climate change mitigation outcome - the “Peak, Plateau and Decline” (PPD) greenhouse gas emission trajectory



Energy Systems Analysis Group

Graduate School of Technology Management,
University of Pretoria



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Who are we?

With a view on these and the importance with which the South African Government views energy security and its positive contribution to the national economy it is evident that opportunities exist for focused energy-related research as well as the training of scientists and engineers in the energy field. The University of Pretoria has in the last few years been involved in a number of energy related research activities, notably with regards to Energy Efficiency, Demand Side Management, Fluoro-materials, Carbon Materials, Nuclear Energy, Advanced Materials, Thermoflow as well as Engineering & Technology Management. This, coupled with the fact that the University houses the largest engineering faculty in South Africa and the only Graduate School of Technology and Engineering Management (GSTM) in South Africa, places the University in a unique position to leverage its well-developed and highly rated scientific, engineering and management capabilities in support of Government's energy objectives.



In support of this the GSTM some years ago established a small but active Energy Systems Analysis Research Group. The group is led by two experienced academics supported by a number of research students:

Dr Jörg Lalk PrEng



He is a professional electrical engineer with electrical and electronic engineering degrees from the Potchefstroom University for CHE (BSc and BEng Hons), University of Pretoria (MEng) and a PhD with a focus on systems design from Cranfield University, United Kingdom. In addition he has completed the UNISA/WIPO Specialisation Programme in Intellectual Property Law as well as the MIT Sloan School of Management's Programme on Developing and Managing a Successful Technology and Product Strategy. He is member of the International Council on Systems Engineering (INCOSE) and senior member of the Institute of Electrical and Electronic Engineers (IEEE). He is a past-president of the INCOSE South Africa Chapter and the serving INCOSE Associate-Director for Technical Review (international). He has some 32 years industry experience and held various senior management and systems engineering positions in the aerospace, automotive, ICT, energy (nuclear) and consulting industries. His current research focus is on systems engineering and energy research, the latter with specific focus on techno-economic analysis, the application of novel intelligent Kalman filter techniques applied to energy planning analysis and the application of systems engineering in energy.

Dr George Alex Thopil PrEng



He is a registered professional engineer and has a Bachelor's and Master's degree in electronic engineering from VTU, India and Stellenbosch University respectively. He holds a PhD in engineering management with a focus on energy and environmental policy, from the University of Pretoria. Additionally he has completed his professional education in energy, sustainability and life cycle assessment, from MIT, USA. He is currently chair of the Engineering Management Society, South Africa chapter. He is also a member of IEEE and a senior member of SAIEE. He is employed at the Graduate School of Technology Management at the University of Pretoria where his research focus is mainly on the topics of energy & environmental policy, energy efficiency and impact assessment of energy technologies. He also lectures and consults on a part-time basis on topics of energy and life cycle analysis.

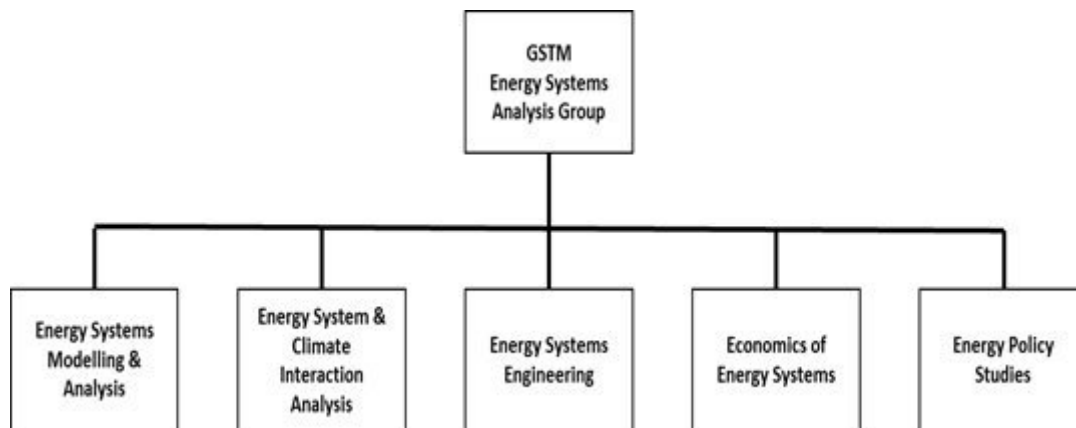
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Our Research Focus

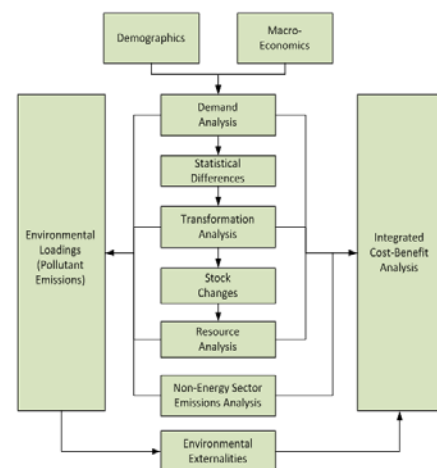
The group focuses on a number of important themes within the overall national energy picture.



In addition to the above themes we also do research on systems engineering (as applied to energy systems), as well as advanced energy prediction and cost models and tools.

Our Facilities and Tools

In support of this the group has available a number of high-end work stations in support of appropriate energy modelling and simulation. These work stations are all available with some of the “best-of-breed” energy modelling tool sets such as Matlab (including relevant toolboxes such as), LEAP (Long Range Energy Alternatives Planning scenario-based tool) OSeMOSYS (Open Source energy MOdelling SYstem), PLEXOS (Integrated energy modelling tool; work stations will only be made available with PLEXOS upon request and motivation by students as a specific agreement on its use is required from the tool vendor/developer) and WASP (industry standard wind energy resource modelling). These work stations are available to students who can spend a reasonable amount of time on campus or are full time students. In certain cases some of the tool sets are also available as academic licenses for use by



individual students on their own computers (this requires an application by the student to the tool set vendor who may make such a license available on a time restricted, typically 6 months at a time, basis).

Some of our current student research projects focusing on desalination and carbon tax analysis make extensive use of our Matlab and LEAP tools.

Our Past and Present Research Projects

Since 2012 we saw a growing trend in students wanting to do energy research, some of the projects/topics of individual students are listed below.

Past student research projects

Since its establishment the group has seen 46 student research projects successfully concluded:

- M Ward. *Effect of surface solar radiation on PV performance* (MTM)
- N. Thomas. *Demand side management: An investigation of the attitudes that drive energy efficient behavior in South African residential households* (MEM)
- H Segwagwa. *The potential impact of South Africa's proposed nuclear build programme on the broader socio-economic indicators* (MPM)
- A Ameen. *Wind energy development in sub-Saharan Africa: An application of the SATSA framework* (MPM)
- M Mamogobe. *Impacts of climate change on renewable energy technologies* (MPM)
- R Clarke. *Integration of energy simulation tools* (MTM)
- R Norman. *Challenges and proposed technical solutions to negate the impact of load curtailment within the diamond mining industry* (MPM)
- S Kunene. *Impact of EPC contracts on renewable energy tariffs: RE IPP procurement programme* (MTM)
- J Motaung. *Investigating the effect of regulation enforcement on energy efficiency in South Africa* (MEM)
- P Kanelombe. *Impact of climate change on renewable energy in Namibia* (MTM)
- J de Vos. *Smart grid systems within South Africa: An analysis of the current national energy policies and regulating framework* (MTM)
- M Mamogobo. *Impact of climate change on renewable energies* (MEM)
- M Mgcina. *Energy theft: Impact on power utilities and the public* (MEM)
- B Byng. *Quantifying the cost benefits of green building interventions* (MPM)
- L Netsianda. *An investigation of technical and business solutions to mitigate tower member theft* (MTM)
- R Singh. *An Investigation into the Drivers and Barriers to Energy Efficiency within Medium and Large Manufacturing firms operating within the eThekweni Municipal Area* (MTM)
- N Badal. *A study of gross energy intensity trends and analysis for a single ethylene production plant* (MTM)
- S Shongwe. *Exploitation of natural gas availability for residential use to relieve pressure on the constrained electricity supply in South Africa* (MPM)
- J Rossouw. *Electrical load – Regional policy studies* (MPM)



- M Masukume. *Investigation of the feasibility of renewable energy private sector investment in South Africa* (MPM)
- M Khan. *Why South Africa's vertically integrated electricity supply industry continues and how to introduce practical power sector restructuring and reforms* (MEM)
- F Cronje. *Techno-economic modeling and analysis of ocean energy development in South Africa* (MEM)
- T Nkuna. *A potential to substitute South Africa's coal-based electricity by renewables* (MPM)
- S Dhlomo. *Improving safety culture in the nuclear industry through communication* (MEM)
- A Prithiraj. *Electricity generation from gas: Technology selection for the petrochemical industry* (MTM)
- N Ngwenya. *Effectiveness of public private partnerships as a vehicle to deliver renewable energy projects in South Africa* (MTM)
- M Majodina. *Influence of climate variability on South African electricity production* (MEM)
- S Moodley. *Technical resource allocation in major capital projects within the energy sector* (MTM)
- L Kapolo. *Lack of investment in large scale generation plants in the Southern African Power Pool: A question of policy, political will, pricing or planning?* (MTM)
- J Raghubir. *Reliability-based network planning and design at Eskom* (MPM)
- E Nyandoro. *Risk management in long-term energy plans* (MEM)
- D Mvura. *Determination of costs and barriers to the uptake of new energy technologies to meet IRP2010 requirements* (MEM)
- B Petersen. *An evaluation of power quality programmes for major electrical utilities within South Africa* (MEM)
- N Bongelo. *Development and assessment of electrical cable ageing management strategies for the Koeberg operating unit* (MTM)
- N Nkwana. *The impact that organizational culture has on project success and failure: A study of the Pebble Bed Modular Reactor project* (MTM)
- F Blignaut. *Delivering business value through the implementation of Enterprise Mobility – The case of Eskom* (MTM)
- T Jasat. *Analysis of South Africa's Agricultural Sector as a Biofuels Producer* (MPM)
- W van Zyl. *A framework for the implementation of energy efficiency initiatives in a South African petrochemical plant* (MEM)
- P Machisa. *Socio-economic Impacts of REIPPPP Projects in Local Communities* (MPM)
- I Govender. *Critical Analysis of the Implementation of a Biogas to Electricity Project* (MPM)
- H Amsterdam. *Waste to electricity policy opportunities for South Africa* (MEM)
- P Naicker. *Assessment of criteria for renewable energy sectors in South Africa for the purpose of ranking technologies* (MEM)
- H Visser. *Determining the variable LCOE for biomass power plants in South Africa* (MTM)
- M Begemann. *Behaviour of residential consumers and the effect of this on load management potential in the South African residential sector* (MEM)

- T Feresu. *The energy efficiency benefits of adding multi-reflective material to roof thermal insulation retrofits (MEM)*
- W Chipeta. *Energy efficiency opportunities in small and medium enterprises (MPM)*

Current student research projects

Currently 16 student research projects are active within the group:

- P Okoye. *A novel systems approach to energy poverty in sub-Saharan Africa: A South African informal settlement as case study (PhD)*
- P Inda. *Critical factors for successful funding of wind energy projects in Africa: A case for Kenya (PhD)*
- H Mathekga. *Sustainable development of bio-fuel production: A systems dynamic approach (PhD)*
- J Rwamabare. *Impact assessment of solar water heating: A Rwandan case study (MPM)*
- G Makhomu. *A comparison study of REI4P and GFIP's procurement processes (MPM)*
- J Marsh. *The effect of renewable and nuclear power generation on the coal industry in South Africa (MPM)*
- C Sachse. *Techno-economic study of the different types of PV panel technologies relating to the economic, financial and technological impact within the context of the South African climate (MTM)*
- T Ncube. *Integrated demand management: An analysis of the benefits and results of energy efficiency in South African industry (MEM)*
- P. Rikhotso. *Key factors contributing to success or failure of Eskom's distribution network projects in the Gauteng operating unit (MPM)*
- M Mavhenge. *Improving the participation of South Africa's sugar industry in the REI4P programme (MEM)*
- N Mpanza. *Smart grids: Integrating renewable energy in developing countries (MPM)*
- H Mtshizana. *The evaluation of engineering services in response to South Africa's REI4P programme (MEM)*
- A Papadouris. *The Future of Renewable Energy Desalination Technologies: A Strategic Technology Management Evaluation (MTM)*
- D Mullineux. *Carbon Dioxide optimisation in the South African industrial Sector (MTM)*
- N Mahlangu. *Estimation of externalities within Concentrated Solar Power in South Africa – A life cycle analysis (MTM)*
- W van der Westhuizen. *A life cycle estimation of externalities from on shore wind power in South Africa (MPM)*

Research Collaborations

The group collaborates with a number of overseas institutions in support of its own research:

- Institute for Energy Economics and the Rational Use of Energy (IER), Department Energy Economics and Systems Analysis (ESA), University of Stuttgart, Germany
- Institute for Economic Research, University of Lugano, Switzerland
- Slovak University of Technology, Bratislava, Slovakian Republic
- Swiss Federal Institute of Technology, Zurich, Switzerland

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- Delft Institute of Technology, Netherlands

In addition, the group participates in a number of local and international working groups:

- Power and Energy Working Group, International Council of Systems Engineering (INCOSE)
- Systems Engineering Case Study Working Group (INCOSE)
- South African Energy Modelling Alliance

Research Opportunities

The group has opportunities for masters and doctoral research projects in any of the research themes of the GSTM Energy Systems Analysis Group. We are specifically looking for students who

- Have strong analytical skills
- Have a natural tendency to always see the big picture (systems view) yet remain cognizant of the details (a working knowledge of Systems Thinking and Engineering techniques would be beneficial)
- Are excellent two-way communicators including excellent English writing skills
- Are naturally curious and self-driven
- Are committed to deliver high-quality results on time



We are also looking for a few students who possess the characteristics above and in addition have strong mathematical and statistical skills. These students will be tasked to do their research on *Advanced Energy Prediction Algorithms* and *Advanced Energy Costing Models*. Students who, in addition, also have a strong software background are also required to participate in a project on the *integration of energy modelling toolsets*.



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