



**A SOCIO-TECHNICAL INQUIRY INTO SEMIOTICS AND ETHNOLOGY IN SOUTH AFRICA,
WITH SPECIAL REFERENCE TO ELECTRICITY.**

BY

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THESIS SUBMITTED IN FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

MASTER OF TECHNOLOGY: INDUSTRIAL DESIGN

IN THE FACULTY OF INFORMATICS AND DESIGN

AT THE CAPE PENINSULA UNIVERSITY OF TECHNOLOGY

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DECLARATION

I, Byron Qually, declare that the contents of this dissertation/thesis represent my own unaided work, and that the dissertation/thesis has not previously been submitted for academic examination towards any qualification. Furthermore, it represents my own opinions and not necessarily those of the Cape Peninsula University of Technology.



20 August 2010

Signed

Date

ABSTRACT

Demand Side Management (DSM) within a South African context requires a transdisciplinary approach to comprehend electricity consumption. Current research suggests a technical determinism, whereby design teams fail to acknowledge social factors and cultural influences when conceptualising DSM artefacts. The result of which, is that artefacts fail to be adopted by the market, and consumer behaviour and electricity consumption remains unchanged. The thesis aims to demonstrate the hypothesis, that semiotics and ethnology may affect sustainable residential electricity management in South Africa. The ubiquitous literature on electricity management is administered by means of the theoretical lens, Socio-technical Theory. Mixed method instrument obtain fieldwork data from three of the eleven official South African languages: Afrikaans, English and IsiXhosa.

ACKNOWLEDGEMENTS

I wish to thank the following:

Bart Verveckken, for ongoing support and assistance with navigating academic structures.

Ignatius Nothnagel, for providing critical path support, both professional and academic.

Mugendi M'Rithaa, for ongoing support and inspiration.

Professor Ernst Uken, for providing his knowledge of the South African energy industry.

Rolf Proske, for all hour, including holiday, literature review support.

Simone Lazarus, for her research enthusiasm and insightful consultations.

Stephanie Loy, for assisting in the pilot study.

The research participants, for their substantial investment in time, skill, and insight.

Welekasi Jumba, for capturing of bibliographic data and organising desktop chaos.

Zayd Minty, Cape Town Partnership and Creative Communities, for his / their assistance in obtaining research participants.

My parents, for introducing me to the world, and providing unconditional love and support.

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CLARIFICATION OF BASIC TERMS AND CONCEPTS

Acculturation, n: The adoption and assimilation of an alien culture (*OED*, 2009).

Artefact, n: A functional or decorative man-made object (*OED*, 2009).

Demand Side Management, n: The planning, implementation, and monitoring of utility activities designed to encourage consumers to modify patterns of electricity usage, including the timing and level of electricity demand. Demand-Side Management covers the complete range of load-shape objectives, including strategic conservation and load management, as well as strategic load growth (EIA, 2008).

Diachronic, adj: Concerned with the way in which something, especially language, has developed through time (*OED*, 2009).

Ethnography, n: The scientific description of peoples and cultures (*OED*, 2009).

Ethnology, n: The study of the characteristics of different peoples and the differences and relationships between them (*OED*, 2009).

Ideogram, n: A character symbolizing the idea of a thing without indicating the sounds used to say it (*OED*, 2009).

Linguistics, n: The science of languages; philology (*OED*, 2009).

Load shedding, n: The deliberate shutdown of electric power in a part or parts of a power-distribution system, generally to prevent the failure of the entire system when the demand strains the capacity of the system (*Dictionary.com*, 2009).

Makoti, n: IsiXhosa term for “daughter-in-law” (Meintjes, 2001:344).

Rebound effect, n: When the lower effective price of the energy service will lead to changes in the demand for other goods and services. To the extent that these require energy for their provision, there will be indirect effects on aggregate energy consumption (UKERC, 2005).

Semiosis, n: Refers to the process of meaning-making. Specifically during the interaction between the representamen, the object and the interpretant (Chandler, 2002:259).

Semiotics, n: The science of communication studied through the interpretation of signs and symbols as they operate in various fields (*OED*, 2009).

LIST OF ACRONYMS

CFL: Compact Fluorescent Lamp
CPUT: Cape Peninsula University of Technology
DEAT: Department of Environmental Affairs and Tourism
DME: Department of Minerals and Energy
DOE: Department of Education
DoL: Department of Labour (South Africa)
DSM: Demand Side Management
DST: Department of Science and Technology (South Africa)
DUE: Domestic Use of Energy (CPUT)
EC: Electricity Consumption
EI: Energy Institute (CPUT)
ESCOM: Electricity Supply Commission
ETP: Eco Team Programs
FDA: Food and Drug Administration
GT: Grounded Theory
GUI: Graphic User Interface
ICUE: Industrial and Commercial Use of Energy (CPUT)
ID: Industrial Design
IEC: International Electrotechnical Commission
IEE: Institute of Electrical Engineers
INEP: Integrated National Electrification Programme
LPG: Liquefied petroleum gas
LSM: Living Standard Measurement
MLP: Multi-level perspective
MMI: Man Machine Interfaces
NDA: Non-disclosure Agreement
NPD: New Product Development
OPEC: Organisation of Petroleum Exporting Countries
SABS: South African Bureau of Standards
STT: Socio-technical Theory
SWH: Solar Water Heater
UCM: User Conceptual Model
UCT: University of Cape Town
UKERC: United Kingdom Energy Research Centre

1 CHAPTER ONE: BACKGROUND TO THE RESEARCH

1.1 INTRODUCTION

“Ono gwhe lera nitsoi opuno” (Ugiomoh, 2004:7)

This Nigerian proverb translates to: “it is the man asleep (or dead) whose fire made from wood extinguishes,” and suggest that “a man’s zeal for life, symbolised in the flame from wood, is constantly kept aglow so long as he fans the fire he made from it.” (Ugiomoh, 2004:7). The thesis, similar to the proverb, embodies multiple and provoking layers, and one which runs throughout the text, is a reflection on the interdependence between humankind and electricity. In other words, the complex relationship society has with a source of energy that can define, sustain and take life, will be explored.

The research will unpack the characteristics of electricity within a residential household. On the one hand, the Oxford University Press (Qually, 2009) defines the word “electricity” as being derived from the post-classical Latin adjective relating to amber, with which electrical phenomena were first observed. Perhaps such a naturally occurring origin could be dismissed by contemporary user of electricity. However, contra to such a supposition, the thesis will argue that history and subconscious attitudes directly influence artefact design, and subsequent electricity consumption.

The literature review and fieldwork data develop a postmodern stance on electricity. In other words, instead of electricity being considered an objective product that is primarily based of functional attributes, a subjective and varied understanding is developed. The research will argue that electricity’s abstract qualities continue to manifest multiple and arguably opposing perspectives. The result of which, is a disparity in international and South African approaches to electricity conservation. Additionally, and within a national framework, the epistemological imperative of South African research into electricity consumption will be explored by means of semiotics and ethnology.

1.1.1 Contribution of the research

1.1.1.1 Academic contribution

The literature review noted ubiquitous academic research into electricity usage, notably by engineering and social science disciplines. However, similar to Midden, Kaiser and McCalley (2007:156), who comment that “technology as related to environmental resource use is often set apart from the study of human behaviour and resource conservation,” the literature was frequently completed in isolation, often resulting in engineering solutions not suiting the intended context, and social insight not being translated into utilitarian benefit. The thesis makes use of ID to synthesise these two disciplines, and from an artefact creation perspective it will contribute to what Davis (2008:72) describes as a “paradigm shift in the focus of the design process from objects to experiences”.

1.1.1.2 Professional contribution

The thesis’ professional contribution, specifically to South Africa, will be a list of key ID principles to be considered when designing artefacts that manage electricity consumption. If used by product developers, the principles will assist in managing the complex relationship between electricity and the user, and creating artefacts that will be successfully adopted by the market. Conversely, if European and North American solutions are imported for domestic consumption, the principles can provide a form of acceptance criteria.

1.2 DIRECTIONS FROM PREVIOUS RESEARCH

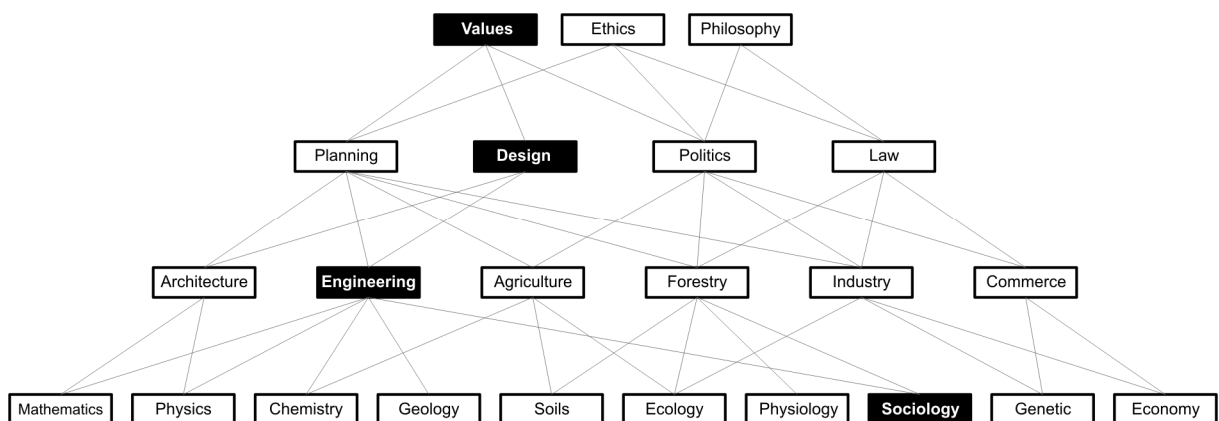
1.2.1 Local and international direction

Numerous research reports exist on residential electricity, due to its central role in influencing a variety of household applications. Europe and the USA have highly cited data on residential energy consumption dating back to the early nineteen hundreds (Soddy, 1912; Carver, 1924; White, 1943; Cottrell, 1955; Hubbert, 1956). South Africa, although more recently, is generating academic knowledge from centres such as the University of Cape Town’s Energy Research Centre (UCT ERC) and the Cape Peninsula University of Technology’s Energy Institute (CPUT EI). The EI’s annual conference on Domestic Use of Energy (DUE) and Industrial and Commercial Use of Energy (ICUE) has provided a platform to discuss cross-disciplinary energy strategies.

The thesis takes its primary direction from international research into social and cultural influences on residential energy (Rosa, Machlis & Keating, 1988:163; Wilson & Dowlatabadi, 2007:193; Midden et al., 2007:169). Specifically, Abrahamse, Steg, Vlek, and Rothengatter's (2005:274) suggestion that, with regard to social and environmental studies on household energy conservation, research is "theory driven and aims to identify underlying determinants of energy use, such as attitudes." This direction is applied to a South African context and provides a partial answer to Winkler, Spalding-fecher, Tyani, and Matibe's (2002:604) recommendation to the Department of Minerals and Energy (DME), that research should "[deepen] our understanding of the behavioural, social and cultural variables that influence the effectiveness of energy-efficiency measures".

1.2.2 A transdisciplinary approach

Due to ID attempting to bridge social and engineering disciplines, direction has been taken from Max-Neef's (2005:6-9) research into the various paradigms for cross-disciplinary collaboration, specifically his unpacking of information flow and what constitutes a significant data source. He describes four categories of disciplinary collaboration, suggesting that the first category, "multidisciplinary", is analogous to concurrent streams of knowledge without clear "connections between them". The second category is "pluridisciplinary", and is suggestive of collaboration between disciplines without coordination. The third category, "interdisciplinary", indicates collaboration between groups of related disciplines in hierarchical format, and is perhaps synonymous with electricity research in South Africa. Max-Neef suggests that all three approaches are limiting, and that groups and disciplines require synchronised interaction, which can be achieved with the "transdisciplinary" approach illustrated in Figure 1.1 below.



**Figure 1.1: An interdisciplinary approach
(After Max-Neef, 2005:9)**

The interdisciplinary figure is read from the bottom level to the top level; that is, from the empirical level, to the purposeful level, to the normative level, and finishing with the value

level. Transdisciplinary activities arise from relationships forming across all four levels, with this thesis' approach highlighted in black. Importantly, when the figure is read from the empirical, or "what exists", level to the value, or "what we must do", level, Max-Neef (2005:9) stresses that "the economic process would be determined by natural laws, instead of being the result of human action."

1.3 RESEARCH PROBLEM

1.3.1 Research hypothesis

The research aims to demonstrate the hypothesis that semiotics and ethnology may affect sustainable residential electricity management in South Africa.

1.3.2 Research question and sub-questions

What semiotics and ethnology may affect sustainable residential electricity management in South Africa's Western Cape?

Table 1.1: Research sub-questions

RESEARCH SUB-QUESTIONS	
1.	What semiotics are unique to residential electricity in South Africa?
2.	What ethnology is unique to residential electricity in South Africa?
3.	What STT facilitates the design of residential electricity artefacts?

1.4 INTRODUCTION TO RESEARCH DESIGN AND METHODOLOGY

1.4.1 Socio-technical Theory (STT)

The thesis' transdisciplinary inquiry into electricity is facilitated by a research theory capable of unpacking social and technical data, namely Socio-technical Theory (STT). It suits such an application and has been used in previous residential energy research (Wilson & Dowlatabadi, 2007:186). Albert Cherns (1976:784), a primary originator of STT, explains that "objectives are best met not by the optimisation of the technical system and the adaptation of a social system to it, but by the joint optimisation of the technical and the social aspects." The literature review and subsequent presentation of fieldwork data make use of Cherns' (1976:785-792; 1987:154-160) ten principles of Socio-technical design. Figure 1.2 below provides an overview of STT's structure relative to transdisciplinarity and variables noted throughout the thesis.

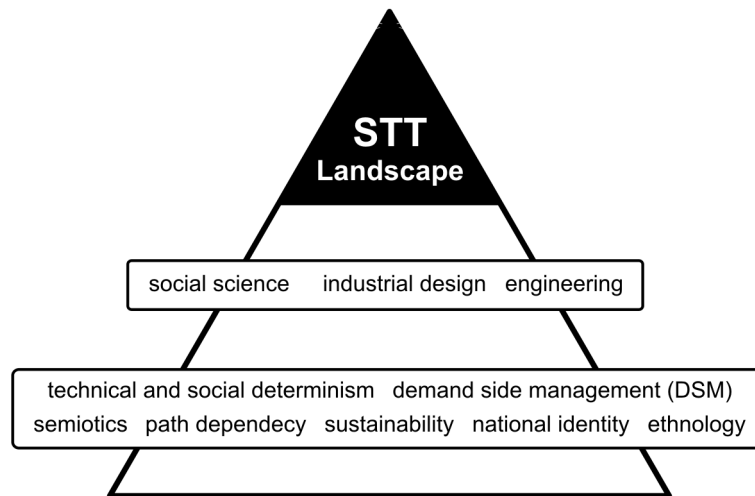


Figure 1.2: The Socio-technical Theory landscape

1.4.2 Grounded theory

In response to the research question, an appropriate research method to identify semiotic and ethnological data is Grounded theory. Although various authors have contributed to this theory, Glaser and Strauss' (1967) approach has been selected due to what Charmaz (2006:8) describes as its "method of discovery, treating categories as emergent from the data".

1.4.3 Visual sociology

Visual sociology has been chosen as a qualitative instrument due to its ability to empower respondents to provide sensitive semiotic data. In other words, Chandler (2002:11), a prolific writer on semiotics, suggests that "to decline the study of signs is to leave to others the control of the world of meanings which we inhabit."

1.5 THESIS STRUCTURE

1.5.1 Inverted pyramid format

The thesis is structured according to an inverted pyramid format due to the substantial amount of literature on residential electricity. The tapering format facilitated a broad and in-depth literature review, ultimately narrowing alongside STT, which unpacks and manages the data. The inverted pyramid structure is illustrated visually in Figure 1.3 below.

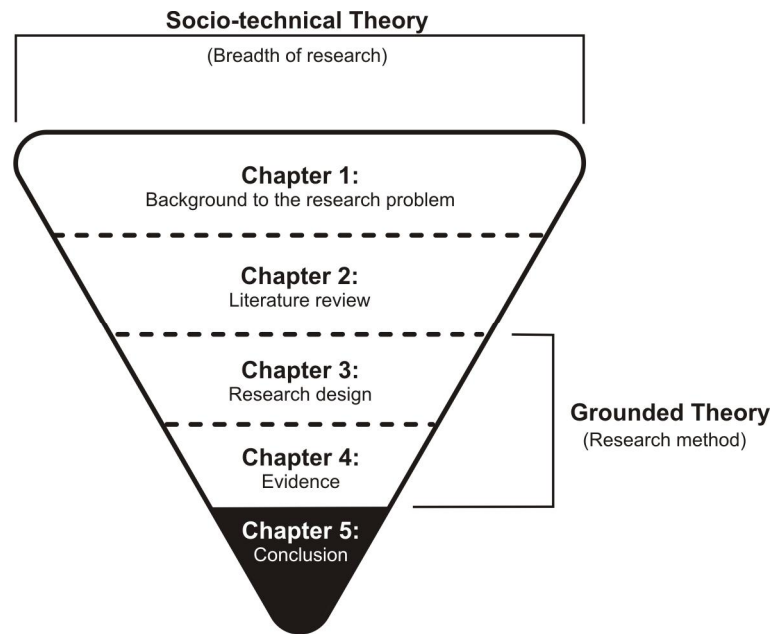


Figure 1.3: An inverted pyramid format demonstrating thesis structure

1.5.2 Philosophical underpinnings

“A study is shaped by the researcher’s guiding principles associated with a paradigm or world view, which encompasses ontological, epistemological and methodological assumptions.” (Jeon, 2004:249)

Due to potential sensitivities arising from cross-cultural research, it is important to note the author’s epistemological imperative, which is weighted towards the relative, and as such is not attempting to make cultural judgments. Issues of ethnologic practices in South Africa, and indeed abroad (Lee, 2008), may be of concern to the reader. However, a central goal of the thesis is to liberate the “voice” of the respondent, and the author acknowledges that the thesis’ sampling method provides a partial outlook. In other words, the data follows Pettigrew’s (2000:256) comments that “ethnography claims only to provide one interpretation of the phenomenon of interest; potentially one of many.”

2 CHAPTER TWO: LITERATURE REVIEW

2.1 INTRODUCTION

The literature review is arranged into three categories. Section 2.2 details research boundaries and academic diligence. Section 2.3 introduces the literature review's key findings. Section 2.4 discusses the findings by means of Socio-technical Theory.

2.2 DELINEATION OF THE RESEARCH

2.2.1 Residential electricity user

The research focuses only on residential users of electricity. Industrial and business related consumers are only cited if influential on residential behaviour. Additionally, the sustainable aspect of the research question is unpacked by means of the relationship between society and technology, and not by identifying new sources of electricity.

2.2.2 Experts consulted

- | | |
|------------------------|---|
| Prof Ernst Uken: | (MSc, PhD, MSc (Eng), MA)
Head of the CPUT Energy Institute. |
| Jian Swiegers: | (M.Eng (Mech), Hons)
Optimal Energy founder, shareholder, and head of engineering. |
| Prof Renfrew Christie: | (B Com Hons, BA Hons, MA, D Phil)
Academic focusing on electricity and society. |
| Phil Goodwin: | (ND 3D design)
Freeplay Energy director and head of product management. |

2.2.3 Search keywords and phrases

The following search keywords and phrases were used in the research: Domestic energy, domestic energy metaphor journal, electricity and culture journal, electricity and semiotics, energy and culture journal, energy management, energy metaphor journal, Eskom, residential energy, residential energy consumption, residential energy patterns journal, residential energy system, smart home journal, appliance attachment gender, objects female metaphor, pronoun inanimate, history colour cable coding, and origin wire insulation.

2.2.4 Websites and search engines

The following websites and search engines were used in the research: Amazon, ARNO Academic publications online, CPUT Domestic Use of Energy (DUE), CPUT Industrial and Commercial Use of Energy (ICUE), Directory of South African psychologists, Eskom DSM, Google Scholar, MIT Press Journals, South African Translators' Institute (SATI), The Economist, UCT Energy Research Centre, and YouTube.

2.2.5 Commercial databases

The following commercial databases were used: Annual Reviews, Blackwell Synergy, Cambridge Journals Online, EBSCOhost, Elsevier, Emerald Publishing, Engineering Village, Gale, Illumina, Inderscience, Informaworld, IngentaConnect, JSTOR, ProQuest, Questia, Sage Journals Online, ScienceDirect, SpringerLink, and Wiley InterScience.

2.2.6 Journals reviewed (DOE approved)

The following Department of Education (DOE) scholarly journals have been reviewed: Advances in Consumer Research, American Anthropologist, Annals of Science, Annual Review of Environment and Resources, Anthropology & Education Quarterly, Applied Economics, Contemporary Educational Psychology, Creativity Research Journal, Critical Social Policy, Critical Sociology, Cross-Cultural Research, Cultural Dynamics, Cultural Sociology, Cultural Studies & Critical Methodologies, Current Sociology, Design Issues, Design Studies, Development Southern Africa, Digestive and Liver Disease, Ecological Economics, Endeavour, Energy, Energy and Buildings, Energy Environment, Energy Policy, Environment and Behaviour, Environment and Resources, Environment and Urbanization, Environmental & Resource Economics, Ethics, Place and Environment, Field Methods, Futures, History of Psychiatry, Human and Experimental Toxicology, Human Relations, International Journal of Behavioural Development, International Journal of Cross Cultural Management, International Journal of Engineering Education, International Journal of Qualitative Methods, International Small Business Journal, Journal of Advertising, Journal of Asian and African Studies, Journal of Australian Studies, Journal of Black Studies, Journal of Consumer Culture, Journal of Consumer Research, Journal of Design History, Journal of Developing Societies, Journal of Economic Psychology, Journal of Electrostatics, Journal of Energy in South Africa, Journal of Environmental Psychology, Journal of Material Culture, Journal of Popular Culture, Journal of Social Issues, Journal of Social Work Practice, Journal of Urban History, Knowledge Based Systems, Lighting Research and Technology, Media, Culture & Society, Natural History, New Scientist, Organization Studies, Policy Science,

Public Understanding of Science, Punishment and Society, Qualitative Inquiry, Quality and Quantity, Race & Class, Research Policy, Review of Educational Research, Scandinavian Journal Of Caring Sciences, Science, Technology & Human Values, Technology & Society, Sex Roles, Social Science Information, Social Studies of Science, Sociology, Systems Research and Behavioural Science, The Energy Journal, The Information Society, The Journal of Applied Behavioural Science, The Journal of the Learning Sciences, Theory, Culture & Society, Third Text, Transportation Research Part D, and Urban Studies.

2.2.7 Journals reviewed (Not DOE approved)

The following journals have been reviewed: Information Development, International Journal of Design, Marketing Theory, and Qualitative Social Work.

2.2.8 Literature review sources

Literature dating back to the introduction of electricity has been obtained from South African, European and American sources. The literature has been acquired from digital and non-digital methods, to incorporate Dr Evans' (Anon, 2008:89) suggestion that digital methods alone prematurely narrow literature reviews. Figure 2.1 below provides an overview of the literature covered. All items, excluding books, have been read or viewed in their entirety.

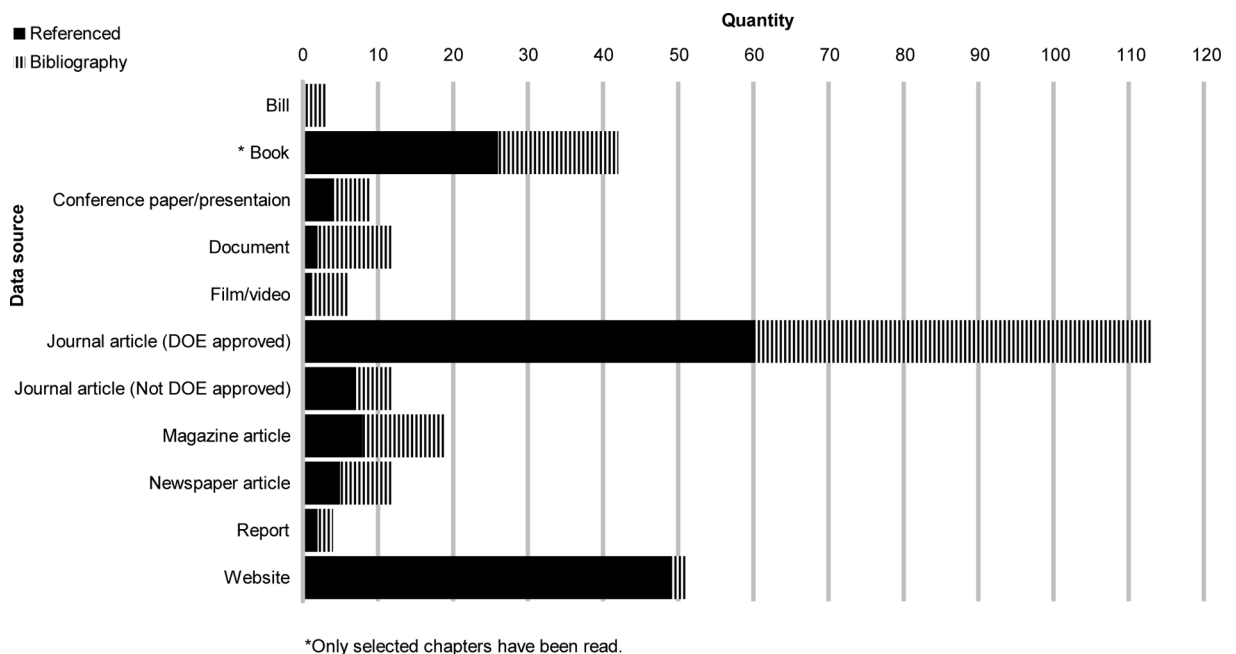


Figure 2.1: Literature review sources

2.3 KEY CONCEPTS

2.3.1 Introduction

The following concepts emerged from the literature review. Each concept aims to reveal the complex relationship between society and technology, ultimately providing a response to the research question and sub-questions.

2.3.2 Sustainability and demand side management (DSM)

The literature noted that a variety of perspectives and approaches aim to achieve sustainable electricity. On the one hand, data suggested a prominent focus on supply side strategy (SSS), which broadly aims to “promote cleaner power generation” (New South Wales Government, 2008). An example of SSS can be found in electricity generated from wind or tidal sources. However, it is not the intention of this thesis to discuss electricity generation technologies, but rather to concentrate on the behavioural aspects surrounding residential consumption of electricity. A practice that performs such an undertaking is demand side management (DSM). DSM encompasses the strategic activities surrounding “planning, implementation, and monitoring of utility activities designed to encourage consumers to modify patterns of electricity usage” (Energy Information Administration, 2008).

DSM programs have been in existence in the United States since the 1970’s. Auffhammer, Blumstein and Fowle (2008:91-92), note how DSM attempted to reduce electricity consumption by providing education and free installation of more efficient technologies. On the one hand, DSM was only formally implemented in South Africa in 1994 (Eskom, 2005). However, on the other hand, as McDonald’s (2009:62) notes, early measures had already been carried out. For example, Eskom, the main utility provider, was required “to introduce policies of load shedding over the period 1948-1953” due to excessive electricity demand from the gold-mining industry.

South African DSM programs have been successful in reducing electricity consumption (Statistics South Africa, 2008). Future initiatives are well documented in Eskom’s “Accelerated Energy Efficiency Plan” (Eskom DSM, 2005), whereby it is attempting to reduce electricity demand by 3 000 MW by 2012. Strategies include awareness campaigns, developing appropriate legislation to manage the importation and use of “inefficient” equipment, and legislation to standardise minimum energy efficiency requirements for buildings. Additionally, proactive incentives such as free efficient lighting and geyser blankets have been supplied to the residential sector in order to conserve electricity.

However, following DSM, electricity consumption may inadvertently increase due to “rebound effects”, whereby, following a DSM campaign, electricity may be consumed in greater quantities than prior to the campaign. For example, the introduction of an energy saving illumination technology may appear attractive to customers due to a reduced wattage generating financial savings. However, due to these savings, customers may purchase more bulbs and additional products, resulting in total electricity consumption potentially increasing. In other words, technology shifts may create unforeseen social opportunities. Internationally, there is also consensus that the understanding of rebound effects is challenging (Midden et al. 2007:160; Loughran & Kulick, 2004:25; UK Energy Research Centre, 2005).

In order to focus DSM on South Africa’s Western Cape and residential markets, Figure 2.2 below provides an overview of Cape Town’s energy usage, with electricity noted in white. The three pie charts highlight various energy consumption patterns. Firstly, electricity, noted in chart A, is the second highest consumed energy source. Secondly, residential energy, noted in chart B, is half the quantity of energy allocated to both industry and commerce. Lastly, chart C clearly notes that electricity creates more than twice the amount of carbon-dioxide when compared to the combination of the remaining sources. Electricity’s large carbon-dioxide footprint is due to South Africa’s abundant cheap coal, which generates ninety-five percent (95%) of the national grid’s electricity (South Africa. Department of Environmental Management, 2003:3). Notably, carbon-dioxide emissions in South Africa have the potential to increase due to electricity consumption, which is forecast to grow fastest in developing countries (Holman, 2009:70 citing Frost & Sullivan, 2008).

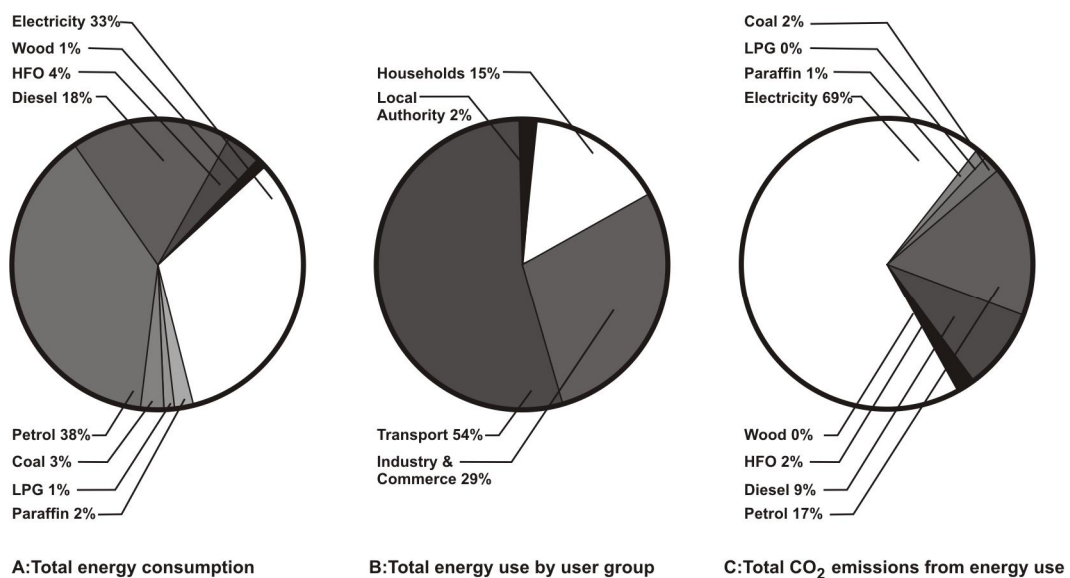


Figure 2.2: Cape Town energy usage statistics
(After South Africa. Department of Environmental Management, 2003:3-5)

2.3.3 Social and technical determinism

The complex role DSM plays in bridging society and technology required an in-depth literature review into both fields. On the one hand, the review identified extensive engineering research, and a preoccupation with developing new technologies to generate further electricity. Such an approach is suggestive of a technical determinism, which Fleischmann (2006:79-80) describes as “the interactions between technology and society as a one-way causal relationship”. With respect to electricity conservation, technically biased solutions may not be accepted by the market. For example, Ziramba (2008:2465) suggests that “price increase alone will not discourage residential EC [*Electricity Consumption*] and that the increase in income does not induce a significant increase in residential electricity demand.”

On the other hand, a disregard for technology’s agency is problematic due to a resulting social determinism. Fleischmann (2006:79-80) describes such determinism as dismissive of the impact technology has on society, and, instead, focused on “the influence of society and culture on technology.” In terms of electricity and DSM, social determinism can actually be to the detriment of renewable electricity. For example, Verbong and Geels (2007:1033-1035) point out how Dutch social protests against the introduction of wind turbines were due to concerns of the technology polluting the natural landscape. However, Verbong and Geels continue by suggesting that such a negative stance on wind energy is partly due to “the neglect of societal embedding of wind energy, with innovation activities focusing only on technical aspects”.

National, social, and technical determinism can dictate DSM trajectories, whereby government policy may encourage research and development with far reaching implications. For example, electric vehicle developments with high upfront costs may require government support. Calef and Goble (2007:1-8) suggest negotiations for such support, financial or policy related, is culturally unique. They point out how during the introduction of electric vehicles, France made use of a non-adversarial approach, by means of academic debate and voluntary participation. On the other hand, they suggest that America lacked public participation, and placed stringent financial penalties on automakers that breached contractual goals.

With regard to DSM, attempts are underway to bridge technical and social determinism. For example, Figure 2.3 illustrates both a technical and social influence to develop a market acceptable CFL. Specifically, the incandescent bulb on the left was initially replaced by the energy efficient technology of the CFL, noted in the centre. Perhaps due to the CFL’s

technically explicit form and poor market acceptance, its exterior was reverse-engineered to represent the familiar incandescent shape, the result of which is indicated in the far right.



Figure 2.3: Bridging illumination technologies

Whereas the CFL makes use of form to link social and technical factors, the three examples noted in Figure 2.4 below suggest a paradigm shift. The turnstile noted on the left stores energy generated from human kinetics and a dynamo, rather than automatically rotating to facilitate pedestrian traffic. The light switch noted in the central image makes use of tactile feedback technology to provide real-time DSM information. For example, during peak electricity demand, although the switch can be turned on, it requires excessive force on the user's part to activate it. The Power-Aware Cord noted on the right is a revised household electrical extension, which makes use of illumination to illustrate electricity and “to make the connection between behaviour and consumption” (Redström, 2006). All three examples demonstrate a unique ability to motivate behaviour change in an ongoing and non-confrontational manner. Additionally, energy conservation positioned at the point of user agency perhaps assists in developing long-term behaviour.

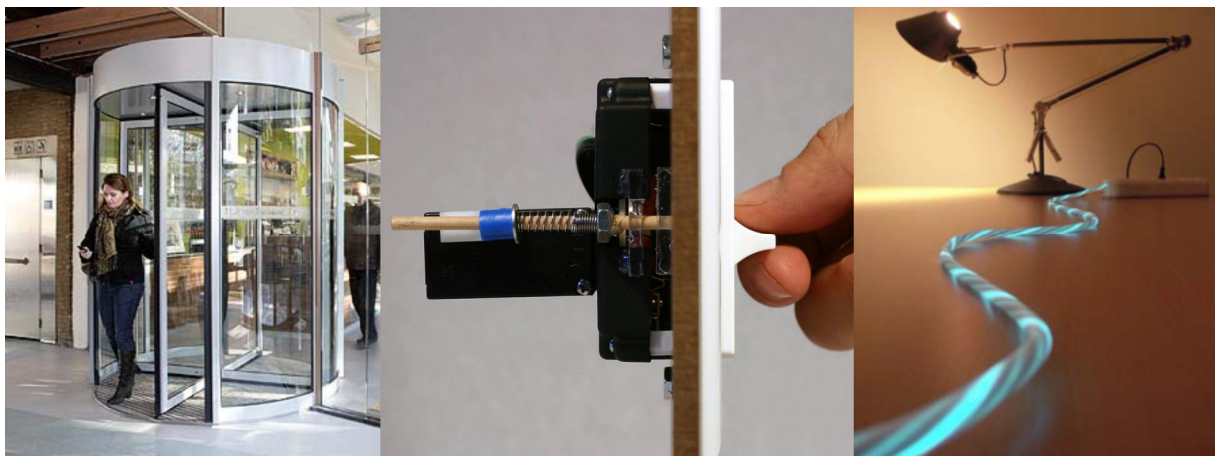


Figure 2.4: Attempts at bridging social and technical determinism (Boon Edam, 2008; Core 77, 2009; Redström, 2006)

Familiar artefacts and terminology may facilitate the introduction of novel technologies. However, from an academic standpoint, if a scientific theory undergoes a paradigm shift, associated vocabulary should in turn be updated. For example, Hewson and Hamlyn (1985:40) point out that outdated terms relating to heat are still incorrectly used in South Africa and Europe. The late eighteenth century caloric theory, which understood heat to be a kind of fluid called “caloric”, has since been replaced by the theory of kinetic energy. The concern arises, as they point out, that caloric terms such as “heat flow” are still used to describe kinetic energy. A similar contemporary example is the generic name for the palm operated computer interface device called the “mouse”. The term originated following an engineer’s description of a prototype in 1960 (Moggridge, 2006:29). Although the term remains almost half a century later, the mouse’s wire, or tail, has been replaced by wireless technology, and the ear buttons by roller buttons. The result is a very limited resemblance to a physical mouse.

2.3.4 Path dependency and national identity

Path dependence, in a national context, is a technical term that describes societies that “become wedded to a particular form of production and move too slowly to adopt new processes” (Nye, 1999:130). The extent of path dependency, or the lack therefore, can be based on a country’s unique history. Nye (1999:145) compares European and American attitudes to energy consumption and carbon-dioxide emissions. Specifically, he suggests that the European approach to reduce carbon emissions through behavioural change contrasts with the American approach of using carbon-dioxide emissions “as a tradeable commodity”, and energy, in turn, is used not as “a limited resource but rather as an abundant product to be bought and sold in the market”. Simms (2009:22) develops Nye’s point further, suggesting a shortcoming in using market solutions, such as carbon trading, to manage environmental problems. In other words, he questions the ethics of identifying the “killing tonne” of carbon-dioxide that will tip the environment into decline.

Path dependency can be transferred across national boundaries in the form of artefacts and branding. Similar to Nye’s aforementioned comments, the compatibility of national brands can be profoundly cultural. For example, Tomaselli (2001:307) comments on an advert for a Japanese automobile which is suggestive of path dependence. Specifically, the automobile claims to “[*tame*] the wild”, which Tomaselli suggests is inappropriate due to circumstances surrounding African independence and political liberation. In a similar vein, Ugiomoh (2004:8) suggests that African art “was central to Western man’s bid to understand himself in a supposedly ‘romantic world’ of a ‘primitive’ age which he has transcended with modernity”. In

the context of this thesis' research into residential electricity, the literature review further explores South African path dependency and its compatibility with foreign forms.

2.3.5 Semiotics

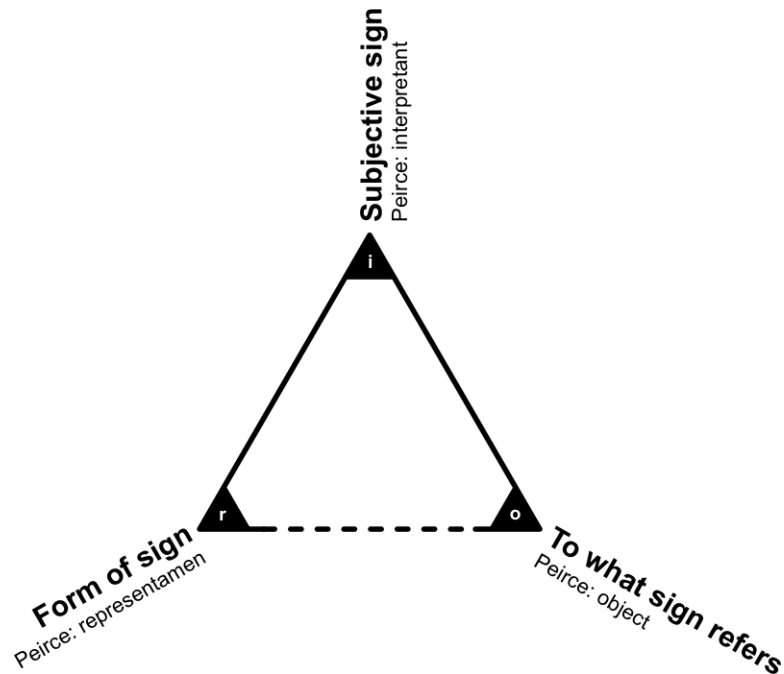
The thesis makes use of semiotics to explore the relationship between electricity, artefacts, and residential users. Semiotics' primary goal is "to establish the underlying conventions ... system of categories, relations, connotations, [*and*] distinctions" of a culture (Aberystwyth University, 2005). Chandler (2002:13) suggests that "we interpret things as signs largely unconsciously by relating them to familiar systems of conventions." In other words, semiotics is the study of symbolism and subjective interpretations.

The field of semiotics is by no means new. It dates back to 460 BC, when Hippocrates detailed "bodily manifested symptoms (signs) as conveyors of messages about physical and mental states" (Mick, 1986:197). Although semiotics may appear in a variety of forms, this thesis is primarily concerned with visual, physical, audible, and olfactory semiotics, both identified in the literature review and from empirical data. In the context of electricity, semiotics can be expressed via branding, gestures, and notably in the form of an artefact. For example, a semiotic in the form of a coal stove is discussed by Meintjes (2001:355). Her research into residential appliances use in Soweto, a South African suburb, notes a semiotic contradiction or dualism. On the one hand, she suggests that the resident's "coal stoves were imbued with symbolic associations of old times, of bad old times of apartheid." On the other hand, they were representative of their "grandmother's teachings that coal stoves – as the place of fire in an urban house – provide a link to ancestors."

Perhaps due to their transitory nature, audible semiotics receive less attention. However, Ludden and Schifferstein (2007:30) highlight their importance; for example, when citing Lyon (2003) and Sapherstein (1998), they point out how Harley Davidson, a fashionable motorbike manufacturer, attempted to register the sound of their engine as a trademark. Although this semiotic is along brand identity, audible semiotics, or the lack thereof, can also have safety ramifications. For example, with the introduction of the electric vehicles that give off low noise relative to the combustion engine, audible semiotics are being reconsidered in an attempt to prevent accidents. Specifically, the American Pedestrian Safety Enhancement Act of 2008 is calling for research into the minimum motor vehicle sound level required to alert pedestrians of vehicle presence (Open Congress, 1998).

Semiotics as a discipline embodies multiple models and manifestations, which have been developed by a variety of authors. For the purpose of this thesis, Charles Sanders Peirce's

semiotic approach has been selected. A deciding factor was his broad scope of semiotic emphasis. For example, whereas other semioticians, such as Ferdinand de Saussure, tend to focus on linguistics, Peirce includes tangible items (Chandler, 2002:33). Additionally, due to the thesis' making use of ethnology, Peirce's semiotic approach is diachronic; which is to say it studies an issue in terms of its evolution over time (Chandler, 2002:9). Peirce's approach to semiotics is illustrated in Figure 2.5 below.



**Figure 2.5: Peirce's triadic model
(After Chandler, 2002:29-30)**

Chandler (2002:29-30) explains Peirce's triadic model as follows: the representamen, indicated on the bottom left, is the form the sign takes, which need not be tangible. The interpretant, noted at the top of the triangle, is the user's understanding of the sign. The object on the bottom right is that to which the sign refers. The broken line between the representamen and object indicates that there is not necessarily a direct or obvious link between the two. All three elements are required to qualify as a "sign". Peirce refers to the communication between the three features as "semeiosis" [*sic*] or semiosis (Chandler, 2002:30). Figure 2.6 provides an example as applied to Peirce's triadic model. The representamen, noted on the bottom left, is the switch. The object, noted on the bottom right, is the incandescent bulb. The interpretant, noted at the top, is the sun or light. When the three images are collectively examined, they could qualify as a sign of induced daylight.

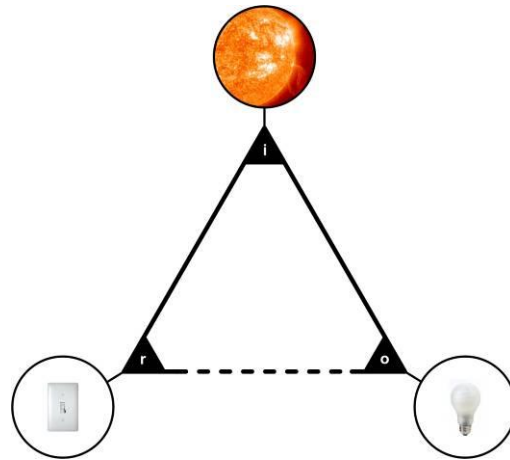
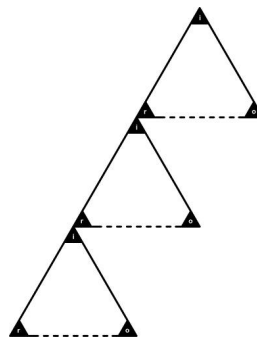


Figure 2.6: Peirce's triadic model example

Peirce's triadic model has a typology of signs, namely: indexical, iconic, and symbolic. These modes aim to classify and describe the relationship between the representamen and the object or interpretant. Chandler (2002:35-47) and Mick (1986:199) explain the modes as follows: Indexical signs point to objects by "blind compulsion", the relationship is direct, unequivocal and contiguous. An example would be a sundial. Iconic signs suggest a perceived resemblance, likeness, or imitation. For example, an actor dressed as the well know political leader Nelson Mandela would be considered iconic. Symbolic signs occur when the signs are based on "conventional association", and refer to objects in a documented and standardised manner. The mathematic symbol π would be an example. Importantly, a sign can be a collection of any combination of modes, and context influences the choice hierarchical positioning of a mode (Chandler, 2002:44).

An important feature of Peirce's model is the dual nature of the interpretant. Mick (1986:199) notes that "since any initial meaning can be re-interpreted (and often is), each interpretant is thus a sign leading to another interpretant." Such an organic and developmental system can be infinite and arguably progressively abstracted. Peirce's successive triadic model is illustrated in Figure 2.7 below, and will be developed in the discussion section 2.4.1.1.



**Figure 2.7: Peirce's successive interpretant
(After Chandler, 2002:29-32)**

2.3.6 Ethnology

Ethnology is the study of the differences and relationships between people's characteristics. With regard to this thesis' focus on residential electricity, the literature review covers predominantly African, European, and North American ethnologies. Fieldwork, on the other hand, focuses only on three Western Cape home languages, which are Afrikaans, English and IsiXhosa. Ethnology, as a practice, has its origin in anthropology, though it is increasingly being used for design research (Laurel & Lunenfeld, 2003:32-37). For example, it is used to understand what Margolin (2002) describes as "the relation between products and how people construct ideals of human happiness".

As a method of enquiry, ethnology assists in identifying and unpacking the relationship between semiotics and electricity, such as the terminology used. Nye's (1999:138) research into the sociology of energy overconsumption notes popular metaphors that emerged with the increase in electricity use. Positive associations between electricity and society resulted in descriptions of successful people as "powerhouses" and talented musicians as giving "electrifying performances". On the other hand, less complimentary descriptions emerged, such as confused individuals having their "wires crossed" or having suffered a "mental short circuit".

2.4 DISCUSSION

The following discussion makes use of Socio-technical Theory (STT) to develop and organise the literature review data. Each of the ten principles noted below firstly introduce Cherns' STT criteria, and secondly unpack residential electricity's semiotics and ethnology.

Principle 1: Compatibility

Principle 2: Minimal Critical Specification

Principle 3: Variance Control

Principle 4: Boundary Location

Principle 5: Information Flow

Principle 6: Power and Authority

Principle 7: The Multifunctional Principle

Principle 8: Support Congruence

Principle 9: Transitional Organisation

Principle 10: Incompletion or the Forth Bridge Principle

2.4.1 Principle 1: Compatibility

2.4.1.1 Unforeseen objectives

Cherns (1976:785) states that "the process of design must be compatible with its objectives." Perhaps the multitude of uses for electricity makes identifying a single objective unfeasible. However, analysing artefact semiotics assists in unpacking potential objectives. For example, Heffner, Kurani and Turrentine (2007:398) suggest that the use of electricity in hybrid electric vehicles, although beneficial in reducing carbon-dioxide emissions, also plays a symbolic role in developing the driver's personal identity. In other words, for the driver of the vehicle, an environmentally aware semiotic may be of similar importance to tangible environmental benefits.

A semiotic is subjective and contextually sensitive. Its reading is influenced by culture and its originator (Feijs & Meinel, 2005:67). Meintjes' (2001:345-360) research into the use of washing machines in Soweto provides some insight into artefacts and semiotics. Her paper outlines the purchasing of washing machines to portray symbolic wealth rather than to provide utilitarian benefit. What is of interest in her research is that the washing machines remain unplugged and, instead, displayed as ornaments. Wives and makotis instead wash the family's clothes by hand, outside the residence, and in full view of the community. Figure

2.8 below illustrates Meintjes' observation using Peirce's successive triadic model. The two triadic models illustrate the dualist and unforeseen nature that the washing machine symbolises. Cassano (2009:380), who draws on the work of Veblen (2008), might describe Meintjes' observations as "a generalized semiotic mechanism through which social actors receive a status wage for their identification with normative value systems". In other words, the washing machine symbolically represents a middle class existence, and the public display of washing clothing by hand reinforces the notion that hard work is a sign of cultural individuality, and washing machines are for the "lazy".

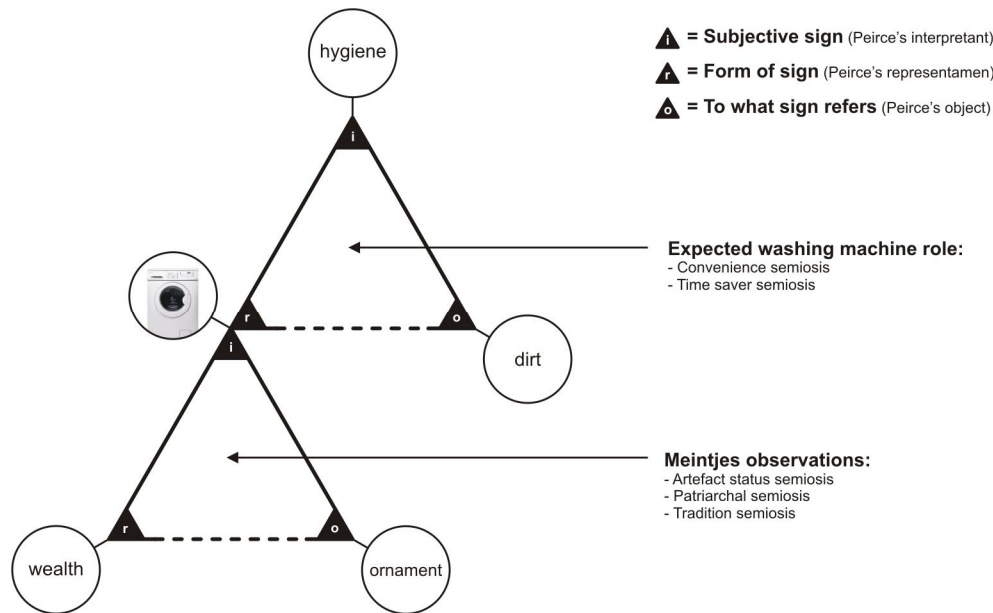


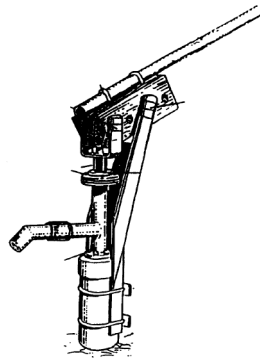
Figure 2.8: Peirce's successive interpretant example

2.4.1.2 Identifying the expert

Cherns (1987:155) argues that "experts ... are required to reveal their assumptions for challenge." From an academic standpoint, peer review mechanisms and DOE certification can encourage such a challenge. However, in professional and commercial environments, expert opinions and assumptions may remain unchallenged and protected by contractual procedures or non-disclosure agreements (NDA). For example, Lemanski (2008:396-399) reveals how in 1997 a housing development in Cape Town was "dominated by the developers and local interest groups rather than the beneficiaries themselves." The beneficiaries were unable to negotiate with the "experts", which in turn led to problems that still required attention eight years after the houses were completed.

If a community is approached in a collaborative and non-hierarchical manner, the aforementioned concern may be avoided. De Laet and Mol (2000) note a Zimbabwean

designed and manufactured bush pump that successfully manages coercive expertise. The product, illustrated in Figure 2.9 below, takes its design intent and maintenance methodology from the community who ultimately use the device. The design encourages the community to update and improve the product by “ingenious adoption” (De Laet & Mol, 2000:42). In doing so, a “fluid technology” was implemented to liberate the users from expert support networks. Barab, Dodge, Thomas, Jackson, and Tuzun (2007:288) provide an additional perspective on managing experts whereby, in support of local adaptation, they introduced continuous design iterations with local control to ensure the technical design translated to the intended context.



**Figure 2.9: Zimbabwean bush pump
(De Laet and Mol citation of Morgan, 2000:229)**

Local objectives may not correspond with international purposes, which is to imply that international experts may not understand local paradigms. For example, Tomaselli (2001:286) described a lack of local technical consistency when “conventional Western signification” is not understood by teams in developing contexts who “don’t themselves always have the wherewithal to use them [*artefact*] or don’t understand the colour and spatial codes of the West.”

2.4.1.3 Conflicting objectives

Cherns (1987:154) maintains that “design is an arena for conflict ... it has to satisfy an array of objectives.” The CFL noted in section 2.3.3 provides an appropriate DSM conflict, whereby its technology struggles to satisfy a variety of objectives. For example, similar to the technical deterministic form of the CFL, its undesirable quality of light may ultimately result in low sales (Hobson, 2006:326). Such a concern is understandable, and may ultimately be resolved following market pressure driving product improvements. However, the deployment of an undesirable technology or semiotic to a market may conflict with future objectives and opportunities. For example, in response to Eskom’s DSM campaign of providing free CFL lighting to “lower-income residents as a ‘sustainability’ project”, Prof Dieter Holm (Reddy, 2006:12) notes that:

“If such technology [*CFL*] is introduced to lower income groups and not seen to be used by higher income users, the product becomes stigmatized — a very real possibility in the South African context.”

The significance of Prof Holm’s comment is realised when read in conjunction with Figure 2.10 below. The two pie charts compare residential energy use for low-income and mid/high-income users for the city of Cape Town. The figure notes a startling contrast, whereby electricity in white powers all the mid/high-income appliances, whilst the low-income households make use of a variety of technologies. Conceivably, Eskom’s energy saving plan to provide over two million CFLs a month to low-income houses (Enslin-Payne, 2008) is misdirected, and should rather be directed to the high electricity consuming, mid/high-income residents. Additionally, following socioeconomic stigmatisation, the adoption of CFLs by mid/high-income residents may be a DSM challenge. It is important to note that, on the one hand, the data in Figure 2.10 is based on “severe data shortages on household energy use in Cape Town” (South Africa. Department of Environmental Management, 2003:6), suggesting unqualified assumptions may have been made. However, on the other hand, McDonald (2009:15) reaffirms such concerns, noting that “middle-to high-income urban households in South Africa are very high energy consumers ... consuming approximately 9 600 kilowatt-hours per year (kWh/year).”

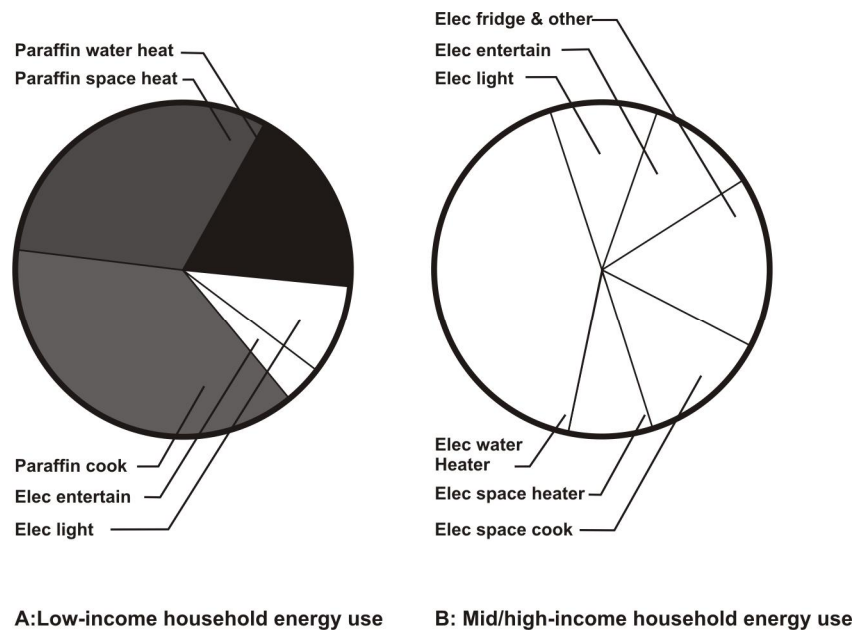


Figure 2.10: Low-income and mid/high-income household energy use (After South Africa. Department of Environmental Management, 2003:6)

The rationale behind South Africa’s DSM interventions for lower income earners is a contentious issue. Winkler et al.’s (2002:602) cost–benefit analysis into a Reconstruction and Development Programme (RDP) points out that implementing energy efficient solutions

requires higher than normal upfront payments, which, in turn, low-income users cannot provide, and results in additional government funding required. Prof Renfrew Christie (2009) develops this argument further, noting that the South African government's rural electrification programs lack long term feasibility, and that energy programs should rather focus on planned urbanisation and industrial scale renewable solutions. If all the aforementioned examples are considered alongside Cherns' request for design to be an "arena for conflict", it is arguable that sustainable residential electricity solutions have yet to take up the struggle. In other words, rather than focusing on low barrier to entry low-income markets, DSM should target the demanding mid/high-income markets that consume the majority of residential electricity.

2.4.1.4 Historic monopolies

Cherns (1987:155) suggests that "majority rule, horse trading, or power plays, are unacceptable." With regard to residential electricity in a South African context, Cherns' request is problematic. Specifically, due to the country's electricity supply having been dominated by a single utility for almost a century. The utility, formerly known as the Electricity Supply Commission (Escom), was set up in 1922 to supply cheap power for mining, transport, and manufacturing (Christie, 1984:1-84). On the one hand, its formation as a utility monopoly was due to certain practical realities, such as exorbitant electrical network setup costs. However, on the other hand, as McDonald (2009:61) notes, far reaching political goals ultimately materialised. He quotes Eberhard's (2003) citation of Jan Smuts, the South African Prime Minister from 1919 to 1924 and 1939 to 1948. Smuts justified Eskom's newly formed monopoly by stating that "there are certain industries which experience has taught us can be driven better by Government without loss through wasteful competition."

It would be incorrect to suggest that South Africa is the only country with an electricity utility monopoly. A similar American form of market dominance arose in the form of companies such as General Electric (GE) and Westinghouse at the turn of the nineteenth century. The corporations formed close-knit associations, for example the "Electric Club", which, although not a monopoly, functioned as an oligopoly (Nye, 1992:173). In other words, it remained profitable by, for example, supplying both industrial equipment and domestic products, managing losses from one market with gains from another (Nye, 1992:18). The extent of GE's current service offering (General Electric, 2009), which supplies diverse energy sources and the appliances which consume such energy, suggests it is a monopoly of insurmountable proportions. Attempts in the energy sector have been made to prevent or remove monopolies and oligopolies. For example, the Dutch government centralised energy strategies to the minister of economic affairs and away from the private sector. Their 1989 electricity law

enforced the separation of electricity production from distribution, and the allowed electricity imports from neighbouring countries (Verbong & Geels, 2005:1027-1031).

2.4.2 Principle 2: Minimal Critical Specification

2.4.2.1 Defining the nominal

Cherns (1976:786) begins this principle by stating that “no more should be specified than is absolutely essential.” Although contentious (McDonald, 2009:24), South Africa has identified a minimum specification for supplying free electricity to its RDP developments. Individuals below a certain income bracket are provided with fifty kilowatt-hours of free grid electricity per month, for use on “basic lighting, basic media access, basic water heating using a kettle, and basic ironing in terms of grid electricity” (Department of Minerals and Energy, 2000). Winkler (2009:211), when citing Borchers et al. (2001) notes that “electricity consumption rose by thirty to thirty-five kilowatt-hour per month, per customer, after the introduction of the poverty tariff,” suggesting the emergence of unforeseen rebound affects.

In order to understand what constitutes minimum electricity use for a broader culture, Table 2.1 indicates 2006 net electricity consumption for Africa, Europe, and North America. The data is provided by the Energy Information Administration (EIA) and the International Energy Agency (IEA). The EIA (2008) describes electricity consumption, excluding the United States, as the “total net electricity generation + electricity imports - electricity exports - electricity distribution losses”. The IEA (2009) describes electricity consumption as the “gross production + imports - exports - transmission/distribution losses of electricity”.

Table 2.1: Net electricity consumption 2006
(Energy Information Administration, 2008; International Energy Agency, 2009)

	ENERGY INFORMATION ADMINISTRATION (EIA)	INTERNATIONAL ENERGY AGENCY (IEA)
Africa	0,480 (TWh)	0,160 to 1,060 (TWh)
Europe	3,296 (TWh)	2,860 to 3,760 (TWh)
North America	4,543 (TWh)	3,760 to 4,660 (TWh)

Although the EIA and IEA definition of net electricity varies to some degree, the noted 2006 consumption corresponds, and illustrates the vast difference in continental and, arguably, cultural usage. Specifically, North America used thirteen percent (13%) more electricity than Europe, and almost ten times more electricity than Africa. Perhaps in agreement with the data, Nye (1999:139-142) suggests that American energy use “seems [to be] an inalienable American right, a kind of entitlement”. He continues, noting a cultural preference for

illumination, whereby “Danish homes seem dim to American visitors.” The artefact itself has historically distinguished between socioeconomic systems. For example, the 1959 “kitchen debate” matched up capitalism to communism by means of a discussion between the United States President Nixon and the Soviet Union Premier Khrushchev. It took place in an American simulated kitchen interior complete with “novel” appliances. When Nixon commented on America’s attempts to “make life easier for women” using kitchen appliances, Khrushchev retorted: “Your [*American*] capitalistic attitude toward women does not occur under Communism” (Teaching American History, 2008). In other words, national cultures can influence or dictate how residents purchase artefacts and consume electricity.

2.4.2.2 Shifting targets

Cherns (1976:786) argues that good design originates from providing what needs to be done, rather than how it must be done. On the one hand, due to electricity being generated by a selection of sources, which in turn power a variety of artefacts, perhaps makes identifying what needs to be done unattainable. On the other hand, understanding agency between an artefact’s technical and social characteristics may highlight what design is required (Kroes, Franssen, van de Poel & Ottens, 2006:806; Mick & Fournier, 1998:124). This pluralist role artefact embody, is further explained by means of the following air-conditioning example.

Wilson and Dowlatabadi (2007:187) cite Kempton and Lutzenhiser’s (1992) shifting air-conditioning usage statistics for American households. They found that, from 1962 to 2001, usage increased from twelve percent (12%) to seventy-five percent (75%). On the other hand, the increases simply arose following mass production’s economies of scale opportunities. However, on the other hand, as Hitchings and Lee (2008:259-263) point out; cultural identity can directly influence air conditioning usage. Their Singaporean study notes that, following a greater access to international fashions, youth are increasingly adopting a foreign dress sense. However, due to the clothing worn not being suited to Singapore’s humid climate, air-conditioning is frequently used. Additionally, they continue to note that technically appropriate and historically relevant clothing that allows homogenous cultural expression is on the decline, and that natural sweating is often depicted as representing illness.

The demand for electricity obtained from renewable resources has complicated DSM and SSS. Midden et al (2007:158) suggest that, although individual behaviour patterns may be negligible, collective behaviour and consumption can be significant. For example, the increase in off-grid implementations such as solar and micro generation can lead to difficulties in balancing demand and supply loads. In some cases, the use of industrial scale

wind parks has resulted in irregular load patterns and subsequent “blackouts” (Verbong & Geels, 2006:1031).

2.4.2.3 Green electricity and consumer

Cherns (1976:786) maintains that each design decision should be challenged and alternative solutions offered. Two broad residential electricity categories have emerged, namely the renewable and the non-renewable energy adopters. South Africa currently provides no significant alternative electricity options to its residential users, and users have no ability to purchase only a coal or nuclear source. However, society’s subjective perspective on the various sources reveals electricity semiotics.

For example, Hartmann and Apaolaza-Ibáñez (2008:820) suggest that individuals are willing to pay a premium for renewable energy, which is frequently described as green-energy or clean-technology. They continue, in support of Menges, Schroeder, and Traub (2005:431), by suggesting that a uniformed purchase of green energy is an “impure altruism”. In other words, consumers may not have the environmental benefit as the rationale behind their purchase, but rather a personal goal of buying a socially approved service. Hartman and Apaolaza-Ibáñez suggest that the ultimate goal for such altruistic purchases is to obtain the “warm glow of giving”.

Altruistic and emotive purchasing discussions can coalesce into organisations such as Germany’s Green Party, which originated from environmental protests against nuclear power (Encyclopaedia Britannica, 2009). Perhaps such manifestations are reactionary, as Verbong and Geels (2006:1029) suggest, illustrating how Ukraine’s Tsjernobyl [*sic*] (Chernobyl) nuclear energy reactor accident in 1986 ended a lengthy Dutch debate on nuclear energy policy. Additionally, artefact or service providers are being publically scrutinised following their claims of sustainable product. For example, Calef and Goble (2007:16) note how electric vehicle programs have been vetoed by environmental groups, due to concerns of the vehicles power still being obtained from nuclear sources. Mackay (2009:168) places electricity origination concerns into perspective in Figure 2.11. The data summarises the fatality rate per gigawatt-year (GWy) for nine electricity generation technologies. Notably, coal and oil have the highest death rates, and nuclear and hydroelectricity the lowest, suggesting misinformation has occurred regarding nuclear energy’s safety.

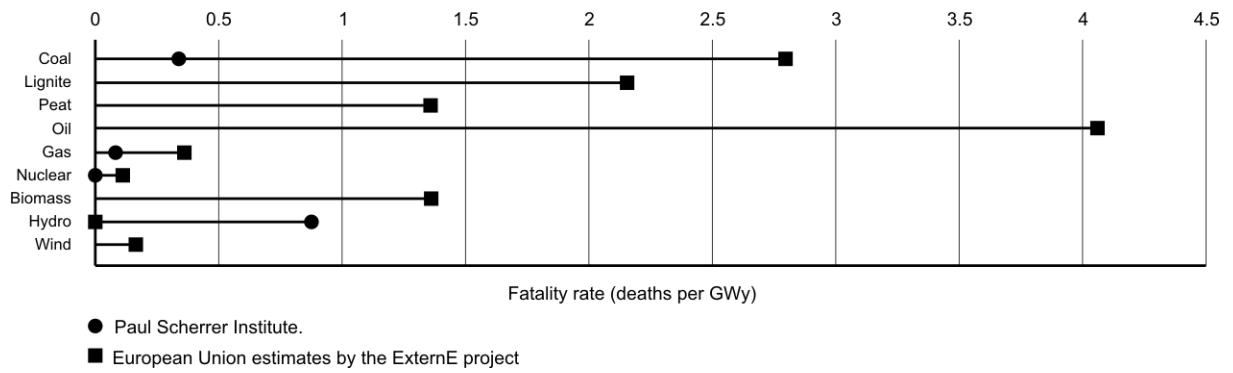


Figure 2.11: Death rates of electricity generation technologies (After Mackay, 2009:168)

An additional factor that can dictate electricity’s minimal specification is the scale of power generation. On the one hand, industrial scale developments are required in order for renewable energy to be viable, following Prof Christie’s suggestion. However, societal reactions to such developments can in turn be negative. For example, Pearce (2009:33) highlights environmental complications surrounding a fourteen billion dollar tidal power initiative that was intended to replace eight coal-fired power stations. Surprisingly, environmentalists argued against the project, claiming it would displace and endanger local wildlife. Pearce suggests the unfortunate paradox is one of scale, and, in agreement with Christie, he suggests that industrial scale projects are required to satisfy electricity consumption, whilst minor projects act more as symbolic agents. He concludes, asking whether “environmental energy comes at an environmental cost.”

It is important to note unqualified claims that have been made on the benefits of non-renewable energy. For example, when atomic power achieved an industrial scale generative capability, America suggested that it would be "too cheap to meter" (Nye, 1999:141). Although such claims have subsequently been discredited, misconceptions of nuclear energy as a non-renewable source perhaps remain. In other words, the renewable energy debate may be considered by society as academic, and that long-term electricity can be derived from nuclear sources. However, Professor of Physics, David L. Goodstein points out that if nuclear energy immediately replaced our current dependence on fossil fuels, and energy consumption rate, the known reserves of uranium would only last up to twenty years (A crude awakening, 2006). Although not in disagreement, Mackay (2009:162-164) notes that the concern of depleting uranium reserves is largely dependant on nuclear technology and uranium resource access. Fast breeder reactors are sixty times more efficient than “once-through reactors” and a substantial amount of uranium remain in largely untapped ocean reserves.

2.4.3 Principle 3: Variance Control

2.4.3.1 Locating electricity's origin

Cherns (1976:787) outlines that “variances, if they cannot be eliminated, must be controlled as near to their point of origin as possible.” He defines variance as an unforeseen event that significantly affects an outcome. In order to identify electricity’s potential variance, Johnson’s (2008:521) socio-technical paper on science and policy provides an appropriate starting point. He notes that design, although beginning with perceived needs, has no optimal solution, but rather a compromised reality. Electricity indeed satisfies a multitude of residential needs, however, the extent to which it or associated artefacts are compromised, requires further discussion.

Humankind’s awareness of electricity potentially arose in the form of lightning. Contemporary definitions of lightning have literal descriptions, for example, the Oxford English Dictionary describes it as “the occurrence of a high-voltage electrical discharge between a cloud and the ground or within a cloud, accompanied by a bright flash”. However, as Chevalier and Gheerbrant (1996:606-607) indicate, lightning was frequently cited in mythical, spiritual, and biblical contexts. For example, they note the bible, specifically Daniel 10:6 and Job 36:32 in which it is respectively noted that God’s face flashed like lightning and his hands were covered with lightning. The ancient Babylonian “figure” and Greek god, Zeus, is the god of the thunderbolt. Aboriginal mythology on the other hand refers to lightning as a “tumescient penis”, and similarly African Pygmy myth refers to lightning as the marriage between Heaven and Earth.

The aforementioned natural and creationist origins of electricity as a concept can perhaps be considered premodern due to their unscientific expression. In a different light, Bertucci (2007:88-93) presents compelling insight into how electricity was used as a source of entertainment for the eighteenth century aristocracy. It was named the “electric fire”, and its properties were demonstrated with acts of magic and superstition. For example, in 1730, Stephen Gray developed an act called “the flying boy experiment”, whereby a youth suspended by silk cords used electricity to levitate pieces of paper. Importantly, Bertucci describes how electricity was understood by society at that period:

“The electric fire revealed itself to the eyes, the ears and even the nose ... audiences in search of entertainment and education were particularly impressed by the sensuous experience of the electric fire.”

Bertucci (2007:90-92) continues to point out how electricity's former creationist and domineering stature was replaced with human qualities such as the "youngest daughter of the sciences." Additionally, he describes the German professor Georg Matthias Bose, who in, perhaps attempting to convey the abstract qualities of electricity to a greater audience, created gender specific attributes for electricity:

"The male fire, emitted by metals and animal bodies, was unsurprisingly strong and powerful: sparks, with their crackling sound, were visible manifestations of this kind of fire. The female fire, instead, was a weak luminous emanation, the kind of light that characterized the aurora borealis."

Several electricity terms that are still in use today can be traced back to the Age of Enlightenment. For example, the volt is named after Alessandro Volta, who conceived of the electric battery following his bioelectricity research that induced muscular movements in animals (Conniff, 2008:44). Volta's research was revolutionary, and had its foundation in the scientific and cultural intellectual life of the Age of Enlightenment, which tended to be focussed in the British Isles and continental Europe (Basalla, 2005:146). The result of this, as Conniff points out (2008:44), was a concentrated scientific community with direct access to the "spectacle" of the natural world.

2.4.3.2 Postmodern trajectory

The aforementioned creationist, analytical, and later industrial examples of electricity are suggestive of a premodern to a postmodern trajectory. Specifically, premodern accounts of lightning were superseded by the Enlightenment's experiments with electricity, which suggested the existence of modernism. The subsequent amalgamation of electricity into an artefact is, in turn, suggestive of postmodernism. In other words, an individual's relationship with electricity has shifted from a primary interaction, to a secondary and supportive role. In electricity's postmodern materialisation, an artefact would arguably be considered the agent with which an emotional need is satisfied, and electricity is merely considered an abstract power requirement.

Electricity's postmodern trajectory is of importance to this thesis. The literature review suggested that South Africa had minor involvement in the evolution of electricity when compared to America and Europe. Consequently, scientific developments at the epicentre of the Enlightenment would create divergent perspectives on electricity use for countries not involved in the Enlightenment. For example, a society participating in the unfolding of electricity would have a different view to a society where it is installed in an industrial form.

2.4.4 Principle 4: Boundary Location

2.4.4.1 Invisible borders

Cherns (1976:788) recommends that “boundaries have to be drawn somewhere.” Examples of residential electricity boundaries can be electricity suppliers, purchasers, consumers and maintainers. With regard to renewable energy, these boundaries are shifting and in some cases being removed altogether. For example, solar or wind energy has placed an emphasis on the energy maintainer rather than supplier. Boundaries have geographic delineations, however they also comprise of non-geographic boundaries or social worlds. Fleischmann (2006:78) defines social worlds in a STT context as “a set of common or joint activities or concerns bound together by a network of communication.” He continues to note how artefacts act as boundary mediators to “bridge social worlds”.

An example of such mediation is Hobson’s (2006:324-329) paper on sustainable living in suburban social worlds. Similar to Meintjes’ washing machine example, she illustrates how recycling bins and CFLs’ convey and connect community and individual social practices. Her research suggests that these artefacts indicate “iconic suburban” practices, that unite individual behavioural boundaries with municipal health and environmental boundaries. Hobson continues to note that although most residents owned a recycling bin, very few residents had carried out a “bin audit” or “re-use objects”. She defines such an artefact as a “knowledge object”, due to its public display of how technical systems are woven into society.

2.4.4.2 Maintaining boundaries

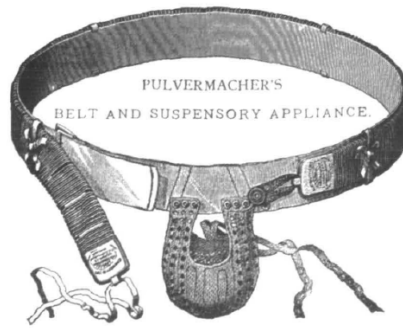
Cherns (1987:156) highlights that “boundaries should not be drawn so as to impede the sharing of information, knowledge, and learning.” Various residential electricity DSM initiatives are underway to provide information by means of social interaction or artefact design. For example, Eskom provides real-time load management information using the national television broadcaster to manage boundaries. Venter and van der Walt (2007:6) suggest that “calls to action (such as those implemented via Power Alert) [*An Eskom initiative*] are a resounding success in a crisis situation.” In a more focused manner, Abrahamse et al. (2005:280) suggest that energy saving information can be distributed in the form of EcoTeam Programs (ETP). An EcoTeam comprises of neighbours, friends, and families who assemble once a month to exchange energy-saving tips.

2.4.4.3 Boundary stigma

The diverse implementations electricity allows can in turn lead to subjective and contradictory boundary influences. The following examples describe how electricity has been used to end life, detect life, and improve life. With regard to capital punishment, Denver, Best and Haas (2008:236) note how both Thomas Edison and George Westinghouse, respective developers of direct and alternating current, endorsed each other's product for electrocution. The intent of this was to ensure their product was not associated with death. In a somewhat amusing approach, Thomas Edison, when proposing that the state use Westinghouse's alternating current, suggested death by electrocution be defined as an individual being "westinghoused". Denver et al. continue, pointing out how botched electrocutions, which ultimately made use of alternating current, became synonymous with dreadful odours, frying sounds, and sparks from the head. In an ironic turn of events, electricity was also used to detect life after lethal injection in the form of an Electroencephalogram (EEG) monitor (Denver et al., 2008:241).

Gilman (2008:340-353) notes how the use of electricity as a means of identifying or improving health dates back to when the Greeks used static electricity, generated by rubbing fur on amber, as a form of electrotherapy. However, he indicates how contemporary accounts of electrotherapy for physical and mental benefits have largely correlated to the placebo affect, and states that in the 1890's, Freud "came to judge electrotherapy as unsuccessful since it deemed to be only effective through suggestion." In other words, electrotherapists suggested that sparks from static machines provide a psychic curing ability. However, electrotherapy has recently gained acknowledgement in the improvement of mental health. Gilman notes that in 2001, the Food and Drug Administration (FDA) approved the use of pacemakers to electrically stimulate the vagus nerve, in order to treat chronic depression.

Electricity's link to virility/fertility emerged during the eighteenth century and at the turn of the nineteenth century. For example, Bertucci (2007:92) describes the "Celestial Bed", which was developed by George Graham. The bed claimed to help "couples fight against barrenness [*impotence*]" by means of electric vapours that surrounded the bed. In a more intimate approach, De la Pena (2001:276-278) describes the "electric belt" which proposed that a direct link between electricity and male sexual energy existed. The belt, illustrated in Figure 2.12, aimed to cure erectile dysfunction by replenishing lost "energy" by applying galvanic current to the user's genitals. The advertisers of the belt claimed that "the only 'modern body' was an electric body."



**Figure 2.12: The early Pulvermacher electric belt (1882)
(De la Pena, 2001:277)**

2.4.5 Principle 5: Information Flow

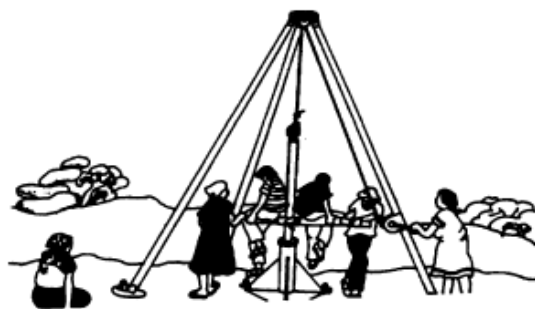
2.4.5.1 User participation

Cherns (1987:157) advises that information systems should “be designed in cooperation with their primary users”. Broadly defined, electricity has three primary users. These are residential, commercial, and industrial users. On the one hand, as far as cooperation is concerned, government primarily drives electricity related policy and users provide little input (Verborg and Geels, 2007:1027). On the other hand, as Christie (1984:1-84) notes, residential users in South Africa have not been required to provide input, due to Eskom being obligated to operated for many years with a “power without profit” agreement with government.

However, since 1992 the electricity landscape has changed in South Africa, with Eskom’s rapid household electrification program. Ziramba (2008: 3460), when citing Davidson, Tyani, and Afrane-Okesse, notes that by 2025, an estimated additional eleven-and-a-half million residential households will be connected to the national grid in South Africa. Arguably, one consequence of this would be that a larger market would have more influence on energy related policy. Enslin-Payne (2008:1) suggests that, following Eskom’s public announcement to reduce electricity consumption, such a trend has already commenced. Citing Statistics SA, she notes how, following Eskom’s request to reduce consumption, key industrial customers, who represent forty percent (40%) of overall electricity use, responded by reducing their consumption by ten percent (10%). However, non-industrial users “barely cut demand at all”, and electricity consumption continued to rise two-point-three percent (2.3%) when compared to the previous year.

Barab et al.’s (2007:280) paper titled “Our designs and the social agendas they carry” describe users as “collaborators” rather than participants. They note that such an approach

"resulted in a grounded appreciation of their actual needs and interests - as opposed to our prior assumptions - and thus changed our initial conceptions." In other words, teams developing socio-technical artefacts within electricity markets should recognise the information already held by the users. An appropriate example illustrating user participation is the aforementioned Zimbabwean bush pump. User participation is required throughout the product development, including installation (de Laet and Mol, 2000). The pump's borehole is installed not by an external contractor, but by the community which it will service. Specifically, men weigh down the iron cross bar illustrated in Figure 2.13 below, and women rotate the pipe into the ground. The authors suggest that community aligned developments encourage product longevity by creating a sense of ownership.



**Figure 2.13: Community service delivery
(de Laet and Mol citing Morgan, 2000:233)**

Community participation within residential electricity markets is perhaps more complex. Additionally, due to poor service delivery in South Africa, many residents have illegally connected their household to the national grid. Residents living in such communities have developed their own electricity grid complete with distribution points and financial models. Mkalipi (2008:5), who titled his newspaper article "The only way for poor is illegal connections", notes how consumers pay between fifty and one-hundred rand to be connected to the grid. On the one hand, the connection, although operational, can have fatal consequences due to unregistered contractors with potentially inferior skills providing the service. On the other hand, as Kalamane (2008:1) points out on the disconnection of 2,458 illegally connected "shacks", a city power revenue protection officer simply stated that "they [*residents*] will have some electricity by tonight." Arguably, safety and legal ramifications are of secondary importance to residential users without electricity. Brazil, whose favela's have many similarities to South Africa's informal townships, has made use of socioeconomic factors to benefit both utility providers and the residents themselves. Uken (2009:6), when citing Mollet (2009), describes how the "poorest of the poor" pay for electricity in a manner that ensures their physical address is formally recognised. In other words, the payments carry the benefit that financial institutions have enough personal details to risk granting the residents a loan.

2.4.5.2 Acting with information

Cherns (1987:157) argues that “information for action should be directed first to those whose task it is to act.” In the context of this research, information for behavioural change is a fundamental goal of DSM. On the one hand, Van Raaij and Verhallen (1983:122) indicate that energy efficiency campaigns generate an energy-conscious attitude. However, on the other hand, these campaigns do not always lead to long-term energy-conserving behaviour. Factors such as monthly billing may demotivate energy conscious attitudes, due to the lack of immediate feedback on hourly or daily energy conscious actions. A frequently cited solution to such concerns is with smart-home artefacts that convert wattage used to financial goals in real-time (SmartHomeUSA, 2009). However, the implementation cost relative to finances saved is questioned in electricity journals (Anon, 2008:6-7).

Unlike some homogenous European countries, South Africa’s racially exclusive and intricate past further complicates the introduction of DSM programs. For example, the attempt at managing municipal services such as water through pre-payment meters has been criticised by Muller (2008:85). He suggests that, “due to errors of inclusion and exclusion ... [it] has been further suggested that the way in which tariffs are now calculated reinforces inequality.” His concerns were reinforced by a Johannesburg High Court judge, who declared that a water saving initiative that was facilitated by prepayment meters was “not only unreasonable, unfair, and inequitable, it [was] also discriminatory solely on the basis of colour.” The judge cited the ability of predominantly white suburban residents to obtain credit for water, whilst black suburban residents could not (African Energy News Review, 2008).

2.4.5.3 Symbolic agency

Semiotics is frequently used in DSM consumer awareness campaigns. Ang and Lim (2006:40-50) provide further insight into the relationship between product type, brand personality, and semiotics. They cite Paivio and Csapo (1973), who suggest that pictures are superior to words in enhancing recall. Additionally, visual metaphors provide a useful and effective method to convey culturally appropriate messages. They suggest that metaphors provide pleasurable “artistic deviations” which, in order to be discovered, require users to contemplate and search their knowledge base. Ang and Lim’s (2006:40-50) research is of importance to designers working with DSM, following their conclusion that “symbolic products were perceived to be more sophisticated and exciting, but were less associated with sincerity and competency, than utilitarian products.”

Midden et al. (2007:164-163) point out how popular culture films make use of metaphors to reinforce environmental concerns. For example, they cite Leiserowitz's (2004) survey on American viewers who watched the 2004 climate change drama "The Day after Tomorrow". Viewers noted that the film appeared to increase concerns about threats to their livelihood. However, no data was provided on the duration or extent of such concerns. Additionally, Midden et al. (2007:164-163) reference a Dutch television campaign on low-emission cars and the disposal of chemicals. They point out that, although visual media is more easily "accessed", knowledge creation and subsequent motivation to understand more did not increase.

A South African indigenous semiotic has been used to protect the country's electricity grid. Specifically, Eskom, in an attempt to curb copper cable theft from the grid, used the African metaphor for snakes "izinyoka" in an awareness campaign. The IsiXhosa term intended to associate criminals and snakes, with the implication that they, being enemies of the community, need to be observed for covert movements (Anon, 2005:62). Perhaps unique to South Africa's politically sensitive climate, the campaign was considered offensive, as it was claimed that it created an impression that only "black people" steal electricity. However, the Advertising Standards Authority (ASA) stated that "after careful consideration, the ASA decided the ad contained no insinuation of racism, discrimination, or inducement of fear" (Biz-community, 2009).

2.4.6 Principle 6: Power and Authority

2.4.6.1 Trust in authority

Cherns (1987:157) maintains that "those who need equipment, materials, or other resources to carry out their responsibilities should have access to them." Residential users of electricity require a variety of equipment to sustain or improve their lifestyle. Additionally, their relationship with this equipment may be of a constructive or destructive nature. As a means of coping with complex interactions, Mick and Fournier (1998:125-138) describe how consumers frequently "partner" with their possession. They suggest that such relationships can be paradoxical, and, when citing Winner (1994), they note that "the same technology that creates radiant feelings of intelligence and efficacy can also precipitate feelings of stupidity and ineptitude." Midden et al. (2007:169-171) support Mick and Fournier's view, suggesting that, with technology's fluid nature, modern systems increasingly lack visibility and predictability. Such systems, they argue, compromise trustworthiness and lack user cooperation.

2.4.6.2 Community authority

Cherns (1987:157) proposes that individuals must have authority to command resources and equipment. On the one hand, authority is frequently expressed in terms of qualifications or successive ranking structures, for example, the proverbial corporate ladder. On the other hand, De Laet and Mol (2000:258-259) describe an indigenous form of authority, perhaps unfamiliar to western paradigms. They explain how the Nganga, who is a Zimbabwean community authority, requires consultation when deciding on a water-well placement. The Nganga has geological knowledge; however, it is only with his personal approval and subsequent blessing of a well that the community will in-fact make use of it. In South Africa, Lemanski (2008:402) suggests that collective community authority may be on the decline. With regard to her aforementioned RDP case study in Westlake informal settlement, she suggests that community adhesion developed during the “struggle” has since been diluted by a newfound democracy. The result of this is that contractors are able to manipulate fractured communities.

2.4.6.3 National authority

Electricity’s vast economy of scale frequently requires national implementation. Additionally, the prerequisite skills and capital investment may reduce the number of national actors. The emergence of authoritarian nations in turn creates countries that are dependent on their uninterrupted supply of electricity. Similar to dominant forms of electricity suppliers in Europe (such as France), actors are emerging on the African continent. For example, Lesotho and Swaziland are dependant on South Africa’s electricity generation capability (McDonald, 2009:31). However, the emergence of the Democratic Republic of the Congo’s (DRC) Inga project, which has the potential to be the largest single-point source of hydro-power in the world (McDonald, 2009:34), suggests the emergence of a new national authority.

The relations between a national authority and the country’s inhabitants may not be harmonious. For example, South African reactions to the load-shedding practices of the national electricity provider, Eskom, is well documented on www.eskomsucks.co.za. The website’s visual identity parodies the Eskom brand, complete with a “suck-o-meter” that emulates their “Power Alert” meter (Eskom sucks, n.d.). Although this example illustrates a form of South African creative activism, Calef and Goble (2007:21-24) suggest that the United States society has an innate distrust of government “interference” in public dealings. Nye (1999:136), in support of such a comment, notes that many Americans felt the Organization of Petroleum Exporting Countries (OPEC) had artificially created the 1970’s oil crisis. In other words, Americans claimed that oil reserves were in-fact stable, and that

government warnings were intended to maximise their financial gains resulting from an inflated petrol price.

2.4.6.4 Natural authority

Prior to the eighteenth hundreds, nature “had been locked away behind moral lessons and mythology” (Conniff, 2008:44). The Age of Enlightenment provided a paradigm shift in humankind’s relationship to nature, whereby scientific endeavour allowed nature to be re-assessed and effectively harnessed. However, Stanford Professor of political science, Terry Lynn Karl, highlights an energy and humanity paradox (A crude awakening, 2006). She cites Juan Perez Alfonzo’s description of oil, “El excremento del Diablo”, which translates to “The Devil’s excrement”. Alfonzo, an OPEC Founder and diplomat, was commenting on the ironic devastation following the initial success that oil brings to a country.

Lightning has already been noted in a creationist context. However, Cooray and Andrews (2007:386-392) provide insight into the tangible affects that occur when individuals are struck by lighting. They point out that, although physical injuries to the respiratory and cardiovascular system can be substantial, it is the “psychological components of the injury that cause the most ongoing distress”. Psychological injuries such as anxiety, depression, and disorders of memory have been reported. Importantly, death by lightning is frequently related to population density and rural housing conditions. Lightning statistics are available only for a few countries, however, Table 2.2 below illustrates that South Africa has the highest probability of death-by-lightning of all the countries listed.

Table 2.2: Lightning statistics
(Extracted from Cooray and Andrews, 2007:386)

AVERAGE/PROBABILITY	RSA URBAN	RSA RURAL	SRI LANKA	SWEDEN	UK	USA
Injuries per annum					50	
Deaths per annum			50	1	3	100
Death per 1 million	1.5	9			0.05	

2.4.7 Principle 7: The Multifunctional Principle

2.4.7.1 Cartesian systems

Cherns (1987:158) argues that individuals should adapt to their environment. The method with which an individual or country adapts may vary. For example, Tomaselli (2001:286) notes that South African approaches to technical enquiry differ from international norms. Specifically, he suggests that European Cartesian logic, which has its foundation in doubting

all knowledge until facts and opinions can be repetitively proven, is “often subverted by indigenous forms of reasoning, which operate on circular and nonlinear patterns.” In other words, European procedures are perhaps not suited to a South African context, and cultural agency may supersede iterative criterion. Similarly, Calef and Goble (2007:21) note that French policymakers favour Cartesian systems over American pluralist models. The pluralist model is when public policy emerges from the influence of prominence, wealth, and strength between competing groups (San Antonio College, 2009).

On the one hand, it would be premature to identify a method of enquiry for South Africa, due to the country’s recent democracy and fluid political structures. However, on the other hand, Woolfrey (2009:23) argues that for many African governments, empirical research is largely considered conceptual and used to support, rather than drive, policy creation. He points out how, academic contribution to policy creation has commenced only recently, citing how in 1984, UCT was branded as “seditious” by the government of the time, following their report into Southern African poverty.

2.4.7.2 Social variance

Cherns (1987:158) suggests that elements need to adapt to their environments, of which the most important are usually other elements. With regard to social adaptation, gender elements can dictate residential use of artefacts and consumption behavioural patterns. For example, Meintjes’ (2001:349) washing machine example illustrates how product usage can be motivated by patriarchal roles when she cites a male respondent’s comment that washing machines make “lazy women”, and that those that use them are “good for nothing”. She points out how the washing machines conflict with the “patriarchal notion of the ‘proper’ role of African women as hardworking domestic labourers.”

Similarly, Freeplay Energy, a company that develops and distributes human powered radios, also encounters patriarchal influences in Africa. Goodwin (2009) explains how men frequently remove batteries from the household’s radio prior to leaving for work, and reinstall them on their return. He notes that radios in remote areas can symbolise and provide an unbiased “truth”, which male-headed households deny access to, thus perpetuating the situation of women and children living a disenfranchised reality. Notably, the radio was banned by the Zimbabwean government, due to it being considered a “subversive tool” (Action for Southern Africa, 2009). However, it is important to note that, although patriarchal structures are evident throughout Africa, it would be incorrect to brand the continent as paternal. For example, a law passed in 2003 guarantees that thirty percent (30%) of seats in parliament will be held by women (The Economist, 2008).

2.4.7.3 Learned behaviour

A fundamental goal of DSM is to modify excessive electricity consumption behaviour. On the one hand, Chambers and Andre (1995:389) suggest that learning behaviour should be identified prior to changing usage behaviour. Specifically, they suggest that gender plays a role in learning, and suggest that “the sexes may react differently to text manipulations designed to facilitate learning basic electricity concepts” and that “this observed difference may be related to level of interest in or experience with the subject matter.” Importantly, they point out how all individuals’ “pre-existing concepts” from earlier experiences are used to understand contemporary scientific concepts. Hewson and Hamlyn (1985:40-41) describe such a learning approach as constructivist, whereby a learner constructs meaning by relating newly acquired knowledge to pre-existing notions of the world.

On the other hand, the psychophysicologist Alexandrov (2008:427-451) suggests that learning is far more diverse. Citing his laboratory experimentation on animals, he suggests that “brain organization of a behavioural act depends on its position in the behavioural continuum,” and that “brain subserving [*sic*] of previously formed behavior is modified by forming a new behaviour.” Figure 2.14 below illustrates his systemic structure of behaviour, whereby old systems (OS) are not replaced, but rather superimposed by new systems (NS). He suggests, when citing Shvyrkov’ (1986) neural comments, that “the formation of a new behavioral act is always a formation of a new system.” With regard to electricity conservation, if DSM cannot permanently alter a consumer’s behaviour, it should perhaps introduce individuals to sustainable actions prior to creating the undesirable behaviour.

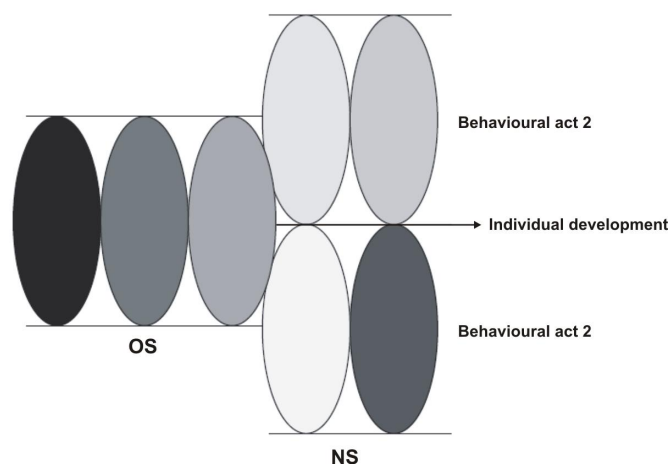


Figure 2.14: Systemic structure of behaviour (Alexandrov, 2008:427)

2.4.8 Principle 8: Support Congruence (conformity)

2.4.8.1 National identities

Cherns (1976:790) maintains that social support should be designed to reinforce overarching social structures. The consumption of social artefacts and services can evolve into institutionalised symbols. Figure 2.15 below illustrates three countries that aim to inspire such social cohesion. The Proudly South African logo, which is noted on the left, conveys an ideology that “[*supports*] job creation, [*to*] help build our young nation” (Proudly South African, 2009). The “Certified American Made” logo, noted in the centre, is arguably a reaction to the familiar “Made in China” stamp noted on the right. The originator of the American stamp commented that “economic turmoil has created a chance for private initiatives to drum up much more interest in patriotic purchasing—and to profit from it, too” (The Economist, 2009).



Figure 2.15: National identities
(Proudly South African, 2009; The Economist, 2009)

2.4.8.2 Technical branding

The standardisation of labelling that effectively conveys an artefact’s technical characteristics can assist DSM. On the one hand, Van Raaij and Verhallen (1983:125), when citing Anderson and Claxton (1982) and Redinger and Staelm (1981), suggest that energy efficiency labelling has negligible impact on consumer choice, unless a salesperson emphasizes and explains the label to the customer. Omotosho’s (2008:646-660) symbolic interactionism study into Nigerian consumer awareness of product labels supports such a view. His study suggests that high levels of education have no significant link to label knowledge, however, perhaps due to the freedom finances provide, income does have an impact on label knowledge. On the other hand, in 1993, South Africa identified technical labelling as an important DSM consideration (Uken, 1993:45). Contemporary literature supports such a stance; for example, air-conditioning units with “energy efficiency labelling immediately influenced the sales patterns towards a more energy efficient unit” (Uken, 2009:5).

2.4.9 Principle 9: Transitional Organisation

2.4.9.1 Paradigm shift

Cherns (1987:159) states that a transition is both different and more complex than either old or new states. As the aforementioned literature noted, transition can occur in both individual and national frameworks. For example, the American path dependence described by Nye (1999:135) suggests that a national introspective is required to manage what were thought to be abundant natural resources. The manner in which transition is implemented is contentious and, in some cases, ironic. Hobson (2006:319-320), when citing Davison (2001, 2004), suggests that a “reliance upon technology is believed to re-embed the very mechanisms that allow daily profligate [*wasteful*] resource use to flourish in the first place.”

A direct and controversial approach to alter consumer-purchasing patterns is described by Sandlin and Callahan (2009:85). Citing Mestrovic (1997), they suggest society has become engrained in “postemotionalism”, which is a numbed state which emerges due to the “overuse of emotionally laden languages and images in the mass media.” They note that, in an attempt to shift consumers from a postemotionalist state, “culture jamming” strategies are being implemented. Examples are the “Billboard Liberation Front” and “Reverend Billy and the Church of Stop Shopping”.

2.4.9.2 Policy change

Cherns (1987:159) outlines that “from an old to new system of values, we need to see the design team and its process as a vehicle of transition.” Johnson (2008:535-536) supports Cherns, when suggesting that, in order for complex futures to be successfully managed, the policy design teams should closely monitor the design process to ensure their designs reach fruition. He also notes that “policy formulation is design” and, as such, “policies are artefacts”. However, for countries in a transitional state such as South Africa, managing the relationship between a system of values and design is highly complex. For example, Eskom may have diluted their brand value when they changed from a private electricity supplier to a not-for-profit institution in 1948 (Christie, 1984:3), and again changed into a corporation in 2001 (Bekker, Eberhard, Gaunt & Marquard, 2008). On the one hand, customers may be unaware of such transitions, gauging their relationship with Eskom on price constraints alone.

In support of both Cherns and Johnson aforementioned comments, Feijs and Meinel (2005:73) suggest that “design is a political act” and that artefacts contribute symbolically or tangibly to the direction, the world will move in. Indeed, if such a comment is read in

conjunction with the South Africa's prepayment meter, the design team has arguably failed to act as vehicle of positive transition. The interpretation of an artefact or semiotic can also have political ramifications, and as Barab et al. (2007:294) suggest, designs should be considered with an understanding and sensitivity towards "political baggage". For example, Raynor (2009:179) describes how the image of Black Barbie dolls can reinforce stereotypes and "transform the standards of beauty for little Black girls."

2.4.10 Principle 10: Incompletion or the Forth Bridge Principle

2.4.10.1 The rebound effect

Cherns (1987:159) points out that "the stability myth is reassuring but dangerous as it leaves us unprepared to review and revise." From a DSM perspective, the rebound effect is partly related to this principle. However, when considering general socio-technical paradigms, Midden et al. (2007:156) suggest if "behaviour is augmented with technology, the consumption of natural resources is amplified too." In other words, if residential markets increasingly make use of technology for utilitarian, entertainment, and management artefacts; the definition of what constitutes a stable network may need to be reconsidered. Additionally, consumer agency and cognisance should not be underestimated. For example, Sandlin and Callahan (2009:84) point out how the advertising-creates-false-needs argument has been "thoroughly discredited" by social scientists. They point out how consumers negotiate their own meanings from advertisements, and in turn, are able to construct their own meanings through a creative use of products.

2.4.10.2 Crisis or predicament

Rosa et al. (1988:168) suggest that the term "crisis" is frequently cited in reference to the complex relationship between energy and society. They suggest that, whereas crisis depicts a "rapidly deteriorating situation", a more appropriate term would be predicament. In other words, societal acknowledgement that a problem exists is firstly required, and if not acted on, a crisis may emerge. The distinction, although subtle, is an important one. For example, the use of crisis or point-of-no return methodology in popular features such as "An inconvenient Truth", may paralyse, rather than encourage social change.

Designing within a predicament rather than a crisis framework, will encourage artefact designers to challenge impulsive constraints. For example, Eskom's distribution of approximately twenty million CFLs (Enslin-Payne, 2008) in an unprecedented attempt to reduce electricity consumption, may have introduced toxic mercury into the environment

following incorrect disposal practices. Although Eskom have placed a legal disclaimer on their website in an attempt to prevent litigation (Eskom DSM, 2005), their solution appears to be a short-term reaction to a crisis, rather than a long-term DSM strategy. Additionally, the potential of introducing poisonous mercury into the environment may prevent society adopting future DSM practices. Midden et al. (2007:158) describes such a conundrum, as an ethical dilemma, whereby “conscientious actors” find themselves polluting the very environment that they intended to protect.

2.5 CONCLUSION

The literature review suggests that South Africa is at an intersection. On the one hand, it is in a process of conscious redefinition based on indigenous ideology. For example, Said (1994:200) argues that Africa has been largely described and defined by foreign literature, resulting in Africa having “no history worth telling, no fiction worth entertaining, no authority worth consulting.” Similarly, The South Africa’s President from 1999 to 2008, Thabo Mbeki, described in his “African Renaissance” speech that Africa “must be its own liberator from the condition which seeks to describe our Continent and its people” (African National Congress, 1998). On the other hand, perhaps it is at a point whereby a redefinition is unexpectedly emerging from socio-technical developments. For example, academic such as Prahalad (2006:26) describe indigenous artefacts designed for dual and emerging economies that make use of local cultures and practices. He notes solutions that contain a level of technical sophistication that is arguably well beyond western requirements or paradigms, for example, cleaning equipment that caters for fast moving streams or nappies designed for an entire days use.

3 CHAPTER THREE: RESEARCH DESIGN AND METHODOLOGY

3.1 INTRODUCTION

This thesis aims to understand what semiotics and ethnology may affect sustainable residential electricity management in South Africa. Key concepts running through the thesis are sustainability, Demand side management (DSM), technical and social determinism, path dependency and industrial design's (ID) mediation capabilities. The literature elaborated on these concepts by unpacking electricity variables such as gender, education, country, and importantly, the abstract quality of electricity. The following outlines the thesis' chosen fieldwork research design and methodology to obtain similar electricity variables in South Africa's Western Cape.

3.1.1 Research theory

Theoretical attempts to define energy's relationship with society date back to the nineteenth century. Two broad categories tend to emerge, namely energy enthusiasts and energy conservers. A well-documented energy enthusiast and prominent anthropologist, Leslie A. White, described society's relationship with energy in the form of an equation. In the 1940s, he developed the law of cultural evolution which proposed that "culture develops when the amount of energy harnessed by man per capita is increased" (White, 1943:335-356). In other words, the ongoing increase in energy consumption leads to a more sophisticated culture. Perhaps due to lack of knowledge on the industrial revolutions "rebound effects" and subsequent environment degradation, White's formula omits environmental sustainability as a factor of societal progress. In the concluding arguments of his paper, White (1943:350) somewhat ironically summarises that "the key to the future, in any event, lies in the energy situation."

Rosa et al. (1998:151-153) note the Nobel laureate and energy conserver Frederick Soddy, who countered the energy enthusiasts argument with his inclination to the second law of thermodynamics. This law states that "energy, unlike materials, cannot be recycled." Rosa et al. continue by noting the 1950's sociologist Fred Cottrell, who states that the "available energy limits the range of human activity, with recognition of energy limits as its foundation". Although not specifically an energy conserver, he contributed to the debate that social, political, and even psychological variations occur with societies that change from a low-energy to a high-energy consumption.

The geophysicist and energy conserver, Dr. Hubbert, correctly predicted declining fossil fuel reserves as early as 1949 (Hubbert Peak of Oil Production, 2007). His 1956 presentation as Shell's chief general geology consultant to the American Petroleum Institute has become synonymous with the 1970's oil crisis. Specifically his "Hubbert Peak" theory, which clearly predicted declining oil supply, and humankind's use of non-renewable fossil-fuel reserves, is indicated in his presentation graphs Figure 3.1 and Figure 3.2.

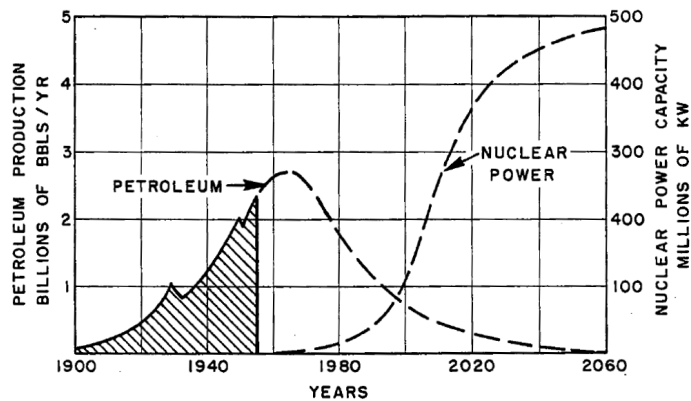


Figure 3.1: Decline of petroleum production (Hubbert, 1956:36-37)

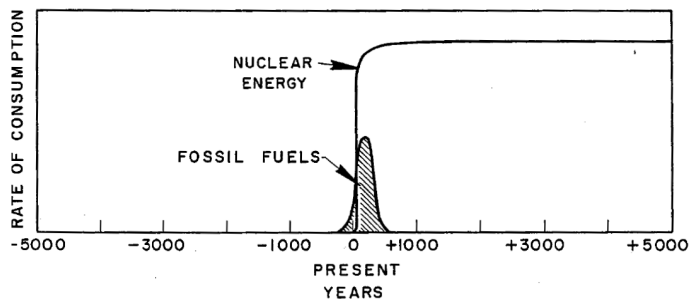


Figure 3.2: Fossil-fuel consumption (Hubbert, 1956:36-37)

More recently, Wilson and Dowlatabadi (2007:169-194) provide a comparison of interdisciplinary and transdisciplinary approaches to analysing energy in residential contexts. Their paper explores four standpoints, namely: conventional and behaviour economics, technology adoption theory and attitude-based decision making, social and environmental psychology, and lastly sociology. They note how socio-technical models have the ability to unpack "social, cultural and technical determinants of energy demand embedded in routine behavior" (Wilson & Dowlatabadi, 2007:190). Additionally, the models can manage large and often conflicting historical views, for example, Carolan's (2009:421) STT inquiry into the use of ethanol and gasoline in the USA.

Numerous theoretical lenses were considered, two potential theories being Actor Network Theory (ANT) and Postcolonial theory. The Ritzer Encyclopedia (2004) describes ANT as a "conceptual frame for exploring collective sociotechnical processes". A unique characteristic

of the theory, and one which has been integrated into this thesis, is the “equal” agency of human and nonhuman actors. Both ultimately aim to be appropriately placed and create a stable conceptual network. Ultimately, ANT’s goal of network stability excluded it from being used in entirety for this thesis. It arguably tends to prevent the serendipitous emergence of fieldwork patterns or, as Fleischmann (2006:80) citing Hess suggests, ANT “flattens” social actions and ignores “the deeper social structures and cultural meanings that shape human history.”

The literature review suggests that South Africa’s colonial past dictates and influences contemporary views of electricity. A theory-based approach that develops this further is Postcolonial theory. Moalosi, Popovic and Hickling-Hudson (2007:36) suggest that Postcolonial theory is suited to understanding the origination of “hybrid cultural identities” and “recognises the importance of exploring the interaction between the colonising, colonised, and decolonising cultures”. Again, as with ANT, elements of this theory have been incorporated in the thesis’ Socio-technical Theory.

3.1.2 Variables

This thesis makes use of dependent and independent variables to unpack ethnology and semiotics. Babbie (2007:18) describes an independent variable as one that is “presumed to cause or determine a dependent variable”, and respectively describes a dependent variable as one that depends on or is caused by another. He continues by noting how variables embody attributes which describe an object or person. An interplay of determinism and agency, expressed through variables and attributes, was evident in the literature. For example, gender was cited in patriarchal environments and learning aptitudes. Table 3.1 provides a summary of notable variables and attributes that emerged from the literature review. The variables were used to identify and formulate research instruments, and structure the subsequent data analysis.

Table 3.1: Variable and attributes

VARIABLE	ATTRIBUTE
Gender	Male, female, and androgynous.
Occupation/discipline	Engineer, industrial designer, and the social scientist.
Country	Europe, South Africa, and North America.
Language (home)	Afrikaans, English, and IsiXhosa.
Smell	Natural and artificial.
Form	Observable and unobservable.
Colour	Red, green, blue, etc.

3.2 INSTRUMENT DESIGN

3.2.1 Introduction

Instruments have been developed in accordance with the literature review findings, research question, and sub-questions. Mixed method instruments have been utilised, however, they focus primarily on obtaining qualitative data. Such a focus is due to qualitative instruments' ability to encourage the emergence of new data, and which, in doing so, responds to the literature reviews finding that negligible semiotic and ethnological data about electricity exists in South Africa's Western Cape. Such an approach is supported by Vanderheyden, Verhoef and Hilsden (2006:61) who note that "qualitative methods are used when the goal is to advance a comprehensive model or hypothesis or to explore a phenomenon." Similarly, and in support of in-depth research, Small (2008:5-8) suggests that "statistical surveys rely on abstractions of the world into pre-determined variables, and thus are inherently once-removed from empirical reality," and continues to note that "the strengths of qualitative work come from understanding how and why, not understanding how many."

On the other hand, this thesis's quantitative instrument provides an important function, which, rather than being a definitive source of information, provides a method of assessing and confirming respondent qualitative data. In other words, the quantitative data facilitates the comparison of respondent's subjective views on electricity usage against consumption patterns, or what Onwuegbuzie and Leech (2007:106) describe as determining a respondent's "truth space". The following section details the two qualitative and one quantitative instruments, which comprise of: an artefact creation, an oral presentation, and a Living Standards Measurement (LSM) survey; and although origination of the instruments is discussed, all are appended and only provided in English. Instruments in all three home languages are noted under Qually (2009) in the bibliography.

3.2.2 Instrument one – Artefact creation

Murthy (2008:837) when citing Kent notes that "ethnography cannot give us a glimpse of reality that resides beyond the story told within the ethnography; the story is all." The literature review's ethnographic inquiry into electricity revealed that even with frequent use, unidentified "stories" surrounding electricity consumption remain. Therefore an instrument capable of inducing respondent reflection on electricity experiences, either tangible or abstract, was sought. In addition, the instrument had to be capable of communicating and documenting the individual's "narrative" to the researcher.

An instrument that suits the aforementioned requirements, originates from Gauntlett's (2007:96) visual-sociology methodologies. Although similar methods date back over twenty-five years, Gauntlett makes use of contemporary construction methods such as Lego to communicate respondent's individual metaphors. Visual-sociology provides semiotic data in the act of creative expression, and the resultant artefact provides a stable medium with which semiotic data can be obtained following respondent participation.

The chosen creative medium for the electricity research was two dimensional to avoid complex construction methods and to provide familiar and therefore less intimidating equipment to be used. A graphic design kit comprising of the following was provided to the respondents: twenty-four colour wax crayons, sixteen colour oil pastels, twelve colour pencils, three colour acrylic paints, three sheets of paper and one paintbrush. The mediums allowed for expressive, random, and controlled designs, facilitating the documentation of a range of responded expressions.

The graphic design kit was provided free to the respondents, acting as a means of compensation for participating in the research. Importantly, all kits were identical to encourage uniform and comparable data. The mobile nature of the instrument allowed for flexible respondent participation, and notably, completion of the artefact could occur in an environment free of competition and coercion from other respondents. Table 3.2 provides details extracted from the brief enclosed in the graphic design kit.

Table 3.2: Artefact creation brief extracts

CATEGORY	DETAIL AND COMMENTS
Aim	Create a simple artwork of an imaginary character.
	The character should be placed in a setting and doing something.
	The character should represent your individual, personal history with electricity.
Instruction:	There is no right or wrong character.
	Feel free to explore without boundaries.
	Drawings skills are not a concern and will not influence the research.
	Please only use the graphic design kit provided.
Consider the following:	When did you first become aware of electricity?
	How old were you and where was this?
	What was important about this moment and do you still feel the same today?
	How does your understanding of electricity differ from that of your grandparents?
	What colour, shape, smell, sound, gender and age does your electricity have?
	What unique personality traits would it have? Would you like or dislike it?
	If you could give it a human name, what would it be and why?

3.2.3 Instrument two – Oral presentation

The completed artefact provided a focal point for the second instrument, which comprised of an oral presentation by the respondent. The presentation aimed to collect additional forms of data from respondent agency and interviewer observation. Whilst filming the participant's explanation, a range of expressions, words, and gestures not captured in the tangible artwork were revealed. Additionally, a visual account of residential living conditions was observed and noted by the interviewer.

3.2.4 Instrument three – LSM survey

Whereas instrument one and two provided qualitative data, the third instrument captured quantitative data in the form of a Living Standard Measurement (LSM) survey. The survey's primary aim is to improve the type and quality of household data collected in developing countries. LSM was implemented in 1980 by the World Bank, who is "made up of two unique development institutions owned by 185 member countries - the International Bank for Reconstruction and Development, (IBRD) and the International Development Association (IDA)" (The World Bank, 2009).

Importantly, LSM is a quantitative tool, and can be adapted and combined with other surveys to suit the needs and constraints of deployment (Grosh & Muñoz, 1996:5-7). The survey used in this study is largely based on O'Sullivan and Barnes's (2007:33-40) working paper, entitled "Energy Policies and Multitopic Household Surveys: Guidelines for Questionnaire Design in Living Standards Measurement Studies." Similar to the thesis' use of STT, the benefit of using LSM is that it compliments and enriches an existing body of literature.

The LSM survey's online format allowed participants to complete the forms within their own timescales. The survey itself was constructed using surveymonkey.com, which facilitated customised layouts and question format. Figure 3.3 below provides a sample question from the English survey.

What colour is your electricity: LSM
E02 Electricity sources (Grid)

89%

For household items that use grid electricity from a public company or municipality, please tick up to five items below in order of importance.
 (1 = most important and 5 = least important)

	1	2	3	4	5
Lighting	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
TV/radio	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Fan/air conditioning	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>
Refrigeration	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cooking	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Hot water for washing/bathing	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Water pumping	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
Irrigation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Space heating	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Computing	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other small appliances (Please specify)	<input type="text"/>				

Figure 3.3: Living Standard Measurement survey

3.3 SAMPLE DESIGN AND SAMPLING METHODS

3.3.1 Introduction

Sampling has been developed in accordance with the literature review findings, research question, sub-questions, and concurrent to instrument design. Apart from practical considerations such as time and financial constraints, sampling methods are in accordance with the author’s relativist epistemological imperative. As a result, respondent data is obtained with the acknowledgement that a diversity of factors can influence respondent contribution, and along with instrument design, an in-depth rather than broad approach prevents prematurely foreshortening and categorisation of respondent descriptions. It is also important to note that it is not the intention of this thesis to generalise or amplify fieldwork results to a larger audience. Such an approach is considered commonplace and supported by Onwuegbuzie and Leech (2007:115), who note that “there is general agreement that the goal of qualitative research is not to generalize beyond a sample to the population”. Details on sample design and sampling methods are provided below.

3.3.2 Unit of analysis

The research unit of analysis comprises of individuals and their distinctive understanding of residential electricity.

3.3.3 Population and subpopulation

The research population comprises of South African citizens living in the Western Cape. The subpopulation in turn encompasses the three largest home language groups, which are Afrikaans, English, and IsiXhosa. The 2001 South Africa census (Statistics South Africa, 2005) indicates Afrikaans as the largest language in the Western Cape group with 2 500 748 citizens, IsiXhosa as the second largest with 1 073 951 citizens, and third largest is English with 874 660 citizens. Figure 3.4 below provides a pictorial view with percentages of the noted language groups.



**Figure 3.4: South Africa 2001 home language census
(After Statistics South Africa, 2005)**

3.3.4 Sampling method

The grounded theory approach to obtaining respondent feedback resulted in a sampling method suggestive of a case study format. For example, grounded theory's aim of striving for theoretical saturation rather than statistical deduction, is reminiscent of Small's (2008:4) descriptions that "the number of cases is unknown until the study is completed" and that "case study logic is critical when asking how and why questions, with which a sampling logic has greater difficulty." However, similar to the literature review's use of STT to focus ubiquitous data, electricity's commonplace usage in South Africa's Western Cape required delineations to be placed on the case study approach. For example, a symmetric and

minimal requirement precursor was placed on gender selection, home language selection, education attained or aspirations thereof, and computer literacy to encourage unbiased data.

Such a sampling approach is supported by Vanderheyden et al. (2006:61), who mention that “it is necessary to work with a small number of participants who are willing to discuss their experiences in detail,” and continue to suggest that participants with “a range of characteristics related to the concept of interest” should be handpicked. An appropriate sampling method, which suits the modified case study approach and emergent properties of qualitative data, is a “Critical Case Sampling” method, which Onwuegbuzie and Leech (2007:112) describe as follows:

“In critical case sampling, individuals, groups, or settings are selected that bring to the fore the phenomenon of interest such that the researcher can learn more about the phenomenon than would have been learned without including these critical cases.”

3.3.5 Sample size

The aforementioned discussion highlighted the research requirement for in-depth rather than broad data acquisition, however, due to STT synthesising contrasting disciplines such as social-science and engineering, expectations on sample size requires further discussion. For example, whereas an engineering discipline would arguably encourage a large sample size to identify and validate trends, the qualitative leaning approach to instrument design for this thesis originates from social science methods and is well suited to small sample sizes. Such a standing is supported by Crouch and McKenzie (2006:484) who point out that “interview-based studies involving a small number of respondents are becoming more common in social science” and continue to note that “the labour-intensive nature of research focused on depth ... can be evoked to justify a small sample size.”

This is not to say that data obtained from a small sample is negligible. Although depth of fieldwork data will be formally presented in chapter 4, it is worthwhile to note opinions held by Vanderheyden et al. (2006:61), who state that “qualitative research can generate large amounts of data that require a large amount of time, special skills, and special software to analyse.” They continue by noting that it is not “feasible to include a large number of participants and still obtain the same depth”. Furthermore, in support of the in-depth literature review and subsequent respondent engagements, Crouch and McKenzie (2006:494) go even further to suggest that small samples allow for data quality not achievable in large samples. They suggest that:

“In order to arrive at this point, our analysis has had to build on our intense engagement with respondents and be supported by intensive study of extant literature. This process precluded and, indeed, would have been undermined by a large number of respondents”

3.3.6 Sampling saturation

Due to sampling saturation being a primary driver of the fieldwork methodology, the points noted below helped to identify fieldwork completion and, importantly, data quality. The points are derived from Charmaz’s (2006:18-19) grounded theory methods:

- § Do the data reveal what lies beneath the surface?
- § Are the data sufficient to reveal changes over time?
- § What kinds of comparisons can I make between data?
- § How do these comparisons generate and inform my ideas?
- § Have I gained multiple views of the participants' range of actions?
- § Have I gathered data that enable me to develop analytic categories?
- § Have I gained detailed descriptions of a range of participants' views and actions?

3.3.7 Sampling data overview

Fieldwork data saturation for the three home languages was achieved with two female and two male respondents per subpopulation. Each participant completed the three tasks: an artwork creation, an oral presentation, and a fifty-page survey, resulting in in-depth data originating from thirty-six sources. Table 3.3 below provides a breakdown of the data analysed and the approximate duration in hours of each respondent’s contribution to the research.

Table 3.3: Samples size and depth of data

HOME LANGUAGE	INSTRUMENT	QTY UNITS	QTY DURATION
Afrikaans female	Instrument 1 – Artefact creation	2	4 hr
	Instrument 2 – Oral presentation	2	2 hr
	Instrument 3 – LSM survey	2	1 hr
Afrikaans male	Instrument 1 – Artefact creation	2	4 hr
	Instrument 2 – Oral presentation	2	2 hr
	Instrument 3 – LSM survey	2	1 hr
English female	Instrument 1 – Artefact creation	2	4 hr
	Instrument 2 – Oral presentation	2	2 hr
	Instrument 3 – LSM survey	2	1 hr
English male	Instrument 1 – Artefact creation	2	4 hr
	Instrument 2 – Oral presentation	2	2 hr

	Instrument 3 – LSM survey	2	1 hr
IsiXhosa female	Instrument 1 – Artefact creation	2	4 hr
	Instrument 2 – Oral presentation	2	2 hr
	Instrument 3 – LSM survey	2	1 hr
IsiXhosa male	Instrument 1 – Artefact creation	2	4 hr
	Instrument 2 – Oral presentation	2	2 hr
	Instrument 3 – LSM survey	2	1 hr
Total		36	42 hr

3.4 DATA COLLECTION AND FIELDWORK

3.4.1 Gaining respondent participation

A dedicated online research application point was provided. The website provided background to the research in each of the home languages under consideration. This proved valuable in explaining the abstract methodology and, importantly, persuading participants who initially felt that their contribution would be gauged on technical merit only. Such a non-confrontational manner allowed readers to consider applying at their discretion without coercion on the researcher's part. An abridged English homepage is indicated in Figure 3.5 below.



Figure 3.5: Application instrument

3.4.2 Ethics and consent

Documented approval from all respondents was requested in the online application point. Specifically, the respondents were required to acknowledge their wish to participate in the research prior to the researcher making contact. Although no elderly respondents were research participants, one ninety-five-year-old British woman provided qualitative data. Due to her residing in a retirement village, written consent was requested by a gatekeeper, who in this instance was her daughter and power of attorney. Two adolescent research participants,

aged eighteen, contributed to the data. Written consent was provided by the participant's parents.

The research concentrated on ethical research within digital environments. As suggested by Murthy's (2008:840) reference to Schrum's (1995) electronic research ethical guidelines, when considering respondent privacy, the "researchers [*must*] ... be overt rather than 'lurk'." With such an approach in mind, during the online application point and face-to-face discussions with respondents, it was stated that personal details remain confidential and that, if required, pseudonyms could be provided. Additionally, references to fieldwork data is done via a file naming convention described in the section 3.5.1.

3.4.3 Reliable data and prevention of bias

Attention to data clarity, quality, and prevention of bias was considered throughout the thesis in areas of translation, appropriate interview environments, and group respondent influences. Although it was not possible to conduct interviews with individuals from the same cultural group, as suggested by Hewson and Hamlyn's (1985:43) citation of Kamara and Easley (1977), interview questions and subsequent answers were provided in the respondent's mother tongue. Translations that followed the interviews were again compiled by individuals from the same home language as the respondent.

According to Tourangeau, Rips and Rasinski (2000:2-3), errors on surveys can be due to internal features of language comprehension, memory, and choice, as well as the way a response is executed. This thesis attempted to overcome such error, with the three-instrument approach, for obtaining data from a single respondent. Specifically, the artefact creation instruments allowed sufficient time for respondents to reflect on personal histories and provide a considered answer, whilst the face-to-face interview captured answers that are more impulsive.

In accordance with Lange (2003:434), who notes that "the nuances of the language were essential when translating ethnography," ongoing observations into respondent subtleties, mannerisms, and contexts were implemented. Post-interview memos were captured on a dictaphone. Instruments were piloted with CPUT BTech students and appropriately modified prior to use in the field. No financial compensation for research participation was provided. Respondents involved in previous or similar electricity research were excluded from the sample. To encourage a uniform digital literacy for the sample, online research applications took precedence over analogue methods. Respondents were requested not to disclose their

research contribution with other participants to ensure data remained spontaneous and authentic. Interviews, where possible, were conducted at the respondents' residence.

An important factor in striving for unbiased data was to avoid snowball sampling which Small (2008:4) describes as “asking respondents to recommend other respondents”. Although avoiding such a method resulted in extended fieldwork timeframes, the data obtained was of a cleaner and superior quality due to respondent perspectives being removed from familiar networks and influences.

3.5 DATA CAPTURING AND EDITING

3.5.1 File management and data logging

Research and respondent data, was archived and managed in digital format. Secure backups, were performed weekly, and off-site on a monthly basis. The file naming conventions are described in Table 3.4 below.

Table 3.4: File naming conventions

ITEM	DETAILS
Work-in progress format:	BQMTEch – DDDDD – EFFF
DDDDD:	Category of file e.g. thesis or project plan.
E:	Issue type e.g. A is under development, B is first issue.
FFF:	Sub issue e.g. 001, 002 etc.
Example	BQMTECH – Thesis – A032.doc
Interview naming format:	BQMTEch – AAAAA BB – CC/CC/CC
AAAAA:	Category of interview e.g. expert or respondent.
BB:	Initials of interviewee.
CC/CC/CC:	Date of interview.
Example:	BQMTEch - Participant DA - 090402.rtf
Participant referencing format:	DEF–G
D:	Language group e.g. X is for IsiXhosa.
E:	Gender identification.
F:	Number of respondent.
G:	Item of artwork.
Example:	XM1-A
Participant colour format:	Used to differentiate graphic data.
AF1 and AF2:	Orange
AM1 and AM2:	50% black
EF1 and EF2:	Light orange
EM1 and EM2:	20% black
XF1 and XF2:	Orange brown
XM1 and XM2:	80% black

3.5.2 Data capturing

Dissemination of data to contractors and supervisors was facilitated by digital file formats. Respondent, expert, and supervisor interviews were captured in digital format with a Sony PCM-D50 24bit stereo dictaphone and a Samsung VP-D381i Mini DV camera. The online LSM survey was implemented and managed with SurveyMonkey.com.

3.5.3 Editing, transcribing, and translating

Audio data was edited in Sony Sound Forge® Audio Studio™ 9.0, whereby audio levels and background levels were adjusted for improved listening. Video footage was edited in Microsoft® Windows® Movie Maker 5.1, whereby non-relevant scenes were omitted. All unedited master files have been archived. English interviews were transcribed with Transcriber 1.5.1 - Copyright © 1998-2002, DGA. Afrikaans and IsiXhosa transcriptions were edited at the contractor's discretion.

For academically appropriate translating, quality control procedures were considered. Dialect sensitivities were acknowledged with the translators home language being that of the language being converted, and the translator residing within the sample population's geographic delineation. Both Afrikaans and IsiXhosa translators were registered and accredited with the South African Translators Institute (SATI). Both held qualifications in language disciplines; a DPhil and MPhil were respectively held by the Afrikaans and IsiXhosa translator.

3.5.4 Qualitative and quantitative software

In conformance with grounded theory's focus on emergence of theory through rich data, the software package ATLAS.ti 6.0.16 - Copyright © 1993-2009 by ATLAS.ti GmbH, Berlin - was used. The software allowed for qualitative coding to be derived from the digitally captured data. Quantitative data and subsequent presentations originated from Microsoft® Office Excel 2003.

3.6 DATA ANALYSIS

3.6.1 Variable-oriented analysis

The variables noted in Table 3.1 encapsulate the key aspects that emerged from the literature review. The variables provide further structure to chapter 4's Socio-technical Theory (STT). Peirce's triadic model manages the dependant and independent variable characteristics.

3.6.2 Conversation analysis (CA) and coding procedures

Rich qualitative data obtained from interviews was analysed using open coding and axial coding methods. Open coding procedures were applied to each sentence to provide "initial classification and labelling of concepts" (Babbie, 2007:385). On completion of the open coding procedure, grounded theory's axial coding process was implemented to relate "categories to subcategories ... to give coherence to the emerging analysis" (Charmaz, 2006:60). Importantly, the author completed all coding procedures to ensure fieldwork observations further enrich the coding process.

Figure 3.6 illustrates one of the open and axial coding networks that emerged from the respondents' textual and artwork data. The network should be interpreted from the primary category in the centre, to the subcategories that enclose it. The primary category, or what ATLAS.ti defines as a code family (CF), is titled with the word 'shock' and graphically represented with a bold yellow icon. Similarly represented, the subcategories or codes are located on the periphery of the figure. They include two numerals; the first indicates code groundedness and the second, code density. Code groundedness points out the number of quotations or artwork details to which it is linked, and code density describes the number of other codes that connect to it. Supporting textual quotes are graphically indicated with a page icon. The red and black cross referencing arrows link the primary categories to subcategories, however it is the black arrows with descriptive text that are of importance in identifying the emergence of prominent semiotics and ethnological factors. For example, when the black arrows and supportive text are read in conjunction with code groundedness and density, the strength of a code can be analysed relative to the overall network and emergent theme.

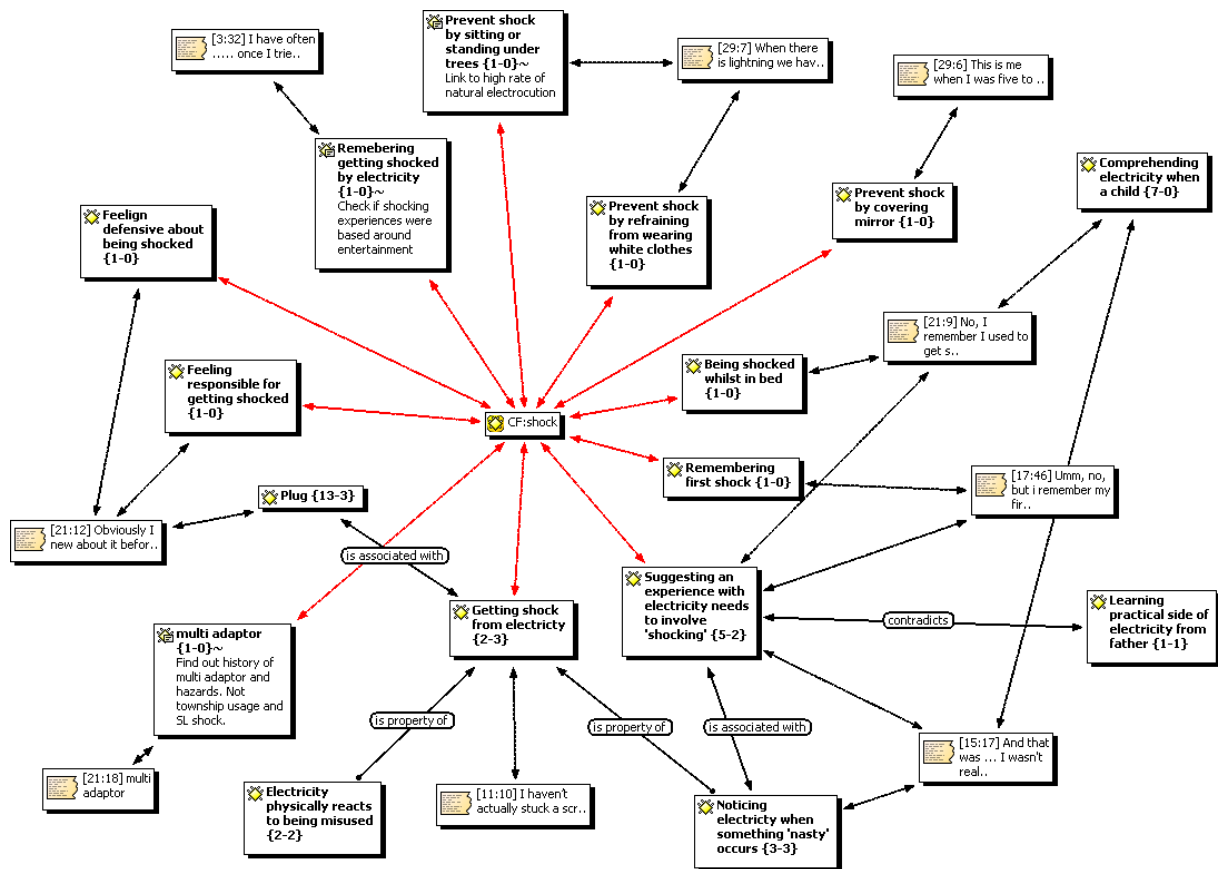


Figure 3.6: ATLAS.ti open and axial coding network

3.6.3 Art therapist

The analysis of respondent artwork was facilitated by a qualified art therapist based in Cape Town South Africa, due to the discipline providing “a form of psychotherapy that uses art media as its primary mode of communication” (The British Association of Art Therapists, 2008).

3.7 RESEARCH SHORTCOMINGS

3.7.1 Researcher as symbol

The introduction noted that the author’s epistemological imperative is weighted towards the relative, and as such, does not attempt to make cultural judgments. In practice, conscious attempts were made to acknowledge and respect respondent cultural individuality. For example, instruments were translated into the appropriate home languages of the subpopulations being researched. However, relative to Afrikaans and English, additional attempts were required to encourage IsiXhosa participation. The reason for which, might relate to XF1’s question if the research focused on the “Black Diamond” market, which describes South Africa’s fastest growing and influential black community (TNS Research

Surveys, 2008). In other words, IsiXhosa respondents may have questioned if the research had ulterior financial motives.

3.7.2 Student participation

From a professional standpoint, the author's industry experience and partnership in the ID firm Dot Dot Dot Ex Why Zed Design (Pty) Ltd may have influenced data quality. Specifically, from the research sample, the four CPUT BTech ID participants may have adapted their contribution to cater for potential future employment. However, the practice of using student samples per se for "cross-cultural" studies is, as noted by Flere and Lavric (2008:411), considered a "relatively reliable predictors of general cross-cultural differences".

3.7.3 LSM sample size

Living Standards Surveys (LSM) traditionally, as Grosh and Muñoz (1996:53) indicate, should have sample sizes "of generally from 2,000 to 5,000 households, to balance sampling and non-sampling errors." The vastly reduced sample size of twelve could contain certain biases, however, unlike conventional LSM surveys, it was not a primary objective to obtain comprehensive LSM data, but rather to use the information to support qualitative data.

4 CHAPTER FOUR: EVIDENCE

4.1 INTRODUCTION

Chapter four divides the fieldwork data into two primary sections, with the first presenting the fieldwork and the second discussing it. For ease of cross-referencing, the presentation section corresponds with chapter 3's instrument layout, and the discussion section, similar to the literature review, makes use of Socio-technical Theory (STT) as a theoretical lens to manage the fieldwork data.

4.1.1 Grounded Theory sampling

Table 4.1 below illustrates the grounded theory development in obtaining respondent participation. Although the research application was only available via a dedicated website format, it was advertised in community forums and interest groups that complimented the thesis topic. The date column indicates when the application instrument was formally launched, and the "QTY" and "UNIT" columns respectively indicate potential respondents and in what context the application was viewed. The table notes quantities in excess of 500 units, however for website groups; individuals may not have read the author's request for participation, due to their potential lack of group involvement. Additionally, the high rate of visits to the thesis' home page must be read in conjunction with all data sources which ultimately directed respondents back to it. The table also notes that additional attempts were required to obtain IsiXhosa participation.

Table 4.1: Grounded Theory sampling

DATA SOURCE	DATA DEFINITION	DATE	QTY	UNIT
What colour is your electricity?	Website: Dedicated fieldwork explanation and application point.	2009/02/07	474	visits
...XYZ Design (Pty) Ltd	Website: Design consultancy: Innovation centre news.	2009/02/14	91	visits
Gumtree Online Community	Website: Classified advertisements: Community - activities and hobbies.	2009/03/27	49	visits
Creative Cape Town	Website: Facebook, entertainment and arts, general group.	2009/04/20	629	members
Xhosa Names and their Meanings	Website: Facebook, common interest, languages group.	2009/04/22	724	members
Xhosa Society	Website: Facebook, common interest, languages group.	2009/04/22	10	members
Xhosa Nostra	Website: Facebook, organizations, general group.	2009/04/22	27	members
Xhosa Dictionary	Website: Facebook, student and creative arts groups.	2009/04/22	31	members
Xhosa Lite	Website: Facebook, just for fun, fan club group.	2009/04/22	665	members
Learn Xhosa	Website: Facebook, common interest, languages group.	2009/04/22	59	members
Xhosa	Website: Facebook, common interest, languages group.	2009/04/22	25	members
IsiXhosa Open Society	Website: Facebook, student and ethnic/cultural groups.	2009/04/22	74	members

4.1.2 Residential location

All respondents resided in South Africa's Western Cape, and, when Figure 4.1 below is read in conjunction with the aforementioned Figure 3.4, eight respondents resided within the same home language designations as specified in the South Africa 2001 home language census. AM1 and AM2 lived within the census' English home language density, and EF2 and XM2 lived adjacent to their home language density.

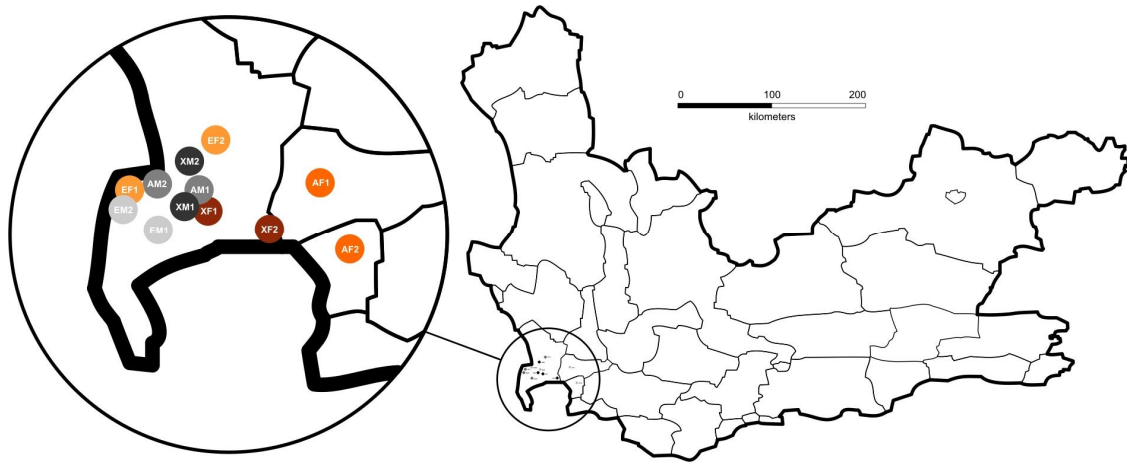


Figure 4.1: Respondent geographic placement

4.1.3 Respondent age

The research focused on respondents who at the time of the fieldwork were eighteen years of age or older. Figure 4.2 below notes the respondents' age, with the youngest being eighteen, the oldest forty, and an average sample age of twenty-six and a half years.

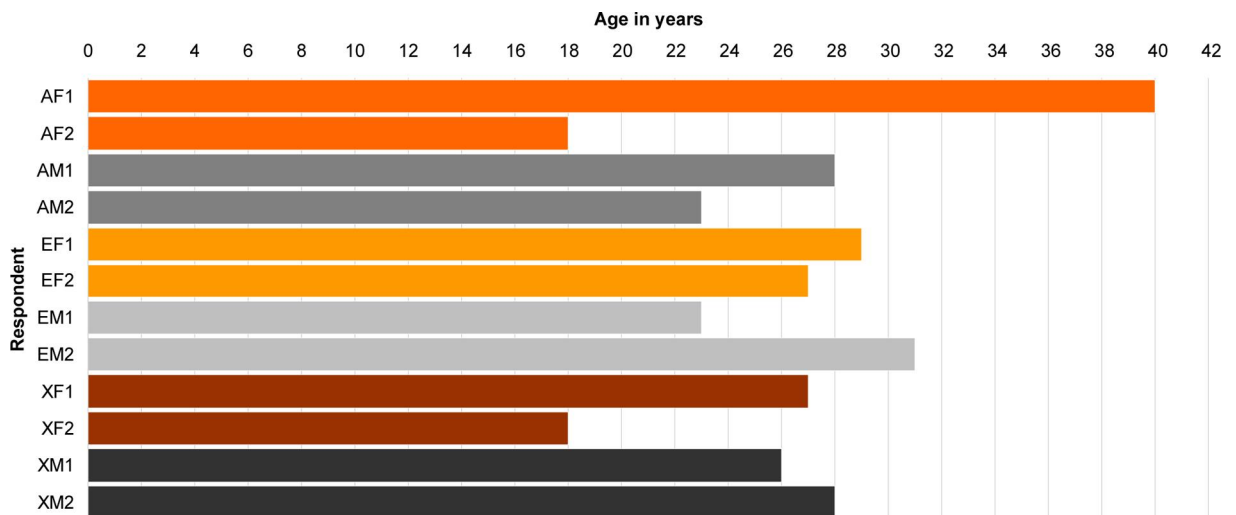


Figure 4.2: Respondent age

4.1.4 Education background

The sample's trend in academic proficiency was aligned with the South African LSM household survey (World Bank, 2009) whereby a code of fifteen and sixteen is evident. Code fifteen indicates an education of standard ten and some university courses, and code sixteen indicates the completion of a university degree. It must be noted that, at the time of the research, two respondents were completing grade twelve (standard ten), although with the intention of continuing on to tertiary education. Additionally, five respondents were completing a South African university degree, and one was applying to an international university.

4.1.5 Qualitative coding

Respondents' qualitative data were analysed in ATLAS.ti using open coding procedures, resulting in the creation of 475 codes. The codes were grouped into code families in order to identify prominent semiotics and ethnological factors.

4.2 DATA PRESENTATION

4.2.1 Instrument 1 – Artefact creation

Respondents successfully completed their artworks, the results of which are provided in the appendix. The artwork is discussed in section 4.3 and additional comments are noted below.

- § XF2 drew a young girl being attacked by snakes, or "Izinyoka".
- § Two respondents concealed the entire page with media.
- § Four respondents drew a fictional character, and five drew themselves.
- § Five respondents created more than one artwork.
- § Ten respondents drew electrical artefacts in their artwork.
- § Four respondents drew forms that were cropped by the paper's border.
- § The respondents' graphic media preference is noted in Table 4.2. Crayons were the most used media, and oil pastels the least.

Table 4.2: Respondents' use of graphic media

MEDIA	AF1	AF2	AM1	AM2	EF1	EF2	EM1	EM2	XF1	XF2	XM1	XM2	TOTAL
Crayons	X	X	X	X	X	X	X	X	X		X	X	11
Oil pastels	X			X			X						3
Pencil		X	X	X	X	X	X			X	X	X	9
Paint	X	X				X	X	X	X	X	X		8

4.2.2 Instrument 2 – Oral presentation

The artefact creation brief was used during presentations, whereby six questions assisted respondents to focus their discussion. Direct respondent quotes have been included below each of the following questions, or in section 4.3. Their inclusion follows Vanderheyden et al.'s (2006:62) suggestion that “the representation of participant quotes makes qualitative research results more tangible, gives power to the participants’ voice.” An example of a transcription is provided in the appendixes.

4.2.2.1 Colour of electricity

Participants were requested to identify the colour of their electricity, and Figure 4.3 below notes a fifty percent (50%) prominence in electricity being considered blue. Natural associations with the sky (lightning) and popular description of the Van de Graaff generator were expressed as supportive of such views. Notably, sixty-six percent (66%) of all males indicated the colour of their electricity to be blue. EM2 and XF1 respectively suggested that electricity has no set colour but rather society “[puts] the face to it” and is “multi-coloured to indicate that electricity is something that keeps on changing”. In a similar vein, AF1 noted her electricity’s colour to be grey-brown due to its ability to “[transform] a multicoloured world into another multicoloured world so he does not have a specific colour himself”. AF2’s electricity colour stems not so much from the electricity itself, but rather colour preference across her range of appliances. AM1 noted his electricity to be green suggesting it represents a spontaneous act of growth.



Figure 4.3: Respondents’ colour of electricity

4.2.2.2 Shape of electricity

The question of electricity’s shape was put to respondents, with fifty percent (50%) stating that no clearly defined shape exists or that electricity is shapeless. AF1 described her electricity’s character as an amoeba, whereby it mutates rather than evolves, and EM2 noted his as reminiscent of a “multi-headed animal”. EM1, a recent mechanical engineering graduate, remarked when visualising electricity that “it’s that classic water in a hosepipe thing, where the resistance is the thickness of the pipe and voltage is the pressure and current is how fast the water is flowing down the pipe.” Similar associations in the form of “pipe”, “tube”,

“wire”, and “conduit” were noted by AF1, AF2, and EF2. Both IsiXhosa male respondents described their electricity as being a “zigzag shape”.

4.2.2.3 Smell of electricity

Regarding the smell of electricity, forty-one percent (41%) of respondents noted “wet” and “earthy” smells following a rain as representing their smell of electricity. AF2 and AM1 noted electricity’s smell as unpleasant and reminiscent of burning and nasal irritation. EM1, EM2, XM1, and XM2 provided no answer to this question.

4.2.2.4 Sound of electricity

The sound of electricity was associated with thunder by male respondents AM2, EM1, XM1, and XM2. Electricity that sounded “irritating” and “chaotic” was mentioned by three female respondents AF1, AF2, and XF2. Conversely, two female respondents, EF2 and XF1, respectively suggested their electricity sounded quietly “alive” and like “music”. Male participants appeared to avoid stating a preference for their sound of electricity, whilst female respondents described pleasure or discomfort sensations.

4.2.2.5 Gender of electricity

Figure 4.4 below provides a scale comparison whereby electricity’s gender in the fieldwork data is noted as being predominantly male. Specifically, male gender preference is four times greater than female and androgynous alternatives combined. The rationale behind choosing a male gender is offered by AF2, who suggests that “women are much more fragile and you really need drive for electricity to go through the wires.” AM1 noted that electricity is male “because [it] is such a powerful medium; it is not something that you must underestimate,” and AM2 stated that “it has overwhelming power and is strong and makes a great big noise.” EF2 suggested that it is male because “he operates in a simple manner, just being like clear and concise.”



Figure 4.4: Respondents’ electricity gender

4.2.2.6 Age of electricity

The age of electricity tended to be varied across the sample. One third of respondents stated that electricity has no quantifiable age, suggesting that it is “ageless” or “immortal”, and EM1 stated that electricity itself cannot age and would “remain constant like electricity”. Three respondents noted specific ages, which are outlined in Table 4.3 below.

Table 4.3: Respondents’ age of electricity

RESPONDENT	AGE	RESPONDENT QUOTE OR COMMENT
AM1	22	Quantity of years since his first encounter with electricity.
EM2	16	“Young and slightly out of control and reckless.”
XF2	10	“Has no experience about life, but who is used through different unacceptable ways by many people although she is still very young.”

4.2.2.7 Electric epiphany

Figure 4.5 below firstly notes the age each respondent was first aware of electricity, and secondly provides details about the encounter. The figure points out that almost two thirds of the sample recall an incident from the ages three and a half to six, whilst five respondents mention no definite age. Eighty-three percent (83%) of respondents note manmade artefacts as being central to their first awareness of electricity, with entertainment in the form of television and radio frequently in the majority. Only one respondent, XM2, noted natural factors as a first awareness of electricity.

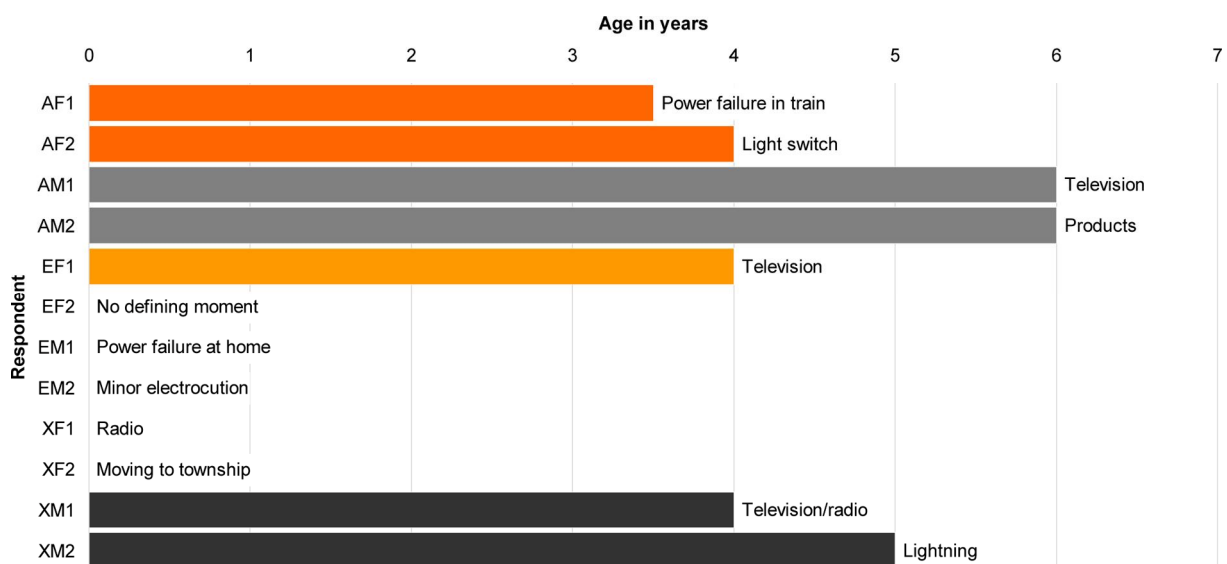


Figure 4.5: Age and item respondent was first aware of electricity

4.2.2.8 Name of electricity

Table 4.4 below provides the name respondents chose to call their electricity character. Half of the sample suggested that electricity has no personal name, primarily due to it being considered functional or utilitarian.

Table 4.4: Respondents' name for electricity

RESPONDENT	NAME	RESPONDENT QUOTE OR COMMENT
AF1	No name	"It is not a personal thing."
AF2	No name	"Just something we use to make life easier."
AM1	No name	Respondent could not think of a name.
AM2	No name	"For me a name is something that you interact with."
EF1	Selma	"Because it sounds alive."
EF2	Polanski	"The sort of duality of its shapes, those smooth and also sharp forms."
EM1	No name	"His name would be a description of what he does."
EM2	No name	"I don't see it so much as a character, that's the thing."
XF1	Nwabisa	"Name means someone who comes with happiness."
XF2	N/A	Respondent was not asked this question.
XM1	Ukukhanya	"Ukukhanya [<i>light</i>] because it provides light."
XM2	Frightening	"I was very scared of thunder."

4.2.3 Instrument 3 – LSM survey

Respondent feedback from the Living Standards Measurement (LSM) survey is provided in this section. Where possible, the data is presented as per O'Sullivan and Barnes' (2007:33-40) original survey format. Prior to each figure, notable characteristics are discussed and, where applicable, an indication of data cleaning procedures carried out. Importantly, the data does not aim to reflect residential consumption of electricity in its entirety, but rather to provide a measurable index and method to cross-examine qualitative data.

4.2.3.1 Respondents' sources of electricity

Figure 4.6, noted below, provides an overview of sources available to respondents, whereby a single unit selection indicates the use of that source. From a selection of eight options, only three options were selected by the sample. Notably, and without exception, grid electricity from a public company or municipality is the primary source of electricity for all respondents. Grid electricity from a neighbour or relative was only selected by IsiXhosa language groups. Similarly, dry cell batteries were identified as used only by Afrikaans and English language groups.

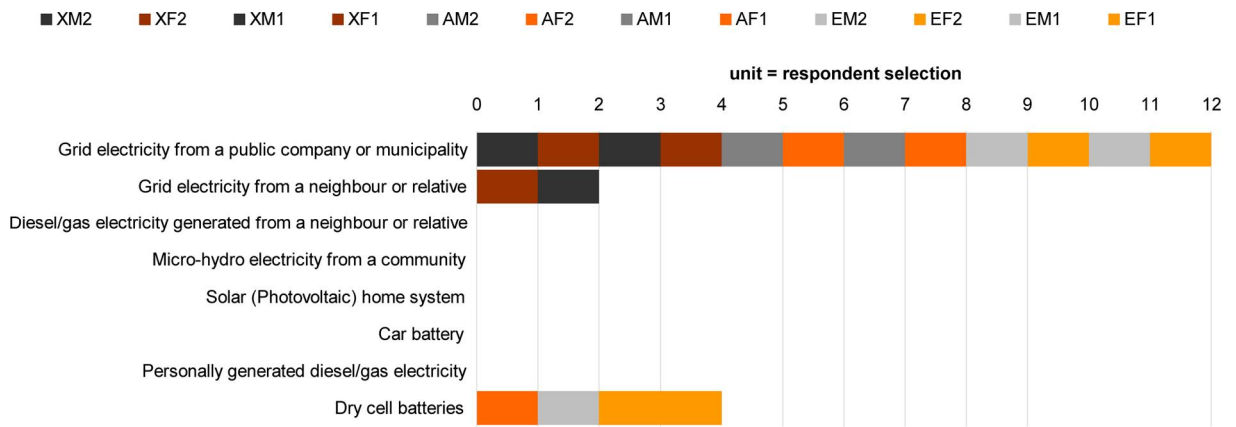
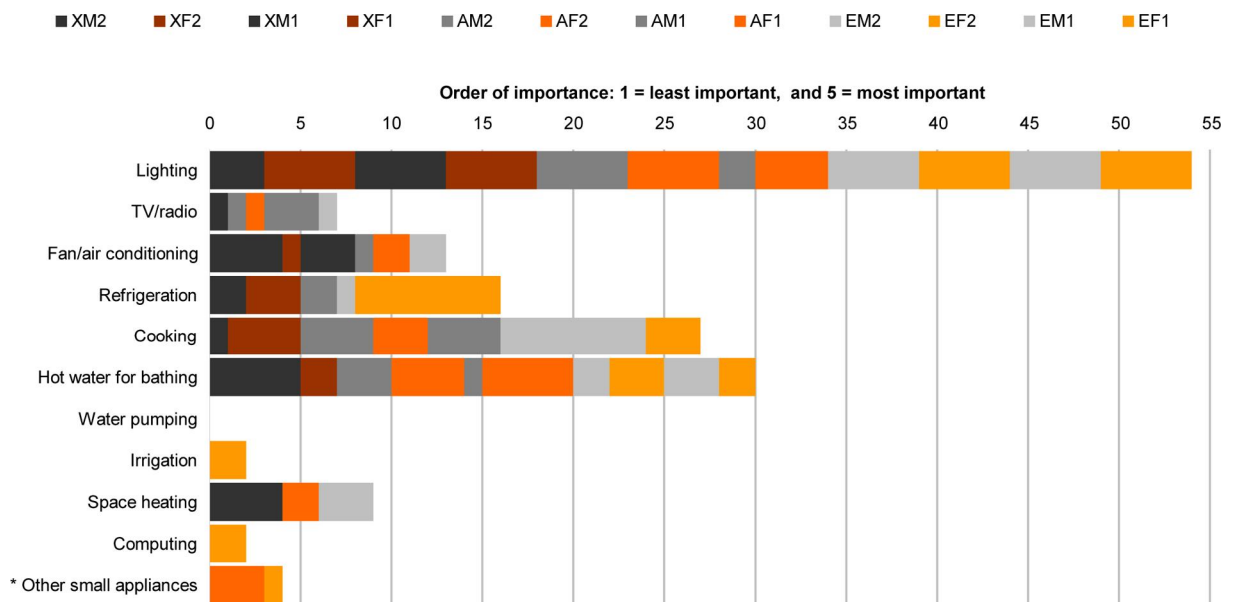


Figure 4.6: Respondents' source of electricity

4.2.3.2 Household items that use grid electricity from a public company

The stacked bar chart in Figure 4.7 below notes the sample's preference for electricity across eleven areas of Eskom generated electricity. Three areas of collective preference stand out, namely: illumination, hot water for bathing, and cooking. Notably, electricity for illumination is collectively felt to be almost twice as important as the next most important item, hot water for bathing. The least important application for this source of electricity is water pumps, with no respondents selecting this category. Although irrigation and computing are collectively noted as being second last by individual importance, they do compare with some respondent's selection for TV/radio.



* ADSL connection, wireless access point, coffee machine, soldering iron, and battery charger.

Figure 4.7: Household items that use grid electricity from a public company/municipality

Additional LSM data, although not illustrated on the graph, point out that fifty-eight-point-three percent (58.3%) of the sample pay for their utility electricity via utility meters, eight-point-three

percent (8.3%) have the cost included in their rental statement, and the remaining thirty-three-point-three percent (33.3%) pay by “other” methods, or did not complete this part of the survey. Notably, seventy-five percent (75%) of the sample were able to provide or estimate in South African Rand (SAR) the amount paid for their last thirty days of grid electricity usage, and fifty-eight-point-three (58.3%) were able to provide or estimate how much electricity in kilowatt-hours was used for the same period. Few respondents selected “other small appliances”, which is surprising due to all respondents owning a cellphone, which is commonly charged with grid electricity.

4.2.3.3 Respondents’ household items that use dry cell batteries

Figure 4.8 below details the second most selected source of residential electricity, which in this case is off-grid electricity supplied in a dry cell battery format. Although the “other small appliances” selection indicates prominent usage for this electricity source, it is worthwhile noting that the LSM survey provided a torch and a radio battery as an example of a dry cell, which in turn might have influenced respondent selection. Similar to grid electricity from a utility, illumination is noted as important in this case only by female English respondents. All respondents paid cash for their dry cell batteries, and half could recall or estimate the amount paid for the last thirty days of dry cell electricity.

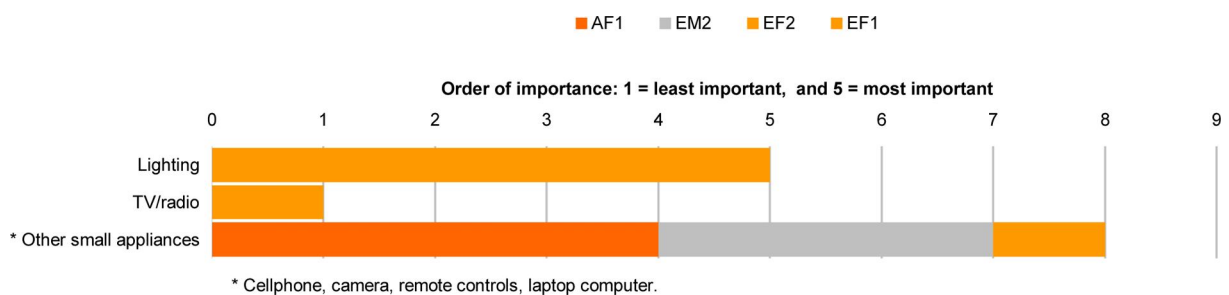


Figure 4.8: Respondents’ household items that use dry cell batteries

4.2.3.4 Household items that use grid electricity from a neighbour or relative

IsiXhosa respondents, XM1 and XF2, selected grid electricity from a neighbour or relative. Figure 4.9 below notes the importance of the electricity source for entertainment in the form of television and radio. XF2 paid for her consumption with a utility meter, and was able to estimate the rand value of the payment and the estimated kilowatt-hours used over the last thirty-day period, and XM1 noted his consumption as included in his rental statement.

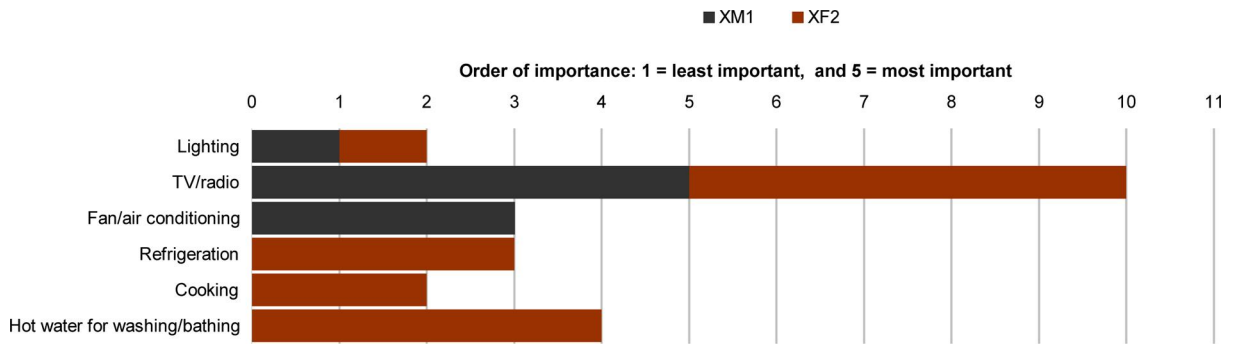


Figure 4.9: Household items that use grid electricity from a neighbour or relative

4.2.3.5 Respondents' quantity of bulbs owned

Figure 4.10 below compares the type and quantity of illuminating technologies used by the sample, and which are incandescent bulbs, fluorescent tubes, and energy saving bulbs (CFL). Due to dissimilar living arrangements, the number of bulbs specified by each respondent has been divided by the total number of occupants living in the household. Additionally, the questionnaire provided a bulb quantity range, rather than exact amount. For the purpose of this graph, the selected range has been averaged out, for example, a range option between one and ten bulbs is noted as five bulbs.

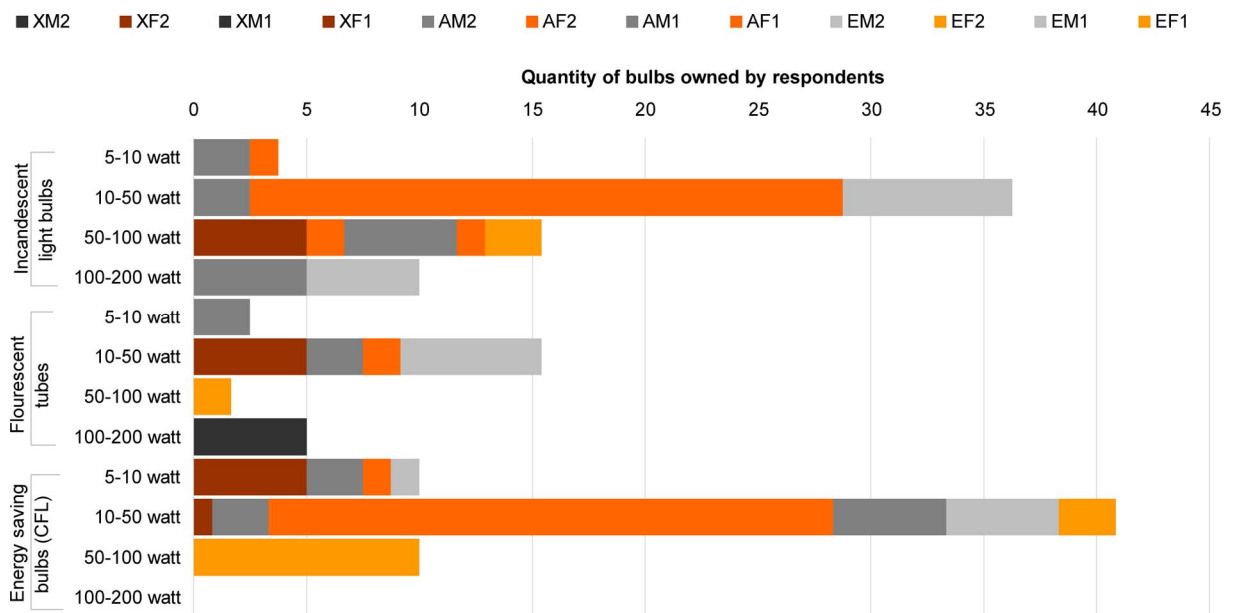


Figure 4.10: Respondents' quantity of bulbs owned

The graph illustrates a ten to fifty watt preference across the illuminating technologies. Notably, the total ownership of incandescent and energy saving bulbs (CFL) appears comparable, and incandescent bulbs are predominantly used by Afrikaans and English males, and conversely, energy saving bulbs are principally used by all three female subpopulations.

XM1 is the only respondent to use a single illuminating technology, which in his case is fluorescent illumination. XM2 did not complete this part of the survey.

4.2.3.6 Respondents' kilowatt expenditure on illumination

The Figure 4.11 below provides a breakdown of illumination electricity consumed in kilowatt-hours. The data is based on the sample's use of incandescent bulbs, fluorescent tubes, and energy saving bulbs (CFL) for a one-week period. As per the aforementioned quantity of bulbs owned, the total energy usage is divided by the total number of occupants living in the household, and bulb quantities have been averaged out. Similarly, wattage ranges have been averaged, whereby a fifty to one-hundred watt bulb is noted as a seventy-five watt bulb. Light bulbs are assumed to be in use and not stored.

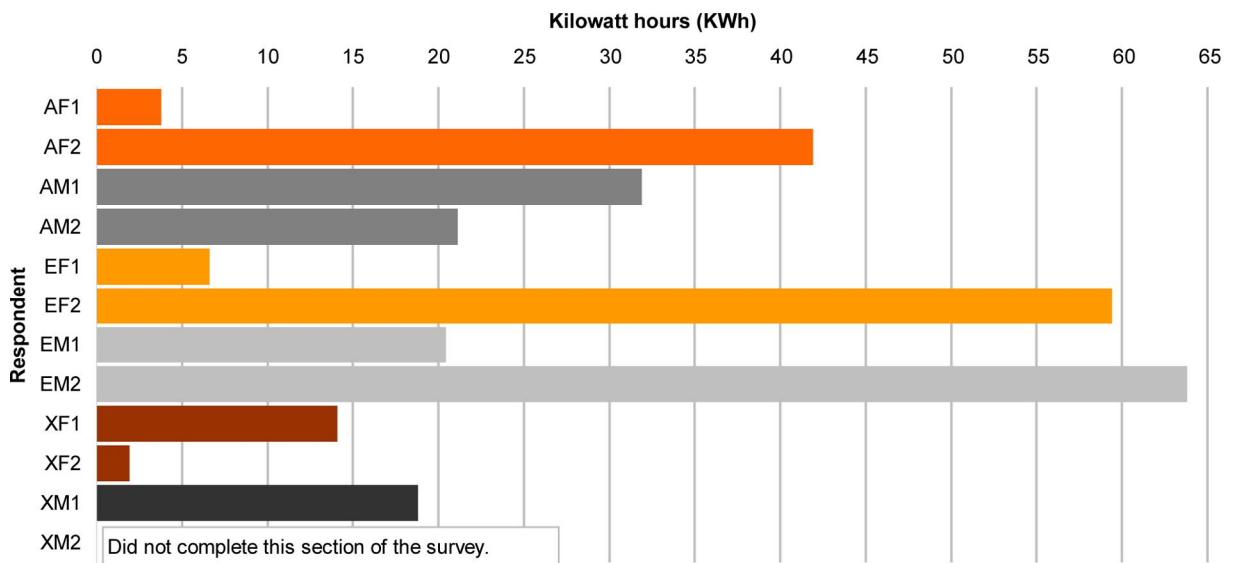


Figure 4.11: Respondents' kilowatt expenditure on illumination.

Figure 4.12 below outlines Figure 4.11 kilowatt-hour (KWh) calculation method, whereby (X) indicates the respondent, (Y) the quantity of all bulbs owned, and (Z) the number of household occupants.

$$X(\text{KWh}) = \frac{\text{Incandescent bulbs, Fluorescent tubes and energy saving bulbs (CFL)} \left((Y \times 7.5W) + (Y \times 30W) + (Y \times 75W) + (Y \times 150W) \right)}{1000} / Z$$

Figure 4.12: Illumination expenditure formula

4.2.3.7 Respondents' household appliances

A further understanding of energy consumption behaviour is provided in Figure 4.13 below, with a list of LSM specified appliances, whereby a single unit selection indicates the use and ownership for that item. For this section the total quantity of products has not been divided by the number of household occupants. The results note ownership of refrigerators, computers, and hot water geysers as prominent appliances. A refrigerator is owned by all respondents and in some instances more than one per household. Compound ownership has perhaps influenced the results, for example, AF1 owns more than four computers, suggesting computer significance is inflated. Of the items selected, fifty-five percent (55%) of respondents could identify or estimate the appliance wattage, and eight-three percent (83%) could estimate the hours used within the last week.

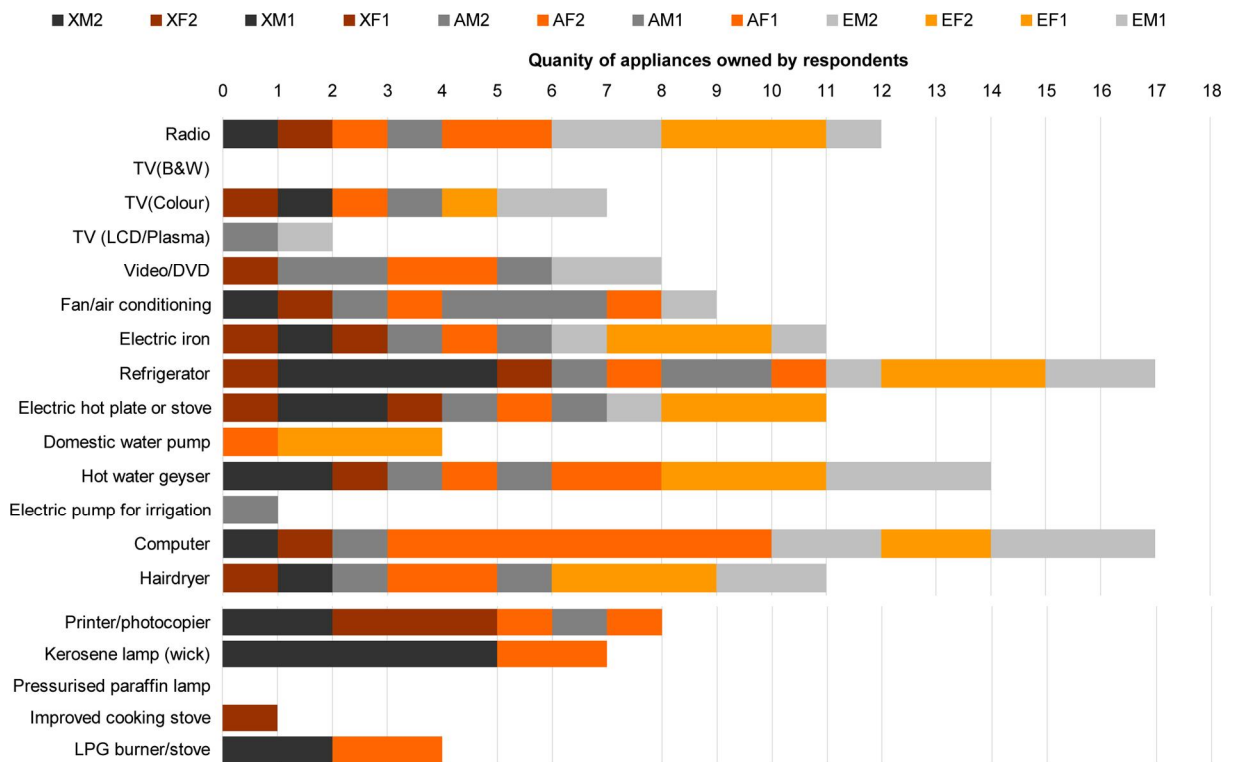


Figure 4.13: Respondents' household appliances

4.3 DATA DISCUSSION

Fieldwork data is discussed with reference to the research question and sub-questions, whereby notable semiotic and ethnological points that affect sustainable residential electricity management are discussed in detail. The author's opinion is introduced in a retroductive-reasoning manner, whereby notable observations are firstly highlighted and subsequent deductions are supported with existing literature. Similar to the literature review, Socio-

technical Theory (STT) will manage the data, and conceptual themes will make use of Peirce's triadic model and successive signs as illustrated in Figure 4.14 below.

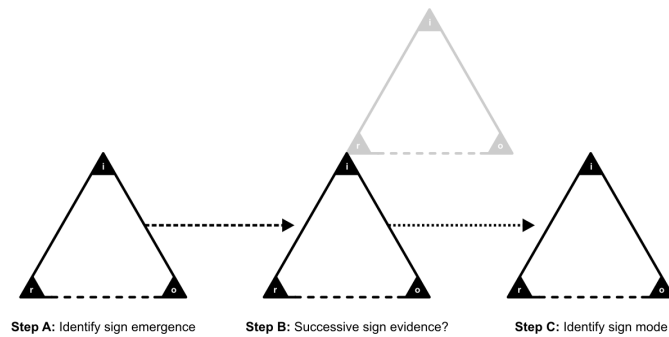


Figure 4.14: Semiotic method

4.3.1 Principle 1: Compatibility

A semiotic in the form of water was identified in the fieldwork data. Respondents frequently cited it as a method to describe electricity's characteristic, for example smell. EM1 stated that, as a metaphor, he makes use of water to conceptually understand electricity's abstract qualities or behaviour. With reference to Cherns' compatibility principle, whereby design development must be compatible with its objectives, Figure 4.15 below unpacks the water semiotic in order to understand its influence on DSM. A successive triadic model is proposed illustrating residential electricity with the origin of electricity on the lower triadic model and learning methodology on the upper. For the purpose of this discussion water can be considered an independent variable due to its relative agency to the model. From a modal perspective, it is iconic due to its perceived resemblance to electricity.

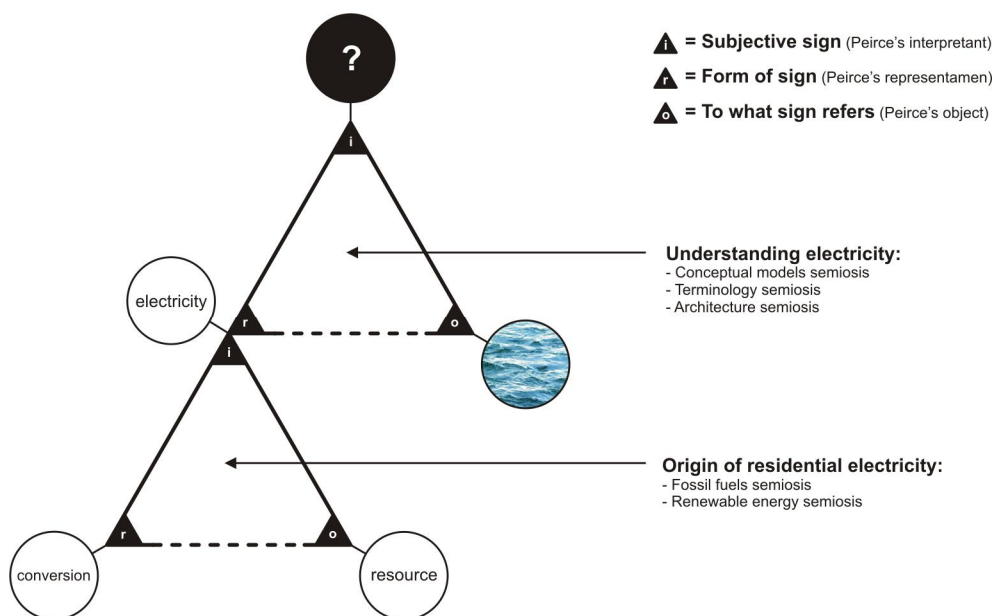


Figure 4.15: Electricity and water relationship

On the one hand, describing electricity's characteristics as noted in the upper triadic model by means of water is convenient. The analogy allows a direct and universal visualisation of electricity's attributes, which for the most part, remain abstract. Krippendorff (2005:105-108) defines such relationships as User Conceptual Models (UCM), whereby metaphors are created to inform, for example, on an artefact's use. He continues by highlighting how the metaphor of electricity flowing through wires is common, and the water/electricity UCM is perhaps further influenced by plumbing and electrical similarities such as flow diameters and routing considerations. On the other hand, although the analogy is fitting in educational contexts, electricity's indoctrinated water semiotic is arguably confusing DSM objectives. For example, the reliance on water, which in its own right has DSM constraints and municipal supply factors, to describe electricity's attributes can arguably diminish electricity awareness campaigns.

An appropriate design paradigm shift to encourage compatibility between energy source and end user is illustrated in contemporary vehicle instrumentation. Rather than displaying the vehicles remaining travel potential in terms of volumetric measurements, a conceptual shift has taken place, whereby potential is described in term of remaining distance. In other words, kilometre measurements are directly used to plan a route, rather than requiring a conversion of the litre equivalent. Electricity artefacts frequently use volumetric methods to describe an appliances energy capacity, similar to the familiar battery icon noted in Figure 4.16 below. Although the icon effectively communicates a cylindrical dry cell battery, it describes very little about artefact functionality and, due to technological shifts, it has little association with the physical shape of the battery used by the artefact. For examples, the Nokia Classic mobile phone makes use of a prismatic battery but displays a cylindrical battery icon.



Figure 4.16: Electricity and capacity

To conclude principle 1: the above-mentioned water semiotic should be further researched using quantitative methods to understand the extent of its impact on DSM. Similarly, the development of an electricity specific conceptual model should be developed and researched to understand potential DSM benefits and drawbacks. With this in mind, it is worthwhile noting that, similar to the literature review's mention of caloric terminology being outdated but still in use, there appears to be academic concerns regarding associating the term "flowing" with electricity. Specifically, quantities of electricity and flows of electricity are considered technically incorrect and outdated, and should rather be referred to as charge and current respectively (Ohio State University, 1998; Academic dictionaries and encyclopedias, n.d.).

4.3.2 Principle 2: Minimal Critical Specification

Figure 4.7 and Figure 4.8 in the data presentation section note an outright importance for illumination from grid electricity, and although off-grid sources were not as prevalent, illumination was also noted as important there. Qualitative data in turn frequently noted bulb artefacts and descriptions relating to illumination. For example, XM1 named his electricity character “Ukukhanya” which translates to “light”, and EM1’s “evil” character embodied a “connotation of the darkness”, and is “only satisfied when the lights are out, you know, when there is nothing left.” However, it is with XF2’s comment that “when you see darkness, it is because she has no way out,” that the semiotic of fear and illumination was identified. The semiotic triadic model in Figure 4.17 below unpacks a possible intention behind illumination, and whereby the subjective sign is considered to be fear, or the prevention thereof.

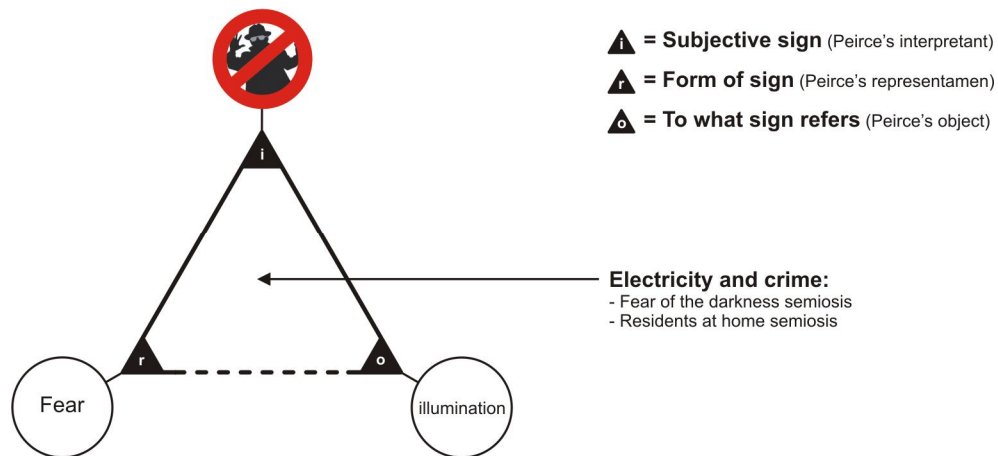


Figure 4.17: Electricity and fear

Although fear is by no means a semiotic unique to South Africa, the use of illumination in high crime areas, which South Africa indeed has, is therefore a factor that needs consideration. Such a perspective is supported by Nkomo’s (2005) research into a South African village, when he suggests that “lamps burning outdoors at night deter crime and enhance a feeling of security among households.” Although this illumination suggests household occupancy, or practically prevents criminals hiding in the shadows, STT would necessitate the formalisation of a minimum quantity of bulbs or wattage required to prevent a criminal act. In doing so, the relationship between illumination and crime could be academically compared to DSM objectives.

A British crime prevention study provides clarity on illumination as a crime prevention semiotic. The research notes that, over a three year period, 3500 new street lights were introduced to an inner London Borough with high levels of crime, and, although the additional

illumination resulted in an average four-fold increase in the intensity of street lighting, the researchers concluded that “no evidence could be found to support the hypothesis that improved street lighting reduces reported crime” (England, Home Office Crime Prevention Unit, 1991:19-20). A subsequent paper commenting on the study provides further insight, suggesting that “better street lighting helps to reduce the public’s fear of crime” (England, Home Office Crime Prevention Unit, 1991:24). To conclude principle 2: research specific to a South Africa context would assist in optimising DSM strategies by unpacking the relationship between illumination, crime statistics, and residential anxiety. In other words, a breakdown of expended wattage relative to crime prevention technologies using illumination would indicate if electricity is being unnecessarily used.

4.3.3 Principle 3: Variance Control

It is not within the scope of this thesis to identify and unpack semiotic variance within the fieldwork sample, however, linking respondent expectations to industry developments provides an indication on what semiotic variance affects DSM. For example, in accordance with Cherns’ requirement for variance to be controlled as close to the point of origin as possible, the abstract quality of electricity’s colour and form can be used as a variance benchmark. On the one hand, the respondents’ choice of colour for their electricity character, which is noted in the aforementioned Figure 4.3, suggests a blue prominence. On the other hand, the majority of the colours surprisingly resemble the South African selection of cable core colours, which are blue, green, and brown. As 4.2.2.2 notes, the respondents frequently commented that the form of their electricity is in a conduit or tube format, suggesting the familiar appliance wire or cord. For the purpose of the following discussion, both semiotics are superimposed on the “form of sign” in Peirce’s triadic model, illustrated in Figure 4.18 below.

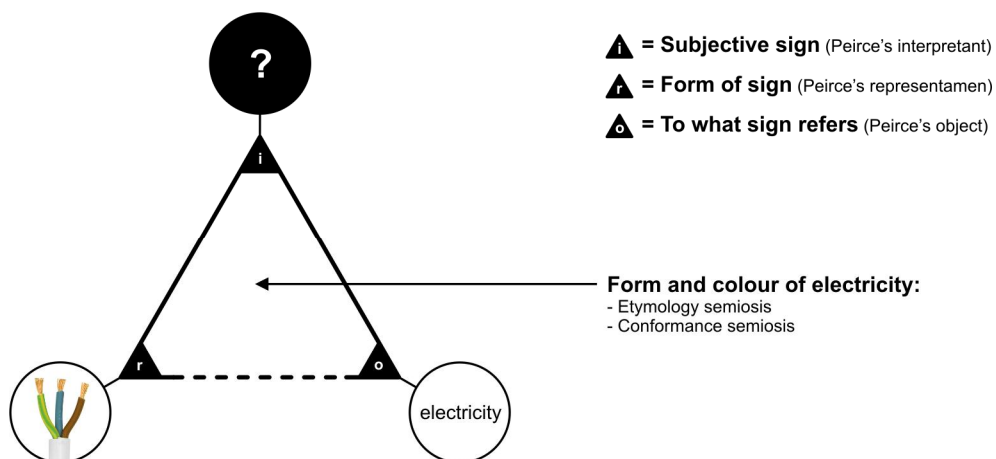


Figure 4.18: Form and colour of electricity

It is important to note that colour's abstract qualities are highly subjective and contextually sensitive, or, as Riley (1995) suggests, "no system or code can ever sufficiently account for its effect." However, if STT requires that variance is to be controlled close to an origin, the unpacking of wire and core cabling is necessary. On revisiting existing literature to understand the intention behind cables colour coding conventions, no comprehensive insight emerged. However, Black's (1983) historical overview into the development of electric wires and cables dating back to the eighteenth hundreds provides insight into what can be considered outdated methods of manufacturing cable insulation. With this in mind, perhaps the initial process using oil-impregnated paper, enamelling, and vulcanised India-rubber dictated colour choice and subsequent coding, and which in turn suggests a form of technical determinism.

The variation in the aforementioned colour semiotic, similar to Tomaselli's (2001) example of incorrectly inverted red and blue faucets, may have DSM implications. For example, colours' relation to electricity is experiencing global transformations, whereby Britain's Institute of Electrical Engineers (IEE) has been investigating changing its cable core colours since 1969, due to incompatible colour conventions with Europe (IET, 2004). Electricity colour coding directives are placing national cultural practices in an international forum. For example, the International Electrotechnical Commission (IEC), which originated in London in 1906 (IEC, 2009), has their IEC 60446 cable colour standard adopted in many parts of the world.

To conclude principle 3: although the standardisation of electricity's colour is intended to improve safety, it may have contrary results due to the decline of indigenous or instinctual colour semiotics' guiding behaviour. In other words, the reduction of semiotic variance by implementing global standards, arguably along British trends, may be in direct contradiction to localised cultural norms. Further research will be required to determine if this indeed does occur.

4.3.4 Principle 4: Boundary Location

A semiotic in the form of a residential electricity wall-socket was identified in fieldwork data following the emergence of similar shapes in respondent artwork. With reference to Cherns' boundary principle, the wall-socket can be considered an STT boundary, due to its conceptually demarcating residential electricity usage between an electricity grid and an artefact. The Figure 4.19 notes its position in Peirce's triadic model as the form of the sign. For the purpose of this discussion, the plug is the model's subjective sign.

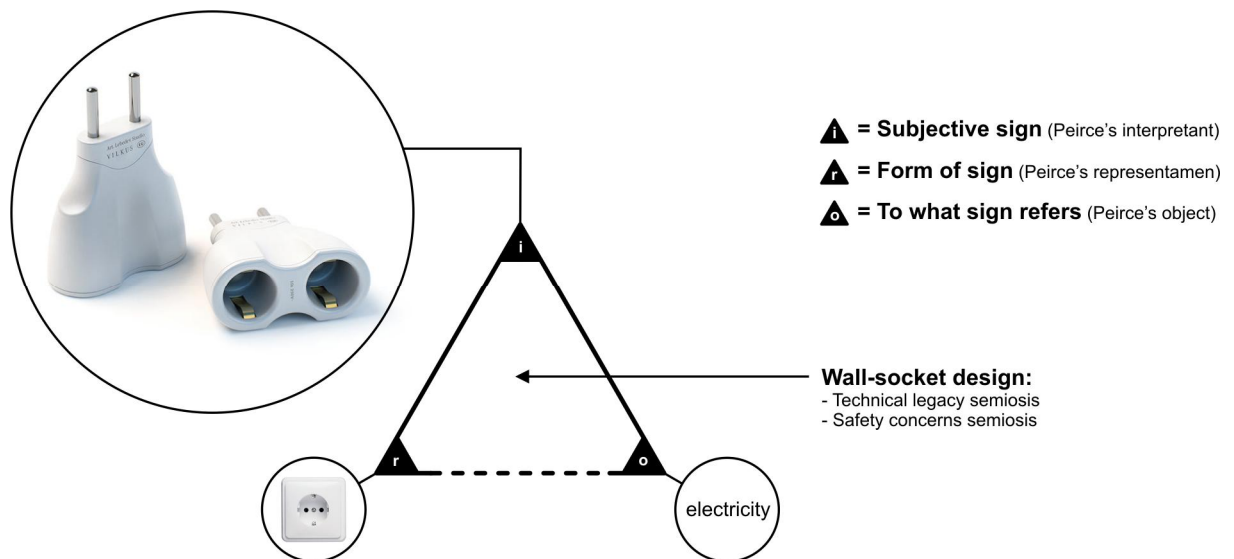


Figure 4.19: Wall-socket design

The plug is in response to the sample reminiscing, either real or imagined, on electrocution. Specifically, EF1 and EF2 drew screwdrivers inserted into wall-sockets, although both confirmed that they have not personally done so. AF2 and EM2 noted instances when they were “shocked” and, importantly, when respondent EM1 was questioned about recollections on his first power cut, he responded with “no, but I remember my first shock.” On the one hand, the frequent mention of electrocution simply suggests the existence of a poorly designed artefact. On the other hand, and from a conceptual perspective, the household plug arguably challenges safety boundaries, whereby the act of electrocution, rather than being considered dangerous and preferably avoided, is suggestive of an inevitable “rite of passage”. Supportive of such a perspective, the two-pin plug, or subjective sign in Figure 4.19 above, is a conceptual piece by industrial designers Alexei Sharshakov and Timur Burbayev (Art. Lebedev Studio, 2007). They somewhat wryly point out that current wall-sockets are poorly considered, and instead of using a screwdrivers to gain access to electrical components, their adapter, complete with ergonomically designed finger insertion openings, plugs directly into existing wall-sockets and provides users instant electrocution.

To conclude principle 4: although the wall-socket semiotic and electrocution juxtaposition is perhaps an extreme subjective sign, it is worthwhile noting that contemporary socket and pin designs have distinct similarities with Harvey Hubbell’s century old design, which was patented in 1904 (United States Patent and Trademark Office, 2009). Additionally, from a DSM perspective, although the wall-socket semiotic provides a common visual reference to electricity sources, its technical legacy might be hampering energy saving opportunities. On the one hand, global developments are addressing this area; for example, the GSMA’s goal for a common mobile phone charger format to reduce an estimated fifty percent (50%) in

standby energy consumption (GSMA, 2009). On the other hand, the solution further entrenches the paradigm whereby evolving artefact technology dictates wall-socket designs, rather than being developed in parallel.

4.3.5 Principle 5: Information Flow

A digital versus analogue semiotic was identified in fieldwork data, arguably reminiscent of technical determinism. Respondents suggested a semiosis between the two, and that they are in a state of conflict. For example, with reference to overhead power lines, AF2 noted that “there’s always the electrical wires in the picture ... can never take a picture without including [them].” XF1 stated that “according to my understanding of studies related to nature, I try to use electricity sparingly.” The data suggested the existence of a successive triadic model as illustrated in Figure 4.20 below, whereby electricity’s analogue origin is situated on the lower triadic model, and its digital manifestation is on the upper model.

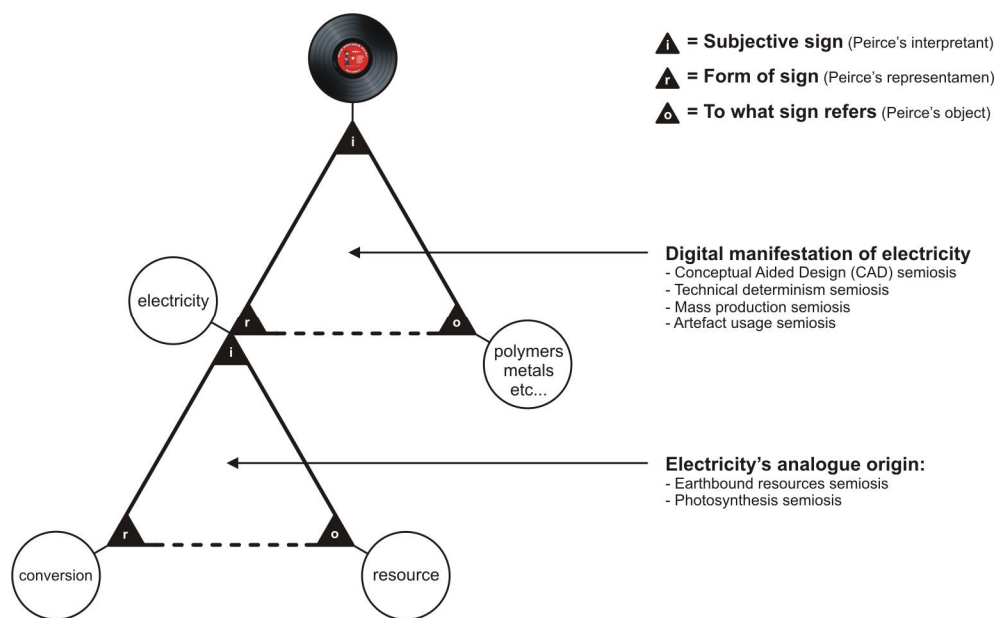


Figure 4.20: Digital versus analogue

When commenting on semiotics, Chandler (2002:47) suggests that individuals have an attachment to analogue data, often regarding digital alternatives as less authentic. He continues to propose that analogue signs embody “infinite subtleties” often incommunicable with words alone. Plasketes’ (1992:118) study into societal reaction to the compact disk (CD) provides additional clarity when he notes that “with that sense of history comes an emotional attachment to the artefact,” suggesting that the poor initial CD uptake was due to the demise of the vinyl record, and not the emergence of the CD. Although Plasketes’ paper can be considered technically outdated due to the music industry having implemented new

technology and online paradigms, it does provide insight into consumer relationships to analogue and digital concepts. In support of the above, XM1 suggested, when commenting on humankind's treatment of the earth, that the "human heart has changed to a machine," and noted electricity semiotics such as industrial power lines and electricity signage in his artwork.

In a similar vein, electricity's subjective sign can influence DSM. For example, if the City of Cape Town's Solar Water Heater (SWH) noted in Figure 4.21 below is considered alongside Chandler's (2002:47) semiotic preference, the imposing nature of the SWH on housing design and arguably residents is suggestive of a digital or technical determinism. In other words, the device itself appears to explain very little about the benefits of solar energy or have any affiliation to the resident. Cherns' STT request for a design to be developed in conjunction with its primary users also appears to be overlooked in this example. It can be argued that economic considerations necessitated such a process; however, ironically, such a foreign and technical semiotic can ultimately be rejected by the community it was intended to assist. For example, Uken (2009) notes a case in South Africa whereby a solar installation was provided to farm labourers who were without electricity. The solution was ultimately removed and replaced with a grid solution due to the labourers commenting that it did not provide "proper electricity".



**Figure 4.21: Digital reinforcement
(Mahomed, 2006; REEEP, 2009)**

To conclude principle 5: artefacts embody digital and analogue semiotics that can directly influence DSM success. In addition, it is arguable that renewable energy cannot rely on good intentions alone, and that further research is required to ascertain how it, as a semiotic, is perceived by low-income and mid/high income households.

Principle 6: Power and Authority

A semiotic in the form of a zigzag was identified in XM1's and XM2's fieldwork data. It held varying significance, for example, XM1 noted the form of his electricity to have a "zigzag" shape and included the symbol in his artwork as suggestive of an industrial warning sign. XM2 on the other hand drew his "zigzag" shape as a reflection in a mirror with an alarmed character looking on. He commented that "when there is lightning we have to cover the mirror", and continued to explain how it prevents lightning entering the room and electrocuting the occupant. Additionally, XM2 placed an emphasis on "ancestral beliefs" and that in "ancient times" the power of lighting could be harnessed by individuals, and suggested that "if they didn't like a certain family ... they would threaten that family. They would do such things using the power of electricity [*lightning*]." Figure 4.22 below places the zigzag shape in relation to Cherns' power and authority principle, whereby he states that, for allocating responsibility, individuals must have authority and skill to command resources. The zigzag semiotic can be considered an indexical sign due to its form and its naturally occurring manifestation, lightning, being direct, unequivocal, and contiguous.

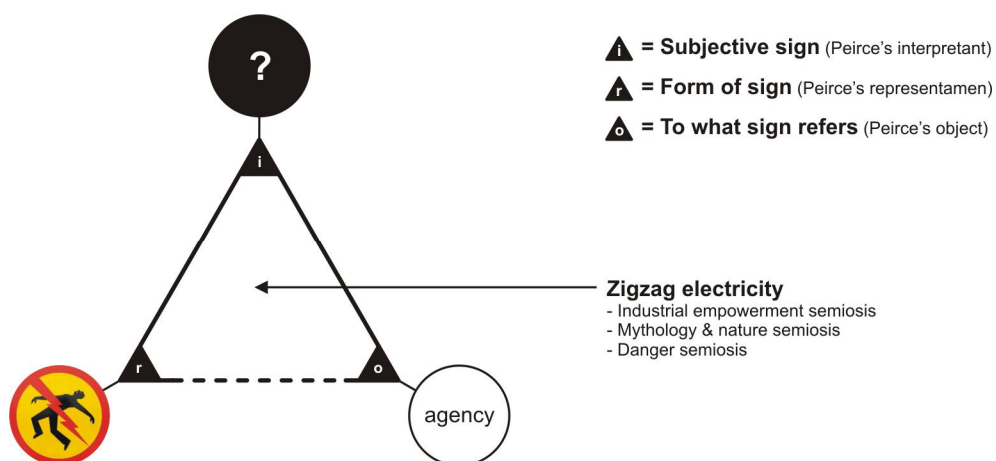


Figure 4.22: Zigzag electricity

From an etymological perspective, the zigzag symbol is an amalgamation of the symbol for danger, heat or energy, and a directional arrow. It is a common ideogram for lightning, high voltage electric current, and flash bulbs for photographic appliances (Symbols, 2006). In Roman mythology, the zigzag ideogram is evident in Jupiter's staff, who, being the equivalent of the Greek god Zeus, was "associated with lightning, thunderstorms, and the power to agitate the waters". Notably, variations of the ideogram originate from Neolithic rock engravings (Symbols, 2006).

Although XM1 described his semiotic from an industrial perspective, and XM2 correspondingly natural, both suggest a form of dissuasion. For example, when they are placed alongside Cherns' aforementioned authority statement, a potentially contradictory DSM framework exists. In other words, if users are confronted with such graphic imagery of fatality, potential electricity saving practices may be abandoned due to residential users considering them too dangerous. A preferred approach is found in industrial breathing-mask signage, which makes use of procedural rather than instructive methods. In other words, the signage informs the user of what equipment is required for safe handling or operation, and perhaps in doing so, encourages what Mick and Fournier (1998:125-138) in the literature review defined as partnering between artefact and user.

4.3.6 Principle 7: The Multifunctional Principle

Cherns' multifunctional principle requires individuals to adapt to their environments; however, no semiotic or ethnological observations applicable to this principle were identified in the fieldwork data.

4.3.7 Principle 8: Support Congruence (conformity)

Gender is a semiotic that intentionally emerged from fieldwork data, whereby respondents were specifically required to identifying their electricity's gender. Importantly, no criteria for gender selection was provided, but rather respondents were requested to explain the rationale behind their choice. Figure 4.23 below places the gender semiotic within Peirce's triadic model, and its relation to DSM is unpacked following the figure.

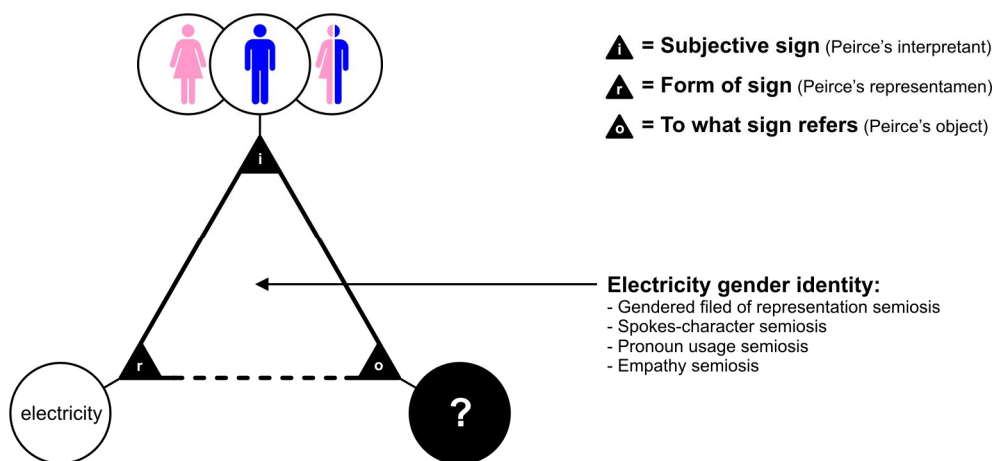


Figure 4.23: Electricity's gender identity

Kate Peirce's (2001) paper titled "What If the Energizer Bunny Were Female?" provides insight on gender and appliance "spokes-characters". Advertisers frequently make use of such characters due to their successful consumer recall rate and ability to be customized to a company's brand. Peirce suggests that "changing the gender of a spokes-character changes perceptions of the product," and continues to point out that gender stereotyping, via media such as television, is understood by children. Citing various authors, he suggests that, in marketing to children, advertisers prefer male stereotypes due to boys preferring same-sex models and girls accepting either gender. Peirce's comments are supported by this thesis' data noted in the aforementioned Figure 4.4, whereby all males chose their own gender, and females' gender selection was uniform across male, female, and androgynous groupings.

Feminist theory can further unpack gender and electricity relations. The Stanford Encyclopedia of Philosophy (2009) suggests that "sex" is a physical and biological disparity between male and females; gender on the other hand, comprises of real or imaged definitions and meanings of sexuality created by society. It continues to point out how inanimate objects can be placed in a "gendered field of representation" through behavioural patterns and metaphorical thinking. For example, in a nuclear family, kitchen appliances are frequently considered to be within the female domain. Additionally, the use of pronouns in describing objects is of significance to industrial designers. Enfield (2002:111) notes that pronoun usage is sensitive to cultural attitudes, and, in some English dialects, inanimate objects can be referred to as "he" and "she" which he refers to as "animate gender assignment". When referring to Tasmanian Vernacular English (TVE), he suggests that portable objects such as implements and computers have variable assignments, with the exception of vehicles, which have a fixed gender. Elements of the "natural inanimate environment" such as land, sea, and interestingly lightning, are considered feminine. Of importance to this research, he suggests that "she" is used to express a personal interest or emotional involvement with an object, whereas masculine pronoun usage suggests detachment or indifference.

To conclude principle 8: if the gender semiotic is considered alongside the aforementioned discussion, it is arguable that the sample's sixteen percent (16%) selection for female electricity is a DSM challenge. For example, a majority male electricity that is described as "strong", "clear and concise", and embodying "overwhelming power" perhaps indicates that users will have little empathy or sentimental attachment to electricity. In other words, an emotional preoccupation with performance perhaps overshadows sustainable or conservation behaviour. Further quantitative research into electricity's gender is required to answer such a question.

4.3.8 Principle 9: Transitional Organisation

Respondents AF1 and AF2 provided data that suggests artefact design can affect future DSM developments. For example, AF1 compared her grandparents' use of electricity to her own, and suggested that contemporary electricity is increasingly transient, both in scale and mobility, and compared its format to "little eggs of electricity that [*people*] carry around with them". AF2 noted her grandmother's apprehension to new technical artefacts, and suggested that "it's as if she is afraid of it," and continued to note that "I think it is difficult for a person at that age to accept that things change." Cherns' transitional principle acknowledges the grandmother's concern by suggesting that a transitional design contains far greater complexity than a new design. Figure 4.24 below unpacks this principle with reference to industrial design and DSM.

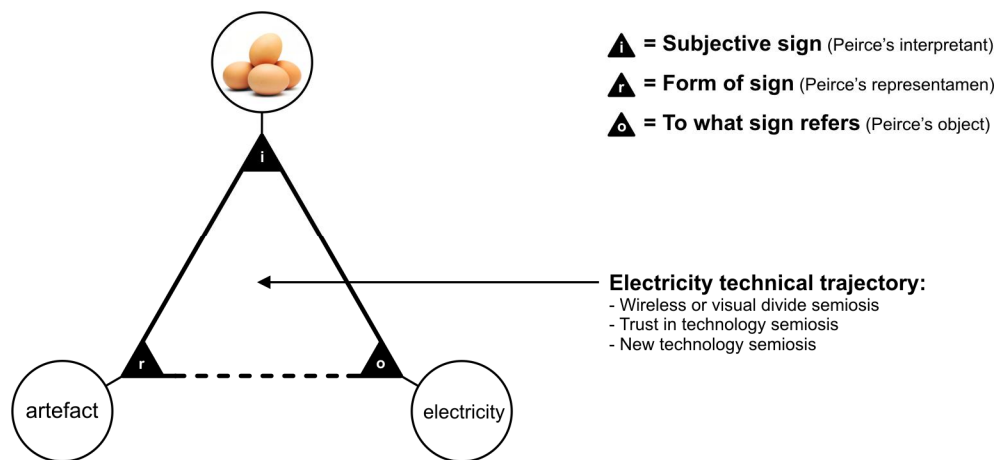


Figure 4.24: Electricity's shifting trajectory

A resistance of new ideas is by no means new, and, with indication to the initial public acceptance of modern psychology, the term "misoneism" is cited by Jung (1964:33), which he describes as "an unreasonable fear or hatred of new ideas". With regard to this thesis, Jung provides an appropriate illustration of misoneism by the American satirist James Thurber (1894-1961), who described his aunt's fear, following a broken light bulb, that electricity was "leaking all over the place". With the benefit of hindsight, similar concerns can be categorised under Toffler's "third wave" or "digital divide" paradigms. However, as AM1 correctly notes, "new technology where electricity can even be transmitted wireless" is being developed. Wireless paradigms can further subject electricity to being an abstract technology that prevents users from understanding its origin. For example, Pendry (Technology Review, 2006), a professor of physics at London's Imperial College, when commenting on a low-frequency electromagnetic radiation technology that can "wirelessly [*supply*] power to devices", notes that he can't think of any reason to worry about health concerns, but that other people will. Similar to the abovementioned authority example, if wireless technologies

are used in conjunction with DSM developments, apprehensions affecting successful uptake will require design strategies to encourage artefact “partnering”.

A semiotic in the form of a moral semiosis was identified in fieldwork data. For example, regarding the use of non-renewable resources, AF1 acknowledges that in creating electricity, “certain sacrifices have to be made to it ... to gain these advantages.” Additionally, XM1, whose artwork is noted in Figure 4.25 below, suggests that “the manner [*in which*] people feel their emotions is like a machine plugged into electricity.”

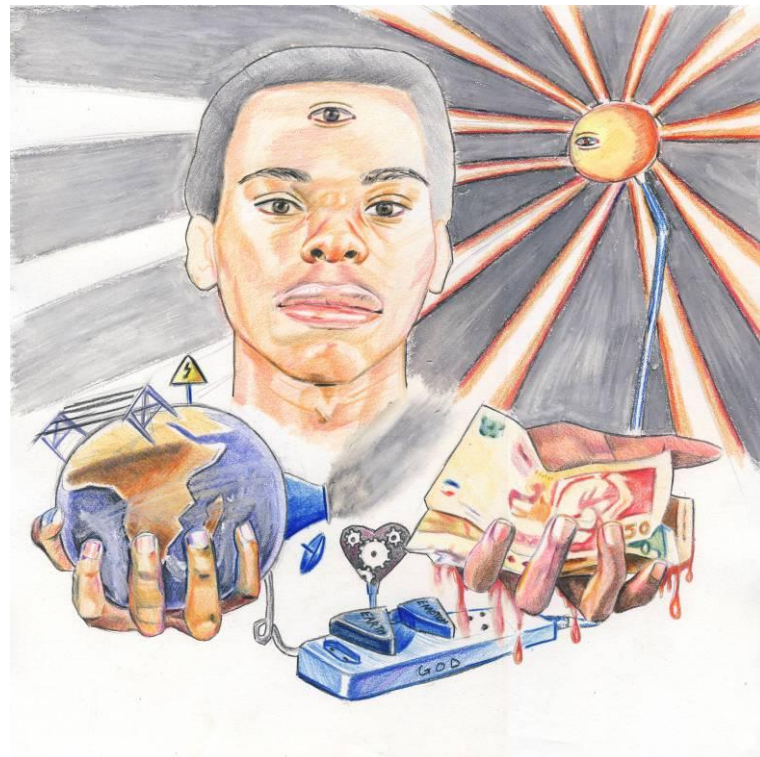


Figure 4.25: Awareness of electricity

It is important to note that fieldwork criteria did not question respondents about sustainable and renewable technology or issues pertaining to ethics. However, if the two respondents' comments, which are suggestive of morals and ethics, are noted alongside Hobson's (2006: 324-329) example of the symbolic value behind suburban recycling bins, the complex relationship between morality and sustainability surfaces. Further understanding of ethics is provided by Winnicott (1988:57) in her description of “the development of a personal moral code”. She suggests that in nurturing a child's sense of morality, two parenting methods exist, whereby on the one hand a parent will “plant” or induce moral coding on their child from birth, and on the other hand, parents will leave such coding to the child's discretion and agency. She continues by suggesting that “the point in time when a child feels responsible for his or her ideas and actions” is linked with the beginning of the individual for society. To conclude principle 9: Cherns' (1987:159) request that the design team assist in managing the transition from old to new systems of values suggests that electricity's transitional state and moral

disposition requires consideration. In other words, a DSM artefact may need to make use of a moral semiotic the specific pertains to the market under consideration.

4.3.9 Principle 10: Incompletion or the Forth Bridge Principle

A semiotic in the form of a semiosis between entertainment and learning was identified, whereby respondents in the aforementioned Figure 4.5, noted that entertainment related artefacts provided their first awareness of electricity. Figure 4.26 below develops this semiotic with Cherns' final principle, whereby he states that system stability is a myth and constant review is required. Following respondent data, entertainment is considered the independent variable due to its apparent agency.

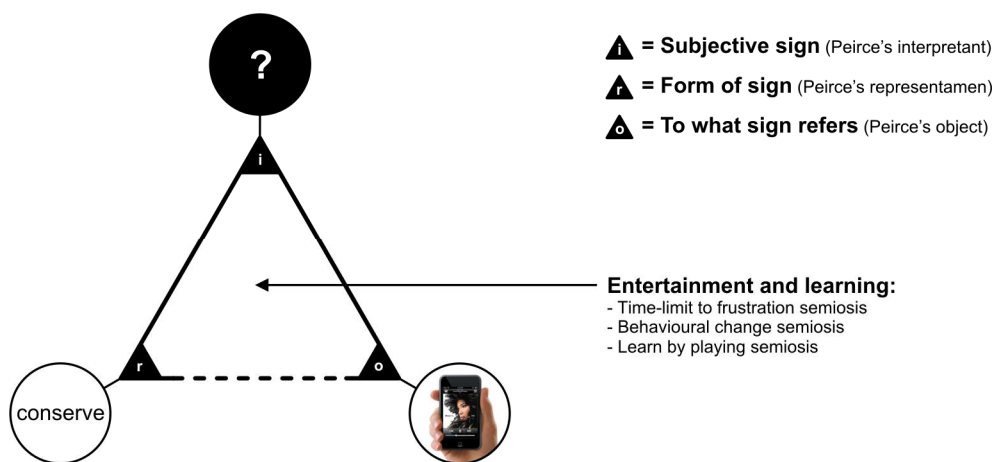


Figure 4.26: Entertainment and learning

Winnicott (1989:9-10) provides partial insight into the semiosis between entertainment and learning with psychoanalytic theory and transitional objects (TO), which assist in developing an infants external reality, both metaphorically and tangibly. She notes that a TO predates reality testing and may even develop into an adult obsessive object. Infants negotiate with the TO by controlled means of manipulation and possessiveness, and, importantly, what she describes as a “time-limit to frustration”, perhaps reminiscent of instant gratification paradigms. Although a TO is frequently biological, for example, a mothers breast, Winnicott suggests they can also be the “object of the first relationship”, and for the purpose of this discussion, a TO is electricity.

If respondent entertainment artefacts are considered alongside Winnicott's TO and “time to frustration” paradigm, electricity and DSM awareness is perhaps occurring too late in an infant's intellectual growth. For example, with regards to television and DVD/video viewing, Zimmerman, Christakis and Meltzoff's (2007:473) note that media exposure of children they researched increased from forty percent (40%) at three months of age to ninety percent

(90%) at twenty-four months of age. Similarly, XM1, when commenting on his first awareness of electricity at age four via television and radio, stated that electricity “is not new or something surprising ... it is the way of life ... it is like drinking water or breathing.” It would be unfair to suggest that XM1 lacks DSM intentions, but rather his initial relationship to electricity perhaps led to a form of path dependence, and subsequent denial of electricity use would be in disagreement with his childhood TO.

The fieldwork describes respondents’ abstract descriptions of electricity; however, its technical terminology additionally may influence learning. For example, AF2 and XM1 struggled to describe electricity’s technical details in their home language, and ultimately reverted to English in order to complete their thoughts. AF2 noted that “it’s easier to talk about electricity in English. I find ... most developers ... communicate their appliance in English.” Additionally, a preferred method of measuring residential electricity consumption was identified, whereby few respondents could quantify the amount of watts expended per month or week, but most could estimating hours used or costs paid.

To conclude principle 10: if the entertainment and learning semiotic is considered alongside DSM objectives, the design of artefacts that encourage and instil desired electricity relationships should be provided to infants at birth. Additionally, rather than relying on labelling as a means of communicating DSM awareness, or ironically with artefacts that require electricity to operate, objects that inform in a didactic manner should be designed. For example, a “recycling truck” developed by Toys that Teach (2009) makes use of “recycle chutes” and a “movable recycling bed with open/shut rear door” to teach children sustainable behaviour.

5 CHAPTER FIVE: CONCLUSION

5.1 INTRODUCTION

The concluding chapter is provided in three main sections. Section 5.2 summarises the fieldwork data in reply to the thesis' research question and sub-questions. Section 5.2.2.3 makes use of Socio-technical Theory to interpret the research questions with reference to chapter two's literature review. Section 5.4 provides academic, policy, and industrial design recommendations.

5.2 SUMMARY OF FINDINGS

5.2.1 Research question

The following points list the semiotics that were identified in fieldwork data, and which may affect sustainable residential electricity management in South Africa's Western Cape.

- § A water semiotic, that facilitates the characterisation of electricity's abstract qualities.
- § An illumination semiotic, that intends to proactively deter crime, or fear thereof.
- § A colour and form semiotic, whose variance influences the safe handling of electricity.
- § A residential wall-socket semiotic, that demarcates a Socio-technical Theory boundary.
- § A digital versus analogue semiotic, that signifies the existence of technical determinism.
- § A zigzag semiotic, that provides instructive, rather than procedural, electricity information.
- § A gender semiotic, that influences partnering between artefact and user.
- § A transitional semiotic, that may influence the design of an artefact's interface.
- § A moral or ethical semiotic, that aims to reinforce environmental awareness.
- § An entertainment and learning semiotic, that infants and adults may perceive differently.

5.2.2 Research sub-questions

The influence of ethnology on the research is summarised in the following sub-questions.

5.2.2.1 What semiotics are unique to residential electricity in South Africa?

- § Pre-modern accounts of humankind's ability to manipulate lightning, in acts of authority.
- § The omission of Afrikaans and IsiXhosa languages from product labelling and terminology.
- § Eskom's grid electricity is defined as "proper electricity".

5.2.2.2 What ethnology is unique to residential electricity in South Africa?

- § The development of the South African electricity grid, which is politicised and synonymous with individual rights.
- § The lack of South African participation, or documentation thereof, in electricity's emergence during the Age of Enlightenment when compared to the USA and Europe.

5.2.2.3 What STT facilitates the design of residential electricity artefacts?

Principle 1: Compatibility

The design team should take cognisance of cultural and indigenous characteristics that may encourage or dissuade a consumer partnering with an artefact. On the one hand, characteristics may be embedded in behaviour, for example, patriarchal structures may dictate who in a family purchases or uses electricity. On the other hand, the artefact itself may contain no cultural significance that encourages a user to adopt it. For example, wattage consumed, should be communicated using indigenous semiotics and non-technical vocabulary that is appropriate to the context in which the artefact will operate.

Principle 2: Minimal Critical Specification

Social and technical objectives should be considered when designing an artefact. In defining the objectives, data should be obtained from both qualitative and quantitative sources. Additionally, the data should provided information to the design team that describes the markets' migratory and aspirational patterns. The artefact should aim to solve the root cause of a problem and not the market's or client's perceived solution.

Principle 3: Variance Control

Technical and social variance that may dictate artefact design should be identified. The artefact in turn must be positioned as close to the origin of these variances as possible. Data must be provided to design teams of global attempts to minimise variance, with which the design teams can establish what local ramifications require management. Where applicable, the design team should take into account creationist or misinformation, for example, lightning's ability to enter a household and reflect off mirrors.

Principle 4: Boundary Location

Tangible and invisible boundaries which might affect artefact acceptance should be understood. Additionally the artefact should be designed to allow for ease of boundary maintenance, For example, the design should be upgradeable alongside technological trajectories and cater for shifting ethical paradigms.

Principle 5: Information Flow

The design team should obtain data directly from the user or community for which the artefact is intended. The data collection instruments should ensure user observations are, firstly, acknowledged, and secondly, implemented into the final design. The artefact should be considered within a system framework. For example, if a DSM artefact is to be coupled to a housing design, the Architect of the house should be consulted to ensure the artefact compliments, rather than conflicts, with the structure.

Principle 6: Power and Authority

Technical, societal, political, and community forms of authority should be consulted prior to developing the artefact. Where applicable, coercive elements should be removed and replaced with participatory practices. For example, the artefact should symbolise community empowerment and, rather than making use of instructive methods, didactic or knowledge based informative should be provided.

Principle 7: The Multifunctional Principle

The artefact should be designed to cater for the users' method of enquiry. For example, artefacts based on Cartesian logic frameworks should not be used in market with non-linear forms of reasoning. This principle can also be applied to artefacts that are imported from countries that have dissimilar logic frameworks to South Africa.

Principle 8: Support Congruence (conformity)

Emotional patterns that are in close proximity to the user, and are of community significance and national importance, should be identified. If possible, data should include what emotional affiliation the market may have with the artefact. For example, the design team should consider gendered fields of representation and pronoun usage that encourages an emotional attachment to the artefact under consideration.

Principle 9: Transitional Organisation

An acknowledgment that society has varying perspectives on sustainable electricity, will in turn influence the choice of key technology used in the artefact. If the artefact is to be implemented in large-scale South African RDP development, the design team should consider mass produced technology to reduce the artefacts unit cost.

Principle 10: Incompletion or the Forth Bridge Principle

The design team should carry out in-depth ethnological research, using prototypes, in the community the artefact is to be installed. Ongoing evaluation of the artefact working in its intended context will assist the design team in identifying rebound affects that may subsequently consume electricity savings.

5.3 DATA ANOMALIES AND DEVIATIONS

The qualitative data collected from XM2 referred to mythological themes. Although it is in accordance with the literature review findings, the extent of his conviction was surprising to the author. This is not to say the respondent is in any means incorrect or uniformed, but rather that the extent of his contribution requires further research. Quantitative data, presented in 4.2.3.2 noted a negligible selection for “other small appliances”. The low selection is technically incorrect, due to all respondents owning a cellphone, which is commonly charged with grid electricity. Respondents may have misinterpreted this section of the LSM survey, and therefore, it requires reconsideration before being implemented in similar research.

5.4 RECOMMENDATIONS

5.4.1 Policy recommendations

Two primary policy recommendations are proposed. The first calls for ID to have a greater involvement in the origination of energy related policies. The second requests greater awareness and recognition of ID’s contribution to the growth of the South African economy.

Blankley and Moses’ (2009) frequent reference to ID in their survey of innovation for the South African Department of Science and Technology (DST) suggests that it plays a key role in developing the economy. It is therefore of surprise that Kraak (2009) provides little

evidence of ID in his book on “Sectors and Skills: The Need for Policy Alignment”, which appears to be targeted to the South African Department of Labour (DoL). Specifically, there is no mention of the discipline in either his energy chapter or his creative industries chapter. If this literature is read in conjunction with ID’s contribution to Freeplay Energy’s wind-up radio and Optimal Energy’s electric vehicle, its omission is unexpected. Additionally, the placement of ID as a subset of Information and Communication technologies (ICT) is highly questionable from this author’s industry perspective.

On the other hand, it is arguable that contemporary South African product developments focus on industrial black-box solutions and ornamental craft products, both of which do not adequately target the consumer market, and may in turn influence policy decisions. If indigenous societal dynamics are successfully synthesised with engineering considerations, South Africa can become a global centre of excellence in designing for dual economies and consequently export its products to similar economies. Noticeably, as Pang (2008:122) points out, the amalgamation of creativity and industry is already being implemented in the emerging economy of China, who is aiming to ensure that creativity is “not aesthetic but economic, which is meant to be used, circulated ... [*and to*] solve problems and be reassembled.”

5.4.2 Academic research

The implementation of transdisciplinary research practices between faculties and universities should be encouraged. It must be noted that such an approach requires diligence and persistence on the research part. Impediments were encountered by this thesis’ author, and, perhaps due to underdeveloped inter-university research programs, the academic transdisciplinary approach was ultimately replaced with an equivalent industry transdisciplinary approach. This is by no means a novel request, as Max-Neef (2005:9) points out when citing Leibnitz’s three century old comment that universities “in terms of faculties, impeded the expansion of knowledge across and beyond disciplines.”

5.4.3 Industrial design (ID)

The following ID research suggestions should take the aforementioned Socio-technical Theory and transdisciplinary approach into account.

5.4.3.1 Household wall-socket and plug

The fieldwork data indicated that the South African wall-socket and plug artefacts are socially and technically outdated. Further research into behavioural characteristics surrounding artefact

and electricity grid use is required. Practically, the artefact that emerges from this research should, among others, cater for technology's shifting trajectory, safety compliance, and non-standard users – for example the elderly and disabled.

5.4.3.2 Community based energy management system

The literature review and fieldwork data suggested that DSM could be improved by means of community agency, rather than technical determinism. Further research into methods of measuring community electricity consumption is required; specifically, the research should place behavioural monitoring and information dissemination within the scope and control of the community. Similar to Hobson's (2006) recycling bin example, the symbolic and aspirational element of an artefact may prove valuable.

5.4.3.3 DSM educational toy

The fieldwork data suggested that frequent DSM awareness campaigns are focusing on modifying existing behavioural patterns, rather than proactively introducing information prior to the formation of the behaviour. Further research is required to firstly establish how infants recognise electricity, secondly, with what means, and thirdly in what context. The data should be translated into educational toys that develop and encourage sustainable behaviour.

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APPENDICES

Appendix A: Letter to Oxford University Press

OXFORD
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A/Ask Oxford/mc

2 January 2009

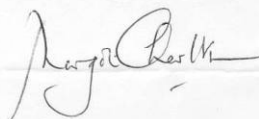
Dear Mr Qually,

Thank you for your letter of 23 December 2008 to the Oxford Word and Language Service.

The word *electricity* is a straightforward derivative of the adjective and noun *electric*, and the full *Oxford English Dictionary* sets out the main etymology at that word: see the enclosed printout. It is indeed derived from a post-classical Latin adjective relating to amber, the substance in which electrical phenomena were first observed. For your further information I have also printed out the etymology of *electrum*.

For a more detailed history of this set of words I think you will need to consult a history of the science of electricity.

Yours sincerely,



Margot Charlton (Miss)
Ask Oxford
Oxford English Dictionary

Mr Byron Qually
G1 Victoria Court
301 Long Street
Cape Town 8001
SOUTH AFRICA

Enc.

Oxford University Press is a department of the University of Oxford. It furthers the University's objective of excellence in research, scholarship, and education by publishing worldwide

Appendix B: Respondent consent form

The CPUT Faculty Research Committee (FRC) requires consent from participants in postgraduate work to ensure ethical research practices are adhered to. For individuals under the age of 18, consent must be provided by a guardian or gatekeeper. This form protects the participant as follows:

- § All information provided by the participant is strictly confidential.
- § Information provided, will be at the participants discretion and without coercion.
- § Interviews with the participant may be video taped for subsequent academic analysis.

NAME	POSITION	SIGNATURE	DATE
.....	Participant
Byron Qually	Interviewer
.....	Gatekeeper

CONTACT DETAILS

Focus:	Researcher	MTech supervisor
Name:	Byron Alexander Qually	Bart Verveckken
Institution:	Cape Peninsula University of Technology	Cape Peninsula University of Technology
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Telephone:	021 421 7236	021 460 3911

Appendix C: Instrument one – Artefact creation

The following artworks indicate a single item form each respondents. All artworks in a higher resolution, are noted under Qually (2009) in the bibliography.



AF1



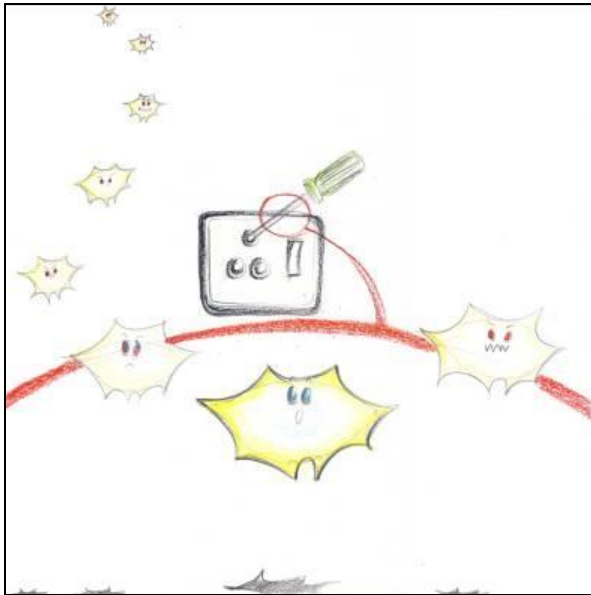
AF2



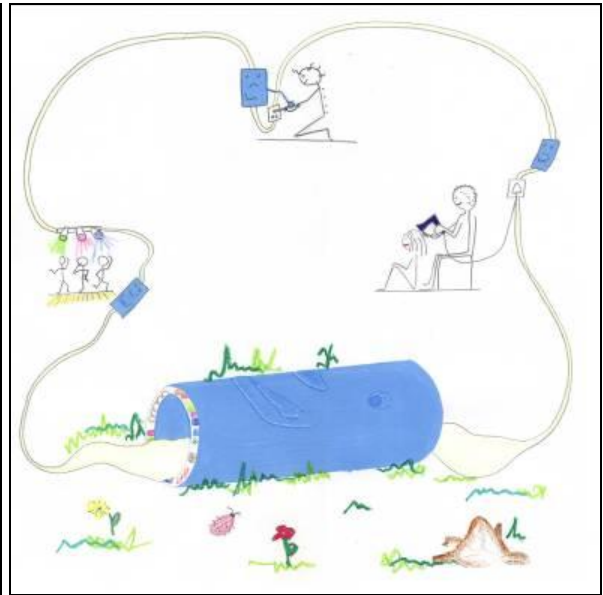
AM1



AM2



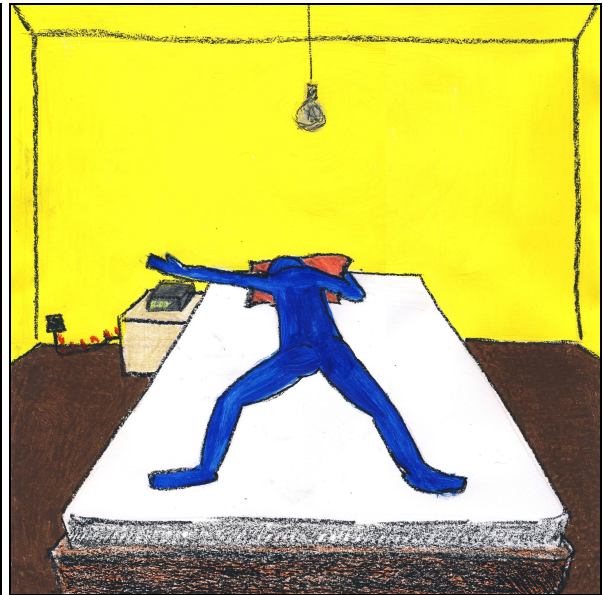
EF1



EF2



EM1



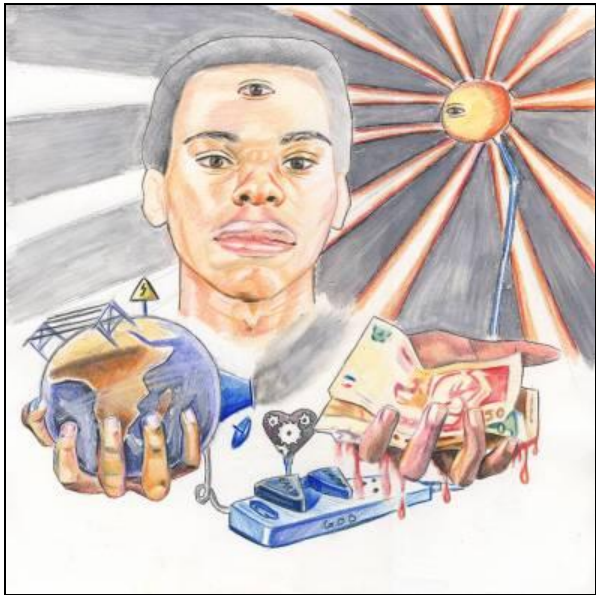
EM2



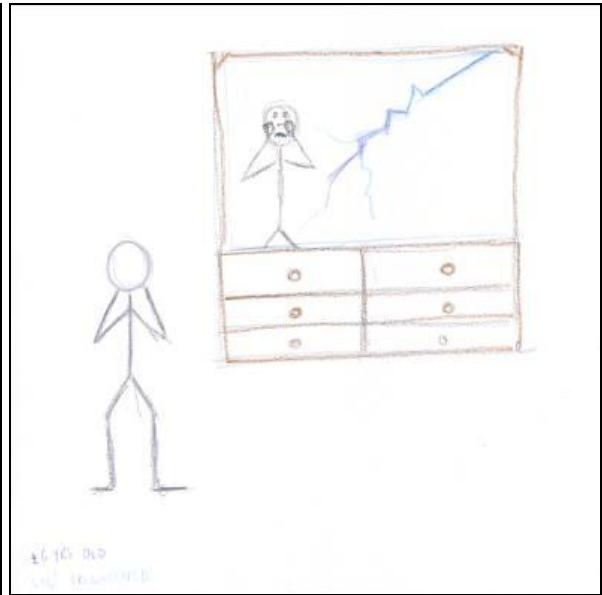
XF1



XF2



XM1



XM2

Appendix D: Instrument two – Oral presentation transcript

The following transcription is for respondent AF1. All respondent transcriptions are noted under Qually (2009) in the bibliography.

BQ: Introduction and general communication.

AF1: One of the questions was how old I was when I became aware of electricity for the first time and I tried to go back in my memories and where I ended up was that I was in a tube train below London.

AF1: There was a strike and we came to a standstill.

AF1: It was dark and we could not move because a power that would normally have been there, that would have moved us from one place to the next was no longer there.

AF1: So my very first awareness of electricity was when it was absent and that we were completely dependent on it – that total panic-stricken dependence and that is also something that you see nowadays when the electricity goes off.

AF1: People get very angry.

AF1: People think it's their right.

AF1: People think that's how it has to be and how can one live without electricity and they are, we all are unbelievably dependent on it.

AF1: And we are all like that.

BQ: And was that in South Africa or did you say London?

AF1: It was in London.

BQ: How old were you?

AF1: I was 3½.

BQ: 3½? Wow!

AF1: And simultaneously at that time when I began thinking back, where we stayed was in a tall building and if there was no electricity you had to climb those stairs, whereas you would normally not, but if you were on the 20th storey and there was no electricity, you had to climb stairs.

AF1: So once again that absolute dependence on electricity and that it forms such a power, whatever that is.

AF1: Okay, and then the other question was how my understanding of electricity differs from that of my grandfather's or grandmother's and I think we are used to having portable electricity.

AF1: I have it in my laptop; it's in my telephone.

AF1: And then when I reach a certain stage, I say, "Oh, gosh, my power is running low.

AF1: I must plug it in and recharge it".

AF1: So I think they did use electricity, it's part of their lifestyle, but we use it because it's much more portable.

AF1: We have batteries.

AF1: We have rechargeable batteries and we take it with us where ever we go.

BQ: It's just in a different format?

AF1: Yes, it gets transformed into a different format and then packaged into little cells, little battery packs, little cells and we carry it everywhere with us.

AF1: Like if you think what's in my handbag, if you think of my handbag, there is a phone in with rechargeable batteries, there is a GPS in with rechargeable batteries, there is a ... ten to one there are batteries in if I look at such a large bag with the large number of things in, the whole of society functions with these small little things, little eggs of electricity that they carry around with them.

AF1: Children have toys that operate with batteries that can be recharged.

AF1: And if you want to see someone get nervous and dependent, just tell him there is no plug to recharge one's cell phone.

AF1: Then one gets very uneasy.

AF1: So once again it's almost a type of primeval force.

AF1: It's a type of archetypal force that has to be there and if it is missing, we are prepared to, I don't know, buy more equipment or are prepared to buy little UPS's or generators, we will do anything, anything to solve the problem.

BQ: That's very interesting what you're saying. You're saying in a sense that if you had to compare your lifestyle to your grandparents, are you saying it is kind of the same in a sense that the expectation of electricity where although it's in the background, often you only know that it's there when it's not available but now it's more like as you say in the egg format – it's more dispersed

and it's more mobile now than it used to be in their day – but the expectation, do you think it's quite similar? Or what?

AF1: I think, if I think of my grandmother or grandfather, they maybe used electricity when they want to watch TV or when they want to cook and for the rest maybe to put on a light, but for the rest they are not actually so involved with it in a way.

MGS: And what about the refrigerator?

AF1: Oh, the refrigerator, of course.

AF1: If the refrigerator goes off, there is a crisis.

AF1: So their lifestyle is – there is the underlying electricity that supports it, but it's not part of their daily activities.

AF1: But where we are at this moment, people cannot function without that thing with a battery in their hand and if you ...

AF1: We were in India and there you see people everywhere that plug their phones into wall plugs.

AF1: There are places everywhere where you can charge your phone.

AF1: You can be in a place, you can be in a coffee shop and part of the service of the coffee shop is that you can charge your phone.

AF1: The coffee shop will probably have different chargers if you do not have your charger with you.

AF1: So that's the way things are organised.

AF1: It is not quite the same here because people here have electricity at home where they do that and the circle in which I move, people recharge things at home.

AF1: I think if you are in the situation where people's batteries are not so reliable, then you have the type of situation within the infrastructure that there are spots where you are able to recharge the things.

BQ: That's very interesting.

AF1: That's what I think the big difference is.

AF1: So based on that I created a bit of a mind map as you can see and for me it felt as though electricity has two personalities; the one side that represents the wonderful, rosy positive things like cooking food and we are on the internet and it makes machines work, the lights go on and there are your little eggs and then there are in between things that make it somewhat more negative, that makes us more dependent on it

MGS: Like games

AF1: And then there's a totally negative side that we don't even want to be true and it is a type like a primeval force that devours everything to sustain it, to be able to sustain it in order to maintain these electrical things and it's partly by, here I have a blindfold on.

AF1: The thing is like a shapeless creature that just devours.

AF1: So it devours everything and on the one side, on the dark side there is smoke coming out, so it's this incredible sense of consumption.

AF1: Things that are consumed, primeval energies, things that, its power that say came from the sun and got caught in the trees millions and millions of years ago, that is in coal under the earth and this force indiscriminately devours it all.

AF1: If you throw in tree stumps, and not just solid forms but also landscapes, environments, anything, just to be able to maintain this wonderful brightly coloured world and what people expect of it.

AF1: People expect that they are able to charge their phones, that their refrigerators will run, the electricity cannot go off and this creature that devours drives all this.

BQ: Yes, and it's ... I like the way you've explained it because it's on the one side people talk about awareness, but it's – what is the depth of that awareness as well as how you understand how it's actually created.

AF1: It's like we're offering everything.

AF1: It's like this huge beast that we're just sacrificing everything to so that our laptop will work, that we can go onto the Internet and that we can do those things.

MGS: How can we be sacrificing if we're the beast?

AF1: We are not the beast – it's the electricity.

AF1: But I may draw it as I think it would look like.

AF1: Like a figure of speech.

AF1: So there, those are the concepts ...

AF1: So here you can see the tongues that just devour the colourful beautiful world without using any discretion regarding what is devoured, what is consumed and from this comes computers and lights and communication channels and machines that work and these little eggs of electricity.

BQ: That's all the form.

AF1: Yes, he's a form like that, but it's not a solid shape.

AF1: Actually at some stage I thought it's rather a she, but it's something that can change shape, as one digs something into the earth, can dig out the ore, as areas are taken over for the need, so it changes shape almost like an amoeba.

AF1: The reason why he has this form is just so that I could fit the two halves onto one page, because the environment in which he or she, probably a genderless thing, because it's a primeval force.

AF1: Because we, I think the modern person's experience of it is like a primeval force, like what a person in the Stone Age would think of thunder, it's that kind of force, but that has an evil side, but to us it looks good, but certain sacrifices have to be made to it to gain these advantages.

BQ: So the lines coming down here, that's almost like a bird, almost like the beaks.

AF1: These are trees and clouds and puffs of smoke and coal and more clouds and puffs of smoke and then just all the life forces that are grabbed by these tongues and are then converted and actually a grey world with things that we perceive as beautiful and as positive and as...

BQ: Is it fair to say, just from where I'm sitting, here this almost looks like the human interpretation in a sense and this is the natural interpretation. It actually looks like a bird. I don't know if that was intentional at all?

AF1: No. You mean like the heads over there?

AF1: Oh no, no. It could be, but no. That's not intended like that.

BQ: You touched on talking about the gender and if we had to develop those seven questions, those seven attributes.

AF1: Oh yes, there are seven attributes.

AF1: At the bottom there, the very last one

AF1: Age old, primeval force, female is what I wrote here.

AF1: But when I talk about it it's not necessarily just female.

AF1: I think it is a... because it does not have such a creative element to it.

AF1: It doesn't have, but it's transforming, it's... I'm not sure

MGS: You are that side and we are that.

AF1: You think so?

AF1: But this side is the computer.

MGS: We are those things.

AF1: Okay, here I wrote: creature that devours everything that comes it's way in exchange for heat, communication, light, machines that turn.

AF1: Okay, colour.

AF1: The colour is partly grey brown because it transforms a multicoloured world into another multicoloured world so he does not have a specific colour himself.

AF1: He can convert any colour into another colour because it is a creature that changes things, he himself does not keep the things.

AF1: He himself does not keep the characteristics of what he converts.

AF1: So if this side is black or green or whatever, or hard or hot or cold, he converts it into something else, but he himself does not keep any of those characteristics.

AF1: It's like a conduit; it's almost like a pipe because you do not know what the element of the pipe is.

BQ: If people had to understand that there was evolution between this would they only see that?

AF1: The creature?

BQ: Would he just disguise the colours and then interpret it to them or would it be a case of they're looking for.....

AF1: I don't know.

AF1: Firstly I don't know if it's evolution.

AF1: I think it's a mutation, a transmutation of things.

AF1: I don't know if this is better than this or if this is better than this necessarily.

AF1: But it's not something we can; we're on this path and I don't think one sees the creature.

AF1: It's like also not you see effigies of the creature.

AF1: You see secondary results of the creature.

AF1: You see places stripped of trees, say or you see the results of the creature, but it's like in Egyptian times with a logical creature that only exists if people draw pictures of him, if people, try and capture their ideas in a way.

AF1: Then and only then can images of him appear.

BQ: Age?

AF1: The age?

AF1: Very old.

AF1: Because the energy is stored.

AF1: The stored energy that we use now was caught up, was started to be caught up thousands of years ago by the sun and converted in trees and changed into coal, so the source of energy that we use is very old.

AF1: How we experience it now, is new.

AF1: The current manifestations are new.

AF1: But the source of energy is very old.

AF1: And the process to tap that energy and to convert it is also a very old process.

AF1: I would say I think of someone who is cold whilst sleeping at night and then basks in the sun the following morning, it's the start of taking up that energy and getting his own little cells going with it.

AF1: Even at reptile level there is sun energy – transformation that takes place.

AF1: The form changes for two reasons; to get sources, find sources for the energy and the other to be able to offer what is expected.

AF1: So it must change in form to be able to offer what is expected, but it must also change form to be able to extract what is necessary as a source of energy because all the things.

AF1: I don't know how to say this to you.

AF1: You can't say stripy or spotty.

AF1: That all doesn't sound right for something that is so final.

AF1: It's too final.

AF1: It needs a sound that is a primal name

AF1: It needs a primeval name but I do not have access to a good primeval name that will work for me.

BQ: Is that more like the name is more of an introduction rather than something, which is a personal name?

AF1: It is not a personal thing and you will only need a name for it if you try and explain it to someone or if you want to worship it.

AF1: If you want to start carrying out rituals and have to chant it, then you must have a name for it.

AF1: But we do worship it in a way because we sacrifice so much, even if it is not consciously.

AF1: It's extremely important to us.

AF1: Important.

AF1: It's very important.

AF1: We're prepared to sacrifice a lot.

AF1: So we are in a way turning it into a deity because it's important and there are sacrifices.

BQ: Sound and the smell?

AF1: The sound and the smell.

AF1: The sound sounds like something like the noise going on here outside.

AF1: It's definitely something that is loud and not quiet.

AF1: It can be irritating but the fact that it is coupled to something like electricity means you can switch it off.

AF1: So there is the possibility that it can be completely and totally silent, provided that you switch it off.

AF1: So and the smell?

AF1: Well, on the one hand you have the smell of delicious food cooking and on the other hand the smell of burning coal, or wood fires that burn and smoke.

BQ: So is it almost like a natural smell if you had to associate it to the one side?

AF1: It could be but it doesn't need to be because the creature eats anything that comes its way.

AF1: It will eat molten plastic if it must.

AF1: The first thing that comes to mind – what would that be if you think of the smell?

AF1: Well, burning coal.