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M&M Post-Graduate Topics

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Contents

Mr Johann Bredell
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- **Research Field**
  Structural analysis and design. Wind engineering.
- **General Description of Research Field**
  Structural analysis and design. Wind engineering. Solar tracking structures. Finite element analysis.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Design and analysis of PV support structurers Cost effective and durable support structures are key to the success of solar photovoltaic power generation. Noval approaches are needed to quantify the loads and resistances associated with fixed-tilt and tracking structures to ensure structural reliability. The research is likely to involve both experimental and simulation work. The topic will be formulated in cooperation with an industry partner to address a specific need. There may be a possibility of funding. **Requirements:** FEM		✓		✓
Design and analysis of glass alternative concentrated solar power reflectors The most common material for reflectors used in the concentrated solar power (CSP) industry is mirrored glass. However, glass has many undesirable properties. The research aims to develop feasible glass alternative reflectors for CSP applications. The project will involve structural design, building of prototypes, and performance testing. Various simulation technologies can also be incorporated in the project. **Requirements:** FEM		✓		

Dr Nur Dhansay
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- **Research Field**
  Fracture Mechanics
- **General Description of Research Field**
  The investigation of cracks propagating through a material. The focus typically lies in providing crack prediction models for the various mechanisms of fracture. The general fracture mechanisms include fatigue, creep, stress corrosion cracking and environmentally induced cracking. A variety components in real world applications undergo loading application which produces the failure mechanisms mentioned previously. It is therefor of benefit to better understand these mechanisms in order to produce more accurate crack prediction models and prevent any unwanted failure/fracture in components.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Crack tip strain localisation investigation of hydrogen-induced fracture mechanisms for pipeline metals Considering the drive towards "green energy", it is believed that hydrogen will play a key role in transitioning from fossil fuels to renewable energy. Hydrogen gas requires transportation via pipeline. Unfortunately, metals are susceptible to hydrogen embrittlement (HE) which reduces the structural integrity of the material. Furthermore, the behaviour of HE metals tends to vary significantly, requiring special attention to be focussed on this topic. This research proposes to investigate the crack tip strain localisation of hydrogen-induced fracture mechanisms in pipeline steels using digital image correlation. **Requirements:** Ideally: Strength of Materials W334 Material Science A244		✓		

Mr. Rashid Haffejee
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- **Research Field**
  Thermofluid Systems Modelling
- **General Description of Research Field**
  Thermofluid network modelling is a powerful simulation tool that can be applied to study complex thermofluid systems, ranging from utility-scale power cycles, and heating and refrigeration to human cardiovascular dynamics. Thermofluid network models can be used to predict the performance of these complex systems for wide ranges of operating conditions, which helps to design, optimise and manage these intricate systems.

  By also incorporating machine learning techniques with thermofluid networks, condition monitoring tools can be developed to help detect anomalies, aid in design optimisation, and also drive breakthroughs in enhancing energy efficiency.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Optimization of a natural draft direct dry cooling system (NDDDCS) for a supercritical carbon dioxide (sCO2) power cycle using an artificial intelligence based surrogate model Global research interest into supercritical CO2 (sCO2) power cycles is increasing, due to their superior efficiencies and reduced component size requirements. These cycles, linked to concentrated solar power (CSP) 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. Modern thermal power plants in arid and semi-arid locations employ water conserving dry cooling technologies to reject the required heat from the cycle to the environment. Among these technologies are traditional mechanical draft air-cooled condensers (ACCs), natural draft indirect dry cooling systems and a new alternative, the natural draft direct dry cooling system (NDDDCS). This study will optimize a NDDDCS for the pre-cooler and intercooler heat loads of a sCO2 power cycle, linked to a 50 MWe CSP plant. The work will modify and utilize an existing co-simulation model (coupled Flownex one-dimensional and Fluent three-dimensional Computational Fluid Dynamics model) that has been developed to assess the performance of a NDDDCS specifically for this application. The optimization will consider alternative cooling tower shape and heat exchanger configurations. A neural network surrogate model, to be developed using the co-simulation model, will be used to perform the optimization. (This project will be co-supervised by Mr Rashid Haffejee and will form part of research conducted by the Solar Thermal Energy Research Group) **Requirements:** Strong interest and performance in Thermo-fluids modules. Computational Fluid Dynamics.		✓		

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**
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		✓	✓	

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.			✓	✓
Thermal radiation in a packed bed At high temperatures, radiation plays a significant role in the heat transfer in packed beds. This radiation may be modeled via a participating medium, but the absorption and scattering of radiation in the medium are expected to depend on particle size and shape, thermal conductivity, surface emissivity, and the porosity of the bed. Existing models make use of modifications to the effective thermal conductivity to cater for thermal radiation, but it gives poor results when the medium interacts with external structures. In this study, the student should extract the bulk radiation properties of the bed from CFD/DEM simulations, and validate it against experimental data. **Requirements:** good CFD skills will be advantageous.		✓	✓	
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.	✓			

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Particle characterization for pressure drop in an anisotropic packed bed The usual parameters like particle size, shape (sphericity or aspect ratio) and porosity fail to explain why the pressure drop in a packed bed of crushed rock particles differ for different flow directions through the bed. This is most notable when the flow is vertical or horizontal with respect to the pour direction of the particles. It is expected of the student to introduce new particle or bed (tortuosity) characteristics that can declare this behaviour. Using a CFD/DEM approach for particles with a simple geometric shape with aspect ratio's other than 1 may provide valuable information about the local flow patterns that contribute to the overall effect, but it will require experimental validation. **Requirements:** A working knowledge of CFD will be advatageous.		✓	✓	✓
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, or cooler temperatures at night may be released to cool the greenhouse on warm days. 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.	✓	✓		✓
Critical evaluation of the Ergun equation for anisotropic packed beds The Ergun equation is widely used in modelling flow through porous media for its simplicity. It depends on only a few parameters, like (the area equivalent) spherical diameter of the particles, fluid properties, and the porosity of the bed. The Ergun equation seems to work reasonably well for plug flow. However, the values of the (constant) coefficients in the Ergun equation is disputed in the literature. Some researchers reported a Reynolds number dependence of the coefficients, whilst other introduced extra (but often difficult to measure) parameters into the equation. It is expected that the student derive an alternative formulation for the pressure drop through an anisotropic bed, and validate it against experimental data. Using a combination of CFD and DEM will yield detailed information about the local flow patterns to inform the model, but isn't a necessary requirement to complete the project. **Requirements:** Good CFD skills might be advantageous.		✓	✓	✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Heat transfer and pressure drop in a packed beds of variable sized particles Flow and heat transfer in a packed beds is usually described in terms of a representative spherical particle. When the bed comprise of particles spanning a wide range of sizes (dmax > 5*dmin), this approximation may break down. It is expected of the student to come up with an appropriate formulation of the Reynolds number for the bed (usually a function of particle size, shape and porosity of the bed). Use this Reynolds number (and perhaps tortuosity) to define new correlations for the friction factor and Nusselt number. Using a CFD/DEM approach of the bed will give valuable insights into local flow and temperature profiles to inform the model(s). Validation of the model(s) against experimental data is required. Part of the project may be conducted at Sherbrooke or McGill University in Canada. **Requirements:** A working knowledge of CFD will be advantageous.		✓		

Prof Ryno Laubscher
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- **Research Field**
  Thermal-fluid dynamics
- **General Description of Research Field**
  Fundamental and applied research in combustion systems, heat exchangers and power cycles. Additionally my research focusses on the development of novel AI-based partial differential equation solvers for thermal-fluid problems.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Optimization of turbomachinery layout for concentrated solar sCO2 power cycles with the aid of integrated thermofluid network modelling Supercritical carbon dioxide (sCO2) power cycles have been identified as a promising future power conversion technology due to its high cycle efficiency and compact footprint. Using sCO2 power cycles with concentrated solar power (CSP) technology would lead to smaller mirror fields compared to Rankine-based CSP plants that has the same power output level, making it a more competitive renewable energy solution. One of the major costs associated with sCO2 power cycles is that of the large recuperator heat exchangers. Researchers have shown that the heat exchangers can be drastically reduced in size, and thus cost, if the turbomachinery efficiencies are increased even marginally. The present project sets out to compare and optimize various turbomachinery layouts for a 50 MWe CSP sCO2 power cycle with the aid of integrated thermofluid network models. The study will include different turbomachinery types, such as centrifugal and axial, along with different shaft configurations, such as dual- and single-shaft layouts. Gradient-based and metaheuristic optimization algorithms will be applied to the integrated cycle simulation models to tune turbomachine parameters such as blade solidity and blade aspect ratios for the various compressors and turbines. The study will cover both steady-state and transient operating scenarios. **Requirements:** Mechanical engineering undergraduate degree.			✓	

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 configuration of solar thermal multi-tower field layout Central receiver CSP plants, or power towers, are built on a very large scale (typically 50 to 100 MW or more). They require significant capital, and the 150- to 250-metre-tall tower can take up to two years to build. Conversely, utility photovoltaic (PV) plants can potentially be constructed within six months and require much less upfront capital. This project intends to design and optimise a CSP plant composed of an array of heliostat field/tower modules (multi-tower system) that can be constructed quickly and sequentially and supply a single power plant. Such a system has the potential to start generating electricity (and hence revenue) after the completion of the first module of the array. The study will develop a simulation of the multi-tower, including optical and thermal components, together with a cost model, which will be used to optimise the system's configuration. See e.g. https://doi.org/10.1063/5.0028916. **Requirements:** none		✓	✓	✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Advanced Acoustic Monitoring for Predictive Maintenance in Concentrated Solar Power Plants This project aims to develop and implement an advanced acoustic monitoring system for predictive maintenance in parabolic trough concentrated solar power (CSP) plants. The research will focus on replacing manual listening techniques with a network of strategically placed acoustic sensors to detect early signs of thermal stress and metal fatigue in collector tubes and piping systems. The study will involve designing an array of acoustic emission (AE) sensors, developing signal processing algorithms to interpret the collected data, and creating machine learning models to predict potential failures. The project will explore integrating this acoustic monitoring system with other sensor data (e.g., temperature, pressure, flow rates) to enhance the accuracy of failure predictions and optimize maintenance schedules. The ultimate goal is to improve the reliability and efficiency of CSP plants while reducing downtime and maintenance costs, thus contributing to the broader objective of industrial decarbonization. **Requirements:** none		✓	✓	
Analytical Solutions to Non-imaging Solar Concentrator Optical Design This project aims to develop an analytical method for generating the optical surface of solar concentrators. The primary objective is to create a mathematical model that determines the ideal surface geometry to achieve a specified irradiance distribution on a target, given a set of input ray parameters. The study may incorporate varying solar irradiance data over daily and annual cycles to generate an optical surface design. The performance of the analytical solution will be comparatively assessed against conventional tracking troughs and heliostats, potentially offering insights into more efficient solar concentration techniques for industrial decarbonization applications. **Requirements:** none		✓	✓	✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Novel Ceramic Composites for Thermal Energy Storage 1. Investigation of Novel Ceramic Composites for Thermal Energy Storage This project aims to develop advanced ceramic composite materials for thermal energy storage (TES) applications, particularly in molten salt storage systems. The research will explore innovative fabrication methods, material compatibility, the effects of additives (e.g., graphene), reliability, and novel compositions to improve the thermal and structural properties of the storage media. The project will involve material characterization, compatibility testing, and optimization to identify suitable ceramic-based alternatives to conventional molten salt storage materials. Additionally, the project includes the design, fabrication, and testing of an experimental TES testbed to validate the performance of the developed ceramic composites. 2. Transient Modeling and Simulation of Thermal Energy Storage Systems** This project focuses on developing a detailed transient model for thermal energy storage (TES) systems. The model will simulate the dynamic behaviour of the TES system, accounting for environmental factors, charge/discharge cycles, and design changes. The goal is to create a comprehensive simulation tool to provide insights into TES system performance and enable informed decision-making and optimization. The model will be extensively validated against experimental data from the TES testbed developed in the first project, and the model's limitations will be identified to ensure reliable and accurate predictions. **Requirements:** none		✓	✓	✓
High Temp Heat Pumps This project focuses on developing an advanced thermodynamic model for high-temperature industrial heat pumps. The model will simulate the performance and efficiency of heat pump systems capable of generating heat above 100°C, which is critical for displacing fossil fuel-based industrial heating processes. The project will involve gathering data on the latest heat pump technologies, incorporating realistic operating conditions, and validating the model against experimental results. The goal is to provide a robust tool for optimizing high-temp heat pump designs to support industrial decarbonization efforts. **Requirements:** none		✓	✓	✓
Mini Industry Heat Network Title: (District, Wooster) Description: This project aims to develop a detailed model and feasibility study for implementing a mini-industry heat network in the Wooster district. The goal is to analyze the potential for recovering and distributing waste heat from nearby industrial facilities to supply surrounding users. The project will involve mapping heat sources and sinks, designing an optimal heat distribution network, and evaluating such a system's technical and economic viability. The findings could inform future district-level decarbonization efforts in similar industrial areas.	✓			

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Requirements: none				
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		✓	✓	
Design and analysis of glass alternative concentrated solar power reflectors Mirrored glass is the most common material for reflectors used in the concentrated solar power (CSP) industry. However, glass has many undesirable properties. The research aims to develop feasible glass alternative reflectors for CSP applications. The project will involve structural design, prototype building, and performance testing. Various simulation technologies can also be incorporated into the project. **Requirements:** none		✓	✓	✓

Topics	**MEng Struct**	**MEng Resrch**	**PhD**	**Potential Funding**
Concentrating Solar Power Grid Services for the South African Electricity Network This project aims to assess the ability of Concentrating Solar Power (CSP) technology to provide grid services and support the integration of renewable energy in the South African electricity network. The study will evaluate the performance and capabilities of various CSP technologies in providing services like grid stability, load balancing, and renewable energy integration. (i) Economic Evaluation: The project will model the impact of CSP technology in a competitive bid market, using classical programming languages (e.g., Python, MATLAB) coupled with optimization toolboxes. This analysis will quantify the economic benefits of deploying CSP-based grid services and make the models available to plant designers and grid managers. (ii) Grid Stability Analysis: The project will conduct a stochastic analysis to evaluate CSP technology's grid stability impacts based on realistic renewable resource variability modelling using South African meteorological data. The performance of CSP with thermal energy storage will be compared to the other technologies under different load scenarios, using a co-optimization approach that considers economic and risk-aversion criteria. Various simulation models, such as Python-based PyPSA and PLEXOS, will be considered to assess the grid services provided by the CSP technologies. The outcomes of this research can help inform policymakers, grid operators, and CSP developers on the potential benefits and strategies for leveraging CSP technology to enhance the resilience and sustainability of the South African power grid. **Requirements:** none		✓	✓	✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
SU 1kW PEM Electrolyser Project SU has a commercial Hogen (Proton Energy Systems, now Nel Hydrogen) 1 kW PEM electrolyser system on a semi-permanent loan. Objective: to recommission the Hogen 1kW PEM electrolyser at SU and use it as a model system to reverse-engineer a prototype SU electrolyser. The Hogen electrolyser system comprises separable sub-systems, which may be categorized as follows: • PEM Stack – bipolar plates, MEA, seals & sealing, performance characterization. • Power Electronics – hardware, control and interface software, load/battery ... • Balance of Plant (BoP) – water subsystem, H2 & O2 management (buffer, offtake). • Physical Embodiment – enclosure, HM interface, component layout, look & feel) • Safety Protocols – H2 and O2 management, high currents. Initial efforts aimed at the above objective point the following first development sub-projects as MSc studies, namely: 1. STACK (M&M) - involves the design, component manufacture, assembly and demonstration of a reverse-engineered 1 kW PEM stack for substitution into the Hogen reference system. Includes flow field end/bipolar plates, stack compression mechanism (sealing), H2, O2, H2O and electric current ducting, temperature management and necessary diagnostics/analytics – specifically excludes electrocatalyst/MEA development which is to be purchased/outsourced. 2. POWER ELECTRONICS (E&E) – involves designing, constructing and demonstrating an electrolyser stack power management system for substitution into the Hogen reference system. Includes electronics hardware, control software and diagnostic/analytics to monitor stack/system performance. 3. PRODUCT DESIGN (IND) – includes physical product embodiment and features (BoP and sub-system layout, operability, safety, look & feel, HM interface, IoT monitoring). Consists of the design and build of an SU system for incorporating stack and power electronics ex projects (1) & (2), above. Note: the above assumes the existing Hogen system is successfully commissioned and operational for access by the proposed project groups, i.e. this is not seen as part of the MSc studies themselves. **Requirements:** none		✓		✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Numerical Solution for a Solar Concentrating Optical Surface Design The project aims to investigate a numerical solution for the optical surface of a solar concentrator. The topic's primary objective is to develop a method to solve the analytical solution for an optical surface that would irradiate a given target, given a set of input rays. Using the developed model, a solution for the optical surface can be found for different input cases. An optimised optical surface can be found using an input dataset that is representative of solar irradiance over a day (or a year). The optimised solution can be compared to traditional tracking troughs/heliostats. This approach particularly applies to photoelectrochemical (PEC) hydrogen production, where reactors have unique irradiance requirements. The ability to control input and output rays during the design phase allows for carefully addressing these specific needs in PEC systems. The following paper shows how concentrating optics is incorporated into a PEC hydrogen production system: https://doi.org/10.1038/s41560-023-01247-2. **Requirements:** none	✓	✓		✓

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.				
Development of a reduced order model (ROM) for a bespoke natural draft direct dry cooling system (NDDDCS) finned tube heat exchanger Modern thermal power plants in arid and semi-arid locations employ water conserving dry cooling technologies to reject the required heat from the cycle to the environment. Among these technologies are traditional mechanical draft air-cooled condensers (ACCs), natural draft indirect dry cooling systems and a new alternative, the natural draft direct dry cooling system (NDDDCS). ACCs employ a multitude of large diameter axial flow fans to force airflow across heat exchanger bundles. The capital cost of these systems are relatively low, but operational costs are high due to parasitic power consumption and maintenance cost on the many moving parts. Direct steam condensation inside the finned tubes of the heat exchangers ensure high thermal efficiencies. In contrast, natural draft indirect dry cooling systems use the natural draft created by buoyancy effects to drive airflow through a large cooling tower, and across heat exchanger bundles around the tower periphery at ground level. Such systems utilize a shell-and-tube condenser to condense the turbine exhaust steam, while a separate loop pumps the cooling water to be re-cooled in the cooling tower. Due to their large footprint, these systems have high capital costs, but operational costs are much reduced compared to the ACC due to the reduced rotating mechanical equipment requirement. The NDDDCS combines the advantages of reduced operational cost of a natural draft system with the higher thermal efficiencies of direct steam condensation, as steam is conveyed directly from the turbine exhaust into heat exchangers in a natural draft cooling tower. This study will develop a reduced order parametric model (ROM) of the thermo-hydraulic performance of a flattened finned tube heat exchanger, based on the results of multiple Computational Fluid Dynamics (CFD) simulations. The intention is to find the best combination of tube and fin geometry that would provide an optimal finned tube for application within a given NDDDCS. The work will continue the development of a current CFD model and ROM that evaluated limited parameter variations. The ROM will also be integrated into an existing one-dimensional NDDDCS model to predict the optimal tube configuration based on the selected NDDDCS design. (This project will be co-supervised by Dr Hannes Pretorius and will form part of research conducted by the Solar Thermal Energy Research Group). **Requirements:** Strong interest and performance in Thermo-fluids modules. Computational Fluid Dynamics.		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Modelling annual performance of a natural draft direct dry cooling system (NDDDCS) for a 50 MWe concentrating solar power (CSP) application Modern thermal power plants in arid and semi-arid locations employ water conserving dry cooling technologies to reject the required heat from the cycle to the environment. Among these technologies are traditional mechanical draft air-cooled condensers (ACCs), natural draft indirect dry cooling systems and a new alternative, the natural draft direct dry cooling system (NDDDCS). ACCs employ a multitude of large diameter axial flow fans to force airflow across heat exchanger bundles. The capital cost of these systems are relatively low, but operational costs are high due to parasitic power consumption and maintenance cost on the many moving parts. Direct steam condensation inside the finned tubes of the heat exchangers ensure high thermal efficiencies. In contrast, natural draft indirect dry cooling systems use the natural draft created by buoyancy effects to drive airflow through a large cooling tower, and across heat exchanger bundles around the tower periphery at ground level. Such systems utilize a shell-and-tube condenser to condense the turbine exhaust steam, while a separate loop pumps the cooling water to be re-cooled in the cooling tower. Due to their large footprint, these systems have high capital costs, but operational costs are much reduced compared to the ACC due to the reduced rotating mechanical equipment requirement. Indirect steam condensation to cooling results in lower thermal efficiencies compared to direct systems. The NDDDCS combines the advantages of reduced operational cost of a natural draft system with the higher thermal efficiencies of direct steam condensation, as steam is conveyed directly from the turbine exhaust into heat exchangers in a natural draft cooling tower. This study will develop a reduced order model (ROM) of NDDDCs performance as a function of ambient conditions (including wind), based on the results of multiple Computational Fluid Dynamics (CFD) simulations. The intention is to evaluate the annual performance of a NDDDCS without having to simulate each ambient condition using CFD. The work will continue development of an existing CFD model of a NDDDCS, and the investigation will consider system performance as part of a 50 MWe concentrating solar power (CSP) plant. The NDDDCS will be sized for a typical CSP application and design of experiments will be used to develop the ROM. (This project will be co-supervised by Dr Hannes Pretorius and will form part of research conducted by the Solar Thermal Energy Research Group). **Requirements:** Strong interest and performance in Thermo-fluids modules. Computational Fluid Dynamics.		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Investigating the impact of site winds on utility-scale PV power plant output Solar power generation using Photovoltaic (PV) power plants has 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. Forced convection heat transfer from modules due to winds at a PV power plant site can reduce the operating temperatures of the modules. This reduction in temperature improves their efficiency and ultimately enhances the plant's output. The impact of wind on module temperature is likely to be different across the PV array and sensitive to both wind speed and direction. There is little understanding of this behaviour at present. This study will evaluate the impact of winds on the module temperature and corresponding output of a utility-scale PV power plant. Computational Fluid Dynamics (CFD) models will be used to evaluate the flow over the modules in order to determine their effective temperature. Existing one-dimensional models and / or commercial software will be used to assess the resulting impact on plant performance. With a better understanding of wind effects and associated temperature distributions, several possible research questions can be interrogated (e.g. is there a potential benefit to accounting for prevailing wind direction in the orientation of a PV plant?). This topic will be co-supervised by Dr Hannes Pretorius and Dr Arnold Rix (E&E). **Requirements:** Strong interest and performance in Thermo-fluids modules. Computational Fluid Dynamics.		✓		✓
Optimising specific energy consumption in raceway ponds for large scale aquafarming of seaweed for biofuel generation Seaweed is emerging as prominent resource in the transition to sustainability in many industries. A common type of farming occurs in onshore ponds, where the seaweed is kept in suspension using aeration or paddle wheels to introduce turbidity into the water. A key parameter for the economic feasibility of any land-based aquaculture project is the energy required to keep the seaweed suspended. This study will use numerical models to optimise raceway pond geometry for minimum specific energy consumption while maintaining adequate turbidity distribution. This project will be co-supervised by Dr Adam Venter and will be in collaboration with an industry partner. **Requirements:** CFD		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Curbing food losses through solar drying integrated with biogas-assisted dehumidification See full topic description under Prof Eugene van Rensburg. The project will be co-supervised by Prof van Rensburg and myself. **Requirements:** See full topic description.	✓	✓		✓

Dr Hannes Pretorius
jpp@sun.ac.za

- **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
Comparative techno-economic assessment of dry cooling system alternatives for a 50 MWe concentrating solar power (CSP) application Modern thermal power plants in arid and semi-arid locations employ water conserving dry cooling technologies to reject the required heat from the cycle to the environment. Among these technologies are traditional mechanical draft air-cooled condensers (ACCs), natural draft indirect dry cooling systems and a new alternative, the natural draft direct dry cooling system (NDDDCS). ACCs employ a multitude of large diameter axial flow fans to force airflow across heat exchanger bundles. The capital cost of these systems is relatively low, but operational costs are high due to parasitic power consumption and maintenance cost on the many moving parts. Direct steam condensation inside the finned tubes of the heat exchangers ensures high thermal efficiencies. In contrast, natural draft indirect dry cooling systems use the natural draft created by buoyancy effects to drive airflow through a large cooling tower, and across heat exchanger bundles around the tower periphery at ground level. Such systems utilize a shell-and-tube condenser to condense the turbine exhaust steam, while a separate loop pumps the cooling water to be re-cooled in the cooling tower. Due to their large footprint, these systems have high capital costs, but operational costs are much reduced compared to the ACC due to the reduced rotating mechanical equipment requirement. Indirect steam condensation to cooling results in lower thermal efficiencies compared to direct systems. The NDDDCS combines the advantages of reduced operational cost of a natural draft system with the higher thermal efficiencies of direct steam condensation, as steam is conveyed directly from the turbine exhaust into heat exchangers situated inside a natural draft cooling tower. This study will evaluate the Levelized Cost of Electricity (LCOE) for each cooling option, as part of a 50 MWe concentrating solar power plant. The investigation will build on one-dimensional thermo-fluid models which have been developed for each of these systems to evaluate the performance of each over an annual basis. Costing models will also be developed towards performing the techno-economic evaluation for each alternative. (This project will form part of research conducted by the Solar Thermal Energy Research Group) **Requirements:** Strong interest and performance in Thermo-fluids modules.		✓		

Topics	**MEng Struct**	**MEng Resrch**	**PhD**	**Potential Funding**
Sensitivity analysis on a natural draft direct dry cooling system (NDDDCS) for large- and medium-scale power generation applications Modern thermal power plants in arid and semi-arid locations employ water conserving dry cooling technologies to reject the required heat from the cycle to the environment. Among these technologies are traditional mechanical draft air-cooled condensers (ACCs), natural draft indirect dry cooling systems and a new alternative, the natural draft direct dry cooling system (NDDDCS). ACCs employ a multitude of large diameter axial flow fans to force airflow across heat exchanger bundles. The capital cost of these systems is relatively low, but operational costs are high due to parasitic power consumption and maintenance cost on the many moving parts. Direct steam condensation inside the finned tubes of the heat exchangers ensures high thermal efficiencies. In contrast, natural draft indirect dry cooling systems use the natural draft created by buoyancy effects to drive airflow through a large cooling tower, and across heat exchanger bundles around the tower periphery at ground level. Such systems utilize a shell-and-tube condenser to condense the turbine exhaust steam, while a separate loop pumps the cooling water to be re-cooled in the cooling tower. Due to their large footprint, these systems have high capital costs, but operational costs are much reduced compared to the ACC due to the reduced rotating mechanical equipment requirement. Indirect steam condensation to cooling results in lower thermal efficiencies compared to direct systems. The NDDDCS combines the advantages of reduced operational cost of a natural draft system with the higher thermal efficiencies of direct steam condensation, as steam is conveyed directly from the turbine exhaust into heat exchangers situated inside a natural draft cooling tower. This study will conduct a sensitivity analysis on the performance of a NDDDCS for changes to the heat exchanger configuration, heat exchanger performance characteristics, tower geometry and shape, and inclusion of wind mitigation measures. The investigation will build on current Computational Fluid Dynamics (CFD) models of a NDDDCS which have been developed for medium (100 MW CSP) and large (900 MW thermal) scale power generation applications. CFD simulations will be executed based on the updated geometries and features and the impact on system performance assessed. (This project will form part of research conducted by the Solar Thermal Energy Research Group) **Requirements:** Strong interest and performance in Thermo-fluids modules. Computational Fluid Dynamics.		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Development of a reduced order model (ROM) for a bespoke natural draft direct dry cooling system (NDDDCS) finned tube heat exchanger Modern thermal power plants in arid and semi-arid locations employ water conserving dry cooling technologies to reject the required heat from the cycle to the environment. Among these technologies are traditional mechanical draft air-cooled condensers (ACCs), natural draft indirect dry cooling systems and a new alternative, the natural draft direct dry cooling system (NDDDCS). ACCs employ a multitude of large diameter axial flow fans to force airflow across heat exchanger bundles. The capital cost of these systems is relatively low, but operational costs are high due to parasitic power consumption and maintenance cost on the many moving parts. Direct steam condensation inside the finned tubes of the heat exchangers ensures high thermal efficiencies. In contrast, natural draft indirect dry cooling systems use the natural draft created by buoyancy effects to drive airflow through a large cooling tower, and across heat exchanger bundles around the tower periphery at ground level. Such systems utilize a shell-and-tube condenser to condense the turbine exhaust steam, while a separate loop pumps the cooling water to be re-cooled in the cooling tower. Due to their large footprint, these systems have high capital costs, but operational costs are much reduced compared to the ACC due to the reduced rotating mechanical equipment requirement. Indirect steam condensation to cooling results in lower thermal efficiencies compared to direct systems. The NDDDCS combines the advantages of reduced operational cost of a natural draft system with the higher thermal efficiencies of direct steam condensation, as steam is conveyed directly from the turbine exhaust into heat exchangers situated inside a natural draft cooling tower. Mechanical draft ACCs employ flattened finned tube heat exchanger tubes. These tubes were specifically developed for mechanical draft applications and may not be optimal within the context of a NDDDCS. This study will develop a reduced order parametric model (ROM) of the thermo-hydraulic performance of a flattened finned tube heat exchanger, based on the results of multiple Computational Fluid Dynamics (CFD) simulations. The intention is to find the best combination of tube and fin geometry that would provide an optimal finned tube for application within a given NDDDCS. The work will continue the development of a current CFD model and ROM that evaluated limited parameter variations. The ROM will also be integrated into an existing one-dimensional NDDDCS model to predict the optimal tube configuration based on the selected NDDDCS design. (This project will be co-supervised by Prof Mike Owen and will form part of research conducted by the Solar Thermal Energy Research Group) **Requirements:** Strong interest and performance in Thermo-fluids modules. Computational Fluid Dynamics.		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Modelling annual performance of a natural draft direct dry cooling system (NDDDCS) for a 50 MWe concentrating solar power (CSP) application Modern thermal power plants in arid and semi-arid locations employ water conserving dry cooling technologies to reject the required heat from the cycle to the environment. Among these technologies are traditional mechanical draft air-cooled condensers (ACCs), natural draft indirect dry cooling systems and a new alternative, the natural draft direct dry cooling system (NDDDCS). ACCs employ a multitude of large diameter axial flow fans to force airflow across heat exchanger bundles. The capital cost of these systems is relatively low, but operational costs are high due to parasitic power consumption and maintenance cost on the many moving parts. Direct steam condensation inside the finned tubes of the heat exchangers ensures high thermal efficiencies. In contrast, natural draft indirect dry cooling systems use the natural draft created by buoyancy effects to drive airflow through a large cooling tower, and across heat exchanger bundles around the tower periphery at ground level. Such systems utilize a shell-and-tube condenser to condense the turbine exhaust steam, while a separate loop pumps the cooling water to be re-cooled in the cooling tower. Due to their large footprint, these systems have high capital costs, but operational costs are much reduced compared to the ACC due to the reduced rotating mechanical equipment requirement. Indirect steam condensation to cooling results in lower thermal efficiencies compared to direct systems. The NDDDCS combines the advantages of reduced operational cost of a natural draft system with the higher thermal efficiencies of direct steam condensation, as steam is conveyed directly from the turbine exhaust into heat exchangers situated inside a natural draft cooling tower. This study will develop a reduced order model (ROM) of NDDDCS performance as a function of ambient conditions (including wind), based on the results of multiple Computational Fluid Dynamics (CFD) simulations. The intention is to evaluate the annual performance of a NDDDCS without having to simulate each ambient condition using CFD. The work will continue development of an existing CFD model of a NDDDCS, and the investigation will consider system performance as part of a 50 MWe concentrating solar power (CSP) plant. The NDDDCS will be sized for a typical CSP application and design of experiments will be used to develop the ROM. (This project will be co-supervised by Prof Mike Owen and will form part of research conducted by the Solar Thermal Energy Research Group) **Requirements:** Strong interest and performance in Thermo-fluids modules. Computational Fluid Dynamics.		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Performance modelling of axial drive- and power turbines for a supercritical carbon dioxide (sCO2) power cycle Concentrated Solar Power (CSP) is a renewable energy source that generates electricity using direct solar radiation. CSP complements traditional energy sources like coal, natural gas, and nuclear. Environmental fluctuations and varying output requirements impact CSP plants' thermal and economic performance, causing efficiency reductions when operating off-design. Consequently, large and costly CSP plants are needed to meet energy demands. Techno-economic analyses indicate that improving power block efficiency can significantly reduce costs. Global research interest into supercritical carbon dioxide (sCO2) power cycles is increasing, due to their superior efficiencies and reduced component size requirements. These cycles, linked to CSP applications represent a modern evolution to sustainable and efficient power production. The design of turbomachinery for sCO2 cycles is critical, as efficiency greatly affects the system. The unique properties of CO2 in the critical region pose challenges, prompting extensive research. One-dimensional (1D) mean-line models are favoured for analysis and design due to their lower computational cost compared to three-dimensional (3D) Computational Fluid Dynamics (CFD) models. Choosing suitable loss correlations is key for accurate turbomachinery modelling and reliable efficiency results. This work aims to design efficient drive and power turbines for a 50 MWe CSP plant using a sCO2 power cycle. This involves preliminary turbine designs as well as developing 1D models that account for the real gas effects of CO2 and various loss mechanisms. Additionally, CFD simulations will validate the turbine designs at their selected operational speeds. (NOTE: This topic has already been allocated to a student for 2025.) (This project will be co-supervised by Prof Ryno Laubscher and will form part of research conducted by the Solar Thermal Energy Research Group) **Requirements:** Strong interest and performance in Thermo-fluids modules. Computational Fluid Dynamics.		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Optimization of a natural draft direct dry cooling system (NDDDCS) for a supercritical carbon dioxide (sCO2) power cycle using an artificial-intelligence-based surrogate model Global research interest into supercritical CO2 (sCO2) power cycles is increasing, due to their superior efficiencies and reduced component size requirements. These cycles, linked to concentrated solar power (CSP) 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. Modern thermal power plants in arid and semi-arid locations employ water conserving dry cooling technologies to reject the required heat from the cycle to the environment. Among these technologies are traditional mechanical draft air-cooled condensers (ACCs), natural draft indirect dry cooling systems and a new alternative, the natural draft direct dry cooling system (NDDDCS). This study will optimize a NDDDCS for the pre-cooler and intercooler heat loads of a sCO2 power cycle, linked to a 50 MWe CSP plant. The work will modify and utilize an existing co-simulation model (coupled Flownex one-dimensional and Fluent three-dimensional Computational Fluid Dynamics model) that has been developed to assess the performance of a NDDDCS specifically for this application. The optimization will consider alternative cooling tower shape and heat exchanger configurations. A neural network surrogate model, to be developed using the co-simulation model, will be used to perform the optimization. (NOTE: This topic has already been allocated to a student for 2025.) (This project will be co-supervised by Mr Rashid Haffejee and will form part of research conducted by the Solar Thermal Energy Research Group) **Requirements:** Strong interest and performance in Thermo-fluids modules. Computational Fluid Dynamics.		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Investigating the impact of site winds on utility-scale PV power plant output Solar power generation using Photovoltaic (PV) power plants has 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. Forced convection heat transfer from modules due to winds at a PV power plant site can reduce the operating temperatures of the modules. This reduction in temperature improves their efficiency and ultimately enhances the plant's output. The impact of wind on module temperature is likely to be different across the PV array and sensitive to both wind speed and direction. There is little understanding of this behaviour at present. This study will evaluate the impact of prevailing winds on the module temperature and corresponding output of a utility-scale PV power plant. Computational Fluid Dynamics (CFD) models will be used to evaluate the flow over the modules in order to determine their effective temperature. Existing one-dimensional models and / or commercial software will be used to assess the resulting impact on plant performance. With a better understanding of wind effects and associated temperature distributions, several possible research questions can be interrogated (e.g. is there a potential benefit to accounting for prevailing wind direction in the orientation of a PV plant?) (NOTE: This topic has already been allocated to a student for 2025.) (This topic will be co-supervised by Prof Mike Owen and Dr Arnold Rix (E&E), and a full scholarship from SCATEC will most likely be available) **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
A Novel Heliostat Facet Design A heliostat is a facet (mirror) placed on a pedestal. The facet is controlled by two actuators so that it reflects and concentrates solar rays onto a target that can be hundreds of meters away. Our research group has done a lot of work on new heliostat designs. The design shows a lot of promise. This project aims to design a heliostat facet for mass production. The design should then be built and tested. **Requirements:** None.		✓		
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.		✓		

Dr Gerrit Ter Haar
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- **Research Field**
  Overcoming metal corrosion degradation in hydrogen cells
- **General Description of Research Field**
  Metal corrosion is a significant challenge in hydrogen electrolyzers and fuel cells, primarily due to the harsh electrochemical environments present in these devices. In electrolyzers, the anode experiences highly oxidizing conditions during the oxygen evolution reaction, leading to corrosion of metallic components. This corrosion can result in the degradation of electrode materials, reduced efficiency, and contamination of the produced hydrogen. This metal degradation not only diminishes the performance and lifespan of the devices but can also lead to the release of metal ions that may poison catalysts or contaminate membranes. Consequently, the development of corrosion-resistant materials and protective coatings is crucial for enhancing the durability and efficiency of hydrogen electrolyzers and fuel cells. Corrosion-resistant materials such as titanium are popular, but expensive. Therefore, to reduce costs, materials engineers are investigated alternative approaches. One such approach is in using low-cost material (e.g., stainless steel) and applying ani-corrosive surface treatments. This project entails investigating cheaper alternative materials, characterising them and validating their performance in an anodic environment that matches that of real-world cell conditions. Potential funding is available.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Design, build and test a solid oxide electrolysis cell A Solid Oxide Electrolysis Cell (SOEC) is a device that uses electricity to split water (or sometimes carbon dioxide) into hydrogen (and potentially carbon monoxide). Operating at high temperatures (600-900°C), SOECs are highly efficient, particularly when using waste heat or renewable electricity. This makes them a promising technology for large-scale hydrogen production, energy storage, and carbon utilization. However, the high operating temperatures present challenges, such as material degradation, thermal cycling stress, and high costs. Research is focused on improving durability, reducing costs, and optimizing integration with renewable energy sources. This project entails the design, manufacturing and testing of a small-scale SOEC with a focus on materials engineering to overcome the challenges mentioned. **Requirements:** Previous experience with design and manufacturing of mechanical systems will be useful. Interested in materials engineering.		✓		✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Materials engineering of metal hydride hydrogen storage structures Hydrogen is emerging as a crucial tool in the global effort to reduce carbon emissions. One of the main challenges remains safe storage of hydrogen. Storing hydrogen in compressed tanks is dangerous and therefore other methods are being researched such as metal hydrides. Metal hydride technology allows for solid-state hydrogen storage through absorption and desorption processes. This method is safer than pressurized tanks and suitable for distributed storage, especially in South Africa where it reduces the need for extensive hydrogen infrastructure. To enhance reaction kinetics, powdered metal hydrides with large surface areas are used in storage tanks. Powdered metal hydrides however have poor thermal diffusivity, causing inefficiencies such as uneven temperatures in the tank, longer activation times, slower hydrogen loading, and difficulties in scaling up tank size. This project aims to develop novel metal hydride storage tanks that are structurally optimize for improved thermal management. These tanks are to be build using additive manufacturing (3D printing) from metal hydride materials. The feasibility of using additive manufacturing to build complex porous structures from metal hydride materials remains uncertain. Therefore, this research investigates additively manufactured porous (e.g., periodic and random open cellular porous) metal hydride structures. **Requirements:** Interest in materials science / engineering and design for additive manufacturing.		✓	✓	✓

Prof Eugene van Rensburg
eugenevrb@sun.ac.za

- **Research Field**
  Renewable energy, Bioprocess development, Fermentation, Mushroom valorisation
- **General Description of Research Field**
  Prof van Rensburg's main research interests include (i) bioprocess development with emphasis on fermentation systems and associated up- and downstream processing where microbes and their products are exploited for commercial gain, (ii) biomass processing and extraction of valuable products, and (iii) energy generation from agricultural, bioprocessing and industrial wastes. He seeks to integrate these foci in a multidisciplinary approach where bio-based technologies can be applied to address the Food-Energy-Water Nexus triple challenge within the context of sustainable development in rural Africa.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Curbing food losses through solar drying integrated with biogas-assisted dehumidification Solar thermal drying is a mature technology and converting perishable food to shelf-stable commodities through dehydration is a proven practice. Yet, effective technologies remain under-utilised in rural African settings that are frequently characterised by high levels of poverty and malnutrition. More than 30% of all fresh produce in sub-Saharan Africa (SSA) is lost or wasted after harvesting due to spoilage or damaged during storage, transport and at markets. Affordable and low technology level interventions are thus required to lower the barriers to innovative technology deployment. On-farm drying is a potential solution to this challenge, which additionally empowers rural small farmers to add value and serve more predictable markets. Anaerobic digestion (AD) of farm wastes e.g., offcuts generated in the preparation for drying, such as peeling and trimming, in combination with farm animal manure, is a synergistic technology that can provide biogas as a source of heat for absorption cooling or dehumidifying desiccation, to provide a dehumidification system integrated with solar drying. This study aims to assess the effectiveness of AD in combination with on-farm solar drying on representative food applications, such as fish, fruit, vegetables and leafy greens, as part of a circular food waste prevention system. An opportunity is available for postgraduate research to investigate the use of waste to generate cooling through the combustion of biogas from anaerobic digestion (AD) to avoid food spoilage, especially at the post-harvest stage. Integration of the AD technology with a solar drying system forms a unique aspect of the work. Such technology is specifically targeted at subsistence farmers in rural settings throughout the African continent where such a robust and rugged system will serve as a key intervention to minimise food losses by drying. The project will include (i) technical modelling to determine mass and energy balances to determine the sizing of all equipment components, including AD reactor, dehumidifier components and the contribution of solar radiation, (ii) development, commission, and test a drying system, (iii) integrate the dehumidifier into a real size (ca. 80 kg capacity) hybrid solar drying technology system consisting of a solar drying tunnel with forced air circulation, and (iv) use experimental data to populate a simulation model to estimate financial return and benefits through avoided food waste. Note, the project will use synthetic biogas, which means the incumbent will not be required to do anaerobic digestion. The project will be fully funded and will include a competitive bursary. **Requirements:** BEng Mechanical Engineering	✓	✓		✓

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 the 24 ft. installed MinwaterCSP axial flow fan. The project will specifically focus on modelling and accurately measuring the performance of the 24 ft MinwaterCSP axial flow fan. Existing work has focused on the measurement and modelling of this fan's performance under both stable and unstable conditions. The idea is to expand this work in order to improve the fan's performance under various operating conditions. The possible improvements will be modelled in CFD and implemented in the large diameter fan. **Requirements:** CFD		✓	✓	✓
Reducing the noise signature of a large diameter axial flow cooling fan. Existing work has focused on the measurement and modelling of the noise emitted by a large diameter cooling fan. This project will now attempt to reduce the noise characteristics of such a fan by altering the blade configuration of the fan, without replacing the fan blades. Modifications must therefore be made in the form of attachments added to the fan blade. The work will involve intensive experimental evaluation, as well as numerical modelling of the flow around the fan blades. **Requirements:** CFD	✓	✓	✓	✓