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Manufacturing Solar Water Heaters in South Africa:

The Benefits and Costs

By Craig Backe-Hansen

Student Number: 208506813

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Supervisor: Dr Mihalis Chasomeris

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DECLARATION

I, Craig Backe-Hansen declare that

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ABSTRACT

There is potential to use solar energy instead of electricity as an energy efficient method of heating water. This study investigated the costs and benefits of solar water heater manufacture in South Africa and aimed to provide a better understanding of the industry in order to promote a better life for all.

Local manufacturers have already recognised the costs and benefits of solar water heaters. This study drew on the findings of international practices and applied these to the South African context. The costs and benefits include the high price of solar water heaters, lack of awareness of the technology, the absence of legislation, a tedious process for rebates, non-mandatory standards, insufficient training facilities leading to a shortage of skills and the low price of electricity.

The research methodology was qualitative in nature and the study was supported by current relevant theory and the results of six open-ended questionnaires completed by local manufacturers. The information gathered from the questionnaires was analysed and compared with the theory and international current best practice.

The benefits of solar water heating can be enhanced by more government involvement in the development of policies to promote local manufacture and educate the public on alternative energy sources. Poor public awareness of the technology can be improved through awareness programmes at schools and frequent broadcasts on all media.

There is a dire need for the development of cost effective financing mechanisms as the high costs of production directly influence the price of solar water heaters. Financial incentive models such as rebates could be used more effectively to assist low and middle-income groups with partial funding for the purchase of a solar water heater.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION TO THE RESEARCH

1.1 Introduction

This chapter introduces the problem statement. It examines the need for solar heating to be rolled out far more widely in South Africa. This is an important strategy because of the electricity crisis in the country, the high cost of power and the need to be environmentally friendly. The objectives of the study are outlined in this chapter, as are the research methodologies used, the limitations and the significance of the research. A chapter outline is also provided.

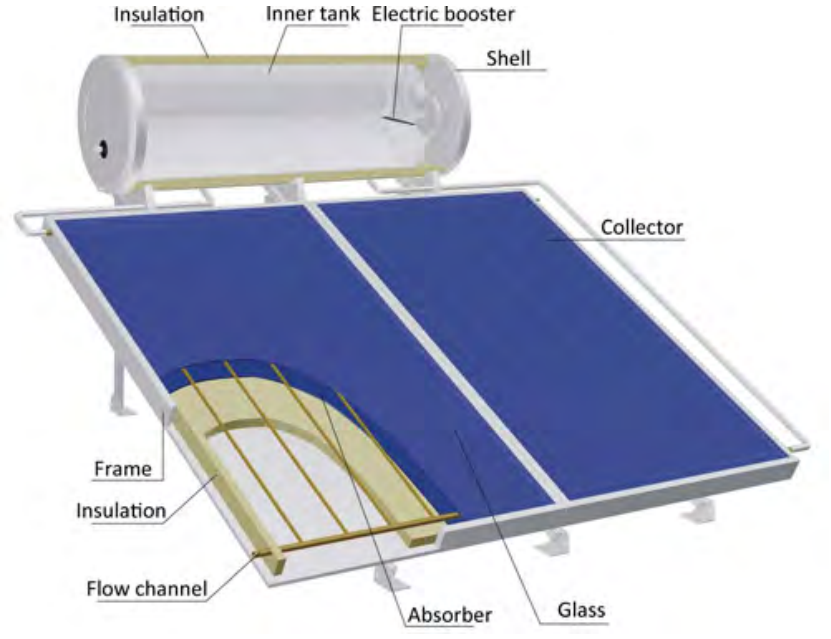
1.2 Background

Due to significant climate change across the globe, environmental activists are applying intense pressure on governments and organisations to implement 'green' technologies to reduce the threats from and reliance on fossil fuels. The Kyoto Protocol, signed and undertaken by several developing and developed countries in 1997, and described as "a commitment to reducing their greenhouse gas emissions by an average of 5.2% of their 1990 levels" (IEA, The Kyoto Protocol in 2002 opportunities for coal, Deborah Adams 2002, p. 5) is a further indication of the seriousness of this situation. Fossil fuel is currently the primary energy source for the generation of electricity. As a result, companies using the electricity generated by these plants are responsible for a significant portion of the greenhouse gases emitted into the atmosphere. The replacement of fossil fuels by renewable energy sources in the generation of electricity will have the direct consequence of reducing greenhouse gas emissions. This in turn, will save the planet from the perils it faces as a result of increased global temperatures and general climate change.

Many sources of renewable energy are available to replace fossil fuels. These include wind, solar, wave, and hydroelectric energy. This study focuses on solar energy which, through the installation of solar collectors, can be used to heat water for both household and industrial use. The potential costs and benefits of the local manufacture of solar water heating units is the main focus of the study. There are currently only six local manufacturers of solar water heaters and a large number of South African companies currently import these units. The aim

of the study is to demonstrate how increased local manufacture of solar water heating units can contribute in different ways to both the national economy and the national skills base. The training required to manufacture the units will mean that local people are up-skilled and have the opportunity to increase their personal earning power. The local market for local raw materials will grow and South Africa will be able to retain economic value that is currently being lost to international manufacturers.

The basic process of a solar water heater relies on the principle that black objects absorb a great amount of heat energy produced by the sun. In order to harness this energy, a solar collector is constructed. The collector is a large, flat box that contains an absorption plate, a set of collection tubes with a manifold at each end and a plate glass cover plate. The collector plate, the collection tubes and the inside of the box are all painted black. The collector is then connected to a geyser that incorporates a timer, and the entire assembly is then mounted on the roof of a house or factory. It is angled so that it receives maximum exposure to the sun. In the Southern Hemisphere this is done by facing the collector north at an angle of latitude plus 10°. The incoming water is connected to the inlet at the lowest point while the geyser is connected to the outlet at the highest point. As the water flows up the collection tubes it is heated by absorbing energy from the sun and this hot water is then stored in the geyser. Figure 1.1 below illustrates this process.



(Figure 1.1).

Google Image Result for http--www.himinsun.com-1Solar-Water-Heater-9-1.jpg

Solar water heaters are built in various configurations to fulfill different needs. There are two main classifications: active systems and passive systems. In an active system, the circulation is forced by means of a pump. There are four different types of passive systems: thermo-siphon, close coupled, split solar system and integral solar systems. This study investigates the manufacture of these systems in South Africa. In a bid to encourage people to install solar systems rather than rely on electricity for their water heating needs, to date all government sponsored subsidies and incentives have targeted the consumer.

Local manufacturers of solar systems are expected to compete against imported systems, particularly those from China and Europe. These systems come into South Africa in two different forms, either fully assembled or as component parts ready for local assembly. At present no import duties are levied on either the Chinese and European systems. The local industry is therefore under immense pressure to compete in terms of price. Practices such as the industrial dumping of old technology products by countries like China are also an ever-present threat.

1.3 Overview of Solar Water Heater Manufacture in South Africa

Solar water heater manufacturers in South Africa are currently experiencing a decline in production as a direct result of increased imports, mostly from China. At the National Solar Water Heating Workshop held in February 2009, the Chief Executive of the SA National Energy Research Institute (SANERI) commented that the development of the local solar water heater industry was similar to "the gestation period of an elephant" (Nassiep, 2008), a reference to the slow pace of development in the industry as a whole.

Domestic water heating consumes approximately 18% of South Africa's total coal-generated electricity. If this consumption could be replaced with a renewable energy source such as solar water heating, there would be a significant reduction in domestic demand for electricity (Gabashe, 2009). Eskom estimated in 2009 that the installation of 925 000 solar water heaters would cut its peak demand by 578 MW (Gabashe, 2009). This calculation is based on the assumption that domestic electric geysers account for between 30% and 50% of the average household electricity account.

1.4 Motivation for the Study

The motivation for this study is the need to identify both the costs and benefits of the local manufacture of solar water heaters. Many previous studies focused on the rollout of solar water heaters. There is a paucity of research on the economic role that could be played by the manufacturers and second tier suppliers that are active in this sector of the economy. Many media reports on the solar water heater manufacturing sector in South Africa have emphasised the failure of these companies to survive. However, Greve (2012) found that there has been an overall increase in the number of manufacturers in South Africa.

1.5 Value of the Study

Eskom recognises the benefits of solar energy as a renewable energy source. These benefits are twofold. Firstly, Eskom would benefit by augmenting its energy generation source with this renewable energy. Secondly, there would be a reduction in electricity demand due to the support offered by solar water heaters and this would reduce the pressure on Eskom's grid.

The value of this study is that it will clearly identify that true costs and benefits of the local manufacture of solar water heaters in order to optimise production to the benefit of the country.

1.6 Problem Statement

The current problem that requires immediate and urgent attention is the security of the electricity supply in South Africa. This is currently under threat due to the small electricity reserve margin available for continuous supply to consumers. Outages and rolling blackouts have had an extremely negative effect on the South African economy. Inadequate supply is due to increasing demand for electricity combined with a delay in the commencement of capacity expansion programmes in the form of new power stations. In order to better control the demand side of their business, Eskom's Demand Side Management department has identified two items as being of significant importance: water heating and lighting. A large portion of electricity usage is attributed to the use of electric geysers. A successful national programme to distribute energy-saving light bulbs to households was one of the first steps in the strategy to conserve energy. Plans were also put in place for the installation of one million water heaters by 2014. It is envisaged that these will augment or be substitutes for current electric water heaters.

Dintchev (2004) identifies the following major barriers to solar water heating in South Africa:

- The low cost of electricity inhibits the mass implementation of electric water heaters.
- The high cost of solar water heaters prevents low-income consumers from using this product.
- A lack of consumer awareness of the impact of electric water heating on the environment.
- Lack of awareness of the potential reduction in energy related costs from using solar water heaters.
- The absence of legislation to facilitate or promote the expansion of solar water heater technology.
- The absence of compulsory standards for the testing and certification of solar water heater products.

- A shortage of technically trained personnel for installation and maintenance of solar water heater products.

Holm (2005) identified a lack of awareness and the high initial costs associated with the purchase of solar water heaters as barriers to international market penetration. Further technical barriers include standardisation; testing; quality assurance; quality management; technical arbitration; mediation and dispute resolution; installation skills; maintenance skills; and certification. The barriers identified by Dintchev (2004) and Holm (2005) have been confirmed by other solar water heating experts.

1.7 Objectives of the Study

The objectives of this study are as follows:

- to identify the costs of solar water heater manufacturing in South Africa
- to identify the benefits of solar water heater manufacturing in South Africa

1.8 Research Methodology

The study employed a qualitative approach. Information was collected from peer-reviewed articles, suppliers, and manufacturers as well as recognised industry experts. Peer-reviewed articles were used to:

- determine the costs and benefits that exist in the solar water heater market; and
- investigate international practices to optimise these costs and benefits by considering, inter alia, the financing requirements for solar water heaters and the introduction of possible legislation.

There are seven manufacturers that use only locally sourced materials (not assemblers of imported components or knock down kits). seven open-ended questionnaires were forwarded to recognised solar water heater manufacturers to:

- expand on and validate the barriers identified by Dintchev (2004) and Holm (2005);
- identify any additional costs and benefits present in the market; and
- identify practical solutions to optimise the costs and benefits in South Africa.

The questionnaires were analysed as follows:

- Using an inductive approach, the collected information was perused to establish broad categories.
- Data was then analysed and interpreted to uncover relationships between categories and to develop further categories.
- The data in the identified categories was further analysed to establish relationships between categories.
- The data was integrated and summarised, offering proposals and acknowledging bias where this was obvious.

1.9 Limitations of the Study

This study identified possible solutions to optimise the relationship between the costs and benefits of the local manufacture of solar water heating systems. However, it did not determine the specific time required to implement such solutions.

The study was also limited to six recognised industry respondents. Although it incorporates relevant opinions from market participants, it does not reflect total consensus on the part of the solar water heating industry.

As the information contained herein is in the public domain, the study is limited to the available information. The author did not access any confidential Eskom documentation.

1.10 Structure of this Study

The study is divided into five chapters. The research methodology adopted was highlighted in subsection 1.5. This study includes a study of the relevant theory and international studies on solar water heaters in order to determine a framework for the dissertation. The theory is supported by responses to the questionnaires, enhancing the objectivity of the study.

Chapter One

Chapter One outlines the motivation for the study, its value, the problem statement, and the objectives, research methodology, limitations and structure of the study.

Chapter Two

This chapter presents a literature review to enable a broad understanding of the topic. It provides theoretical and practical insight into the barriers identified. Various data sources are critically examined in order to expand on the study's objectives. The findings of this chapter feed into Chapter Four.

Chapter Three

Chapter Three outlines the research methodology used in this study. It describes how the data was collected from primary and secondary sources. An open-ended questionnaire was used as a research instrument. The respondents were recognised industry experts. The process of integrating and analysing all data sources is discussed.

Chapter Four

The theory on which the study is based is discussed in this chapter. The interviews are also examined. The theory obtained from the literature review in Chapter Two is compared with the results obtained from the open-ended questionnaires administered to the respondents in the solar water heater market. The responses from the questionnaires are critically analysed and discussed to ensure that the responses are valid. A critical analysis is undertaken of all sources of information to remove any bias and to establish practical solutions that can be implemented.

Chapter Five

This chapter concludes the study and provides recommendations. The limitations of the study are discussed and areas for further research are suggested.

1.11 Summary

This chapter set out the framework for the study. It identified the problem and set objectives to resolve this problem. The research approach was described, including the methodology and research instruments. Finally, the limitations of the study were discussed and the structure of the dissertation was outlined.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter provides an overview of the literature on the topic under study. It begins with a broad overview of the economic and social benefits of manufacturing and its attendant problems. It addresses some of the strategies to overcome certain of these problems, especially sustainable manufacturing and links this strategy to the use of solar water heaters. An overview is provided of the gains and challenges of solar water heater manufacture and utilisation. The chapter concludes with an exploration of the current situation in South Africa in terms of the manufacturing and utilisation of solar water heaters.

Manufacturing is one of the cornerstones of any viable economy. It serves as the bedrock of modern-day economies. In the United States, manufacturing drives domestic research and development efforts, determines the nation's export trade and, to a large extent, determines the domestic standard of living (Langdon & Lehrman, 2012). China's impressive economic growth over the past three decades which started with radical reforms in the agricultural sector, owes its current success to its strong manufacturing sector (Brandt, Van Biesebroeck & Zhang, 2012). Great Britain's world dominance in the early 19th Century was attributed to the country's early adoption of manufacturing (or industrialisation, to use a broader term) as a key economic driver.

The divide between developed and developing economies is a combination of how early each region adopts industrialisation and the initial conditions in the region (Szirmai, 2012). However, Szirmai (2012) concluded that manufacturing had been the engine of growth in developing nations in the past 50 years and observed that, it was difficult to find examples of national development which had not been driven by manufacturing in the developing world within this time span.

A nation's success in manufacturing has traditionally been linked to its fast and judicious use of the triad of resources, land and population. A good example is the evolution of industrialisation in the USA, where industrialisation thrived thanks to the abundance of resources and land, and its population provided a ready market for mass-produced goods

(Rosenfeld, 2012). However, the frontiers of industrialisation have now expanded to the extent that nations seek to gain access to the resources of other countries through state-backed multinationals (Bremmer, 2008).

2.2 Manufacturing in South Africa

Although manufacturing has been one of the engines of economic growth in South Africa, it has been severely constrained by a dearth of infrastructure and skilled labour. The expansion of the manufacturing sector will result in improved economic growth and employment, building a stronger national economy (Rodrik, 2008). South Africa's national view on manufacturing is succinctly captured in a Department of Trade and Industry (2003, p. 31) report as follows:

South Africa, through its past policies, has developed an established a diversified manufacturing base that has demonstrated resilience and the potential to compete in a global economy. The manufacturing sector provides a locus for stimulating the growth of other activities, such as services, and achieving specific outcomes, such as value addition, employment creation, and economic empowerment. This platform of manufacturing presents an opportunity to significantly accelerate our growth and development if approached appropriately. If this capacity does not exist, as is the case in many African economies, then prior steps to build infrastructure and institutions are essential. This is the approach taken in Nepad in relation to the economic development of the African continent.

While South Africa is richly endowed with basic resources such as abundant labour and cheap land which should encourage both domestic and foreign interest in its manufacturing sector (Asafo-Adjei, 2009), manufacturing has not reached its full potential.

2.2.1 Benefits of Manufacturing

As noted earlier, manufacturing offers a host of benefits and value-adding advantages. Rosenfeld (2012) believes that in addition to job creation, manufacturing is a tool to develop rural communities. It results in the mass production of goods which reduces their selling price and ultimately improves citizens' quality of life. Moving from a mineral exploration-based

economy to a more manufacturing intensive one that exploits its abundant resources, would accelerate South Africa's development and put the country on par with the developmental nations of the 21st century (Edigheji, 2010). However, it is worth noting that this manufacturing-driven development is contingent on the judicious use of resource rents that would accrue from manufacturing; otherwise South Africa runs the risk of becoming another victim of resources curse (Frankel, 2010), where the country's resources are plundered by international companies who profit far more from the deal than the local population. Good examples of this can be seen in Africa where countries with great mineral wealth struggle with poor economic performance.

Other ways in which manufacturing adds value to the national economy is through commodity exports and the attracting foreign direct investments. However, if not carefully structured, these adjuncts of trade liberalisation may spell doom for a nation. Buckley (2009) believed that multinational companies tend to lower the price of both physical and service inputs in the developing host country through their high purchasing power whilst also attracting small entrepreneurs (who may have been their competitors) to take up managerial positions in the bigger company. There is also potential for industrial growth to be constrained in these global factories if the host developing countries are seen as mere suppliers of labour intensive manufacturing or service providers. Buckley further argued that this trend could have long term devastating effects on national development if the host country does not have the capability to develop without foreign investors. While the presence of multinationals and foreign direct investments may stimulate employment growth, and knowledge and technology transfer in certain sectors, this may not hold true in others. The benefits depend largely on the nature of different industries (Blalock & Simon, 2009; Motohashi & Yuan, 2010). In order to balance the matrix, Edigheji (2010) advocated for sound policies that promote import substitution and export promotion, opening up new markets for the developing manufacturing sector.

The unprecedented changes in the global economy have impacted the manufacturing as well as other sectors. While manufacturing was traditionally the biggest job generator, it is fast losing that status in the face of technology which is shifting many processes from being labour intensive to capital intensive (Evans & Staveteig, 2009). An additional factor in Southern Africa if the already high and increasing industrial concentration in a few large manufacturers (Fedderke & Szalontai, 2009). This results in a less competitive environment where price and quality are determined by one or two organisations, and the rest of the

industry is forced to operate at the same levels. “It is the degree to which production in an industry - or in the economy as a whole - is dominated by a few large firms” (Shughart II, 2008). Fedderke & Szalontai (2009) believed that the nature and trend of industrial concentration in South Africa raises product mark-up significantly above marginal cost, thereby lowering productivity growth.

Despite these challenges, the importance and relevance of manufacturing (as is the case for agriculture) for economic growth cannot be overestimated even if the sector is not the principal source that drives employment and increased well-being (Edigheji, 2010).

2.2.2 The Cost of Manufacturing

Like any other endeavour, manufacturing has its attendant downsides or costs. Manufacturing activities often require entrepreneurs, customers and the general public to make some trade-offs. Firstly, delineating certain areas or an expanse of land as non-cumulative industrial zones means that such areas are reserved solely for industrial purposes. This obviously means that this land is not available for other worthy purposes. Furthermore, the location of industries can increase the distance to market for the manufactured goods, with attendant cost implications for consumers (Hills & Schleicher, 2010).

It is a common knowledge that human activities have a very real tendency to subvert global ecological and geopolitical stability based largely on our material consumption and energy requirements (Rees & Wackernagel, 2012). Both material consumption and energy requirements have a close relationship with manufacturing. Manufacturing activities have profoundly negative impacts on natural resources both in term of depletion as a result of the demand for raw material and the contamination of some of these resources, notably air and water (Despeisse, Ball, Evans & Levers, 2012; Okonkwo, 2013). Furthermore, a significant proportion of manufacturing activities in South Africa, as is the case in other developing countries, relies on fossil fuel. Both the consumption and manufacturing of fossil fuel are sources of carbon dioxide which is one of the major causes of the global eco-imbalance (Arrow, Dasgupta, Goulder, Mumford & Oleson, 2010).

Technology enhanced manufacturing which is best practice in the current era, has far reaching social implications. One of these is what Brynjolfsson & McAfee (2011) described as “the race against the machine”. This implies that as a result of high-tech manufacturing, its

employment generating capability has been reduced. Dependence on automated machines translates to lower requirements for human labour. Fewer people are employed and those who are need to be highly-skilled. The effect is more significant in developing countries where there is not a ready pool of highly skilled workers; employees with the necessary skills are brought in from the foreign investor's home country. This means that the host country's job creation levels are low when foreign owned companies set up manufacturing sites. On the other side of the equation, production downtime in these high-tech production environments puts manufacturers at the mercy of machines and if appropriate technological skills are not readily available, this could have far reaching economic and business implications.

Despite the advances in manufacturing technologies and their global diffusion, Fuchs (2012) noted that these advances do not necessarily translate into innovation and profitability. In his investigation of the relationship between locations and the innovation trajectories of manufacturing technologies, he submitted that technology that works perfectly in one location might not do the same in another location. He observed that, contrary to the thinking in neoclassical economic literature,

> *moving manufacturing to developing countries, rather than leading firms to invest more in higher-value added activities, can lead to firms reducing innovation back in the home country* (Fuchs, 2012, p. 2).

2.3 Manufacturing, Environment and Sustainability

The Industrial Revolution not only transformed society via rapid development and the introduction of a variety of new products, it equally bequeathed humankind the depletion of our natural resources, the alteration of natural habitats and high pollution levels from industrial processes and by-products as well as from discarded products that have outlived their usefulness. All these have serious ecological implications and recognition of the severity of the situation has led the drive towards cleaner production processes and strategies (Young, Byrne & Cotterell, 1997). There is now strong advocacy for sustainable development (SD) which is "an approach to progress which meets the needs of the present without compromising the ability of future generations to meet their own needs." (WCED, 1987, p. 8). The mantra of being sustainable is *people, profit and planet*' this is one of the keys to a safer future (Despeisse, Mbaye, Ball & Levers, 2012).

The literature on manufacturing suggests a plethora of initiatives and innovations to achieve sustainability. These include, but are not limited to, the concepts of lean manufacturing, green manufacturing, green supply chain management, etc.

Lean manufacturing implies a set of manufacturing principles and practices that aim to eliminate waste. According to Reeb & Leavengood (2010), common manufacturing waste areas that have become the focus of lean manufacturing include over-production, waiting or idle time, unnecessary movement of people and materials, and non-value adding processes and procedures. Although green and lean manufacturing are similar as both are geared towards waste elimination, they have an entirely different focus. While lean sets out to save costs, green aims to protect the environment. However, recent studies have confirmed that companies that adhere to lean principles, naturally transcend to being green and are generally greener than non-lean companies (Bergmiller & McCright, 2009; Miller, Pawloski, & Standridge, 2010; Yang, Hong & Modi, 2011).

Green manufacturing refers to an eco-friendly paradigm. This could either mean the manufacture of "green" products, particularly those used in clean technology of all kinds and renewable energy systems, or the "greening" of the manufacturing process which implies the adoption of processes and systems that aim to reduce pollution and waste. This could be achieved by minimising natural resource use, recycling and reusing waste, and reducing emissions (Allwood, 2005). Green manufacturing is concerned with those wastes that negatively impact the environment (Bergmiller & McCright, 2009). The core strategy therefore involves creating products/systems that use less energy, substituting toxic or non-renewable inputs with non-toxic or renewable ones and reducing or converting unwanted outputs (Deif, 2011).

Green supply chain management (GSCM) is a cross-disciplinary approach adopted by companies to improve their environmental performance (Abdul Rashid, Evans & Longhurst, 2008). GSCM emerged primarily in response to international awareness of the environmental impact of supply chain activities and the impact of associated cost savings and improved brand image on the bottom-line (Min & Kim, 2012). It refers to the integration of environmentally friendly choices with supply chain practices (Srivastava, 2007). Min & Kim (2012, p. 40) broadly defined green supply chain management as:

> *an incorporation of environment-friendly initiatives into every aspect of supply chain activities encompassing sourcing, product design and development, manufacturing,*

transportation, packaging, storage, retrieval, disposal, and post-sales services including end-of-product life management.

It is worth noting that paradoxically, studies have found that the economic implications of green purchasing are much more significant than its environmental implications (Green, Zelbst, Meacham & Bhadauria, 2012; Zhu & Sarkis, 2007).

2.4 The Solar Water Heater

Solar energy is regarded as a major energy source for a sustainable and greener future. Its transformation is highly eco-friendly and it is abundantly available. Thirugnanasambandam, Iniyan & Goic, (2010, p. 313) noted that:

> *the Sun emits energy at a rate of 3.8 1023 kW, of which, approximately 1.8 1014 kW is intercepted by the earth, which is located about 150 million km from the sun. About 60% of this amount or 1.08 1014 reaches the surface of the earth. The rest is reflected back into space and absorbed by the atmosphere. About 0.1% of this energy, when converted at an efficiency of 10% would generate four times the world's total generating capacity of about 3000 GW. It is also worth noting that the total annual solar radiation falling on the earth is more than 7500 times the world's total annual primary energy consumption of 450 EJ.*

The solar water heater is arguably the oldest and the most widely deployed solar energy-based technology(Li, Rubin & Onyina, 2013); its technology harnesses the heating capacity of the sun's energy. From time immemorial people have used the sun's radiation to heat water. However, since the adequacy of such heating cannot be guaranteed at all times due to the unpredictability of the weather, it is necessary to find a way to store the solar energy for use when the sun is not shining; hence the emergence of solar water heaters (Laughton, 2010). The origins of the solar water heater date back to the early 19th century if not a little earlier (Laughton, 2010) and its economic benefits compared with electricity powered water heating was recognised in parts of the USA as early as 1938 (Scott, 1976). There is record of a US patent for solar water heaters as early as 1908 (Huntoon, 1908). The solar water heater industry has grown steadily. Mekhilef, Saidur & Safari (2011) noted that global utilisation of solar water heaters grew at an annual rate of 30% in the past 32 years.

Solar water heaters offer significant economic and environmental benefits. A life cycle analysis by Kalogirou (2009) showed that a solar water heater is far cheaper than heating with electricity or diesel fuel and has a shorter payback period. Furthermore, solar water heaters have minimal maintenance costs, are free from green-house gases that usually accompany the use of fossil fuels to heat water and some designs can even store the heat from ambient air as well as from solar radiation (Thirugnanasambandam *et al*., 2010).

Despite their short payback period, and low maintenance costs, solar water heaters still pose affordability issues, especially in poor communities as the installation costs are higher than traditional water heating methods. Even in China with its mass production of solar water heaters (Han, Mol & Lu, 2010), there are very high upfront costs compared with other energy sources. Lack of awareness, poor public perception and a lack of government policy are some of the major issues which work against the widespread utilisation of solar water heaters in developing countries (Ogueke, Anyanwu & Ekechukwu, 2009).

Another problem is the lack of standardisation and certification in the solar water heater manufacturing industry (Ogueke *et al*., 2009) leading to widely varying experiences amongst users. The efficiency and performance of the product will largely depend on the configuration or design and the manufacturer. Almost 70% of the solar water heaters produced in China, currently the largest producer and consumer of the product, are of low quality (Liu & Liu, 2013). Also germane to the economics of solar water heaters is their life span under different climatic and water quality conditions (Raisul Islam, Sumathy & Ullah Khan, 2013); these obviously have considerable implications for the decision to purchase and install the system.

2.4.1 Solar Water Heaters in South Africa

Electricity demand in South Africa increased by 50% between 1990 and 2007 and has been on the increase since then, resulting in billions of rand being committed to electricity generation annually. The country's electricity generation remains insufficient to meet current demand. The solar alternative has been grossly underutilised, despite the country's high proportion of sunny days per year (Donev, van Sark, Blok & Dintchev, 2012). South Africa currently relies on coal for 92% of its electricity generation, illustrating the need for a more sustainable power source (Özdemir, Marathe, Tomaschek, Dobbins & Eltrop, 2012).

In a bid to address nation energy challenges, in 2009, the South African government resolved to ensure that one million solar water heaters were installed over the next five years through the electricity utility company, Eskom (Department of Education, 2009).

2.4.2 Government Solar Subsidies

The primary goal of the government's solar subsidies as a demand side management mechanism was to increase the demand for solar water heaters. Hertzog (2011) stated that at the beginning of the programme, 50% to 70% of all solar systems installed in South Africa were locally manufactured. At the time, Eskom was adamant that local industry did not have the required capacity, even though Eskom had not yet included a local content multiplier in the rebate formula (Hertzog, 2011). Francois Du Plessis, the chief executive of Green Cape, an agency established by the Western Cape provincial government is quoted as saying, "many of the procurement rules and incentives had been written without taking into account the practicalities of the market and manufacturers that already exist" (Hertzog, 2011).

The installation rebate is calculated on each solar water heater system's Q-factor (the systems capability to replace electricity). Each system is tested by the South African Bureau of Standards and receives a rating on its capability to replace electricity. Rebates therefore vary according to the specific size of the system installed. Current rebates range between R3 218 and R8 964. The system that was set up in South Africa proved costly for local component manufacturers to break into and it discriminated against them in favour of imported systems. Du Plessis said "we are paying tax payers money in rebates to import products" (Hertzog, 2011). This means that the only sector that experienced any growth as a result of the subsidy was the sales and installation sector. Local material suppliers and manufacturers reaped little or no benefit from the cheap electricity sold to the smelters and other local raw materials manufacturers. This ultimately translated into to a more expensive product from local solar water heater manufacturers which put them out of the market in the face of cheaper imported alternatives. Although this problem was experienced during the initial stages of the solar water heater programme, good sense subsequently prevailed and the rebate system programme was comprehensively overhauled.

The new rebate system released in November 2012 offers considerably more favourable terms for local manufacture and content. Although the South African government has an on-

going programme to electrify low income rural housing, at the current price of electricity, the majority of these households rely heavily on the government's free basic electricity of 50kwh a month. This allocation is, however, insufficient to support the operation of an electric water heater. Because of their low rate of consumption, this sector of the population is not the sector that will produce the greatest savings in electricity. These savings will come from the more affluent portion of the population, the middle and upper income sectors that use far more electricity. Dintchev (2004) stated that solar water heaters are attractive to these sectors as they are able to afford them, and are able to offset the capital cost of the equipment against the electricity savings achieved. Although the Global Environmental Facility (1997) stated that solar water heaters are considered a luxury item by middle to high income earners, on-going escalation in electricity tariffs and the potential for blackouts is fast changing this perception.

All six respondents to the questionnaires were of the opinion that they are able to manufacture solar water heaters at competitive prices. These manufacturers use local components, adding to the local economic growth potential offered by this sector.

2.5 Costs

The costs of local manufacture include the costs of all inputs normally associated with manufacture, namely materials, overheads and labour. The average production cost of a solar water heater in South Africa was estimated at R3 756.00/m^2 with materials constituting 31.2% and labour 16% of the costs (Cheng, Lin, Ross and Chung, 2011). Costs include distribution, installation and maintenance which together amount to approximately one third of the total installed cost.

Additional costs include lost opportunity costs caused by imports. These costs not only directly affect this sector, but second tier suppliers and the country's economy as a whole. In South Africa, the suppliers of at least some of the raw materials derive benefits from specially negotiated cheap electricity prices from Eskom. However, this does not represent a competitive advantage for the local business or industry in the form of better pricing structures for locally manufactured raw materials.

The economies of scale and brand loyalty barriers to entry discussed in Naicker's (2010) dissertation "Solar water heating: reducing the barriers" can also be regarded as costs and benefits to the industry. For example, there is a cost in terms of job creation and price levels

not being met due to the fact that the economies of scale have not yet been achieved. At present, there are no large manufacturers in the sector and there is a great deal of competition in terms of cost and price from importers currently in the market.

Naicker (2010, p. 6) defined brand loyalty as, “the repeated purchase behaviour based on consumers’ satisfaction with their accumulated experiences in purchasing the same brand”. In the case of solar water heaters, brand loyalty cannot be strictly applied in this study because extensive market exposure does not currently exist in South Africa. As noted by Naicker (2010), a more appropriate term to explain a consumer’s choice of a solar water heater would be the “technology of choice”. This is due to the fact that the only real choice for the end user is currently between an electrical system and a solar water heating system.

The cost to the manufacturers of local solar water heaters is a macro-economic one. Eskom supplies electricity at preferential rates to the manufacturers of the raw aluminium and copper that are used to produce solar water heaters. This material is then supplied to local manufacturers at a certain price, which is not reduced despite the cheap electricity rates received by the aluminium and copper smelters. Coupled with the limited number of manufacturers delivering only a few product types, this restricts the competitive forces of economies of scale within the local marketplace which could promote price reductions. According to Chang, Lin, Ross & Chung (2011 p 4) “domestic manufacturers can meet 60% of the local demand in 2009”. It should be noted that the manufacture of flat plate collectors does not require large amounts of capital and is therefore easily scalable to meet increased demand, should it arise.

2.6 Benefits

Local solar water heater manufacturers stand to benefit greatly from South Africa's favourable solar radiation situation. Unlike countries in, for example, Europe, South Africa experiences a favourable average number of sunny days in which to generate solar power. Table 2.1 shows the available solar radiation in 12 South African cities, indicating the potential for solar water heaters in the country.

Location	Optimal tilt angle (Degree from horizontal)	Worst month at this tilt angle	Average daily insolation in worst month (Wh/m2/day	Average daily insolation over the year at this tilt angle (Wh/m2/day
Alexander Bay	30	June	5634	6713
Bloemfontein	30	June	6058	6656
Cape Town	35	June	4193	6029
Durban	35	September	4759	5075
Grootfontein	35	June	5984	6669
Nelspruit	30	November	4840	5598
Port Elizabeth	35	June	4782	5767
Pretoria	30	January	5652	6029
Roodepoort	30	January	5896	6133
Upington	30	June	6105	6914
AVERAGE			5390	6158

(Adapted from Naicker, 2010)

However, these benefits will not be properly exploited unless well-founded and proven business practices are adopted. While technical agreements and joint ventures exist in South Africa that could benefit and grow the sector, are these having the desired effect of delivering technology, jobs and capacity? In 2012 Minister of Mineral and Energy Affairs, Dipuo Peters stated that “a new approach of supporting the manufacturers that commit to bringing their manufacturing facilities to South Africa will be announced” (Peters, 2012).

The Greek government promoted locally produced solar water heaters by offering financial support to local manufacturers. It created an opportunity, and a market for the emergence and establishment of a local industry which developed during the 1980s (East Harbour, 2002). This development had progressed very well by the 1990s and became a significant contributor to the growth of the solar water heater industry in Greece.

In Jordan, the government assisted the local industry to produce inexpensive solar water heaters by exempting Jordanian companies from paying customs duty on the materials required for their production (RCREEE, 2010)

Similarly, in Barbados, legislation was promulgated to allow manufacturers to import materials duty-free and consumers were given either a partial or full tax deduction (Meyer, 2008). In Barbados, "there are currently over 35,000 solar water heaters installed and this is equivalent to about one in every three households. Solar water heaters are also widely used in the hotel industry" (Refocus, 2004). Given that Barbados is a small island, the state's support in the form of legislation and incentives to promote solar water heaters is commendable. The management of import duties on the components for solar water heaters in South Africa could be an important catalyst as local manufacturers at all levels can be supported in this way.

2.7 Operations and Supply Chain Management

Optimal management of operations and the supply chain are critical factors in managing and maintaining competitive advantage. The owners and managers of local solar water heater manufacturing plants would be well advised to take note of current trends in operations and supply management that require specialist knowledge of manufacturing, purchasing and distribution. Modern supply chain management feeds essential information to the Chief Financial Officer, Chief Information Officer, operations and customer service executives and CEOs. This is an extremely dynamic field that can have far-reaching impact on a company.

The primary objective of operations and supply management is to get the work done efficiently, quickly and without error and to ship the product to customers at the lowest possible cost. These components all contribute to the delivery of a cost effective product to the consumer. Every rand saved is an additional rand profit for the manufacturer. Innovation

in operations is a relatively reliable and low cost means of stimulating growth in a company when compared with technology investments, acquisitions, and major marketing campaigns, for example. The three main pillars in the creation of an efficient and effective operation are efficiency, effectiveness, and value. "Operations and supply management provides a systematic way of looking at organizational processes" (Jacobs, Chase and Aquilano, 2009, p6)

The Linear Programming and mathematical optimisation techniques for the allocation of limited resources among competing demands detailed by Jacobs et al, Chase and Aquilano (2009) could possibly be applied to aggregate sales and operations planning in order to determine the minimum cost production schedule. This can be used to develop short and long term plans to meet expected demand within a known set of constraints such as production capacity and workforce size. All relevant costs including regular pay rates, overtime labour rights, hiring, firing, subcontracting and inventory can be included in the calculation (Jacobs, Chase and Aquilano, 2009, p37).

Service or manufacturing productivity analysis is the comparison of efficiency between the different service and manufacturing factors to determine how to utilise the organisation's resources to achieve the same standard as the best performing unit. Data envelopment analysis is the tool used for this analysis.

Product planning is the method used when several products have different costs and resource requirements. This method will enable the organisation to determine the best product mix that will allow the manufacturer to optimise their systems and resources in order to deliver the best possible quality to cost ratio. Product routing can be used by manufacturers to determine their optimal production path. This process takes into consideration the fact that the product must be produced sequentially through several different process centres, each with its own cost and output characteristics. Some of the processes are listed below:

- Vehicle and crew scheduling: the optimal use of resources such as delivery vehicles and their operating crews optimises the movement of materials and deliveries.
- Process control: minimising scrap by planning the optimal cutting of material to achieve the sizes required for production.

- Inventory control: controlling the optimal quantity and location of the stock necessary to support production.
- Distribution scheduling: determining the most cost effective shipping schedule for the distribution of products between factories, warehouses, and retailers or installations.
- Plant location studies: determining the optimal location relative to both suppliers and customers.
- Material handling: determining the minimum cost solution for material handling within the plant as well as from suppliers to the plant and finished goods to the customer.

Linear programming comes in many forms and is called various names, including advanced planning options, synchronised planning, and process optimisation. In order for linear programming to be relevant, the following five essential conditions should exist in the problem situation:

- limited resources;
- an explicit objective,
- linearity,
- homogeneity, and
- divisibility.

The local production of solar water heaters fits these criteria well enough to make them relevant to all local manufacturers. Local manufacturers can use linear programming to hone and fine tune their production systems in order to maximise their geographic competitive advantage in the South African market (Jacobs et al, Chase and Aquilano, 2009 p38-39).

While operations management is an essential facet of manufacturing, project management contributes certain positive spin offs. Jacobs et al, Chase and Aquilano (2009 p. 59) define project management as follows:

"a project may be defined as a series of related jobs usually directed towards some major output and requiring a significant period of time to perform. Project management can be defined as planning, directing and controlling resources (people, equipment, materials) to meet the technical, cost, and time constraints of the project."

In many instances, local solar water heater manufacturers would benefit from implementing sound project management practices. The most beneficial form of project management for this particular type of industry would be functional project management because there would be minimal duplication of resources, equipment and people.

Some of the benefits of this form of project management are that team members can work on several projects simultaneously. Technical expertise would be maintained in the functional area of the business even if there was high staff turnover because the critical mass of specialised functions within the area creates synergistic solutions to a project's technical problems. There are, however, disadvantages as aspects of the project that are not directly related to the function could receive less attention, team motivation is often weak, and responses to the needs of the client are often slow.

2.8 Conclusion

It is evident from the literature that, while there are both costs and benefits to the manufacture of solar water heaters in South Africa, the benefits can far outweigh the costs as they extend across multiple layers of industry. By and large, the costs can be mitigated especially where raw material costs are concerned; this can be achieved through the local beneficiation of much of the raw material that would otherwise be exported from South Africa. The literature review revealed that many other countries have been very successful in creating large-scale employment that has been sustainable over a long period and has produced an industry that in most cases, exports its products. The benefits extend also to other spheres of society due to the fact that the goods manufactured require installation and future maintenance. Stimulating growth in this sector offers an opportunity to provide technical skills training in all the tiers of manufacturing associated with the local manufacture of solar water heaters. Other spinoffs are that it is possible to start a small manufacturing concern with minimal outlay; this fits well with South Africa's Broad Based Black Economic Empowerment policies for young black entrepreneurs and school leavers.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

Research methodology refers to the approach or the detailed steps adopted by the researcher to address the research concerns. Thus it includes the appropriate selection of participants, research instruments such as surveys, interviews questionnaires, etc., and an approach to analyse the collected data. It is not out of place to describe the research methodology as a map that provides direction for the entire research journey or process in order to accomplish the goals and aims of the research. The collection and critical review of scientific data is crucial in order to propose a solution to a problem. The choice of research methodology is of paramount importance. Leedy and Ormrod (2005) and Blumberg, Cooper and Schindler (2005) note that the research methodology determines how the research process and a critical review of the literature is conducted, using both primary and secondary sources. The Research Onion methodology (Saunders, Lewis and Thornhill, 2003) is used to address the issues of ethics, data collection processes and data analysis techniques.

This chapter therefore describes the steps taken by the researcher to acquire and analyse the data and the justifications for such choices.

3.2 Setting of the Study

While much is known about the costs and benefits of manufacturing as a whole, the generalisation of such results may not be appropriate considering the fact that each nation has its own unique economic history, trajectories and configurations that shape what works and what does not. Beneficiation that is largely associated with success often depends on the availability, nature and quality of the requisite economic factors in each context. Thus it is appropriate to conduct country specific studies in order to properly characterise the manufacturing terrain.

Like many other nations, South Africa is moving towards the green economy and one of the practical steps it is taking towards this is the widespread adoption of solar water heating for domestic use. However, it is disappointing to note that, despite the increasing adoption of these heaters, there is very little local manufacturing; indeed, this sector is in decline. This underscores the importance of this study. While the potential list of stakeholders is extensive,

as an exploratory study, this study is restricted to stakeholders who are directly involved in manufacturing solar water heaters in South Africa. The aim was to solicit their experiences and views on the benefits and cost of the local manufacturing of solar water heaters. Attempts were made to access archival materials from these organisations in terms of operating data, with little success, due to the fact that these are small organisations that are often reluctant to reveal such information.

3.3 The Research Process

The choice of the research method is critical as a poor choice will render the study open to criticism of being unscientific and illogical; “Choosing a research design for a study involves selecting the most appropriate methods or techniques to solve a particular problem under investigation” (Anderson and Poole, 2009 p. 22).

The research process follows clearly defined steps and is by nature sequential. However, it is sufficiently flexible to allow continuation even while the research and analysis continues to the next step, the skipping of steps and revisiting steps (Blumberg, Cooper and Schindler, 2005).

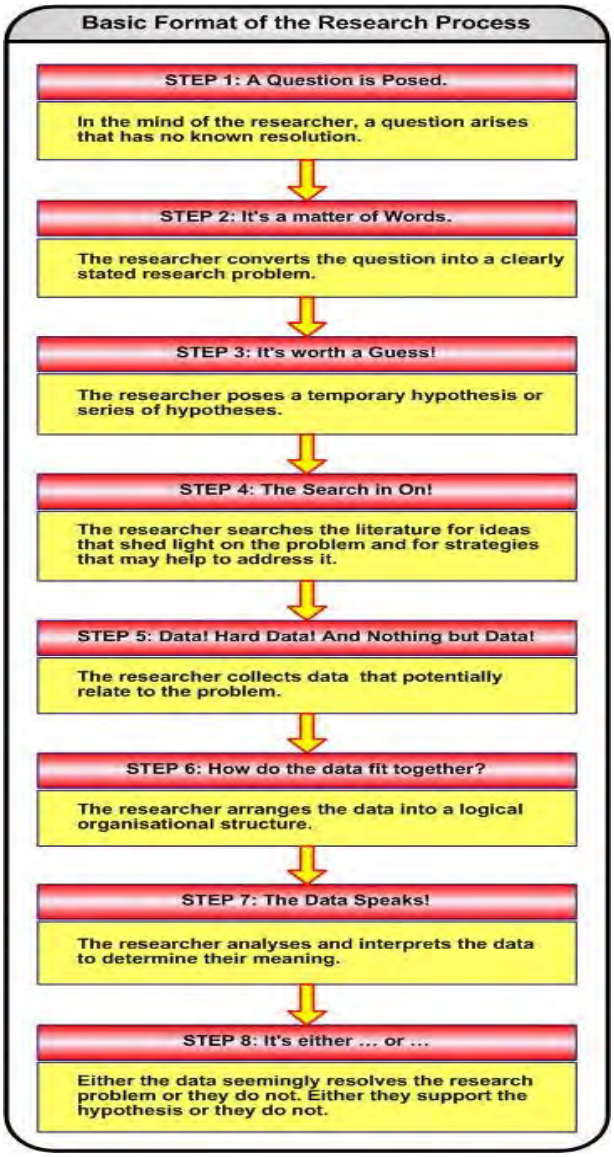


Figure 3.1. The Basic Format of the Research Process

Source: Leedy and Ormrod, 2005 p. 86.

In order to formulate a plan, an all-encompassing research process is required that details the steps towards the end goal. This will ensure that all the preliminary steps are complete before embarking on the next stage (Saunders, Lewis and Thornhill, 2003).

3.3.1 Definition of the Research Problem

The clear and unambiguous definition of the research problem is the basis of any study that focuses on a single goal. This definition is therefore the core of the research and is an essential contributor to the success of the study. Leedy and Ormrod (2003 p. 49) state, that, it is necessary to "see the problem with unwavering clarity and to state it in precise and unmistakable terms". A clearly articulated statement that identifies a single core goal (Leedy and Ormrod, 2003) assists researchers in their efforts to collect information as it minimises the collection of information that is not strictly goal-aligned.

The use of a checklist such as the one above assists in identifying any legitimate problems with the associated research area. The checklist contains attributes that assist the researcher to ensure that the chosen topic is able to generate a positive outcome. In many instances, topics that are common to the researcher's interests and knowledge can assist him/her to identify gaps and in so doing, develop expertise in the subject. Leedy and Ormrod's (2003, p. 45) six strategies which were developed to assist both the novice and expert researchers, and Anderson and Poole's (2009 p. 19) criteria which were developed for topic selection have a common theme and are in agreement with the questions posed in Figure 3.1.

Leedy and Ormrod (2003, p. 47) state, that the research problem should be sufficiently clear "that anyone who reads English can read and understand it". The research problem must be presented in a clear and unambiguous manner in order to correctly align the research with the problem. This will prevent any mismatch between the topic and the research and will assist in providing sound solutions to current problems.

The researcher may proceed to the research methodology provided the responses against the checklist are positive.

3.3.2 Research Approach and Strategy

Saunders, Lewis and Thornhill (2003, p. 82) propose a "Research Onion" model. Much like a real onion, the research onion is made up of five layers of data of varying levels of importance. These levels of data are then analysed (peeled away) progressively until the core which represents the final result, is reached.

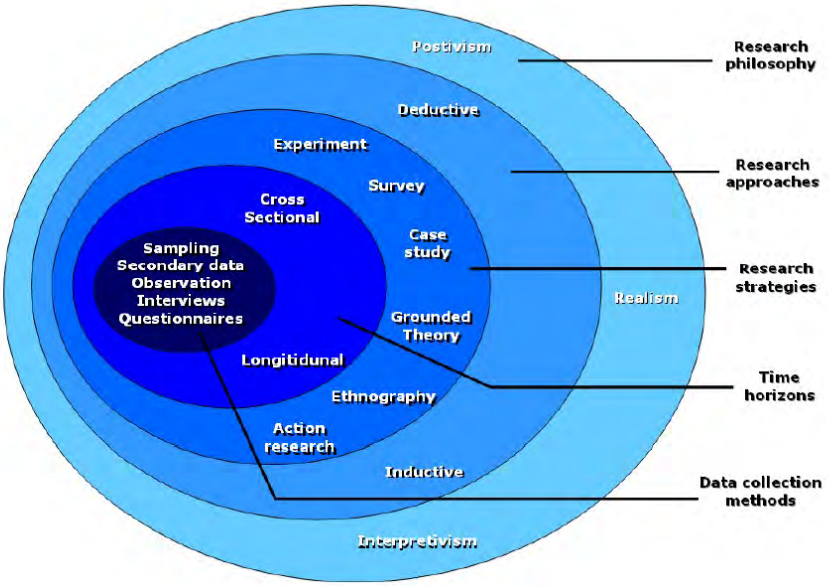


Figure 3.2. The Research 'Onion'

Source: Saunders, Lewis and Thornhill, 2003, p. 82.

The first layer raises the question of the research philosophy. These include positivism, interpretivism and realism. The current research contains a blend of these philosophies.

The second layer describes the research approach that stems from the philosophy. These approaches could either be deductive or inductive. The current research follows a predominantly inductive approach, but will apply deductive reasoning where necessary.

The third layer is the research strategy to be followed. This determines whether the researcher will use grounded theory, interviews, case studies, ethnography, experiments or surveys. In the current research, grounded theory is used to form the theoretical framework and the interview questionnaires are used to support the theoretical framework.

The fourth layer of the research onion is the time horizons. This research is a representation of events over a period of time that seeks new insights that allow the results to be practically applied to the problem at hand.

The fifth (innermost) layer is the data collection technique that involves the interview questionnaires being administered to recognised subject experts (Saunders, Lewis and Thornhill., 2003).

3.4 Study Participants

Since this research focuses on unravelling the existing and potential costs and benefits as well as the challenges militating against the local manufacture of solar water heaters in South Africa, the participants logically included individuals, organisations and institutions involved in solar water heater manufacturing in the country. All the aforementioned form the "research population". The research population refers to individuals or groups from whom a researcher solicits information to answer his/her research questions (Lunsford and Lunsford, 1995). In most cases, the research population is too large to be involved in its entirety; consequently, a smaller portion known as "sample" of the population is often selected in order to make the research feasible.

3.4.1 Criteria for sample Selection

There are usually exclusion and inclusion criteria for sample selection. These are used to select certain individuals to participate in a research study and to exclude others (Lunsford and Lunsford 1995).

The major criterion for inclusion and exclusion of participants was possession of a global view of the solar water manufacturing industry. Access to rich and detailed information about the manufacturing activities, as well as the decision process and operating details of the industry was of paramount importance. Thus participation was restricted to the owners of the seven manufacturing companies in the country. It should be noted that at the time of the study, only six of these companies were actually producing while the seventh was about to commence production.

3.4.2 Sampling Procedure

As noted earlier it is often not possible to include everyone that constitutes the research population in a study. Sampling is a methodological procedure for selecting a subset of

participants (sample) from the population. To obtain the sample that is most likely to suit their research needs, researchers make use of either probability or non-probability sampling techniques. The non-probability sampling approach is employed in this study for reasons that are explained later.

In probability sampling, all participants have a non-zero probability of being selected and the researcher's bias is greatly reduced as a result of the random selection of individuals (Lunsford and Lunsford 1995). This is often the method of choice in research where generalisation across a large population is a priority (Sekaran and Bougie 2010).

3.4.3 Non-probability sampling technique

This is the sampling designed employed for this study. In non-probability sampling, the elements in the population do not have any probability of being selected as part of the sample; rather such choice is subject to the researcher's preference, limiting the generalisability of the research findings to the population (Sekaran and Bougie 2010). However, non-probability sampling allows the researcher the freedom to select participants that adequately fit the selection criteria and that are willing and possess rich information which is of paramount importance in qualitative studies (Lunsford and Lunsford 1995) such as the present one. Sekaran and Bougie (2010) noted that non-probability sampling remains the method of choice in exploratory research and in research where a limited number of people can provide the required information.

Non-probability sampling methods are categorised as convenience sampling and purposive sampling.

3.4.3.1 Convenience sampling

This is when information is sourced only from those elements of the population that are *conveniently* available to provide it. Convenience in such cases is determined by time, cost or proximity (Lunsford and Lunsford, 1995). Sekaran and Bougie (2010) argued that, in terms of generalisability, convenience sampling is the least reliable sampling method.

3.4.3.2 Purposive sampling

This represents the sampling procedure used in this study. It involves obtaining information from a target group of people. This is usually done because such people have the required information or because they conform most to the requirements set by the researcher (Sekaran

and Bougie, 2010). Thus, rather than statistical representation, the driving force in purposive sample is the knowledge and characteristics of the participants.

This method was chosen for this research as it guarantees the accuracy of the data at minimum cost and time, which are the primary goals of sampling (Lunsford and Lunsford. 1995).

3.4.4 Recruitment

Prospective participants were contacted via telephone and email to seek their permission for inclusion in the study. The researcher ensured that all were contacted and they expressed their willingness to be part of the study.

As the participants were dispersed all over the country, face-to-face interviews were not always feasible due to time, financial and geographical constraints. The researcher decided to conduct some face-to-face interviews and to send open-ended questionnaires to the rest. While convincing these participants to participate in the study seemed almost effortless, getting them to actually participate was a significant challenge.

All seven participants enjoy national sales exposure and therefore have experience in the issues raised in this study across South Africa.

Lunsford and Lunsford (1995) noted, that there is often an inverse relationship between the ease of participants' recruitment and the success of the actual data collection. As mentioned in section 3.4, these participants are business owners who are deeply involved in the day-to-day running of their business, rendering physical access and the completion and return of questionnaires a challenge. After almost a year's effort of trying to secure face-to-face interviews without success, the researcher concluded that interviews were no longer feasible given the time frame of the study; thus open-ended questionnaires were sent to all the participants.

To mitigate some of the potential drawbacks of the lack of physical contact with the participants, a detailed explanation of the purpose and intention of the research as well as a guarantee of confidentiality was provided in the consent letter that accompanied the questionnaires. The responses showed that these were well received and understood by the participants.

3.5 Data collection

3.5.1 Data Access

Data resides in various sources (for example. books, journals, the Internet and personal experience). The choice of relevant sources is governed by the research question, the objectives and the strategy (Saunders, Lewis and Thornhill., 2003, p. 114). Issues such as a lack of time and manpower within organisations that can assist the researcher often restrict 'physical access' to data (Gummesson,2000, as cited in Saunders, Lewis and Thornhill, 2003). This is considered "the first level of access or entry." Johnson (1975, as cited in Saunders, Lewis and Thornhill, 2003, p. 114) described this impediment as a 'false start'.

Of the many levels of access that are required in order to achieve the milestones detailed in a research strategy, the achievement of physical access is but the first. Gummesson (2000) and Marshall and Rossman (1999) are in agreement that this is a process, not a single event; a sense of continuity is required.

Cognitive access follows physical access. The researcher must then position him/herself to reveal the reality of what is occurring in relation to the research conducted.

3.5.2 Tools and methods

The essence of data collection in qualitative research is to obtain and analyse different perspectives on an issue or event so as to achieve a more comprehensive understanding of the issue or event (Sale and Brazil, 2004). Thus, the instruments used in qualitative research aim to capture multiple perspectives in a reflective manner to produce new knowledge.

The field work for this study aimed to gather as much in-depth information as possible. The initial intention was to conduct interviews, but due to the accessibility issues described in section 3.4.4, the researcher settled for open ended-questionnaires. This decision was reached not only because it was the only alternative given the time factor, but also because open ended-questionnaires are the near equivalent of face-to-face interviews in terms of the richness of information gathered (Gafni, Moshinsky et al., 2003) although interviews offer advantages over questionnaires, notable among which is the effect of the questioning context even when the interview and questionnaire comprise identical questions.

In order to increase the richness of the information acquired and for data triangulation purposes, efforts were made to access archival material from participating organisations in

the form of operating data, supply records etc., but there was unanimous reluctance on the part of these manufacturing companies to provide such information. There is also little or no information in the public domain in this regard.

3.5.3 Ethics

Ethical issues abound during the researcher's journey through any organisation. Saunders, Lewis and Thornhill (2003, p129) define ethics as "the appropriateness of our behaviour in relation to the rights of those who become the subject of your work or are affected by it." Ethical issues occur at all stages of research: data collection, data analysis, and during the reporting phase. Respect for the right to privacy, openness, honesty, and the guarantee of anonymity and confidentiality are essential to protect the participants. To this end, informed consent should be obtained from all respondents. All of the above were also applied to the additional respondent and the responses have been included in this dissertation mostly highlighted in chapter four in italics.

Ethical clearance for this study was obtained and is appended to this document as Appendix 1.

3.6 Analysis of the Data

In order to reduce the collected data to its base themes, a thorough analysis must be conducted. It is commonly recognised that there is no 'right' way to analyse data in a qualitative study.

The starting point is the body of information collected by the researcher. Through a process of inductive reasoning this data is sorted and categorised (Leedy and Ormrod, 2005, p. 15). This process of analysing qualitative data is time-consuming and complex. Saunders, Lewis and Thornhill (2003); Yin (1994) as cited in Saunders, Lewis and Thornhill (2003, p. 379) and Leedy and Ormrod (2003, p. 151) agree on this point. They also refer to data that remains unanalysed for long periods due to the researcher's indecision about which analytical process to use.

Saunders, Lewis and Thornhill (2003) identified a number of common process features of the different strategies used to analyse qualitative data. The general processes are listed below:

- "Categorisation;
- 'unitising' the data;

- recognising relationships and developing the categories you are using to facilitate this;
- developing and testing the hypotheses to reach conclusions" (Saunders, Lewis and Thornhill, 2003, pp. 381-384).

The analysis of qualitative data will always be influenced to some extent by the researcher's personal values and bias. However, researchers can adopt strategies to minimise these influences on the final analysis. These strategies are listed below:

- "Collect two or more different kinds of data (e.g., observations, interviews) related to any particular phenomenon
- Get multiple and varying perspectives on any single issue or event
- Make a concerted effort to look for evidence that contradicts your hypotheses
- State any bias that you may have so that the reader can take this into account when reading the report" (Leedy and Ormrod, 2005, p. 151).

The approach to data analysis adopted in this research is the grounded theory approach. This is an iterative approach in which the researcher attempts to identify common or contradictory themes from the data. These are then used to interpret the data (Easterby-Smith, Thorpe et al., 2012).

3.7 Summary

This chapter discussed the research methodology selected for this research study. The processes and manner in which the research was conducted were also discussed. The methodology, data analysis, and ethical considerations described in this chapter provided the parameters to successfully undertake this study.

The results from the seven local manufacturers that completed the questionnaires that form the basis of the findings, together with the data and viewpoints outlined in the literature review were compiled and understood. These are presented in chapter four and the researcher's recommendations are provided in chapter five.

CHAPTER FOUR
PRESENTATION AND DISCUSSION OF RESULTS

4.1 Introduction

This chapter presents and analyses the data generated by the fieldwork. It provides insight into the respondents' experience, expertise and knowledge. As noted in chapter three, while the initial intention was to conduct interviews, due to the unavailability of the targeted respondents, a questionnaire was administered. However, while 70% of the questions were open-ended questions requiring detailed comments and explanations, they were answered in very terse statements. Thus, in order to enrich the findings, the researcher made an extra effort which yielded face-to-face interviews with two of the respondents. Nevertheless, the interviews went a long way to enrich the data collected earlier via the questionnaires.

The production costs and financing options are presented to enable a better understanding of the high price of solar water heaters in South Africa. Education campaigns to raise awareness are proposed, along with proposals for legislation to promote the growth of the solar water heater industry. The chapter concludes with an examination of the nature and volatility of electricity supply in South Africa.

4.2 Respondents

Seven respondents participated in the study. All are manufacturers from first principles operating in different geographic locations around South Africa. To identify their locations would compromise their anonymity; therefore they are referred to as Respondents 1 to 7.

4.2.1 Profile of Respondents

Respondent 1: SWH manufacturer
Respondent 2: SWH manufacturer, and installer
Respondent 3: SWH manufacturer
Respondent 4: SWH manufacturer and installer
Respondent 5: SWH manufacturer and installer
Respondent 6: SWH manufacturer
Respondent 7: SWH manufacturer about to commence production.

4.2.2 Presentation of Data (Questionnaires)

The data is presented based on the order of the questions in the questionnaire with sub-headings according to the major issues and themes that were identified through the inductive analysis of field data.

However, on account of the paucity of field data, some of the findings were augmented with findings from the literature. Thus the findings presented are mainly from the fieldwork, with supplementary relevant information gleaned from the literature.

Each question and the relevant data from the literature review are discussed together with the data collected from the respondents to form an all-encompassing view of the local situation based on local issues, theory and international current and historic practices.

4.3 The Challenges Faced by Local Manufacturers

4.3.1 Production Costs

The greatest common challenge confronting South African manufacturers is to produce a cost-competitive product. There are several reasons for this, one of which is the flood of cheap products into South Africa. These originate primarily in China that has successfully grown its manufacturing capacity to be able to capitalise on the economies of scale that present themselves for the size of production facilities they have developed. China also has various initiatives that strongly support the installation of solar water heaters. All the respondents alluded to the menace of imports, with more detailed explanations provided during the two interviews.

"There is fierce competition from imports and these imported products are mostly low quality items. There are a lot of low quality items. And when it gets here they usually fail."
(Respondent)

One respondent argued that the dominance of these imported and sometimes low quality products derives from the fact that existing policies make importation very easy.

"Relative easy entry into market - has resulted in saturated market."(Respondent)

The market is flooded by cheap imports and this is negatively affecting our sales volume and by extension our business' expansion." (Respondent)

While consumer subsidies are in place in South Africa, this has not attracted the flood of sales that was expected. At present, South African manufacturers that could contribute to the economy through increased demand and through all tiers of supply and thus create jobs at all these levels, enjoy no government support. This makes it difficult to reduce the price of local products. Support for local manufacturers is currently under negotiation. In Eskom's view, the solar water heater industry in South Africa "is still characterized by high manufacturing costs and low sales volumes" (Eskom, 2008, as cited in Bega, 2008).

One of the reasons identified for high and uncompetitive production costs is the cost of components. Locally-sourced components are expensive, despite the fact that some of the components' producers benefit from incentives.

"…… the material costs are so expensive, it's ridiculous, for example I am sourcing aluminium frames for solar panels locally, South Africa now process our own aluminium right here in Richards Bay the cheapest electricity in the world. Send it to Pietermaritzburg 50k up the road from me, they extrude it & sell it to me here in Durban at around R53.00 per kilo. Whereas I can buy aluminium extrusions from China at R26.00 per kilo."

However, the implementation of the current consumer subsidy regime is not very effective, even though it does not focus on manufacturers. The subsidy was designed as an incentive to consumers to adopt solar water heating.

"Recently it has changed as far as the subsidy goes and every time they run out of money they stop it. After extensive marketing campaign it cannot be guaranteed that the customer will receive his rebate once the budget is exhausted."

Solar water heater manufacturers' production costs primarily comprise the cost of components and labour costs. The responses to the questionnaires revealed that manufacturers do not benefit from subsidies and therefore cannot easily reduce costs. However, while the smelters of copper and aluminum are paying unpublished, extremely favourable rates for the huge amounts of electricity they consume to manufacture their products locally; the local manufacturer still pays London Metal Exchange (LME) rates for these products. Eskom could be trading cheap electricity for a better price for the copper and

aluminum produced in order to reduce the costs of the very solar water heating systems they are encouraging consumers to fit to their homes to save electricity.

"If they sell at the London Metal Exchange, (everything is linked to the Metal Exchange), so every time the dollar gets stronger, we crash and the price goes up. Now, if they sell to local manufacturers at a reasonable Rand based price, (export in dollars, fine) then we would be competitive, material-wise and could expect cheaper finished goods. That is what they need to look at and not just base everything on the London Metal Exchange."

Other important components that drive up production cost are certification (SABS) and training costs. Locally manufactured products are subjected to a very expensive certification process whose costs are solely borne by manufacturers.

"Protracted Eskom/SABS procedure and/policies with regards to product approval. Testing regime requires testing of a system and not components. Repeat testing of flat plate collector with each make of geyser size or configuration at a cost of R60k per test. (Respondent)

Cost cutting is made even more difficult due to the fact that imported components attract an import duty of 15% (Du Plooy, 2007). Although this is also under review, no decision has yet been made. The respondents would be able to improve their prices if they benefitted from local component manufacturers; this would also enable them to adopt lean manufacturing initiatives such as lower inventories and Just In Time deliveries (both inbound and outbound). All of these small initiatives will ultimately result in lower production costs through better business management.

4.3.2 Import Duties

In the current economic climate, it is important for the state to stimulate the local manufacturing sector by imposing import duties. Five of the seven respondents identified the need to *"stop all product imports"* as part of their recommendations to boost local manufacturing. According to Du Plooy (2007 p81), China produces cheap solar water heater components in large volumes which they export across the globe. While judicious use of import duties is necessary, they should only be applied to components that are locally manufactured. South Africa desperately needs every job it can muster in order to reduce its unemployment rate, and in this case, import duties are harming the solar water heating industry. Some of the respondents suggested that in addition to stopping imports, government needs to put measures in place to improve local manufacturing practices and technologies.

"Government need to help bolster manufacturing expertise by facilitating technology agreements with multinationals in the industry. We also need to adopt the culture of continuous improvement / lean manufacturing, associated with the competitive automotive business."

Competitive forces may eventually force manufacturers to pass on price benefits whether as a result of more competitive component costs or lower import duties. This may lower the retail price of solar water heaters.

4.3.3 Compliance Certification

SABS certification of all solar water heater products is mandatory and the Eskom rebate only applies to certified products (How to choose a solar system-Eskom). The cost of compliance certification is built into the sales price.

"Protracted Eskom/SABS procedure and/policies with regards to product approval. Testing regime requires testing of a system and not components. Repeat testing of flat plate collector with each make of geyser size or configuration at a cost of R60k per test."(Respondent)

"There should be more flexibility from the SABS in terms of testing regimes. SABS testing regime should take into account testing done at Solar Keymark / Certif laboratories overseas." (Respondent)

A possible solution to introduce a degree of flexibility in testing is that certification for locally produced solar water heaters that use local materials could be free or at least subsidised.

4.3.4 Training Costs

Another cost that is built into the sales price of every solar water heater is the costs associated with training staff. Many of the respondents directly or impliedly mentioned staff training or skilling as a challenge. It is possible to offset some of this cost through the Skills Development Levy and the ESETA in South Africa. Currently, all organisations pay approximately 1% of their salary bill towards this levy (Department of Labour, 2010). A company can claim training costs back from this levy; this would assist in offsetting the cost of technical training. Training could also be outsourced to facilities that have developed

training programmes. Outsourced training costs may be lower than undertaking in-house training.

4.4 Some proposed cost reduction measures

In order to improve the competitiveness and affordability of locally manufactured solar water heaters, the following could be introduced in the industry:

- Locally produced solar water heater components should be protected by import duties raised on their international competitors.
- Local raw material costs should be lowered as a direct result of Eskom's provision of low priced electricity to smelters.
- Unit testing and certification by SABS of locally manufactured systems should be offered to local manufacturers free of charge (these costs could be covered by the Eskom Rebate).
- Training rebates could be claimed from the Skills Development Fund, or subsidised training could be provided by Eskom.
- Training should be outsourced to local institutions.

In summary, a list of cost reductions for manufacturing is shown in Table 4.2 below:

Proposed Cost Reduction Action	
SWH Components	Eskom to negotiate better local raw material prices from local smelters that are benefitting from reduced electricity prices.
Unit testing and certification	Introduce possible rebates for manufacturers. SABS to reduce or scrap certification costs.
Training	Possible rebates from Skills Development Fund. Outsource training to local institutions. Training subsidies to be provided by Eskom.
Maximise management skill levels	Expand management skills in lean manufacturing.

Table 4.2. Manufacturing Cost Reduction Proposals

4.5 The Benefits of Local Manufacturing

Local manufacturing offers major benefits for the South African economy, many in the second and third tier supplier base.

The first line benefits are many, including savings from reduced electricity demand. Water heating consumes about 18% of South Africa's total electricity generated from coal (National Solar Water Heating Workshop, February 2009). The fieldwork findings suggest that local manufacturers have the potential to increase employment in both the production line and installation in the field. Second level jobs will also be created to sustain the supply chain in local industry. Furthermore, local manufacturing will guarantee quality and essential backup services.

"Better understanding of local conditions; opportunities to up skill and provide employment; opportunities to upgrade supply chain to reduce costs and lead times." (Respondent)

"It's a lot cheaper. As you say you have got it down here as jobs, that makes a difference obviously and then the back-up and customers will get traceable warranties so they can now trace you, and should we have any problems, we have the technical guys to help." (Respondent)

The literature review revealed that a number of countries have benefited from building their own solar water heater manufacturing sectors. Examples include China, Germany, and Barbados (Menanteau, 2007). Establishing a local manufacturing base in South Africa would mean that, taxpayers' money which is currently being used to pay rebates to import products can be released and used to build the local manufacturing sector and create jobs (Hertzog, 2011). The then prime minister of Barbados used the local manufacture of these systems to build a thriving industry. Between 1974 and 1992, 23 388 installations took place in this small state (Meyer, 2008c). This promoted such a successful industry that they were able to export to nearby islands; such are the potential benefits of this business if correctly managed. The large volumes, good quality and favourable prices offered by Chinese manufacturers bear further testimony to the benefits of local manufacture.

Further benefits would include savings that will increase as the much discussed but not yet finalised annual Eskom increases kick in. The requested 25% per year will make any saving significant once the full extent of the total collective increase in the rate is in place.

4.6 Can Local Manufacturers Compete with Imports?

While 67% of the respondents claimed that local producers can compete with imports, further probing during the face-to-face interviews revealed some challenges. Imported products still have superior finishes. This is because the local industry is small and thus lacks the requisite technology and equipment. This makes local products look inferior.

> *"What tends to happen is that guys cannot afford the tooling costs because of the volumes. Therefore it looks like it has been fabricated, the quality of the unit is probably better and suits the local conditions but the finishes are not as good as imported units, so instead of investing hundreds of thousand into a die, they fabricate a piece of steel. If you look at them they might not look as good as the imported unit but certainly quality-wise they are as good, if not better than the imported item." (Respondent)*

In terms of retail pricing, it is clear that the price of solar water heaters will not decrease unless the associated manufacturing costs decrease and this will only occur when the local manufacturing sector's systems are able to support structural change. Changes in financing methods can enhance affordability. Financing mechanisms have been applied in other countries and have assisted end users to purchase solar water heaters. Table 4.3 illustrates the monthly instalments (interest compounded monthly) for a range of capital costs:

Finance Period = 5 years							
Interest Rate (per annum)	**0%**	**5%**	**10%**	**15%**	**20%**	**25%**	**30%**
Capital Cost							
R5,000	83.33	94.39	106.24	118.95	132.47	146.76	161.77
R10,000	166.67	188.71	212.47	237.90	264.94	293.51	323.53
R15,000	250.00	283.07	318.71	356.85	397.41	440.27	485.30
R20,000	333.33	377.42	424.94	475.80	529.88	587.03	647.07
R25,000	416.67	471.78	531.18	594.75	662.35	733.78	808.83
R30,000	500.00	566.14	637.41	713.70	794.82	880.54	970.60

*The finance period is set at five years because this coincides with the warranty period of the solar water heater.

Table 4.3. Monthly Instalments for Financing SWHs over Various Periods (**Source:** Naicker, 2010 p. 77).

Etzinger (2007) stated that the capital cost ranges from R5 000 to R30 000. The actual average manufactured cost of a solar water heater in South Africa is estimated at R 3 756.00 per m^2. This amounts to approximately one third of the total installed cost.

4.6.1 Is Local Manufacturing Feasible?

All six respondents were unanimous in their response to this question. They all agreed or strongly agreed that local manufacture is feasible and that there is a sufficient market to support local manufacture. They also all found reliable local suppliers for the various materials they use. Another reason advanced for the feasibility of local manufacturing is the availability of sufficient know-how.

"Some good local knowledge in thermal solar heating, some good local water tank manufacturing available, some good government initiatives (DTI, Rebates etc) available to encourage local production." (Respondent)

All six respondents agree that their position as manufacturers could be enhanced by proposed future legislation on rebates on only locally manufactured solar water heaters. This legislation was due to become operational at the beginning of 2013 but is currently still under discussion. According to Hertzog (2011) between 50% and 70% of all solar systems installed in South Africa are currently locally manufactured. Eskom is adamant that the local industry does not have the capacity to meet this requirement even though it has not yet implemented a local content multiplier in the rebate formula.

The very nature of the solar water heater manufacturing business is that it is easily scalable with reasonable capital inputs that are achievable for small and medium companies. Francois Du Plessis (as cited by Hertzog, 2011), the chief executive of the Green Cape Agency established by the Western Cape provincial government is quoted as saying that, "many of the procurement rules and incentives have been written without taking into account the practicalities of the market and manufactures that already exist". It would appear that the proposed new legislation with regard to the Eskom rebates is a well-founded, sensible and reasonable initiative in terms of the proposal to offer rebates on only locally manufactured solar water heaters. This suggests that Eskom has taken cognisance of the potential of the South African manufacturing sector and is finally doing something positive about it.

4.6.2 Does the Current Legislation Enhance or Impede Local Manufacturing?

There were mixed responses to this question. The respondents were evenly split with regard to the current legislation. It appears that those who manufacture and install solar water heaters perceive the current legislation as less favourable than those simply involved in manufacturing. It is possible that this is due to the fact that the former are also subject to plumbing regulations. The legislation which applies to this sector is not only national legislation, but municipal legislation, as many municipalities have passed their own bylaws.

In 2010 Cape Town introduced a bylaw enforcing the use of solar water heaters. This is applied to all new buildings and all public buildings, and will be extended over three to five

years to cover older buildings as well. A commonly held belief among respondents was that the "Barcelona Building Regulations" should be applicable to all municipalities nationwide. It is often questioned why consumers should be forced to install solar water heaters when there is no tangible return. However, this argument is currently losing momentum due to increases in the cost of South Africa's previously cheap electricity.

The bylaws proposed by the city of Cape Town raise certain issues due to their lack of clarity. These issues will, in all likelihood cause confusion and might potentially be misinterpreted. The issues are listed below:

- The 60% of heating requirements would be difficult to measure on new property since there are no electricity consumption records to compare with. People have different requirements even though the house size and location may be the same, and some may prefer heaters while others prefer none.
- The energy requirements audit on the property will be expensive. Who will pay for it?
- The bylaw will be applied to properties valued at over R500,000. Due to the vast difference between municipal valuation and market valuation, it will be difficult to determine which value should be used. What happens if the purchaser cannot afford the solar water heater? Will the cost be included before or after the R500, 000 cut off point?

Although many recommendations have been made with regard to house size and house value in applying the bylaw, there appears to be no clear direction on who will undertake the installation or the auditing to ensure that the building regulations are complied with.

While bylaws have been successfully implemented in Barcelona and Brazil, it is essential that the above-mentioned issues are clarified prior to implementation in South Africa. A possible loophole in the bylaw is the exemption of "water used only for industrial purposes in buildings where hot water requirements exceed that which can be reasonably obtained through solar water heating" (Prasad, 2007, p. 14). It would have to stipulate the size of the solar water heater in such a situation, thereby maximising energy savings.

In addition to regulation, public education will go a long way in promoting the adoption of solar water heaters. In Shandong province in in China for example, carefully implemented

public education made the use of solar water heaters the norm after 15 years. Part of the public enlightenment approach was the installation of solar water heaters in government buildings and it was also bolstered by the leadership shown by senior government officials who all installed them in their homes (Flavin & Starke, 2007, p. 108). To date, the South African government has shown no such leadership and there is a great opportunity for municipalities to lead by example.

Municipalities should become the champions of the solar water heater cause. They need to keep the bigger picture in mind in terms of electricity shortages, and environmental concerns even though the possibility of municipal revenue losses exists. Visagie and Prasad (2006, p19) suggested that "local government will prepare and pass bylaws to make the inclusion of SWH mandatory in new housing and gradually retrofit SWH in old houses."

Another way of increasing the demand for solar water heaters is to halt the production of electric water heaters. However, the question that arises is how replacement solar water heaters will be financed. Moosa (2007) suggests that partnerships be developed with the insurance industry to replace damaged electric water heaters with their solar counterparts.

In summary, the current legislation leaves room for improvement and can become an effective tool to enhance the position of local manufacturers. In turn, this will boost employment, enhance skills development and retain foreign exchange that is currently "feeding the Chinese". Part of the problem in South Africa is that the legislation is constantly changing and this causes a great deal of uncertainty in the industry.

4.6.3 Are there Benefits in re-Focusing the Subsidies from the Consumer to the Manufacturer?

The respondents were also evenly split on this issue. The primary concern amongst the respondents that disagreed with manufacturers receiving a subsidy was a possible increase in the levels of fraud and corruption in the country. However, those who felt that the subsidy should be refocused, including ultimate reversion of these subsidies to consumers in the form of affordable pricing, felt that this would boast local production capacity, ultimately lead to exports and thus bring in earnings for the nation, as well as employment creation.

"It would be better to have a tax rebate on it or a VAT free product which would already give one a 14% advantage on the local product. Another thing would be a saving on electricity be

passed on to the consumer. If the volume was kept local and they give it to approved South African manufacturers, they would gear up to accommodate the volume, bring in the technology and create employment. A change in attitude from 'feed the Chinese to feed the South Africans', needs to take place in both the industry and Government for this sector to be grown effectively." (Respondent)

Other countries have used incentives such as subsidies and tax deductions to entice consumers to adopt solar water heater technology (Menanteau, 2007). South Africa's energy supplier, Eskom, offers a rebate to attract consumers to the technology. However, according to Naicker (2010, p. 87) "the hurdles crossed to earn a subsidy far outweigh the value of the subsidy." The "red tape" involved in obtaining the subsidy is a serious impediment. The criteria for a consumer to claim the rebate from Eskom include:

- The SABS test, which is an additional expense. Imported products carry the 'solar keymark' which is accepted internationally but they still have to go through these local tests. The subsidy should be used to reduce the cost of the SABS test.
- The installation of a timer or load management device is an additional cost borne by the consumer, thereby making the rebate close to zero.
- Very few suppliers can offer a life expectancy of 10 to 15 years. How does one measure this if the comprehensive guarantee is five years? (Naicker, 2010)

Naicker (2010) therefore found that, "The subsidy was inadequate to drive the change required by end users and should be applied to industrial and commercial consumers. It should also be linked to the size of the collector area. Currently, the rebates value is based on the SWH efficiency as derived from the SABS performance test."

Balmer (2007, p. 16) offers a lesson learnt by Germany and China. "In countries where the subsidy is calculated based on energy actually produced, there is an active interest for all involved to increase solar energy output, which in turn boosts research and development focussed on the most efficient solution." There are many different options, each with its own failings. Should the powers that be in South Africa decide to opt for a change in the subsidy system to the manufacturer they will need to ensure that they chose current best practice and are cognizant of South African weaknesses in similar systems.

4.6.4 Are there sufficient South African Suppliers to meet Manufacturing needs?

All the respondents stated that there are sufficient local suppliers of the required hardware and consumables to meet their needs in terms of manufacturing. The copper sheet, tube and fittings and the aluminium extrusion are all manufactured in South Africa. This manufacturing is done using power supplied by Eskom; however, no benefit from the cheap electricity used to manufacture these products accrues to South African products. "With Eskom's current average selling electricity price now at about R0,50 per kWh, the price being paid by BHP Billiton for electricity remains a secret, and the special pricing deal for its Hillside aluminium smelter only expires in 2028!" (Yelland, 2011)

With the aluminium supplier benefitting from favourable prices for their electricity inputs, Eskom should be able to negotiate better prices for the material used locally to improve the competitive advantage of locally manufactured solar water heaters.

All six respondents use a great deal of local raw materials, including glass. This is a good indication of the impact that increased local manufacturing will have on the South African economy as they all have second tier suppliers that will benefit from the increased volume of business. However, the two respondents that were interviewed explained that a few specialised components are still imported either because there is no local supplier or because they are not readily available.

"Not in all areas of interest, for example specialized coatings (vapour disposition-TiAlSiOxNy) for absorber sheets are not locally available while anti-reflective glass coatings not readily available." (Respondent)

4.6.5 Local Production Rate (Number of Solar Water Heaters produced by Number of Staff)

The average number of solar water heaters produced per month is 50 with a staff complement of between 15 and 18 people.

Training has been identified as a cost. Training was formerly done 'on the job' because there were no official courses. This has been resolved by the CEF and other institutions and SAQA Level 3 and Level 4 training modules are now available. All the respondents agreed with the

findings of the literature review that there is a skills shortage in the manufacturing sector: "there is a skills shortage and …the SETAs should be responsible for training" (Naicker, 2010, p. 90). Visagie and Prasad (2006) called for training courses to be set up or expanded by the Energy Sector Education and Training Authority (ESETA). Training courses, including those for the manufacturing sector, should be implemented at all institutions to broaden the knowledge and skills base of the workers in this sector.

4.7 Suggested Measures to Support the Local Manufacture of Solar Water Heaters

The six local manufacturers all made a positive contribution to this question based on their individual experiences in the industry. The following three suggestions were common to all respondents:

- Import duties on all imported solar water heaters and individual solar water heater components should be set at a level that offers a competitive advantage to locally produced products. This would help local manufacturers to build their businesses on a volume basis.

- Only locally produced solar water heaters should qualify for government subsidies, as well as receive support for the cost of the SABS testing. This testing adds significantly to the cost of solar water heaters that manufacturers of necessity pass on to the end user.

- Instead of South Africa exporting raw material for other countries to convert to saleable products, we should use our raw material at favorable prices (preferably not LME prices) to provide local manufacturers with raw materials at prices that give them a significant advantage in the market.

4.8 Conclusion

These suggestions made by the six local manufacturers raise valid points, particularly the issues surrounding the secretly negotiated cheap electricity prices that are available to local smelters as these have significant bearing on the raw materials available for the production of

both the components and the solar water heater. The other two suggestions with regard to import duties and SABS testing would also give local manufacturers a competitive advantage. Such advantage offers the added benefit of supporting the second tier suppliers and creating much-needed jobs in South Africa.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter summarises and discusses the study's findings. Conclusions are drawn and recommendations made.

5.2 Findings Based on the Literature

Many challenges confront local solar water heater manufacturers, including high raw material input costs, high labour costs with low productivity, high training costs, and high certification costs, to name but a few. Some of these costs could be mitigated through various means, including import duties on imported products and components as well as beneficial rates for the certification of locally manufactured systems. It is import to note that other countries, especially China, used their manufacturing sector, particularly solar water heater manufacturers, to create a wide variety and large number of jobs. Such manufacturing gives China a large advantage in terms of economies of scale that South Africa would be wise to note. These challenges provide an opportunity for the solar water heater industry to address the current problems in the industry, including the development of human capital, poor communication, and the need for financial management to be part and parcel of the management and growth of the industry. Focused attention to these aspects will improve the chances of success of the various enterprises. These views are supported by Jones and George (2009, p. 264) and are of paramount importance to the sustainability of the industry.

South African solar water heater manufacturing businesses provide many multi-level economic benefits, not only in the manufacturing base but through the second and third tier supplier base. It follows that stimulating growth in the local solar water heater manufacturing sector would promote growth in the associated supplier base. Good examples are Germany, Barbados and China, all of which have grown their industries to the point where they are able to export their products. As noted by Hertzog (2011), taxpayers' money that is currently used to pay rebates could be redirected to improve benefits to local manufacturers, thereby creating more jobs in South Africa.

The literature review noted that manufacturing is one of the cornerstones of any viable economy. The United States' manufacturing sector drives domestic research and development efforts; it also determines the nation's exports and to a large extent determines the domestic standard of living due to the quality and quantity of jobs provided by this sector. A nation's success in manufacturing has traditionally been linked to its fast and judicious use of three of resources, namely, land, labour and capital. The management style of an enterprise needs to be holistic and comprehensive in order to cater for the numerous facets and dimensions of business. It cannot merely attend to a few isolated issues. No simple remedies or tactics exist that can be employed to ensure success; the answers lie in sound planning, effective and efficient use of resources, positive management of supply chain relationships and positive customer relationship management. Fastidious attention should be paid to manufacturing quality products, with management/owners paying attention to all aspects of their businesses.

Manufacturing in South Africa holds the promise of improving economic growth and employment which will lead to a stronger national economy. If correctly managed, it presents a unique opportunity for significant acceleration in growth and development. Of particular interest are the benefits that can arise from development in rural communities that could lead to mass production, which in turn ultimately helps to reduce prices and improve the quality of life. The local manufacture of solar water heaters in South Africa offers a unique opportunity to South African manufacturers to produce and service solar water heaters that contribute to the reduction of greenhouse gas emissions and a reduction in the country's overall carbon footprint. The importance and sustainability of the sector is evident in the literature on green manufacturing, lean manufacturing, and green supply chain management.

5.3 Conclusions and Recommendations Based on the Fieldwork

Production costs are affected by the flood of imported cheap solar water heaters to South Africa, primarily from China. The growth of China's manufacturing capacity is due to its ability to capitalise on economies of scale from the size of production facilities; this presents a challenge to South African manufacturers to produce a cost-competitive product. There are several reasons why this is difficult; one is that the flood of cheap products into South Africa erodes local economies of scale. Even with consumer subsidies in place in South Africa, this means that the expected sales have not materialised. South African manufacturers currently

receive no government support even though they contribute to the economy through increased demand and jobs at all tiers. This lack of subsidies and low domestic demand for solar water heaters make it difficult to reduce the price of local products.

While the copper and aluminum smelters are paying unpublished yet extremely favourable rates for the electricity they consume, local manufacturers of solar water heaters gain no economic advantage from purchasing products from these plants. Despite manufacturing their products locally, the local manufacturer still pay London Metal Exchange rates for these products. Eskom could trade this cheap electricity for a better price for the copper and aluminum produced in order to reduce the price of the very solar water heaters they are encouraging consumers to fit to their homes to save electricity. Therefore, one measure that would benefit from further investigation is the reduction of the cost of local raw materials, particularly the aluminium produced in South African smelters.

There is an opportunity to support manufacturers in the costs of production, certification (SABS) and training. The respondents would be able to improve their prices if they benefitted from local component manufacturer incentives. In addition, lean manufacturing initiatives such as lower inventories and Just In Time deliveries (both inbound and outbound) will ultimately result in lower production costs through better business management.

In the current economic climate, the state should judiciously use import duties to stimulate the local manufacturing sector. Import duties should be applied to components that are not locally manufactured.

SABS certification of all solar water heater products is mandatory and the Eskom rebate only applies to certified products. Free, or at least subsidised, certification for locally produced solar water heaters will add a competitive advantage that will also facilitate price reductions with a view to local manufacturers achieving the required economies of scale.

Local production of solar water heaters offers major potential benefits to the South African economy, many in the second and third tier supplier base. The first line benefits are many, including savings as a result of reduced electricity demand. There will also be an increase in employment in order to build and fit the solar water heaters in the field. While multi-level job

creation to sustain the supply chain in the local industry is an added benefit, the exact number of potential jobs is difficult to determine.

The redeployment of South African taxpayers' money, which is currently being used to pay rebates to import products, will stimulate the local manufacturing sector and create jobs. Further benefits will be evident in the savings realised as Eskom's annual electricity price continues to increase.

Local manufacturers are able to compete with products produced overseas. Four of the six of the respondents are competing with imported products. All six respondents agreed or strongly agreed that local manufacturing is feasible and that there is a sufficient market to support local manufacture. Reliable local suppliers for the various materials used are available. The position of local manufacturers could be enhanced by the proposed legislation on rebates on locally manufactured solar water heaters only. The very nature of the solar water heater manufacturing business is that it is easily scalable with reasonable capital inputs that are achievable for small and medium companies.

The respondents were evenly split with regard to the current legislation. It appears that those who both manufacture and install solar water heaters perceive the legislation to be less favourable than those that simply manufacture. This is possibly due to the fact that the former are also subject to plumbing regulations. Both national and municipal legislation apply to this sector, as many municipalities have passed their own bylaws.

Finally, in other parts of the world, high-ranking political leaders promoted their country's solar power programmes. These leaders installed solar water heaters in their own homes. The South African government has not shown such leadership and a great opportunity exists for municipalities to lead by example.

5.4 Opportunities for future studies.

Opportunities for future studies that emerge from this study could encompass the effects on current users or producers of both solar water heaters as well as other types of conversion devices. Current verses new patterns of manufacture as well as current technology verses new technology are two more areas that would be beneficial to study. The relevance of current suppliers/technology to the needs of the users in this field would shed light on the best use of resources and supplier capability for the future. Finally, a future study should compare the local costs of manufacturing individual solar water heaters with the total imported costs (including transport costs and import duties).

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Questionnaire.

1) What are the challenges faced by South African solar water heater manufacturers?
   Comment

2) What are the benefits of local manufacture?
   Comment

3) Can the local manufacture compete with imports?
   Strongly Disagree Disagree Neutral Agree Strongly Agree

4) Is local manufacture feasible, please explain?
   Strongly Disagree Disagree Neutral Agree Strongly Agree

5) Does the current legislation impede or enhance the situation for local manufacturers?
   Yes No

6) Do you think re-focusing the subsidies from the consumer to the manufacturers would be beneficial and why?
   Strongly Disagree Disagree Neutral Agree Strongly Agree

7) Do you have enough local (South African) suppliers to meet your manufacturing please explain?
   Yes No Comment

8) What proportion of your raw material needs are imported for the manufacture of solar water heaters?
   0 25% 50% 75% 100%

9) How many solar water heaters does your company make per month, how many
   employees are directly involved in the production of these solar water heaters, how many employees would you require to meet an equitable share of the government's targets?
   Number

10) What measures do you believe should be taken to support local solar water heater manufacture?
    Comment

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

16 November 2012

Mr Craig Backe-Hansen (208506813)
School of Management, IT & Governance
Westville Campus

Dear Mr Backe-Hansen

Protocol Reference Number: HSS/1225/012M
Project Title: Manufacturing Solar Water Heaters in South Africa: The benefits and costs

EXPEDITED APPROVAL

I wish to inform you that your application has been granted Full Approval through an expedited review process:

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment/modification prior to its implementation. In case you have further queries, please quote the above reference number. PLEASE NOTE: Research data should be securely stored in the school/department for a period of 5 years.

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully

.....

Professor Steven Collings (Chair)
/ms

cc Supervisor: Dr Mihalis Chasomeris
cc Academic Leader: Professor KK Govender
cc School Admin: Debbie Cunynghame

Professor S Collings (Chair)
Humanities & Social Sc Research Ethics Committee
Westville Campus, Govan Mbeki Building
Postal Address: Private Bag X54001, Durban, 4000, South Africa
Telephone: +27 (0)31 260 3587/8350 **Facsimile:** +27 (0)31 260 4609 **Email:** ximbap@ukzn.ac.za / snymanm@ukzn.ac.za