An Exploration of The Effects of Solar Water Heaters on Selected Households In Thulamela Local Municipality: Challenges and Benefits

by

Sikhitha Fhatuwani Robert

Student number: 8600055

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Supervisor: Dr. AI Nemushungwa

Co-Supervisor: Dr. LG Nkondo

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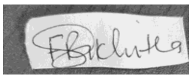
DECLARATION

I, Sikhitha Fhatuwani Robert, declare that the dissertation titled “An Exploration of Solar Water Heaters on Selected Households in Thulamela Local Municipality: Challenges and Benefits” - for a Master of Commerce degree in Economics, at the University of Venda has not been previously submitted in part or in full, for a degree at this or any other institution. It is a product of my own investigation, and all reference materials contained therein have been fully acknowledged, and a list of references is given.

Signature  **Date 31/January/2025**

Sikhitha Fhatuwani Robert

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ABSTRACT

South Africa has abundant coal supplies, so electricity costs are significantly lower than in other countries, albeit the advantage of lower energy costs is slowly being eroded. The low electricity costs have led to the widespread use of appliances that almost exclusively utilizes electricity, including heating water, through conventional electric geysers. Electric geysers account for anything between 25% and 40% of average household's monthly electricity bill; this cost can be prevented through the use of Solar Water Heaters (SWH), given South Africa's high solar radiation levels.

SWH has high initial costs compared with conventional electric geysers; however, they have short buyback periods which is further reduced whenever electricity tariffs escalate. Moreover, they have a relatively long lifespan of around twenty to twenty-five years, which implies that if households can switch from conventional geysers to SWHs, they can essentially enjoy hot water for free for the remaining lifespan of the SWHs, thus ensuring significant financial savings and potential additional funds for household expenditures. Switching to SHW, therefore, potentially confers socio-economic, environmental, and health benefits, to households.

Keywords: **Solar water heaters, buyback periods, benefits of solar water heaters**

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LIST OF ABBREVIATIONS

ATLAS Ti	Archive of Technology, Life World and Language
CBA	Cost-benefit analysis
CDM	Customer data management
CO_2	Carbon dioxide
CV	Contingent Valuation
CVM	Contingent Valuation Method
DoE	Department of Energy
e.g.	for example,
EMT	Ecological Modernization Theory
EPBT	Energy payback time
Eskom	Electricity Supply Commission
GHG	Greenhouse Gas
GHGs	Greenhouse gases
IEA	International Energy Agency
kW	kilowatt
MW	Megawatt
OLS	Ordinary Least Squares
PBC	Perceived Behavioural Control
PCM	Phase change materials
PV	Solar Photovoltaic energy/photovoltaic
SA	South Africa
SANS	South African National Standard
SWH	Solar Water Heater

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SWHP	Water Heating Program
SWHs	Solar Water Heaters
SWHSs	Solar Water Heating Systems
TPB	Theory of Planned Behaviour
VC	Venture Capital
WTP	Willingness to Pay

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CHAPTER 1

ORIENTATION OF THE STUDY

1.1 INTRODUCTION AND BACKGROUND OF THE STUDY

Access to energy and water heating are strongly linked to universal quality of life, which is crucial for sustainable development (Bohlmann & Inglesi-Lotz, 2018; Thobejane, 2019). In nations' pursuit of improving living standards and economic growth, energy resources, especially fossil fuels, are being extracted and used continuously, causing extremely detrimental changes to the environment and climate (Sampaio & González, 2017; von Hirsch, 2019). As a result of the growing population and an increase in energy demand, the world is facing environmental issues, such as greenhouse gas emissions and climate change (Conti, Holtberg, Diefenderfer, LaRose, Turnure, & Westfall, 2016; Bozsik, 2024).

To ensure a sustainable world for current and future generations, the United Nations set 17 Sustainable Development Goals in 2015, of which Goal Number 7 targets "Affordable and clean energy"; this proposes universal access to affordable, reliable, and modern energy services, by 2030 (United Nation, 2019; von Hirsch, 2019). As a result of the increased need for electricity, rapid population expansion, and rising costs of fossil fuels, like natural gas and oil, solar energy is evolving into an alternative promising renewable energy source (Rasha, 2020). A solar water heating system uses 20% or less of the power a family uses overall. Thus, it is the most affordable and environmentally beneficial way to get hot water (Rabbani & Tariq, 2019).

Ninety-five (95) percent of the power in South Africa is produced by the nation's public utility, Eskom (van der Merwe et al., (2020) & Dzaga, (2023). Coal combustion, the primary energy source, releases greenhouse gases (GHGs) linked to global warming (Ting et al., 2020; Ndlovu et al., 2020). Additionally, the environmental sustainability of this energy source is limited because it is non-renewable and causes environmental harm (Nathaniel et al., 2021). It is also doubtful if the utility can continue to provide a consistent and reliable power supply. This is mainly because Eskom's power plants' dependability is questioned because of the allegedly inferior construction of recently built stations and their rapidly decreasing useful lifespan (Barnard, Smit, Middelberg, & Botha, 2021); as a result of this, there is limited power supply, causing power

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outages (Du Venage, 2020). Additionally, according to Shaw (2019), Eskom's electricity production costs are increasing exponentially, yet another sign that coal is becoming more expensive and less accessible.

On June 23, 2009, the then-Minister of Energy, Dipuo Peters stated in her budget speech that "the Department would ensure that one million solar water heaters (SWHs) were installed in households and commercial buildings over five years". This is a clear indication of the South African government's commitment to pursue an energy mix that will include clean and renewable energy resources (Department of Mineral Resources, n.d.). Since solar water heater systems have demonstrated a propensity to save between 55% and 70% of expenditures associated with water, it was predicted that households would reduce their power spending (South African Energy Development Institute, 2015; Wang et al., 2015; Msibi & Kornelius, 2017; Thobejane, 2019).

1.2 STATEMENT OF THE RESEARCH PROBLEM

It has been established that solar energy has unique advantages, such as - wide distribution, free access, absence of greenhouse gas (GHG) emission, relatively low environmental impact, great potential, low dependence on public facilities, and wide application, such as water heating – however, it also has some obvious disadvantages which seriously affect its utilization. Amongst them are - low energy density, intermittent supply, the requirement of a large area of land for solar energy device installation, and a high cost of storage and conversion on a large scale (Niu et al., 2017).

As stated by Li et al. (2011) and Peter et al. (2022), the major challenges of the SWHs are to provide hot water under chilly weather conditions (in winter), as there are usually days that are characterized by clouds and no solar radiation, therefore, SWHs are designed to incorporate an auxiliary water heater to guarantee an all-year performance. Other challenges include the initial capital and installation costs, as the average capital and installation costs of a flat plate 1 kW, 100 L high-pressure SWH, 2 kW, 150 L high-pressure SWHs, and 2 kW, 200 L high-pressure SWH are R 9600, R 16,330, and R 16,000, respectively (Peter, 2022). The net present value payback period of SWHs can range from 3–8 years which can even be shortened by any increase in the electricity tariff and the rate of return on investment (Ferrer, 2017). It is

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crucial to note that the present value of money is also higher than the future value of money (Peter, 2022).

Furthermore, there are numerous perspectives and debates on the thermal efficiency and associated costs of solar water heaters, especially when users consider transitioning from conventional water heating to solar systems (Nshimyumuremyi & Junqi, 2019). This diversity of opinions underscores the need for a comprehensive study to evaluate the potential benefits and costs of solar water heating, particularly in the unique context of South Africa, hence, one of the motivations for this study.

There is extensive research on solar water heating systems; despite this, there is a noticeable lack of literature on the cost-benefit analysis of these systems, particularly in South Africa. A study by Thobejane et al. (2019) provides a comprehensive evaluation of the literature, highlighting the benefits and drawbacks of SWH geysers in low-income areas and the efficiency of solar water heating systems in South Africa. Peter et al.'s (2022) study quantifies the effects of solar water heating in South Africa, without considering its costs and benefits.

In addition, there seems to be no study conducted on the effects of solar water heaters on households, particularly in Thulamela Municipality. The current study contributes to the academic discourse by addressing the gap in existing literature regarding the specific effects of Solar Water Heaters (SWHs) on households in the Thulamela Municipality. While the work by Chidembo et al. (2024) provides valuable insights into the underlying beliefs and factors that influence the adoption of Solar Heater Systems (SHS) in the broader Vhembe District of South Africa, there remains a distinct lack of research that specifically examines the impacts and outcomes of SWH implementation at the municipal level, particularly in Thulamela.

By exploring this previously under-researched area, this study aims to provide a deeper understanding of how SWH systems affect household dynamics in terms of cost savings, energy efficiency, environmental benefits, and social acceptance within the local context of Thulamela Municipality. This contribution is particularly significant because it will inform both policy and practice by providing empirical evidence specific to Thulamela, which can be used to guide future solar energy initiatives and interventions.

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Furthermore, this study will build on Chidembo et al.'s findings by contextualizing the broader trends observed in the Vhembe District to the unique socio-economic, environmental, and infrastructural conditions of Thulamela Municipality. As such, this work will expand the scope of renewable energy adoption studies in South Africa, offering critical insights that can inform localized strategies for enhancing the uptake of sustainable energy technologies.

1. 3 RESEARCH OBJECTIVES

1.3.1 PURPOSE OF THE STUDY

The present study aimed to explore the effects of solar water heaters on households, in Thulamela Municipality, Limpopo Province, South Africa.

1.3.2 SPECIFIC OBJECTIVES

- To investigate the benefits of using solar water heating systems for domestic purposes in Thulamela Municipality.
- To explore the challenges of using solar water heating systems for domestic purposes in Thulamela Municipality.
- To determine the feasibility of using solar energy as an alternative power source.
- To make policy recommendations from conclusions drawn.

1.4 RESEARCH QUESTIONS

- What are the benefits of using solar water heating systems for domestic purposes?
- What are the challenges of using solar water heating systems for domestic purposes?
- How feasible is solar energy as an alternative power source?
- What are the policy recommendations that can be made from the conclusions drawn?

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1.5 SIGNIFICANCE OF THE STUDY

The importance of the study on the effects of solar water heaters (SWHs) in Thulamela Municipality, South Africa, lies in several key areas, particularly concerning sustainable energy, socioeconomic development, and rural empowerment.

Like many rural areas in South Africa, Thulamela Municipality faces challenges related to limited access to reliable and affordable electricity. This study provides insights into how solar water heaters can alleviate energy poverty by reducing household electricity consumption, especially for water heating, a significant portion of household energy use. By exploring the viability of SHS in this specific context, the study could promote greater energy access and improve living standards for low-income families in rural communities.

South Africa has made significant strides toward integrating renewable energy into its national grid. However, rural areas still lag in terms of clean energy adoption. This study is essential as it focuses on the potential of solar water heaters as a sustainable energy solution in the Vhembe District, offering insights that could be applied to other rural areas in the country. It contributes to understanding renewable energy adoption at the grassroots level, informing future policies and strategies for clean energy deployment.

Solar water heaters are a key component of renewable energy solutions that reduce reliance on fossil fuels, lower carbon emissions, and help mitigate the effects of climate change. The study's findings could encourage the adoption of solar water heaters in Thulamela Municipality, contributing to South Africa's broader environmental goals. By demonstrating the environmental benefits of SHS in rural settings, this study could support national and regional efforts to reduce greenhouse gas emissions.

One of the critical advantages of solar water heaters is their ability to significantly reduce electricity costs for households. This study will provide data on how much families in Thulamela Municipality can save on their energy bills through the adoption of SHS. The economic implications are crucial, particularly in areas where affordability is a concern. The findings could highlight solar water heaters as a cost-effective solution that brings long-term economic benefits to communities, ultimately improving household income and savings.

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As noted, the effects of solar water heaters on households in Thulamela have not been thoroughly studied, and existing research on this topic in South Africa is limited. This study is one of the first to examine this specific issue, filling a critical gap in the academic literature. The findings will not only add to the body of knowledge regarding SHS adoption in rural South Africa but also serve as a valuable reference for similar studies in other regions of the country.

The study offers valuable data that can inform local and national energy policies, particularly regarding rural electrification and renewable energy adoption. By providing evidence on the benefits and challenges of SHS in Thulamela, the study can guide policymakers in designing more targeted interventions, such as subsidies, incentives, and educational campaigns to promote the use of solar water heaters. It can also help the municipalities plan for the integration of SHS into their energy mix, contributing to sustainable urban and rural development.

The introduction and adoption of solar water heaters have the potential to empower local communities by providing access to cleaner, more affordable energy. This study could also highlight the importance of skills development and capacity building in the region. By exploring the technical and social aspects of SHS installation and maintenance, the research could advocate for training programs that create job opportunities and develop local expertise in renewable energy technologies.

1.6 DELIMITATIONS OF THE STUDY

This study seeks to compare the challenges and benefits of SWHSs in South Africa, however, it was limited to a representative sample from the Thulamela Local Municipality in Limpopo Province. Resource constraints have also limited the utilization of more variables to assess the costs and benefits of SWHSs.

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1.7 STRUCTURE OF THE STUDY

The dissertation consists of six (6) chapters, which are structured as follows:

Chapter One: The general overview of this study is highlighted. This chapter is also focused on - the introduction and background of the study, research gap, problem statement, aims of the study, objectives of the study, research questions, significance of the study, delimitations of the study, as well as the structure of the whole research report.

Chapter Two: This chapter reviews the existing literature on the topic. In the process, the researcher sought to understand what other scholars were saying about the costs and benefits of solar water heaters in places like the Thulamela Municipality in Limpopo Province, South Africa.

Chapter Three: This chapter focuses on the technicalities of how the study was conducted. Aspects focused upon are - the study area, research design, research paradigm, target population and sampling technique, data collection and analysis, ways of ensuring trustworthiness, and the ethical considerations adhered to in conducting the study.

Chapter Four: In this chapter, the researcher details the analysis and interpretations of the data collected.

Chapter Five: This chapter presents a comprehensive discussion of the results. These findings are then compared to those of past scholars, who either - concurred, supported, found similarities, or contradicted - these current findings.

Chapter Six: A summary of the findings, conclusions on the research questions, and recommendations are presented in this final chapter.

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CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter reviews the literature exploring the challenges and benefits of solar water heaters, particularly, in places like the Thulamela Local Municipality, South Africa. The chapter is structured as follows: Section 2.2 discusses the theories related to the impact of solar water heaters on households; The empirical literature is examined and assessed, in section 2.3, while section 2.4 presents a summary of the information.

2.1.1 THEORETICAL LITERATURE REVIEW

This section dwells on some of the theoretical models for solar water heaters. Several theories are proposed to explain individuals' willingness to pay for and adopt strategies aimed at the environment’s wellness. Among these models are the basic economic models, contingent valuation, solar energy technology, the theory of planned behavior, and Pareto optimum theory.

2.1.2 THEORETICAL MODELS ON SOLAR WATER HEATERS

2.1.2.1 BASIC ECONOMIC MODEL

Basic economic models focus on two determinants of Willingness to Pay (WTP): income and using the good in question. WTP is the maximum price a customer is willing to pay for a product or service (Kalish & Nelson, 1991). When individuals consider paying for improved environmental quality, their choices and responses are constrained by their (disposable) income. Income should correlate to the amount of money respondents are willing to spend to obtain environmental goods, therefore, income is regularly included in stated preference surveys and is expected to positively affect WTP (Liebe et al., 2016).

Solar energy is any energy generated by the sun. The radiant energy of sunlight is captured and converted into thermal energy through thermal solar collectors, then through the heat exchangers integrated into the solar collectors. An active solar thermal system for indirect domestic hot water preparation and for supporting the space heating involves - the solar collectors, the thermal storage tank with an

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integrated heat exchanger in the tank or external, the circulation pumps of the solar thermal agent (in the case of forced circulation) and the automation system for controlling, regulating and limiting the related parameters (temperature and pressure).

Greenhouse gas pollution has long been recognized as a significant issue, particularly for developing countries (Vu, 2023). The ongoing global energy crisis presents a unique opportunity to advance renewable energy systems. The International Energy Agency (IEA) has also highlighted that the demand for renewable energy will soon play a pivotal role in the global economy (Yang et al., 2022). Solar energy, in particular, has the potential to reduce greenhouse gas emissions by up to 50% (Nguyen et al., 2022). Furthermore, Zander et al. (2019) noted that several governments have implemented policies to provide financial support for the installation of solar power systems in households and businesses.

2.1.2.2 THE CONTINGENT VALUATION METHOD (CVM)

The Contingent Valuation Method is a widely used non-market valuation method, particularly for environmental cost-benefit analysis and environmental impact assessment (Mitchell & Carson, 1989; Cummings et al., 1986), hence, its application in environmental economics includes such non-market use values (Choi et al., 2018; Loomis & du Vair, 1993). The model was originally proposed by Ciriacy-Wantrup (1947) but was first used by Davis (1963) in a study on hunters in Maine and later by Walsh et al. (1984) and Brookshire et al. (1993).

The model has had some criticisms from a group of academics (Hausman, 1993), however, it has been commonly used in developing countries to elicit individuals' preferences for basic infrastructural projects, such as water supply and sanitation (Whittington, 1998 & Merret, 2002).

CVM is a valuation process implemented, usually through a questionnaire, that offers the respondents an opportunity to make an economic decision on goods and services for which no market exists - that is, the valuation is contingent upon the simulated market presented to the respondents. CV is capable of - producing option price estimates in the presence of uncertainty, valuing goods not previously available, and estimating all existing class benefits. and estimating relevant ordinary and Hicks

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compensated (direct and inverse) demand curves. The CVM is usable in estimating the individuals' willingness to pay for the benefits of goods or services through a survey method (Portney, 1994; Hanemann, 1994).

CVM can be utilized to evaluate the economic values of various ecosystem types and environmental services. This is one of the most popular methods to evaluate non-use values, although, it can also be used to estimate use values as model considers individuals' willingness to pay for a specific environmental service (Whitehead & Haab, 2013). In addition, people's willingness to get compensation for leaving an environmental service is included in many of these evaluation cases. Sometimes, the utilities given by the non-market resources to the people may not have market value due to their non-saleable nature, hence, they are typically evaluated by price-based models (Ferreira & Marques, 2015); these issues can effectively, be handled by the CVM. The discussions now focus on steps used in the CVM process.

The process commences with defining a problem considered for evaluation and then proceeds with a preliminary survey that includes interaction with people. After this, the main survey is conducted (which is relatively complex and time-consuming) and finally, the findings are implemented, followed by an analysis of the results.

Figure 2.1: CVM evaluation process.

Source: (Nautiyal & Goel, 2021)

Critics of CVM point to a number of concerns about the model - the hypothetical nature of the questions; the ability of practitioners to influence results through question format, econometric manipulation, and the often conflicting results on tests of validity - as evidence of the inadmissibility of CVM-derived values, in policy analysis (Whitehead, & Haab, 2013).

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2.1.2.3 SOLAR ENERGY TECHNOLOGY

For years, solar energy technology has offered a feasible alternative to fossil fuel use in heating and electricity (Farhar et al., 1980; Shama, 1982). Scholars who conducted surveys in America between 1973 and 1979, based on their results, had an overwhelmingly optimistic view of the future of solar energy technology in replacing foreign oil (Schelly, 2015). Solar energy was rated as the second energy source to coal; hence, it was adopted around 2010 during President Barack Obama's State of the Union address on environmental justice (Mulvaney, 2023).
Solar energy technology is seen as economically feasible in freeing the environment from carbon metabolisms caused by the materials, processes, and industrial forms of organization used by human societies in both developed and developing countries.

2.1.2.4 THE THEORY OF PLANNED BEHAVIOR (TPB)

The Theory of Planned Behaviour is a framework commonly used to predict human behaviour when people have no complete volitional control. (Ajzen, 2001). In this theory, the most powerful determinant of individual behaviour is the individual's intentions to perform the behaviour (Ajzen, 1991). Behavioural intention is a function of attitude toward the behavior, subjective norms, and perceived behavior (PBC) (Han & Stoel, 2017). Attitudes towards the behaviour, subjective norms, and PBC are the antecedents, in this case, for a household to adopt a solar heating system (SHS). Attitude is defined as an individual's feelings (negative and positive) to perform a specific behaviour (Armitage & Conner, 2001; Gao et al., 2017); in this case, it highlights an individual's intention of adopting rooftop SHS - thus, the more positive the attitude, the stronger the intention to adopt a SHS.

The second component of the theory focuses on subjective norms. They are an individual's perceived social pressures from others who are important to them, who think they should or should not perform a behaviour (Ajzen, 1991; Gao et al., 2017). Finally, the last component of the theory is perceived behavioural control (PBC). It relates to the individual's perception of factors that might foster or hinder the expression of a behaviour (Guido et al., 2010).

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2.1.2.5 PARETO OPTIMUM THEORY

In electricity generation by coal, there is carbon emission, which is environmentally unfriendly. Seeking carbon emission reduction and clean-energy utilization, photovoltaic (PV) capacity is increasing rapidly (Wang, 2022). Solar photovoltaic energy, or PV, directly converts sunlight into electricity using radiation from the sun when heating a photoelectric cell on a solar panel. The most important benefits of solar-photovoltaic electricity are that it is inexhaustible and has no carbon emissions. The energy management strategy of hybrid energy storage can also be based on the Pareto Optimality Model to minimize the life cycle cost of externalities by using solar heating systems in manufacturing industries.

2.2 EMPIRICAL LITERATURE REVIEW ON SOLAR WATER HEATERS

2.2.1 INTRODUCTION

This sub-section presents a literature review on solar water heaters, with special reference to - installation, payback period, state subsidies, benefits, and challenges of solar water heaters. Before the empirical literature review is presented, a summary of the programme, policy, legislation, and standards is given. Subsection 2.2.2 presents the discussion on these aspects.

2.2.2 POLICIES, REGULATIONS, AND STANDARDS

2.2.2.1 SOLAR WATER HEATER PROGRAMME-POLICIES

The Solar Water Heating Programme is a government initiative with an initial goal to install 1 million solar water heaters by 2014 and was expected to save approximately 650MW of electricity demand. The deployment of solar water heater (SWH) systems was identified in the South African National Energy Efficiency Strategy of 2005 as integral to improving energy utilization in South Africa. Following the closure of the previous programme-delivery model, the Department of Energy (DoE), subsequently initiated a strategic revision of the programme's rollout methodology.

In 2014, the Government decided to stop subsidizing imported SWH systems in favor of locally manufactured ones to increase job creation, industrialization, and the socio-economic impact of the program. In pursuit of the 2030 SWH target contained

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in the National Development Plan, it was envisaged that procurement, supply, installation, and maintenance of up to 1.25 million SWHs by 2019 in residential dwellings throughout South Africa.

2.2.2.2 REGULATION

Subject to Section 3 of the Electricity (Solar Water Heating) Regulations, 2019, 1482: after the stipulated time for the installation and use of solar water heating systems, no owner of any premises, after the effective day of these regulations, shall connect electrical geysers but may, at his or her own expense, install and use solar water heating systems.

2.2.2.2.1 APPLIANCE STANDARDS AND LABELLING REGULATIONS

Appliance standards and labeling regulations that promote the purchase of energy-efficient appliances have been assigned. The regulations have two components: a requirement that certain that appliances carry a South African Energy Efficiency Label, and the application of Minimum Energy Performance Standards (MEPS) to several appliances.

2.2.2.2.2. THE ELECTRICITY REGULATION AMENDMENT ACT

The Electricity Regulation Amendment Act in South Africa aims to deliver structural changes in the energy sector, address electricity blackouts, and encourage investment in renewable projects. The amended regulations allow municipalities to establish new generation capacity through internal or external mechanisms.

2.3. EMPIRICAL LITERATURE REVIEW ON COST-BENEFIT ANALYSIS

2.3.1 INSTALLATION OF SOLAR WATER HEATERS (SWHs).

According to Ismail and Khembo (2015), installing an SWH in low-income households can reduce electricity consumption for water heating by 60%. This may save approximately 25–30% on an average monthly electricity bill.

Similarly, Mujuru et al. (2020) also proved that SWHs are efficient at generating hot water for consumption, potentially saving 49% of energy, and thus preventing 49% of greenhouse gases. The study found that besides complaints about the performance

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and quality of the geysers supplied to the inhabitants in the sample area, a generally positive attitude towards SWH was noted.

Huang et al. (2019) show that installing SWH systems in high-rise buildings is feasible and reliable. Individual household systems (61%) were more popular than centralized systems (25%), and hybrid systems account for 14%. The average area of solar collectors per household was 2.17 m^2/household, the average design solar fraction was 52%. Flat-plate solar collectors (53%) were the most commonly used, while electric heating elements (89%) were the most common auxiliary heat sources for SWH systems, followed by gas water heaters and air-source heat pumps. The cost of SWH systems per m^2 of a building area was 22 CNY/m^2 to 75 CNY/m^2.

Singh et al. (2021) investigated the environmental, technical, and financial viability of evacuated tube-type solar water heating systems at different geographical locations, across seven cities in India. Their findings show that the government must provide at least 50% incentives to make such installation feasible.

2.3.2 PAYBACK PERIOD OF SWHs

The cost in payback time is defined as the number of years required to recover the cost invested during the lifetime of a product or system (Gude,2018). It simply refers to the time required for an investment to recover its initial costs in terms of saving; this varies as the cost depends on numerous factors, like the price of fossil fuels, rate of subsidy, and solar isolation.

The payback period of SWH technologies depends on the type of technology, the materials used in the construction of the solar collectors, and the volume of hot water consumed (Ayompe et al, 2011). Cassard et al. (2011) and Shukla et al. (2013) also demonstrated that solar water heating can reduce the hot-water energy demand by 50–80%, and it possesses a favorable payback period that ranges from 2 to 4 years. These studies, however, show that the performance depends on the system's type and size (Peter, 2022).

Lin et al. (2015) established a systematic procedure to estimate the payback period of domestic SWHs regarding operation costs and the determined energy savings compared to conventional heating fuels.

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Zhang et al. (2018) identified the technology level, supplementary energy type, natural conditions, and policy support as the key factors affecting the payback period of SWHs. These authors employed meta-analyses to quantify the impact of these critical factors on the payback period of SWHs.

Ferrer (2017) performed an economic analysis on the attractiveness of SWHs within selected municipalities across South Africa - in low-density housing, a hot-water consuming profile, and the average historic and economic data. The study focused on the variation of the parameters, such as - electricity price, discount rate, mortgage rate, solar water heater efficiency, fuel-price inflation, and house size - to achieve the best payback period. The findings revealed that the average payback period was 8 years, which exceeds the stipulated 3-year warranty period of the SWHs.

Nshimyumuremyi & Junqi (2019) found that system efficiency ranges from 60–70% and also depends on the design and material composition of the absorber plate. They further found that due to higher efficiency, the payback period of the system was attained 2 years earlier than the standard payback period, of the majority of SWHs.

Yousef and Hassan (2020) conducted a study in Egypt on energy payback time (EPBT) using a thermal energy storage system with a solar desalination system. Their findings on solar irradiance throughout the accessible days illustrated that the EPBT value based on energy methodology for solar still, without and with phase change materials (PCM), is 1.3 and 1.6 years, respectively.

Additionally, Serban et al. (2016) used sensitivity analysis to conclude that an installed solar water heating system with up to 50% subsidies can reduce the payback period to 3.5 years and increase the net annual savings to approximately EUR 1743.

A study on the economic and environmental impact of investing in solar water heating systems in Romania was conducted by Serban et al. in 2016. They analyzed the potential benefits offered by solar systems, and they estimated a discounted payback period of the system to be 8.6 years.

Singh et al. (2021) investigated the environmental, technical, and financial viability of evacuated tube-type solar water heating systems at different geographical locations across seven cities in India. The findings show that the payback period is between 7 and 10 years. They recommended that the government must provide at least 50%

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incentives to make such installations feasible, thereby generating interest in individuals in households. Their results established that it is more beneficial to subsidize SWH projects instead of subsidies to grid-connected electricity for heating water through electric geysers; these findings could be of great significance to CDM-approved projects in India.

The payback period of SWH technologies depends on the type of technology, the materials used in the construction of the solar collectors, and the volume of hot water consumed. Peter et al. (2022), in their study in South Africa, revealed that the payback period of hybrid SWH was 4.32 years and that replacing electric water heaters led to a 40% annual energy reduction in Dimbaza, South Africa.

A study by Ferrer (2017), investigating the economic attractiveness of SWHs for chosen municipalities across South Africa, found that the average payback period is 8 years in South Africa, which exceeds the SWH warranty period by three years.

2.3.3 STATE SUBSIDIES FOR SWHs

Many countries, for example, Spain, Israel, Germany, Portugal, Taiwan, and Italy, have adopted rebate programs as the most appropriate mechanism to accelerate the growth of SWHs in residential sectors over conventional heating fuels through direct subsidies and credit tax reductions (Roulleau & Lloyd, 2008). In their study, Choi et al. (2018) have added that a renewable energy policy is a prerequisite to boost market penetration for renewable and sustainable energy technologies, such as SWHs.

Gerarden (2018) analyzed the impact of consumer subsidies on the global market for solar panels. They revealed that consumer subsidies can have at least two effects. First, subsidies establish demand and increase equilibrium quantities, thereby holding production costs fixed; second, subsidies may encourage firms to be innovative and to reduce costs over time. Garden (2018) quantifies these impacts by estimating a dynamic structural model of competition among solar panel manufacturers. The model produces two key insights. First, ignoring long-run supply responses can generate biased estimates of the effects of government policy. Without accounting for induced innovation, subsidies increased global solar adoption by 49 percent from 2010-2015, leading to over $15 billion in external social benefits which accounted for induced innovation increases of external benefits by at least 22 percent. Second, decentralized

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government intervention in the global market is inefficient; hence, a subsidy in one country increases long-run solar adoption elsewhere. because the process increases investment in innovation by international firms.

By considering 92 renewable energy-listed enterprises in China between 2007 and 2016 as a sample, Yang et al. (2019) constructed a panel threshold-effect model to investigate the effect of government subsidies on renewable energy investment; they further explored the effects and differences regarding government subsidy types and enterprise size, on the threshold effect. The results show that, first, government subsidies have a positive threshold effect on renewable energy investment in China. This meant that, when energy consumption intensity and bank credit are great and the level of economic development is less than the threshold value, the contribution of government subsidies to renewable energy investment is significantly enhanced. Second, monetary subsidies and tax incentive policies can promote renewable energy investment, but the effect of tax incentives is more significant. Third, government subsidies are the main force supporting the development of medium, small, and micro-sized renewable energy enterprises.

Ryan et al. (2019) used the OLS estimator to determine which policy incentives are more effective at increasing the electricity generated from solar photovoltaics at the state level. The results suggest that renewable portfolio standards are the most effective policy incentives, and policy portfolios, including both market creation and expansion policies, can be more effective at developing solar photovoltaic markets. The payback period analysis of their study indicates that the government must give at least a 50% incentive to increase the interest of individuals in the household, towards the projects. It is, therefore, more beneficial to subsidize SWH projects than to grid-connected electricity for water heating through electric geysers. These findings could be of significance for CDM-approved projects in India.

A study that focused on short-term and long-term subsidy programs in Taiwan, (Chang et al., 2018) found that there has been a strong impact on the local market expansion and the uptake of SWHs in the short term, because, the initial capital cost for a SWH was still greater than for a conventional water heater. Upon the termination of the subsidy program at the end of 2017, in the country, the enforcement of the

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Greenhouse Gas Emission Reduction and Management Act, however, promoted the use of SWHs in industrial applications.

Netshiozwi (2019) investigated the causes of the failure of the South African Solar Water Heating Program (SWHP) and recommended ways in which the programme can be revived to contribute to the social, environmental, and economic benefits they were intended to achieve. The study established that the program failed due to - the subsidization of imported products, poor quality installations leading to non-functioning SWHs, lack of training, and poor planning by the involved institutions.

2.3.4 CHALLENGES OF THE SWHs

As Li et al. (2011) stated the major challenges of the SWHs are to provide hot water under extremely cold weather conditions (in winter), as clouds and no solar radiation usually characterize such days. SWHs, therefore, are designed to incorporate an auxiliary water heater to guarantee an all-year performance. Other challenges include the initial capital and installation costs. The average capital and installation costs of a flat plate 1 kW, 100 L high-pressure SWH, 2 kW, 150 L high-pressure SWHs, and a 2 kW, 200 L high-pressure SWH are R 9600, R 16,330, and R 16,000, respectively (Peter, 2022). Presently, the net value-payback period of SWHs can range from 3–8 years and can even be shortened with an increase in the electricity tariff and the rate of return on investment (Ferrer, 2017). It is essential to note that the present value of money is also higher than the future value of money (Peter, 2022).

In a study that investigated the causes of failure of the South African Solar Water Heating Program (SWHP), Netshiozwi (2019) found that the programme failed due to - the subsidization of imported products, poor quality installations leading to non-functioning SWHs, lack of training, the problem of poor alignment, the non-impact of reducing electricity demand as installations were focused in low-electricity consumption areas only. The study also found that the lack of maintenance obligations by the suppliers and poor workmanship, which resulted in SWHs being dysfunctional, also contributed greatly to the programme's failure. Netshiozwi (2019) also established that SWHs are only easily accessible to those who receive them through the Department of Energy (DoE) social program because the prices of SWHs are

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exorbitant. These above findings made it impossible for most of South Africa's households to enjoy access to hot water through SWHs.

Curry, Cherni, and Mapako (2017) conducted a study to assess the effects of the government programme for the supply of SWHs, for poor townships, on - the reduction of household electricity consumption, a decline in energy poverty, and a reduction in CO_2 emissions – thereby, estimate the impact of SWH on reducing electricity demand, nationwide. The researchers concluded that a lack of awareness of the use of solar water heaters, combined with the failure to give proper education, had resulted in fewer savings on electricity and had led to the programme's abandonment.

Thobejane et al., 2019 reviewed the literature on the effectiveness of solar water heating geysers in low-income households in South Africa. They evaluated the implementation of the strategy and the effectiveness of the SWH geysers in reducing household grid energy demand, between 2009 and 2017. The results of the study indicated that the failures of the SWH geysers programme can be attributed to - the quality of the installation, lack of training and maintenance, lack of standards for testing SWH geysers, and inadequate public awareness. For the effectiveness of the SWHs, the researchers recommended - addressing the programme's sustainability, providing training to ensure competent installers, implementing mandatory policies for testing geysers, and training programs to raise public awareness of the benefits and uses of SWH.

2.3.5 BENEFITS OF SOLAR WATER HEATERS (SWHs)

Kakaza and Folly (2015) found that solar water heaters and heat-pump technologies resulted in energy consumption reduction when compared with electric hot water heaters. Solar water heaters have a daily energy consumption of 58%, thus saving 42% of energy, compared to electrical geysers.

Compared to a conventional geyser, the cost of purchasing and installing a SWH system is still high in South Africa. Around 2017, the average cost of purchasing a high-pressure SWH unit was found to range from R16,000 to R30,000, and installation costs to around R2,000 and R6,000, while the conventional geyser is significantly cheaper in that their price ranges between R3,000 and R6,000 (Hardie, 2010; Ntodeni

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et al., 2017). SWHs, however, ensure significant financial savings and potential additional funds for household expenditure despite their initial exorbitant costs. In addition to potential financial gains, households may experience social, environmental, and health benefits from switching to SHW. Additionally, Pan & Wong (2012) and Peter (2022) showed the urgency of implementing SWHs regarding the environmental and sustainability benefits, over conventional electric water heaters.

As Jamar et al. (2016) stated, solar energy is one of the widely used renewable energies that can be harnessed by directly deriving energy from sunlight or indirectly. The benefits achieved by implementing SWHs can be categorized into economic, environmental, and social impacts; another significant benefit is the potential for disseminating the technology due to the ease of harnessing solar resources (Zafar et al, 2018).

In an investigation of the economic attractiveness of SWHs for chosen municipalities across South Africa, by the process of establishing a “base case” scenario of an average SWH, Ferrer (2017) stressed that, even though the study was unconvincing on solar water heater installations due to the absence of subsidies, SWHs were found to be generally favourable. Its abandonment would be found to be wasteful if not utilized for SA’s good solar potential by using a cheaper system.Curry, Cherni & Mapako, (2017) also show that although, in South Africa, savings of almost 40% are theoretically possible, however, 30% is more likely. The government should, therefore, update the goals of any continuing solar-heater programmes to ensure its sustainable implementation.

2.4 SUMMARY

In this chapter, theoretical as well as empirical literature on solar water heaters is reviewed. The chapter commenced by presenting theoretical foundations related to the effects of solar water heaters. Before the empirical literature review is presented, a discussion on the policies, regulations, and standards relating to solar water heaters is presented. The empirical literature on solar water heaters is then presented, specifically focusing on installation, payback period, state subsidies, benefits, and challenges, in both national and international contexts.

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CHAPTER 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter provides a comprehensive description of the methodology used to address the research questions. It covers all aspects of the research process, from the research paradigm to the data collection strategy, and the research's ethical considerations. The chapter is structured as follows: Sections 3.2 and 3.3 present the study area and research paradigm, respectively and in Section 3.4, the research design is presented. The sampling technique, data collection procedure, and trustworthiness are detailed in sections 3.5, 3.6, and 3.7, respectively, while sections 3.8 and 3.9 outline data analysis and the ethical considerations adhered to.

3.2 STUDY AREA

The study was conducted in one province in South Africa - Limpopo Province – specifically, in the Thulamela Municipality.

Figure 3.1: Map of the study area

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Thulamela Local Municipality, located in the Vhembe District of Limpopo Province, faces a range of challenges related to energy access and sustainability. As a predominantly rural municipality, the community often relies on traditional energy sources, including electricity from the national grid, as well as firewood and liquid petroleum gas (LPG). These energy sources, while widely used, present significant environmental, economic, and social challenges, such as high electricity costs, environmental degradation from wood collection, and limited access to consistent energy supply.

In response to these challenges, there is growing interest in renewable energy solutions, with solar energy emerging as a key option due to its abundance, especially in the sunny regions of Limpopo. One of the most promising applications of solar energy in Thulamela is the adoption of solar water heating (SWH) systems.

Thulamela's geographic location, with its ample sunlight throughout the year, makes it an ideal candidate for solar water heating solutions. Solar water heaters use energy from the sun to heat water for domestic use, reducing the reliance on electricity for water heating. This technology can provide several advantages, particularly in rural municipalities like Thulamela where the electricity supply is inconsistent, and many households rely on expensive and environmentally harmful alternatives for heating water.

3.3 RESEARCH PARADIGM

The study adopts an interpretivism paradigm. The adoption of the interpretivism paradigm can provide an in-depth understanding of certain contexts, such as cross-cultural studies, and factors influencing certain development through the collection and interpretation of qualitative data, leading to deep insight and conclusions that may differ from others, hence making it very independent and unbiased as argued by (Myers, 2008; Saunders et al., 2012). Adopting the interpretivism paradigm would generate high-level data validity based on personal contributions, considering the different variables utilized (Myers. 2008; Alharahsheh & Pius, 2020).

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The interpretive paradigm, as discussed above, would enable researchers to consider different factors, such as behavioral aspects based on participants' experiences, and help to describe reality, given the assumptions and beliefs of the interpretive researcher. Furthermore, the paradigm enables researchers to acknowledge the research context and the situation as unique, considering the circumstances and the participants involved.

Utilizing this paradigm would also support the research to be more focused on the specific topic and prevent the research from heading towards generalizations as demonstrated in the positivist paradigm (Moustakas, 1994; Remenyi et al., 2012; Alharahsheh & Pius, 2020). The researcher will employ subjectivity in his conclusions; hence, the current study adheres to the interpretive philosophical paradigm.

3.4 RESEARCH DESIGN

Lewis (2015) defined research design as an overall outline that guides the researcher on issues such as - how the study subjects are to be selected and how data should be collected. Similarly, Asenahabi, Busula, and Ronoh (2019) describe research design as a blueprint adopted by a researcher before data collection begins, and it acts as a guide to ensure the valid achievement of the research objective. It is a comprehensive plan that describes how data will be gathered, quantified, and analyzed to answer research questions (Sekaran & Bougie, 2016). A research design can be a quantitative, qualitative, or mixed method. A qualitative approach was employed in this study.

3.4.1 RESEARCH STRATEGY

The research strategy is derived from the study's purpose and question. It is a subset of the research design that includes data collection and analysis elements. There are differences between these techniques, regarding their - ontological assumptions, how they apply ideas and concepts logically, the kinds of explanation and comprehension they use, and the outcomes of their work. Every technique is related to specific research paradigms or theoretical and philosophical traditions (Blaikie, 2007; Malhotra, 2017); the two methods to be considered are correlational and experimental.

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3.4.1.1 CORRELATIONAL RESEARCH STRATEGY

Correlational research strategy refers to a non-experimental research method that studies the relationship between two variables with the help of statistical analysis. Correlational research design does not examine the effects of extraneous variables only those under study. In cases where experimental research is unethical, correlational research can be used to determine the relationship between variables. In correlation design, the researchers study the effect of a potential cause that cannot be manipulated (Lau, 2017).

Correlational studies differ from comparative studies in that the evaluator does not control the allocation of subjects into comparison groups or the assignment of the intervention to specific groups. Instead, the evaluator defines a set of variables, including an outcome of interest, and tests for hypothesized relations among these variables. The outcome is referred to as the “dependent variable” and the variables being tested for the association are the “independent variables” (Lau, 2017).

3.4.1.2 EXPERIMENTAL RESEARCH STRATEGY

Experimental research, on the contrary, is a method of conducting research in which one or more variables are changed to see how they affect different variables. Experimental research aims to establish a cause-and-effect link between the variables. To guarantee that the groups are equal, participants in experimental studies are usually randomly assigned to several groups in a controlled setting. Measurements and observations are utilized to gather data, and statistical analysis is then employed to test the hypotheses (Hassan, 2023). In this study, a non-experimental research design was employed to explore the challenges and benefits of solar water heaters in Thulamela Municipality, Limpopo Province, South Africa.

3.4.1.3 CASE STUDY RESEARCH STRATEGY

The study employs a case study research strategy. A case study is a methodological approach to generate an in-depth understanding of a contemporary issue or phenomenon. It is often used in the social sciences and humanities to explore complex issues and to provide insights into specific phenomena or situations. It may involve multiple data sources, such as interviews, observations, or documents, and it aims to gain a detailed and nuanced understanding of a subject and generate new

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theories or insights; it is one of the most widely used and accepted means of qualitative data collection methods in the social sciences (Bloomberg & Volpe, 2022).

The case study approach is particularly useful when there is a need to obtain an in-depth comprehension of an issue, event, or phenomenon of interest in its natural, real-life context (Crowe et al., 2011). This approach, therefore, provides researchers with an opportunity to gain a greater depth of understanding of an issue (Stake, 2010). The strategy is preferred when answers to "how," "why," and "what" questions are of interest to the researcher (Yin, 2018).

3.5 SAMPLING TECHNIQUES

Sampling becomes critical when there is a vast potential population relevant to the research topic. A population is a fundamental component of research technique; it is a group of people who share certain features and are in a specific institutional or geographic area (Martínez-Mesa et al., 2016). The population establishes the general framework for developing research questions and hypotheses, as well as laying the foundation for future research endeavors. Researchers can explore a variety of phenomena and focus on different aspects with the help of the population, thereby, giving them a thorough grasp of the group, they are studying (Martínez-Mesa et al., 2016).

On the other hand, the target population is a subset of the larger population under investigation, distinguished by specific characteristics or requirements pertinent to the research question (Alvi, 2016). Researchers can concentrate their investigations on population segments of particular interest or significance by using this subset, which is defined according to factors that correspond with the goals and purview of the research study (Asiamah et al., 2017; Casteel & Bridier, 2021; Willie, 2024).

Researchers can adjust their sample plans and research goals by determining the target population, ensuring they are consistent with the study objectives (Alvi, 2016). Differentiation is essential in research techniques since it allows investigators to customize their methods and approaches to the population's demands and features, thus increasing the findings' applicability and relevance. The target population consists of households in Thulamela Municipality in Limpopo, South Africa.

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The technique of selecting cases to represent an entire society and the population is known as sampling (Madlala, 2017). Judgmental sampling, or purposeful sampling, allows researchers to choose participants or situations that best enable them to address the study's goals and research questions (Saunders et al., 2019).

A purposive sampling approach was adopted in the selection process of this study. Purposive sampling represents a group of different non-probability sampling techniques. Also known as “judgmental”, “selective”, or “subjective sampling”, purposive sampling relies on the judgment of the researcher when it comes to selecting the units - people, cases/organizations, events, and pieces of data - that are to be studied. Usually, the sample being investigated in qualitative research is quite small, especially when compared with probability sampling techniques (Rai & Thapa, 2015).

One of the major benefits of purposive sampling is the wide range of population sampling techniques that can be used across qualitative research designs; purposive sampling techniques range from homogeneous sampling to critical case sampling, expert sampling, and more (Rai & Thapa, 2015). Purposive sampling is useful when the research is orientated toward a clear-cut research interest (Barglowski, 2018) and the cases that met the inclusion criteria were deemed information-rich by this study. The minimum sample was set at 15 participants; however, the maximum will depend on data saturation.

3.6 DATA COLLECTION PROCEDURES

Data collection is an information-acquiring process to address the research problem (Madlala, 2017). Data will be collected through in-depth, face-to-face interviews. Before collecting the data, permission and scheduled interview dates will be obtained from the participants. A former University of Venda student was a research assistant in the data collection process.

This study, as mentioned earlier, was qualitative and data was collected using a structured interview guide and a recording device. The semi-structured interview is a popular data collection method since it has proved versatile and flexible (Kallio et al., 2016). One of the primary benefits of the semi-structured interview approach is its

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proven ability to foster reciprocity between the interviewer and the interviewee (Galletta & Cross, 2013), thereby, allowing the interviewer to compose follow-up questions based on the subject's responses (Rubin & Rubin, 2005; Polit & Beck, 2010; Kallio et al, 2016). This atmosphere provides room for a unique verbal interaction (Kallio et al., 2016).

3.7 RELIABILITY AND VALIDITY (TRUSTWORTHINESS)

In qualitative studies, trustworthiness refers to the research findings' quality, authenticity, and truthfulness (Schmidt & Brown, 2019). Qualitative researchers commonly have different opinions about which criteria are the best for evaluating trustworthiness, however, the current consensus is that credibility, transferability, dependability, confirmability, and authenticity are the five most relevant aspects for establishing the trustworthiness of research (Kyngäs & Kääriäinen, 2020).

To win the participants' trust and confidence, the researcher and the assistant will briefly explain the purpose for conducting this study and point out the rights of the participants, for example, their right to withdraw their participation at any moment. The researcher and the assistant ensured the interviews were conducted at an agreed time frame to avoid disrupting the participants' schedules.

To ensure trustworthiness, interviews were conducted face-to-face, individually, with each participant. The researcher will conduct a face-face with each participant to prevent the participants from influencing each other's responses. The researcher will also provide a summary profile to allow the readers to either criticize or compare the applicability of the findings of this study to other settings and experiences.

3.8 DATA ANALYSIS

Thematic analysis is a method to analyze qualitative data. It involves identifying and reporting patterns in a data set, which are then interpreted for their inherent meaning (Braun & Clarke, 2006; Liebenberg et al., 2020; Xu & Zammit, 2020; Naeem et al., 2023).

A thematic analysis was employed to arrange the collected qualitative data; this involved a systematic process of identifying themes and patterns from the acquired qualitative data (Maguire & Delahunt, 2017). The type of analysis seeks to identify

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themes, that is, patterns in the collected qualitative data that are important, relevant, or interesting, and use the identified theses to address the research problems and research questions or say something about the research issue or topic (Clarke & Braun, 2013)

Braun and Clarke (2006) suggest it is an essential qualitative method as it provides core skills for conducting many other kinds of analysis. A further advantage is that it is a method rather than a methodology (Braun & Clarke, 2006; Clarke & Braun, 2013). This means that, unlike many qualitative methodologies, it is not tied to a particular epistemological or theoretical perspective. This makes it a very flexible method, a considerable advantage given the diversity of research topics and approaches.

3.9 ETHICAL CONSIDERATIONS

The researcher put measures in place to ensure that the rights of the participants are taken into consideration, should they choose to participate in this study. The participants were protected by the principles and procedures specified by international research standards and the University of Venda Research Ethics Committee. The ethical clearance certificate was obtained from the University's Research Department. The study adhered to the following procedures and guidelines:

3.9.1 INFORMED CONSENT

The purpose of the research and the nature of the participant's involvement in this study were given before commencement. The researcher clarified what was expected of the participants and made them aware that they have the right to withdraw their participation from this study at any stage should they wish to. Consent from the participants was requested and secured before the beginning of the data-gathering interviews.

3.9.2 RIGHT TO PRIVACY

Researchers must ensure that participants' rights are protected. To achieve this, participants' information, such as identity and addresses, will not be disclosed in this report. The researcher, however, will create pseudonyms for the participants; for example, they will be referred to as Respondent 1 or Respondent 15.

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3.9.3 DIGNITY

The researcher protected and maintained the dignity of the participants, by ensuring that they were not subjected to any embarrassing behaviour just because they had consented to participate in this study.

3.9.4 HONESTY

The researcher has reported as honestly as possible, the findings, regardless of whether the results were favorable or different from the researcher’s expectations. The researcher has also cited all the works from other scholars whose works were utilized in the study by providing a comprehensive list of references at the end of this report.

3.10 SUMMARY

In this chapter, a detailed description of the different aspects of the methodology applied to address the research questions. The instruments used to collect data, the study design, the research paradigm, and the techniques used to analyze the data have all been covered in detail in this chapter's sections on research methodology. The study opted for qualitative research methods as they are versatile and enable a thorough theoretical explanation of a phenomenon. The chapter also focused on a full explanation and justification of the methods used to collect the primary data, and all ethical measures adhered to.

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CHAPTER 4

PRESENTATION OF THE EMPIRICAL ANALYSIS

4.1 INTRODUCTION

This chapter details the key findings of the study titled - *An Exploration of the Effects of Solar Water Heaters on Households in Thulamela Local Municipality: Challenges and Benefits*. The results, therefore, align with the study's objectives to explore the benefits and challenges households face in adopting solar water heaters. The study reveals various factors influencing this technology's use, focusing on its advantages and the obstacles households encounter in utilizing solar water heaters.

These results are visually represented through ATLAS.Ti.23 network diagrams; this enabled the capturing of participants' insights into the research's key themes - the benefits of solar water heaters and the challenges and feasibility of solar water heaters. The diagrams provide a visual summary of how solar water heaters affect the daily lives of households, illustrating both the potential of this technology to improve energy sustainability and the practical challenges that need to be addressed. This practical approach has ensured that the study's results are relevant to policymakers, researchers, and individuals interested in adopting sustainable energy solutions. P on quotations represent participant number.

Table 4.1: Participants Profile.

Participant	Years Using Solar Water Heaters	Gender	Age	Work Status
P1	5	Male	55-61	Employed
P2	4	Female	50-56	Employed
P3	2	Male	45-51	Unemployed
P4	10	Female	65-70	Unemployed
P5	7	Male	60-66	Unemployed
P6	5	Female	54-58	Employed
P7	6	Male	50-57	Employed
P8	3	Female	49-53	Unemployed
P9	4	Male	31-36	Employed
P10	1	Female	40-45	Employed
P11	2	Female	25-28	Employed
P12	5	Male	40-45	Unemployed

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4.2 BENEFITS OF SOLAR WATER HEATERS

The first objective of this study was to explore the benefits of solar water heaters as experienced by households in Thulamela Local Municipality. The ATLAS.Ti network diagrams were utilized to visually depict the interconnected themes and insights from the participants' feedback. These diagrams capture key aspects such as - cost savings, energy efficiency, reliability, environmental benefits, and long-term affordability – thereby offering a clear representation of how solar water heaters can positively impact households. (See the ATLAS.Ti network diagram below).

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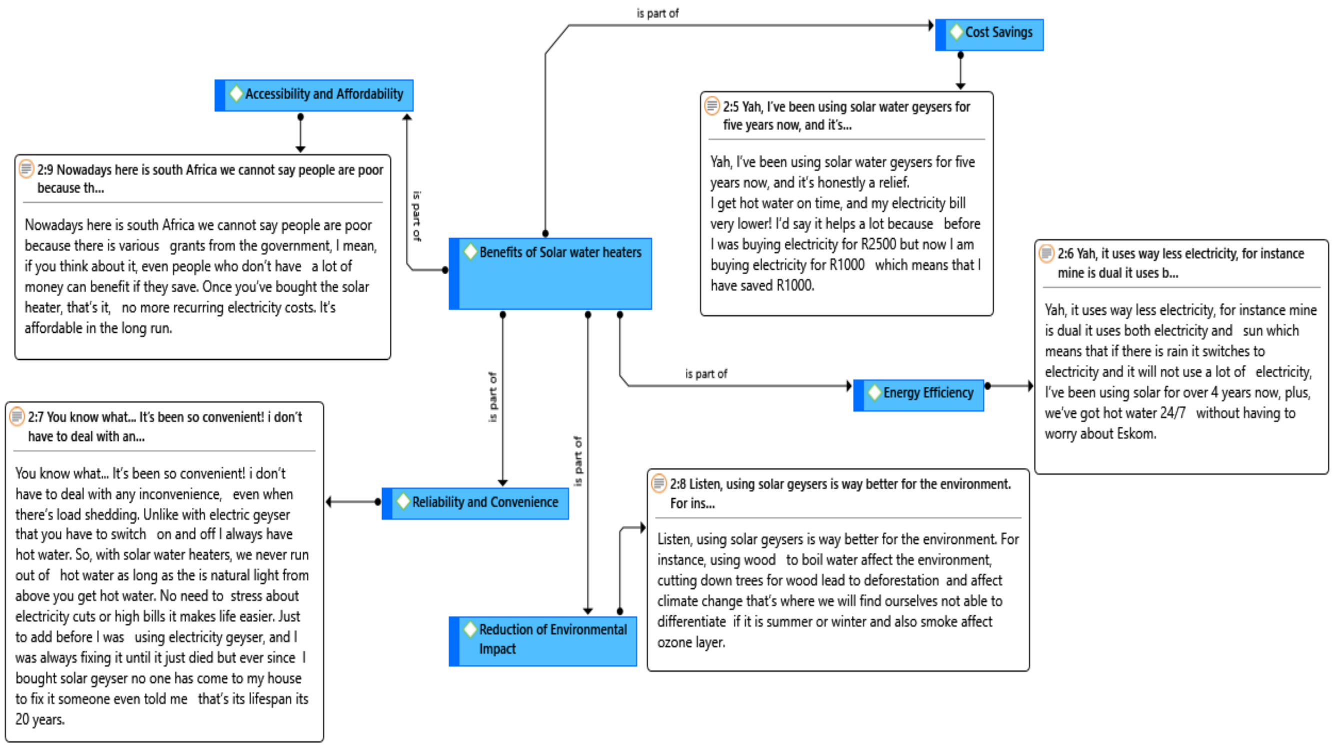

Diagram 4.1: Illustrates answers of respondents on the benefits of solar water heaters

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4.2.1 COST SAVINGS

One of the immediate noticeable benefits of installing a solar water heater is the drastic reduction in electricity bills. participants across the board reported significant financial savings after switching to solar energy. Participant 1 shared that the household’s monthly electricity expenditure had been reduced by over R1000 since adopting a solar water geyser:

"I’ve been using solar water geysers for five years now, and it’s honestly a relief. I get hot water on time, and my electricity bill is very low! Before, I was buying electricity for R2500, but now I am buying electricity for R1500, which means I have saved R1000”. P1

This reduction in utility bills has provided households with more financial flexibility, allowing them to allocate resources more efficiently. Another participant expressed astonishment at the continued reliance on traditional electric geysers, noting that solar energy provides a more cost-effective and rational solution:

"Oh, for sure, it saves a ton on electricity! I don’t know why people are still holding on to electric geysers, to be honest. Solar is just smarter" P9.

For many households, this decision to switch to solar was described as "life-changing," with participants recognizing the long-term economic benefits that go beyond the immediate savings as shown in the following quotation:

"We were paying so much for electricity, and now? We barely buy units since we installed the solar geyser. It’s such a life-changing decision" P10.

In summary, solar water heaters allow users to cut down on one of the largest household expenses - electricity - making energy consumption more sustainable and manageable.

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4.2.2 ENERGY EFFICIENCY

The results revealed that energy efficiency is one of the primary motivations for individuals adopting solar water heaters. Unlike conventional electric geysers, which rely entirely on electricity, solar geysers harness natural sunlight, reducing the demand on the electrical grid and lowering overall energy consumption. One participant emphasized the versatility and efficiency of solar water heaters, particularly those with dual functionality:

"Yah, it uses way less electricity. Mine is dual; it uses both electricity and the sun, which means that if there is rain, it switches to electricity, and it will not use a lot of electricity. I've been using solar for over four years now, plus, we've hot water 24/7 without having to worry about Eskom". P7

The dual functionality of solar water heaters, which allows households to switch to electric power only when sunlight is insufficient, makes them highly adaptable to different weather conditions, ensuring continuous access to hot water while minimizing electricity usage. Another participant echoed these sentiments, appreciating how solar geysers take advantage of the natural, renewable resources:

"Honestly, it's way better than the electric one because solar geysers use the sun's radiation. I mean, why not use what's naturally there?".P3

This sub-theme illustrates that solar water heaters are not only an environmentally friendly conscious choice but also an energy-efficient one. By relying on the sun's radiation, households reduce the strain on the electricity grid, contributing to a more sustainable energy system.

4.2.3 RELIABILITY AND CONVENIENCE

The reliability of solar water heating is one of its standout benefits, particularly in regions prone to power outages or load shedding. Many participants noted that they no longer have to worry about any hot water supply interruptions, even when electricity is unavailable. One respondent explained:

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"It's been so convenient! I don't have to deal with any inconvenience, even when there's load shedding. Unlike with the electric geyser, where you must switch it on and off, I always have hot water. With solar water heaters, we never run out of hot water as long as there is natural light".P4

This reliability brings immense convenience to users, eliminating the need for constant monitoring or manual intervention. Electric geysers are often cumbersome and susceptible to breakdowns; however, solar water heaters ensure a steady hot water supply as long as natural sunlight is available. As noted by the same participant, this convenience extends beyond just hot water supply to a broader lifestyle improvement:

"No need to stress about electricity cuts or high bills; it makes life easier".P3

Having access to hot water regardless of electricity grid power disruptions is a significant advantage for households, offering them peace of mind and reducing the daily stress associated with electricity outages.

4.2.4 REDUCTION OF ENVIRONMENTAL IMPACT

The participants' views were that solar water heaters also contribute positively to environmental sustainability, making them an eco-friendly alternative to traditional electric geysers. By using solar energy, households can significantly reduce their reliance on non-renewable energy sources, such as fossil fuels. One participant pointed out the detrimental environmental effects of using other traditional energy sources, particularly wood:

"Using wood to boil water affects the environment. Cutting down trees for wood leads to deforestation and affects climate change. That's where we will find ourselves, not able to differentiate if it is summer or winter, and smoke affects the ozone layer".P4

Beyond the financial and personal benefits, solar water heaters allow households to actively participate in environmental conservation. One participant remarked on the dual benefits of solar water heaters, highlighting how they not only save money but also support ecological well-being:

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"These solar heaters really help cut down on energy use, and you're not just saving money; you're doing your part for the environment too!".P8

Thus, solar water heaters align with broader goals of environmental preservation by reducing carbon footprints, minimizing deforestation, and contributing to the fight against climate change.

4.2.5 ACCESSIBILITY AND AFFORDABILITY

Despite the initial investment required for a solar water heater, participants generally agree that the long-term affordability of these systems makes them a worthwhile investment. Once installed, solar geysers eliminate the recurring costs associated with electricity for heating water, providing households with financial relief over time. As one participant noted:

"Once you've bought the solar heater, that's it, no more recurring electricity costs. It's affordable in the long run".P2

In addition, some respondents suggested that even those with limited financial resources could eventually afford solar water heaters, particularly, with government support or by saving overtime:

"Nowadays, here in South Africa, we cannot say people are poor because there are various grants from the government. Even people who don't have a lot of money can benefit if they save".

The long-term cost savings make solar water heaters accessible to wider demographic groups as indicated by a participant.

"With solar, I don't need to worry about finding money for electricity every month. The water's always hot, and it doesn't break the bank!".P11

The perceived affordability of solar water heaters stems not only from immediate financial savings but also from their potential to provide long-term economic benefits, making them an attractive option for diverse households. Adopting solar water heaters, therefore, offers numerous benefits beyond financial savings. These heating systems

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provide energy efficiency, reliability, and significant environmental benefits, while also being accessible and affordable in the long term. Solar water heaters exemplify a sustainable and innovative solution to modern energy needs, making them an ideal choice for households aiming to reduce costs, conserve energy, and contribute positively to the environment. Their increasing adoption reflects a shift toward more sustainable and cost-effective energy solutions, highlighting the role of renewable energy technologies in shaping the future of household energy consumption.

4.3 Challenges of Solar Water Heaters

The second objective of this study was to explore the challenges of adopting and using solar water heaters, as perceived by households in Thulamela Local Municipality. ATLAS.Ti network diagrams were employed to visually represent the interconnected challenges identified during the interviews. Key challenges include - dependence on weather conditions, occasional maintenance issues, limited hot water during extended cloudy or rainy periods, and infrastructure-related constraints, such as inconsistent water supply. The diagram provides a clear depiction of how these challenges affect the daily use of solar water heaters in the local context of Thulamela Municipality. (See the ATLAS.Ti network diagramelow)

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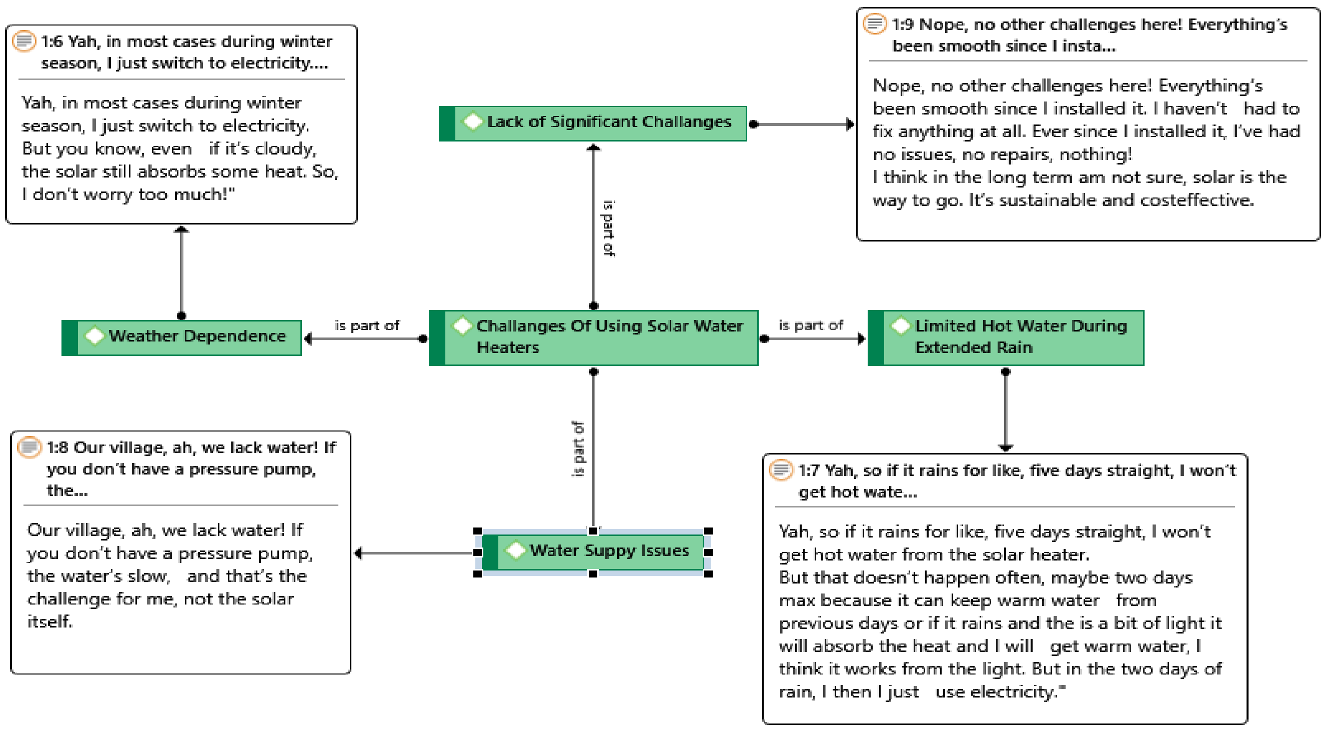

Diagram 4.2: Illustrates answers of respondents on the challenges of solar water heat

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4.3.1 WEATHER DEPENDENCE

One of the most prominent challenges of using solar water heaters is the system’s reliance on favourable weather conditions, particularly sunny weather. Solar water heaters are designed to harness energy from the sun, which means their efficiency drops during cloudy or rainy weather. Users understood that solar water heaters perform best on sunny days, hence, some participants admitted that during inclement weather, they switch to electricity to ensure they have access to hot water. As one participant noted:

"Yah, if it’s raining, and in most cases during the winter season, I just switch to electricity. But you know, even if it’s cloudy, the solar still absorbs some heat. So, I don’t worry too much!".P1

This statement reflects the flexibility users have in managing their energy needs when the solar system cannot fully meet their hot water demands; when that happens, electricity becomes a reliable backup. A participant expressed a similar sentiment:

"Honestly, when it rains, I just use electricity. The water will still be a bit warm, but yah, I switch when I need to".P2

For most users, this weather dependence is not seen as a major inconvenience because of the adaptability of their solar water heaters. Alternating between solar energy and electricity offers a practical solution, allowing households to maintain access to hot water regardless of weather conditions. One participant explained:

"When the sun’s not shining, I just plug in the electricity, and everything’s fine".P7

Solar water heaters’ weather dependence can be perceived as a drawback; however, most users accept it as a manageable limitation. The dual-functionality feature in many solar water heaters, which allow them to switch between solar energy and electricity, mitigates the inconvenience, thus, although users acknowledge this challenge, they view it as a minor trade-off for the overall benefits of solar energy.

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4.3.2 LACK OF SIGNIFICANT CHALLENGES

Interestingly, many participants reported experiencing few to no major challenges after installing their solar water heaters. For these users, the transition to solar-powered water heating has been smooth, with minimal need for repairs or maintenance. This lack of technical issues underscores the reliability of solar water heaters, particularly over long periods of time. As one user confidently stated:

"Nope, no other challenges here! Everything's been smooth since I installed it. I haven't had to fix anything at all. Ever since I installed it, I've had no issues, no repairs, nothing! I think in the long term, solar is the way to go. It's sustainable and cost-effective".P5

This participant's experience highlights not only the lack of challenges but also users' long-term confidence in the sustainability and cost-effectiveness of solar water heaters. For them, the absence of frequent repairs and malfunctions makes the system even more appealing. Another participant echoed similar feelings:

"Honestly, no challenges. I've been using it for a while, and it's all good. Life's just easier with solar!".P7

The general consensus among these users suggests that, while some minor adjustments may be necessary in dealing with the system's weather dependence, the absence of significant maintenance challenges makes solar water heaters an attractive investment. The system's reliability, combined with low maintenance, contributes to the long-term appeal of solar water heating as a sustainable energy solution. This positive feedback from users reinforces the perception that solar water heaters offer more benefits than challenges.

4.3.3 LIMITED HOT WATER DURING EXTENDED RAIN

Participants indicated that while solar water heaters are generally reliable, extended periods of rain or cloudy weather can limit the amount of hot water they can provide. Participants noted that, during prolonged rainy spells, the solar heater's efficiency

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drops, and they cannot generate enough hot water to meet their needs. One participant described how his system performs during extended rainy periods:

"Yah, so if it rains for like, five days straight, I won't get hot water from the solar heater. But that doesn't happen often, maybe two days max, because it can keep warm water from previous days, or if it rains and there is a bit of light, it will absorb the heat, and I will get warm water. I think it works from the light. But for two days of rain, I then just use electricity".P12

This response highlights that while solar water heaters can maintain warm water for short periods of rainy weather, they eventually require backup from electric sources if such weather conditions persist. The system is designed to retain some heat from sunlight, but it cannot fully meet the hot water demands during extended cloudy periods. Another participant shared a similar experience:

"If it rains, then we can't use the solar, obviously. So, we have to switch to electricity, but it's not that big of a deal".P4

For most users, this issue was not seen as a significant hindrance since they could seamlessly switch to electricity during extended rain. While it is a limitation, the system's adaptability allows users to work around it. Another participant confirmed this:

"When it rains a lot, we just use electricity. It's okay though because it doesn't rain for too long".P8

Ultimately, while solar water heaters face limitations during extended rain, these situations are manageable for most users. The ability to switch to electricity ensures that hot water remains available, and since the frequency of extended rain is generally low, this makes this particular challenge more of a minor inconvenience than a significant issue.

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4.3.4 WATER SUPPLY ISSUES

Some participants indicated that some of the challenges are not related to technology itself, but rather to the availability and pressure of the water supply. For users in rural or under-developed areas, the lack of a consistent water supply can affect the efficiency of the solar water heater. One participant from a village where water access is limited responded:

"Our village, ah, we lack water! If you don't have a pressure pump, the water's slow, and that's the challenge for me, not the solar itself".P11

This answer illustrates that the benefits of solar water heaters can be compromised in regions with poor water infrastructure. In such areas, even if the solar heater is functioning well, its effectiveness is limited by water unavailability. This issue, therefore, highlights a broader infrastructural challenge than a problem inherent to solar water heating systems, for while solar water heaters can be a sustainable solution for energy consumption, they still rely on a stable water supply to function optimally.

The challenge, hence, is not with the solar heater system but the surrounding infrastructure in these cases. This suggests that, for solar water heaters to be fully effective, they must be implemented in areas with sufficient water access or accompanied by investments in water infrastructure, such as pressure pumps. These identified challenges associated with using solar water heaters, although notable, are generally manageable by most users. The system's sunny-weather dependence remains a key concern, particularly during prolonged periods of rain or cloud cover. However, users have adapted to this limitation by relying on electricity as a backup, which ensures they still have access to hot water. For many, this adaptability mitigates the potential drawbacks; hence, most users reported no significant challenges; rather, they emphasized the low-maintenance and reliable nature of solar water heaters. Water unavailability poses a challenge in regions with poor water supply infrastructure, but this is not related to the solar technology itself.

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Overall, the challenges faced by users of solar water heaters seem to be generally predictable and manageable as these systems provide a sustainable and energy-efficient solution, with minor limitations that users have learned to navigate. The ability to switch between solar energy and electricity, coupled with the absence of significant maintenance issues, reinforces the value of solar water heaters as a viable long-term investment. For many households, the benefits of solar water heaters far outweigh these challenges, making them a practical and eco-friendly alternative to traditional water heating systems.

4.4 THE FEASIBILITY OF SOLAR WATER HEATERS AND MEASURES TO ADDRESS THE ENERGY

4.4.1 INTRODUCTION

The third objective of this study was to assess the feasibility of solar water heaters for households in Thulamela Local Municipality. ATLAS.Ti network diagrams represent participants' views on factors influencing feasibility, such as affordability, long-term financial savings, ease of installation, and the potential for reducing reliance on non-renewable energy sources. The diagram highlights how solar water heaters can be a practical and sustainable solution for households, despite the initial investment, by offering long-term economic and environmental benefits. (See the ATLAS.Ti network diagram below)

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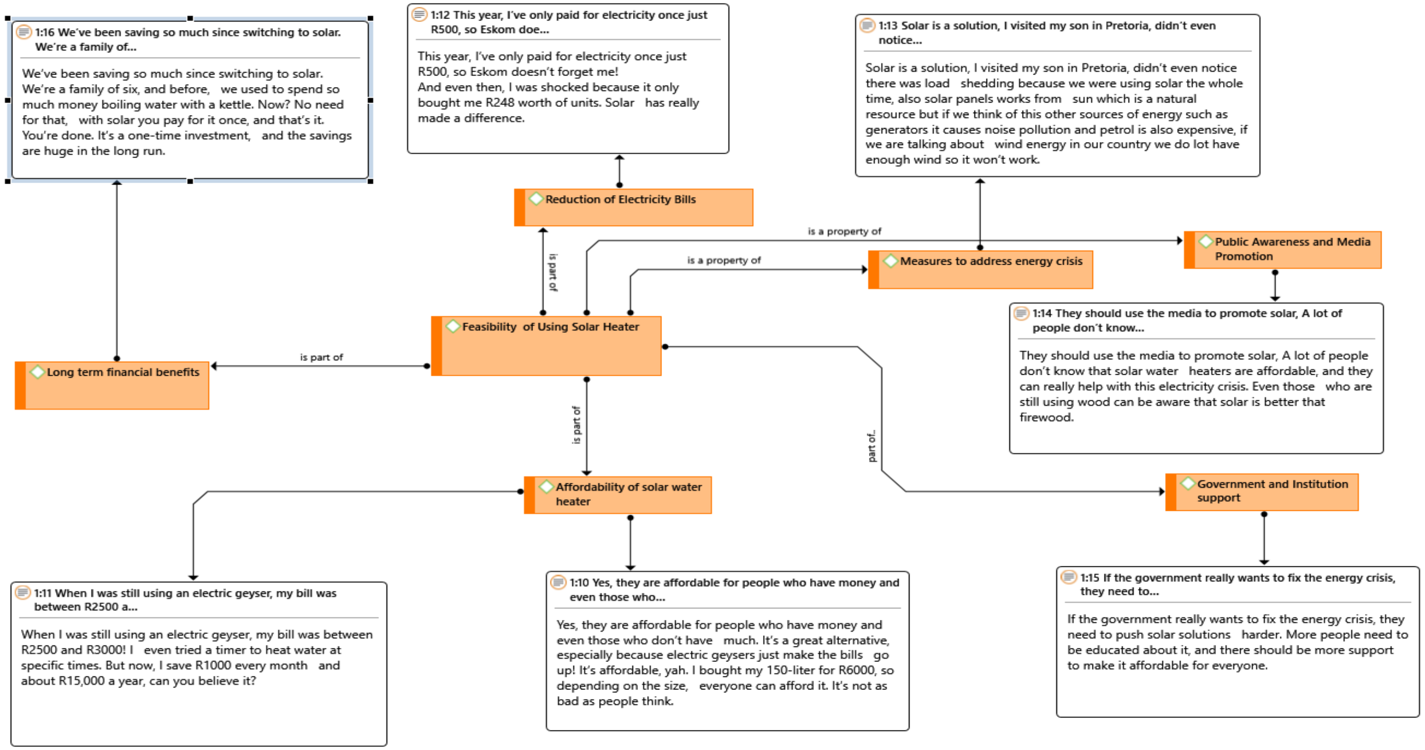

Diagram 4.3: Illustrates respondents' answers on the feasibility and measures to address the energy challenges.

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4.4.2 AFFORDABILITY OF SOLAR WATER HEATERS

The results revealed that affordability is a central aspect of the feasibility of solar water heaters, particularly given the rising costs of traditional energy sources. Participants acknowledged that, while the initial purchase of a solar water heater might seem exorbitant, it is affordable for a wide range of income groups when considering the long-term financial savings. One participant highlighted the accessibility of these systems even for households with modest incomes:

"Yes, they are affordable for people who have money and even those who don't have much. It's a great alternative, especially because electric geysers just make the bills go up! It's affordable, yah. I bought my 150-liter for R6000, so depending on the size, everyone can afford it. It's not as bad as people think".(P5).

This statement underscores that, despite the upfront cost, the long-term affordability of solar water heaters makes them accessible to a broader audience. As electricity prices continue to rise, the affordability of solar technology makes it an attractive option for many households seeking to minimize monthly energy costs. In addition, the variations in pricing, depending on the size and capacity of the system, provide options for households with different needs. This flexibility ensures that solar water heaters can cater to varying budget constraints, increasing their overall feasibility in the South African context.

4.4.3 REDUCTION OF ELECTRICITY BILLS

One of the most compelling reasons for adopting solar water heaters was perceived to be its subsequent drastic reduction in electricity bills. Participants repeatedly emphasized how switching from electric geysers to solar water heaters has resulted in significant savings, thereby, proving the economic feasibility and attractiveness of the system. One participant shared the impact this transition had on the household's finances:
"When I was still using an electric geyser, my bill was between R2500 and R3000! I even tried a timer to heat water at specific times. But now, I save R1000 every month and about R15,000 a year, can you believe it?".P1

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This substantial reduction in energy costs highlights the financial relief that solar water heaters can provide, especially for households burdened by high electricity bills. The decrease in monthly expenses enhances the financial sustainability of these systems, making them a practical solution for households aiming to reduce their energy consumption and expenditure. Another participant reiterated these sentiments about the savings, noting how the solar water heater has resulted in them making minimal electricity purchases throughout the year:

" I do not only use solar water heater, I also use solar for everything at home. This year, I've only paid for electricity once just R500, so Eskom doesn't forget me! And even then, I was shocked because it only bought me 248 worth of units. Solar has really made a difference".P3

These testimonials demonstrate how solar water heaters have enabled households to reduce their reliance on the national electricity grid, leading to more predictable and manageable energy costs.

4.4.4 LONG-TERM FINANCIAL BENEFITS

The long-term financial benefits of solar water heaters are other key factors contributing to their feasibility. The initial cost of solar heaters may be higher than that of an electric geyser, however, participants consistently reported significant savings over time, making the one-time investment worthwhile. For families, especially large households, these savings become even more pronounced. As one participant explained:

"We've been saving so much since switching to solar. We're a family of six, and before, we used to spend so much money boiling water with a kettle. Now? No need for that, with solar you pay for it once, and that's it. You're done. It's a one-time investment, and the savings are huge in the long run".P8

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This perspective highlights how solar water heaters can provide consistent and lasting financial relief, particularly for large households with high water-heating needs. The initial investment in solar technology is recouped over time, through substantial reductions in electricity bills and energy consumption.

The notion of a "one-time investment" was a recurring theme among participants; many felt that the lack of ongoing costs made solar water heaters an attractive option for those seeking long-term financial sustainability. Solar water heaters, hence, provide households with greater financial freedom and stability by eliminating recurring energy expenses.

4.5 MEASURES TO ADDRESS THE ENERGY CRISIS

As South Africa faces ongoing challenges with electricity supply and load shedding, solar water heaters offer a feasible solution to reduce pressure on the national grid. Many participants voiced strong support for solar energy as a means of addressing the country's energy crisis. One participant shared how solar technology allowed the household to remain unaffected by load shedding during a visit to Pretoria:

"*Solar is a solution. I visited my son in Pretoria and didn't even notice there was load shedding because we were using solar the whole time".P2*

This example underscores the advantage of solar water heaters in providing uninterrupted access to hot water, even during power outages. The reliance on solar energy, a natural and abundant resource, demonstrates the system's feasibility in a country where electricity supply is often inconsistent. Another participant emphasized the environmental benefits of solar compared to other energy sources, such as generators, which cause noise pollution and rely on expensive fuel:

"Also, solar panels work from the sun, which is a natural resource. But if we think of these other sources of energy, such as generators, they cause noise pollution and petrol is also expensive".P7

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Solar water heaters thus offer a cleaner, more sustainable alternative to traditional energy sources, making them an ideal solution for both the energy crisis and environmental conservation.

4.5.1 PUBLIC AWARENESS AND MEDIA PROMOTION

Responses from the participants testified to the clear benefits of solar water heaters, however, there is a need for greater public awareness about their affordability and advantages. Many participants felt that media campaigns could play a crucial role in promoting the adoption of solar energy. One participant suggested:

"They should use the media to promote solar. A lot of people don't know that solar water heaters are affordable and that they can help with this electricity crisis. Even those who are still using wood can be aware that solar is better than firewood".P5

Public education about solar technology would not only increase its adoption but also help combat traditional practices that are harmful to the environment, such as using firewood for heating. By raising awareness of the cost savings and environmental benefits of solar water heaters, more people could be encouraged to make the switch, further contributing to the energy crisis solution.

4.5.2 THE NEED FOR GOVERNMENT AND INSTITUTIONAL SUPPORT

The feasibility of solar water heaters is also tied to the role of government and other stakeholders support in promoting and subsidizing this technology. Participants stressed the urgency of government intervention in making solar solutions more accessible to the public. One participant stated:

"If the government wants to fix the energy crisis, they need to push solar solutions harder. More people need to be educated about it, and there should be more support to make it affordable for everyone".P6

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Government subsidies, incentives, and education programs could make solar water heaters more accessible to lower-income households, increasing the overall implementation of solar energy in addressing the country's energy challenges. Institutional support, in the form of policies that promote renewable energy, could further drive the adoption of solar water heaters and accelerate the transition to sustainable energy solutions. The feasibility of using solar water heaters, thus, is supported by their affordability, long-term financial benefits, and significant reductions in electricity bills. The solar system not only offers an environmentally friendly solution to South Africa's energy crisis but will also provide households with reliable, cost-effective alternatives to traditional electric geysers. Public awareness campaigns and greater government support are essential to expanding the adoption of solar water heaters, so as to make them a viable solution for a wider population. Overall, solar water heaters represent a practical, sustainable, and financially feasible option for addressing energy needs, in both urban and rural contexts.

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CHAPTER 5

DISCUSSION OF THE RESULTS

5.1 INTRODUCTION

This chapter will provide an in-depth examination of the findings from the data analyzed and presented in Chapter 4, concentrating on the role and effectiveness of solar water heaters (SWHs) in homes in Thulamela Local Municipality. The results underscore significant themes such as - the financial advantages stemming from decreased electricity expenses, the ecological benefits of reduced greenhouse gas emissions, and the efficiency of SWH systems. These findings are framed within existing literature, reinforcing the practicality of SWHs as a solution for energy conservation in regions grappling with persistent energy issues. The discussions focus on participants' experiences, illustrating the real long-term savings and contributions to sustainability that SWHs can provide, aligning with broader national objectives for energy efficiency. By merging participants' lived experiences with pertinent academic and policy literature, this chapter offers a well-rounded discussion of the results, presenting a thorough understanding of the viability and prospects of solar water heaters, as a sustainable energy option for households in Thulamela Local Municipality.

5.2 BENEFITS OF SOLAR WATER HEATERS

The study's findings underscore the significant financial benefits of solar water heaters for households, as by reducing electricity expenses, these systems can lead to substantial savings. Many participants reported a decrease in their monthly electricity bills by up to R1000, demonstrating the system’s potential for cost reduction. This aligns with Ismail and Khembo's (2015) research, which suggested that solar water heaters could lower electricity consumption by up to 60%, resulting in an estimated 25-30% reduction in household utility bills. Donev et al. (2012) also supported this, maintaining that adopting solar water heaters can lead to substantial energy savings and lower overall water heating costs. The decrease in utility bills will not only ease the financial strain on households but will also allow for more efficient resource allocation, providing greater economic flexibility. The long-term savings observed by participants, from using solar water heaters, are

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consistent with the literature, which indicates a favourable payback period for these systems, typically ranging from 3 to 8 years, depending on the system type and location (Cassard et al., 2011; Ferrer, 2017). The cost-saving benefits of solar water heaters, therefore, contribute to their increasing adoption, especially as households strive to manage escalating electricity prices. These findings mirror the broader trend of households investing in energy-efficient technologies to achieve long-term financial sustainability.

Participants in the study highlighted the energy efficiency of solar water heaters, with many pointing out that these systems use significantly less electricity than conventional geysers. Solar water heaters primarily rely on sunlight, which reduces dependence on grid electricity and contributes to lower energy consumption. This is corroborated by Cassard et al. (2011), who discovered that solar water heating systems can reduce energy demand by up to 80%, making them highly energy-efficient. Additionally, the dual functionality of some solar water heaters, which can switch to electric power when sunlight is insufficient, enhances their adaptability, flexibility, and efficiency. Pan and Wong (2012) demonstrated that these hybrid systems provide a reliable source of hot water while minimizing overall energy use, ensuring efficiency, even in less sunny climates. Participants' comments that they always have access to hot water, regardless of weather conditions, underscore the reliability of these systems in reducing household reliance on the national grid. The literature also highlights the broader environmental impact of energy-efficient systems like solar water heaters. Donev et al. (2012) estimated that widespread adoption of solar water heaters could result in substantial energy savings at a national level, which aligns with participants' experiences of reduced electricity consumption. This illustrates the significant role of solar water heaters in creating a more sustainable energy ecosystem, appealing to eco-conscious individuals.

The study's results demonstrate the dependability and ease of use of solar water heaters, especially in areas affected by power outages or load shedding. Several participants observed that installing solar water heaters eased worries about electricity interruptions and ensured a consistent hot water supply. This finding aligns with Huang et al. (2019),

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who discovered that individual household solar water heating systems are highly dependable, delivering a steady hot water supply despite external disruptions. Participants highlighted the convenience of not manually controlling the system, contrasting with traditional electric geysers requiring users to manage them during power shortages. The automatic nature of solar water heaters, especially those with auxiliary backup systems, enhances their reliability. These systems switch to electricity only when sunlight is insufficient, ensuring uninterrupted service.

Pan and Wong (2012) also noted the adaptability of hybrid systems, which allow for seamless operation even during periods of insufficient sunlight. It was also established that the convenience of solar water heaters goes beyond their technical functionality and that transitioning to solar heating eliminated the stress of constantly monitoring electricity usage and managing increasing utility bills. This aligns with the findings of Chang et al. (2011), who showed that solar water heating systems reduce energy consumption and provide a low-maintenance solution, enhancing convenience for households. These findings indicate that solar water heaters contribute to an overall better quality of life by reducing dependency on unstable electricity grids and simplifying household energy management. This dependability and convenience underscore the increasing adoption of solar water heaters as a practical and efficient alternative to traditional heating methods, especially in regions like South Africa, where power interruptions are frequent.

The study participants consistently acknowledged the positive impact of solar water heaters (SWH) on the environment, especially in reducing dependence on non-renewable energy sources and lessening environmental harm. This aligns with Mujuru et al. (2020), who showed that SWH systems can reduce greenhouse gas emissions by up to 49%, actively contributing to climate change mitigation. Participants emphasized the harmful environmental effects of using traditional energy sources, like wood, for water heating, which leads to deforestation and contributes to climate change. This observation aligns with existing literature, as solar energy is a clean, sustainable source that reduces households' carbon footprint. Donev et al. (2012) also quantified the potential for significant Carbon Dioxide reduction through adopting SWH systems in South Africa, estimating a reduction of up to 297.7 Mt of emissions.

These findings support participants' understanding that transitioning to solar water heating is not only a cost-effective choice but also an environmentally responsible one. Furthermore, the adoption of SWH is in line with global and national sustainability goals. South Africa's National Energy Efficiency Strategy and the South African Solar Water Heating Programme have identified SWHs as crucial for reducing electricity demand and improving energy efficiency. These programs recognize the long-term environmental benefits of SWH systems in reducing reliance on coal-based electricity, which remains a primary power source in South Africa.

Participants' comments, such as acknowledging that using solar water heaters "helps reduce energy consumption" and "contributes to environmental preservation," demonstrate an increasing awareness of households' role in global sustainability efforts. Government initiatives and global trends toward cleaner energy sources support this growing environmental consciousness. The literature emphasizes that this is not just an individual effort but part of a larger, collective shift toward adopting renewable energy, which has both immediate and long-term positive environmental effects.

The study participants expressed concerns about the cost of solar water heaters, particularly the high initial installation expenses. However, they recognized that despite the exorbitant upfront investment, the long-term financial benefits outweigh the initial cost. This viewpoint is well-supported in existing literature. Ferrer (2017) concluded that while SWH systems have a higher initial cost compared to conventional electric geysers, the payback period in South Africa is approximately 8 years, making them highly affordable due to the long-term cost savings. On the issue of costs, Chang et al. (2018) and Serban et al. (2016) noted the significance of subsidies, tax incentives, and rebates in improving accessibility to SWH systems for broader demographic groups. The Solar Water Heating Programme in South Africa, which provided subsidies and rebates for SWH systems, aimed to make these systems affordable for low-income households, and although this

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initiative failed to fully achieve its goals, it established the foundation for future policies, promoting renewable energy technologies.

Participants' statements reflect a positive perspective that focused on the heaters' long-term affordability, based on the absence of recurring electricity costs once the solar heater is purchased. Mujuru et al. (2020) illustrated that SWHs are efficient and cost-effective over time, particularly in reducing household energy expenses. Furthermore, government backing for renewable energy technologies can significantly diminish the initial financial barriers, making SWH systems more accessible to low-income households. The notion that even individuals with limited financial resources could eventually afford solar water heaters, especially with government support or through gradual savings, aligns with the point of Purohit and Michaelowa (2008), who discussed the role of subsidies and incentives in increasing the adoption of SWH systems.

Additionally, participants' comments about the long-term economic advantages align with Zhang et al. (2018), who advocated policy support in alleviating the financial burden of transitioning to renewable energy. This long-term affordability and accessibility positions SWH systems as a compelling option not only for affluent households but also for low-income groups, as confirmed by participants who acknowledged the role of savings and governmental grants in enabling more people to afford these systems.

5.3 CHALLENGES IN USING SOLAR WATER HEATERS

The participants in this research emphasized that solar water heaters (SWHs) face a significant challenge due to relying on favourable weather conditions. SWHs are most efficient on sunny days, but their effectiveness decreases during cloudy or rainy weather, leading to the need for electricity as a backup. Many users narrated similar experiences on switching between solar and electric power. These findings are consistent with Li et al. (2011), who identified the difficulty of providing hot water during cold or cloudy periods as a major drawback with SWHs. They note that SWHs often come with additional heating systems, such as electric heaters, to ensure year-round functionality. Ferrer (2017) also stressed the need to incorporate backup systems to maintain efficiency during

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unfavorable weather conditions - a view shared by the participants in this study. The weather dependence of SWHs, despite being viewed as a challenge, is manageable due to the ease of switching to alternative power sources.

After installing their SWHs, participants mentioned limited challenges with their solar water heaters. Many participants reported that their SWHs had not required any repairs or upkeep since being installed. This demonstrates the dependability and low-maintenance characteristics of SWHs once installed, adding to their attractiveness. This finding aligns with Donev et al. (2012) which found that the long-term benefits of SWHs, such as reduced energy expenses, often outweigh any initial installation challenges. This indicates that proper installation and setup, as recommended by Thobejane et al. (2019), are crucial in ensuring that users encounter minimal ongoing problems. The lack of any significant major maintenance requirements, once installed, also attests to the sustainability of SWHs, making them an appealing long-term solution for households.

Solar water heaters are generally dependable, although some users reported that prolonged periods of rain can restrict their access to hot water; nevertheless, users have overcome this challenge by switching to electricity when needed. These findings align with Li et al. (2011), who emphasized that SWHs may struggle to deliver hot water during prolonged periods of insufficient sunlight, underscoring the urgency of backup systems. Similarly, Curry et al. (2017) discovered that the option to switch to alternative energy sources ensures that this limitation does not significantly impact households. The challenge of limited hot water during extended rain, therefore, is not viewed as a major drawback, as most participating users have adapted to limited amounts of hot water due to weather fluctuations or switch to electricity.

In areas where water supply is inconsistent, participants have noted that the performance of solar water heaters can be compromised. A participant from a rural location noted that slow water flow due to the absence of a pressure pump rather than the solar technology itself posed a challenge. This challenge, hence, is not directly linked to solar technology but rather to the broader issues of water access and pressure, which can impact the

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effectiveness of SWHs. Netshiozwi (2019) also recognized inadequate water infrastructure as a hindrance to the efficient use of SWHs in rural areas, for SWHs depend on a reliable water supply to provide hot water. This factor indicates that for SWHs to work optimally, broader improvements in the water supply systems are required. Addressing water supply challenges, therefore, could substantially improve the effectiveness of solar water heaters in rural and underdeveloped regions.

5.4 THE FEASIBILITY OF SOLAR WATER HEATERS AS MEASURES TO ADDRESS THE ENERGY CRISIS

The feasibility of solar water heaters in South Africa is also influenced by affordability. According to the participants in this study, although the initial purchase cost of a solar water heater may appear high, long-term financial savings make these systems affordable to a wide range of income groups. This indicates that while SWHs may require a substantial initial investment, this is mitigated by the considerable reduction in ongoing electricity expenses. This finding aligns with existing research, such as Peter's (2022) study, which maintains that despite the high initial costs of SWHs, they ultimately become a cost-effective option by helping households save on monthly energy bills. The variety of prices based on system size and capacity provides flexibility for different budget levels, making SWHs a viable solution for households across diverse economic backgrounds.

Using solar water heaters offers a compelling benefit by significantly reducing electricity bills, as reported consistently by participants. This considerable reduction in energy costs highlights the economic viability of SWHs, especially for households with increasing electricity requirements. Mujuru et al. (2020) also support this point, asserting that SWHs can cut energy consumption by up to 49%, resulting in substantial financial savings. In addition, the capacity to decrease reliance on the national electricity grid further enhances the cost-effectiveness of SWHs, presenting them as a pragmatic solution for households seeking to manage their energy expenditures. The financial advantages of solar water heaters (SWHs) were emphasized by participants as a key factor in their viability. One participant noted that solar water heaters require a single payment, making it a one-time

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investment with substantial long-term savings. This viewpoint illustrates the belief that even though the initial cost of solar water heaters may be higher than traditional electric geysers, the long-term savings justify the investment. Chang (2011) also stressed that the payback period for SWHs is shorter than the system's lifespan, making purchasing them a financially sound decision. For large households, the cost savings become even more evident over time, confirming the idea that SWHs provide significant financial relief in the long term by reducing recurring energy costs.

Amid South Africa's persistent energy crisis and frequent load shedding, participants acknowledged the significance of solar water heaters in alleviating pressure on the national grid. One participant asserted that solar power mitigates the impact of load shedding, citing the experience of uninterrupted energy supply due to relying on solar energy. This highlights the capability of SWHs to ensure continuous access to hot water, even during power interruptions. This observation is reinforced by the South African government's initiatives (Peter, 2022) in advocating for solar energy as a solution to the country's electricity challenges. Solar water heaters, which harness the sun's energy, present a sustainable substitute for conventional energy sources such as electric geysers, which strain the grid during peak demand. Consequently, SWHs are pivotal in addressing energy supply constraints and environmental issues. The financial and environmental benefits of solar water heaters are evident. Hence, participants stressed the need for increasing public awareness and media promotion.

One participant recommended leveraging the media to raise awareness about the affordability of solar water heaters, as many people are unaware of this. This confirms the necessity of educating the public about the cost-effectiveness and benefits of solar technology. As suggested by Naidoo (2020), public awareness campaigns may motivate more households to embrace solar water heaters. By demonstrating the cost savings, environmental advantages, and ease of installation, media promotion could have a crucial impact on expanding the adoption of SWHs throughout South Africa, especially in regions where electricity expenses pose a significant burden.

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The government and institutional support levels will determine how widely solar water heaters are adopted. According to one participant, the government must prioritize solar solutions to address the ongoing energy crisis. By implementing well-planned policies and incentives, government and other stakeholders can significantly reduce the cost barrier for low-income households, thus making solar water heaters more accessible to a larger population.

Wlokas and Ellis (2013) focus on the impact of government subsidies and incentives in increasing the use of solar water heaters. These financial aids can alleviate the initial costs of purchasing and installing solar systems, making them a more feasible option for those with limited resources. Additionally, institutional support through renewable energy policies can further promote the widespread use of solar water heaters. These policies may involve tax credits, feed-in tariffs, and simplified permit processes, which can create a favourable environment for the solar industry's growth. By prioritizing solar water heaters, governments can tackle the urgent energy challenges and contribute to a more sustainable future. Solar water heaters provide a clean, renewable, and cost-effective alternative to traditional energy sources; hence, their widespread adoption can assist in reducing dependence on fossil fuels, lower greenhouse gas emissions, and enhance energy security (Peter, 2022).

5.6 CHAPTER SUMMARY

This chapter examines the key outcomes from the data analysis regarding implementing solar water heaters (SWHs) in households within Thulamela Local Municipality. The findings identified notable financial advantages, with numerous households seeing significant decreases in electricity expenses, thereby, contributing to their long-term financial stability. Additionally, the environmental benefits of SWHs were also outlined, especially in lowering greenhouse gas emissions and encouraging a transition towards renewable energy sources. These advantages align with national and global sustainability objectives, highlighting the potential of SWHs as a feasible alternative energy option.

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The discussions also acknowledged some difficulties in adopting SWHs, particularly their dependency on suitable weather conditions and the substantial upfront installation expenses. Feedback from participants pointed to the necessity for hybrid systems and governmental support to address these challenges, guaranteeing reliable performance and greater accessibility. In summary, these discussions offer a comprehensive view of the advantages and challenges around SWHs, providing insights into their viability and potential for broader adoption in the Thulamela area. This analysis lays the groundwork for further investigation into policy support and technological innovations that could bolster the use of solar water heaters as a sustainable energy solution in South Africa.

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CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 INTRODUCTION

The purpose of this chapter is to summarize the research findings from chapters one to five, draw conclusions based on the analysis, and offer recommendations that could guide further action or research. This study sought to explore the effects of Solar Water Heaters (SWHs) on households in Thulamela Local Municipality, focusing on their challenges and benefits. The key objectives were to investigate the benefits of using SWHs, the challenges in their implementation, and the feasibility of SWHs in addressing the energy crisis in South Africa. The specific research objectives were formulated as follows:

- To investigate the benefits of using solar water heating systems for domestic
- purposes in Thulamela Municipality.
- To explore the challenges of using solar water heating systems for domestic purposes in Thulamela Municipality.
- To determine the feasibility of solar water heaters as a measure to address the energy crisis in South Africa.
- To suggest policy recommendations from the conclusions drawn.

6.2 SUMMARY OF CHAPTERS

6.2.1 CHAPTER 1: INTRODUCTION

Chapter One provided an overview of the study's purpose, objectives, and significance. In the chapter was discussed the increasing demand for affordable, clean energy, with a specific focus on solar water heaters in South Africa. Details were also provided on the research problem, which centered on the need to evaluate the adoption of solar water heaters, given their potential to reduce energy costs and greenhouse gas emissions. The specific research objectives and questions aimed at addressing the benefits, challenges, and feasibility of SWHs were introduced.

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6.2.2 CHAPTER 2: LITERATURE REVIEW

Chapter Two focused on reviewing theoretical and empirical literature related to solar water heaters. Key theories like the Contingent Valuation Theory and the Theory of Planned Behavior were explored to understand the factors influencing the adoption of SWHs. Empirical studies from local and international contexts provided insight into the benefits and challenges associated with SWH implementation, dwelling on aspects such as - economic savings, environmental impact, issues related to high initial costs, and the system's efficiency under varying weather conditions. The chapter also discussed South African renewable energy and solar water heating policies.

6.2.3 CHAPTER 3: RESEARCH METHODOLOGY

In Chapter Three, the research methodology was outlined, focusing on a qualitative research approach. Data collection was through in-depth interviews with selected households in Thulamela Municipality. In addition, details were provided on the sampling technique employed (purposive sampling), targeting participants with relevant experiences with SWH systems. The chapter also highlighted the ethical considerations adhered to throughout the study, ensuring the protection of the rights of the participants.

6.2.4 CHAPTER 4: DATA ANALYSIS AND INTERPRETATION

Chapter Four focused on the findings of the study, which revealed several key benefits and challenges of SWHs. The analysis showed that while SWHs have significant potential for energy savings and environmental benefits, their adoption also faces barriers, such as high initial costs, inconsistent performance during cold seasons, and lack of public awareness. Thematic analysis was used to organize the data, and the results were compared with findings from previous studies to draw broader conclusions about the feasibility of SWHs in the local context.

6.2.5 CHAPTER 5: DISCUSSION OF RESULTS

Chapter Five discussed the key findings of the research questions and objectives. It was observed that the main benefit of SWHs is the reduction of energy costs, but this is offset by challenges, such as the high upfront capital required for installation and the systems'

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dependency on consistent sunlight. Recommendations were made for increasing public awareness, providing government subsidies, and improving technical support for SWH installations. The results were also compared to literature, identifying similarities and contradictions with existing studies.

6.3 SUMMARY OF RESULTS

This comprehensive study, which employed qualitative research methods, investigated the impact of solar water heaters (SWHs) on households in Thulamela Local Municipality, focusing on three specific objectives: investigating the benefits of SWHs, exploring the challenges associated with the heaters and determining their feasibility in addressing the energy crisis. This thorough approach of the study instills confidence in the research findings.

6.3.1 OBJECTIVE 1: TO INVESTIGATE THE BENEFITS OF USING SOLAR WATER HEATING SYSTEMS FOR DOMESTIC PURPOSES IN THULAMELA MUNICIPALITY

The study revealed several positive impacts of SWHs on households in the Thulamela Local Municipality. Key benefits include:

- **Energy savings**: SWHs significantly reduce household electricity consumption, reducing household electricity costs. Households that adopted SWHs, especially in low-income areas, experienced substantial financial relief in their monthly energy bills. This aligns with the South African Appliance Standards and Labelling regulations that promote the purchase of energy-efficient appliances.

- **Reduced reliance on grid electricity**: Solar energy lessens dependency on Eskom's electricity grid, making households less vulnerable to load-shedding and rising electricity prices. The *Electricity Regulation Amendment Act* aims to liberalize the energy market, reduce reliance on Eskom, and address the country’s persistent load-shedding crisis.

- **Environmental benefits**: The adoption of SWHs contributes to lowering carbon emissions and supports South Africa's broader goals for renewable energy

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adoption and climate change mitigation. This makes SWHs a critical tool for promoting environmental sustainability in rural areas. This aligns with the Climate Change Act 22 of 2024 intends:

- to enable the development of an effective climate change response and a long-term, just transition to a low-carbon and climate-resilient economy and society for South Africa in the context of sustainable development.

6.3.2 OBJECTIVE 2: TO EXPLORE THE CHALLENGES OF USING SOLAR WATER HEATING SYSTEMS FOR DOMESTIC PURPOSES IN THULAMELA MUNICIPALITY

Several challenges were identified as hindering the widespread adoption of SWHs in Thulamela Municipality despite the benefits:

- **High initial installation costs**: Many households face financial constraints that prevent them from affording the exorbitant upfront costs of SWH installations. This has been a significant barrier to adoption, particularly for low-income families.
- **Inconsistent performance during cold months**: SWHs rely heavily on sunlight, decreasing their efficiency during winter or cloudy weather. This seasonal variability in performance has made some households hesitant to invest in technology.
- **Lack of significant challenges**: Findings revealed the reliability and long-term sustainability of solar water heaters. The absence of significant challenges, particularly maintenance, reinforces the system's appeal to users. Some limitations, such as the heaters' weather dependence, were identified. However, users generally viewed the lack of technical difficulties as an advantage, making SWHs an attractive, cost-effective, and low-maintenance solution for their households.

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6.3.3 OBJECTIVE 3: TO DETERMINE THE FEASIBILITY OF SOLAR WATER HEATERS AS MEASURES TO ADDRESS THE ENERGY CRISIS IN SOUTH AFRICA.

The study assessed the feasibility of SWHs as a solution to the energy crisis in the Thulamela Municipality by focusing on the following key points:

- **Feasibility of SWHs**: SWHs present a viable solution for reducing household electricity consumption, however, their success depends on addressing the financial and technical challenges identified. If these challenges are mitigated, SWHs could significantly contribute to addressing energy shortages in the region.

- **Addressing the energy crisis**: SWHs can play a crucial role in alleviating pressure on the national grid by reducing the demand for electricity for water heating purposes. By promoting SWH adoption, the Municipality could enhance energy security and reduce the frequency of load-shedding.

- **Measures to improve feasibility**: To make SWHs more feasible, several measures are recommended:

  - **Government subsidies and financial incentives**: Financial support from the government, in the form of subsidies or low-interest loans, would help reduce the high initial-installation costs and make SWHs more accessible to low-income households.

  - **Public awareness campaigns**: The government and renewable energy organizations should collaborate to educate the public about the financial, environmental, and energy-saving benefits of SWHs - such increased awareness would drive their demand and adoption.

  - **Improved technical support**: Establishing accessible maintenance and technical support services is critical to ensuring the long-term operations of SWHs. Reliable technical support would address concerns over system failures and encourage more households to invest in SWHs.

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6.4 CONCLUSIONS

Based on the findings of the study, several conclusions can be drawn:

1. **Energy Savings and Financial Benefits**

   SWHs can significantly reduce household energy costs, especially for low-income families in Thulamela Municipality, although, these savings are only realized after the payback period, ranging from 3 to 8 years, depending on the system.

2. **Environmental impact**

   Using SWHs contributes to reducing greenhouse gas emissions, which aligns with the national and global goals of promoting renewable energy and combating climate change. This makes SWHs a viable option for sustainable development in South Africa.

3. **Challenges in Adoption**

   There were several benefits mentioned, however, challenges were also identified as hindering the widespread adoption of SWHs, including - high initial costs, and the inconsistent availability of sunlight during cold months.

4. **Feasibility of SWHs as measures for addressing the energy crises in S. A**

   The study concluded that solar water heaters (SWHs) are a feasible solution for addressing the energy crisis in South Africa, however, their long-term success and widespread adoption depend on substantial support from both the government and the private sector. This support can be in the form of offering financial incentives, such as subsidies or low-interest loans, to make the systems more accessible to low-income households, as well as ensuring the availability of technical support for maintenance and repair. These measures would improve the feasibility of SWHs and promote their sustained use across the community.

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6.5 Recommendations for the Thulamela Municipality Regarding Solar Water Heaters (SWHs)

1. **Increase Government Subsidies and Financial Support**

To promote the widespread adoption of Solar Water Heaters (SWHs) in the Thulamela Municipality, the government should consider offering increased financial incentives, such as subsidies, grants, or low-interest loans. This would be especially beneficial for low-income households, who may otherwise be unable to afford the initial installation costs. By reducing the upfront capital required, the technology would become more accessible to a broader demographic, encouraging both residential and commercial adoption of solar water heating systems.

2. **Public Awareness Campaigns**

A concerted effort should be made to raise awareness about the benefits of solar energy, specifically solar water heating, within the Thulamela Municipality. Targeted public awareness campaigns should focus on educating residents about the long-term cost-saving potential of solar water heaters, as well as their positive environmental impact. These campaigns could be conducted in collaboration with local municipalities and renewable energy organizations, using various media platforms such as radio, social media, and community workshops to ensure maximum reach and engagement.

3. **Policy Advocacy for Renewable Energy**

Policy reforms are essential to ensure the integration of renewable energy solutions, such as solar water heaters, into the municipality's infrastructure. The Thulamela Municipality should advocate for policies that make the installation of SWHs mandatory in new housing developments and renovations. Additionally, these policies should establish stringent regulations to guarantee the quality, safety, and durability of the systems, ensuring that all installations meet high standards. This would not only accelerate the adoption of SWH technology but also ensure its long-term effectiveness.

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4. Further Research on Solar Water Heater Performance

While solar water heaters offer numerous advantages, there are still challenges related to their efficiency during colder months and overcast days. To improve the performance of SWH systems in the Thulamela Municipality, further research should be conducted into new technologies or system modifications that could increase their reliability in diverse weather conditions. Research focusing on improving energy storage and backup systems during low sunlight periods could enhance the overall efficiency and practicality of solar water heaters, making them a more viable option year-round.

These recommendations, tailored to the specific needs of Thulamela Municipality, will not only help in promoting the adoption of solar water heaters but will also contribute to the municipality's long-term sustainability and energy independence.

6.6 CONCLUSIONS ON RESEARCH QUESTIONS AND OBJECTIVES

6.6.1 RESEARCH QUESTION 1: WHAT ARE THE BENEFITS OF USING SOLAR WATER HEATING SYSTEMS FOR DOMESTIC PURPOSES IN THULAMELA MUNICIPALITY?

The study established that the primary benefit of SWHs in the Thulamela Local Municipality is their potential to reduce household electricity costs by up to 50%, as found in both the empirical data and the literature. Households that use SWHs reported significant savings, especially in low-income areas where energy costs comprise a large portion of household budgets. Additionally, the environmental benefits of SWHs, including the reduction of carbon emissions, are in line with South Africa's sustainable energy goals. These findings confirm that SWHs offer both financial and environmental advantages.

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6.6.2 RESEARCH QUESTION 2: WHAT ARE THE CHALLENGES OF USING SOLAR WATER HEATING SYSTEMS FOR DOMESTIC PURPOSES IN THULAMELA MUNICIPALITY?

Challenges to adopting SWHs identified in the study include high initial installation costs and inconsistent performance, particularly during cold months when sunlight is limited. Many households cited the lack of reliable technical support and the need for maintenance as significant barriers. Inadequate awareness about the long-term benefits of SWHs and the long-term cost savings were other barriers, as many families hesitated to make the initial investment without clear information. These challenges need to be addressed through government incentives and support programs.

6.6.3 RESEARCH QUESTION 3: WHAT IS THE FEASIBILITY OF SOLAR WATER HEATERS AS MEASURES TO ADDRESS THE ENERGY CRISIS IN SOUTH AFRICA?

The study concluded that SWHs are feasible in helping to address the energy crisis, especially in regions like Thulamela, where access to electricity is often inconsistent. The ability of SWHs to provide hot water without relying on Eskom’s grid offers a solution to energy shortages and rising electricity costs. The feasibility of SWHs, however, is contingent on the support provided by government programs, technical training, and public awareness campaigns. Without this, SWH adoption will likely remain slow and limited to high-income households.

6.7 CONTRIBUTIONS OF THE STUDY TO THE BODY OF KNOWLEDGE

The effects of solar water heaters on homes, specifically in Thulamela Municipality, appear to have not been studied, while Chidembo et al.'s (2024) study examines the underlying assumptions that influence the adoption of solar heater systems (SHS) in South Africa's Vhembe District. Due to this notable deficiency, research on the advantages and disadvantages of solar water heaters for families in Thulamela Local Municipality is required. As the first inquiry of its kind to be carried out in South Africa, the current study represents a novelty and advances academic knowledge.

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6.8 IMPLICATIONS FOR PRACTICE AND RECOMMENDATIONS TO STAKEHOLDERS

The study into the effects of solar water heaters (SHS) on homes in Thulamela Municipality, as highlighted in the study, carries significant implications for energy policy, sustainable development, and rural empowerment in South Africa. As the first study of its kind in the region, it provides valuable insights into the practical benefits and challenges of SHS adoption, which can inform policy decisions at both local and national levels.

The key policy implications of this research are as follows:

1.Promotion of Renewable Energy Adoption: The findings from the study can serve as a foundation for promoting the adoption of SHS as a sustainable energy solution. The South African government, particularly through the Department of Energy and municipalities like Thulamela, should consider scaling up programs that support the installation and adoption of solar water heaters in rural and underserved areas. Policies that incentivize the installation of SHS, such as tax credits or subsidies, could significantly reduce household energy costs, thereby improving the quality of life for families.

2. Integration of Solar Water Heating in Rural Development Strategies: The research highlights the potential of SHS to improve energy access and reduce dependency on grid-based electricity, which is often unreliable in rural areas. As such, Thulamela Municipality could integrate SHS into broader rural development strategies. This may include leveraging SHS as part of a wider initiative to achieve energy security, alleviate energy poverty, and enhance climate resilience. Policy frameworks could be developed to ensure that SHS are affordable and accessible to all households, particularly those in remote rural communities.

3. Addressing Socioeconomic and Environmental Benefits: Solar water heaters have clear economic and environmental benefits, such as reducing electricity bills and lowering carbon emissions. Policymakers could emphasize these advantages

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in the design of national energy transition policies and initiatives aimed at mitigating climate change. The findings from Thulamela could be used as a case study to encourage other municipalities to adopt similar renewable energy technologies, particularly in low-income areas.

4. Education and Awareness Campaigns: For SHS adoption to succeed, it is essential to raise awareness about the potential benefits of solar energy systems. The study's findings suggest that local communities in Thulamela may lack sufficient information about solar water heaters. A government-led or municipal-level policy initiative could include the establishment of educational campaigns and workshops to educate communities on the long-term savings, sustainability, and environmental benefits of SHS.

5. Overcoming Barriers to Adoption: As the study explores the advantages and disadvantages of SHS for families, it is important to identify and address the barriers preventing widespread adoption. These could include financial constraints, lack of technical knowledge, or limited infrastructure. Policymakers could design targeted interventions that address these barriers, such as financing options for low-income households, training programs for local technicians, or partnerships with private companies to reduce installation costs.

6. Support for Further Research and Data Collection: The research underscores the importance of continuing studies on SHS adoption, especially in underserved areas like Thulamela. Policymakers should support further academic and field research that can help track the long-term impacts of SHS, including cost-effectiveness, social benefits, and scalability. Such research can guide future policy decisions and improve the implementation of solar energy programs across South Africa.

7. Alignment with National Energy and Climate Goals: The promotion of SHS in rural municipalities aligns with South Africa's broader national energy and climate goals,

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particularly the shift towards a low-carbon economy. Policymakers can use the findings from this study to strengthen national strategies like the Integrated Resource Plan (IRP) and the National Development Plan (NDP), which call for the diversification of energy sources and the reduction of carbon emissions.

In conclusion, this study offers critical insights into the potential of solar water heaters to address energy challenges in Thulamela Municipality, while also contributing to South Africa's renewable energy goals. Policymakers can leverage these findings to design more inclusive, sustainable energy policies that support the adoption of solar technologies in rural and marginalized communities.

6.9 LIMITATIONS OF THE STUDY AND DIRECTIONS FOR FUTURE RESEARCH

6.9.1 STUDY LIMITATIONS

1. The research was limited to Thulamela Local Municipality, which may affect the generalizability of the findings to other regions in South Africa or beyond. While the study provides valuable insights, its applicability to different socio-economic contexts should be approached cautiously.
2. The study employed a qualitative research approach, which provided in-depth insights but did not include statistical analysis. Future research could complement these findings with quantitative data to validate the conclusions more broadly.
3. The study could have explored non-adopters of SWHs in the municipality,

6.9.2 FUTURE RESEARCH DIRECTIONS

1. Replicating the Study in Other Municipalities

Future researchers may find value in replicating this study in other rural and urban municipalities across South Africa. This could provide a comparative analysis to aid understanding of whether the challenges and benefits identified in this study are consistent across different geographical and socio-economic contexts.

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2. Exploring Quantitative Analysis

A future study using a quantitative approach would provide statistical evidence on the financial and environmental impact of SWHs. Such research could analyze large-scale data to offer more precise insights into the cost-benefit analysis of SWH adoption in rural and urban households.

3. Exploring a comparative Analysis

The study focuses on Thulamela Municipality; future research could explore a comparative analysis across different regions to enhance generalizability.

6.10 CONCLUSION

The purpose of this study was to explore the effects of solar water heaters (SWHs) on households in Thulamela Local Municipality, focusing on both the benefits and challenges of adoption. The study's findings revealed that SWHs offer significant financial and environmental advantages to households. Solar water heaters reduce reliance on grid electricity, resulting in substantial savings on energy costs, particularly for low-income households. In addition, SWHs contribute to reducing carbon emissions, aligning with South Africa's broader goals for promoting renewable energy and combating climate change.

One of the key outcomes of the study is that while solar water heaters require an initial investment, they represent a long-term solution, with a lifespan of up to 20 years. Participants reported a lack of physical challenges after installation, highlighting that SWHs are generally low-maintenance systems, which continue to provide reliable hot water with minimal concerns. SWHs, hence, are seen as a durable, cost-effective investment for households over the long term, making them a viable solution for reducing energy costs and enhancing energy security.

The results revealed the long-term benefits of SWHs, however, the high initial installation costs remain a significant barrier for many households, particularly in low-income areas.

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This challenge, along with limited awareness about the advantages of SWHs, restricts their widespread adoption. The results, therefore, have acknowledged the critical role of government support in overcoming these barriers. South Africa faces an energy crisis, with frequent load-shedding and rising electricity prices. In this context, SWHs offer a practical solution to reduce pressure on the national grid by cutting electricity demand for water heating. Government interventions, such as financial subsidies, low-interest loans, and incentives for adopting renewable energy solutions, are necessary to make SWHs more accessible to all households.

In conclusion, solar water heaters represent a feasible and sustainable solution for addressing household energy needs and the broader energy challenges in South Africa. Their long lifespan, minimal maintenance requirements, and significant energy savings make solar heaters a smart investment for the future. For SWHs to achieve widespread adoption, it is, however, essential that the government plays an active role in supporting solar-energy initiatives, particularly by providing financial assistance and creating public awareness. With the right support and policies, SWHs have the potential to contribute significantly to alleviating South Africa's energy crisis while at the same time promoting environmental sustainability and economic savings for households.

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APPENDIX: RESEARCH QUESTIONS

Research Question 1: What are the benefits of using solar water heating systems for domestic purposes in Thulamela Municipality?

Research Question 2: What are the challenges of using solar water heating systems for domestic purposes in Thulamela Municipality?

Research Question 3: What is the feasibility of Solar Water Heaters and measures to address the energy crisis in South Africa?

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