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M&M Post-Graduate Topics

October 16, 2023

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Contents

Prof Jaap Hoffmann
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- **Research Field**
  Solar thermal energy
- **General Description of Research Field**
  Solar thermal energy is a source of clean energy for electricity generation, process heat and thermal comfort that is unfortunately only available while the sun is shining. Thermal energy storage in rock beds using air as heat transfer fluid provides a low cost solution to store energy harvested during the day for night-time use. The large size of rock bed thermal energy storage, and irregular nature of crushed rock particles means that much of previous research done on prismatic beds of spherical particles is inadequate to describe pressure drop and heat transfer through packed beds. Hydrogen fuel cells and electric vehicles are the most promising substitutes for petrol and diesel driven vehicles in a post fossil fuel work. Hydrogen vehicles offer ranges and refueling times like those achieved by internal combustion engines. Hydrogen is a form of chemical energy that can be stored indefinitely. On the downside, hydrogen infrastructure is lagging that of electricity distribution. Overall, the outlook for hydrogen as a replacement for petrol and diesel in the transport sector is positive provided that it can be produced competitively. The copper-chlorine cycle as the most promising of all the thermochemical cycles for hydrogen production. In this cycle, water (steam) first reacts with CuCl2 to form HCl, and the HCl is then split into H2 and CuCl in an electrolyzer. Splitting HCl requires only about a third of the electricity input of that of splitting H2O. To facilitate the chemical reactions and recycle chemicals, the cycle requires several heat inputs at different temperatures. Some reactions are exothermic, and the heat released can be internally recycled to reduce the overall heat requirement of the cycle.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Solar hydrogen generation using the Cu-Cl cycle The Cu-Cl cycle was developed and demonstrated by Ontario Tech in Canada. This cycle requires a heat source (about 530 °C) and electricity. Both requirements can be met by a molten salt concentrated solar power (CSP) plant. The challenge is to find a suitable configuration of CSP plant to serve both high and low (100 °C) temperature heat exchangers - molten salts typically solidifies at about 250 °C. The student must develop, validate, and integrate working models of a CSP plant and the Cu-Cl cycle. The models (s) should be able to predict the shut-down procedure required when the CSP plant is running low on (stored) thermal energy. Several of these plants might be situated around South Africa where there are sufficient solar and (fresh) water resources to run the plant, and the necessary infrastructure to transport the product to a point of export/end use. Site selection forms part of the project, as well as the economic feasibility of the project. The student will spend 3 - 6 months at Ontario Tech. **Requirements:** Solar Thermal Energy Systems 814 A strong background in thermofluids will be advantageous.			✓	✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Green hydrogen via CSP pathways Evaluate the technology pathway(s) required, the current and future levelized cost of green hydrogen, and South Africa's potential for producing green hydrogen via the Cu-Cl cycle **Requirements:** Solar Thermal Energy Systems 814		✓		✓
Solar still with a submerged absorber Interfacial evaporation in a solar still make effective use of the available sunlight as the bulk water remains cold, whilst evaporation happens only at the top of a membrane. The membrane wicks water to its upper surface. When using concentrated sunlight, the evaporation rate can exceed the transport rate of water through the membrane, leading tot dry-out. When this happens, evaporation stops. A submerged absorber can take advantage of a high surface temperature, whilst providing free access of water to the surface. The challenge is to develop a submerged membrane that mimics interfacial evaporation without any liquid flow restriction. **Requirements:** A solid background in undergraduate thermofluids subjects is required.	✓			
Turbulence modelling in porous media Flow through porous media is tortuous, and the presence of the solid matric causes additional turbulence production that is not present in flow through open channels. This turbulence helps to redistribute heat and momentum in a porous media. There are a few models in the literature to capture the extra turbulence production in the k-epsilon framework, but none (or few) for the k-omega turbulence models. Develop and validate (through the use of appropriate source terms) a model that can predict the extra turbulence dispersion in packed beds. Closure might be achieved on RANS, LES or DNS level. This project is expected to be mathematically intensive. **Requirements:** Numerical Fluid Dynamics 414/814 or equivalent		✓	✓	
Optimization of a packed bed thermal energy facility. Maximize bed utilization and minimize pumping cost for several discrete and continues design variables, such as number and size of inlets and outlets, bed length, bed height, particle size, etc. Since the flow is expected to be fully three dimensional, validated CFD model(s) of the bed (flow through porous media) is required. Existing models can be used/refined. The time scales for heat transfer and fluid flow is substantially different - the student must investigate ways to accommodate both in the same model, while keeping the simulation time down to levels that lend themselves to formal mathematical optimization. **Requirements:** Numerical Fluid Dynamics 414/814 or equivalent Advanced Design 814 or equivalent qualification in optimization A solid foundation in fluid dynamics and heat transfer will be advantageous		✓	✓	

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Climate control in a greenhouse using solar thermal energy For optimal crop growth, greenhouse temperatures and humidity must be kept within narrow bands. Harvested solar energy collected during the day can be released to raise night-time temperatures. The student should develop a thermal energy storage facility capable of preventing cold damage to crops, and evaluate its economic feasibility. **Requirements:** A working knowledge of CFD is recommended.	✓			

Prof Craig McGregor
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- **Research Field**
  Solar thermal energy, green hydrogen
- **General Description of Research Field**
  Solar thermal Energy and Green Hydrogen research, focusing on:

  * techno-economic analysis * systems engineering and optimization * heliostat design and mechatronics * thermofluid design of solar receivers and thermal energy storage systems * industrial application of solar thermal heat * power cycle design for CSP and high temperature heat pumps

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Design and thermodynamic modelling of a compound piston steam expander for concentrating solar thermal applications. For several years, the Solar Thermal Energy Research Group has developed steam piston expansion (steam engine) technology optimized for application in concentrating solar power (CSP). This research culminated in 2022 when a previous student converted a Detroit diesel engine to run on compressed air and steam. This research topic expands this research by considering the application of compound (multi-stage) steam engines. Steam piston expanders offer advantages over steam turbines at smaller scales where turbines are costly, whilst compound engines offer higher cycle efficiencies than a single expansion cycle. The project has two primary focus areas: the Rankine cycle thermodynamic modeling and the mechanical design of a commercial-scale compound steam engine. The Rankine cycle thermodynamic model will enable the assessment of the system's performance across diverse conditions, ensuring optimal energy extraction from concentrated solar sources. The program's second facet delves into the mechanical realm, where the compound steam engine's crucial components are designed to enhance energy conversion efficiency and overall operational robustness. Practical application: The project offers a unique chance to develop energy modeling and design skills in a project that combines mechanical engineering with sustainable energy technology. **Requirements:** thermodynamics		✓	✓	

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Modelling of the world's primary energy system to assess the role of green hydrogen This project offers an unparalleled opportunity to explore and dissect the intricate dynamics of global energy transformation, focusing on the prospect of a "hydrogen economy". As green hydrogen gains prominence as a potential energy carrier, this study delves into its viability for transporting renewable energy from resource-rich areas to energy-deficient regions. However, a compelling counterargument supports the supremacy of high-voltage direct current (HVDC) transmission due to its minimal energy losses. This study aims to illuminate the best path forward through analysis, technological assessment, and economic modelling. Undertaking this study, you will construct a panoramic view of the world's primary energy system. By developing a comprehensive energy production and consumption model using PyPSA (Python for Power System Analysis), you will gain a profound understanding of the interplay between renewable resources, energy generation, and consumption across the globe. This model will serve as the foundation for a rigorous technical and economic evaluation of two contrasting paradigms for energy transport: green hydrogen and HVDC transmission. Practical application: the study develops expertise in energy modelling, analysis, and economic evaluation, highly relevant to industries driving the renewable energy revolution; your findings could shape the energy policies of South Africa, influencing the transition to cleaner, more efficient energy systems. **Requirements:** Python programming skills a preference.		✓	✓	
Optimising Concentrating Solar Power Plant Siting in Southern Africa for Enhanced Industrial Integration. Sited in high-solar-resource regions of the Northern Cape, the current Concentrating Solar Power (CSP) plants in South Africa have faced challenges due to their geographical isolation. This study addresses this dilemma by exploring the feasibility of strategically locating CSP plants closer to major industrial hubs whilst balancing solar resource potential to optimise the siting of CSP plants in Southern Africa. The primary focus is maximising the integration with major industrial centres to facilitate improved maintenance accessibility, streamlined supply chains, and enhanced collaboration with expert resources by investigating the trade-offs between lower solar resource locations and proximity to industrial hubs. By considering factors such as energy output, transportation costs, and operational efficiency, the study will analyse the impact of CSP plant siting on maintenance services, spare and replacement parts availability, and access to international expertise, aiming for reduced downtime and increased cost-effectiveness. Practical application: Acquire insights highly relevant to energy companies, industries, and policymakers aiming to streamline energy logistics and contribute to solving a pressing challenge in the renewable energy sector, optimising CSP plant siting to align energy generation with industrial demands.		✓	✓	

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Requirements: none				
Fuel-fired augmentation of CSP plants in South Africa as back-up for poor solar days Given our excellent solar resources in South Africa, concentrating solar power (CSP) offers an excellent opportunity to address our current electricity supply constraints whilst establishing a significant manufacturing industry in the country. Because a CSP plant includes a significant amount of thermal energy storage it can dispatch power throughout the night. Even in the desert locations such as the Karoo of the Northern Cape where CSP plants are located, there are periods of overcast or cloudy weather that would interrupt generation. A CSP plant that includes a fuel-fired system that would be able to continue generating electricity during periods of low solar resource, making CSP a firm and dependable power source. This project will study the technical and economic aspects of such a fuel-fired augmentation of CSP. The project should consider biomass and fossil fuel sources and investigate the best power cycle configuration (direct integration through the addition of a fuel-fired boiler, or an integrated solar combined cycle mode obtained by adding an open cycle gas turbine to the existing steam Rankine cycle of the CSP plant). **Requirements:** thermodynamics	✓	✓		

Prof Josua Meyer
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- **Research Field**
  Heat transfer

- **General Description of Research Field**
  Heat transfer conveys energy from a high temperature to a lower temperature. The mechanisms of heat transfer are defined as conduction, radiation and convective. In convective heat transfer the heat transfer might be external forced convection, internal forced convection, or natural convection. Heat transfer has many applications and happens everywhere.

  The human body is constantly generating and/or rejecting heat by metabolic processes and exchanged with the environment and among internal organs by conduction, convection, evaporation, and radiation. Heat transfer is also one of the most important factors to consider when designing household appliances such as a heating and air-conditioning system, refrigerator, freezer, water heater, personal computer, mobile phone, TV, etc.

  Heat transfer also occurs in many other applications such as in car radiators, solar collectors, orbiting satellites, etc. However, one of the most important applications is in the generation of electricity which can happen in fossil fuel power plants, nuclear power plants or concentrating solar plants. The heat transfer during the generation of electricity happens in heat exchangers which normally has at least one passage through which a fluid flows. The passage geometry can be as simple such as a circular tube or it can have a very complex geometry with fins that not only enhances the heat transfer but induces flow rotation which reduces the size of the heat exchanger.

  For all these configurations empirical correlations are required for design and analyses purposes that can be used to estimate heat transfer rates. To develop thousands of empirical equations are not desirable as we first need to have a better understanding of the fundamentals and flow phenomena. Furthermore, different flow regimes (laminar, transitional or turbulent) normally each require its own empirical equations. Thus, to be able to understand complex heat transfer flow phenomena in complex geometries we must first understand what happens in simple geometries, such as in circular tubes.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Developing flow in smooth circular horizontal tubes with a uniform wall temperature; forced and mixed convection. Relevant to concentrated solar power (CSP) generation and heat transfer in blood vessels through human organs. A lot of work has been conducted in the field of heat transfer in circular tubes. Most of this work was limited to forced convection flow through horizontal tubes, and with fully developed flow. Thus implying that the flow was both hydrodynamically and thermally fully developed. However, forced convection occurs very rarely in practical applications. It only occurs for heat transfer in small tube diameters, low heat fluxes and for flow in zero gravity conditions. Therefore, if the heat transfer condition does not satisfy forced convection conditions the heat transfer phenomena would definitely and most probably result in mixed convection. However, no work has been done for mixed convection with a uniform wall temperature during developing conditions. The purpose of this study would therefore be to numerically investigate and compare with CFD in a circular tube developing flow for forced and mixed convection with a uniform wall temperature. **Requirements:** CFD		✓	✓	✓
Local and average heat transfer coefficients for developing single-phase laminar flow in horizontal circular tubes with a constant heat flux boundary condition. Wide range of Prandtl numbers. Relevance: concentrated solar power (CSP) generation and heat transfer in blood vessels through human organs. Correlations to calculate the local and average heat transfer coefficients for single-phase laminar flow in horizontal circular tubes with a constant heat flux are usually restricted to fully developed flow, high Prandtl numbers or constant fluid properties. Recently work has been conducted with water (see URL: 10.1016/j.ijheatmasstransfer.2017.10.070). The purpose of this study is to conduct a similar study, however, using CFD, and as working fluids air and glycol. The reason for air and glycol is that its Prandtl numbers are about an order of magnitude lower and higher than that of water. The equations that were developed in the previous study for water can therefore not be used for a wide range of Prandtl number applications. **Requirements:** CFD		✓	✓	✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Local and average heat transfer coefficients for developing single-phase laminar gas and glycol flow in horizontal circular tubes with a uniform temperature boundary condition. Relevant to concentrated solar power (CSP) generation and heat transfer in blood vessels through human organs. Correlations to calculate the local and average heat transfer coefficients for single-phase laminar flow in horizontal circular tubes with a uniform heat flux are usually restricted to fully developed flow, high Prandtl numbers or constant fluid properties. Recently work has been conducted with water (see URL: 10.1016/j.ijheatmasstransfer.2017.10.070). The purpose of this study is to conduct a similar study, however, using CFD, with air and glycol as working fluid. The reason for air and glycol is that its Prandtl numbers are about an order of magnitude lower and higher than that of water. The equations that were developed in the previous study for water can therefore not be used for a wide range of Prandtl number applications and were also developed for a constant heat flux boundary condition – not a uniform wall temperature. In this study a uniform heat flux needs to be used. **Requirements:** CFD		✓	✓	✓
Local and average heat transfer coefficients for developing single-phase laminar gas and glycol flow in horizontal circular tubes with a uniform heat flux boundary condition. Relevant to concentrated solar power (CSP) generation and heat transfer in blood vessels through human organs. Correlations to calculate the local and average heat transfer coefficients for single-phase laminar flow in horizontal circular tubes with a constant heat flux are usually restricted to fully developed flow, high Prandtl numbers or constant fluid properties. Recently work has been conducted with water (see URL: 10.1016/j.ijheatmasstransfer.2017.10.070). The purpose of this study is to conduct a similar study, however, using CFD, with and air and glycol as working fluid. The reason for air and glycol is that its Prandtl numbers are about an order of magnitude lower and higher than that of water. The equations that were developed in the previous study for water can therefore not be used for a wide range of Prandtl number applications and were also developed for a constant heat flux boundary condition – not a uniform wall temperature. In this study a uniform heat flux needs to be used. **Requirements:** CFD		✓	✓	✓

Dr Michael Owen
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- **Research Field**
  Heat transfer, thermodynamics, fluid mechanics
- **General Description of Research Field**
  Overall my research aims to contribute to sustainable production, use and manipulation of thermal energy. I make use of a combination of experimental, numerical (typically by means of CFD) and analytical methods to investigate thermodynamic cycles, thermal energy systems and components at a number of levels including high level feasibility analysis, system testing and analysis and component-level testing and simulation. There is a strong focus on industrial heat exchangers and cooling towers in particular (dry, wet and hybrid), as these systems directly affect thermal power plant efficiency (fossil-fuelled, nuclear and renewable) and have a direct influence on the energy/water nexus.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Reduced-order modelling of air-cooled condenser performance under windy conditions Air-cooled condensers (ACCs) are a direct dry cooling technology that significantly reduces the water footprint of thermal power generation. These systems are widely used in concentrating solar power (CSP) plants since these plants are typically built in arid regions with high solar resource but limited water availability. The performance of the condenser direclty impacts the thermal efficiency of the power plant (by influencing the turbine back pressure) and is thus a critical (but often overlooked) component in the power cycle. The majority of ACCs are mechanical draft systems where air flow is driven by large axial fans. As an alternative, natural draft systems use bouyancy as the motive force and thus eliminate the need for fans (thus offering benefits in terms of net power output). There is currently only one natural draft ACC at a CSP in the world (Khi Solar 1, Upington South Africa), and the relative performance and costs (compared to mechanical draft systems) are not well understood. Ultimately, our aim is to conduct a direct comparison of mechanical and natural draft ACCs for application in CSP based on life-cycle cost. This comparison requires an understanding of how these two systems would perform over a typical meteorological year in a representative location (taking into account ambient conditions including temperture and wind). In this project, we will develop a reduced order model of the performance of a mechanical draft ACC (using CFD simulations to generate training data) as a function of both ambient temperature and wind. This model will be applied in the overarching comparitive study mentioned previously.		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Requirements: The project requires the student to have completed, or to do, a CFD module (or have relevant experience with CFD). ANSYS FLUENT is the preferred software.				
Solar-aided power generation in the South African context: "greening" our coal South Africa's energy supply is highly dependent on its fleet of coal-fired power plants, with over eighty percent of electricity demand being met with this fossil-fuel energy source. Considering that we will remain dependant on our coal power plants for several decades, the question arises as to how we can reduce the environmental footprint of our coal power or leverage the infrastructure at our coal stations to bring renewable energy online quickly and at lower cost? Solar-aided power generation (SAPG) is a hybridized approach in which solar thermal energy is incorporated into existing thermal power plants to improve the overall performance of the plant. Studies have considered using solar thermal heat for feedwater heating in coal-fired (Rankine cycle) plants to reduce the extraction of steam from the turbines for this purpose. In this way, the efficiency benefits of feedwater heating are realized while the steam flow through the turbines remains higher and thus (a) the turbine power output is greater for the same fuel consumption; or (b) the same power output can be achieved with lower fuel consumption. At the same time, the solar thermal energy is effectively converted to electricity but via the higher thermal efficiency of the coal-fired plant and at lower cost since it uses the existing power block and transmission infrastructure. Previous work on this topic at Stellenbosch University identified SAPG as an attractive option for the South African context. The work was however based on several simplifying assumptions and more work is required to better understand the techno-economic feasibility of this concept. This study aims to develop a more detailed thermodynamic model capable of simulating the performance of a SAPG plant under varying operating conditions (e.g. varying solar resource, ambient conditions and part load operation) and incorporating thermal energy storage. The study aims to answer the question of whether SAPG can and should be considered in South Africa. The project will be co-supervised by myself and Prof. Ryno Laubscher. **Requirements:** A strong grounding in fundamental heat transfer and thermodynamics at undergraduate level is required.	✓	✓		

Topics	**MEng Struct**	**MEng Resrch**	**PhD**	**Potential Funding**
An assessment of the feasibility, energy and water saving potential of sea water air conditioning in South Africa: Building climate control (HVAC) is responsible for approximately 10% of global energy consumption and considerable efforts are needed to reduce the energy footprint of this activity. The cooling loop of a typical building air conditioning system makes use of chilled water supplied by a refrigeration cycle (typically referred to as a chiller). The heat sink in these chillers is typically an evaporative cooling tower and the maximum COP is thus is constrained by the ambient wetbulb temperature. In addition, since heat transfer in the cooling tower is predominantly due to evaporation, the water footprint of building cooling is considerable. Sea water air conditioning (SWAC) systems make use of the ocean as the heat sink and, if the ocean temperatures are favourable, either remove the need for a chiller entirely or offer lower sink temperatures and thus higher chiller COP (reduced energy consumption for the same cooling load). In addition, evaporation in the cooling tower is replaced by sensible heat transfer to sea water and fresh water consumption is eliminated. SWAC is used in many developed parts of the world already (e.g. Stockholm, Sweden, is almost entirely sea-water cooled). A preliminary analysis of SWAC for a commercial building in Cape Town predicted a 50% decrease in energy consumption and the elimination of 1500 kg/hr of fresh water consumption (for a specific operating point). The potential of SWAC to contribute to more sustainable building operation in South Africa is thus significant and extremely important to energy and water security in our country. This aims to develop a tool that can be used to determine the feasibility, energy and water saving potential of SWAC for South Africa (taking into account the diverse climate and ocean conditions along our coastline). The project will be co-supervised by Dr James Joubert (Sustainability Engineer, Ecolution Consulting). The scope of the project can be adjusted to be a MEng (research) thesis or MEng (structured) project. **Requirements:** N/A	✓	✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Tunable PCM-boosted particle storage for NextGen CSP: a techno-economic assessment Concentrated Solar Power (CSP) plants convert solar energy to high quality (temperature) heat to drive a thermal power cycle (e.g. the Brayton and / or Rankine cycle). CSP plants typically use a thermal energy storage (TES) system (currently molten salt storage is most comment, T 560 deg C) as a means of managing the transient heat input, providing extended generation (i.e. after sunset) and dispatchability (e.g. energy is stored during the day and dispatched in the evening to service peak demand). The next generation of CSP plants will operate at higher temperatures (700 deg C) to power innovative power cycles (e.g. the supercritical CO2 Brayton cycle) to acheive higher efficiencies. New TES solutions are required to support these NextGen CSP plants. A candidate solution involves the use of ovaline particles as the heat transfer fluid and TES medium. This system operates in a similar way to molten salt but at higher temperature. Unfortunately, while cheaper than molten salt and able to handle the higher temperatures, the particles have a lower specific storage capacity and thus TES enhancement is required. A research consortium (consisting of partners from France, Belgium, Spain, the UK and South Africa) is considering the use of a Zinc-allow phase change material (PCM) as a TES booster in the context of the partical-based CSP system. Stellenbosch University will contribute to the techno-economic feasibility assessment of the PCM TES boost concept through this project (in collaboration with CNRS-PROMES, France). At this stage, funding is being applied for via an EU grant. Should the application be successful, the project will go ahead with full project funding - including a student bursary. **Requirements:** N/A		✓	✓	✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
The technoeconomic feasibility of reversible heat pump storage in industrial process heat systems Industrial process heat accounts for approximately 20% of South Africa's total energy consumption (200 TWh of energy per annum). The vast majority of this energy is supplied by fossil fuels (mostly coal but also including heavy fuel oil and gas) and the carbon footprint of idustrial process heat in South Africa is thus enormous. Reducing fossil fuel use through waste heat recovery (e.g. using heat pumps) and renewable energy (e.g. solar thermal energy) has considerable potential to reduce our national greenhouse gas emissions. This project will consider the feasibility of using novel high temperature heat pumps (capable of achieving 200 deg C at high COP) in combination with solar thermal energy technologies and thermal energy storage as a strategy for decarbonization of industrial process heat in South Africa. The project forms part of a larger study involving an international consortium of research partners, predominantly from Europe, and including Stellenbosch University and Greenline Africa as African partners. At this stage, funding is being applied for via an EU grant. Should the application be successful, the project will go ahead with full project funding - including a student bursary. **Requirements:** N/A		✓		✓

Dr Hannes Pretorius
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- **Research Field**
  Thermofluids & Solar Energy
- **General Description of Research Field**
  Dry cooling systems for power generation applications; Axial flow fan performance; Heat transfer analysis from PV panels; Floating solar PV power generation; Thermo-economic evaluation on CSP / PV power plants

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Heat dissipation factors for bi-facial PV modules in open-rack and building-attached configuration Solar power generation using Photovoltaic (PV) power plants have seen a dramatic rise in popularity in recent years. Large PV plants continue to be constructed all around the world, including South Africa. Due to the continually decreasing price of PV panels and the relative construction simplicity of such power plants, it is expected that they will remain competitive in the medium to long term. The efficiency of PV modules is negatively affected by an increase in operating temperature of the module. To predict power output accurately, it is important that the heat dissipation from the PV module is accurately modelled. PV simulation models exist which typically employ empirical heat dissipation factors obtained from open-racked mono-facial module experiments. Little research is available on what these factors are for bi-facial PV panels in open-rack and building-attached (BAPV) configuration. This study will experimentally determine heat dissipation factors for mono- and bi-facial PV panels in open-rack and BAPV configuration. The commercial simulation tool PVSyst will be used to simulate the annual performance of a simple system with these newly obtained heat dissipation factors, and comparisons made to predictions with default inputs. The study will also aim to establish which relative angle maximizes annual power output. **Requirements:** Strong interest and performance in Thermo-fluid modules. This topic will be focused on experimental work.	✓			

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Natural draft direct dry heat rejection system for a supercritical CO2 power cycle Global research interest into supercritical CO2 power cycles is increasing, due to their superior efficiencies and reduced component size requirements. These cycles, linked to concentrated solar power applications represent a modern evolution to sustainable and efficient power production. The sCO2 cycle needs a heat rejection system to dissipate heat loads from the pre-cooler and intercooler heat exchangers to the environment. To further enhance cycle efficiency and promote sustainability, a heat rejection system with low parasitic power- and no water consumption requirements would be very beneficial. This study investigates the performance characteristics of a natural draft direct dry heat rejection system for the pre-cooler and intercooler heat loads of a sCO2 power cycle, linked to a 50 MWe solar CSP plant. The investigation uses 1D methods to size the heat rejection system, after which co-simulation of the 1D model and a 3D computational fluid dynamics model is employed to evaluate the performance of the system under varying ambient temperature and wind conditions. This project is co-supervised by Prof Ryno Laubscher. (Note: This project has been allocated to a student for 2024) **Requirements:** Strong interest and performance in Thermo-fluids modules. Computational Fluid Dynamics.		✓		

Dr Willie Smit
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- **Research Field**
  Robotics and Control in Concentrated Solar Power Plants
- **General Description of Research Field**
  The Solar Thermal Energy Research Group (STERG) is researching environmentally friendly and sustainable solar thermal technologies. In particular, we are looking at concentrated solar power (CSP) plants. We think that multi-copters and ground-based robots can provide services to plant operators.

  Here is a good video that gives an overview of the state-of-the-art CSP plant: https://youtu.be/QW42wBthN2A

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Locating a drone close to a parabolic trough Parabolic troughs concentrate solar rays onto a central tube. The tube contains oil that heats up to close to 400 'C. The heated oil is used to generate steam which powers a turbine. The mirrors need to be cleaned every few days. It should be easy for a drone to automatically clean the mirrors. This project aims to develop a system with which the drone can accurately locate itself inside the parabolic trough. The system might use ultrasonic sensors, cameras, laser range finders and so on. **Requirements:** Good programming skills.		✓		

Prof Martin Venter
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- **Research Field**
  Generative Design, Machine Learning, Material Modelling, Soft Robots and Inflatables

- **General Description of Research Field**
  I am interested in computational methods as part of the design process. This allows us to share the burden of making design decisions that can become complex, like biologically inspired artificial creatures and inflatable structures. Over the past few years, I have been exploring the potential applications of compliant and selectively reinforced materials in the fields of pressure-rigidised structures and soft robotics. In addition, our research group is interested in combining powerful non-linear simulation tools, such as finite element methods, with the ever more important field of machine learning in a modern generative design approach.

  This is a multidisciplinary field taking elements from several computational fields. Researchers in this area will develop non-linear finite element methods, numerical design optimisation, programming and machine learning skills. Much of what we do requires insightful experiment planning in tandem with advanced tools to deal with large volumes of data. This new field is open to exploration, which can be both challenging and rewarding.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Alternative Solar Panel Backing Structure This proposed Master's project focuses on exploring and developing an alternative backing structure for solar panels. Traditional solar panels commonly utilize rigid and heavy materials, such as glass or aluminium, as their backing structure. However, these conventional materials need to be revised regarding cost, weight, and installation flexibility. The project aims to investigate and propose an alternative backing structure that overcomes the limitations of conventional materials while maintaining the required mechanical support and durability for solar panels. The alternative structure will be designed to enhance the efficiency, performance, and sustainability of solar energy systems. The project will begin by reviewing existing materials and structures used in solar panel backings and innovative approaches in other industries. Potential alternatives, such as lightweight composites, flexible polymers, or hybrid materials, will be considered. Based on the review, a computational analysis and modelling framework will be developed to simulate and assess the proposed alternative backing structure's mechanical properties and structural behaviour. Finite element analysis (FEA) or other suitable numerical methods will be employed to evaluate the design's structural integrity, thermal performance, and reliability. The project will involve prototyping and experimental validation to verify the performance of the alternative backing structure. Physical testing will be conducted to assess its mechanical strength, resistance to environmental conditions, and compatibility with solar panel components. The outcomes of this project will contribute to the advancement of solar panel technology by providing a more efficient, lightweight, and cost-effective alternative for the backing structure. The proposed alternative can potentially improve the overall efficiency of solar energy systems, reduce installation costs, and facilitate the integration of solar panels into a wider range of applications, including portable and flexible solar panels. Additionally, the project aligns with the growing emphasis on sustainable materials and green energy technologies. **Requirements:** Complete the intro to FEM in the first six months.		✓		

Prof Johan van der Spuy

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- **Research Field**
  Turbomachinery
- **General Description of Research Field**
  1) The use of direct dry-cooling in power generation systems is a means of ensuring sustainable water usage. The efficient, low noise, operation of the axial flow fans that form part of such an air-cooled system is essential for a well-performing system. These research topics (topics 1, 2 and 3) focus on the design, testing and analysis of axial flow fans for these systems. 2) The use of micro gas turbines (MGTs) for the propulsion of aerial vehicles or solar thermal power applications hold specific advantages. The topic is related to the development of a turboshaft micro gas turbine.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Improving the performance of a solarised micro gas turbine The performance of an existing micro gas turbine needs to be improved. A New impeller and diffuser has been design for the gas generator component and needs to be manufactured and tested on the gas turbine. The power turbine has to be replaced with a smaller, more realistically sized unit and a concept for an actual generator has to be developed. The system was developed to originally operated under solarised conditions but is currently being converted for research on hydrogen combustion. This work will be done in conjunction with the PhD student currently working on the system. **Requirements:** CFD, good CAD skills		✓		
The development of a 30 kW turboshaft micro gas turbine. An existing project has developed the methodology for the design of a 30 kW turboshaft micro gas turbine. This project will continue this work by developing an actual gas turbine engine. Once completed, the engine will be tested and its performance verified. **Requirements:** CFD, thermofluids 344		✓		✓