Literature Review

Introduction

This project aims to provide solar water heating to university residences of UCT. To accomplish this careful analysis and investigation will be conducted to find an appropriate and sufficient strategy that can be implemented. This analysis will consist of developing 2 models across two residents in different locations on lower/middle campus and comparing the performance across a set of different potential scenarios. The end goal is to save UCT money, heating water is a substantial portion of UCT's expenses, there is a financial gain for the university while also becoming "greener" and more sustainable. Sustainability was once an idea but is now becoming integral to engineering, finance and business as humans try to mitigate global warming and client change therefore the transition to renewable energy is soon and as Africa's top tertiary institution it should lead this endeavour. This project is a foot in that direction.

Relevance - financial

Across the x UCT residence UCT spends Rx on heating water per day, per year this Rx. This is equivalent to sending x number of students to UCT for a year. Using renewable energy just for heating saves UCT Rx and over a period of 10 years this is x. The financial gain is large and with the uncertainty of load shedding glooming over South Africa it only makes this strategy more attractive and the need for it more imminent. The financial aspect of this project will be investigated in depth later in the project providing a cost breakdown of the model and future financial gains.

Relevance - energy

The energy required for heating the water consumed in a day across UCTs residences is x% of the total energy UCT consumes per day and x% of the energy consumed in the Rondebosch area per day. Monthly this is equivalent to.. And per year this is equivalent to ... .The sphere of influence of UCT is large, growing academia, culture and sport in South Africa however with this production comes great consumption. UCTs carbon footprint is x which is equivalent to… .UCT therefore has a responsibility and can not only take into account its own personal needs but those around it that are also affected by its action.

Current state of the planet, importance of sustainability…

Motivation - end of introduction/talk

Becoming a more sustainable institution should be part of UCTs philosophy just like becoming more diverse and inclusive after 1994 but hopefully it doesn't take a catastrophe to start a green revolution just a few small actions and this project aims to provide a basis for the first real step.

Technologies - history of solar panels.

Solar energy is the most abundant source of energy on the earth, fueling plants and crops sustaining all life on earth. In 2023 globally humans required xJ of energy, the natural world including plants and animals required xJ. Ancient homo-sapiens harnessed the power of the sun in 7th century BC to make fire and the first solar panel harnessing the sun's energy to produce electricity was in New York in 1883 by Charles Fritz. In 1905 Einstein theory of the photoelectric effect, stating that light behaves as particles called photons which project electrons above a certain energy level on the surface of a semiconductor. Earning him a Nobel Prize and providing a base for further scientific research. In 1954 at Bell Labs the first modern solar cell was developed by accident, noticing that when certain impurities were added to silicon and exposed to light an electric current was detected. The solar panel industry has grown from a science experiment to a 260.16 billion US dollar global industry.

https://www.statista.com/statistics/1457473/global-market-size-solar-panels/#:~:text=The%20market%20value%20of%20solar,billion%20U.S.%20dollars%20in%202031.

Technologies - thermal and PV simple breakdown, how do they work ? How do they harness energy ? What are they used for ?

Solar technologies convert solar radiation emitted by the sun into useful forms of energy through chemical processes. The three dominating different types of solar generation technologies are photovoltaic, solar thermal and concentrated solar power. Concentrated solar power (CSP) and photo-voltaic dominate the industrial solar power generation space being used in solar farms because they suit large scale electrical energy/power generation whereas solar thermal is mainly used for domestic heating as it is not scalable for mass power generation.

Photovoltaic, PV systems consist of photovoltaic cells manufactured from semiconductors materials mainly silicon however the latest PV panels use perosvskit cells. The cell consists of 2 layers: a negative phosphorus layer (n-type) end and a boron layer (p-type) forming a pn junction. Photons emitted by the sun's solar radiation cause excitation due to a potential difference upon the junction freeing an electron from their atomic bonds creating a number of electron-hole pairs resulting in a flow of electron charge. Thus an electrical field is formed at the junction driving the electrons towards the n-type end and holes towards the p-type end, generating direct current (DC). Which is then converted into alternating current which power most household appliances and industrial machinery.

https://tamesol.com/future-of-solar-energy/

Concentrated solar power (CSP) plants use mirrors to concentrate the sun’s energy to drive steam turbines generating electricity. Curved mirrors in conjunction with a heat-exchanger or tubes of water or heating hydrogen fluid are combinations used in CSP systems. The 4 main CSP technologies namely parabolic trough, compact linear fresnel reflector, power tower and

dish engines. CSP plants vary from 5 acres up to 1000 acres, due to them requiring large open areas therefore they are not used for domestic purposes

https://www.seia.org/initiatives/concentrating-solar-power

Solar thermal systems use collectors to extract energy from the sun and convert it into heat. A heat transfer fluid flows through pipes in the collectors absorbing heat from absorber plates which convert energy from the sun into heat. The heated fluid circulates to a storage tank and can be used upon demand. The 2 main absorption plate technologies are flat-plate collectors and evacuated tube collectors. Flat-plate collectors consist of a flat insulated box covered by a sheet of glass and dark coloured plate capturing and converting the sun's energy. Evacuated tube collectors consist of a series of glass tubes each containing an absorption plate while a vacuum between tubes avoids heat loss.

Why rule out CSP ?

The application in question is one of domestic use, PV and solar thermal suite small scale heating projects. Concentrated solar power requires large open areas with constant direct sun for maximum output but also to reach the minimum threshold requires direct sun. The Rondebosch area does not receive constant direct sun throughout the day because of Table Mountain blocking a portion of the rays upon sunset and buildings obscuring the sun in earlier parts of the day, although this is marginal and the majority of energy generation does not occur during these hours it is still a factor to consider because of the high initial capital cost. Secondly and more importantly there is simply not enough space to accommodate the components that form the CSP system. The roof can't fit the mirrors and heat exchanger, not considering the other machinery and technology required therefore it is not a viable option.

https://www.sciencedirect.com/science/article/pii/S1364032117312108?ref=pdf_download&fr=RR-2&rr=8b5a89ca88f73eab

Environmental - Advantages ? Limitations ? A Economic & Financial & Political climate - Advantages ? Limitations ? B

Solar power is a sustainable energy source leaving no stain on the earth unlike conventional energy extraction and generation methods such as coal and oil.

Fossil Fuel Challenges EXPAND

This sustainable source relies on mother nature to provide the correct set of conditions to make solar power generation possible. Sustainable energy avoids many issues that conventional energy production faces such as resource depletion, increased cost of production and environmental restrictions, fossil fuel power generated plants have to obey certain government restrictions protecting the environment and resources decreasing companies energy output and profit margin.

Solar Power Advantages FIX/RESEARCH

Solar power generation energy does not cause any atmospheric pollution, no greenhouse gases or noise is emitted to the atmosphere while operating. Photo-voltaic panels are constructed from silicium which is one of the most abundant elements on planet earth making it an extremely sustainable material to use. Conventional energy production produces power on one main site on a large scale and distributes to consumers via the electrical grid but solar power generation can produce power on many different isolated sites. In the context of South Africa producing power in a decentralised way has major benefits with the uncertainty of load-shedding, business can keep operating and hospitals can keep saving lives

Solar Power Limitations

Light and radiation from the sun is varying throughout the day and seasons, declining at certain times and over different seasons. No light after nightfall therefore no power can be produced. Sometimes there is an excess of power produced, this is stored in lithium ion batteries which are highly toxic and expensive however this is not completely necessary if the system is connected to the grid or is being used for heating. Electrical power from solar systems is in the form of direct current (DC) however household appliances require alternating current (AC), to convert DC to AC a simple inverter is used however this is an additional expense.

Thermal and PV - specific technologies (breakdown) - model constraints Natural/environment factors influencing power generation - inhibiting & favouring each technology - this might go into other sections

Methodology - model - findings

Ambient water temperature

Quantity of water

Heating required

Geyser model

Results - discussion

Relate the relevance of A & B to nigerian case study