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RE-THINKING COST-BENEFIT EVALUATION FOR SUSTAINABILITY: A PROSPECT THEORY PERSPECTIVE ON CHOICE AND DECISION MAKING FOR SOLAR WATER HEATING IN SOUTHERN AFRICA

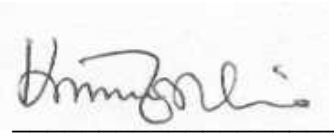
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Doctor of Philosophy

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Declaration

I declare that this thesis is my own unaided work. It is submitted for the degree of Doctor of Philosophy in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University.



Signature of Candidate

On the *22nd* day of *April* year *2014*

Abstract

This study applies empirical case-study data and theoretically-guided analyses to forge a link between CBA evaluation and sustainability paradigm with prospect theory, behavioural economics and neuro-economics. This link is applied to explain the contradictory scenario where solar water heating failed to emerge as a preferred water-heating technology in South Africa compared to electric geysers before the 2006-2008 electricity crisis, only to suddenly emerge into high market-visibility after the onset of the crisis.

The core argument of the study is that CBA evaluation, sustainability assessment and emerging assessment tools are premised on the rational-agent model and revealed-preference assumptions of choice and decision making whose empirical merits are growing increasingly weak. Instead, choice and decision making is increasingly being understood to be guided by a combination of *irrational* or boundedly rational heuristics (System-2) and emotion-guided biological (System-1) mechanisms.

Primary data from face-to-face interviews and electronic communication, as well as secondary data from previously commissioned reports, media articles and reports related to decision making patterns were collected and analysed. Literature review was used towards the theoretical contextualisation of the study.

The key findings indicate that choice and decision making in the solar water heating sector and projects is characterised by informally sensed/assessed economic/financial gains or loss (with initial cost commitment, operational cost-saving and payback period as key salient/reference points) where the immediate-benefit logic and self-preservation are the key drivers. In contrast, environmental, collective and long-term benefits such as intra- and inter-generational equity are systematically dis-counted (underweighted and thus not salient) as choice and decision reference points. Choice and decision making is thus primarily based on

attitudes, perceptions and mental accounting, rather than empirical evaluations and objective calculations.

One of the key insights is that it was a System-1 driven *nudge* (provoked by electricity crisis and subsequent cost-escalation) which triggered a significant shift in choice and decision making, which in turn produced significant changes in favour of solar water heating where close to two decades of rational-agent and objectivist-oriented interventions hardly achieved any impact. The findings suggest that expectations of achieving sustainability transitions purely through rational and objective choice procedures are most likely misplaced.

The study concludes that rational-agent-based choice and decision making tools such as CBA evaluation and sustainability assessment methods most likely fail to trigger the level of emotions and feelings which can evoke a shift in attitudes and perceptions, which would effect a shift towards sustainable lifestyles. The findings suggest that facts do not always speak for themselves, especially when confronted with subconsciously-driven and emotions-informed motivators. Significantly also, the study concludes that money/finance seems to have evolved into a critical biological mediator whose significance has not been fully appreciated or empirically studied in sustainability science.

The study also concludes that both CBA evaluation and sustainability assessment methods should go beyond the rational-agent paradigm and engage with prospect theory behavioural heuristics and neuro-economics mechanisms that catalyse change in order to achieve the required transition. *Framing* and *nudging* approaches for sustainability transitions thus emerge as critical new fields for future investigation.

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The completion of this study marks the conclusion of a journey towards the fulfilment of a life-time dream. I thank the almighty God for His faithfulness and guidance throughout the journey. It is His inspiration and strength that made the dream worth pursuing even when the challenges seemed insurmountable. May this work be to His glory and honour.

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Contents

Declaration ii
Abstract iii
Acknowledgements v
Contents vii
List of figures xi
List of tables xii
List of abbreviations and acronyms xiii

Chapter 1: Introduction 1
1.1 Overview 1
1.2 The sustainability perspective, goals and principles 2
1.3 Behavioural economics and prospect theory 6
1.4 The conventional approach to evaluation in cost-benefit analysis 12
1.5 The evolving and adaptive cost-benefit analysis 15
1.6 The co-evolution and complexity theory perspective 20
1.7 Evolution of attitudes and value systems in society 22
1.8 Bounded rationality, emotions and perceptions in decision making 24
1.9 Renewable energy and energy efficiency technologies 29
1.10 Overview of electricity and solar water heating in South Africa 30
1.11 Statement of the research problem and research question 38
1.11.1 Overview 38
1.11.2 Objectives of the study 40
1.11.3 The research question 41
1.11.4 Working hypothesis and definition of key concepts 44
1.12 Delimitation of scope 53
1.13 Structure and organisation of the thesis 56

Chapter 2: Literature review and theoretical framework 60
2.1 Overview 60

2.2 The economic foundations of conventional CBA 62
2.3 Application of CBA evaluation for solar water heating in Greece..... 64
2.4 The sustainability debate 68
2.5 Prospect theory and decision making 71
2.5.1 Cost-benefit analysis, sustainability and prospect theory 71
2.5.2 Prospect theory model 73
2.5.3 Mental accounting 76
2.5.4 The two-system thinking and modern decision theory 77
2.6 Comparative analysis of CBA evaluation and sustainability assessment 80
2.6.1 Overview 80
2.6.2 The time-related attributes..... 82
2.6.3 The scope and stakeholder attributes..... 89
2.6.4 The attitudes and perceptions attributes 95
2.6.5 Emerging sustainability assessment tools 97
2.6.6 Conclusion..... 110

Chapter 3: Research method 113
3.1 Overview of research and knowledge creation..... 113
3.2 Research design 117
3.3 Data analysis and interpretation 123

Chapter 4: Prospect theory and decision making in the solar water heating sector in southern Africa 130
4.1 Introduction 130
4.2 Data overview..... 132
4.3 Decision making in the solar water heating sector in South Africa: a historical perspective..... 136
4.4 Decision making and perceptions in the solar water heating sector..... 140
4.5 Electricity and solar water heating pricing structure in South Africa 146

4.6 The electricity crisis and decision making in the solar water heating sector 154
4.7 Decision making and market interventions in the solar water heating sector 163
4.8 Conclusion 169

Chapter 5: Prospect theory and decision making for solar water heating projects in southern Africa 171
5.1 Introduction 171
5.2 Data overview 172
5.3 Time-related factors in choices and decision making for solar water heating projects 177
5.4 Scope and stakeholder-related factors in choices and decision making for solar water heating projects 182
5.5 Attitudes and perceptions-related factors in choices and decision making for solar water heating projects 187
5.6 Conclusion 190

Chapter 6: Consolidation of findings 202
6.1 Overview 202
6.2 The present versus future contradictions in decision making 212
6.3 The individual versus collective mindset contradictions in decision making 217
6.4 Attitudes and perceptions contradictions in decision making 222
6.5 Conclusion 230

Chapter 7: Conclusions and recommendations 240
7.1 Summary and conclusions 240
7.2 Recommendations for further research 248

References 251

Appendix 1: Step-by-step procedure for conventional and evolved cost-benefit analysis 266
Appendix 2: Generic criteria for sustainability assessment 268
Appendix 3: Interview questions: Suppliers in solar water heating projects 271
Appendix 4: Case Study 1: Suppliers of solar water heaters: Solahart Botswana 272
Appendix 5: Interview questions: Completed institutional solar water heating projects 276
Appendix 6: Case Study 2: Long-time users of solar water heating: The University of Botswana student hostels 278
Appendix 7: Case Study 3: Completed solar water heating project: Deutshes Senioren Wohnheim (DSW), Pretoria, South Africa 281
Appendix 8: Case Study 4: Solar water heating project in progress: University of Pretoria student hostels 284
Appendix 9: Interview questions: Solar water heating not considered 287
Appendix 10: Case study 5: Solar water heating option not taken: Tshwane University of Technology, Pretoria 289
Appendix 11: Comments to internet articles on solar water heating 292
Appendix 12: Eskom-consumer communication 295
Appendix 13: List of interviewees 297
Appendix 14: Illustration of standardization and discount rate 298

List of figures

1.1: Illustration of loss aversion.....9
1.2: Summary of the evolution of the economic market system 22
2.1: Cascading structure of project effects.....93
2.2: Illustration of the CIEL model.....105
4.1: Perceived advantages of solar water heating 141
4.2: Perceived disadvantages of solar water heating 142
4.3: Major factors influencing the purchase of a solar water heater.....143
4.4: Discount rates for residential electricity and solar water heaters 150
4.5 Total area of solar water heaters supplied in South Africa (m^2).....151

List of tables

3.1 Summary of the types of data used and their application in the study 126
3.2 Summary of key prospect theory and bounded rationality heuristics.....126
4.1 Comparative analysis of residential electricity and solar water heater prices in South Africa.....149
5.1: Summary of the time-related responses from interviews 192
5.2: Summary of the scope-related responses from interviews 196
5.3: Summary of the stakeholder-related responses from interviews.....198
5.4: Summary of the attitudes and perceptions-related responses from interviews.....200
6.1: Summary of the time-related approaches and contradictions.....205
6.2: Summary of the scope and stakeholder approaches and contradictions.....207
6.3: Summary of the attitudes and perceptions approaches and contradictions.....209
6.4 Summary of key contradictions and findings 237

List of abbreviations and acronyms

B	Benefit(s)
BCA	Benefit cost analysis
BP	British Petroleum
C	Cost(s)
CaBEERE	Capacity Building in Energy Efficiency and Renewable Energy
CBA	Cost-benefit analysis
CDM	Clean Development Mechanism
CFL	Compact fluorescent light
CIEL	Climate Impact Equity Lens
CRED	Climate and Regional Economics for Development
CVM	Contingent valuation method
DANIDA	Danish International Development Agency
DBSA	Development Bank of South Africa
DEAT	Department of Environmental Affairs and Tourism (South Africa)
DME	Department of Minerals and Energy (South Africa)
DSM	Demand side management
DSW	Deutshes Senioren Wohnheim
EDC	Energy Development Corporation
EDRC	Energy and Development Research Centre
EE	Ecological economics
ENRA	Environmental and Natural Resource Accounts
ERE	Environmental and Resource Economics
ERR	Economic rate of return
Eskom	Electricity Supply Commission (South African utility)
FV	Future value
GBCSA	Green Building Council of South Africa
GDP	Gross Domestic Product
GEF	Global Environment Facility
IFC	International Finance Corporation
IIEC	International Institute for Energy Conservation

IRR	Internal rate of return
MCDA	Multi-criteria decision analysis
NERSA	National Energy Regulator of South Africa
NGOs	Non-governmental organisations
NPV	Net present value
OPEC	Organisation of Petroleum Exporting Countries
PV	Present value
RAPS	Rural Area Power Solutions (Pty) Ltd
REEETs	Renewable energy and energy efficiency technologies
SABS	South African Bureau of Standards
SAM	Sustainability assessment model
SEED	Sustainable Energy, Environment and Development
SESSA	Sustainable Energy Society of southern Africa
SIDA	Swedish International Development Agency
SNA	System of National Accounts
swh	solar water heating/heater
TUT	Tshwane University of Technology
UB	University of Botswana
UK	United Kingdom
UNDP	United Nations Development Programme
UP	University of Pretoria
US	United States
USAID	United States Agency for International Development
WCED	World Commission on Environment and Development
WSSD	World Summit on Sustainable Development
WTA	Willingness to accept (compensation)
WTP	Willingness to pay

Chapter 1

Introduction

1.1 Overview

The sudden switch in favour of solar water heating and other alternative water heating technologies such as heat pumps since the 2006-2008 electricity crisis in South Africa constitutes a bitter-sweet poser for sustainability. Was it a seed in long-term paradigmatic shift to long-term sustainability? Was it purely an ad hoc market reaction to the electricity supply sub-sector crisis? Does it reflect a purely selfish or rational economic response as would be expected out of a conventional cost benefit analysis (CBA) evaluation? This study engages with this poser through a prospect theory perspective and the interrogation of CBA evaluation in relation to sustainability with a view towards a better understanding of CBA evaluation, in relation to paradigmatic transformation towards sustainable production and consumption lifestyles of individuals and collectives such as communities and economies.

The study's focus-point of reference is the model of human behaviour assumed in both CBA evaluation and sustainability assessment, and how this compares to the model espoused from recent scientific developments in neuro-science and prospect theory in psychology. For the decision maker or evaluating entity, CBA references the status-quo which has a bias towards the present as the welfare reference point, which must be maintained or improved on. Sustainability represents the view that the status-quo and its future-oriented projections is problematic and therefore calls for a change of course for current production and consumption activities and lifestyles. Sustainability shows an implicit bias for the future, which then serves as the reference point.

Both CBA and sustainability approaches to evaluation of choices for decision making suffer from their grounding on the rational-agent paradigm which assumes

that when the objective facts are passively and neutrally presented to a rational decision-maker, she will automatically choose the option which optimises welfare, including equitable distribution, in both immediate and long-term interests, without having to offer any further subjective motivations or facilitation for such choices.

However, under prospect theory and neuroscience in particular, the classical economic and rational-agent model of human behaviour has been proven to be without scientific merit. Close to 50-years of prospect theory research in psychology and neuro-science studies have clearly substantiated the reality of emotional/intuitive basis of choice and decision-making under risk and uncertainty (Trepel et al., 2005), which in turn has informed the paradigm of two systems of human thinking. System-1 is primarily autonomic and out of conscious control, while System-2 is primarily conscious, but with severe limitations with regard to capacity of the mind for information processing, type and quality of available information and time constraints within which choices and decisions have to be reached.

1.2 The sustainability perspective, goals and principles

The notion of sustainable development gained prominence towards the 1970s when the effects of unprecedented growth of world economies in the 19th and 20th centuries brought into sharp focus the vulnerability of the natural capital required for production (Elliot, 1994; van Dieren, 1995). According to Peterson (1997:29) "…evolution theory, scientific specialisation and an unprecedented scale of economic development… provided the context for modernity, the context in which sustainability would develop social currency".

Hopwood et al. (2005), Vucetich and Nelson (2010) and von der Heidt and Lamberton (2011) among many others, highlight the evolution of the sustainable development paradigm from the Brundtland Report (WCED, 1987) among others, to how it acquired its close association with social justice and hence the eventual

common usage of the term sustainability. Robinson (2004) suggests that in earlier years, the term development was interpreted as having economic growth connotations hence the preference of the term 'sustainability' rather than 'sustainable development'. Robinson (2004:370), Lippert (2004:4-5) and Farrell and Twining-Ward (2005:118) discuss the futility of trying to distinguish between the two terms and allude to the common use of the two terms interchangeably.

The concept of sustainability has since evolved into a blend of positivistic and normative paradigm which stems from a value system characterised by recognition of the following:

- An eco-system science of a symbiotic interaction between species, habitats and natural systems in general.
- An on-going exponential growth in human population, which is linked to an equally exponential growth in consumption as reflected in indicators such as national and per capita Gross Domestic Product (GDP) and global footprint (van Dieren, 1995:66-67; Jackson, 2009:3).
- The finiteness and on-going rapid diminishing of the earth's regenerative bio-physical capacity as captured by indicators such as bio-diversity species loss, climate change, pollution and rate of degradation (Jackson, 2009:35-48; Ekins, 2011:629-632). There is recognition that the resources that nature provides to humanity for production of goods and services to satisfy human needs are not limitless and the adverse effects of depletion of natural resources go beyond national boundaries as well as generations of humanity. Likewise, threats to the global environment, including atmospheric and climate change have moved from local, national and regional concern to global scale thus requiring a global response (Pearson, 2000).
- Impending threats to continued human well-being and subsequently survival on the planet primarily as a result of anthropogenic drivers. The effects of these threats have gained increased significance for future generations hence the obligation for today's generation to match their

production and consumption lifestyles to levels that do not compromise the needs of future generations (van Dieren, 1995:104).

- A normative view that it is essential and also an ethical challenge to mitigate these risks which now threaten continued well-being and survival of species, habitats and natural systems in general (Weber, 2006:103; Sekerka and Stimel, 2012:195).

Farrell and Twining-Ward (2005) argue that it is not possible to achieve sustainability. "In the past sustainability or often sustainable development suggested the possibility of attainment, at some time in the future. The new conception expressed by sustainability transition suggests that this situation is for most purposes unlikely" (Farrell and Twining-Ward, 2005:118). Accordingly, the evolving view of sustainability or sustainable development as continuous development towards non-diminishing or non-declining biophysical and human well-being means the process can never be finite.

However, this study adopts the alternative interpretation in which the idea of achieving sustainability should be seen in the context of goals, milestones and indicators for measuring sustainability, which when satisfied should lead to the conclusion that the goals of sustainability are cumulatively achieved to that particular extent. An example of a generic criteria for measuring sustainability developed from George (2000:69), Gichia (2003) and Holcim Foundation (2004) is found in Appendix 2. It is in such a context that Campbell (1996), Ekins (2011) and Sekerka and Stimel (2012) discuss ways of measuring achievements in the transition to sustainability.

Evolution in sustainability has seen the emergence of an academic discipline that focuses on implications of sustainability in other mainstream disciplines. Sustainability science has emerged out of the challenge to better understand the character of social ecological systems, especially within the context of the environmental challenges and related debate over the past two decades (Andersson et al., 2008; de Lange et al., 2008; Vucetich and Nelson, 2010).

Sustainability science "promotes a transdisciplinary approach to scientific research and stakeholder engagement, anthropology, economics, ecology, geography and political science" (de Lange et al., 2008:243). The discipline promotes effective dialogue and integration of ideas among scientists, policy makers and a wide range of stakeholders in the sustainability discourse.

One of the goals of sustainability science is to develop approaches and mechanisms to understand the dynamics of social ecological systems, the fundamental uncertainties especially regarding measuring and evaluating their performance, and to incorporate them into decision making processes (de Lange et al., 2008). However, it does not yet recognise the 'subjective', emotive factors underlying decision making and the necessary responses according to current scientific studies in neuro-economics, prospect theory and psychological and behavioural economics among others (Rangel et al., 2008; Gordon, 2011; Kahneman, 2011; Tomer, 2012 among many others).

Within the discipline of sustainability science, the field of Environmental and Resource Economics (ERE) has emerged as an attempt to bridge the gap between externalities and monetary valuation of environmental resources (de Lange et al., 2008:250). ERE proposes to address the complexities inherent in the valuation of environmental resources by introducing a methodology for incorporating externalities into market prices and therefore account for such externalities in decision making. There are limitations however in that ERE still applies conventional utility and preference theory techniques to derive the prices while disregarding the more common, experiential and emotion-driven decision making processes (Bechara and Damasio, 2005; Weber, 2006; Rangel et al., 2008; Gordon, 2011; Kahneman, 2011; Tomer, 2012).

Valuation in ERE relies on human preference techniques (which are inherently anthropocentric), such as willingness to pay (WTP), willingness to receive payment, travel cost and hedonic pricing. These techniques have been criticised for their inadequacy in valuing environmental and other intrinsic goods (de Lange

et al., 2008:254), thereby inducing the opt-out bottlenecks such as those experienced in the solar water heating sector, as argued in the later chapters of this study.

The main barriers to the goals and principles of sustainability are essentially based on society's value systems especially the way it values natural resources, its attitudes to change, and the way society goes about accepting innovations, new ideas and new technologies (Mawhinney, 2002:114). Despite the advances made in sensitising society on the consequences of high greenhouse gas emissions and other pollutants for example, alternative renewable energy and energy efficiency technologies (REEETs) have generally seen a very slow rate of acceptance.

Externalities (external costs) in the fossil fuels and related energy sources are not fully captured in the pricing of the final product. The main tools used to evaluate public projects, with immense influence in decision making in public and private sector institutions, appear flawed in that they are premised on a value system that is primarily based on an economic perspective (Ackerman, 2008). Although the tools are seen to be biased against the goals and principles of sustainability, sustainability transition confronts similar constraints to the extent that its evaluation criteria also rely on the same objective, rational-agent paradigm of choice and behaviour for the desired transition.

1.3 Behavioural economics and prospect theory

Prospect theory is a psychology-based paradigm, which explains common decision making behaviour in choice under risk and uncertainty (Kahneman and Tversky, 2000). It is based on the view that the rational-agent model assumed in choice and decision making under classical and neo-classical economics especially within the context of finite mind and limited or scarce resources, is an abstracted ideal, which does not exist in reality (see for example Ariely, 2008; Thaler and Sunstein, 2008; Kahneman, 2011; Shogren, 2012). In the real context however, the best that one can get is 'the reasonable agent', who exercises

'bounded rationality', and who has to contend with the diversity of constraints which limit the realisation of the ideals of the rational-agent model.

Bounded rationality is described in Hedborg, (1996:5) as the "more operational version of rationality in decision making than that assumed in economic theory". It is based on the reasoning that decision makers, even when they want to act rationally, do not make decisions in a vacuum, but are influenced by such external factors as the decision context, personal characteristics, education and personal experiences. Forester (1984), Selten (1999:3) and Muramatsu and Hanoch (2005) among others, provide detailed discussions on the origins, the various aspects and the on-going debate on bounded rationality (Section 1.8). They discuss bounded rationality in terms of the common contradictions in human choice and decision making, the link with emotions and human biological mechanisms, and the limitations of human cognition as opposed to the 'mythical' full rationality assumed in economic theory (Trepel et al., 2005:34).

This emerging view is corroborated by other science fields such as neuro-science, genetics and evolutionary studies. It is shown that the economics-based objective, rational decision maker is actually subjected to a more human-based, emotion-driven secondary level of evaluation by the primacy of autonomic and semi-autonomic physiological and psychological drivers (Bechara and Damasio, 2005; Thaler and Sunstein, 2008:6-8). The psychology and prospect theory perspective recognises two interacting systems that evaluate and process choices and decision making under conditions of uncertainty (Frederick, 2002; Sloman, 2002; Weber, 2003; Thaler and Sunstein, 2008:19-22; Marx and Weber, 2009; Kahneman, 2011).

System-1 is intuitive and automatic, operating with little or no effort and no sense of voluntary control. Often referred to as 'gut feeling', it is controlled by the oldest part of the brain (Bechara and Damasio, 2005:352; Thaler and Sunstein, 2008:21). The reflective and rational System-2 deals with decisions that require more attention and effortful mental activities such as complex computations. It is

associated with the sense of agency, choice control and conscious thought. Choices that prove too complicated for System-1 are automatically referred to System-2 for further analysis, interpretation and computation.

Behavioural economics and prospect theory also explain the role of ***heuristics*** or simple, usually unconscious decision making procedures of finding answers to difficult questions, assessing the likelihood of events and justifying decisions which the '*irrational*' mind has already reached (Gilovich et al., 2002:xv; Marx and Weber, 2009:10; Gordon, 2011:4; Kahneman, 2011:98). Decision making under uncertainty involves several other behavioural techniques, all of which are linked to the two systems discussed above. According to Shogren (2012:9), "Behavioural economists categorize and catalogue the expanding list of deviations *(or biases)* from rational choice theory. Examples of anomalous behaviour are numerous, including the *status-quo bias* and *endowment effect*, *loss aversion*, *framing effects*, *anchoring*…". Such heuristics and other behavioural economics tendencies conflict with rational-agent model and decision-theory expectations (Fujiwara and Campbell, 2011:18; Shogren, 2012).

Loss aversion is one of the key cognitive features at the heart of prospect theory (Kahneman, 2011:282). The process of choice and decision making involves a psychological evaluation in which a loss is valued more than a gain of the same good. When directly compared or weighted against each other, losses loom larger than gains as illustrated in the asymmetrical *loss aversion* curve from prospect theory (Figure 1.1). Thaler and Sunstein (2008:33) note that "roughly speaking, losing something makes you twice as miserable as gaining the same thing makes you happy".

Loss aversion is the key to the challenge directed towards the rational-agent model theory in classical and neo-classical economics. In particular, the willingness-to-pay vis-à-vis willingness-to-accept variation which has always upset the potential Pareto improvement criterion in conventional economic theory and CBA is attributed to *loss aversion* and the *endowment effect* in prospect

theory (Cullis and Jones, 2009: 489; Shogren, 2012:9). *Loss aversion* induces the strong reluctance to give up what we have because we do not want to incur losses, to an extent that we even reject otherwise optimal offers. According to Thaler and Sunstein (2008:34), "loss aversion operates as a kind of cognitive nudge, pressuring us not to make changes, even when *(such)* changes are very much in our interest".

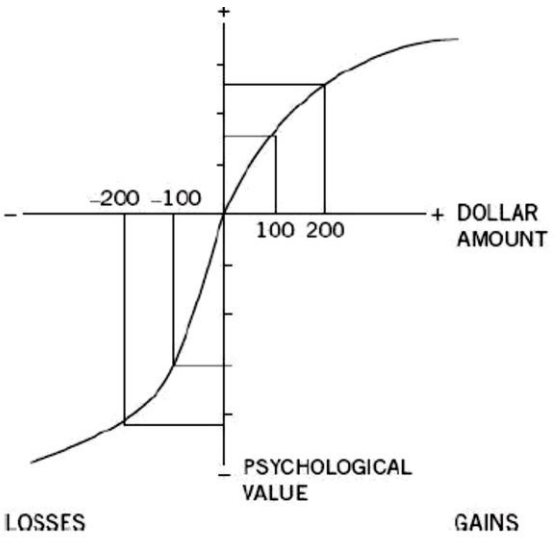


Fig. 1.1: Illustration of loss aversion
(Source: Kahneman, 2011:283)

This behaviour is obviously contradictory to the revealed preference theory in which we are expected to automatically take better, benefit-optimizing offers. In addition *loss aversion* is the basis for *inertia* and *status-quo bias,* the strong tendency in decision making to stick to the current position or *default option* (Thaler and Sunstein, 2008:34; Kahneman, 2011:304). *Status-quo bias* and *inertia* explain to a certain extent the resistance to change generally, or to acceptance of emerging technologies such as solar water heating.

Closely related to *loss aversion* and *status-quo bias*, the *endowment effect* is a behavioural tendency in which individuals systematically allocate higher value to goods because they already possess them, ('a bird in hand is worth two in the bush' logic). Kahneman (2011:293) and Gazheli et al. (2012:9) observe that

owning an object/product appears to increase its "affective value" or sense of emotional attachment hence the owner requires higher value compensation than what they are willing to pay to buy the same product anew. Ariely (2008:129) also notes that when one owns something one begins to value it more than one would do as a prospective owner.

The System-1 tendency to replace difficult questions with related easier ones also creates the common behaviour of *confirmation bias*, where people seek data that are likely to be compatible or confirms the beliefs they currently hold (Kahneman, 2011:81). According to Kahneman, System-1 is gullible and biased to believing while System-2 is in charge of doubting and unbelieving, or scrutinising information before believing. More often however, people believe and then search for confirming evidence in what is referred to as '*positive test strategy*', and generally rely on emotive/intuitive evidence or opinions which they can neither explain nor defend (Section 1.8). Because the *confirmation bias* and *positive test strategy* behaviour serves to justify or rationalise choices and decisions that have already been made, this study will refer to the behavioural heuristic as '*post-rationalisation*' in choice and decision making.

In addition and contrary to the rational-agent model decision-theory ideal, decision makers can be influenced or nudged in various ways. It has been found that cognitive bias can be caused by the way in which information regarding available choices is communicated or framed. Thaler and Sunstein (2008) provide a detailed narrative of the various techniques that amount to nudges. One of the nudge techniques, *framing* is simply the deliberate technique of influencing what choices people make by manipulating the presentation of options in a particular way. "The same contents presented differently result in different decisions" (Gazheli et al., 2012:10).

Positive frames tend to elicit positive decision outcomes. For example, *framing* climate change impacts in terms of gains and losses affects people's perception as well as their attitudes towards mitigation. It is suggested that in order to elicit

positive attitude towards mitigation and higher perceived severity of climate change, communication should focus on the benefits of climate change mitigation instead of stressing the bad consequences as a result of inaction (Gazheli et al., 2012:10). *Framing effects* are also vividly described in Kahneman, (2003:1458) and Kahneman (2011:363-374).

The technique of *anchoring* can also be used to nudge or prime the decision maker‘s judgement into a particular decision outcome. An *anchor* is the reference point or status-quo value from which decisions involving an evaluation are made and subsequent adjustments done. “If you consider how much you should pay for a house, you will be influenced by the asking price” Kahneman (2011:118). Shogren (2012:9) notes that in evaluating the worth of a choice or decision option, people lock onto the external prices or information given to them as a point of reference. Ariely (2008:45) argues that the standard economic framework assumption that the forces of supply and demand independently determine prices is not true, but that in reality, *anchoring* manipulations in form of retail prices, advertised prices, promotions and reserve prices, among many others, determine the consumer’s willingness-to-pay.

Heuristics have a profound effect on decision making under uncertainty in contradiction to the rational-agent model and revealed preference assumption. *Mental accounting* is another common financial choice and decision making heuristic in prospect theory (Sub-section 2.5.3). Other common heuristics from Thaler and Sunstein (2008), Cullis and Jones (2009) and Kahneman (2011) among other sources are:

(i) *Sunk-cost fallacy* – the tendency to throw good money after bad and not to give up on a failing investment or overvaluing the original cost of possession when faced with the prospect of replacing it.

(ii) *Procrastination* – the tendency by System-1 to postpone making a decision or taking action on an issue or task (Sub-sections 2.7.2 and 2.7.4).

(iii) *Availability affect* or bias – recent dramatic and personally experienced events are systematically overweighted in choice and decision making and the likelihood of risks are assessed by how readily examples come to mind.

(iv) *Default option* – the tendency to maintain the status-quo in opt-in or opt-out choice situations.

(v) *Satisficing* – aiming to achieve only satisfactory results in choice and decision making, and tendency to choose the easy rather than optimising or maximising options (Section 1.8).

(vi) Theory, technology or professional *induced blindness* – once a theory, technology or such other concept is accepted it becomes difficult to notice its flaws.

(vii) *Affect heuristic and defective forecasting* – the believe by an individual, due to overconfidence, that negative effects will happen to others but not to the particular individual ('it will not happen to me' mentality) and the tendency to underweight probabilities of events that we do not prioritise even when evidence to the contrary is so overwhelming. Also includes the *optimism and over-confidence effect*, the unrealistic judgement of our abilities, the belief that we know more than we actually do know and a misplaced assurance or belief in positive outcomes for future events, which sometimes leads to dangerous risk taking.

1.4 The conventional approach to evaluation in cost-benefit analysis

In conventional decision-making process, cost-benefit analysis (CBA) is a tool that has gained increasing importance in the assessment of both public and private sector projects. The tool has evolved over time from a theoretical economic concept (Anderson and Settle, 1977; Levin, 1983; Mishan and Quah, 2007; Ackerman, 2008) to an invaluable tool in determining the feasibility of a project or policy programme in modern times. According to Bebbington et al. (2007) and Corner House (2012), policymakers and consultants have promoted CBA as a tool

for clarifying and rationalising social choices and building consensus. Perman et al. (2003:351), see CBA as "the social appraisal of investment projects", while arguing that the evaluation is conducted in accordance with criteria derived from welfare economics rather than commercial criteria, and that it attempts to make adjustments for market failure. This view seems to project a fundamental objective apparently similar to that of sustainability.

In Watkins (2012) a project, programme or policy is worthwhile when the total benefits exceed the cost of that project. Van Dieren (1995) argues that often the benefits of a project or programme are immediate and obvious while several of the risks and associated costs are delayed and uncertain, a fact that is inadequately factored in a CBA evaluation exercise. Because CBA principally deals with the familiar and easily aggregated streams of costs and benefits, it has often been criticised for consistently prejudicing the less quantifiable social and environmental impacts.

Most of the valuation techniques used, primarily the discounting-oriented net present value (NPV) and contingent valuation method (CVM), are premised on a philosophical and socio-cultural framework, which underpins the definition of private versus social costs and benefits primarily from an economic perspective. Even though a number of policies and projects for which CBA is done may have substantial non-monetisable, positive or negative impacts, this aspect is largely disregarded thereby reinforcing the status-quo (Facione et al., 1978). Heavily driven by its attitudes and perceptions, contemporary society seems unable or unwilling to effect any change in this regard. Efforts by environmentalists to include externalities in the costing of fossil fuels have for example been frustrated by what is regarded as a lack of measurable values or observable preferences for the non-monetisable impacts. According to Clark (1995) however, the reason why surrogate market tools such as CVM are introduced is that there is no market, at least in the economic sense, for the environment.

In the 1950's, "economists tried to provide a rigorous, consistent set of methods for measuring benefits and costs and deciding whether a project *(or policy)* is worthwhile" (Watkins, 2012). However, in a society and at a time period where money has been the predominant unit for measuring value, and where social/environmental concerns were not yet prominent, the tools proved inadequate in valuing social and environmental impacts. This situation continued to prevail until social and environmental issues gained prominence and the conventional practice of evaluation in CBA began to be challenged.

This lag in application of a holistic scope of values in CBA contributed to undervaluation of the environment and other public or common goods, especially in the energy sector. In day-to-day life experiences, a conflict between economic value and the other values became evident as described in Inlow (1972) among others. The result is that most exercises in CBA ended up reinforcing the business-as-usual trend, which in turn contributed to escalation of the negative externalities and marginalisation of options exhibiting strong positive externalities. This escalation and marginalisation then ends up reinforcing unsustainable practices and choices.

Collective cost/benefits of externalities versus private preferences/choices thus become the central point of contradiction in environmental CBA, based on conventional economic rationale. In what is referred to as the "tyranny of discounting", Pearce et al. (2003:123) argue that discounting tends to shift the burden of costs to future generations while precluding such generations from inheriting the created natural wealth. It therefore becomes critical to evaluate how any innovative solution can prove feasible based on the conventional CBA evaluation approach, especially where such a solution is meant to achieve sustainability outcomes.

1.5 The evolving and adaptive cost-benefit analysis

Conventional CBA is a positivistic evaluation tool based on the economic assumption of a rational-agent model whose primary motivation is to maximise self-utility assuming a context of perfect market conditions. The rational-agent model is assumed to be fully aware of the utility implications of the choices they make and the exchanges they offer or make in return. An evolved and adaptive CBA recognises that society's aspirations to attain improved welfare in terms of economic, social and environmental well-being have intensified. In order to achieve these aspirations, decision making is required to be integrated, adaptive and holistic with regard to those three aspects of well-being (de Lange et al., 2008:243).

The reality as observed in Fujiwara and Campbell (2011:7) is that "perhaps what people think and feel about their lives as a whole is predominantly determined by 'economic' thinking from an economic welfare perspective". This implies that decision making is predominantly influenced by economic welfare considerations (Gowdy, 2007:28). However, from a prospect theory perspective, the rational-agent model premise of classical and neo-classical economics has been systematically falsified through empirical studies (Ariely, 2008; Kahneman, 2011 among others). According to Tomer (2012:2-3), whereas the economic man or rational-agent model as idealised in classical and neo-classical economics would seem to have a 'perfect machine brain', that operates and makes decisions in the perfect environment, the reality is that "humans are not capable of perfectly rational decision making". The main differences between conventional CBA and the evolved and adaptive CBA can be summarised as follows (the differences are discussed in more details in Chapter 2):

Conventional CBA	***Evolved and adaptive CBA***
• Contingent valuation method (Facione et al., 1978; Faber and Hemmersbaugh, 1993; Clark, 1995; Atkinson and Mourato, 2008;	• Life satisfaction approach (Fujiwara and Campbell, 2011). SAMS (Bebbington, 2006; Bebbington et al., 2007; Frame and Cavanagh,

Watkins, 2012).	2009).
• Monetisation (Facione et al., 1978; Masur and Posner, 2011; Watkins, 2012).	• Non-monetary indicators such as descriptive expressions of value (Elghali et al., 2007:6078; European Union Regional Policy, 2008:68; Frame and Cavanagh, 2009:203-205).
• Discounting and fixed discount rates (Faber and Hemmersbaugh, 1993; Pearce et al., 2003; Atkinson and Mourato, 2008; Weitzman, 2010).	• Time-declining discount rate (Weitzman, 1999; Atkinson and Mourato, 2008).
• Distributional issues based on Pareto optimisation (Boardman et al., 2006; Watkins, 2012).	• Equity weights (Atkinson and Mourato, 2008; European Union Regional Policy, 2008).
• Rational-agent model, revealed preference model (Watkins, 2012).	• Life satisfaction approach (Fujiwara and Campbell, 2011).

Over the years and especially since the mid 1990's various tools and techniques have been developed in response to calls for broader approaches to valuation for decision making. There has been significant interest in improving the CBA evaluation methods to take into account social and environmental elements in a manner that would advance the principles of sustainability. Bebbington et al. (2007:228) among others recognised the inadequacy of CBA approaches in sustainability-related activities and proposed sustainability assessment models (SAMs) as viable alternatives.

But according to Watkins (2012), "some technical issues of CBA have not been wholly resolved even now". This is in reference for example, to the '*endowment effect*' contradiction to the Pareto optimality ideal for evaluation in CBA, the willingness-to-pay vis-à-vis willingness-to-accept disparity caused by *loss aversion* and the choice of discount rate among others (Sienden et al., 2006:60-61) (Section 1.3). Although evaluation in CBA is only one input in the decision making process, it is nevertheless a very influential and decisive component primarily because, from an economic perspective, it does provide a quantitative

rationale for the decision which is presented as rational, objective and thus superior to other approaches.

In recent years, CBA has introduced a more subjective "well-being" oriented *life satisfaction approach,* which measures people's experiences rather than their preferences. By introducing this approach, CBA acknowledges that traditional approaches had become too 'econocentric' and were therefore not adequately responsive to the evolving economic environment (Fujiwara and Campbell, 2011:7). The challenge facing CBA in this evolving and adaptive approach is how to value goods that provide more than economic and utilitarian satisfaction. The introduction of this approach is not meant to diminish the preference or utilitarian aspects of the valuation but to recognise and include the equally important social and environmental aspects into the preference and utility basket.

On the other hand, the task of defining, measuring and valuing the complex, multi-dimensional sustainability concepts, particularly the environment and bio-diversity-related aspects, should not be underestimated (Atkinson and Mourato, 2008:324). In addition, the approach for an evolving and adaptive CBA should take into account the reality that decision making is more often *irrational* (or boundedly-rational) and subject to intuitive, emotion-driven, autonomic heuristics rather than the rational-agent model ideal in evaluation in conventional CBA practice (Selten, 1999; Ariely, 2008; Cullis and Jones, 2009; Kahneman, 2011).

European Union Regional Policy (2008:47) summarises the evolved CBA evaluation in five steps as follows:

- Conversion of market to accounting prices
- Monetisation of non-market impacts
- Inclusion of additional indirect effects (if relevant)
- Discounting of estimated costs and benefits
- Calculation of the performance indicators (net present value, internal rate of return or economic rate of return and benefit to cost ratio)

These steps appear to be a short version of those in the conventional CBA process. Atkinson and Mourato (2008:318) point out that "although the principles of cost-benefit analysis have remained largely the same, the practice of carrying out appraisals has undergone a transformation over the past two decades or so". For example, it is now recognised in evolved CBA that there may be some project costs and benefits, such as environmental or social impacts, for which there are no market values. When such effects are significant in achieving the project's objectives, they need to be regarded more prominently, evaluated and included in the project appraisal. European Union Regional Policy (2008:47) recognises that in evolved CBA, "money is just a convenient welfare metric and, in principle, any numeraire can be used just as well". This is a new and radical approach in the CBA evaluation process where money takes a reduced financial and value implication than in the past, even though in reality it can be very difficult to separate the term 'money' from formal or informal financial valuation in CBA evaluation.

In a landmark decision for environmental evaluation in evolved CBA, a US court ruled in 2008 that if the US Department of Transport used CBA as a decision making tool for a particular project, it could not arbitrarily include benefits such as reduction in vehicle noise and congestion for example, while excluding the benefits of reducing greenhouse gas emissions (Masur and Posner, 2011:1559). Nevertheless, the valuation of such benefits would have to be monetised. This ruling set a precedent in the evolution of CBA in that environmental impacts which were routinely disregarded as insignificant in the past became entrenched in the CBA process. In addition, equity impact (distributional efficiency) has become accepted vocabulary in CBA evaluations for programmes, policies and projects.

The renewed interest in environmental evaluation in CBA has led to advances in finding techniques for valuing environmental impacts (Atkinson and Mourato, 2008; Shapiro 2012). Such efforts focus on the following areas:

- How to value future impacts in light of concerns regarding the use of the discounting method.
- How to deal with uncertainties and irreversible impacts
- Distributional concerns and equity
- Dealing with the issue of validity and reliability in the valuation process

One of the criticisms against CBA evaluation is the application of the Hicks Kador compensation principle which assumes that those who gain from a decision could compensate those who lose so that "no-one is left any worse off" (Atkinson and Mourato, 2008:328). This has been CBA-evaluation's way of dealing with equitable distribution of resources. The evolved CBA approach introduces 'equity weights' especially regarding the distribution of the burden of climate change damage across countries (Atkinson and Mourato, 2008:329). This approach introduces a revised social decision criteria that regards a project to be worthy "if the sum of its equity-weighted net benefits is at least positive". Although the debate regarding what form, nature and magnitude the weights should take is on-going, there is no doubt that some of the weights will have far-reaching effects and make a significant difference to decision making when applied in CBA evaluations. For this reason, there are on-going concerns among some critics that the prevailing ambiguity in the equity weights could still weaken CBA's valuation validity and reliability.

Regarding the application of discounting it has been proposed that the constant discount rate in evaluation in conventional CBA be replaced with a time-declining discount rate in evolved CBA (Atkinson and Mourato, 2008:330). The discount rate gets smaller with time, effectively slowing down the increase in the discount factor which would otherwise cause a reduction in the value of a future investment. Weitzman (1999:23-30) argues passionately for the application of a declining discount rate for long-term projects. The UK Treasury guidelines on how to transform costs and benefits into monetary terms contains pioneering application of a time-declining discount rate for projects, policies or programmes extending beyond 30 years (Atkinson and Mourato, 2008:333).

The co-evolution process extends to emerging assessment tools that have been developed to address criticism of conventional CBA and other similar evaluation tools (Sub-section 2.9.10). These emerging tools may not address all the contentious issues and some may even extend the areas of disagreement. However, they are part of the loops in the co-evolutionary process described in Kemp et al. (2007:2-3). They have emerged from the co-operation, competition and conflict within or among co-evolving systems which underpin CBA theory and practice (Ruhl, 1999:166).

1.6 The co-evolution and complexity theory perspective

The process of transformation in evaluation in CBA practice and the sustainability paradigm discussed in Sections 1.1 and 1.4 does not follow any defined or straight line path and events do not necessarily follow a predictable pattern either. The transformation is more complex, cyclical, and unpredictable. In addition, the magnitude and nature of the change cannot be predicted. Kern and Smith (2008:4094) describe this as "transformation processes in which such systems change structurally over an extended period of time".

Similarly, not all aspects of the on-going transformation in the South African electricity market are predictable. Although there were predictions before 2006 that an electricity crisis in South Africa was imminent, no one knew exactly when this would happen. While the magnitude of the crisis caught everyone by surprise, the consequent impacts have taken a variety of unexpected directions. For example, Eskom has since adopted and invested in renewable energy while previously it adopted a business-as-usual approach. Renewable energy and energy efficiency have become part of Eskom's business portfolio.

The changes in the energy sector have transformed the sector significantly and even if energy suppliers were to revert to previous levels of coal-generated electricity, the sustainability gains achieved so far seem to have reached an

irreversible stage. The events in this transformation were not explicitly coordinated and the details of its onset, how it has progressed and its driving force are not under the control of a single agency. One of the outcomes of this transformation to date is that solar water heating has gained remarkable acceptance as a water heating option in South Africa, thus opening up one of the sustainability pathways for the economy.

Co-evolution explains the dynamics that are at play in the transformation of systems. In Gowdy (2007:209), the concept of co-evolution refers to "the historical and evolutionary connections between individuals, human social groups and the natural world". From another perspective, "the concept of co-evolution has been transferred from the biological sphere to a large range of applications in social-economic contexts" (Noailly, 2008:3). Co-evolutionary applications range from interactions between genes and culture, behaviour and institutions and technology and industry (Noailly, 2008). Noailly credits Norgaard (1994) as being the first to suggest that the use of co-evolution be developed to describe the interactions between the environment and economics. In such a scenario, development is shaped by a process of co-evolution between several sub-systems such as knowledge, values, organisations, technology and the environment. Consequently, the sub-systems create interactive pressure on each other, thus provoking adaptive change (Noailly, 2008:3).

Goldstein (2000:5) notes that the concept of emergence plays a critical role in the field of complexity theory. The adaptive valuation tools and methods in CBA and sustainability assessment can be classified as co-evolving. It is therefore appropriate to analyse the methods and tools within a co-evolutionary and complexity theory framework. Similarly, the combination of events in the transformation of the South African electricity market indicates characteristics of a co-evolutionary complex system that would require to be analysed within a similar context.

1.7 Evolution of attitudes and value systems in society

Any study in the adoption of CBA as the primary tool for evaluating public projects inevitably leads to the fundamental theory of value, which in turn leads to questions regarding the genesis of values and when and how economic values became predominant. Heilbroner (1972) provides a well-narrated account of the evolution from the ancient times to the modern market society from a western world perspective. Although Heilbroner's account may appear out-dated, it nevertheless provides a historical narrative that is simple, well-constructed and therefore easy to grasp. It is also relevant to the on-going transformation in value systems, especially with regard to environmental and social issues. Other accounts are provided by Bowden (1981) and Rosenberg and Birdzell (1986). A diagrammatic summary of this transformation is shown in Figure 1.1.

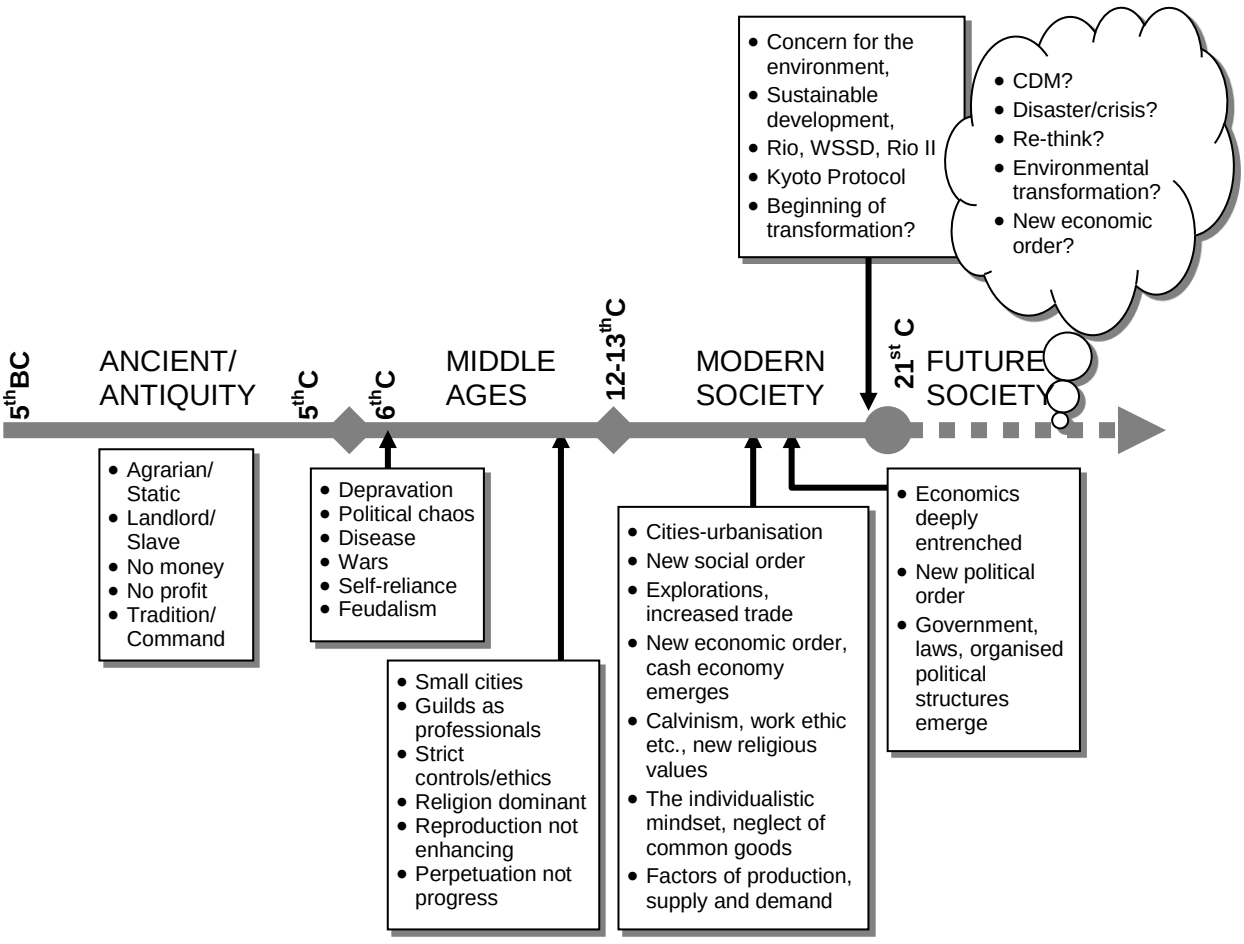


Fig. 1.2: Summary of the evolution of the economic market system
(Adapted from Heilbroner, 1972)

Heilbroner (1972:28) identifies three types of socio-economic systems that have evolved over time to ensure that society satisfies its increasing socio-economic needs. These are tradition, command and market systems. Tradition solves the problems of production and distribution of material needs through traditionally administered social institutions and structures. The economic solution imposed by tradition has however proved to be static and no change occurs over a long period of time. Command solves this problem by imposing allocation of effort or reward by a governing authority. Command therefore becomes a means of achieving rapid and far-reaching economic change and it can take extreme totalitarian or mild democratic forms.

The market system on the other hand is seen as a complex mode of organising society in which order and efficiency emerge spontaneously from a seemingly uncontrollable socio-economic system. Heilbroner however does not indicate what is now regarded as common alternative practice. In the case where absolute command is not desirable and yet the market system is not achieving the desired effect on specific areas such as the environment and strategic issues such as energy supply and economic or social transformation, a combination of command and market systems is applied.

How has society developed and evolved its attitudes and values? Clark (1995:87) observes that nature is enjoyed as much for its beauty and wonder as for its constituent creatures, and enjoyed as much in a social context as in an individual one. According to Clark (1995:87) for example, "…the meanings and values that open spaces hold for individuals are interlinked not only with those individuals' observations of common animals and plants but also with sharing of experiences, with childhood memories that these places evoke, and with the social activities that take place in them. Popular values are grounded as much in real lives as in economic, ethical or scientific abstractions".

O'Brien (1995:167) considers value as economic, political, social, personal and spiritual. It is therefore not difficult to see why techniques such as NPV and CVM mentioned earlier are not, in isolation, appropriate in valuing nature and other similar 'goods and services'. For any group of people who regard such goods as part of their lives, valuing them in monetary terms would be like putting a price to human life. Such an exercise would be unthinkable to the people, and therefore difficult for the practitioner to carry out.

These arguments indicate a need to examine the forces and systems that underlie choice and decision making at individual level and the impact this transfers to institutional decision making. Such a study will further demonstrate the contradictions between the formal, rational-agent-based evaluation tools (such as evaluation in CBA and increasingly sustainability assessment) and the informal, neuro-behavioural and prospect theory-based mechanisms. An understanding of the transformation from traditional or ancient value-systems, to contemporary economics-centred ones and the role of behavioural and biological systems can define the changes required in the choice and decision making mechanisms in order to achieve sustainability goals and outcomes.

1.8 Bounded rationality, emotions and perceptions in decision making

At both individual and institutional decision making level, the commonly held and familiar view is that "to solve problems you must define the problem carefully, collect all relevant information, rank values, evaluate alternatives, and select the best strategy" (Forester, 1984:23; Bechara and Damasio, 2005:337). This 'rational comprehensive position' and process, which is deeply rooted in the rational-agent assumption of classical economics is expected to apply to both formal and informal decision making. Hence, it is the foundation of most of the decision making and evaluation tools such as CBA. There is always a strong urge to follow this process even when it is not practical or realistic to do so.

In reality, however and due to cognitive limitations of time, skills and information resources, actual decision making situations are characterised by various constraints and are therefore considered 'bounded' (Forester, 1984:23). Most of the time, the decision issues are too complex to rationally process within the limited time in which a decision is required, hence the tendency to resort to 'bounded rationality' (Muramatsu and Hanoch, 2005:209; Polic, 2009:80; Tomer, 2012:3).

According to Forester (1984:24) Polic (2009:80) and Tomer (2012:3), the individual therefore constructs a simplified model of the decision task mainly from past experiences (including prejudices and stereotypes) and also present stimuli. Rather than apply the 'rational comprehensive position' for an optimized solution, the individual then conducts a search for alternative solutions and selects one of several satisfactory rather than optimized options (a process which is referred to as 'satisficing'). The process can be instantaneous or gradual depending on the complexity of the problem. Satisficing is however not a mere subjective, elementary decision making process but a combination of complex biological decision making mechanisms whose neuro-scientific underpinning has now been systematically studied.

Herbert Simon pioneered the concept of bounded rationality and specifically the significance of the link with emotion and feelings (Muramatsu and Hanoch, 2005:202, 209-214; Polic, 2009:79). According to this view, emotion is the foundation of bounded rationality. Bounded rationality acts as the option selection process for decision making while emotion acts as the trigger/cue or quality control mechanism for such options. It is however acknowledged that sometimes emotion could undermine human judgement capabilities in decision making, resulting in 'unsatisficing' outcomes and bad choices (Muramatsu and Hanoch, 2005:215).

To illustrate further the role of emotions in decision making, Damasio (1994:173) gives the example of the automatic and instant body sensation that one

experiences before the evaluation of options, to warn the mind of the significance or consequence of any particular option, immediately that option comes to mind for analysis and consideration. We often and more generally refer to this sensation as ‘gut feeling’. Damasio (1994:174) and Bechara and Damasio (2005:339) in their somatic marker hypothesis refer to the signal that guides this process as the ‘somatic marker’. The somatic marker is therefore a ‘biasing device’ in the autonomic cost benefit analysis evaluation and decision making processes, which generates feelings for secondary emotion, leading either to an incentive to continue with an option or an alarm bell to signify rejection of the option. It also triggers will-power or the ability to endure unpleasant experiences for a potentially more rewarding future outcome.

Selten (1999:17) describes two approaches at the very basic level of human decision making. The more formalised analytical approach, which is mainly supported by empirical information, contrasts with the informal intuitive approach which is based on past experiences, perceptions of the issue at hand and biological stimuli such as emotion. Each of the approaches has its advantages and disadvantages and the analytical approach is not necessarily superior. Furthermore, many decision tasks are encountered in situations where only the intuitive and emotion-driven approach would be realistic.

How then do we invoke the reference points or conduct the satisficing process and how does the mind sift through options to decide which task is determined at System-1 and which is referred to System-2 (Section 1.1 and 1.3)? Studies by neuroscientist Antonio Damasio demonstrate that emotion is a core mechanism in this decision making process (Damasio, 1994, Bechara and Damasio, 2005 among others). For example, healthy fear of bad consequences is good for decision making (Kahneman, 2011:139). Emotion and feelings play a key guiding role in evaluating options and in determining which heuristics to apply for which decision task and when (Muramatsu and Hanoch, 2005:214). The behavioural heuristics towards *risk aversion, risk seeking, satisficing, post-rationalisation* and the habit of substituting hard questions with easier ones in choice and decision

making are closely controlled by emotion. People often make judgements and decisions by consulting their emotions in what is referred to as the 'affect heuristic' (Kahneman, 2011:139; Weber, 2006:103-105). Kahneman (2011:139) observes that "people form opinions and make choices that directly expresses their feelings and their basic tendency to approach or avoid, often without knowing that they are doing so".

Kaufman (1999:136) alludes to the earlier view of emotions as subjective mental feelings and the anti-thesis of reason and rationality, reflecting "the lower, more primitive…side of the human psyche". This explains the uneasiness which is expressed in Muramatsu and Hanoch (2005:210), and Kahneman (2011:411), regarding the use of the term 'irrationality' to describe inconsistencies and levels of bounded rationality in decision making. However, the term is now used more liberally in behavioural economics and prospect theory discourse and the literature such as Ariely, (2008) and Cullis and Jones (2009) among others.

The earlier view contrasts with the contemporary view of emotion as the core link between perception, the biological system and the physical responses that determine our very survival. Tooby and Cosmides (1990:410) note that emotion states such as fear, guilt, jealousy, rage, grief and others can be catalysts for setting goals and consequent actions to alleviate or deal with a challenge. Emotion then signals the need to call on survival strategies such as excitement, raised blood pressure, increased heart rate, increased levels of concentration, muscle tone and even panic attacks in the face of challenges (Kaufman, 1999:138). Rationality is therefore primarily an acquired, more often formal behaviour while emotion and bounded rationality are the default state of human behaviour (Kaufman, 1999:139).

Decision making is also heavily influenced by external factors such as social-cultural and environmental background. Crompton (2010:8) notes that dominant cultural values are tied to emotion which, as indicated earlier, is increasingly recognised as playing a key role to human decision making and judgement

processes. Behavioural economics explains why we make decisions that are against our own interests and those of the society we live in (Fischer, 2012:16-17; Tomer, 2012:1).

Often, we are faced with contradictions between decisions that are regarded as ethical from a social-cultural perspective, and the heuristic influences of our autonomic system (System-1). However, due to the human cognitive limitations discussed in this section, bounded rationality and System-1 thinking prevail, while conclusions reached by rational deliberations and informed by formal analytical studies may be overridden by strong emotion-driven impulses (Selten, 1999:3; Tomer, 2012:3). Emphasising the significance of emotions in choice and decision making Bechara and Damasio (2005:348) note that "knowledge without emotional signalling leads to dissociation between what one knows or says and how one decides to act". Emotions influence decision making to the extent that people may say or be consciously aware of 'the right thing' but still proceed to do 'the wrong thing' or act 'the wrong way'.

The rational-agent model assumes that the decision maker is independent and does not need to be influenced or manipulated to make the decision that optimises individual or collective welfare. It is however clear from prospect theory that nudging or priming are common practices that could actually enhance the choices and hence decision outcomes (Section 1.3) in what Cullis and Jones (2009:491) for example, with reference to government interventions, refers to as "protecting citizens from themselves". In the context of this study, there are questions for example on whether house owners should be nudged to replace electric geysers with solar water heaters or whether nudge techniques should be used to initiate a market shift in favour of solar water heating.

Eventually, decisions are a balance between the initial feelings, emotion and perceptions and the subsequent 'objective' processing of alternatives including weighing the pros and cons of a situation. However, we often use the 'objective' process to justify or rationalise the initial feelings and emotion (Sections 1.3 and

Table 3.2). According to Zajonc (1980:155), "most of the time, information collected about alternatives serves us less for making a decision than for justifying it afterward". We often encounter contradictions or dissonance because complete and thorough computation is not performed before decisions are made or we do not systematically follow the recommendations of such computations in our final decision (Quartz, 2009:209).

We are not easily moved to reverse our initial impressions and perceptions because we trust our reactions believing that they accurately represent our internal emotion-driven, gut-feeling state or condition (Zajonc, 1980:157). Choice architectures aimed at promoting transitions to sustainable consumption and production lifestyles must target emotion-driven and bounded-rationality-based drivers in decision making, because that is where the biggest influence to choice and decision-making outcomes originates.

1.9 Renewable energy and energy efficiency technologies

Among the key threats to improved human wellbeing within current and future generations as well as survival of the species are pollution, climate change and global warming (Section 1.1). In order to achieve sustainability and to conserve natural resources, society needs, among other obligations, to reduce greenhouse gas emission which is the major cause of atmospheric pollution, climate change and global warming. One of the sources of heavy pollution in the atmosphere is the process of producing secondary energy from primary fossil fuels such as coal and oil. There is a need to shift from these energy sources to cleaner renewable sources such as solar energy, biomass, geothermal power and small hydro. Another way of achieving sustainability in the energy sector is the conservation of the generated energy or the use of energy in an efficient and non-wasteful manner (energy efficiency).

Among the renewable energy technologies that have been developed to use solar energy are solar water heating appliances that can replace fossil-fuel-based

electrical geysers. However, solar water heaters and other REEETs have not been widely accepted due to various technical, economic and social/political reasons. The REEETs that have been developed over time have faced a hostile market mainly due to market distortions and unfair pricing methods attributed to a market failure situation that prejudices REEETs in a number of ways. For example, externalities (external costs) in the fossil-fuel generated electricity are not fully captured in the pricing of the final product, or the economic evaluation of new power generation capacity. This market failure situation has also not been systematically addressed through comprehensive government interventions in the form of policy and application of necessary legislative and regulatory structures so far.

The argument in this study is based on the view that cost-benefit analysis (CBA) and other similar tools for decision making in public and private sector institutions, are premised on a value system that elevates the economic perspective and diminishes the environmental, social and behavioural aspects of decision making (Ackerman, 2008; Weitzman, 2009). Such tools are inadequate especially because they fail to recognise the impact of prospect theory and neuro-economic dynamics in choice and decision making (Section 1.3 and 1.8). They therefore end up recommending ineffective choice architectures, which in turn ends up reinforcing the market failure situation, which contributes to escalation in the environmental and social crises we face today. The study argues that an emerging transition now evident in the market has been slow and still predominantly driven by prospects of economic gain rather than holistic sustainability considerations, which include environmental, social and human behavioural forces. This issue is discussed further in Sub-section 1.10 as well as in Chapter 4.

1.10 Overview of electricity and solar water heating in South Africa

During South Africa's apartheid era, energy sector development focused heavily on self-reliance and energy security due to the country's international isolation.

The policy was partly favoured by the availability in the country of large reserves of coal that was cheap to mine. South Africa re-entered the global community during the crucial environment re-think period of the late 1980s and early 1990s, which would later see Johannesburg hosting the World Summit on Sustainable Development (WSSD) in 2002. Since then, the country has become a dynamic hub of energy production, supply, research and development in Africa as it tries to position itself in a strategically advantageous position in the energy industry within the region.

As a result of its position as a leading economy in Africa, South Africa is by far the largest emitter of greenhouse gases in Africa and one of the largest emitters of carbon dioxide in the world per capita (van Horen, 1996; Karekezi and Ranja, 1997). Historically close to 93% of South Africa's electricity has been generated from coal (Winkler, 2005:2). In 2001, Eskom, the national electricity utility burned 94.1 million tons of coal and emitted 169.3 million tons of carbon dioxide, 1.5 million tons of sulphur dioxide, 684 000 tons of nitrogen oxides, 59 640 tons of particulates and 2 154 tons of nitrous oxides (Winkler, 2005:2). This situation is attributed to the fact that the mining and heavy manufacturing industries, the backbone of the country's economy, are high intensity users of Eskom's electricity.

From 1994, the new economic opportunities for South Africa and the image re-building process, together with internal re-construction, presented the country with a challenging problem that was particularly apparent in the energy sector. The country set itself to electrify previously un-serviced parts of the economy, achieving 3.4 million new connections between 1994 and 2001 and targeting 300 000 homes a year henceforth. As a significant achievement towards this target, two thirds of the population had access to electricity by 2003 (Winkler, 2005:1).

Nevertheless, the goal of providing electricity to the expansive, predominantly rural countryside made the grid electricity option expensive and inefficient thus presenting a rationale to substitute the grid with renewable energy technologies.

However, the energy requirements of this previously un-serviced population differ substantially from those of industrial and urban domestic consumers. Their basic energy needs are primarily for purposes of lighting, space heating, cooking and to a limited extent water heating and small-scale industries. Current renewable technologies are often faulted for being inadequate in meeting these basic needs as a package in the same way that grid electricity does. This inevitably makes grid electricity the preferred option, thereby entrenching the perception of REEETs as inferior and therefore non-aspirational technology options.

On the other hand, South Africa has been prominent in international forums on various issues, including environmental conservation, climate change and pollution control among others. In order to balance the economic needs and the international obligations, the South African government has over the years since 1994, developed various policies, regulatory and legislative instruments on energy, renewable energy and energy efficiency. In 1998, the Department of Minerals and Energy (DME) published a White Paper that spelt out its policy on energy (DME, 1998). This was followed by another White Paper on renewable energy (DME, 2003) as well as a draft energy efficiency strategy (DME, 2004).

In 2004, it was announced that plans to incorporate energy efficiency into the National Building Regulations were at an advanced stage (DME/CaBEERE, 2004). After a lengthy delay, the necessary amendments were eventually published in September 2011 and became operational in November 2011 as SANS 10400-XA:2011. Another significant policy shift was the publication in July 2008 of a gazette notice setting a 2012 target for all existing buildings to install a facility to remotely control electricity usage for any electric geyser that does not incorporate a solar water heater (Republic of South Africa, 2008:4).

Another notable development is observed in the non-government organisations (NGOs) sector, which received financial support mainly from international donor organisations. NGOs such as PEER Africa, Earthlife Africa, Eco-city, IIEC, SEED and RAPS among others, distinguished themselves in this regard. They

were more often supported by organisations such as DANIDA, SIDA, USAID, World Bank, E+Co, GEF, IFC and DBSA. A number of universities, among them the Witwatersrand, Cape Town and Pretoria, formed links with government departments, NGOs, international donor organisations and the private sector to produce large volumes of data, research reports and several pilot projects. The initiative of the Energy Research Development Unit (EDRC) at the University of Cape Town in research was particularly remarkable. Unfortunately, these efforts dissipated from 2005 onwards without having achieved expected impacts in South Africa's transition to energy efficiency.

In February 2004, 17 institutions founded the Southern African Financiers Network to facilitate financing of good bankable proposals for renewable and energy efficiency projects (Willemse, 2004). The South African electricity utility, Eskom has also initiated several projects through its demand-side management (DSM) programme. Such projects focus mainly on peak load management, energy efficiency, alternative energy and awareness creation.

It is argued in this study that choice architecture plays a significant role in changing the attitudes and perceptions of individuals and society towards new technologies (Section 1.6). The February 2007 launch of an aggressive energy efficiency campaign and solar water heating initiative in the city of Cape Town, following crippling power cuts, indicates that crises can be a catalyst towards the change in attitudes and perceptions. Similarly, the proposal in June 2007 by Eskom to roll out a R2 billion solar water heating programme in South Africa (Davie, 2007) indicates a sudden realisation of this reality in the wake of a looming energy supply crisis. Whether this realisation represents a genuine re-think on sustainability within Eskom or an ad hoc reaction to a crisis can only be tested over time.

Despite the progress made, market-based transition to REEETs continues to be hampered by several constraints and barriers that can be classified as follows:

- Legislative and regulatory barriers: even though government acknowledges the need for intervention to protect the environment and comply with international treaties in which it is a signatory, the formulation of supportive legislative and regulatory tools has been slow. Often the resultant regulations lack enforcement mechanisms and therefore entrench the business-as-usual attitude.
- Organisational and institutional barriers: many organisations and institutions which could promote REEETs do not prioritise such technologies in their budgets. REEETs have often been promoted by a few organisations on an ad hoc and experimental basis. It is only after the electricity crisis in South Africa in 2008 that organisations such as the Solar Energy Society of Southern Africa (SESSA) and Green Building Council of South Africa (GBCSA) have gained traction and prominence.
- Market barriers: due mainly to their high capital costs and perceived long payback periods, REEETs have often faced stiff competition in the economy. Usually, more established competing technologies have hidden subsidies or externalities which are not factored into their prices.
- Technical barriers: one of the key challenges facing REEETs is the lack of skilled installers and maintenance technicians. The failure of several solar water heaters during the winter of 2010 in Gauteng, South Africa was attributed to poor installation and failure by the owners to select the appropriate appliances for the local weather conditions. Solar water heaters have the added disadvantage that they only function optimally when oriented to the north (in southern African region) in order to optimise the capture of solar radiation.
- Political and social barriers: In South Africa, the government has a strong political and economic attachment to Eskom, the electricity utility. In the past, the government has been reluctant to support REEETs due to this conflict of interest. When legislative and regulatory tools have been formulated to promote REEETs, the

> government has been reluctant to introduce enforcement mechanisms. In addition, consumers do not regard most of the REEETs as aspirational technologies but rather as inferior options for poor households. Many people for example maintained a view of solar water heating and other similar energy efficient technologies as interventions for poverty alleviation for low income households, especially prior to 2008. In such a scenario, a solar water heater on the roof top was often viewed as a sign of poverty rather than an expression of environmental consciousness (EDRC, 2003:40).

There is substantial evidence to suggest that overall attitudes and perceptions among consumers in South Africa as well as the individual and collective choice and decision making mindset were not sufficiently motivated towards recognition and acceptance of REEETs prior to the 2008 electricity crisis. The structure of the solar water heating sector in particular was fragmented with each institution or role player acting on its own in scaling up solar water heating. Efforts in this direction were uncoordinated and in most cases duplicated. In addition and more critically, there was little evaluation of such programmes and interventions.

Initial research information was scarce and where available, it was (as a matter of principle) either not shared or issued with caution and treated with extreme confidentiality. During the course of this study (mainly prior to 2008) for example, a request for an interview with suppliers and manufacturers of solar water heaters or leading researchers in the field would draw an enquiry regarding the institutional affiliation and name of the promoter before the interview was granted or any information released. Often, when granted, the interview would yield very little information with guarded and reserved responses sometimes driven by the fear that business secrets could be leaked to competitors. It was therefore found that discussions with industry role players and researchers were mainly done on the basis of established relationships that were difficult to penetrate for new researchers.

The 2006 – 2008 electricity crisis caught stakeholders by surprise and events thereafter seemed to take their own independent course. Since 2008, several theses on solar water heating have been written in a number of South African universities, perhaps indicating that the industry was opening up. In addition, the solar water heating market in southern Africa has since then been flooded with appliances from a variety of local and international sources and advertisements have become common in local media.

Although the plan in June 2007 by Eskom to roll out a R2 billion solar water heating rebate programme was supported by government, there was little involvement of other parties in the plan even though several high profile energy organisations were said to have collaborated to develop the programme. The programme was in fact treated with a lot of secrecy especially at the planning and roll-out stages. The pilot stage of the scheme showed a saving of 22MW from 36 solar water heating units in a five month period, translating to a saving of 24.1 tons of carbon dioxide and 27,000 litres of water (Davie, 2007). Why these obvious savings did not make sense earlier in the organisations involved is not clear. However, despite the savings and hence the implied potential for reduced need to build new coal-fired power stations, plans for such stations were announced in January 2008.

There was clear fragmentation of the decision-making process in the energy sector regarding how to deal with an unprecedented power crisis such as the one experienced in 2006-2008 (Section 4.5). Government, Eskom, private sector financiers and NGOs all gave different signals even when all agreed that there was an urgent need to scale up solar water heating as a way of reducing electricity consumption. This contradiction in terms of obvious opportunity versus the incoherent, fragmented and ineffective drive for solar water heating has motivated its prioritisation as the appropriate REEET for anchoring this study.

The barriers to acceptance of REEETs are mainly based on the conflict between the rational-agent model and the bounded rationality models (Section 1.3).

Programmes and policies to promote REEETs have always assumed that people are rational and that they make the right decisions when presented with statistics and findings of various research initiatives. It is assumed that society's value systems, attitudes to change, and the way society goes about accepting innovations, new ideas and new technologies are based on rational choice and decision making.

Additionally, solar water heaters are not seen as signs of prosperity in the contemporary consumer oriented society. Perhaps due to its perceived association with nature, solar water heating has struggled to achieve the social status associated with electric geysers and other 'modern' energy technologies especially in southern Africa. Low income communities aspire to appliances and consumption patterns of higher income households. On the other hand middle income households interpret government assistance to low income communities to access solar water heaters for example, as proof that solar energy is inferior or a technology for the poor in society (EDRC, 2003).

At institutional level, solar water heating and other renewable energy technologies have sometimes been portrayed as immature and inferior technologies, while electricity and other conventional sources are depicted as well established and hitherto reliable sources of energy (Karekezi, 2002:1056; Martinot et.al, 2002:313; Langniss and Ince, 2004). The argument goes that there is limited technical expertise especially in developing countries and limited awareness about the benefits of solar water heating which has led to limited demand. Furthermore, the solar water heating industry is still much individualised while production of components remains at medium or small-scale industrial level. Additionally, the solar water heating industry lacks the backing of financial institutions which are more likely to consider it as highly risky technology with an uncertain market.

In contrast, electricity is produced by large corporations often with massive government subsidies. In South Africa for example, Eskom is a large corporate brand with a huge workforce and countrywide infrastructure, while an equivalent

structure for the promotion and support of solar water heating does not exist. All these disadvantages have served to entrench a technology lock-in situation which the solar water heating sector has found difficult to penetrate.

The period since the start of the electricity crisis in South Africa in 2006-2008 saw increased activity in the solar water heating sector and in policy formulation. In South Africa and Botswana, new building regulations incorporating energy efficiency were published. It is not yet clear to what extent these changes were either influenced by the crisis or a reflection of changing in attitudes and perceptions towards the principles of sustainability and solar water heating. What is clear is that it was an anticipated step in a co-evolutionary pathway in the transition to sustainability under non-linear complex systems dynamics.

In addition, the changes indicate that the initiatives prior to 2008 were predominantly based on the rational-agent decision making model. The initiatives were characterised by scientific research and pilot projects under an assumption that people will respond to statistics and empirical proof of the merits of solar water heating once all the data and knowledge has been systematically consolidated and disseminated. The eventuality of the 2006 – 2008 electricity crisis and the resultant flurry of policy and market interventions poses significant doubt on the rational-agent assumptions while also bringing to the fore the fallacies which sustainability transformations must acknowledge and respond to.

1.11 Statement of the research problem and research question

1.11.1 Overview

As a decision making tool within a society which prioritises privatised economic benefits, cost-benefit analysis (CBA) has been criticised for under-valuing social and environmental costs and benefits and thus reinforcing behaviour/lifestyle choices which transfer adverse costs of current human production and consumption activities/lifestyles to future generations. On the other hand, the principles of sustainability call for a balanced production and consumption

lifestyle which promotes equal premium for environmental and social benefits as well as equitable allocation of associated costs within and among generations. In its diverse forms, formal and informal CBA has a significant influence on choice and decision making in public and private sector projects, policies and programmes. These decisions impact heavily on the goals and principles of sustainability which in turn impact heavily on the quality of life for current and future generations.

The goals and principles of sustainability principally address the obligation of the current generation to itself as well as to future generations regarding availability of resources, a clean environment and better quality of life for all. Sustainability also advocates for equity through consultation in decision making. The practice of evaluation in CBA (comprising conventional and evolved CBA) is contradictory because it assumes decision making based on a model of a human being who is rational, logical and consistent, and applies the revealed preference principle (Cullis and Jones, 2009:487). In reality however, human decision making can often be emotion-driven, inconsistent or 'predictably irrational' (Ariely, 2008) and subject to bounded rationality (Selten, 1999:4), which refers to the scale of cognitive behaviour between full rationality as assumed in economic theory and extreme *irrationality* (Section 1.3 and 1.8).

The basic assumption in the economic and by extension CBA approach to evaluation is that a utility maximising rational-agent model has evaluated and valued (that is analysed, compared and assigned value ratings) utilities or available options and thus makes a choice decision that would maximise their positive utility and minimise the negative utility. Through psychology and neuro-science, this assumption has been proved to have no empirical basis. Instead, a subjective, behavioural-based model that is closer to natural behaviour patterns is advocated. This would in turn place full recognition of emotional and culturally-induced biases towards decision making in economics and other fields (Section 1.2).

Taking sustainability as one of the critical challenges facing humanity today, both at individual and collective level, and taking into account the slow transition from conventional production and consumption patterns which escalate sustainability risks, the rational-agent model issue is once again brought into focus. In particular, whereas the rational pathways have been systematically articulated, the systematic interpretation into responsive action/behavioural change is not materialising fast enough. If we know the risks and threats of business-as-usual behaviour and we can cognitively perceive possible mitigation response actions, why does humanity (at individual and collective levels) remain stuck on the unsustainable action/behaviour pathways? How would prospect theory and related aspects of neuro-economics explain this dilemma of inaction in face of full cognitive/conscious understanding of the implied risks and threats to our survival?

1.11.2 Objectives of the study

This study uses themes from the decision making behavioural tendencies or heuristics described in prospect theory and neuro-economics (Sections 1.3 and 1.8) to trace the origin or basis of the differences in approach and the consequent inadequacies of CBA evaluation in facilitating transition towards sustainability (Section 1.2). The key heuristics are described in detail in Section 1.3 and summarised in Table 3.2.

Based on prospect theory, behavioural economics and related neuro-economics perspectives, this study explores the underlying weaknesses in the link between the principles and practice of CBA evaluation and the goals and principles of sustainability, and how these weaknesses impact on the transformation process towards improved and sustained well-being for current and future generations. The primary objective of the study is to understand the key differences between the outcomes of evaluation in CBA relative to the objective of equitably valuing public and private projects, with the goal of facilitating transformation towards sustainability.

The study applies a prospect theory and related neuro-economics approach to investigate and substantiate how contemporary CBA evaluation practice imposes a bottleneck to the transition to sustainability by reinforcing status-quo decision outcomes, which contradicts empirical evidence of human decision making, thus frustrating a faster transition process. It is based on the assumption that CBA evaluation shares a common goal with the principles of sustainability to ensure fairness in the allocation of resources, equitable evaluation of choices and opportunity costs and hence improved welfare for humanity within and across generations.

Using examples from the solar water heating sector and selected projects in South Africa and Botswana, the study applies approaches from prospect theory, bounded rationality, behavioural economics and neuro-science to examine the decision-making process in the sector at policy, project and programme level in order to ascertain the extent and manner in which the goals and principles of sustainability are influenced, contradicted or undermined by CBA evaluation theory, principles and practice.

The study contributes to knowledge in the first instance by identifying, demonstrating and extending the link between prospect theory, behavioural economics and neuro-economics with CBA evaluation and the sustainability paradigm. The study also highlights the understanding that, both CBA evaluation and sustainability assessment tools need to go beyond the rational-agent model paradigm and deepen their principles as well as practices within prospect theory behavioural heuristics, as well as neuro-economic mechanisms that would catalyse faster change towards the required sustainability transition.

1.11.3 The research question

The study seeks to substantiate the following research question:
"*How does choice and decision making through CBA evaluation influence status-quo decision outcomes relative to the goals and principles of sustainability and how does this impact on the transition towards sustainability?"*

The preceding introductory discussions in this chapter lead to the view that CBA evaluation and the goals and principles of sustainability share and seek to address a variety of common fundamental issues. As indicated earlier, they share a common goal of ensuring improved welfare for all including fairness in the allocation of resources and that choices, including opportunity costs, are appraised for equitably responsive development outcomes/impacts. They also seek to appraise policies, programmes and projects in a manner that corrects for inadequacies in market mechanisms.

Arising from the background understanding of the previous sections, it is reasonably assumed that an evolved CBA evaluation practice would address concerns of inadequacies in conventional CBA to evolve tools or methods that will adequately support the goals and principles of sustainability. This expectation is especially critical given the constraints in CBA practice with regard to valuation of positive and negative externalities and assessment of equity impacts of programmes, policies and projects. It is acknowledged that the transformation process in sustainability and CBA evaluation is complex and will inevitably take a non-linear co-evolutionary path (Section 1.6). It is also acknowledged that sustainability assessment is similarly caught up in the same trap of assuming the rational-agent model approach to choice and decision making in its assessment and evaluation frameworks especially through its emerging pursuit of objective science-oriented principles and practice. The shared objectives are more clearly observed in the step-by-step CBA evaluation process and sustainability assessment criteria as elaborated in Section 1.4, Appendix 1 and Appendix 2.

On the one hand, both tools (CBA evaluation and sustainability assessment methods) are concerned with guiding the process of choice and decision making when faced with options in a context of risks and uncertainties. It is noted that the theoretical basis of evaluation and practice in CBA does not allow for uncertainties because the rational-agent model is assumed to have all the information at hand (and has infinite capacity of processing and interpreting such

information). On the other hand, one is faced with the challenge of applying this explanation or understanding pro-actively and speculatively so as to reach a decision concerning expected future options. This is referred to as choice under risk and uncertainty, the context in which the rational-agent model of classical and neo-classical economics is required to make decisions speculatively without all the information. It is clear that the rational-agent model cannot be trusted to always work to the benefit of either evaluation in CBA or the principles and goals of sustainability. This is where behavioural economics and prospect theory become relevant.

This study is anchored on the key choice and decision making heuristics as defined in prospect theory (Section 1.3 and Table 3.2). The study analyses the fundamental methodologies and tools applied in CBA evaluations and practice, as well as the principles of sustainability, from a behavioural economics and prospect theory perspective. The study goes further to evaluate how evaluation in CBA responds to criticism emanating from the principles of sustainability and how the subsequent tools and methods conflict with the reality of decision making as defined by behavioural economics and prospect theory. Cullis and Jones (2009:487-488) classify the behavioural tendencies in prospect theory in 3 groups: (i) influence of the past (ii) influence of the present and (iii) influence of the future.

Based on these key themes, the study then derives the following research sub-questions:

(i) What are the key differences and contradictions in empirical practices in choice and decision making as explained under behavioural economics and prospect theory versus explanation under the theory and practice of CBA evaluation relative to the goals and principles of sustainability?

(ii) Do these differences and contradictions demonstrate a systemic pattern of conflict which could explain constraints in the transformation from status-quo towards sustainability?

1.11.4 Working hypothesis and definition of key concepts

In order to achieve the objectives and substantiate the research questions, the study was guided by the following working hypothesis as derived from the key themes and attributes that link behavioural economics and prospect theory, evaluation in CBA and sustainability. The working hypothesis was conceptualised as follows:

> *From a bounded rationality perspective (as elaborated under behavioural economics, and prospect theory and neuro-economics), CBA evaluation principles and practice implicitly place an opt-out bottleneck in favour of status-quo and consequently reinforces an opt-in bottle-neck towards sustainability and thus constrains the expedited transition to more sustainable production and consumption lifestyles for individuals and collectives.*

The solar water heating case studies in the context of South Africa's electricity crisis (prior, during and after the onset of crisis) constitutes a rich empirical context for the substantiation of this argument.

Arising from a bounded rationality perspective, the primary assumption related to the working hypothesis is that 'you (your System-2), cannot value consciously/explicitly or rationally that which you (your System-1) cannot access and assess emotionally'. In other words, you cannot value explicitly that which you cannot value intrinsically.

The key concepts underpinning the study are defined as follows:

Bounded rationality: The paradigm of the rational-agent model emerged during an era when available scholarly knowledge (especially introspectively-based philosophy) assumed a transcendental mind which was externally endowed to the body, and therefore not a product of the body. It was thus easy to conceive and idealise the possibility of unlimited capacity to access and evaluate all

relevant information for choice and decision making through pure reason and logic. In modern cognition and neuroscience (including the study of consciousness and mind), the mind has been re-embodied through the coupling of well understood body-brain anatomy and physiology. This has now emerged as the strongest reinforcement of a bounded rationality paradigm, which was conceptualised in the mid-20th century, especially by Herbert Simon and his colleagues. In its simplest expression, the paradigm locates choice and decision making within the body (including the brain as part of the body), and therefore subject to the constraints the body imposes as the mechanism of information processing and knowing. The key constraints noted are finite brain/mind capacity, finite information (information comes at a cost), finite time (choice and decisions have to be made within time limits/constraints which are not always flexible). It is within these constraints that the concept of bounded rationality was postulated by Herbert Simon and subsequently empirically extended by prospect theory and neuroscience studies in the last forty years.

Choice architecture: This is the configuration and the manner in which choice options are structured and framed in the process of being presented/accessed for evaluation. In recognition of irrational patterns where choice and decision-making are influenced by the manner in which choice options are presented, the choice architecture concept (systematically developed under the *nudge*-strategy) argues for a responsive framing of choice options in a way which biases for the more desirable option as the default or most likely choice. Such an approach (as advocated under *nudge*), would be in total contrast to the rational-agent approach based on a neutral/objective information where the manner in which the information is presented would have no significant effect on the choice outcome.

Cost benefit analysis (CBA) is an economics-based strategy for facilitating the evaluation of alternative options (in policy, programmes or projects) in order to prioritise the most effective, relative to the goals and objectives identified. The objective of the tool is to facilitate decision making in which the policy, programme or project choice with the highest level of net benefits or lowest level

of net costs are achieved (Brent, 1996:4; Cullis and Jones, 2009:162-163). In this study it can be defined as the process by which streams of costs and benefits in policy, project or programme options are identified, categorised, quantified, and compared to determine the holistic viability of the different policy, project or programme options. In addition, this study adopts the view that evaluation in CBA is underpinned by a value system that is heavily influenced by economic theory, particularly the rational-agent model of human behaviour and especially the revealed preferences theory. On-going CBA revisions attempt to address concerns raised over the last two decades regarding the inadequacies of conventional CBA especially in evaluating environmental and social aspects of policy, project and programme options. In the subsequent sections of this study, the term 'CBA evaluation' refers to 'conventional and evolved CBA evaluation'.

Discount rate: In literal terms, discount means not-to-count or count/measure/value comparatively less or underweight an option. When applied in a time context (present versus future for example), the correct term is intertemporal discounting which is the intended meaning assumed in this study. Events/options (positive or negative) happening close to present tend to be overweighted (valued more) compared to similar events/options occurring in a more distant future, which are thus underweighted, valued less or taken to count for less. Discount rate is a quantitative measure of the extent of the dis-count. A high discount rate means an event/option is being taken to count for less compared to a low-discount rate scenario. In neoclassical economics (and in CBA evaluation as well), the intertemporal discount rate is assumed to be constant across all time periods, whereas in behavioural economics or prospect theory, intertemporal discounting has been established to vary inconsistently over time. This has been captured under the hyperbolic discount rate theory. In CBA evaluations, the discount rate is used as a standardisation tool to derive present value of future streams of costs or benefits arising from alternative policy, project and programme options whose benefits and costs only arise at diverse times/periods in the future. One of the key concerns around the discount rate in relation to sustainability is that there is no objective and rational method of determining a

suitable rate. Instead, it is subject to a variety of biases. In modern times for example, individuals and collectives opt for higher discount rates (thus underweighting future eventualities) and tend to overweight for immediate benefits and underweight future benefits and costs, especially externalities.

Evaluation: Assessment of choice and action options for fitness-to-purpose/goal with the status-quo as the reference point (normally also referred to as the baseline). Although evaluation takes this connotation in most instances (and this is the intended meaning in this study), evaluation can also happen as a post-facto process (following a choice/decision/action) with feedback-on-outcome-relative-to-initial-goal as the secondary objective. Given the complexity of choice and decision-scenarios in daily life, and the finite capacity of our brains to resolve such complexities, we often resort to simplified versions/models of the complex scenarios which then allow for simple solution-seeking approaches to guide us to a choice/decision/action outcome. It is this process which constitutes the heuristics strategy as investigated under prospect theory, and especially when such heuristics lead to outcomes/choices which are inconsistent with our "best-interest" when viewed from a rational-agent perspective. Although evaluation happens under any choice scenario, the common understanding as applied in this study is based on the formal process and techniques where rational-model approaches such as formal CBA and sustainability assessment are applied.

Heuristic: In the context of this study, heuristic is taken to be an almost automated- answer approach to a simplified version/model of a more complex cognitive problem of the type humans consistently encounter in life's experiences, especially where no clear/simple solutions exist. The key highlight of relevance to this study is that heuristics (and hence satisficing approach) have been empirically demonstrated to be the most prevalent method in choice and decision-making in most life-contexts as opposed to the rational/objective and optimising approach assumed in most disciplines, especially in neoclassical economics. As argued in prospect and nudge theory, it seems that when confronted with a complex problem (especially with risk and uncertainty involved), our System-2-cognition re-

structures the problem into a simpler version/model (the heuristic), which can be handled almost automatically (and thus effortlessly) through System-1 thinking (most often subconsciously). It is in the course of this process/cycle when subconscious biases and irrationality can manifest, thus resulting to behaviour (choice and decisions) which contradict the rational-agent model expectations.

Intergenerational equity refers to the need for equitable distribution of economic development benefits and related costs across current and future generations as opposed to the prevailing practice of accruing benefits to the present generation and deferring costs/dis-utilities to future generations (with climate change as one principal example). Evaluation of policies, projects or programmes, therefore need to apply systematic criteria which includes assessment of such equity across generations. This is referred to as the long-term equity perspective.

Intragenerational equity is similar to intergenerational equity but applies to different groups within the current generation. This can also be referred to as the short-term equity perspective.

Irrational: In contrast to its every-day connotation of impulsive behaviour (which is equally mistakenly assumed to arise from uncontrolled/unbridled emotions), the use of this term in the study takes its meaning to be the contrast of rational-agent model behaviour expectations. This is the understanding normally used when the term is applied in behavioural economics. The primary purpose for using the term is therefore to highlight the inconsistencies between empirical-based behaviour outcomes compared to what the rational-agent model hypothesis would lead one to expect out of a given choice and decision scenario, especially where such choice and decision is happening under risk and uncertainty conditions. In attempts to explain such inconsistencies (the cause of the irrationality), behavioural economics, prospect theory, cognitive science and neuroscience scholars invoke the bounded rationality constraints and the related coping mechanism which the brain uses in the form of heuristics and their underlying subconscious processes of which a major part of them are emotionally-guided.

The key implication of the empirical studies has been to redeem emotions and feelings as critical brain/body processes for choice and decision making with survival and self-preservation as the primary goal and then socio-economic and cultural functioning as secondary/sublimated goals.

Mental accounting: Empirical behavioural economics studies have established that, in several instances, the value-neutrality and consistency of money (a dollar is a dollar is a dollar) does not hold and in such cases, similar money units get inconsistently different value attributes. For example, for the same consumer, a discount of R10 on a R100-purchase is more likely to be assigned a higher value compared to a saving of R10 (same absolute level of saving) in a purchase of a R10,000 item. Why does the discount shine in the first instance and pale-off in the second even though the actual denominational amount is the same? Prospect theory argues that this arises out of a mental accounting process where secondary entailments (very often System-1 mediated) enter into the evaluation process. Given that there is a certain level of emotional-processing involved, one could even be tempted to term this as 'gut accounting' (to guard against a simplistic mental-arithmetic meaning of mental accounting). This would then mean that one is actually evaluating/accounting instinctively and arriving at a very different outcome compared to what one would anticipate from a rational-agent model. In a similar context, losing R100 where the money accidently drops out of my pocket unnoticed counts as a totally different loss/dis-utility (and therefore possibly more bearable) compared to losing similar amount due to cheating or fraud by someone else. The latter scenario will most likely feel worse (sensed as higher dis-utility from the loss) because it becomes loaded with (or entailed to) the more sinister meaning/feeling of "I was outsmarted", thus evoking a more hostile gut-reaction, which could end up being somatically-marked for future reference as argued by Damasio (1994).

Neuro-economics is an interdisciplinary approach to the study of value, choice and decision making based on empirical research in both behavioural psychology as well as biological studies focusing on brain processes (neuro-science) under

different choice/decision contexts. Such studies extend the concept of economics from its contemporary socio-cultural and humanly-familiar territory to its evolutionary roots where homeostatically-informed value-of-a-stimulus served as the primary guide for action with survival and self-preservation as the primordial goal. Neuro-economics views contemporary understanding/practices in economics as a case of cultural adaptation (sublimation) of the originally-biological survival instincts. When coupled with behavioural economics, neuro-economics attempts to explain the contradictions and inconsistencies observed between rational-agent based expectations of choice and decisions (as assumed in neoclassical economics) versus the predictably irrational outcomes normally observed empirically.

Opt-in and opt-out: According to Kahneman (2003:1459) and Thaler and Sunstein (2006:8), human *inertia* inevitably biases choice and decision-making towards the *status-quo* as the *default option* and thus biasing against options which call for change-effort under scenarios of either exiting the status-quo option and entering into an alternative option. Opt-in and opt-out choices are defined in reference to a default-choice. In this study, the status-quo (contemporary unsustainable lifestyles) serves as the reference scenario (do-nothing option) which needs proactive choice to exit (opt-out) while sustainable lifestyles serve as the desirable choice option which needs to be proactively selected for (opt-in). Under nudge theory, the ideal choice architecture would be when sustainable lifestyles presents as the default option from which actors have to proactively select to opt-out.

Prospect theory is a psychology-based and empirically verified (through replicated experiments) explanation of how individuals make choices and decisions in the context of risk and uncertainties. It helps us to understand the motivation, logic and behaviour behind decision outcomes (Section 1.3). This is in contrast to the rational-agent explanation which has been handed-down through the past 500-years of western knowledge (since the enlightenment), and originating introspectively from philosophy. The contradictions between the two

models of human behaviour have been systematically/empirically studied in the last 50-years under different themes, of which prospect-theory is but one of them. Other approaches used include behavioural economics (bounded rationality) and neuro-science/neuro-economics. Although the contrasting approach of morals, ethics and social-values (as studied in philosophy for example) had been considered as a possible theoretical basis for this study, it was not adopted because its explanatory capacity on the behaviour observed within the empirical case study was deemed to be weak.

Satisficing: In this study, the term is used in its bounded rationality context meaning where satisficing (as opposed to optimising assumed in rational-agent model as applied in CBA and neoclassical economics) is the primary strategy to evaluation for choice and decision-making in real life contexts. In complex choice and decision-making scenarios, especially under risk and uncertainty conditions, it is the first few satisficing options which attract further attention for prioritisation and final decision. Due to bounded rationality constraints (as defined elsewhere in this section), decision makers never aspire nor practice value optimisation as the basis of the choice and decisions they make. The optimisation-delusion espoused under rational-agent model, possibly arises from the perception of thorough evaluation of the set of prioritised options. However, the prioritisation process itself which takes place before the thorough evaluation could not be equally thorough either in exhausting all options or accessing all the relevant information to guide the prioritisation. Even after prioritisation of a couple of options, decision-makers do not aspire to exhaust all possible information related to each option before they can proceed and conclude the evaluation. Given these two scenarios then, satisficing rather than optimising constitutes the more convincing choice and decision-making strategy.

Sublimation: Although not a core term in this study, sublimation is of secondary significance in that the growing pursuit of re-embodied (as opposed to transcendental) mind and consciousness (as investigated through cognitive and neuroscience) brings back the notion of the biological coupling and relevance of

socio-cultural values. Within such a paradigm, a diverse range of socio-cultural practices and behaviour can be argued to be evolutionary-guided re-purposing of innate biological drives. Family and marriage for example (including the related values, morals and norms) can be viewed as a culturally-attuned sublimation of the basic biological drive of reproduction. It is within this context that the cognitive and neuro-science (especially neuro-economics) link to CBA evaluation and sustainability assessment can be postulated.

Sustainability is a concept that has several defining qualities. In this study, sustainability broadly refers to a paradigm that recognises, advocates for and is concerned with (i) continued, indefinite survival of the human race (ii) continued improvement in the well-being of the human race (iii) continued improvement in the equitable distribution of benefits from economic growth within and among generations and (iv) continued improvement in mitigation of costs and externalities associated with the improvement in well-being. Elaborated definitions are found in Section 1.2. In particular, this study focuses on the goals and principles of sustainability which require that decision making for policies, projects and programmes shows responsiveness to these concerns by incorporating strategies towards achieving social/cultural equity, ecological/environmental conservation, intra-generational and intergenerational equity.

Valuing is a process originating from the biological imperative of homeostasis where both internal and external stimuli are constantly assessed for their significance relative homeostatic responses/action (with survival and self-preservation as the primary goals). Through socio-cultural sublimation, valuing takes a secondary economic dimension of utility with the goal of assessing economic stimuli for utility optimisation or dis-utility minimisation. Although the ultimate evolution towards monetary/financial measure as the common standard of assigning value today might seem remote from the homeostatic/biological origin, the logical connection constitutes one of the critical lines of investigation in neuro-economics and neuro-science. In particular, the dynamic neural pathways

which facilitate "old" and "new" brain centres of homeostatic regulations and their correlation with centres of contemporary valuing (monetary or otherwise) constitute the primary focus in neuro-economics. Although the study primarily applies the contemporary understanding of the term as used in CBA evaluation, the link with prospect theory and behavioural economics calls for this background awareness of the biological and evolutionary root/significance of valuing rather than assuming that it is purely a cultural artefact/tool cleverly crafted by a superior/smarter human species. In the context of this study, ***'valuation'*** is the process of assessing or estimating the value or worth of an asset or possible line of action as a facilitation towards making choices and decisions. Valuation is part of the evaluation process even though in several instances the two might appear to be taking place simultaneously – one is aware of valuation as an integral component of CBA evaluation and consequently, the process is often structured to allow for verifiable valuation outcomes as a perquisite of an effective/meaningful evaluation.

1.12 Delimitation of scope

In the recent past, numerous critiques on CBA evaluation in relation to the goals and principles of sustainability have been published. Such critiques have been developed by economists, environmental economists and environmental scientists such as Martin Weitzman, Frank Ackerman, Clive Spash, the late David Pearce and others (see for example Spash and Hanley, 1995; Ackerman and Heinzerling, 2004; Pearce et al., 2006; Aldred, 2009; Gollier and Weitzman, 2009; Hanley and Barbier, 2009; and Weitzman, 2009). While the findings of this study strongly resonate with such previous critiques, its special knowledge contribution is the enquiry into the relevance of prospect theory as a psychology-based premise of choice and decision making, with solar water heating sector in southern Africa as the empirical context of the enquiry.

This study is premised on the view that prospect theory, behavioural economics and neuro-economics can systematically explain why and how the theory and

practice of CBA evaluation significantly contradicts the goals and principles of sustainability and thus continues to undermine the process of transformation to sustainability. One key area where this can be effectively demonstrated is in solar water heating prior-to, during and after the onset of the 2006 – 2008 electricity crisis in South Africa. Despite what appears to be overwhelming evidence (rational knowledge) that solar water heating is the more appropriate choice for heating water from a technical, social and environmental perspective, it had not gained visible acceptance in the market prior to the 2006 – 2008 power crisis, mainly because the conventional financial/economic evaluation consistently yielded a negative outcome. This contradiction in choice and decision outcomes made the solar water heating sector and projects ideal case studies with which to interrogate and substantiate the working hypothesis.

Due to resource and time constraints, the study only focused on case studies from South Africa and Botswana. The proximity of institutional solar water heating projects in some major cities within the two countries and an assumed similarity in the influences to decision-making processes made the two countries ideal choices for the study. Both countries face similar energy challenges and both have made good progress on formulation of policies for renewable energy and energy efficiency. They also rely on the same pool of coal-based primary energy source and are heavily dependent on Eskom for their electricity supply.

Detailed technical evaluations of solar water heating technology options were deliberately omitted from this study because it was assumed that initial decisions to install or not to install a solar water heater are not significantly influenced by the type of solar water heater. The question of direct or indirect, low pressure or high pressure systems would be of secondary importance in the core decision of whether or not to install the system especially as an alternative to the electric geyser.

In addition, this study does not attempt to prove or disapprove the feasibility of solar water heating during the period covered in the study, nor is it primarily a

comparative evaluation between solar water heating and alternatives such as electric geysers or heat pumps. Solar water heating projects were only applied as the empirical context for the substantiation of contradictions and differences between CBA evaluation and sustainability, and how this undermines the process of transition to sustainability based on the well-motivated assumption that solar water heating has stronger sustainability merits compared to electric geysers relying on coal-generated electricity. Consequently, in an economy where electricity is primarily from renewable sources such as solar photovoltaic, solar-thermal, wind or hydro-generated, such an assumption can be challenged.

Initially, institutional solar water heating projects were presumed to have more reliable records and structured decision-making processes and were therefore prioritised initially relative to domestic installations. However, in the course of the study, it became evident that solar water heating projects in most of the institutions relied more on the initiative and drive of particular individuals within the management structures rather than on formal protocols. Attempts to investigate domestic solar water heating projects were hampered by precaution among solar water heating suppliers not to release the contact details of their customers to third-parties. Secondary data on decision making processes in the policy-making and supply-side components of the solar water heating sector were found to adequately bridge this data gap.

Among the various studies accessed on solar water heating, only a limited number of them satisfied the criteria for a formal cost-benefit analysis. For example, although Kaldellis et al. (2005) is referred to as both a feasibility study and a cost-benefit analysis, it does not follow the common step-by-step method for cost-benefit analysis and was therefore difficult to analyse in the context of the study reported. Similar problems were experienced with Nguyen and Pryor (1998). Diakoulaki et al. (2001) however, considers all the major aspects applied in evaluation in CBA and was therefore reviewed in this study (Section 2.3).

This study focuses on the subjects of cost-benefit analysis and sustainability as they undergo a co-evolutionary non-linear dynamic process which effectively makes them interactively coupled, with feedback loops from one to the other. Equally, there has been a tremendous shift in the energy sector in southern Africa between 2005 and 2010 primarily due to a sudden and seemingly unexpected electricity crisis that started in the Western Cape province of South Africa in 2006, later spreading to other cities of South Africa and to neighbouring countries that have traditionally depended on South Africa for electricity supply. Although the crisis eventually stabilised after 2008, the repercussions are still unfolding and therefore the full impact of the crisis falls beyond the scope of this study. For purposes of the study in particular, it was difficult to immediately determine the resultant full impact of the crisis on CBA evaluation and sustainability assessment in subsequent policy, project and programme options. Similarly, the shift in the trend on decision-making in the solar water heating sector can only be highlighted as one of the opportunities for follow-up studies to serve as an extension to the findings of this one.

1.13 Structure and organisation of the thesis

The study is broadly structured in three parts: (i) introduction, theoretical framework and methodology in Chapters 1, 2 and 3, (ii) data analysis and interpretation in Chapters 4 and 5 and (iii) discussion of findings, summary and conclusion in Chapters 6 and 7.

Chapter 1 provides the background, context and motivation of the study. It briefly introduces the key elements beginning with the evolved meaning of the concept of sustainability, what it represents in current discourse, focusing on the risks created by on-going human production and consumption and how this threatens human wellbeing and survival. This is followed by an overview of behavioural economics and prospect theory, which provides the theoretical anchor of the study.

The introduction to cost-benefit analysis (CBA) highlights its background and objectives, and its adaptive co-evolutionary process over the last two decades, especially in response to sustainability assessment and related feedback loops. It highlights the conflict with decision making behaviour under prospect theory and related neuro-economics, based on the challenge to the rational-agent model, which forms the economic foundation of evaluation in CBA. This leads to a brief review of the co-evolution and complexity theory and the evolution of attitudes and value systems which has created the dominance of economic values to the detriment of social and environmental values in contemporary society. The study then presents a brief introduction of the concept of bounded rationality and the role of emotions and perceptions in choice and decision making, within the context of evaluation in CBA and the principles of sustainability. The introductory part of Chapter 1 concludes with an overview of renewable energy and energy efficiency technologies as well as electricity and solar water heating in South Africa. These are discussed in the context of their role in promoting or undermining the transition process towards sustainability.

The foregoing introduction is then contextualised into the statement of the research problem which leads to the formulation of objectives of the study and the research question. This section also includes operationalization of the research question, formulation of a working hypothesis and definition of key concepts. The chapter concludes with sections on delimitation of scope and structure of the thesis.

In Chapter 2, the study reviews the literature on the key concepts and themes of the study including CBA, sustainability, prospect theory and the co-evolution and complexity theory which is used in the study to illustrate the transformation process in evaluation in CBA and sustainability. The chapter also includes a brief review of the application of CBA using an example of solar water heating assessment in Greece. The review concludes with a comparative analysis of the key attributes of evaluation in CBA vis-à-vis the goals and principles of sustainability, within a prospect theory perspective.

Chapter 3 begins with a brief overview of epistemology and knowledge creation, restatement of the research problem, research question and working hypothesis. Data required to substantiate the hypothesis and the appropriate data collection methods are identified. This is followed by a description of the data analysis process and method including interpretation, reliability and validity.

Chapter 4 is a presentation, analysis and interpretation of data on patterns of decision making relating to policy and the market dynamics for the solar water heating sector in South Africa. The decision making patterns are analysed in relation to themes from behavioural economics and prospect theory. Similarly, Chapter 5 is a presentation, analysis and interpretation of data on decision making in selected solar water heating projects in South Africa and Botswana. The decision making patterns are also analysed in relation to themes from behavioural economics and prospect theory. Chapter 6 is a consolidation of findings arising from the interpretation of data in Chapters 4 and 5, linked to the theoretical framework in Chapter 2 and also providing a linkage with the introductory sections of the study in Chapter 1. Chapter 7 summarises and concludes the study.

Appendix 1 is an adaptation of the step-by-step procedure for evaluation in conventional CBA and also the summarised steps for an evolved evaluation in CBA. Appendix 2 is a generic criteria for assessing or measuring sustainability as adapted from diverse sources. Appendices 3 to 10 list the interview questions and transcripts of their respective answers for the solar water heating case studies. Appendix 11 is a collection of comments from South African readers responding to internet articles on the Eskom solar water heater rebate programme and its anticipated impact on the solar water heating market.

Appendix 12 is an extract of communication between Eskom and the KwaZulu Natal Department of Public Works illustrating the nudge tactics applied by Eskom to promote the installation of solar water heaters in government staff housing projects. Appendix 13 is a list of people interviewed for this study representing

various role players in the solar water heating sector in southern Africa. In order to comply with ethics regulations, extracts were sent to individual interviewees who were quoted directly in this study and their respective consents have been granted. Appendix 14 provides a brief definition and illustration of the standardization and discount rate statistical methods used in Table 4.1, Chapter 4.

Chapter 2

Literature review and theoretical framework

2.1 Overview

The research question focuses on a perceived contradiction between cost-benefit analysis (CBA) evaluation based on the economics model of the rational-agent and the goals and principles of sustainability, and the implications of such contradictions on the transformation towards sustainability (Sub-section 1.11.3). The contradiction can be traced to failure of contemporary society to effectively respond, sometimes to the extent of scepticism, to the survival challenge presented by resource depletion, global warming and climate change. This situation is further reinforced by continued reliance on the rational-agent model and revealed preference assumption in CBA evaluation, which is deemed to be without empirical merits from a prospect theory perspective.

In this Chapter, the choice and prioritisation of the literature reviewed was based on ability to easily substantiate on the connection between the core prospect theory and bounded rationality concepts to CBA evaluation and sustainability in order to frame the theoretical basis of the study. The primary purpose of the literature review can therefore be summarised as follows:

- To theoretically contextualise the study question through systematically identifying the core arguments of prevailing understanding in the fields identified. Through this process, the review expounds on the underlying assumption that prospect theory, bounded rationality and neuro-science have a stronger explanatory capacity on our stalled transition to sustainability and that CBA evaluation reinforces the stalling by explicitly reinforcing well-understood but subconscious biases in choice and decision-making under risk and uncertainty.
- To provide prior context for the contextualisation of the research design and method as further substantiated in Chapter 3.

The key themes covered under the literature review are:

- **The economic foundation of CBA:** There is a vast body of literature on CBA evaluation ranging from simplified practical guides for beginners (Anderson and Settle, 1977; Levin, 1983) to complex econometrics (Brent, 1996; Mishan and Quah, 2007 and others). An overview of a variety of perspectives from various authors (Anderson and Settle, 1977; Bojo et al., 1992; Brent, 1996; Conningarth Economists, 2002; Perman et al., 2003) is presented with the objective of clarifying the rational-agent model assumptions which underpin CBA as adapted from economics. The primary aim of the review under this theme is to expound on the tendency towards oversimplified linear-model of cause-effect type in conventional CBA evaluation versus the upfront acceptance of bounded rationality (finite mind, finite information and finite time) in alternative theories.
- **Application of CBA for solar water heating in Greece:** A case study on Greece from Diakoulaki et al. (2001) is reviewed to highlight the practical problems of incorporating externality costs and benefits into CBA. This is primarily aimed at contextualising/highlighting the bounded-rationality/satisficing argument in choice and decision making under risk and uncertainty.
- **The sustainability debate:** Mawhinney (2002) is reviewed briefly for an analysis of the attributes and key principles of the sustainability debate. Ekins (1997), Ekins (2011), Andersson et al. (2008) and de Lange et al. (2008) are quoted for an argument on the justification of sustainability and recent evolutionary trends in sustainability science. The prevailing linear and rational-agent model approach in sustainability literature is further highlighted even though it is fundamentally argued that the field entails non-linear interactions and dynamics.
- **Prospect theory and decision making:** Prospect theory explains how people make choices and how they arrive at decisions when faced with uncertain outcomes (Sub-section 1.10.3). The combined literature review and theoretical

framework follows the original experiments and studies of Kahneman and Tversky (2000), Hastie and Dawes (2001) and Eysenck (2001), with later perspectives, including the two-system thinking from Kahneman (2003), Ariely (2008), Thaler and Sunstein (2008) and Kahneman (2011) among others. In addition, Bernstein (1996), Lewis (1997), Eysenck (2001) and Hastie and Dawes (2001) among others are reviewed to illustrate another perspective of human decision making behaviour, referred to as modern decision theory, which has elements that reinforce prospect theory and the two-system thinking, while Bernstein (1996) adds insight into *mental accounting*.

2.2 The economic foundations of conventional CBA

Cost-benefit analysis (CBA), which is sometimes referred to as benefit cost analysis (BCA), has its origins in welfare economics (hence its similarity with sustainability) but is also a fundamental principle in the theory of choice which is at the core of the subject of economics. Initial theories and literature on CBA tended to emphasise its exclusive and formal application in the public sector policy decision making with focus on social benefits and costs. CBA is presented as the tool that adequately satisfies the needs of evaluation in decision making incorporating economic, social and environmental costs and benefits. The distinction between CBA and profitability or cost-effectiveness analysis (as in private sector project viability evaluations) is no longer prominent and CBA is now used in evaluating not only public sector policy/programmes but also, to a lesser extent, private sector projects (Harding, 1998:145; DEAT, 2004:4), where it blends with other techniques such as life-cycle cost analysis and return-on-investment appraisals.

Brent (1996:4) defines the key objective of the CBA evaluation as to "…maximise the present value of all benefits less that of all costs, subject to specified constraints". This definition emphasises the aspect of bringing together the streams of future costs and benefits to one point in time, and thus links to the concept of net present value (NPV) as the principle method applied to normalise

or standardise the various streams. Other additional normalisation techniques include the internal rate of return (IRR) or economic rate of return (ERR) and the benefit-cost ratio (B/C ratio) (Conningarth Economists, 2002:45).

A more contemporary definition is provided by Perman et al. (2003:351), who see CBA as simply "the social appraisal of investment projects". According to Perman et al., this means that the evaluation is conducted in accordance with criteria derived from welfare economics rather than private-sector oriented commercial criteria and that it attempts to appraise investment projects in ways that make adjustments for market failure, which is also what sustainability aims to address.. Perman et al. (2003:351), make the observation, alluded to earlier, that the common practice of generally relating CBA to non-commercial projects need not always be the case. The reference to social appraisal is nevertheless untenable considering that in practice CBA evaluation heavily applies economic theory, tools and processes, with social and environmental considerations appearing only in its recent stages in theory and practice.

For the purposes of this study, the most appropriate definition is provided in Diakoulaki et al. (2001:1728) who describe CBA as providing "the methodological framework which allows for an overall evaluation of projects and policies by taking account of all cost and benefit parameters, both those referring to the investment party itself (private cost or benefit) as well as those attributed to the external economic and natural environment".

The valuation of costs and benefits with no explicit monetary/market-prices vary according to the type of decision options and the required scope of the CBA evaluation. As the commonly applied approaches, techniques such as opportunity cost, willingness to pay (WTP) and willingness to accept compensation (WTA) have been argued to be inadequate in assessing true value due to the bias created by emphasis on monetisable value while underweighting other values such as social and environmental costs and benefits. Other approaches recommend

application of both private and social-environmental appraisals in CBA valuation for evaluations (Perman et al., 2003).

Conningarth Economists (2002) acknowledge that current CBA methods are in the process of evolution and are therefore continuously undergoing refinement. They also acknowledge that it is necessary to widen the scope of CBA to include broader social costs and benefits derived from a project. While regarding CBA as the core tool of environmental economic evaluation and conceding the need to use a common monetary unit for this purpose, Bojo et al. (1992) observe that CBA results cannot be argued to be always objective especially when conventional monetary value is applied as the standardisation technique.

From the prospect theory perspective, one of the key challenges in CBA theory and practice is its blindness to the boundedly rational behaviour of the theorist or the practitioner specifically, over and above the bounded rationality of the decision making institution under consideration. The unstated assumption that the theorist and the practitioner are themselves rational constitutes one of the most glaring blind spots of the theory. Specifically, prospect theory counters this assumption with systematic evidence on disparity (incongruence) in willingness-to-pay and willingness-to-accept payment on the same good/service. The implications of other numerous heuristics such as *loss aversion* and the *endowment* and *anchoring* effects (Sienden, 2006:60; Fujiwara and Campbell, 2011:18-19) have not been adequately recognised or accommodated in economics or CBA theory and practice.

2.3 Application of CBA evaluation for solar water heating in Greece

According to Diakoulaki et al. (2001:1731), 75% of the Greek electricity demand is generated from lignite, which is a type of fuel coal that is said to be highly polluting with "grave environmental impact(s)". The renewable energy and energy efficient technologies (REEETS) market in Greece is faced with constraints similar to those in South Africa including low prices of the highly

polluting alternatives (van Horen, 1996). Water heating represents about 15% of the total energy consumption in the building sector in Greece. Hotels and hospitals are reported to post the largest demand for hot water, and predominantly use diesel to meet these needs (Diakoulaki et.al, 2001:1732).

It is against this scenario that Diakoulaki et al. (2001) present a CBA evaluation for solar water heating systems in Greece. From the outset, the inadequacy of conventional methods of promoting a policy or project based solely on assessment of financial returns on the investment required is recognised. This inadequacy occurs because financial analysis is not able to include all environmental, social and economic costs and benefits. The situation is frequently argued to be more acute in the evaluation of renewable energy options.

Diakoulaki et al. (2001) acknowledge the dilemma of valuing environmental and social benefits advocating a hybrid CBA that incorporates conventional as well as contemporary methods. The details of the non-monetary valuation criteria or process and the basis for comparison are not provided in Diakoulaki's study. There is however a bias towards the CBA tool in which a lot of confidence is demonstrated, as evident in the statement that "CBA provides the methodological framework which allows for an overall evaluation of projects and policies by taking into account all cost and benefit parameters…" (Diakoulaki et al., 2001:1728). This approach has now been consistently challenged in view of bounded rationality in behavioural economics and prospect theory from psychology.

There are inconsistencies in Diakoulaki's argument for CBA to measure social costs in non-monetary terms. These inconsistencies are especially evident in the stages of the calculation process (the calculations themselves are not presented) and in the discussion on the social benefits derived from the use of solar water heaters. The authors are overly influenced by the same conventional valuation methods derived from neo-classic economic theory which were initially argued to be inadequate. Briefly, the valuation process consists of five stages which are

similar to those derived from Stewart et al. (1997) and Conningarth Economists (2002) as listed in Appendix 1.

Apart from the purely economic benefits of solar water heating, the study identifies the following (categorised as social benefits) but which in reality do include environmental benefits:

- Energy saving arising from the reduction of consumption of electricity, diesel or natural gas as alternative sources of energy for heating water (assumed direct cost-savings).
- Decrease in environmental burdens due to reduction in harmful emissions arising from fuel substitution (especially greenhouse gas emissions reduction).
- Generation of new employment opportunities leading to reduction in unemployment and associated multiplier effect (Diakoulaki et al., 2001).

On the other hand, the social costs include:

- Loss of jobs in the substituted technologies.
- Negative environmental impacts referred to as social pollution costs.

Diakoulaki et al. (2001) uses four clearly explained steps in the data analysis process each with its own set of assumptions. Solar water heating systems are evaluated according to four main categories of consumers, their respective solar water heating system design options (split or central), and the common alternative competing fuel as follows (Diakoulaki et al., 2001:1733):

1. Four-people households using split solar water heating system with electricity and natural gas as competitor fuels.
2. Block of 12 flats using central solar water heating system with electricity and natural gas as competitor fuels.
3. Seasonal 70-bed hotel using central solar water heating system with diesel and natural gas as competitor fuels.

4. 150-bed hospital using central solar water heating system with diesel and natural gas as competitor fuels.

The result of this CBA is that the four consumer scenarios vary depending on the type of substitute fuel. A low value of benefit to cost (B/C) ratio observed for hotels is attributed to their seasonal operations, which does not allow them to take full advantage of the benefits of solar water heaters. Diakoulaki et al. conclude that the introduction of solar water heaters does not appear advisable when the substitute fuel is natural gas. Because natural gas is considered the cleanest of the conventional primary energy fuels, the substitution with solar water heaters does not create any substantial advantage from a sustainability perspective. Overall, according to social criteria however, solar water heaters are superior to conventional technologies that use electricity or diesel. According to the study, natural gas scored a better B/C ratio for water heating, at least in Greece.

Diakoulaki et al. point out that their CBA did not produce the same results as those that would come from a conventional CBA which places more emphasis on economic streams of costs and benefits while treating the social and environmental streams as insignificant. According to Diakoulaki et al. (2001:1737), solar water heaters cannot generate a positive CBA outcome according to strictly private economic criteria except in the domestic household sector which shows a marginal positive return against electricity generated from high polluting lignite.

In the end however, this CBA fails to fully engage the scope of costs and benefits that would combine the economic, environmental and social costs and benefits to deliver a balanced integrated valuation system. It would have been especially more insightful if the economic streams of cost and benefits were included in the valuation. There is overwhelming indication that such an inclusion would yield a negative CBA recommendation in all the scenarios, irrespective of the climate-change mitigation benefits that would accrue from solar water heating compared to all the other options evaluated.

2.4 The sustainability debate

Mawhinney (2002:23) analyses the sustainability debate in detail and identifies three distinct viewpoints mainly linked to different theoretical persuasions. The first viewpoint emerges from mainstream economists who tend to relate to the status-quo and believe that the current systems of making choices and decisions or evaluation tools such as CBA, although not perfect, are the best and most efficient available.

The second viewpoint is espoused by strong environmentalists who tend to look for a more fundamental change in tools as the solution to the identified weaknesses. Some groups in this category believe that current evaluation methods have completely failed mankind and the environment and therefore need a complete overhaul. This viewpoint argues that mainstream economics ignores social and environmental drivers which underpin our socio-economic systems.

The third middle ground viewpoint suggests a need for change and also advocates an evolutionary perspective. It also believes that the current systems need adaptive adjustment in order to effectively respond to the raised concerns. Mawhinney (2002:39) quotes extensively from Pearce et al. (1990) and Hawken et al. (1999) who are categorised as middle ground and referred to as reformists. The World Commission on Environment and Development (WCED) and its Brundtland Report perspective and definition of sustainability can fall into this category.

The sustainability debate mainly centres on issues of climate change, pollution, biodiversity, natural resource depletion as well as equity and inequality. Mawhinney (2002:43) stresses the importance of futurity in the debate and correctly suggests that the contradiction with economic theory arises from precautionary focus of sustainability versus the reactive approach in CBA evaluation. This is systematically recognised in prospect theory especially by the insight on the role which a reference state/point plays in choice and decision-making. On equity and in response to the common argument that technological development is capable of re-generating the natural capital, Mawhinney refers to

Pearce's counter argument that man-made capital cannot be a substitute for natural capital (Mawhinney, 2002:41).

Ekins (1997) describes in detail the futility of using economic tools to value some environmental and other intrinsic resources and cites several discrepancies in such attempts. Ekins therefore argues that there is rarely any generally acceptable way of putting a monetary value to determine the costs of goods with some unique characteristics. There are a number of shortcomings, key among which are the wide variation in willingness to pay (WTP) obtained for the same good and wide variation in the value of a statistical life in various studies (the prospect theory interpretation of this dilemma is discussed in Sections 1.3, 1.5 and 2.2).

> "Microeconomic techniques of hedonic pricing, contingent valuation and cost-benefit analysis are not able to realistically assess the economic costs of (*for example)* displacing millions of people from low-lying coastal areas due to global warming; of hundreds of thousands of extra eye cataracts and skin cancers caused by ozone depletion; of other processes of large scale environmental degradation; of the possibility of species extinction caused by the unravelling ecosystem; of the persistent release of serious toxins for example radiation or the effects of major disasters" (Ekins, 1997:44). *(Italics mine).*

Ekins concurs with Mawhinney and others on the dangers of seeking to arrive at a monetary valuation of these kinds of effects. However, it is almost guaranteed that they will be underweighted and that decisions will be taken in favour of the more certain near term or current benefits while environmental degradation continues to be viewed as inevitable collateral damage in economic development.

It is not the intention of this study to go into the details of the weak and strong sustainability dichotomy. Pearce and Turner (1990) and more recently Dietz and Neumayer (2007), Ekins (2011) and Sustainability Store (2012) among other sources in the literature provide a very detailed study and perspectives on this subject. Weak sustainability is seen as generally concerned with sustaining human welfare, and thought to be more commensurable with economic principles (Vucetich and Nelson, 2010:541). According to de Lange et al., (2008:255), environmental resource economics (ERE) adopts a weak sustainability perspective

which assumes that welfare can be maintained and total stock of capital kept constant over time by substituting natural capital with human-made capital.

Conversely, strong sustainability refers to "living within resources of the planet without damaging the environment now or in the future" (Sustainability Store, 2012). In a more conservative interpretation, Vucetich and Nelson (2010:542) note that "strong sustainability is generally concerned with sustaining natural capital and is thought to be more aligned with traditional conservation values". Ecological economics (EE) adopts a strong sustainability perspective which highlights the interconnectedness and interdependence of the economic and ecological subsystems. In EE and strong sustainability, the economic subsystem is viewed as embedded within a finite biosphere that imposes limits on the amount of natural resources that can be extracted and waste that can be absorbed by the natural system (de Lange et al., 2008:256).

The strong and weak sustainability debate is anchored within extremes of the three elements of the principles of sustainability which coalesce into an economic versus social and environmental exchange, each claiming that sustainable development is biased towards the opposing side. According to Ruhl (1999:180, 184), it is this tension that drives the evolution of the understanding of sustainability. It can also be argued that this tension underlies the tough negotiations that underpin resolutions such as the Kyoto Protocol, carbon trading system and Millennium Development Goals which are all premised on the sustainability agenda.

Mawhinney (2002:86) suggests that although economists, environmentalists and those in between appear to provide some plausible way forward, no one school of thought has managed to consolidate the debate into a workable paradigm yet. It is in this context that sustainability science is emerging as a discipline with a defined research and knowledge agenda which is gradually being integrated into university curricula (Clark, 2007; de Lange et al., 2008; von der Heidt and Lamberton, 2011). As substantiated further in later chapters of this study, the co-

evolution of sustainability towards a purely rational/objective science in the same manner as neo-classical economics and CBA evaluation is unfolding in total obliviousness of the scientific findings from prospect theory and neuro-science among other cognitive science fields.

2.5 Prospect theory and decision making

2.5.1 Cost-benefit analysis, sustainability and prospect theory

Cost-benefit analysis (CBA) is shown to be a product of classical economic theory which assumes maximisation of utility as the foundation of individual choice and decision making (Sections 1.4, 1.5 and 2.2). In line with classical economic theory, CBA is assumed to be a tool for facilitating efficient allocation of resources (allocation of resources in a way that makes the largest number of individuals better off without making any one worse off in the process) (Baumol and Blinder, 2011:286). It can therefore be argued that CBA primarily adopts a utilitarian approach to evaluation such that maximisation of individual utilities (based on individual revealed preferences) becomes the key goal in choice and decision-making (Boardman et al., 2006).

On the other hand, sustainability seeks not only efficient allocation of resources and thus mitigation of waste, but also requires equitable distribution of development costs and benefits (Sections 1.2 and 2.4). It must be emphasised, as noted in Gowdy (2007:28), that the principles of sustainability recognise economic rationality and resource efficiency as positive goals (Section 1.5). It only becomes contentious when economic logic dominates decision making in obliviousness to the related social and environmental impacts of such choices and decisions. This study argues that such obliviousness (or underweighting) primarily arises from bounded rationality constraints as expounded under prospect theory heuristics and neuro-science which demonstrate the significant role of subconscious and emotion-based processes in choice and decision-making.

Behavioural studies in psychology explain the way human beings respond when faced with situations of choice and decision making under risk and uncertainty. This is covered under prospect theory within this section (Kahneman and Tversky, 2000; Ariely, 2008 and Kahneman, 2011 among others). The theory is perceived to be relevant to this study because it coherently explains most of the contradictions and inconsistencies in choice and related behaviour when compared to classical economic theory approach and especially its rational-agent model and revealed preference theory (Kahneman, 2003; Thaler and Sunstein, 2008 and Kahneman, 2011). Although the theory does not initially show a direct relationship with sustainability principles, it indicates and supports the view that collective or individual decision making can be predictably *irrational* unlike what is presumed in neo-classical economics and its CBA evaluation offshoot.

It is however noted that the prospect theory model is primarily founded on decisions relating to gains and losses under conditions of risk and uncertainty (Kahneman and Tversky, 2000; Kahneman, 2003). It highlights informal decision making behaviour in contrast to the formal CBA evaluation which is based on assumptions of a rational and infinite mind, with infinite information and infinite time, which would be the implied conditions of a rational-agent model for comprehensive utility evaluation in choice and decision-making. Consequently, original onslaught mounted by bounded rationality (which originated within economics and branched off to become behavioural economics) is further corroborated by the more recent prospect theory in psychology (Selten, 1999; Kahneman 2003; Muramatsu and Hanoch, 2005:209; Cullis and Jones, 2009; Shogren, 2012), and even much more recently by neuro-economics based on neuro-science. It is the superior explanatory capacity of these new fields which this study relies upon in order to substantiate on the seemingly intractable challenge of transition towards sustainability especially when the objective understanding/knowledge systematically unambiguous on the need for an expedited transition.

2.5.2 Prospect theory model

Prospect theory was systematically articulated and disseminated by two psychologists David Kahneman and the late Amos Tversky over the last 30-year period (Kahneman and Tversky, 2000; Kahneman, 2003; Kahneman, 2011). The theory helps us to understand the motivation, logic and behaviour in modern decision making at individual level, based on experiments that explore how people make choices and how they arrive at decisions when faced with uncertain outcomes of loss or gain (Section 1.3).

According to prospect theory and as discussed in detail in Sections 1.3, 1.5, 1.8 and 1.11, decision making under risk and uncertainty is in reality more commonly based on bounded rationality which is subject to simple behavioural and cognitive (usually unconscious), decision making strategies termed as heuristics (Gilovich et al., 2002:xv; Muramatsu and Hanoch, 2005:209; Thaler and Sunstein, 2008; Cullis and Jones, 2009:487-488; Gordon, 2011:4; Kahneman, 2011:98). The key heuristics applicable to this study are commonly captured under the following categories:

- *Loss aversion*
- *Status-quo bias* and *inertia*
- *Endowment effect* and *inertia*
- *Post-rationalisation*
- *Framing effects*
- *Anchoring* effects
- *Nudge* techniques

There are several illustrations of the application of prospect theory in the literature derived from Kahneman and Tversky (2000), Hastie and Dawes (2001), Thaler and Sunstein (2008) and Kahneman (2011) among others. Tomer (2012) discusses these cognitive heuristics from a neuro-economic perspective which shows that decision making under uncertainty is more likely to be driven by emotions (and thus appear *irrational)* rather than by the rational-agent model and revealed preference as assumed in economic theory and adopted in CBA evaluation. The

link between prospect theory, cognition and neuro-science is reported in Trepel et al., (2005). One of the more comprehensive coverage on the relevance of prospect theory in public choice and finance is presented in Cullis and Jones (2009:486-513).

In utility theory, based on the rational-agent model assumption and hence applied in conventional CBA approach, decision outcomes are deemed to be certain or predictable on the basis of their probabilities. In addition, outcomes obtained with certainty are weighted equally to those which are uncertain if the known expected utility is the same (Cullis and Jones, 2009:488). In contrast, prospect theory says that people overweight outcomes that are considered certain relative to outcomes that are merely probable or uncertain (referred to as the *certainty effect* heuristic) (Kahneman and Tversky, 2000:20).

Bernstein (1996:116) however argues that the logic of probability that is often applied in formal CBA evaluation is overridden because probability does not predict actual occurrence of an event. Bernstein questions the tendency to rely on past experiences to determine what is likely to happen now and in the future, arguing that an impossibility to have complete knowledge of the future, and therefore the information we have in hand, cannot be entirely reliable to predict future events accurately. The contradictions and *irrationalities* evident in decision making under risk (and hence arising from System-1 driven heuristics) versus what one would expect from the rational-agent model of conventional economics and CBA evaluation constitutes the relevance of prospect theory in this study, especially in its attempt to arrive at a better understanding of why clear/objective facts and knowledge on threats/risks to sustainability fail to elicit the responsive action/behaviour-change at the expected rate or time frames.

Eysenck (2001:332) observes that risky decisions are made in the context of the individual's current situation or starting point at the time of making the decision. This is also referred to as *reference point* or *anchor effect* and often serves to entrench the *status-quo bias* (Thaler and Sunstein, 2008:34; Cullis and Jones,

2009:488; Kahneman, 2011:119-128). Due to its high level of uncertainty, and without prior knowledge of the consequences, risky decision making is often influenced by external aspects of the situation such as the precise way in which an issue is presented or framed (Eysenck, 2001:333; Thaler and Sunstein, 2008:36-37; Kahneman, 2011:88). Slight variations in the presentation of the issue, or *framing effects*, can cause a significant shift in the eventual decision.

Decision outcomes depend significantly on whether the decision making involves possible gains or losses. According to prospect theory, decision makers will be loss averse (or risk averse) when choosing between gains and risk seeking when choosing between losses (Hastie and Dawes, 2001:216; Thaler and Sunstein, 2008:33). We often display risk aversion when offered a choice in one setting and become risk seekers when offered the same choice in a different setting, indicating an inconsistency in our decision making process under risk. However, most people are observed to reject a fair gamble in favour of an assured gain suggesting that we are naturally risk (or loss) averse (Bernstein, 1996:272). "It is not so much that people hate uncertainty – but rather that they hate losing…losses will always loom larger than gains" (Bernstein, 1996:274).

Kahneman and Tversky, (2000:341) describe *loss aversion* as the preference for a sure or certain outcome over a gamble, or uncertain outcome, even with a higher or equal expected gain. In contrast, the rejection of a sure outcome of higher or equal expectation in favour of a gamble of lower or equal expectation is referred to as risk seeking. Experiments in prospect theory indicate that people generally underweight outcomes that are merely probable in comparison to outcomes which can be obtained with certainty (Kahneman and Tversky, 2000:20).

This behaviour contradicts the assumptions of the rational-agent model and revealed preference model of classical economics. In particular, *loss aversion* contradicts the assumptions in willingness-to-pay and willingness-to-accept, which form the operational tools of Pareto optimality, and which are commonly used in CBA evaluation to evaluate non-monetisable impacts in policies, projects

and programmes. This constitutes one of the key contradictions between evaluation in CBA and the goals and principles of sustainability.

2.5.3 Mental accounting

Prospect theory also aims to explain apparent *irrational* patterns in decision making processes and outcomes. The reality is that choices are often made on intuitive and impulsive processes. According to Bernstein (1996:271), we tend to resort to more subjective kinds of measurements when faced with uncertainty. Gut rules even when we think we are using measurements. Kahneman and Tversky (2000) referred to this behaviour as **'*mental accounting*'**. Thaler (1999:183), Thaler and Sunstein (2008:50) and Hardman (2009:83) define *mental accounting* as the set of cognitive structures used by individuals and households to organise, evaluate and keep track of financial flows.

Mental accounting is also described as the tendency to compartmentalise our income and expenditure accounts such that a particular amount of money planned for a given purpose can acquire a different mental value/meaning when used for another purpose. Equally, *mental accounting* heuristic is applied to explain why a R5 discount on R20 cost item means more than the same discount on a R100 cost item (Hastie and Dawes, 2001:223; Thaler and Sunstein, 2008:49-52). In this study, the term is additionally used in the general context of explaining how we organise, plan and keep track of financial choices and decisions as well as inconsistencies in the levels of utility we assign to some costs and benefits in relation to others.

The fact that almost all of us use mental accounts even when unaware of doing so indicates that it is an inherently subconscious reaction which is now corroboratively reported through brain imaging and the related physiological change indicators of pulse rate, blood pressure and oxygen levels (De Martino et al., 2006:684-687; Rangel et al., 2008:548-552; Thaler and Sunstein, 2008:50). It also explains the many contradictory saving and spending habits we display that appear to be inconsistent with our economic self-interest or defy any logical

explanation, or decisions often made in direct contradiction or in spite of empirical studies including formal CBA evaluation.

Mental accounting and prospect theory also possibly play an influential role when the rational economist or CBA practitioner applies the formal contingent valuation method, in which intangible resources, goods and services are monetised by allocating them surrogate prices, and the net present value process in which future values are discounted or brought to the present. This aspect of the role of prospect theory heuristics (driven by System-1 and System-2 constraints) in the 'rational' economist or the 'rational' CBA practitioner has not been specifically tackled in existing literature. However, the presence of such heuristics and their role in choice and decision-making is no longer in doubt.

2.5.4 The two-system thinking and modern decision theory

The main difference between the classical economic theory and normative decision theory is that the latter assumes that decision makers frame their choices in terms of the expected outcomes or final consequences of their decisions rather than the baseline or reference point. In conventional economics, a decision or choice is made primarily to enable the decision maker to maximise expected utility or to maximise benefits and minimise costs in whatever form. According to normative decision theory however, a completely rational decision maker would make decisions to maximise expected values (Hedborg, 1996:13; Eysenck, 2001:332; Weber, 2003; Marx and Weber, 2009:6).

In contrast and as discussed in Section 1.8, prospect theory maintains that 'emotions rule decision making' and that "whenever thinking contradicts with emotions, emotions win" (Gordon, 2011:11). In Section 1.3, we noted that choice and decision making are controlled and conducted by a 2-system thinking mechanism. System-1 is primarily an emotion-based physiological mechanism which operates at autonomic and sub-conscious level. It works automatically and quickly, with little or no sense of effort, and no sense of voluntary control. System-2 is the rational self with varying levels of information processing

capabilities, which can be directed to slow but effortful mental activities including complex computations.

In addition, System-2 is often associated with the subjective experience of agency, choice and concentration (Thaler and Sunstein 2008:19; Kahneman, 2011:20; Tomer 2012:6). Furthermore, choice and decision making under uncertainty is subject to biases and manipulation through nudge effects and behavioural heuristics such as *framing*, *status-quo bias*, *anchoring*, the *endowment effect*, *loss aversion* and *post-rationalisation* (Gilovich et al., 2002:xv; Thaler and Sunstein, 2008; Cullis and Jones, 2009:487-488; Gordon, 2011:4; Kahneman, 2011:98).

Regarding the conflict we often experience in perceiving the future, Bernstein (1996:291) observes that, "…one side of our personality is an eternal planner with a long-term perspective, an authority who insists on decisions that weight the future more heavily than the present. The other side seeks immediate gratification. These two sides are in constant conflict." This seems to resonate closely with Kahneman's approach of System-1 and System-2 components of the behavioural self (Kahneman, 2011). The observation supports the suggestion that there could be similar underlying conflicts or contradictions in decision making under CBA evaluation and the principles of sustainability trying to outweigh each other with the aim of influencing or carrying the decision outcome.

Bernstein (1996:292-3) also explains the attitude and reaction towards introduction of new technology and the subsequent confusion in decision making. "When new information arrives, investors revise their beliefs not according to objective methods but by overweighting the new information and underweighting prior longer-term information. They weight the probability of outcomes on the 'distribution of impressions' rather than an objective calculation based on a historical probability distribution." The term 'distribution of impressions', which resonates with System-1 thinking and *post-rationalisation*, refers to the tendency to make decisions based on impressions that are supported and justified by *mental accounting* rather than on the basis of the more rational distribution of probability

substantiated by empirical valuation or objective calculation (Polic, 2009:80). In this study, particularly in data analysis and interpretation, this behaviour is referred to as **'valuation based on personal, subjective impressions rather than empirical valuation and objective calculation.'** Empirical valuation can be based on technical reports, feasibility studies, formal cost benefit analysis or such other formal appraisal tools.

The foregoing discussion indicates that human choice and decision making is consistent, although not always rational, in what Ariely (2008) refers to as predictable *irrationality*. This study shows that decisions regarding solar water heating were not always made in a rushed manner as will be seen in Chapter 4 and 5. Often institutional processes were followed and individuals carefully considered their decisions but the outcomes were not always rational and usually defied logic.

Evidence also suggests that there is no specific pattern in decision making for similar options and circumstances. "…since orderly decisions are predictable there is no basis for the argument that behaviour is going to be random and erratic merely because it fails to provide a perfect match with rigid theoretical assumptions…if we were always rational in making decisions, we would not need the elaborate mechanism we employ *(and in any case)*…few people end up in a either a poorhouse or a nuthouse as a result of their own *(flawed)* decision making" Bernstein (1996:282). This theory suggests that there is always a latitude in which decisions or outcomes will not make much difference in the bigger picture of our lives. It also suggests that there are more options to any decision making dilemma than what we presume and that we are not as self-determined as we would suppose or would be willing to admit.

Hastie and Dawes (2001:20) illustrate modern decision making using the principle of maximising expected utility as opposed to revealed preference in classical economics, which further reinforces prospect theory. Utility in this regard means the degree of worth or desirability as opposed to mere monetary value from a

classical economic theory perspective. Risks are taken according to the current position lending credence to the common phrase, 'desperate times call for desperate measures' and thus reinforcing prospect theory. This often happens as a result of accepting status-quo as the primary reference point for evaluating choices (Hastie and Dawes, 2001). A neuro-economics perspective of this line of thinking is provided in Rangel et al., (2008).

Hastie and Dawes (2001:22) conclude that the pattern of decision making is not always straight forward and there are no guarantees that past experience will influence current decisions. "Not only do the choices of individuals and social decision making groups tend to violate the principle of maximising expected utility, they are often patently irrational…the chooser violates the rules of rational decision making and chooses contradictory courses of action by failing to act consistently…people tend to be irrational in systematic ways."

Whereas there is compelling evidence that decision making is not always rational, some authors argue as if decision makers are always rational and predictable, such that similar scenarios will produce similar outcomes. For instance, Lewis (1997:viii) rationalises that, "so what we mean by good decision is a decision that is the best we can do with what we know at the time…if we have done our best, and have been rational in our thinking, we will have done all that can be expected…what is out of our control is out of our control." This line of thinking attempts to make the rational-agent model and related assumptions the indicators of good choice and decision making under conditions of uncertainty which as we have seen, is not always guaranteed.

2.6 Comparative analysis of CBA evaluation and sustainability assessment

2.6.1 Overview

It is clear from the theoretical and practical analysis of CBA and the principles of sustainability that from a status-quo perspective, both have some common

objectives and share a variety of fundamental factors. Sub-section 1.11.3 has briefly introduced the origin of the common objectives which shape the status-quo framework for evaluation in CBA and sustainability assessment. However, because evaluation in conventional CBA and sustainability assessment use different approaches in dealing with the factors, each achieves fundamentally different and usually conflicting results. Over the last two decades, there has been significant movement in both evaluation in conventional CBA, and sustainability assessment in addressing the contentious issues.

There are several key attributes or factors identified as defining the link and demonstrating the contradictions in CBA and sustainability assessment. These attributes or factors are discussed in more detail in Sub-sections 2.7.2 to 2.7.4 in relation to evaluation in CBA, sustainability assessment and prospect theory. In particular, the attributes are discussed in the context of the fundamental grounding of evaluation in CBA and sustainability in the economic-based rational-agent model vis-à-vis the reality of bounded rationality in prospect theory. These issues have significant influence on the evaluation process. The attributes are grouped as follows:

a) *The time-related attributes:* These are issues regarding initial costs, life-cycle costs, intergenerational and intragenerational considerations, perceptions of past and future time lines, immediate gratification etc.
b) *The scope and stakeholder attributes:* These are issues involving decisions on monetised and difficult-to-monetise streams, internalised and externalised streams, what streams to include and what to exclude and direct and indirect impacts on the project, policy or programme. It also includes issues of distributional fairness, common-good approach, direct and indirect stakeholders, affected parties, participatory process, intergenerational and intragenerational involvement.
c) *The attitudes and perceptions attributes:* These are issues related to attitudes, perceptions and assumptions regarding evaluation, the irreversibility and preventative principle, and the question of equitable

compensation which in economic theory and evaluation in CBA applies the Pareto optimality and Hicks Kador criterion.

Due to persistent criticism and pressure from various forces, there have been attempts in recent years to address the conflicting issues between evaluation in CBA and the principles of sustainability especially in the private sector, where previously there was greater resistance to transform the evaluation in conventional CBA processes to cover non-monetised streams. Some assessment tools such as the ecological footprint, green accounting, multi-criteria decision analysis (MCDA) and the more recent Climate Equity Impact Lens (CIEL) and sustainability assessment model (SAM) have emerged in response to the criticism and pressure. These tools are discussed in Section 2.7.5 with regard to the manner in which they address the differences and contradictions between evaluation in conventional CBA and sustainability assessment from a prospect theory perspective.

2.6.2 The time-related attributes

The principles of sustainability consider that goods and services may have a longer useful existence than the economic period and that they do have a life prior to production, usually in other forms (Heal, 1997; Padilla, 2002). Similarly, human activities have impacts that continue to manifest themselves long after the activity is concluded. In making decisions therefore, life-cycle or full-cost pricing impacts should always be considered. This is a key element in the assessment of a project for sustainability compliance.

A life-cycle cost indicates that the primary production cost alone is not enough to fully evaluate a product. All impacts incurred at pre-production, and post-production stages must be considered along with the direct costing. No costs should be excluded because they might be regarded as intangible or that the resource is a common good. Externalities should be internalised. In producing a specific building product for example, the price should not just be determined by the buying price of the raw materials, the cost of labour and other monetised

production costs. All impacts associated with the extraction of the raw materials and disposal of the building product after demolition should be costed and included in the selling price of the product.

Any action by the current generation that jeopardizes the opportunities of future generations implies a transaction of rights between the generations and should be adequately compensated (Padilla, 2002). It therefore means that if the equitable compensation, adequately valued, exceeds the benefits, then the project should not be carried out. An example of this criterion is the "polluter-pays" principle in which the polluter pays compensation proportionate to levels of pollution emitted (Attfield, 1999). The compensation in whatever form increases proportionately to the level where irreversible harmful pollution is not cost-effective for the polluter. In actual fact it becomes highly punitive and therefore ceases to be an option. In all such cases, quantification of compensation should be adequate, satisfactory, effective and enforceable as opposed to the Hicks-Kador criterion in which the option of paying compensation cannot be enforced (Costanza and Pattern, 1995; Brent, 1996).

It should be emphasized that within the principles of sustainability, there is no conceivable adequate compensation for some externalities such as global warming and other irreversible impacts. Armstrong and Botzler (1993:245) strongly argue that compliance with the principles of sustainability, like equitable income distribution, cannot be properly determined with typical efficiency criteria using techniques such as those applied in conventional CBA.

A sustainable system is one that reaches its expected full lifespan so that it can achieve its full potential and ensure evolutionary adaptation that results in continuity for the system (Costanza and Pattern, 1995). According to this argument therefore, immortality or cutting short of the life of a system is unsustainable. The right to a full life for all systems including the future generations should be respected and observed.

Sustainability values intergenerational and intragenerational equity. The current generation is required to exploit resources in a responsible manner, not to deplete such resources, and to leave a supply of resources at least equal to that which they inherited (Pearce, 1983). The current generation has an obligation to future generations in this regard. When resources are depleted and species become extinct, the options available to future generations are narrowed. "Current generations should not try to second-guess what future generations will need but rather should let them choose their own goals by allowing them the flexibility through keeping options open and maintaining diversity" (Beder, 2000:2). The argument that future generations will be more advanced technologically and can therefore substitute the depleted resources is not equitable (Pearce, 1983). The exploitation of environmental assets and other so-called common goods and conversion into human made products or resources that have to be bought is also not equitable. Future generations will most likely be better off with natural capital (resources) than created wealth (Section 2.8).

According to Padilla (2002:72) sustainability has an equity criterion. When the principles of sustainability are applied in the evaluation of projects, the impacts to future generations should be taken into account and weighted according to levels of severity of any negative effects. The principles of sustainability advocate imposing of limits on decisions that may have irreversible impacts. When the sustainability criteria are applied, policies and projects that can cause irreversible harmful effects to future generations should not pass the evaluation and would therefore not be implemented. Sustainability relies on the premise of uncertainty and unpredictability of the future. It advocates avoiding activities that can cause major disruptions and collapse of systems. If and when impacts are uncertain, the precautionary principle is applied (Costanza et al., 1997; Hossay, 2006).

Sustainability also advocates for equity within the same generation. The reason intragenerational equity is a key principle of sustainability is that inequality within the current generation for example causes environmental degradation in that the poorer a section of society, the more heavily it relies on the immediate

environment for basic survival (Beder, 2000). The result is destruction of the environment for farming, fuel, shelter and other basic needs. This destruction is particularly significant in developing countries where environmental regulations are either lacking or are not enforced. Since the large majority of the poor live in developing countries, the environmental tragedy is multiplied in those areas.

On the other end of the scale, a high level of consumption among the wealthy is equally or even more damaging to the environment. Excessive use of natural resources for production of goods for these high consumer societies has led to depletion of those resources. Excessive use of fossil fuels for production of these goods and the accompanying excessive waste has contributed to high levels of pollution and global warming (Mawhinney, 2002; Hossay, 2006).

According to neoclassical economics, sustainability is supposed to take care of distributive criterion while CBA follows the efficiency criterion (Padilla, 2002; Hossay, 2006). There is no suggestion that the two can be combined to create a tool for evaluating projects in a more holistic manner, and the mechanisms of applying both in parallel or simultaneously has not systematically evolved.

Discounting (intertemporal discounting) is a technique in CBA valuation practice of bringing the future value of benefits and costs to the present, and related discount rates are a way of ensuring the preservation of the "time value" of such costs and benefits (Faber and Hemmersbaugh, 1993; Perkins, 1994; Beder, 2000; Boardman et al., 2006; Atkinson and Mourato, 2008). It focuses on the benefits accruing to the current generation and has the present as the point of reference. On that basis, it is often criticised for its bias against future generations (Pearce, 1983; Beder, 2000). The tool is described in Brent (1996) and Boardman et al. (2006) among a large collection of related literature.

The discount rate used when calculating future or present value is often arbitrary, even though market-based returns are often used, but the impact is great. A difference of five percentage points in the discount rate for example can change

the outcome of the decision to implement or not to implement a project (Anderson and Settle, 1977:82-84; Farber and Hemmersbaugh, 1993:278-279). There is a tendency to impose a higher discount rate and consequently diminish the present value of effects that occur in the distant future in order to mitigate the perceived high risk.

According to Garger (2010), discounting is also a method of comparing different options and scenarios in evaluating the riskiness of an investment (Sub-section 1.10.4). In reality, we never know with certainty whether our investment will actually achieve the anticipated future cash returns. Risk is therefore the probability of an unfavourable decision outcome (Teall and Hasan, 2002). The discount rate accounts for the risk associated with the investment. Risk, represented by the discount rate, can therefore be an indicator of the level of uncertainty or riskiness of a particular investment.

Using the discounting principle, any investment in the future by the current generation translates to foregone present consumption (Farber and Hemmersbaugh, 1993). The further into the future the costs of today's consumption are deferred, the less their present value and the more favourable to the current generation (Schmuck and Schultz, 2002:39). The rational-agent model approach and its immediate gratification attitude associate the future with uncertainty and risk, rather than with an optimistic view with possibility for new opportunities.

The principles of sustainability on the other hand empathise with future generations and demand a close-to-neutral or even negative discount rate. In response, an evolved evaluation in CBA proposes to replace the constant discount rate with a time-declining discount rate. Weitzman (1999:23-30) and Atkinson and Mourato (2008:330) point out that the time-declining discount rate effectively increases the present value of a future investment. According to Atkinson and Mourato (2008:333), this approach has been adopted in the UK Treasury guidelines (Section 1.4).

In conventional CBA terms, the life of a project is its economic life and not merely its natural or performance life. Economic life is the payback period or the period in which the discounted monetary value approaches zero. In Boardman et al. (2006:9) for example, the economic lifetime of a highway in British Columbia, Canada is estimated at 20 years. Heal (1997) notes that there is an obvious mismatch between economic and scientific time scales. Whereas 20 years is a long time in economics, half a century is a relatively short time in terms of sustainability considerations.

According to the positive time preference principle in conventional economics, there is a strong tendency for people to prefer delaying or relegating the payment of the costs of their activities as far away into the future as possible. People also prefer to pay for immediate gains rather than those that will occur in the future (Pearce, 1983; Boardman et al., 2006). At the same time, people want to bring benefits as close as possible to the present. This tendency is identified and formalised in economic principles in general and more particularly in the instant gratification tool of discounting that is commonly applied in determining payback periods. Similar mentality applies in the formulation of values for willingness-to-pay survey responses used in the formal evaluation in CBA process. The instinctive and informal application of this mentality in decision making at individual or collective level is referred to as the **"*immediate-benefit logic*"** in this study.

In human behavioural terms, time discounting and risk are related to patience, the ability to delay or fight immediate gratification. Inconclusive human neuro-imaging experiments indicate varying responses to low and high discount outcomes or rewards (Rangel et al., 2008:550). According to Rangel et al., immediate rewards might activate 'immediacy markers' that increase the valuation signals in the relevant part of the brain.

Confronted with a time-related choice and decision option, System-1 deploys complex neuro-valuation mechanisms activated by arousal levels, to determine the expected future rewards and therefore the gratification delay period. This results in computation of payback periods and also translates to the concept of discounting. However, Shogren (2012:21) points out that people do not use a constant discount rate because they are naturally less patient in the near term period, implying higher discount rates, and more patient in the long term, resulting in lower discount rates. This behaviour which is referred to as hyperbolic discounting also explains *procrastination*, which is the tendency by System-1 to postpone decision or less attractive tasks to the future, and immediate gratification habits such as addiction (Shogren, 2012:21).

The unit of measurement in conventional CBA is money. Even in informal CBA, people often value the intangible and difficult-to-value prospects by assuming a proxy monetary value. Conventional CBA analysts argue that all streams or effects have to be reduced to a common unit for the analysis to be meaningful. Those streams that have no clear monetary value are assigned surrogate or shadow prices (Dasgupta and Pearce, 1978; Boardman et al., 2006). The streams of costs and benefits are therefore monetised and then discounted in order for present values to be determined.

Whereas the prices of tangible streams are easily available, those of intangible streams are difficult to obtain. Some, such as the value of life and the environment, are contentious to the level of any such valuation being considered by some critics as unethical (Boardman et al., 2006:13). However, Pearce (1983) considers such criticism as misplaced and lacking an understanding of what CBA sets out to measure. There has been significant progress in developing methods for valuing intangibles and difficult-to-value effects within CBA evaluation and in emerging tools. For example, the sustainability assessment model (SAM) has developed descriptive expressions of value as indicators for valuing non-monetary effects while the European Union has adopted a similar approach (Elghali et al.,

2007:6078; European Union Regional Policy, 2008:68; Frame and Cavanagh, 2009:203-205).

Neuro-science research shows inconsistencies and distortions in monetising, which can be caused by various nudge techniques (Fujiwara and Campbell, 2011:19). For example, monetising creates a sense or impression of value in people's minds. This *anchoring* effect causes people to associate monetary value with true value and hence tend to allocate greater intrinsic value to that which has greater comparative monetary value and vice versa. The dilemma of the disparity in willingness-to-pay and willingness-to-accept payment in the prospect theory context is discussed in Sections 1.3, 1.5, 2.2 and 2.4.

Whereas CBA entails the valuing of streams of costs and benefits of projects and programmes from a collective scale with the present as the reference point, prospect theory is about valuing the prospects in terms of possible gains and losses at individual (and often instinctive) level. In other words, the decision maker in prospect theory exercises bounded rationality which as mentioned earlier is a CBA-like choice and decision making process under constraints of finite mind, time and information (Section 1.8). In both CBA and prospect theory, values are often framed in monetary terms. The informal and intuitive *mental accounting* is closely related to the formal, empirical contingent valuation method where intangible resources, goods and services are monetised by allocating surrogate values (Section 2.5.3).

2.6.3 The scope and stakeholder attributes

In terms of the principles of sustainability, current and future generations are regarded as stakeholders of the earth as well as its resources and bio-diversity. However, for Boardman et al. (2006:37) future generations cannot be considered in CBA because their WTP cannot be measured due to their very absence. According to this argument, their exclusion has no serious consequence on the evaluation. It has been argued however, that the presence or currency of the stakeholders is not a pre-requisite for decisions to be made in their favour (Beder,

2000; Padilla, 2002). The Brundtland Report (WCED, 1987) makes it clear that sustainable development must meet the needs of the current generation without compromising the ability of future generations to meet their own needs.

Whereas the participation of stakeholders is conceptually possible at the intragenerational level, problems of representation arise at the intergenerational level. Padilla (2002) suggests creation of trusts and investment funds for compensating future generations when projects have impacts that are not irreversible. The responsibility for ensuring adequate resources for future generations therefore lies with the current generation. The same obligation applies to intragenerational stakeholders especially minority groups that tend to be disenfranchised by the structures of contemporary socio-economic systems. In the same category, as discussed passionately in Hossay (2006), are developing countries that are disadvantaged by current global production and consumption patterns.

The sustainability assessment criteria equally aims at mitigating discrimination of any potential stakeholder on the basis of any prejudices (such as by birth, gender, race, property, class, caste, political division, territorial ambition, inequality of income) and practices, and in fact rejects any such prejudice or practice as unsustainable. In particular, mitigation of inequalities with regard to distribution of development benefits and costs among social groups is considered a critical sustainability criterion. Furthermore, the equity principle in sustainability recognises the rights of previously disadvantaged groups, especially those that result from the mentioned prejudices, and in some cases accords such groups an advantage in opportunities.

Where project/policy impacts extend beyond local, regional, national and trans-national boundaries, the inclusion of stakeholders should ideally be extended in the same manner. Mawhinney (2002:56) notes how richer developed countries commonly export their waste either directly or by transferring polluting industries elsewhere or expropriating resources causing net loss to poorer, usually

developing countries. Species and other living beings in habitats affected by a project are considered as stakeholders in sustainability assessment (Armstrong and Botzler, 1993). Any recommended mitigating measures are counted as costs of the project.

Whereas the goals and principles of sustainability are clear (Sections 1.2 and 2.4), the methods for assessing policies, projects and programmes for sustainability fall into the trap of the rational-agent model dilemma. Clearly, ideals promoted by the rational-agent model in economics and evaluation in CBA, which are now proved to be unrealistic, are equally evident in the sustainability assessment methods. The main reason that people fail to fully appreciate or comprehend the relationship between current consumption and production habits to climate change and depletion of earth's resources can therefore be explained in prospect theory in a similar manner to evaluation in CBA. The structured assessment method attempts to create empirical techniques (in CBA or sustainability), which end up encountering the constraints of bounded rationality and the subsequent dominance of System-1 cognitive heuristics.

In evaluating the implications of climate change and such other impacts, the human brain encounters several cognitive limitations (Kahneman 2003; Weber 2010; Kahneman 2011; Tomer, 2012:6-9). According to Tomer (2012:1), the human brain has limited capacity to deal with the complexity of the real world. Real-life decision making under uncertainty is characterised by *defective forecasting*, *over-confidence* and *misplaced optimism* in predicting the future. Intangible events such as climate change, generational equity and stakeholdership are unlikely to motivate significant action because System-1 prioritises decisions on recency and experiential basis (Weber, 2006:104; Weber, 2010:333), while statistical information on the urgency of the problem is referred to System-2 where it can be overridden by experiential information.

Conventional economics and CBA rely on the Pareto optimality and Hicks-Kador criterion in which the winners would ideally pay compensation (if they so wish)

to the losers so that a net social gain is achieved (Pearce, 1983:16; Brent, 1996:32; Boardman et al., 2006:29). However, the Hicks-Kador principle does not require actual compensation or even demonstration of viable mechanisms of achieving such compensatory goals (Dasgupta and Pearce, 1978:58). This is the basis of criticism that evaluation in conventional CBA has a very limited scope with regard to equitable distribution of costs and benefits arising from a policy, project or programme.

In any policy, project or programme, there are often primary, secondary and inconsequential impacts (Anderson and Settle, 1977:22; Boardman et al., 2006:7). Conventional evaluation in CBA organises the impacts, streams or effects into three levels as shown in Figure 2.1. These levels are used to set the policy, project or programme limits in the CBA process. A good example of this cascading effect that can apply to evaluation in CBA and sustainability assessment is given in Anderson and Settle (1977:23).

How then does evaluation in conventional CBA deal with these cascading streams of benefits and costs? According to Anderson and Settle (1977), the issue is not whether or not to exclude the intangibles but how to include them in a meaningful way. This noble intention is however watered down by the solution offered, that the intangible streams should be identified in the study *and where feasible,* estimates of the physical magnitude involved should be provided (Anderson and Settle, 1977:23). The practitioner is therefore given the option of including or excluding the intangibles based on the assessment of their perceived feasibility. This is an example of the weakness that provides justification for practitioners of CBA evaluation to dismiss inclusion of intangibles (benefits or costs) as unfeasible and therefore exclude them from the valuation process.

Conventional evaluation in CBA considers only two levels of the effects arguing that it is only up to this level that ease of valuation in monetary terms exists (Anderson and Settle, 1977). Even at these two levels, intangibles are often regarded as difficult-to-measure and are eventually excluded in the evaluation. It

is further argued in conventional CBA that the third level of benefits and costs is largely a duplication of the first and that this may tend to result in an overall overestimation of the costs and benefits.

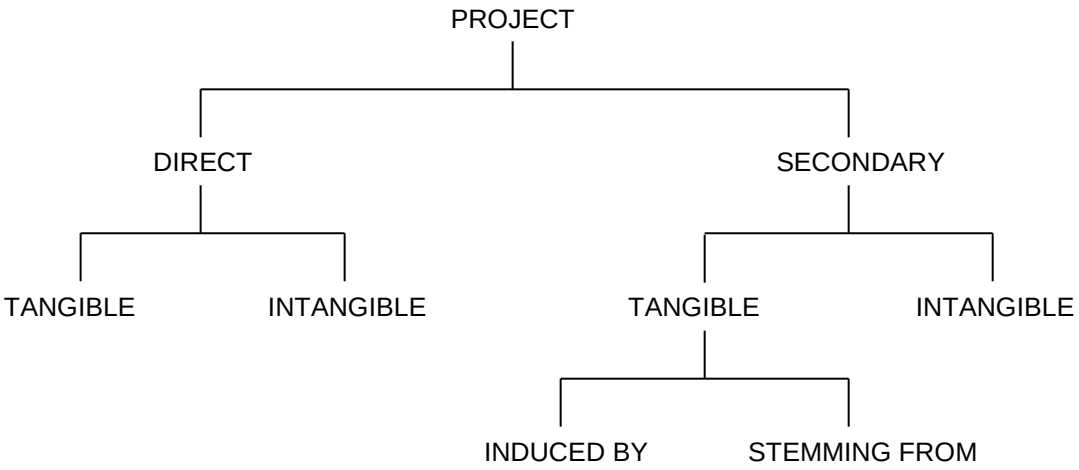


Fig. 2.1: Cascading structure of project effects
(Source: Anderson and Settle, 1997:22)

The weakness of this model is that those resources for which people are only unable to put a monetary value to (especially at the third level) are undervalued in the process. Direct inputs or effects in the form of natural resources also tend to be undervalued or discarded relative to finished products with clearly determined monetary value whose monetised value tend to be overweighted.

Although the search for acceptable or non-controversial ways of valuing the intangibles in CBA evaluation is on-going, this is one of the aspects that have achieved little success in its co-evolution. Among the emerging assessment methods, the more holistic MCDA and SAM address, to a limited extent, the concerns regarding the inclusion of intangible effects. Similarly, ecological footprint addresses the concerns regarding generational and geographical scope. The European Union Regional Policy (2008) advocates inclusion of additional indirect effects in the evolved CBA scope. The US court also set a precedent in the co-evolutionary process by ruling that environmental impacts could not just be

dismissed as insignificant and discarded without due consideration (Masur and Posner, 2011:1559).

The first step in the conventional CBA evaluation is to decide whose benefits and costs have standing and should therefore be counted (Boardman et al., 2006). There are direct, primary stakeholders and indirect, secondary stakeholders, and a whole network of other subsidiary stakeholders arising from them (Figure 2.1). The question that one asks in considering stakeholder factor is: 'Who are the affected parties?' In neoclassical terms, the stakeholder factor would be associated with distributional considerations (Willis and Corkindale, 1995). In evaluation in conventional CBA, the stakeholders may be categorised broadly as follows: (i) initiator of the CBA or client (ii) the CBA practitioner or analyst (iii) the beneficiaries or winners and (iv) the losers.

In the logic of evaluation in conventional CBA, the more stakeholders there are or the wider the scope of stakeholders the more expensive the project could be. In what would be a clear demonstration of choice/discretion within bounded rationality constraints, the evaluation process sets a limit on the scope to be covered in the analysis thereby delimiting the benefits and costs to a specified geographical area. The rationale behind this practice is that it is not possible to include each and every affected party in a project or policy. The parties need to be categorized in a hierarchical order and a decision made on how far the analyst should go down the list. A similar approach is applied with regard to local, regional and international trans-boundary implications. Conventional CBA focuses primarily on the relationship between an impact and individual utility (usability). Impacts that do not have direct value to human beings and therefore non-human stakeholders are also commonly disregarded (Boardman et al., 2006). As mentioned earlier, significant progress has been made in evolved CBA and new methods to accommodate non-quantifiable and difficult-to-measure effects are emerging (Section 1.5).

The attributes discussed above are key areas of contradiction between CBA evaluation and the principles of sustainability. From a prospect theory perspective, the attributes can be categorised as idealistic and analytically complex thus requiring extremely high levels of experience and cognitive effort. Such tasks are processed by System-2, but according to prospect theory they are inevitably substituted with simpler framing of problems solvable through System-1 heuristics (Tomer, 2012:6). Alternatively, they can be categorised by System-1 as inconsequential to decision making and discarded or lead to *inertia* and *procrastination* (Ariely, 2008:109-126).

2.6.4 The attitudes and perceptions attributes

Ideally, sustainability assessment assumes that no impacts, however insignificant, are ignored. It goes further and recognises the existence of tangible and intangible/intrinsic values in projects and policies. For these types of goods, there was previously no adequate measurement to express their true value as opposed to their utility value (Armstrong and Botzler, 1993). In this instance, sustainability assessment adopts a non-monetary assessment method along for example a scenario building exercise. Where irreversible damage can occur and where predictive information is not initially clear, sustainability assessment bases its decision on the preventative principle and recommend that the project or policy should not be implemented (Padilla, 2002).

The attitude that promotes unsustainable behaviour among individuals in the current generation is based on the expectation that one will not have to suffer in a significant way for one's unsustainable behaviour, choices or decisions. It is also based on the attitude that the negative impacts of one's behaviour will mainly affect those in other geographical areas, those in poor countries, those from the poorer sections of the community or some future generations. In other words, this attitude presumes that the negative impacts will not affect oneself or at least not as severely as it affects others. Kahneman (2011:13-14) refers to this behaviour as the '*affect heuristic and defective forecasting*' and attributes it to overconfidence and optimism in predicting future events and outcomes. The behaviour also leads

to *inertia* and *procrastination*, the System-1 tendency to interpret a decision task as not deserving immediate attention and consequently postponing any action on the task. There is also a major element of assumed or unconscious blindness due to inability to consciously comprehend/sense the scale, location and time of future impacts at individual and collective levels.

The evolution of the contemporary market system over time (in which economic matters have taken a dominant position over world affairs), has resulted in the adoption of money as the key measuring tool in contemporary CBA. This development is closely linked with the co-evolution of society's attitudes and value systems (Gowdy, 2007; Fujiwara and Campbell, 2011). The perceptions and speculative logic that has created modern practice of discounting is derived from a value system that is primarily influenced and informed by neo-classical economics (Beder, 2000; Attfield, 2003).

The perceived tendency for people to be impatient where money is concerned and money being deemed to be more valuable now (the 'a bird in hand is worth two in the bush' philosophy) than in the future are examples of this value system (Perkins, 1994; Beder, 2000; Boardman et al., 2006). The relationship between money and the time perspective including discounting is discussed in Sub-section 2.7.2. Ariely (2008:75), notes that markets have gradually taken over our lives in the past few decades indicating, as shown in experiments, that money has developed into an emotive element in decision making and is also more likely to reinforce the self-referential frame of choice and decision-making which often gets perceived as selfishness.

Attitudes and perceptions are over-arching and pre-existing frames which guide choice and decision making, more often at a sub-conscious level. Some of the attitudes and perceptions arise from biological and physiological imperatives while others develop from social-cultural codes and norms. For example, homeostatic and allostatic drivers impose a framework where life-enhancing responses are prioritised and coded with pleasure-inducing notions, while life-

threatening options are coded with pain-inducing emotions and related mechanisms (Sterling, 2004:17-18; Kumar and Kumar, 2008:816). Additional layers of collective social-cultural norms develop from those basic evolutionary and biological norms. But a final layer of subjective attitudes and idiosyncrasies, which still operates at a sub-conscious level, is not normally accessible to the rational mind. Cognitive processes of these layers of rationally inaccessible mind underpin the nature of behavioural outcomes studied under prospect theory, behavioural economics and neuro-economics.

2.6.5 Emerging sustainability assessment tools

The co-evolutionary path towards reconciliation of CBA evaluations and sustainability is characterised by a variety of alternative rational-agent model approaches such as the ecological footprint, environmental accounting, multi-criteria decision analysis, climate impact equity lens, sustainability assessment model. One of the core features of these alternatives is the rational linear cause-effect paradigm which is oblivious of the bounded rationality constraint and prospect theory heuristics as induced by subconscious cognitive processes. This section reviews sample literature which expound on the logic and principles of some of these alternatives.

Ecological footprint: Wackernagel and Rees (1996) describe the ecological footprint as a planning tool that can help translate sustainability concerns into public opinion. The method attempts to package sustainability so that it can be understood by a large section of the population and so that it becomes a way of life the way evaluation in CBA is. The principle behind the ecological footprint is that excessive consumption and wastage are not sustainable and are depleting resources at a rate at which nature cannot replenish them, not just for the current generation but also for future generations.

Ecological footprint is a tool that can assist in decision making after establishing the level at which an individual, organisation, project, human activity or country consumes and wastes resources. The principle of the ecological footprint is

therefore similar to economics in that it calls for optimised use of resources. But whereas economics focuses on production of goods and services, ecological footprint focuses on and reinforces conservation of the earth's resources thereby becoming a credible tool for broadly valuing the effects of current production and consumption on the eco-system and bio-diversity. The procedure for calculating the ecological footprint is described in Wackernagel and Rees (1996), Chambers et al. (2000) and Merkel (2003) among others.

According to Wackernagel and Rees (1996), ecological footprint assumes that optimisation of nature's resources will result in equity between current and future generations. The tool has however been faulted for not being predictive, which refers to its inability to indicate future trends, and also its tendency to only deal with current consumption trends. Ecological footprint however advocates for continued availability of resources for future generations by promoting awareness and responsible uptake of such resources by the current generation. According to ecological footprint, the starting point is to know one's individual, regional or national footprint and adjusting accordingly.

Life cycle costing is applied in ecological footprint and the earth's carrying capacity is the ultimate principal criteria or reference point. Ecological footprint is not a telescope into the future but a way of visualising the consequences of current trends and to assess alternative "what if" scenarios on the road to sustainability (Wackernagel and Rees, 1996:23). The method does not however suggest any means of compensation but assumes that the individual, organisation or country that exceeds its fair share of resource uptake will feel a moral compulsion to improve or make amends. There are no punitive measures for those who decide to maintain their status-quo rather than transforming to sustainable options.

Ecological footprint ensures intergenerational equity by advocating for a per capita fair share of resources in all countries of the world and for all its inhabitants when viewed as equals. The method only deals with the environmental/ecological aspects of sustainability and its inequitable exploitation across countries.

Wackernagel and Rees (1996:4, 7) argue that humanity's economic and social activities depend on the earth's resources. It is observed that the ecosphere is where humanity lives. Humanity is dependent on nature and not the reverse. Nature can re-generate itself without humanity, but humanity cannot do the same without nature, nor can economic development and economic activities be separated from nature's process which includes the environment.

Ecological footprint emphasises that the current generation has the responsibility to ensure adequate resources for future generations and the ability to fulfil this responsibility. The consequences for failure to carry out this responsibility have been felt by the current generation and may prove even more disastrous in the future. Current problems associated with climate change such as floods, drought and other natural disasters can be traced, directly or indirectly to uncontrolled exploitation of natural resources. This situation can be attributed to the failure of contemporary society to relate current production and consumption lifestyles to such disasters, leading to *procrastination* and *inertia*.

One of the most impressive attributes of the ecological footprint is its emphasis on change in attitudes and perceptions as the basis for a sustainable and responsible use of natural resources. The method takes a pragmatic look at the needs of the current generation with regard to production and consumption, and then attempts to prescribe the limit within which the most basic needs should be met without depleting the earth's biodiversity and capital resources and hence compromising future well-being. It serves as a warning system on consumption levels vis-à-vis limitations of the earth's carrying capacity. Growth and related consumption beyond a certain level can lead to an 'overshoot' (Wackernagel and Rees, 1996), where the consumption starts depleting resources at a faster rate than it can be replenished. Ecological footprint however does not prescribe any enforcement system and relies on the conscience and goodwill of the individual to take action and change to sustainability.

We have however seen in Sub-sections 2.7.3 and 2.7.4 that people are prone to *defective forecasting* due to *over-confidence and optimism* in predicting the future. Furthermore, due to human cognitive limitations and the consequent bounded rationality approach, people often make decisions that are distinctly in conflict with their interests (Selten, 1999:3; Tomer, 2012:20). In addition, the ecological footprint model is too abstract and complex to be easily processed by the System-1 self and is therefore likely to be delayed or subjected to *procrastination* in the decision making context (Shogren, 2012:5, 14).

Environmental accounting: Environmental accounting, which is often used interchangeably with green accounting, is a tool that has evolved from attempts to address the inadequacies of the System of National Accounts (SNA) and environmental and natural resource accounts (ENRA) applied at national economy level (Lange, 2000). The concept has penetrated into organisations involved in economic production activities such as industries, companies etc. Companies involved in activities that have impacts on the environment are increasingly being challenged to adopt environmental accounting as a way of life. They are incorporating day-to-day environmental accounting into their hitherto traditional accounting processes which are only concerned with financial stock flows consisting of revenue, expenditure, stocks and depreciation. These changes are not entirely voluntary but are mainly aimed at compliance and not for social or environmental responsibility. Companies do not voluntarily go "beyond compliance" (Greene, 1998). Environmental accounting can be seen as a form of nudge technique which aims to influence behavioural change in order to promote responsible use of natural resources in the production of goods and services.

Huge landmark insurance awards for past environmental discretions and consequent insurance premium increases have put pressure on companies to take responsibility for activities that have negative impacts on the environment. In certain cases, influential environmentally-aware shareholders and environmental activism have put pressure on organisations to take remedial action.

Environmental accounting procedures are modelled on traditional accounting practices and are therefore restricted to the financial year time period. Projections are limited to the budgetary and development plan time periods of traditional accounting. Issues of intragenerational and intergenerational equity rarely feature in the environmental accounting procedures. Even when they do, it is often as an indirect result of the company's evaluation of risk and uncertainty, predictions of future trends and scenario building in environmental legislation. There is a heavy economic efficiency rationale behind environmental accounting practices. At national or individual organisation level, the principles applied in environmental accounting are the same as those applied in traditional accounting practices.

Simon and Proops (2000:124) distinguish the difference between conventional or traditional and environmental accounting. In conventional accounting, the description of transactions focuses on those transactions which are actually carried out in monetary terms. Where no monetary values exist, transactions are valued using comparable market values. In environmental accounting however, physical flows of materials from nature to the economy have to be described as well as all transformation processes within the economy and the material flows back to nature especially in form of waste. Costs are allocated to specific products and specific production stages using the 'polluter pays' principle in what is referred to as the product chain. Any product that performs poorly in this respect can be discontinued or changed (Bennett and James, 1998:36). Life-cycle costing is applied but mostly to a limited extent due to problems of allocating the costs between downstream and upstream operations that a particular company has no control over.

Traditional financial accounting when it is part of the company's business operation tools, tracks the flow of revenue and expenditure in the company's day-to-day operations. In the process, most of the flows that cannot be valued in monetary terms are discarded. The level of inclusion of various flows in the environmental accounting procedure depend on the commitment of the particular company to sustainability issues which in turn will most often depend on the

amount of external pressure exerted on management. In addition to management, the stakeholders will include shareholders, consumers and government.

The application of environmental accounting and the attitude of companies mirror human behaviour with regard to environmental decision making. Companies appear to respond in a prospect theory and bounded rationality approach, where heuristics are applied to simplify a task and to arrive at a satisficing rather than optimising solution in choice and decision making under uncertainty (Selten, 1999).

Multi-criteria decision analysis (MCDA): The MCDA framework is identified with the complexity and uncertainty characteristics associated with co-evolutionary and complex systems, and embraces a collective decision making approach to evaluation. According to Janssen and Munda (2002:263), the MCDA decision making structure adopts an evaluation approach that is "consultative, adaptive, and which incorporates and appropriately weights social, ecological and environmental criteria". It especially prioritises the problem of monetisation in cost-benefit analysis.

The main approach in the MCDA methodology involves ranking and comparing of alternative proposals to establish the most appropriate choice or decision within pre-defined constraints. Criteria are scored and weighted on the basis of relative importance and prioritised options in the project. The option with the highest aggregate preference index represents the best compromise among the alternatives (Diakoulaki and Karangelis, 2007:717). Diakoulaki and Karangelis identify the inherent complexity, uncertainty, conflict and multiplicity in decision making as compelling reasons to adopt multiple methodological approaches to evaluation. In addition such approaches need to balance the economic, social and environmental aspects in the development process.

According to Elghali et al. (2007:6077), the MCDA approach should be used in preference to "economic approaches such as cost/benefit analysis". Nevertheless,

MCDA is intended to complement economic appraisal methods already in use presumably including CBA. In particular, MCDA is a formal analysis that accommodates elements that are not easily expressed in monetary terms. A generic step-by-step procedure for MCDA is described in Elghali et al. (2007:6078).

MCDA incorporates the social and environmental elements of a sustainability assessment. It addresses the stakeholder factor by proposing "decision conferencing" where stakeholders engage in problem-solving sessions and where complex issues are discussed. MCDA involves stakeholders in defining the performance criteria including the weighting to be applied to such criteria and deals with the scoping factors, presumably incorporating a wide scope of scenarios. Although MCDA does not mention how it specifically addresses generational equity issues, it can be assumed that the decision conferencing and stakeholder consultation incorporates issues such as a particular society's attitudes and perceptions towards intrinsic value in relation to the specific project or policy options. It can thus be argued that MCDA follows a process similar to both CBA evaluation and sustainability assessment, which are confronted by the reality of the bounded rationality dilemma, characterised by the same choice and decision making heuristics. MCDA is therefore unlikely to capture the attention of the ordinary decision maker's System-1 as a priority worth referring to System-2 for further processing and decision.

Climate Impact Equity Lens (CIEL): Another emerging valuation tool with a different perspective is the Climate Impact Equity Lens (CIEL) which was developed at the Stockholm Environment Institute (Stanton and Bueno, 2011). It measures the costs of climate change and emissions reductions on an individual level over a period of time. The underlying principle is that CIEL estimates and compares each individual person's losses from failure to stop climate change to savings from not paying for subsequent emissions reductions.

Essentially, CIEL is based on two key outcomes regarding individual attitudes to climate change. These are (i) where the individual does nothing to reduce greenhouse gas emissions and (ii) where the individual does everything to cut down on greenhouse gas emissions. The act of doing nothing to lower emissions results in monetary savings or gains while doing everything to lower emissions potentially results in damages or costs. Each individual person bears her own costs and enjoys her own benefits from their actions. According to Stanton and Bueno (2011:4), the purpose of "…the tool is to illustrate both the severity and diversity of expected impacts from climate change". From a prospect theory perspective, CIEL is a tool whose primary goal is to create awareness rather than actual application in real-life decision making contexts. This is mainly because a single person's or country's decision or action will have no meaningful mitigation effect on climate change in general.

Stanton and Bueno (2011:6) illustrate the CIEL model in form of a graph (Figure 2.2). As mentioned earlier, the model is a comparison of net gains versus net losses from not stopping climate change. The break-even line represents a situation where the gains and losses are equal. The area below the break-even line represents the situation where gains exceed losses resulting in net gains. The area above the break-even line represents the situation where losses exceed gains resulting in net losses.

The examples given here show a comparison of climate damage costs to the savings from not reducing emissions for persons A, B and C (Stanton and Bueno, 2011:7) in the year 2100. In the following explanation, the currency denomination has been changed to South African Rands for relevance to South Africa.

- Person A loses 37% of her income to climate damages in year 2100 but saves an amount equal to 20% of her income by not having to pay for emissions cuts. Her net losses amount to 17% of her income. If for example person A earned R100,000 in year 2100, she would lose about R37,000 but save R20,000. Her net losses would be R17,000.)

- Person B loses 46% of her income to damages but saves 35% in avoided costs. Her net losses are 11% of her income.
- Person C loses 9% of his income to damages but saves 21% in avoided costs. His net gains are12% of his income.
- Persons A, B, and C will experience climate change very differently. For A and B, damages outweigh savings in that year, but for C savings outweigh damages.

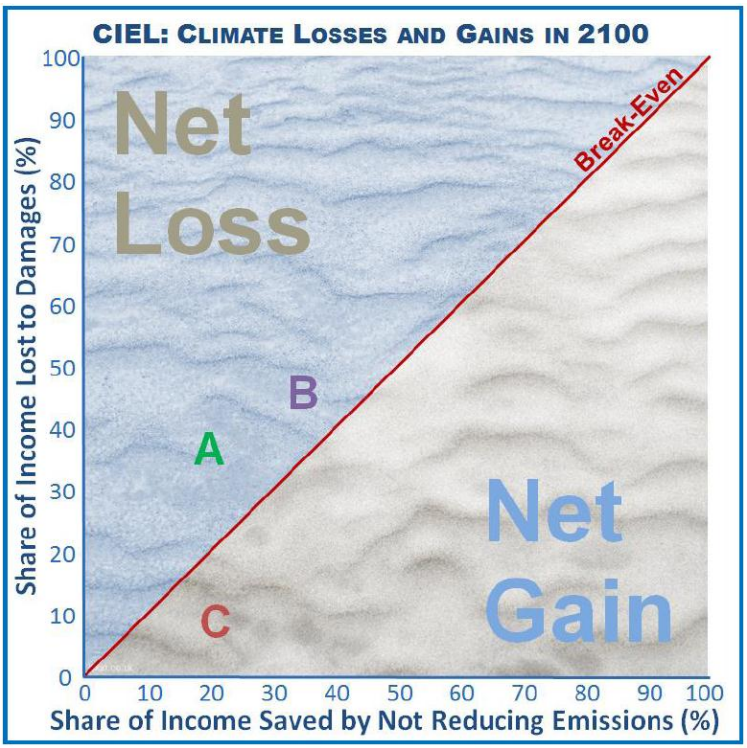


Fig. 2.2: Illustration of the CIEL model
(Source: Stanton and Bueno, 2011:6)

The same illustration can be used to track climate change losses and savings for one person over several years. CIEL argues that people experience climate change impacts differently depending on their economic status and geographical location and uses five criteria in the assessments. These are: income per capita, economic vulnerability, sea-level rise vulnerability, water shortage vulnerability and geographical region. Data for temperature and sea level changes, emissions and

the respective amount of damages, reduction costs and incomes are obtained from the Climate and Regional Economics for Development (CRED) model results.

As would be expected, CIEL approach faces the bounded rationality dilemma because all the assessment criteria are arbitrary even though they are presented as fully logical and rational. The assumptions in CIEL contradict the reality of choice and decision making in prospect theory and especially the *loss aversion* heuristic. Because losses loom larger than gains, the straight line profile of the losses and gains graph in CIEL is not realistic (see Figure 1.1).

CIEL proposes to be different from other similar tools by viewing the net gains and losses from failure to cut greenhouse gas emissions as individual rather than global or national and emphasises that it is not an aggregation of such individual gains and losses. In this respect, it can be seen to partly identify with contemporary society's value systems, which form the foundation of informal and formal CBA evaluation. Another similarity with evaluation in CBA is that gains and losses are valued exclusively in monetary terms.

CIEL is problematic from a sustainability perspective in that it presumes that greenhouse gas emissions are primarily a problem for developing countries hence the emphasis on removal of international aid for climate change initiatives. Alternatively, the tool is meant for developing countries or those that rely on international aid to finance their climate change initiatives. In addition, it uses economic parameters to describe gains and losses, and money as the unit of measure.

There are similarities with the ecological footprint in that CIEL assumes that each person would have to pay her own share of emission reduction costs. But it then goes on to state that, '…rich countries would not…contribute funding for emissions cuts in poor countries; and rich people would not subsidize emissions cuts by the poor within their own countries" (Stanton and Bueno, 2011:5). The impression created by CIEL is that escalation of greenhouse gas emissions are a

result of the poor people or countries' inability to pay for their portion of emissions. It has been established in various climate change forums that the big economies are not only the largest emitters of greenhouse gases, but that they have refused or are reluctant to adopt any protocols for reduction of such emissions.

Any evaluation method with complicated computations is bound to contend with the cognitive limitations of the human mind. According to Quartz (2009:209), "cognitive processes typically involve exact computations according to a cost-benefit calculus whereas emotional processes typically involve approximate heuristic processes that deliver rapid evaluations without mental effort". Shogren (2012:14) notes that people systematically avoid making decisions in situations where the consequences of their actions do not have known probabilities and where their emotive mind cannot evaluate a decision task either because it is too complex or not considered of prioritised importance.

The Sustainability Assessment Model (SAM): SAM is described as "a full-cost-accounting tool that monetises externalities" (Frame and Cavanagh, 2009:195). SAM is an attempt to create a holistic valuation tool that closely responds to the goals of sustainability. It recognises that "stakeholder engagement in sustainability issues is critical for legitimacy and quality of decisions…" (Frame and Cavanagh, 2009:196). It also recognises monetisation of externalities as a difficult and contentious element that is at the very base of the problems which the principles of sustainability seek to address (Frame and Cavanagh, 2009). This is in reference to the difficulty of monetising some social and environmental impacts especially those that are regarded as having intrinsic value. This challenge informed the formulation of SAM.

SAM was developed in the UK by BP, Genesis Oil and Gas Consultants and University of Aberdeen (Bebbington, 2006:2; Bebbington et al., 2007:229; Frame and Cavanagh, 2009:198) and was also used in New Zealand. The oil company wanted to understand more fully the concept of sustainability and what form of re-

engineering was required in order for the company to work in a more sustainable manner, and to incorporate sustainability principles into its overall decision making processes.

SAM was developed with a clear intention to achieve an inclusive valuation outcome rather than one based on trade-offs between only a few dimensions of sustainability (Frame and Cavanagh, 2009:199). There is a clear focus on sustainability issues in SAM, especially where management decisions are heavily influenced and dominated by economic rationalisation to the disadvantage of social and environmental considerations (Frame and Cavanagh, 2009:198).

Rather than develop an antagonistic tool to counter cost-benefit analysis and other tools perceived to lean too much on economic principles, SAM was developed on the co-evolutionary principle that a tool which facilitates sustainability principles in an environment where economics dominates management decisions, ought to operate in the currency of that environment. The principle also recognises that institutional change does not occur in a vacuum but arises from economic, social and environmental forces (van den Bergh and Stagl, 2003). "SAM comes from the perspective that if economic rationalism dominates managements, then providing an alternative information set built around monetisation provides a means to ensure consideration of sustainability issues" (Frame and Cavanagh, 2009:205; Bebbington et al., 2007).

SAM suffers from focusing too much on addressing contentious elements in CBA evaluation practice and the principles of sustainability, and therefore ends up following the same rational-agent model approach as both. This leads to similar bounded rationality dilemma constraints.

According to Bebbington et al. (2007:225), SAM was introduced to demonstrate a form of sustainability accounting that was more participatory and pluralist than what CBA provided. Hence SAM considers the project over its full life cycle, identifies and monetizes the project's impacts including externalities and

dialogues with stakeholders in the process (Frame and Cavanagh, 2009). SAM is an adaptive/evolved/transitional sustainability assessment tool combining neo-classical economic, social and environmental methods.

Accepting monetising in any sustainability-related assessment tool is a significant step towards narrowing the CBA evaluation and sustainability dichotomy. It seems clear then that the objection to monetisation within the evaluation in CBA sustainability argument was about the failure to adequately value the elements rather than the monetising principle itself.

The model is structured in a four-step financial-cost-accounting approach comprising economic, resource, environmental and social impacts of any project (Bebbington, 2006:3; Bebbington et al., 2007:228-9; Frame and Cavanagh, 2009:197). Discussions are held with and consensus sought from any group that may raise concerns on specific issues. SAM is therefore seen as a consensus seeking valuation tool. However, the model also allows certain key items to act as "trump cards" in decision making (Bebbington et al., 2007:230). Where any impact in the project or programme poses an irreversible risk, the "trump cards" can be used to veto the project or programme.

"Data are drawn from specific project activities (e.g. hours worked, barrels of oil produced, volumes of water used, waste produced, and financial performance estimates). This information is used either directly in the model or indirectly to impute the economic, resource use, environmental or social impacts" (Bebbington et al., 2007:229-230).

SAM encountered contentious issues similar to other evaluation tools especially with regard to identification and monetisation of indicators, the relativity of impacts and subjectivity of the measuring tool. Although monetisation remains the most contentious issue, SAM recognises that the rationality of monetisation does not exist in a vacuum but that it has evolved within society's value systems and is a reality of decision making in the world today (Bebbington et al.,

2007:232). Similarly, the expressions used to describe social and environmental impacts such as happier, healthier, reduced crime are difficult to quantify and "the lack of robust data, both for quantifying and monetising impacts, was a significant limitation to the SAM process" (Frame and Cavanagh, 2009:203).

Eventually however, most of the limitations in SAM are attributed to the divergent views in the sustainability discourse rather than in the tool itself. The unfavourable views include claim that the use of monetisation and presentation of costs and benefits give the perception that SAM is another form of CBA (Frame and Cavanagh, 2009:204). The SAM is also said to be unnecessarily too long-drawn, requiring significantly more time and financial resources. This could also present a significant constraint from a behavioural economics and prospect theory perspective, where complex and lengthy computations conflict with the finite mind, finite time and finite resources. Unlike CBA however, SAM "can encourage individual and groups to critically reflect on the unsustainability of organisational practices and provide a mechanism to create site-specific insights into sustainability" (Bebbington et al., 2007:234).

2.6.6 Conclusion

It is clear that although CBA evaluation and sustainability assessment share some common goals they use fundamentally different approaches and eventually achieve polarised outcomes (Sub-section 1.11.2). However, the emergence of the bounded rationality rationale has changed the structure of the perceived contradiction between evaluation in CBA and the principles of sustainability. Both CBA evaluation and sustainability assessments fall into the same trap in applying the rational-agent model assumptions which prospect theory and neuro-science have proven to be without empirical merits (Trepel et al., 2005). In assessing sustainability, various other methods can be used to reinforce the general criteria for sustainability. The ecological footprint for example can be used to provide more accurate evaluation to the environmental-ecological streams of sustainability.

Environmental accounting is a tool that is best suited to ensuring compliance with set targets in much the same way as conventional accounting works with set budgetary controls. It is therefore an appropriate tool for compliance rather than assessment. Whereas evaluation in CBA and ecological footprint are useful as evaluation tools and assist in decision-making before a project is implemented, environmental accounting ensures that set compliance targets are being achieved or followed during implementation and operation of the project.

MCDA significantly addresses concerns regarding monetisation, uncertainty, scoping and stakeholdership including wide consultation in all stages of the evaluation process. The CIEL model attempts to personalise the responsibility of cutting emissions and stopping climate change to the individual level by allocating the benefits and costs of greenhouse gas emissions and climate change to individuals rather than collective entities. But it fails to recognise or trivialises the fact that the consequences of doing nothing to reduce greenhouse gas emissions and stop climate change are global. The sustainability assessment model (SAM) has emerged as a model which significantly addresses the contentious issues in the conflict between CBA evaluation and the principles of sustainability.

CBA (conventional and evolved) is perceived to be biased against the principles of sustainability because of its economic foundation and the commanding position economics occupies in contemporary world affairs. If valuation assesses actual preferences of contemporary society, then it should be adaptable to changing economic trends and might eventually transform fully to the level of or close to the principles of sustainability. Evidently, evaluation in CBA has evolved in certain aspects in response to the criticism regarding its perceived inadequacy in embracing the principles of sustainability.

The bounded rationality dilemma implication is that none of these tools or heuristics will evolve and mature far enough to be deemed acceptable for all decision making contexts. Instead, one can only expect a further abundance,

continuing inadequacies and perpetuation of customisation of approaches similar to SAM. The expectation that evaluation in CBA will evolve to a commonly acceptable level for sustainability assessment or that a new commonly acceptable sustainability-specific tool will emerge has no basis from a prospect theory perspective. As prospect theory related dilemmas become more understood through behavioural economics, behavioural finance or neuro-economics, one can expect a transition towards the emergence of more context-specific tools rather than towards globally homogenising ones.

The key findings in disparities between CBA evaluation and sustainability assessment from bounded rationality and prospect theory perspectives are summarised in Tables 6.1-6.3 (Section 6.1).

Chapter 3

Research method

3.1 Overview on research and knowledge creation

According to Gustavsson (2007:10), knowledge is created through a process of questioning, criticism and substantiation on an improved understanding of a specific knowledge gap or challenge. Hussey and Hussey (2009:1) observe that research is a process of inquiry and investigation which is not only systematic and methodical, but also increases or creates new knowledge through improved understanding. Krauss (2005:763) points out that when one engages in a research effort, one engages in an intensive learning process where new knowledge and understanding are achieved, while Mouton (2004:137) identifies research as a means to the creation of new knowledge. These arguments clearly suggest that knowledge is created when a researcher identifies a knowledge gap (shortfall in understanding) and successfully collects data, analyses and interprets them so as to generate findings and conclusions regarding the research problem (the knowledge gap).

Krauss (2005:759) observes that a researcher's theoretical framework and underlying assumptions largely define the choice of research method applied in the study. The research method is significantly informed by the types of data required to substantiate and answer the research questions which the researcher prioritises (Gustavsson, 2007). Although Krauss (2005:758) notes that mixed research methods tap into the richness of individual experiences, it is emphasised that the method chosen would depend on what one is trying to achieve rather than a commitment to a particular paradigm or theory. This study agrees with the view that researchers can select appropriate research methods by initially focusing on the phenomenon under examination rather than the methodology (Falconer and Mackay, 1999).

Krauss (2005:759) argues that "philosophical assumptions or a theoretical paradigm about the nature of reality are crucial in understanding the overall perspective from which a study is designed and carried out". This is the process and philosophy that was adopted for this study. The primary purpose of this study however, is not to create new models or theories of evaluation but to substantiate the limitations of contemporary theories, principles and practice of CBA evaluation (especially arising from the assumed model of human behaviour borrowed from neo-classical economics) and the subsequent implications on response to the principles and practice of sustainability. Although this is undertaken from a prospect theory perspective, it is not the intention of the study to specifically test the theories (in prospect theory, behavioural economics, bounded rationality or neuro-science) for validation or extension. Instead, the theories are applied as substantiated in the extensive scientific publications covering close to half a century of testing, validation and revisions/extensions. In this study, the primary approach was to investigate if such theories could explain the experienced phenomena (from the case-study data) differently compared to the perspectives informed by mainstream CBA evaluations principles and sustainability assessment methods.

Arising from an established track of the theories applied, the study is guided by the hypothesis that CBA evaluation outcomes continue to significantly impede the transition to more sustainable production and consumption lifestyles at individual and collective levels. It is observed that the strong rational motivation for sustainability transition at individual and collective level is not yielding the expected outcomes in the uptake of sustainable lifestyle options, at production and consumption levels. Instead, there is entrenched persistence of status-quo or business-as-usual practices, even in the face of the dire consequences predicted from such threats as climate change, bio-diversity loss, resource depletion and socio-economic inequalities.

As discussed in Chapters 1 and 2, the persistent behavioural deafness and blindness to the sustainability signals seems to contradict the rational-agent model principle often assumed in most fields of human behaviour and social interactions including applied disciplines. Furthermore, behavioural studies in psychology and neuro-science (mainly in neuro-economics, behavioural economics and prospect theory) have confirmed that human behaviour outcomes consistently demonstrate predictably *irrational* behaviour rather than the commonly assumed rational-agent model expectations, when faced with issues of choice and decision making in the context of risk and uncertainty.

In this regard, this study has prioritised the prospect theory approach and reviewed the status-quo of lifestyle options from a sustainability perspective. With CBA evaluation as one of the primary tools of current practice in choice and decision making, the study argues that from a prospect theory point of view, and especially the bounded rationality constraint, the tool has become an out-dated heuristic which continues to present itself as a rational and valid mechanism for objective choice and decision making. On the other hand, sustainability pursuit persists solely with similar rational-agent model appeal, based on a variety of yet more unacknowledged heuristics, which compete for cognitive mind space in the choice and decision making dynamics at individual and collective level.

This study examines the implication of the resultant conflict in the context of decision making in the solar water heating sector in southern Africa as an empirical context for the substantiation of the argument. In particular, the switch in favour of solar water heating in South Africa after the 2006-2008 electricity crisis has provoked the question of the sustainability merits of this switch especially after an intense status-quo entrenchment of electric geysers as the water heating technology of choice before the crisis. Given the bounded rationality dilemma in both CBA evaluations and sustainability assessment heuristics, how can one explain the switch and how does it in turn explain the rational-agent model versus *irrationality*/prospect theory paradigms of behaviour?

As mentioned earlier, both CBA evaluation and sustainability assessment heuristics suffer from their dogmatic premising on the rational-agent paradigm which assumes that a rational decision-maker will automatically choose the option which optimises welfare in both immediate and long-term interests when neutral facts are objectively presented. The study therefore applies decision making in the solar water-heating sector and related projects to substantiate the fallacy of this premise. The aim is not to dismiss or nullify either of the heuristics, but to enrich them with sub-heuristics which are better informed by the choice-architecture paradigm, making it easier for humans to opt for the sustainability-enhancing choices while avoiding the sustainability-undermining choices in their lifestyles.

Besides the literature review, the study has applied case study and qualitative analysis methods to investigate how decision making in the solar water heating sector in southern Africa can be better understood within the framework of prospect theory and the implications for the supposedly rational objective tools. For example, how did the same CBA evaluation heuristics which entrenched status-quo prior to the 2006-2008 crisis transform to a heuristic for the switch to solar water heating after the crisis? How does this help us to understand better the means and mechanisms for transition to sustainability?

Primary data were collected through semi-structured interviews with selected role players in the solar water heating sector while secondary data were collected from sources such as internet-based research reports, media articles and policy statements (Chapter 4). In addition, five case studies comprising one supplier of solar water heaters from Botswana and four solar water heating projects from South Africa and Botswana are presented (Chapter 5). Interviews and historical records were used to obtain the stories of the selected case studies. Findings and conclusions were drawn regarding the key choice and decision making contradictions in the context of CBA evaluation, sustainability assessment and the emerging evaluation tools, as well as the extent to which these contradictions undermine the transition to production and consumption lifestyles which advance the goals and principles of sustainability.

3.2 Research design

The study develops in the following order:
STEP 1 (Literature-based - Chapter 1): What are the key choice and decision making features and objectives of CBA evaluation (conventional and evolved) and the principles of sustainability as expressed in sustainability assessment? How do these features align with behavioural economics and neuro-science in general, particularly in prospect theory and neuro-economics?
STEP 2 (Literature-based - Chapter 2): What are the key areas of contradiction and weakness between choice and decision making through CBA evaluation and the principles of sustainability. How does evolved CBA evaluation and emerging assessment methods respond to those contradictions and weaknesses? What are the applicable human behavioural responses from a neuro-economics and prospect theory perspective?
STEP 3 (Chapters 4, 5 and 6): This step uses decision making patterns in the solar water heating sector and selected projects in southern Africa to substantiate how in reality choice and decision making routinely demonstrate prospect theory in general and bounded rationality heuristics in particular, rather than the assumed rational-agent model heuristics defined by CBA evaluation and sustainability assessment approaches (see Tables 6.1-6.3). What are the resultant contradictions and implications on the desired transition to sustainable production and consumption lifestyles?
STEP 4 (Chapter 7): This step concludes on the specific way in which from a prospect theory perspective, choice and decision making in CBA evaluation framework contradicts the goals and principles of sustainability, how this constrains the transformation to sustainability and proposes possible remedial approaches which align better with new understanding of choice, behaviour and decision making from a prospect theory and neuro-science perspective.

In order to evolve new understanding out of the main research question, it was broken down into two sub-questions (see sub-section 1.11.3). The main research question (h*ow does choice and decision making through CBA evaluation influence status-quo decision outcomes relative to the goals and principles of*

sustainability and how does this impact on the transition to sustainability?) however remained as the key determinant of the type of data and analyses required. This was substantiated through analyses of the patterns of decision making in the solar water heating sector, based on a prospect theory framework when compared to a conventional CBA evaluation approach. The detailed data analysis and interpretation procedure is discussed in Section 3.3.

Data required are those related to decision-making processes in the solar water heating sector at various levels (both individual and institutional) in policy, industry and projects. How then can those data be obtained? Broadly, data collection which forms Step 3 of the order described above is divided in two parts:

- Data relating to patterns of decision-making in the solar water heating sector in South Africa.
- Data relating to decision-making in selected solar water heating projects in South Africa and Botswana.

The data required can broadly be described as the stories behind decision-making processes in the solar water heating sector and projects from the perspective of the various role players, in this case the manufacturers, suppliers, policy makers, researchers, institutions and individuals. Where does this type of research then lie in terms of the broad classification of research methods? The notion of qualitative methods is derived from quality, which is essentially a descriptive approach to the nature of things while quantitative methods, derived from quantity, is essentially about amounts (Berg, 2004:102). Qualitative design is defined by meanings, concepts, definitions, characteristics and descriptions of things whereas measures (especially statistical ones) define quantitative design (Berg, 2004:102). More appropriately for this study, Yin (2011:8) describes one feature of qualitative research as "contributing insights into existing or emerging concepts that may help to explain human social behaviour".

This study is a search for meaning regarding the contradiction between approaches adopted in CBA evaluation practice and the principles of

sustainability as substantiated through decision making patterns in the solar water heating market and projects, from a prospect theory and neuro-economics perspective. Krauss (2005:763) also describes qualitative research and data analysis process as the most appropriate method for constructing meaning. For this study in particular, accessing the stories behind the decision-making processes in solar water heating fall into the category of qualitative research design because the experiences cannot be meaningfully expressed in conventional statistical analyses.

Case studies: The case study as a research tool is in various ways particularly suitable to this type of study. According to Punch (2005:147), only an in-depth case study can provide understanding of the important aspects of a new or persistently problematic research area. Berg (2004:251) favourably points out that "Extremely rich, detailed, and in-depth information characterize the type of information gathered in a case study". In motivating for the case study method, Yin (2012:5) points out that the other research methods or tools might not produce the rich descriptions or the insightful explorations that arise from a case study. A case study allows information to be gathered in various ways leading to a better understanding of the phenomena under investigation and clearer answers to the research question(s). The case study method also allows triangulation or combinations of various data gathering techniques to be applied.

Comprehensive aspects of the case studies are investigated in depth, not simply to elaborate the case, but to assist the researcher to better understand some external theoretical question or problem. The choice of the particular case to be included in a study is made on the basis of the researcher's motivation that a deeper understanding of his or her research concerns will be advanced by the case study identified. For this study, prioritisation of the particular case studies selected was influenced primarily by relevance and secondarily by resource and time constraints (thus demonstrating a dimension of bounded rationality imperative of satisficing rather than optimising).

Berg (2004) classifies case studies into three categories: intrinsic, collective and instrumental. Baxter and Jack (2008: 548) describe an intrinsic case study as one whose intent is to better understand the case due to its uniqueness. Stake (1995) advises the researcher to opt for an intrinsic case study if interest is in the uniqueness of the situation, suggesting that the case itself is the phenomenon under investigation. A collective or multiple case study provides a general understanding of issues within and across the cases. Comparisons are drawn and findings replicated within and among the cases (Baxter and Jack, 2008:549).

Among the three however, it is the instrumental case study that best represents the character of this study. Instrumental case studies provide insights into an issue or refine a theoretical explanation or phenomena. The case itself becomes of secondary importance, serving only a supportive role and a background against which the actual research interests are played out (Berg, 2004:256). More specifically in an instrumental case study, the researcher selects a small group of subjects in order to examine a certain pattern of behaviour, in this case that of choice and decision making in the solar water heating sector, policy and projects (Zainal, 2007).

Secondary data for the case study of patterns of decision-making in the solar water heating sector in southern Africa are in form of internet-based and commissioned research reports, media articles and policy statements from government and Eskom. These are supplemented with primary data gathered through face-to-face, telephonic and email interviews conducted with a number of role players in the solar water heating sector.

Case studies from five solar water heating projects in southern Africa are analysed. These projects are:

(i) Solahart Botswana –An established supplier of solar water heaters in Botswana representing the supply side perspective of solar water heating projects.

(ii) University of Botswana Student's Hostels –a comprehensive project at the main campus in Gaborone, representing projects that are likely to be influenced by government policy and/or a corporate responsibility policy and a long-time user's perspective of solar water heating projects.

(iii) Deutshes Senioren Wohnheim (DSW) or German Home for the Elderly, Pretoria –a completed, smaller but presumably purely economic driven project.

(iv) University of Pretoria Students' Hostel - an institution where solar water heating has recently been considered and where the project is in progress.

(v) Tshwane University of Technology, Pretoria -An institution where solar water heating has been considered but not taken or where such a project has failed to take off.

Data for these case studies are primarily in the form of interviews which were conducted with various key stakeholders including suppliers of solar water heating systems, individual users and management representatives with decision-making responsibilities in the user organisation. Through these interviews, the stakeholders were expected to give a fair evaluation of the project from different perspectives. Secondary data in the form of feasibility studies, project proposals and reports, client evaluation of the feasibility and records of decision-making forums including minutes of meetings were used where more details and/or clarifications are required.

Berg (2004) identifies three types of interviews: (i) the formal, structured, standardised; (ii) the informal, unstructured, unstandardised and (iii) the semi-standardised, guided semi-structured or focused unstandardised. The semi-structured interview method that this study adopts involves a number of pre-determined questions that are used as a guide to a more fluid discussion rather than the short question, short answer type normally used to facilitate coding for statistical analysis.

Questions for institutional case studies were derived from the key attributes and themes that define the link between evaluation in CBA and the principles of sustainability (Sub-section 2.7.1). The specific questions are in Appendices 3, 5 and 9. The attributes which are briefly introduced in Sub-section 2.7.1 and followed by detailed discussion in Sub-sections 2.7.2 to 2.7.5, are identified and grouped as follows (it will be noted that some of the attributes cut across the groupings and are therefore discussed accordingly):

- Time-related attributes: initial costs, life-cycle costs, payback periods, intergenerational and intragenerational considerations, perceptions of past and future time lines, immediate gratification.
- Scoping and stakeholder attributes: monetisation, inclusion/exclusion of streams in valuation, internalised and externalised streams, direct and indirect impacts on the project, policy or programme, stakeholder approach, participatory process.
- Attitudes and value system attributes: attitudes, perceptions and assumptions regarding evaluation, the irreversibility and preventative principle, equitable compensation.

Using the same framework, the study analyses both the primary and secondary data from the solar water heating sector and selected projects and co-relates with applicable behavioural heuristics in order to identify related biases and contradictions with rational-agent model assumptions. More importantly, emerging patterns are evaluated for findings which substantiate the rationale for prioritising bounded-rational decision biases as the key barriers to the opt-out options under evaluation in CBA and opt-in options in favour of sustainability principles.

In general, a contradiction is identified if a decision making pattern is *irrational* and characterised by one or more prospect theory and bounded-rational heuristics, rather than the assumed rational, evaluation in CBA and sustainability assessment framework. The common *irrational* or bounded-rational decision making heuristics in prospect theory are defined in Section 1.3 and re-stated in summarised form in Table 3.2. Admittedly, not all of these heuristics are expected to manifest out of the empirical observation of the decision making patterns and only the identified heuristics are discussed further in the study. In addition some *irrational*, contradictory and seemingly illogical decision making behavioural patterns may not perfectly fit into any of the descriptions or labels in Section 1.3 and Table 3.2. They however fit the criteria of bounded-rational or prospect theory heuristics and are therefore considered in the analysis.

3.3 Data analysis and interpretation

This study has a more interpretive orientation and therefore organises data in order to uncover patterns, action and meaning as discussed in Berg (2004). It is however acknowledged that the original purpose of the study may not be accomplished and an alternative or unanticipated goal may be identified in the data. The mind is therefore left open to multiple or unanticipated results that may emerge (Berg, 2004:252).

Data are presented, analysed and interpreted primarily in a narrative form as described in Yin (2012), rather than in quantitative/statistical method. A narrative rather than a quantitative appraisal is applied to determine the key patterns of decision making in solar water heating sector and selected projects. Events and behaviour patterns are analysed for evidence of contradictions and conflict between the evaluation in CBA approach and the principles of sustainability on the one hand and the interpretation from prospect theory perspective on the other hand (Chapters 2, 4 and 5).

A decision making behavioural pattern which is characterised by specific evaluation in CBA and sustainability assessment heuristics is deemed to be consistent with the rational-agent model approach. On the other hand, a decision making behavioural pattern which is characterised by prospect theory and other emotion-driven heuristics is deemed to be consistent with the bounded rationality or *irrationality* approach. Behaviour patterns that demonstrate a contradiction between rational-agent model and emotion-driven, bounded-rational/*irrational* decision making are interpreted as constraining the transition to sustainable production and consumption lifestyles. This therefore calls for application of the concept of choice architecture as developed under nudge, in order to evolve more responsive heuristics to guide CBA evaluation and sustainability assessment in a way which mitigates a naive bias towards rational/objective model of human choice and behaviour.

Data analysis and interpretation is organised in the same pattern as data collection. Two sets of data are analysed within the framework of the combined attributes of evaluation in CBA and sustainability assessment and from a prospect theory perspective, using two approaches as follows:

- In Chapter 4, data analysis and interpretation relating to patterns of decision making in the solar water heating policy and industry sector in South Africa, and the general contradiction or inconsistency that emerges between rationality as assumed in evaluation in CBA and sustainability assessment, and *irrationality* as demonstrated in prospect theory.
- In Chapter 5, data analysis and interpretation relating to decision making in selected solar water heating projects in South Africa and Botswana and more specific rational-agent model vis-à-vis prospect theory contradictions or inconsistencies.

The data captured from oral and email interviews, internet-based and commissioned research reports, media articles and policy statements are transcribed, coded and analysed in terms of the patterns that relate to evaluation in

CBA or to the principles of sustainability. The interviews from solar water heating projects and manufacturers are transcribed, coded and analysed in terms of the theories, attributes and themes from which the interview questions were derived (Sub-section 2.7.1). Patterns in data that reflect the respective prospect theory and similar *irrationality* heuristics are systematically identified and coded accordingly.

Consolidation of findings in Chapter 6 follows a grouping similar to Section 2.7 and Chapter 5. In Sections 6.2 to 6.4, patterns in decision making from the solar water heating sector and selected projects are consolidated and interpreted for indications of a common trend of contradictions, inconsistencies or alternatively any alignment with emotive/intuitive-driven prospect theory and bounded rationality heuristics. The conclusion in Section 6.5 consolidates the key findings from each category of attributes.

The overall research argument is finally consolidated in Chapter 7 and key findings from Chapter 6 synthesised into plausible conjectures for the two sub-questions (Sub-section 1.11.3). These coalesce into the answer to the main research question, *"how does choice and decision making through CBA evaluation influence status-quo decision outcomes relative to the goals and principles of sustainability and how does this impact on the transition to sustainability?"*

Ultimately, and based on the answer to the research question, the research working hypothesis is supported or invalidated. Table 3.1 shows a summary of the types of data used and their application in this study. Table 3.2 shows a summary of key prospect theory heuristics applied in the analysis.

Table 3.1: Summary of the types of data used and their application in the study

Data source	Data type	Where analysed and applied	Application intent
Personal comments, face-to-face interviews, electronic communication	Primary data	Chapter 4, 5 & 6	To highlight and demonstrate the nature of decision making patterns in the solar water heating sector and selected projects.
Surveys of solar water heating projects	Primary data	Chapter 5 & 6	To demonstrate the nature of decision making structures and patterns in selected solar water heating projects.
Literature review	Secondary data	Chapter 1 & 2	To introduce the concepts and theoretical background to the study. To provide the theoretical foundation to the study.
Internet sources e.g. American surveys, South African commentators	Secondary data	Chapter 4 & 6	To highlight and demonstrate the nature of decision making patterns in the solar water heating sector.
Commissioned reports e.g. Holm and SolaSure (2005)	Secondary data	Chapter 4 & 6	To highlight and demonstrate the nature of decision making patterns in the solar water heating sector.
Media reports, newspaper articles,	Secondary data	Chapter 4 & 6	To highlight and demonstrate the nature of decision making patterns in the solar water heating sector.

Table 3.2: Summary of the key prospect theory and bounded rationality heuristics

Heuristics	Description
Loss aversion	A psychological behaviour response arising from a biologically-based evaluation in which we are more sensitive to a loss (hence valuing it more) than to a gain of the same scale.
Status-quo bias & inertia	The strong tendency in choice and decision making, to stick to the current position as thus serves as the reference state or *default option.*
Endowment effect	A behavioural tendency in which individuals systematically allocate higher value to that which they already possess compared to how they value the same when evaluating whether to acquire it. This is closely linked to the sunk-cost fallacy/trap.

Post-rationalisation	Often a subconscious process by which a choice/decision arrived at subconsciously is subsequently motivated for consciously within a false belief that the rationalisation preceded or fits into the choice/decision. This is linked to *Confirmation bias* (part of the substitution effect) which is the tendency to first believe in something and then seek confirmation or compatibility; and *positive test strategy* which is the deliberate search for confirming/compatible evidence while underweighting evidence to the contrary.
Framing	The deliberate technique of influencing the choices people make by presenting options in alternative ways rather than assuming objectivity and rational behaviour where the manner of information presentation is assumed to be inconsequential.
Anchoring	A form of priming-effect on choice and decision-making arising when extraneous information is initially presented (explicitly or subliminally) before a choice/decision event is undertaken, and is then determined to have influenced the choice/decision even though it had no direct relevance on the issue being considered.
Mental accounting	The tendency to compartmentalise our evaluations such that money to be spent for a given purpose can acquire a different mental value/reaction or meaning when used for another purpose. This can also apply to the tendency to determine and make choices based on mental calculation rather than scientific or empirical evaluation, and is therefore closely linked to bounded rationality heuristic of satisficing rather than the optimising assumed under rational-agent model (see Sub-sections 1.11.4 and 2.5.3).
Sunk-cost fallacy	The tendency to 'throw good money after bad' and not to give up on a failing investment because we overvalue/over-weight that which we originally possessed (but have now lost).
Procrastination	The tendency to forestall choice and decisions or even action on an issue/matter which is too complex for System-2 to resolve and especially when we cannot easily access a workable heuristic to facilitate the process.
Availability affect	When recent dramatic and personally experienced events (mainly based on level of emotion evoked) are systematically overweighted and the likelihood of risks are assessed by how readily related examples come to mind.
Default option	The tendency to maintain the status-quo in an opt-in or opt-out choice situations.
Satisficing	The autonomic, sometimes emotion-driven choice and decision making process which aims to achieve a satisfactory rather than optimised results. Tendency to choose the easier rather than more difficult option in decision making. Entrenches technology lock-in.
Induced blindness	The cognitive bias in which once a theory, technology or such other concept is accepted it becomes difficult to notice its flaws. It can be argued that society today suffers an induced blindness of CBA evaluation flaws and is unable to see its glaring shortcomings especially when the need for transition to sustainability becomes so urgent.

Affect heuristic and defective forecasting (including the optimism and over-confidence effect)	The belief that negative effects will happen to others but not to our self and to underweight probabilities of events that we classify as not affecting us even when evidence to the contrary is so overwhelming. Also includes the *optimism and over-confidence effect*, which is the unrealistic judgement of our abilities, the belief that we know more than we actually do know and a misplaced assurance or belief in positive outcomes for future events, which sometimes leads to dangerous risk taking.

Reliability and validity: The question of reliability in qualitative research in general and case study method in particular is now fully acknowledged and is no longer a matter of doubt as happened in the past (Yin, 2011, 2012). According to Neuman (2000), reliability in this context is about consistency in making observations even when different techniques of data analysis and interpretation are used as happens in this study. The challenge of analysing and interpreting data from case studies for example is well recognised in Berg (2004:102).

One of the techniques used to mitigate reliability-loss in this study is to analyse and interpret data using prospect theory as the critical overarching framework. In this study, the criteria are broadly based on the key attributes defining evaluation in CBA and sustainability assessment and behavioural patterns defined by prospect theory. Equally, the detailed analysis and interpretation is based on the rational-agent model heuristics assumed in evaluation in CBA and sustainability assessment and bounded rationality heuristics in prospect theory. The themes that are derived from these criteria are matched with the corresponding patterns of decision making in the case studies. These themes therefore contributed substantially to the choice of the cases and the interview questions applied.

The data analysis and interpretation also applies triangulation method to enhance reliability. Triangulation involves the use of multiple methods to examine the same dimension of a research problem or the combination of methodologies in the study of the same phenomena (Jick, 1979; Ammenwerth et al. 2003:245). In this study therefore, the patterns of decision making in the solar water heating sector and projects are studied by evaluating and interpreting data using various

techniques. This includes interviewing role players in the sector, evaluating historical records and commissioned research reports, interpreting data from the electricity supply sector and solar water heating industry and applying a literature-based theoretical framework. In addition and as indicated earlier, the study applies an analytical approach based on literature review, case study and comparative analysis. The focus however remains on decision making patterns in the solar water heating sector and the subsequent implication on the relationship between CBA and the principles of sustainability.

It is acknowledged that different researchers may obtain slightly different outcomes using the same criteria on the same cases. This seeming contradiction can be attributed to the fact that individual qualitative researchers can approach an issue from different perspectives and obtain distinctively different outcomes. That however does not make qualitative research any more unreliable but rather more diverse and therefore exciting. Neuman (2000) observes that qualitative researchers are more concerned with authenticity than validity of data, where the researcher gives a fair, honest and balanced account of the social phenomena under investigation.

The technique of developing data analysis criteria and closely related research questions before the case story is investigated and compiled as is done in this study ensures that the story is eventually told in the context of the criteria and questions. This ensures a high level of consistency and validity of data. Often, as happens in this study, unexpected circumstances and results may emerge at any stage of data collection, analysis and interpretation. The researcher has to adapt the research design to accommodate such eventuality without diluting or nullifying the quality of the research or diverting from the stated objectives.

Chapter 4

Prospect theory and decision making in the solar water heating sector in South Africa

4.1 Introduction

This chapter explores the patterns of decision making in the solar water heating sector in South Africa to evaluate how decision making within the sector could be characterised by contradictions between rational-agent model assumptions and the reality of bounded rationality as argued under prospect theory. The term 'sector' refers to the solar water heating industry including the supply and demand sides, policy, research and development. This chapter presents analyses and interpretation of data on patterns of decision making relating to policy and the market dynamics for the solar water heating sector in South Africa while data and analyses in Chapter 5 relates to decision-making in selected solar water heating projects in South Africa and Botswana.

In the southern Africa region, electric geysers are widely used to heat water for domestic use. Various studies indicate that an electric geyser accounts for up to 40-60% of a domestic electricity bill (Ward, 2002:34; Spadavecchia, 2008). It is therefore logical to use electricity pricing and demand to illustrate the challenges faced by decision makers in the solar water heating sector in South Africa. The contradictions demonstrated in this chapter further illustrate how the rational-agent model assumptions in CBA evaluation and sustainability assessment constrain the transformation to sustainable production and consumption lifestyles.

The reason is that the same principles of decision making, whether formal or informal, inform the evaluation frameworks for CBA and sustainability assessment. The rational-agent model approaches represent the status-quo while bounded rationality outcomes represent the reality of *irrationality* in choice and decision making. *Irrationality* has been systematically defined in Sub-sections

1.11.3 and 2.5.4, and Section 1.3 as inconsistency in choice and decision making under the bounded rationality scale of aspiration levels (Forester, 1984:24; Selten, 1999:2).

Data from various sources are presented, analysed and interpreted for patterns of decision making that are consistent with either the rational-agent model approach or characterised by *irrational* (bounded-rational model of human behaviour) and prospect theory heuristics. Each decision making event is presented and analysed in terms of the extent to which it represents or characterises the rational-agent model or bounded-rational and prospect theory heuristics.

In South Africa, various forces and stakeholder groups play a key role in determining the choices with regard to water heating options and by extension, the level of acceptance of solar water heating. Consequently, the forces have significantly shaped the process of CBA evaluation and sustainability assessments and the relationship between the two systems in a co-evolutionary and complex dynamic process. Each event discussed in this chapter demonstrates an element in the streams of costs and benefits in CBA evaluation as well as a positive or negative sustainability assessment process (explicitly or implicitly) for solar water heating. Each decision making event is evaluated in terms of the extent to which it would potentially promote or undermine the transition process to more sustainable production and consumption lifestyles with solar water heating as the reference-choice.

Data presentation and analysis is structured as follows:

- Data overview.
- Historical perspective of the solar water heating sector in South Africa and how policy decision making has influenced the solar water heating sector.
- How perceptions rather than empirical studies influence decision making, and the role of contradictory, co-evolutionary and complex forces.
- The effect of electricity tariff patterns on the demand, supply and hence decision making regarding the solar water heating option.

- The role of the electricity crisis (2006 – 2008) and its influence on decision making in the solar water heating sector in South Africa. The crisis is viewed as part of the non-linear co-evolutionary dynamics and process in the solar water heating sector.
- The impact of nudge effects or choice architecture in the form of market interventions in decision making with reference to the Eskom rebate programme.

4.2 Data overview

The key events that influenced the direction taken by the solar water heating sector in South Africa since the publication of the 'White Paper on the Energy Policy' in 1998 (DME, 1998) to 2010 took various forms. These include an energy crisis in 2006-2008 and well documented and publicised high increases in electricity tariffs for South African consumers from 2010. Numerous research reports and media articles focusing on trends in the solar water heater market have been published and some of these are used as references in this study. In response, Eskom, the main electricity utility company in South Africa introduced a solar water heater rebate programme while a number of legislative and regulatory (choice architecture) instruments were published. In addition to the literature, some studies from the United States are used to highlight the biasing effects of perceptions in the domestic solar water heating sector.

Holm and SolaSure (2005) study was commissioned by the South African Energy Development Corporation (EDC) and United Nations Development Programme (UNDP) to investigate and establish a baseline (reference state) against which to evaluate the success rate of interventions for the solar water heating market in South Africa. In addition, the survey aimed at estimating the potential market penetration among middle income sections of the population and to initiate awareness and capacity building within the solar water heating industry. These were viewed to be the essential ingredients for a market transformation in the solar water heating sector and hence transformation to sustainability. The survey

used literature review to document the historical background and baseline status. The market survey to determine levels of market penetration was done through questionnaires, historical data and supplementary data from the International Solar Energy Society and International Energy Agency.

The Holm and SolaSure (2005) survey provided a good insight and important data on the solar water heating sector in South Africa particularly on the historical background, current status and perceptions of various role players towards solar water heating. The survey suggested that government should lead by example by installing solar water heaters in all public buildings. It provided opinions and recommendations on use of life-cycle costing to evaluate the benefits of solar water heaters, internalising of externalities in the pricing of solar water heaters and its competitors and introduction of performance-based incentives to correct market distortions. It also recommended the recognition of the value of reduced electricity peak load and avoided costs of new coal-fired power stations as additional benefits of solar water heating.

For an understanding of general domestic consumer perspectives in the solar water heating market, this study accessed and appraised secondary data from a United States study which was similar to Holm and SolaSure (2005), but focusing on awareness and perceptions towards solar water heating among home owners. The Focus Marketing Services (1999) survey was conducted among users and non-users of solar water heaters, using focus group sessions, questionnaires and telephone surveys in the states of Arizona, California and Florida in the United States. The aim of the survey was to gain an understanding of consumer awareness, ignorance and perceptions towards solar water heating. It also identified key barriers and possible motivation for decisions to install or not to install solar water heaters.

Another study from the United States supplemented data on the role of perceptions in decision making for solar water heating. Iltron (2008) was based on a report on the status of the California Centre for Sustainable Energy Solar Water

Heating Pilot Programme. The aim of the report was to determine factors that most influenced a home owner's decision to participate in the programme and to purchase a solar water heating system. One of the purposes of the report was to identify market barriers to solar water heating in California and to make recommendations on how to address them. Another purpose was to determine the cost- effectiveness of solar water heating installations and ways of increasing demand. The survey was conducted through interviews with participants in the programme, workshop attendees, contractors, manufacturers of solar water heaters, programme administrators and other role players.

These studies in the US provided useful secondary data on the role of perceptions in decision making for solar water heating among home owners and were deemed to be applicable to the local context of this study. Complementary data on perceptions among consumers for southern Africa were sourced from research reports, articles from newspapers, professional magazines and websites. For example, articles from Pringle (2010) and Williams (2010) which discussed the advantages and disadvantages of solar water heating drew varying comments from bloggers, which indicated the perceptions and attitudes of ordinary South Africans towards solar water heating. An article in the *Sunday Times* of 21 February 2010 also amplified similar common perceptions and particularly highlighted the perceptions of the writer. An EDRC research report provided some additional data on attitudes to solar water heating in South Africa (EDRC, 2003).

Historical data for the section on the tariff structure for electricity and patterns of tariff increases were sourced from Annual Budget Reports of Tshwane Municipality and Eskom. It was also necessary to supplement those data with comments and opinions from researchers, manufacturers and suppliers of solar water heaters as well as internet articles and websites of various organisations related to electricity tariffs and solar water heating. The interviewees are listed in Appendix 12. Although some of the sources contradicted each other, it was possible to construct a reasonable interpretation regarding the patterns of electricity tariffs and the related impact on market trends for solar water heating.

The 2006–2008 electricity crisis in South Africa was covered extensively in the media and many studies, reviews and evaluations were carried out. Opinions differed but mainly depended on the role of the commentator in the energy sector, organisational and occupational affiliation and the impact the crisis had on their respective organisations. The search and selection of data for this study was guided by the following themes:

- Decision making before, during and after the crisis.
- The impact of the crisis on decision making and consumer behaviour in the solar water heating sector in South Africa.
- The attitude of policy makers towards environmental issues in general and solar water heating in particular. The assumption was that the manner in which the South African government and Eskom managed the crisis indicated the attitude of decision makers at policy and supply-side level respectively.
- Additional data recorded the reactive emergence of the Eskom rebate programme and its increased activity in the solar water heating sector.

The Eskom rebate programme was also widely covered in the media, internet and professional newsletters. These sources provided insight on progress and challenges encountered in implementing the programme. Primary data in form of one face-to-face interview and electronic communication with key role players in the programme and the solar water heating sector provided clarifications or contrasting opinions in this regard. Those data highlighted the prevalence and dominance of economic considerations in decision making, Eskom's methods of promoting the programme and the importance of payback in deciding whether or not to install a solar water heater.

4.3 Decision making in the solar water heating sector in South Africa: a historical perspective

Holm and SolaSure (2005) recognize South Africa as a world leader during the early phases in the development of solar water heating. The survey however notes that some unfortunate experiences with frost damage particularly in the winter of 1982, including corrosive water and clogging had created a bad image for solar water heaters leading to a huge negative impact on the acceptance of solar water heating. These experiences are quoted often in dismissing the efficiency of solar water heating technology in South Africa and are the cause of loss of public confidence in solar water heating (Holm and SolaSure, 2005:31). The response is an indication of how past experiences are carried over to influence decision making in solar water heating projects for many years after an event.

Thereafter, the continuously low electricity tariffs caused the interest in solar water heating to decline even further both at research and demand level. There was also entrenchment of the initial cost rather than life-cycle cost value system and little domestic and institutional support for solar water heating. The continuous reference to past experience even when this was not experienced first-hand is an indication of the *availability affect* in decision making (Table 3.2). Such *availability affect* plays a significant role in reinforcing the status-quo and the resultant *inertia*. Furthermore, there was seemingly no adequate motivation to cause people to change to solar water heating at this stage as electrical water heating was convenient, readily available and affordable for the critical market segment of middle-income households.

The survey confirms the observation that solar water heating is rarely associated with sustainability principles (Holm and SolaSure, 2005:24). In addition, it confirms that market surveys and research work done previously were commissioned by suppliers and manufacturers of solar water heating equipment aimed at establishing or assessing their own market and the efficiency of their own supply chain. Due to their limited scope and partisan agenda, these surveys did not present a fair and comprehensive picture of the solar water heating sector.

Regrettably, the results of the surveys and any other related research information were never put in the public domain not only reportedly for fear that it could get to some competitors, but also due to its commercial value. By failing to make the information available for public dissemination, the manufacturers and suppliers contributed to the inadequate awareness of the positive qualities of solar water heating. There were elements of *status-quo bias* and *framing* in research and development at that time in addition to *induced blindness* all of which entrenched the continued use of electric geysers and bias against transition to solar water heating (Section 1.3 and Table 3.2).

Another barrier to increased demand for solar water heating was the "structural problem" associated with the need to orient the solar panels and the receiving part of the pitched roof towards the north as the optimum source of solar radiation in southern Africa. It is observed that demarcation of sites does not always take into account the need for a northern orientation for solar water heating. In some cases, the topography of the site does not allow a northern orientation hence the need to modify the roof to accommodate the solar water heating installation. We have seen that in prospect theory, people tend to justify the status-quo or their choice by underweighting the flaws in their preferred option and overweighting those of the alternative. In addition, the complexity arising from the need to retrofit the orientation and roof structure to optimise for solar water heating performance serves to reinforce the bias against solar water heating under System-1 thinking.

Technically, there were no similar structural constraints facing the electric geysers which were thus viewed to be flexible while solar water heaters frequently had the orientation challenge to overcome. Electric geysers were a familiar and convenient technology in the eyes and mind of the consumer and therefore claimed the endowment and status-quo positions and similar associated advantages under prospect theory. Sale of electricity was a reliable and already established source of revenue for municipalities in South Africa. Municipalities were therefore more likely to resist promotion of solar water heating because of the *loss aversion* brought about by uncertainty regarding future revenue flows

once consumers shifted to solar water heating. The logistics of acquiring an electric geyser were well established while consumers struggled to trace reliable suppliers of solar water heaters in their locality, and this could have induced *procrastination* and *inertia* with regard to decisions to replace electric geysers with solar water heaters.

Developers have also been known to object to inclusion of solar water heating in their projects citing increased costs and hence difficulty in selling their houses. This attitude has a conventional CBA approach to valuation where emphasis is placed on initial cost with no regard for life-cycle costs. In addition, costs are seen from an individual rather than the collective perspective (such as CO_2 emissions reduction benefits over the life-cycle). Austin and Morris (2004), agree with a common opinion that developers and municipalities could incorporate payment for solar water heating into the mortgage and rates respectively. Municipalities could impose higher tariffs for excessive use of electricity during peak periods. This action would raise the electricity tariffs to reflect some degree of internalised externality-costs into the market-price and thus facilitate consumer interest in the solar water heater option. But this option did not gain favour with developers, municipalities and even consumers. Again *status-quo bias* played a key role in creating the attitude of developers and municipalities. In addition *loss aversion* and some elements of *induced blindness* are evident in these behaviour patterns.

An interesting observation by Holm and SolaSure (2005) is that people with high income levels can afford to experiment and therefore could exercise a higher acceptance of innovation. Similarly, urban areas have a higher visibility and impact because of the higher concentration of built areas. The study therefore suggested that solar water heating programmes should initially target high-income urban earners among whom prestige is an important measure of progress. This group is regarded in society as a trend setter and is therefore likely to create a positive perception of new technology and influence acceptance among the rest of the population. This argument is premised on the rational-agent model which

assumes that people in the same income levels would, in general, always make similar choices and decisions.

The solar water heating sector emerged as fragmented and exposed to unfriendly market forces in contrast to electric geysers which enjoyed subsidised electricity tariffs and protection by government. Furthermore, the solar water heating sector is characterised by small enterprises which are more sensitive to negative market forces (mainly due to their low capitalisation, low liquidity and expensive South African Bureau of Standards (SABS) scrutiny procedures) or more prone to natural forces such as the effect of frost as suffered in 1982 (Holm and SolaSure (2005). In contrast, the electricity corporation and distributor municipalities are able to confront the negative forces that may threaten their operations or market-share from such alternatives as solar water heating.

In this scenario, the electric geyser represents the *default option* for heating water, which from a prospect theory perspective is the *inertia*-induced status-quo (or reference state) which consumers strife to maintain. There was therefore inadequate motivation for a consumer to opt-out of the electric geyser thus limiting the opt-in choices such as solar water heaters.

Solar water heaters are also depicted as unpredictable and therefore unreliable, because they rely on the sun which is not always available especially at night and during cloudy days (Njobeni, 2010). They are reported to have a high initial cost but low life cycle cost while paradoxically, electricity from fossil fuels is seen as inexhaustible. This perception is reinforced by the observation that officials from organisations that promote solar water heaters fail to install the systems in their own houses and presumably continue to rely on electric geysers (Holm and SolaSure, 2005:24). Jennings (2007) and Visagie and Prasad (2006:3) however have a different opinion, which views solar water heaters to be a mature, durable and proven technology in South Africa. These opinions demonstrate high levels of contradictions in decision making and suggest a lack of consensus on the status of the solar water heating industry in the economy. From a prospect theory and

bounded rationality perspective, electric geysers are often used as the *reference point* or serve as *anchoring-effect* in evaluating the viability of solar water heating. In addition, and mainly due to *induced blindness,* the electric geyser is the *default option* in choice and decision making regarding water heating installations.

There is a lack of robust support for research in solar water heating unlike the heightened interest in expanding non-renewable sources of energy. This can be attributed to the *status-quo bias, inertia, induced blindness,* elements of *sunk-cost fallacy* and *affect heuristic* where the prospect of depletion of non-renewable sources of energy is underweighted. However, some noticeable recent initiatives have been implemented, centred around institutions such as the Sustainability Institute and the University of Stellenbosch where several Master's degree dissertations have been produced in the period 2009-2011. These studies can act in helping to re-orientate the *choice architecture* which could in turn trigger revision of attitudes and perceptions towards solar water heating.

4.4 Decision making and perceptions in the solar water heating sector

In a 1999 survey conducted in the states of California, Arizona and Florida in the United States, it was found that gas and electric water heaters (geysers) were the more popular water heating systems compared to solar water heaters. However there was reasonably high awareness of solar water heating as an alternative with the majority of respondents having obtained information mainly from books, magazines, advertisements and from friends (Focus Marketing Services, 1999). It can therefore be expected that where there is less awareness as in South Africa, solar water heating will be even less popular.

Despite the high levels of awareness in the United States, solar water heating was not the most popular method of heating water. This is a clear indication that people are more comfortable with the tried and tested technologies. However,

according to modern decision theory and consistent with prospect theory, when faced with new or untested technologies, people revise their beliefs not according to objective methods, but by overweighting the new information and underweighting prior longer-term information (Sub-section 2.5.4).

The respondents in the United States survey indicate the *irrationality* and erratic nature of decision making under uncertainty. Saving money was by far the most commonly cited advantage of buying and installing a solar water heating system (Figure 4.1). Individuals understand better and relate more to cost savings and only consider environmental benefits as secondary. Most of the respondents in such surveys would have to be *nudged* to include the environment as a possible benefit. The concern for the environment and associated costs are regarded as collective and hence shared, even when consequences could be critical.

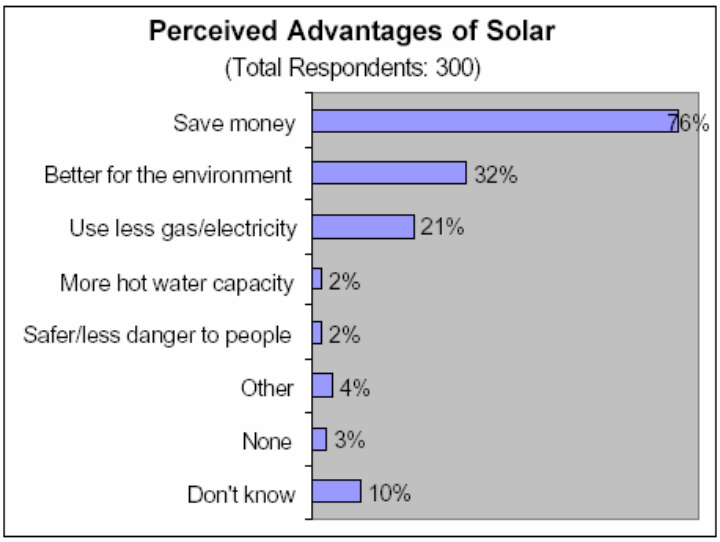


Fig. 4.1: Perceived advantages of solar water heating
(Source: Focus Marketing Services, 1999:9)

Being a highly abstract benefit and subject to negative *affect heuristic* bias, the idea of saving the environment is under-weighted, while that of saving money is emotionally tangible, explicitly experienced and thus easily conceptualised and valued, and hence over-weighted under System-1. In common System-1 priority analysis, the need to save the environment is regarded as an indefinite endeavour which can be extended over time, leading to *procrastination*, while the prospect of

monetary savings is immediate and evokes immediate attention. Maximising of expected values with the shortest payback time is a major factor in such decision making. In prospect theory, this behaviour is attributed to the *affect heuristic and defective forecasting* (Section 1.3 and Table 3.2). The tendency to identify with familiar technologies leads to *induced blindness* for alternative options which reinforces the *endowment effect*, *inertia* and *status-quo bias*.

In the study, the most commonly cited disadvantage was the high initial cost (Figure 4.2). Other disadvantages ranged from fear that there would be inadequate sun and capacity, to uncertainties on maintenance and whether a guarantee was provided or not. The feeling that solar water heaters have an undesirable appearance was also prevalent. This is consistent with immediate gratification and overweighting of current gains against future ones (Sub-section 2.5.4).

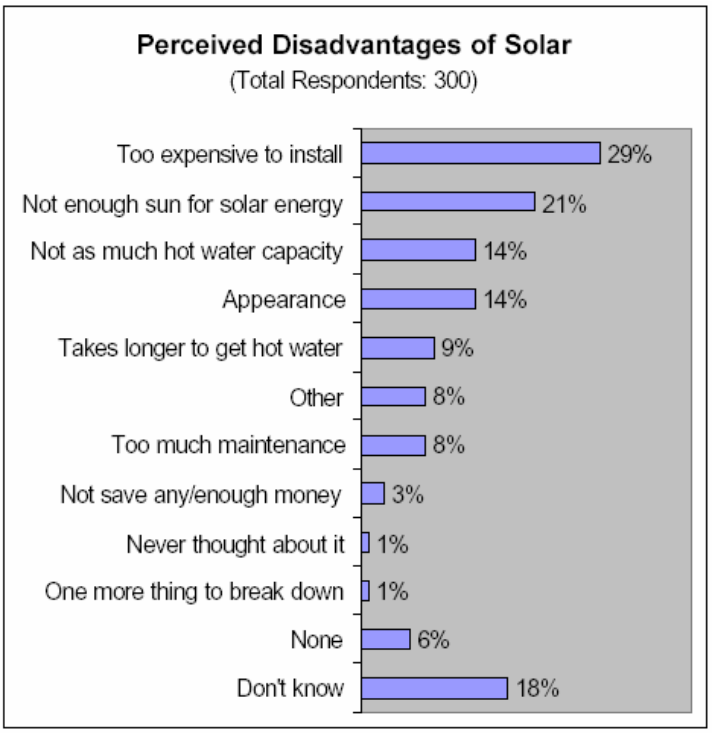


Fig. 4.2: Perceived disadvantages of solar water heating
(Source: Focus Marketing Services, 1999:10)

All these advantages and disadvantages are however primarily based on perceptions. The feelings are strong and prevailing even when they are not backed

by any empirical studies or facts. Many respondents indicated that they were not sure whether owning solar water heater makes economic sense while a few were convinced beyond doubt that installing a solar water heating system was logical and just seemed to make sense (Appendix 7). The behaviour patterns show prevalence of bounded rationality evaluation based on personal/subjective and intuitively sensed impressions rather than empirical valuation and objective calculation (Section 2.5.4).

In another study in California (nine years after the National Renewable Energy Laboratory survey), energy savings were cited as the most important factor influencing a homeowner's decision to install a solar water heating system (Iltron, 2008). By this time and significantly so, concern for the environment seemed to have gained considerable importance as another reason, coming close to energy savings, while payback period was featuring as a lesser influence (Figure 4.3).

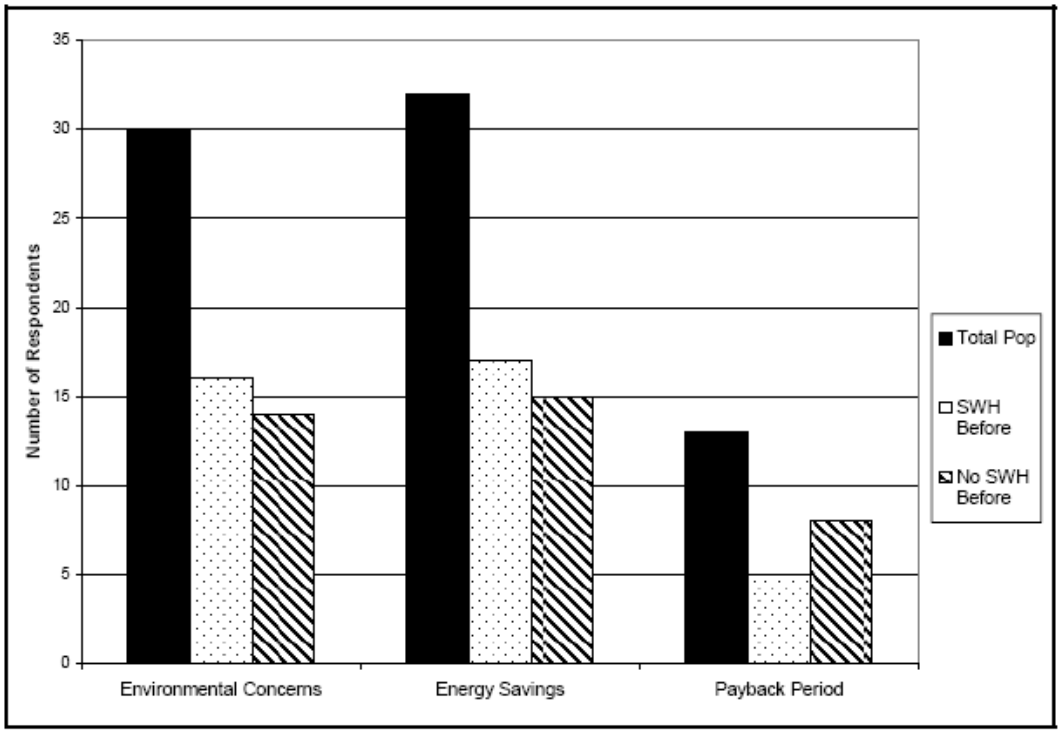


Fig. 4.3: Major factors influencing the purchase of a solar water heater
(Source: Iltron, 2008:1-4)

On the surface level, environmental degradation and its consequences appear to be getting more pronounced in the mental calculations of the respondents, and possibly because of wide media coverage, a certain level of altruism was setting in. Or alternatively, it could have been a case of post-rationalisation in a situation where cost-saving is subconsciously still the dominant driver. This pattern can be associated with revision of decision where life and death issues are involved (Sub-section 2.5.1). The United States studies show the perceived high upfront cost as the most commonly cited disadvantage of solar water heating. Other perceived disadvantages include uncertainty due to inadequate sunlight to heat the water during cloudy days and at night. Of minor concern are inadequate water capacity and the perceived unappealing aesthetics of the solar water heater installation on a roof.

The reported disadvantages compare well with those of South Africa and are equally not backed by any facts or expert studies but strong perceptions by the respondents which are consistent with automatic System-1 evaluation or System-2 heuristics-based thinking. In all cases, there is strong influence from prevailing in-built *status-quo bias* against solar water heating, reinforced by the tendency towards valuation based on impressions and *mental accounting* (Sub-sections 2.5.3 and 2.5.4).

In developing countries such as South Africa, there was the added disadvantage that solar water heating was not regarded as a priority in the majority of households. Most families struggle to satisfy their basic needs and heating of water was not a high enough priority even during the winter months to justify investment in any installed heating system. It was mainly in urban middle class and upper class residential areas where the choices were relevant. Furthermore as mentioned in Section 1.10, many domestic consumers were known to regard solar water heating and other similar energy efficient technologies as interventions for poverty alleviation for low income members of the society rather than aspirational technologies. The tendency by donor agencies and government to focus on low-income households for pilot projects for such interventions perpetuated this

perception (EDRC, 2003:40). Although solar water heater installations were variously cited as aesthetically unpleasant, satellite and channel TV dishes and antennae are easily accepted possibly because they are associated with prestige and hence with higher social status. The dish or antennae announced progress, prosperity, a 'must have', whereas a solar water heating installation did not enjoy such status-enhancing recognition.

There were also widely held perceptions about the inefficiency of solar energy technologies. One newspaper article reports that, "Sustainable energy sources are not appropriate for base load generation requirements. They are unpredictable – the sun does not always shine and the wind does not always blow" (Njobeni, 2010) . Surprisingly, this argument featured often in discussions with building professionals. The prevalence of negative perceptions towards solar water heating in South Africa was demonstrated in comments by bloggers to two internet articles from Pringle (2010) and Williams (2010). These comments are found in Appendix 11. There was misrepresentation or failure to understand the benefits of solar water heating, or a tendency to be blindly pessimistic about the technologies. The comments showed a lack of understanding of the concept and benefit of life-cycle saving, whose benefit was unfortunately not highlighted in the promotions for Eskom's rebate programme (Section 4.6).

These responses consistently indicate that electric geysers were still the preferred option and consumers were more confident with their efficiency. Some consumers seemed to have the impression that the problem was merely about insulation rather than the type of energy used to heat water as noted by the comment, "I have a 6 month old geyser with excellent insulation. I do not need a new one…" (Appendix 11). Others argued that even if solar water heaters were good, they were not the solution to the energy problem. The stereotype response about perceived maintenance problems with solar water heaters and the unreliable availability of sunshine was repeated in these comments. Not only did the comment from 'Anonymous 17 Jan 10' show a lack of awareness of the South

African government gazette notice (Republic of South Africa, 2008), but it also demonstrated how the notice lacked enforcement mechanisms.

The comments show the prevalence of *induced blindness* demonstrated by overweighting of the disadvantages of solar water heaters and underweighting of its advantages relative to electric geysers, based on perceptions evolved from prevailing attitudes in the market. In addition to application of *mental accounting* in valuing the benefits and costs of the two systems, *loss aversion* especially towards an emerging technology weighs heavily against solar water heating. Various prospect theory heuristics are evident in the responses from the US studies as well as the South African comments. These include justification of the *status-quo bias* and *default option* tendencies, *induced blindness* especially among professionals and consumers, *endowment effect* which entrenches technological lock-in and *post-rationalisation* (Section 1.3 and Table 3.2). There is a common tendency to evaluate informally and even instinctively before assigning formal value, which is an indication of *post-rationalisation* among individuals as well as at the collective market level.

4.5 Electricity and solar water heating tariff structure in South Africa

In South Africa, solar water heaters encounter stiff competition from electric geysers in the water heating market. In the past, the market favoured electric geysers at the expense of solar water heaters mostly due to the low prices of geysers and electricity tariffs (Visagie and Prasad, 2006:1, 12). It is widely acknowledged that electricity tariffs in South Africa had always been lower than the real cost-of-production and that many externalities had not been factored into the generation cost. It was also considered that the most effective way to induce load reduction and more efficient use of electricity was by increasing the tariff at least to its real cost-of-production level. However, due to previous over-investment in generation capacity, Eskom, municipalities and the government in general were not keen to hike tariffs, thus demonstrating the sunk-cost trap.

According to Dagut and Bernstein (2008), in a counter-intuitive trend, the real price of electricity had been falling since the late 1980s (see Table 4.1) till around 2008. South Africa's electricity tariffs were then regarded to be among the lowest in the world and consumers did not feel burdened enough by the cost to take any action to reduce or manage usage more efficiently. Suppliers had always avoided applying punitive tariff system such as demand charges with graduated rates for domestic consumers for fear of the knock-on effects on cost of living and the possible threat to economic growth, or even worse, having idle generation capacity whose initial cost had already been sunk (Section 4.4).

High tariff increases were predicted in South Africa for a long time and consumers were alerted in various forums that electricity would become unaffordable in the near future because Eskom would run out of its historical surplus capacity by 2007 (DME, 1998:41). According to Dagut and Bernstein (2008:6), this warning was repeated in workshops in October 2000 and November 2001. The report indicates that the trend of falling electricity tariffs would therefore be reversed from around 2007, as a result of the expected inadequate capacity. Kritzinger (2011:1) notes that electricity shortage, which would result in massive price increases for electricity, were forecast as early as 2003. Usually however, the calls to adopt solar water heating originated from individuals and organizations who promoted reduction of excessive use of fossil fuel based electricity and its subsequent negative impact on the environment. But until 2010, the annual increases were insignificant and therefore, on their own, had little impact on the consumers' choice patterns.

In September 2008, eThekwini (Durban) municipality increased domestic electricity tariffs by 4% including a newly introduced environmental levy. The impact was a R20 increase in monthly bills for households using up to 1000kWh a month (Carnie, 2008). This increase did not seem to persuade consumers to shift to solar water heating and save between 20% and 40% on their electricity bills (Spadavecchia, 2008). Similarly in Tshwane, annual electricity price increases

exceeded 15% only once in 1998 when it reached 18.8%. The increase exceeded 7% only two times during the eight year period between 2000 and 2007 when the average increase was 7.6% (Table 4.1).

By South African urban standards, these were insignificant increases especially among the middle and high income earners. Eventually in February 2010, after a protracted negotiation process and public hearings, Eskom was allowed to increase electricity tariffs by 24.8%, 25.8% and 25.9% for 2010/2011, 2011/2012 and 2012/2013 respectively (NERSA, 2010). This was a massive 76.5% cumulative increase over three years. The impact of this increase on the economy and the solar water heating industry could not be fully evaluated at the time of completion of this study. However, there were signs of the beginning of a shift as the impact of the increases took effect.

Table 4.1 and Figure 4.4 show comparisons between the prices of domestic solar water heaters (Rands) and those of residential electricity tariffs (cents per kWh) in South Africa. The prices of electricity for the period 1992-2007 were obtained from annual financial statistics for Tshwane Municipality. Similar prices were obtained for the period 1996-2012 from Eskom's Annual Reports. These tariffs are revised by the respective utilities every year and are referred to as annual tariffs. It was difficult to get all the prices of solar water heaters for the same period because suppliers and manufacturers of solar water heaters consider their historical prices to be trade secrets. Prices were only available for the period 2000-2010 from SolarPrimeg, one of the manufacturers and suppliers of solar water heaters in South Africa. Prices for the other years in the range are therefore extrapolated. Standardization (Urdan, 2010; StatSoft Electronic Statistics Textbook, 2011) and discount rate (Vishwanath, 2007; Garger, 2010), are used to allow for comparison between the prices of electricity for Tshwane Municipality and Eskom with those of solar water heaters (see Appendix 14 for the underlying method).

Table 4.1: Comparative analysis of residential electricty and solar water heater prices in South Africa

(Based on data from Tshwane Municipality Annual Financial Statistics, Eskom Annual Reports and SolarPrimeg. Italics indicate estimates)

YEAR	n *(year from baseline 1996)*	Tshwane Residential (c/kWh)	Tshwane % Increase	Eskom Residential (c/kWh)	Eskom % Increase	SWH 200L (Rands)	Standardization 1996			Discount Rate Base 1996			1/n
							Tshwane Residential	Eskom Residential	SWH	Tshwane Residential	Eskom Residential	SWH	
1992	-4	15.51		0.00		*6450*	76.78		100.00	**6.8%**		**0.0%**	-0.25
1993	-3	17.00	*9.6%*	0.00		*6450*	84.16		100.00	**5.9%**		**0.0%**	-0.33
1994	-2	18.62	*9.5%*	0.00		*6450*	92.18		100.00	**4.2%**		**0.0%**	-0.50
1995	-1	20.39	*9.5%*	0.00		*6450*	100.94		100.00	**-0.9%**		**0.0%**	-1.00
1996	0	20.20	-0.9%	19.44		6450	100.00	100.00	100.00	**0.0%**	**0.0%**	**0.0%**	0.00
1997	1	20.20	0.0%	21.33	9.7%	*7000*	100.00	109.72	108.53	**0.0%**	**9.7%**	**8.5%**	1.00
1998	2	24.00	18.8%	22.74	6.6%	*8000*	118.81	116.98	124.03	**9.0%**	**8.2%**	**11.4%**	0.50
1999	3	24.24	1.0%	25.36	11.5%	*9000*	120.00	130.45	139.53	**6.3%**	**9.3%**	**11.7%**	0.33
2000	4	25.65	5.8%	27.70	9.2%	*10000*	126.98	142.49	155.04	**6.2%**	**9.3%**	**11.6%**	0.25
2001	5	26.43	3.0%	30.90	11.6%	14480	130.84	158.95	224.50	**5.5%**	**9.7%**	**17.6%**	0.20
2002	6	30.35	14.8%	33.43	8.2%	*15000*	150.25	171.97	232.56	**7.0%**	**9.5%**	**15.1%**	0.17
2003	7	34.27	12.9%	36.58	9.4%	16900	169.65	188.17	262.02	**7.8%**	**9.5%**	**14.8%**	0.14
2004	8	36.16	5.5%	38.70	5.8%	*17000*	179.01	199.07	263.57	**7.5%**	**9.0%**	**12.9%**	0.13
2005	9	38.69	7.0%	40.08	3.6%	*18000*	191.53	206.17	279.07	**7.5%**	**8.4%**	**12.1%**	0.11
2006	10	40.97	5.9%	41.74	4.1%	19200	202.82	214.71	297.67	**7.3%**	**7.9%**	**11.5%**	0.10
2007	11	43.43	6.0%	44.56	6.8%	19800	215.00	229.22	306.98	**7.2%**	**7.8%**	**10.7%**	0.09
2008	12	0.00		53.43	19.9%	21300		274.85	330.23		**8.8%**	**10.5%**	0.08
2009	13	0.00		57.02	6.7%	27000		293.31	418.60		**8.6%**	**11.6%**	0.08
2010	14	0.00		60.60	6.3%	*28000*		311.73	434.11		**8.5%**	**11.1%**	0.07
2011	15	0.00		68.83	13.6%	*29000*		354.06	449.61		**8.8%**	**10.5%**	0.07
2012	16	0.00		78.62	14.2%	*30000*		404.42	465.12		**9.1%**	**10.1%**	0.06

Fig. 4.4: Discount rates for residential electricity and solar water heaters
(Based on data from Tshwane Municipality Annual Financial Statistics, Eskom Annual Reports and SolarPrimeg)

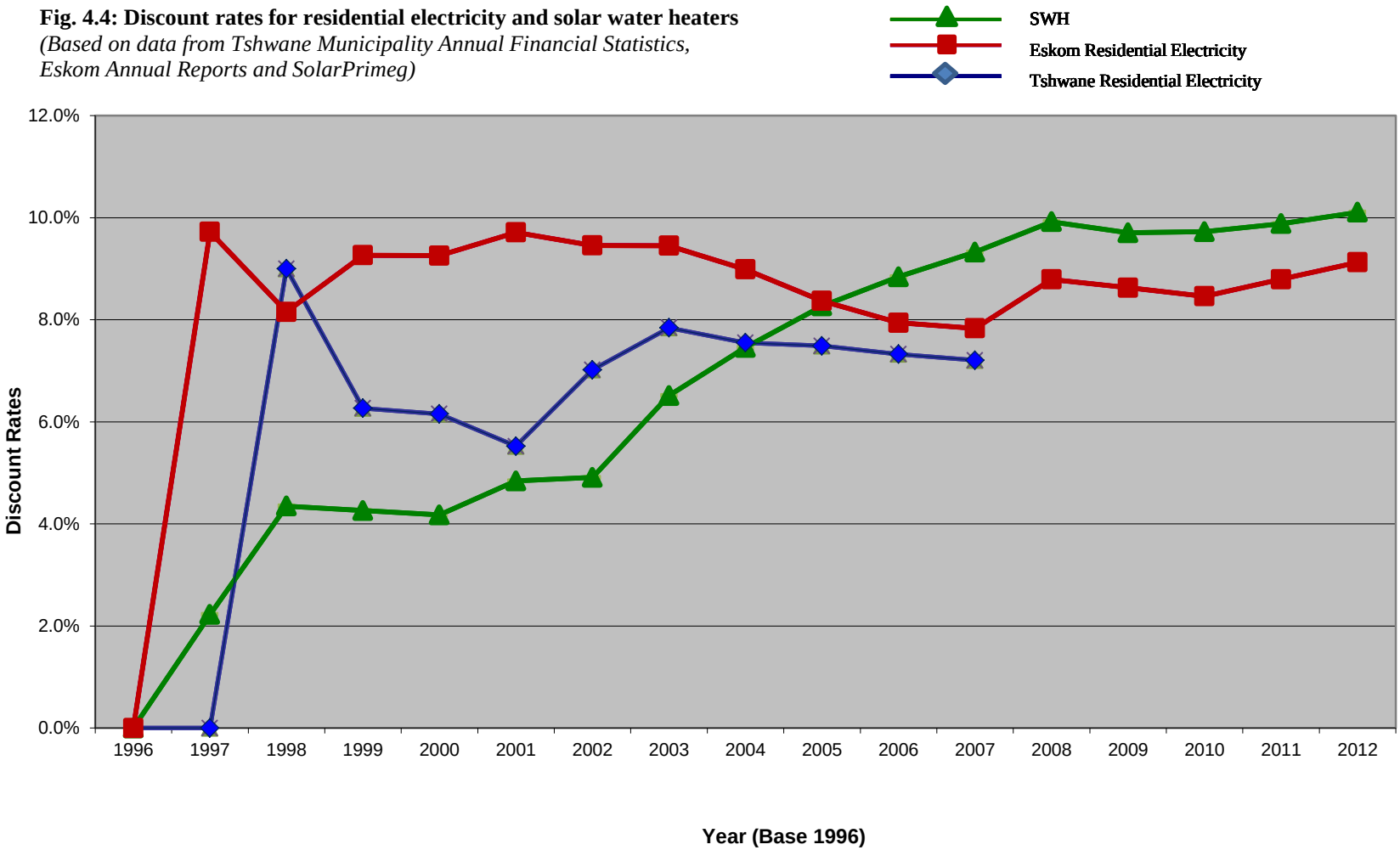


Fig. 4.5: Total area of solar water heaters supplied in South Africa (m^2)
(Source: Eskom 2009:7)

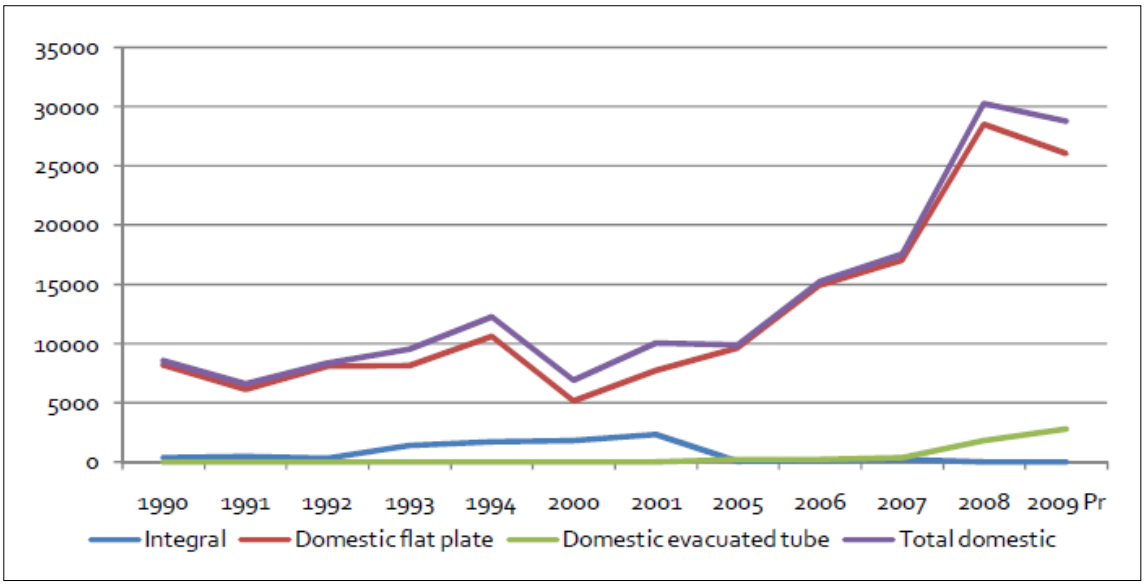


Table 4.1 shows the discount rate or riskiness of a kWh of electricity in Tshwane Municipality and Eskom compared to that of a solar water heater over the period 1992-2012, using 1996 as the baseline year. The graph (Figure 4.4) shows that the discount rate for solar water heaters remained lower than that of Tshwane Municipality and Eskom electricity until 2004 and 2005 respectively. Whereas the discount rate for electricity recorded a constant or downward trend since 1997, that of solar water heaters rose consistently over the same period and especially since 2000. These trends continued and eventually the rate for solar water heaters rose above that of Tshwane Municipality electricity in 2004 and Eskom in 2005. The discount rates for both Eskom electricity and solar water heaters levelled and maintained a similar profile from 2008 although the discount rate for solar water heaters remained higher than that for electricity.

The significance of this pattern is that the discount rate and therefore the perceived riskiness of solar water heaters rose steadily during 2000-2008. This coincides with the period when electricity prices were actually falling (Dagut and Bernstein, 2008). The discount rate for Eskom electricity was either declining or constant over the period 1998-2011, signifying approval of the status-quo from

consumers. The continued high risk associated with solar water heaters would be expected to translate to declining demand for the technology over that period. The levelling of the prices indicates a stabilising of demand although electricity remained the more popular method of heating water. The stabilising could be an indication of a re-think in attitudes towards solar water heating and the beginning of a transformation process. But the re-think is most likely based on intuitive evaluation of expected economic benefits (cost-saving) rather than sustainability considerations (energy-saving and renewable energy to mitigate climate change for example), because economic benefits are tangible and easily quantified under System 1 *mental accounting*, while sustainability benefits are abstract and therefore difficult to evaluate, especially quantitatively.

Elsewhere, it was reported that electricity tariffs were actually falling in real terms during this period while the growth in demand of solar water heaters increased sharply during the 2005-2008 period. Jim Hickey of Solahart South Africa (electronic comm. 24 February 2009) observed that there was no significant increase in electricity tariffs over the period 1998-2008 and even after the electricity crisis (Section 4.5). This is supported by figures from eThekwini and Tshwane municipality (Table 4.1). On the other hand, Eskom increased electricity tariffs by only 5.6% annually in the period 2006-2008 (Prasad, 2007:11). According to J. Hickey (electronic comm. 29 February 2009) however, there was no real increase in the volume of solar water heater sales either. This view is contradicted in Figure 4.5 where it is shown that there was an upward trend indicating a slight increase in the production, and presumably therefore, sales of solar water heaters in South Africa between 2005 and 2007.

There was increased activity in the industry with a large number of new suppliers and manufacturers (Eskom Distribution, 2009). This rise was attributed to the predictions of an electricity crisis, its actual occurrence starting from 2006 and the consequent search for alternative energy sources. At the same time, the first real increase in electricity tariffs was recorded in 2008.

Visagie and Prasad (2006) maintain that the solar water heating industry in South Africa has matured, but faces a hostile market attributed to the low cost of coal-based electricity generation and lack of legislative and regulatory support. But this argument is contradicted by the fact that the introduction of by-laws in Cape Town and Government Gazette Notice No. 31250 of July 2008 did not immediately create a visible increase in demand for domestic solar water heaters (Eskom Distribution, 2009).

Consequently, people were faced with a dilemma over changing from a hitherto trusted and predictable system to what they perceive to be a costly and uncertain technology. The profile of the discount rates in Figure 4.4 represents the thinking of consumers and suggests that transformation to sustainability can only make sense if approached from an economic re-think because the technological lock-in against solar water heating seems to be primarily economic-based. Ethical transformation including sustainability considerations can only follow from an economic re-think. The re-think can be forced by indirect and non-linear circumstances such as the Eskom generation-capacity crisis and the subsequent high electricity tariffs.

There are no clear indications that the rise in supply and demand for solar water heaters could be attributed to increased concern or any transformation in public attitudes towards the environment. Neither can it be attributed to any planned increase in electricity tariffs because the real increase did not happen until 2008. Any increase in electricity tariffs was not to internalise externalities and achieve the true production cost of fossil-fuel generated electricity. On the contrary, various reports point to a need for re-capitalization in anticipation of massive expansion of Eskom's infrastructure and generating capacity, including the construction of new additional coal-fired power stations as the principal reason for the increase.

Contrary to popular opinion in research especially before the crisis, legislative and regulatory tools did not cause any significant shift towards solar water heating. It

is only the electricity crisis in 2008 and the subsequent escalation in tariffs starting from 2010 that eventually triggered the onset of a shift. At individual level, *mental accounting* determined whether any increase in tariffs was worth a change to solar water heating.

As argued in Section 4.3, the benefits and costs of the two competing water heating systems derived from *mental accounting* and *loss aversion*, especially for a perceived emerging technology, weighed heavily against solar water heating. This situation was exacerbated by technological lock-in, which entrenched the *status-quo bias* in which electric geysers were the *default option* for water heating and therefore enjoyed the advantage of opt-out *inertia*. From a prospect theory perspective, the eventual real electricity price increases from 2008 onwards and especially the heavy well-publicised increases from 2010 alerted System-1 to a potential threat which could now be evaluated in *mental accounting* as tangible, rand value increases in electricity bills.

4.6 The electricity crisis and decision making in the solar water heating sector

The South African electricity crisis began in Cape Town in January 2006 and spread to the rest of the country in early 2008. The crisis is still on-going until new generation capacity comes online, especially from the two new power stations (Medupi and Kusile) now under construction. The cause was never quite publicly established and the debate and blame continued till the end of the stabilisation of crisis in 2008/2009. A copious amount of literature has been written about the crisis. But according to some experts, the crisis was not (as indicated in some reports) caused by bad luck, faster-than-expected economic growth or the private sector refusing to invest in electricity generation (Dagut and Bernstein, 2008). It transpires that the government as the major shareholder in Eskom and thus controlling its capital expenditure had been informed for over ten years that the crisis was looming.

As demand increased without any new power stations or increased generation, Eskom was forced to exert pressure on its existing generation and transmission infrastructure which eventually succumbed leading to low output and depletion of reserve margins. Even though most of the players in the sector knew that the crisis was coming (from informed predictions in various forums and studies), they would not have known how the crisis would unfold or manifest. The consequent load shedding (scheduled but sometimes unpredictable power cuts due to a lack of adequate capacity) took most of them by surprise. Moreover, the magnitude of the load shedding was a shock to many stakeholders. The situation was worsened by poor communication from Eskom and the government, both of whom initially denied that there was a crisis and later attempted to shift responsibility (Dagut and Bernstein, 2008:3, 12, 30).

Although the impact was more severe in the industrial sector where mining was severely affected, it was the domestic consumers who reacted more flexibly to the subsequent power rationing. Further, the media reported widely on the crisis focusing especially on its effects in Cape Town in 2006 and Gauteng and Durban in 2008. When some businesses considered alternatives, standby diesel generators were the preferred option.

For unexplained reasons, the South African government decided in 2001 to prevent Eskom from building any new power stations even when it had been predicted that Eskom would run out of peak capacity by 2007 (Dagut and Bernstein, 2008). Options including gas turbines and additional nuclear stations were suggested. During this period, tariff increases were also largely predicted. We have seen in Section 4.5 that the tariff increases did not materialize early enough, and that when they did, it was not within the expected magnitude. They therefore had little impact on the energy-choice and behaviour of consumers.

By 2005, Eskom and the National Energy Regulator of South Africa (NERSA) were experimenting with solar water heating. The South African government was said to have set aside R3.5million for installation of solar water heating in its

subsidized housing programme (Holm and SolaSure, 2005). A review however suggests that this plan was initially not successful with only "several hundred" solar water heaters being installed ten months into the project instead of the projected 300,000 in that period (allafrica.com, 2009). Such intentions, programmes, plans and policy pronouncements were numerous in the ten year period prior to the crisis in 2008.

The challenge by South Africa's Energy Development Corporation (EDC) that government should set a good example by using solar water heating in its houses and office buildings was not taken up. Neither was EDC's encouragement to its own staff to install solar water heating in their own homes taken seriously (Holm and SolaSure, 2005:24, 54). The various nudge techniques introduced during this period failed to achieve the anticipated outcomes because they were premised on the rational-agent model approach and CBA rationale.

Surprisingly, in discussions on the electricity crisis, minimal reference is made to the preceding crisis (which had similar impact, if not magnitude), that occurred in Western Cape Province in early 2006. In that case, various statements were made to the effect that the crisis was a result of sabotage at the nuclear power station in Koeberg even though no evidence was made available. It is however in Cape Town and Western Cape Province in general, where the most significant response occurred as a result of the crisis. The city had proposals from as far back as 2003 to get 10% of its energy from renewable energy and energy efficiency technologies (REEETS) by 2020 (Jennings, 2007:16). Following the crisis, it became the first South African city in March 2007 to publish draft by-laws on solar water heating mandating that all new houses and renovations meet 60% of their water heating requirements using solar water heaters (Jennings, 2007:16). In addition, the by-law set out installation standards, certification and performance reporting mechanism. The objectives given were:

- To improve energy security by reducing electricity use
- To create employment in the solar water heating industry

- To encourage residents to use solar water heating with the objective of reducing emissions of carbon and other greenhouse gases, and waste of the earth's resources (Prasad, 2007:14).

Cape Town was resolving the energy crisis and implementing an energy efficiency policy which also recognised the principles of sustainability, but applying the rational-agent model approach, which failed to register in the System-1 thinking of residents. Cape Town and Eskom were also addressing the issues which had been raised in earlier surveys as obstacles to achieving sustainability in the energy sector. But these decisions were mainly based on the economics of the need to reduce peak load and manage the inadequate supply capacity. However, Cape Town adopted a sustainability approach even though their experience with the electricity crisis and real reason for adopting solar water heating were, in the same way as those at Eskom, clearly driven primarily by economic considerations.

In 2008, the Nelson Mandela Municipality in the Eastern Cape province of South Africa, accepted as part of its renewable energy projects a plan for homeowners to install domestic water heaters and pay on a rent-to-buy basis over 15 years. Although this system was touted as sale of hot water only, a buy-out element was incorporated in the cost (Jennings, 2007). According to one observation, compact fluorescent lamps (CFLs), geyser blankets, energy efficient heaters and gas cookers were given away as part of the Western Cape's 90 Day Recovery Plan, by local authorities and Eskom's DSM, "… but no one was giving away solar water heaters" (Jennings, 2007). Until 2006 and coinciding with the energy crisis, there was little promotion of solar water heating among government departments, municipalities and in Eskom.

In July 2008 the South African Department of Minerals and Energy (DME) published Government Gazette Notice No. 31250 requiring the installation of a solar water heater in all existing buildings by January 2012 or alternatively, a remote control for the supply of electricity to any electric geyser (Republic of

South Africa, 2008). Another acceptable alternative was installation of a 'smart system" that could be used to reduce or increase the supply of electricity to the building. There was however no effective enforcement mechanism in the Gazette Notice. In addition, the DME minister told parliament in March 2008 that all new houses valued at over R750,000 or larger than 300 square metres would be required to install solar water heating by 2010 (African Energy News Review, 2008a). The option of targeted taxes was only introduced in the 2008 budget but the impact is yet to be quantified. It is yet to be determined whether this measure is adequate to encourage large scale acceptance and installation of domestic solar water heating.

The combined application of the gazette notice, by-laws and the rebate programme backed by intensive publicity was likely to create a bigger impact than each of the initiatives applied independently. Furthermore, the regulatory tools should have been synchronised with other related ones for maximum impact and wide application.

The period before the South African energy crisis was characterised by a combination of institutional *irrational* behaviour pattern or heuristics such as *status-quo bias*, *endowment effect*, *induced blindness* and defective forecasting. Decision making informed by scientific research and backed by empirical data was routinely dismissed or ignored at government level, and replaced with decision making based on gut feeling and characterised by *procrastination and inertia*. During this period, the status-quo was as follows:

- Business as usual in the energy sector, high pollution levels with South Africa being the highest emitter of greenhouse gases in Africa. Solar water heating was a no-go area for Eskom, the South African power utility. The only challenge was the excessively high demand for electricity during two peak periods per day. In order to stabilise this peak demand, Eskom's demand side management (DSM) division promoted the use of geyser blankets for the popular electricity driven

domestic heating appliance, installation of remote control of such geysers and CFL fittings.

- Eskom and municipalities generated and distributed mainly low priced electricity from cheap coal, available in abundance. Externalities were not systematically factored into production costs and pricing.
- Government saw no cause to intervene in the market to popularise the use of alternative REEETs.
- There was therefore no obligation or incentive for the market transformation to create a level playing field for fossil fuel-driven appliances and REEETs. The market was significantly biased against REEETs with high initial costs while electricity was priced at below production costs. The assessment methods used were equally biased against REEETs. There was no incentive or agreed-upon method to appropriately weight and value the significant environmental and socio-economic benefits of solar water heating.
- In response to other pressures such as climate change, the South African government published regulations and policy statements referred to as White Papers but these were not enforced as the market was deemed not to be ready. The market was therefore not responsive to these government initiatives and the business-as-usual attitude continued to be entrenched.
- Government failed to liberalise the energy industry and to allow independent power producers or REEETs to compete with Eskom. This would have raised the price of electricity generation to at least production cost level and security of supply would have been guaranteed.
- Arising from this situation, there was no incentive to persuade the demand side to value solar water heating fairly compared to electric geysers.

In response to the crisis, the affected institutions resorted to rational-agent model and CBA aligned mechanisms in interventions to resolve the problem, as demonstrated in the following actions:

- The City of Cape Town published by-laws for solar water heating in 2007. Although the process had been started four years earlier along with other national initiatives, there had been no hurry to operationalize the by-laws until it became urgent after the crisis in January 2006. Nelson Mandela Municipality introduced a solar water heating programme of its own in 2008.
- Eskom launched its rebate programme whereas before the crisis it was not interested in promoting solar water heating. There was increased activity within Eskom and interaction with stakeholders became more evident. The government allocated funds for the solar water heating rebate programme.
- The DME published Gazette Notice No. 31250 on solar water heating in July 2008.

How did the crisis change people's attitudes to solar water heating in South Africa? It emerges that people do not normally have time or money to experiment with new or alternative technology (although solar water heating is really not new technology) and for most people, the method or technology used in heating water is not considered worth a re-think. The exception would seem to be the choice of entertainment related technology which is given a high premium. For water heating, people apply *mental accounting* to make decisions regarding priorities and available options, which results in more willingness to undergo some little inconvenience caused by the power interruptions than to opt for the alternative technology.

There was heightened activity in the solar water heating sector in South Africa in the period immediately after the electricity crisis. Although some of the legislative and regulatory instruments were in the pipeline before the crisis, their processing and roll-out were fast-tracked. The rebate programme had been recommended in

many studies prior to the crisis but the government and Eskom only took up the challenge after the crisis.

According to Cawood (electronic comm. 29 April 2009), the number of manufacturers and importers of solar water heating equipment increased from 21 to over 100 within a two-year period (2006-2008) during and after the onset of the crisis. This indicates a more favourable environment in the solar water heating sector within that period. It can be concluded that the electricity crisis was a major catalyst to transformation in the solar water heating sector in South Africa. From a prospect theory perspective, the crisis provided the context for the *availability affect* (Table 3.2), which became the heuristic for increased demand for solar water heating. But overall, it can be argued that it was the *loss aversion* relative to Eskom power utility bill which did the transformational magic. It is very unlikely that perpetual load-shedding without concurrent tariff hikes could have resulted into such a rapid reversal of attitudes and behaviour.

The pattern of policy decision making in the electricity sector indicates that the promotion of solar water heating was neither deliberate nor sympathetic to environmental and sustainability values. Although it cannot be branded as totally sympathetic to economics either, government and its regulatory institutions allowed the utilities to conduct business as usual. Although government did not allow additional coal-fired power stations at the time (and thus could be deemed to have had environmental benefit), it was equally slow in adopting alternative energy policies to address the diminishing capacity dilemma. This indecision (and possibly a procrastination/inertia heuristic) largely contributed to the onset and deepening of the crisis. It is noted that eventually after the crisis, these new power stations were approved and even partly financed by government. The behaviour of government shows institutional *inertia*, *procrastination*, the *affect heuristic and defective forecasting* (Table 3.2).

The electricity crisis altered the decision making pattern in Eskom. Circumstances of the crisis (rather than regulation or voluntary proactivity) forced Eskom to

develop a paradigm shift that would be sympathetic to solar water heating by default rather than through strategic rational evaluation of multiple alternatives. There were indications that Eskom was driven by the need to manage peak load and that its involvement in solar water heating would end if peak load was reduced to acceptable levels. Although the shift remained questionable and its environmental sincerity suspect, it was nevertheless a radical transformation in decision making. Still, there were questions on the direction it would take especially after the completion of the new power stations or if the energy supply deficit problem eased. Whereas this can only be established and validated over time, the level of tariff escalations is unlikely to be reversed and for this factor alone, one can assume the market and stakeholder behaviour have fundamentally transformed.

The events after the crisis can be interpreted in various ways from a prospect theory perspective. The electricity suppliers especially Eskom, applied various choice architecture techniques or nudges to cause a shift in favour of solar water heating. For example, *framing effects* presented the rebate programme as a cash-back system which not only reduced the payback period for the solar water heater but also significantly reduces the monthly electricity bill. These techniques would hopefully translate the complex evaluation in CBA for solar water heating and electric geysers into a form amenable to System-1 capabilities. It is noted that there was little emphasis on environmental benefits in the solar water heating promotion. Consequently, any environmental/sustainability gains from the crisis will be primarily of a non-linear/secondary outcome rather than a rationally pursued goal of the stakeholders concerned.

However it is the resultant load shedding and associated inconveniences to domestic consumers (who were deprived of electricity and interrupted in the use of domestic appliances), that possibly triggered the first alert in System-1. This alert caused consumers to start paying attention to information on alternative technologies as one of the solutions. This is also when the advertisements for consumers to reduce electricity consumption during peak periods and promotion

of solar water heaters rebate programme started making sense to consumers. The *reference point* or *anchor* shifted from low and affordable electricity tariffs to the crisis and load shedding inconveniences, which were later reinforced by unprecedented huge electricity tariff increases. We can therefore say that the events and experiences translated from the 'do nothing' heuristics such as *status-quo bias, inertia, affect heuristic and defective forecasting* into the *availability affect* in prospect theory.

4.7 Decision making and market interventions in the solar water heating sector

In May 2007, Eskom, the South African power utility, announced an ambitious one million solar water heaters programme worth R2 billion, driven and funded by the government. According to Eskom, customers would earn rebates of 15-20% on the cost of installing a solar water heating system (Davie, 2007). The installation costs ranged between R14000 and R33000 depending on the size of the system and installation complexity related to roof type and profile. The rebate could realise initial cost-savings of R1860-R4900. In order to qualify, the installation was tied to a quality control system in which only South African Bureau of Standards (SABS) certified components could be installed by Eskom accredited installers. The rebate was processed through Deloitte who undertook to settle claims and pay within eight weeks. By October 2008, 565 solar water heaters had been installed with the Eskom subsidy (Africa Energy News Review, 2008b; Spadavecchia, 2008 and allafrica.com, 2009). This figure had risen to 92,392 units by July 2011 which was still less than 10% of total hot water installations sold in South Africa (Kritzinger, 2011:iii).

The benefits of this programme were projected to be:

- growth of the solar water heating industry from 7,000-10,000 units per year to one million over three years. In addition, 10,000 plumbers were to be recruited and capacitated
- savings of 20-40% on electricity bills for consumers

- achieving national environment objectives regarding carbon emissions reduction
- saving Eskom 3,000MW of peak load electricity by 2012 and up to 8,000MW by 2025
- achieving government target to produce 10,000GWh of renewable energy by 2013 with solar water heating contributing 23% of this target (Spadavecchia, 2008).

For a long time, solar water heating was regarded as the more expensive alternative to the electric geyser system in domestic water heating. Why would Eskom suddenly decide to promote solar water heating which all along had been considered to be in direct, though weak competition to its coal-generated electricity in water heating? According to Worthmann (Interview, 28 November 2008), Eskom was influenced by the following considerations:

- The Department of Energy White Paper on Renewable Energy (DME, 2003).
- Eskom foresaw the energy crisis coming especially with the Cape Town experience and before due to the denial by government of approval to expand coal-generated electricity capacity.
- Eskom always wanted to control peak usage of electricity and there was now an opportunity to do so. Worthmann noted that in 2008 there were 4.2 million electric geysers in the country with an additional four million new ones being installed despite the White Paper of 2003 and the Government Gazette Notice (Republic of South Africa, 2008).

There is a strong indication here that regulatory and legislative support alone could not create the transformation required. Previous research called for legislative support and incentives to create the transformation. With the new regulations, incentives and targeted taxes that were formulated by 2008, the expected transformation was barely noticeable and initial cost of solar water heating remained high compared to electric geysers. With the rebate programme,

Eskom proposed to create a market transformation that would result in the reduction of prices of solar water heaters.

Gazheli (2012) suggests that transition policies such as the legislative tools mentioned above and the rebate programme tend to adopt a rational-agent model approach rather than the more realistic bounded-rationality-based recognition of the limits and opportunities for realising such transition. The unique behavioural features of the relevant stakeholders or target groups for a transition programme or policy are crucial in understanding how to design and stimulate transitions in what prospect theory refers to as choice architecture (Ariely, 2008).

The rebate programme however failed to adopt a stakeholder approach in its formulation and implementation. There was little effort to create awareness among individual household customers and building industry professionals. More importantly, the financial bottom-line was a key motivating factor. In fact the environmental benefits were seen primarily in form of enormous gains from carbon credits for Eskom in the short to medium term. In all probability, management was only persuaded to approve the rebate programme on the basis of this prospect. The economic considerations prevailed and the ensuing process adopted an economic approach in spite of the branding of the programme as partly to reduce dependence on coal and therefore reduce environmental pollution. Even when environmental concern was mentioned, it was watered down by revelation of the real intentions of the decision (namely the sale of carbon credits), once again demonstrating non-linear dynamics which serendipitously allow for new patterns to emerge, in a way which could not be rationally configured in advance.

The rebate programme was not entirely voluntary. The carrot and stick strategy was often used to bring institutions on board through other measures such as denying new projects electric-grid connection unless they installed solar water heaters. In KwaZulu Natal province of South Africa for example one consumer who applied for connection to a new clinic in 2008 was advised that the network was embargoed due to inadequate capacity (Appendix 12). After extensive

negotiations, Eskom agreed to provide connection provided the consumer made an effort to reduce total electrical demand by installing solar water heaters instead of electric geysers. The rebate was offered as a further incentive.

Worthmann (Interview, 28 November 2008) conceded that electric geysers would still prevail in a conventional feasibility study when compared to solar water heating. The solar water heating payback of 7-10 years was considered too long. In the case of the Eskom project, a "financial and technical" feasibility study was done but could not be accessed for this study. It is therefore not clear whether it was a formal cost-benefit evaluation. However, the feasibility study projected that the cost of electricity would double in 2011 while payback for solar water heating would reduce to three years. According to Worthmann, this was a major influence in tilting the Eskom study-recommendations in favour of solar water heating. Since the feasibility study was not made available to the public, it was difficult to ascertain how, almost overnight, solar water heating achieved a positive CBA evaluation outcome relative to electric geysers.

Reports on the impact of the solar water heating programme were conflicting. While Eskom was quoted in Hill (2008) reporting that suppliers of solar water heaters could not cope with even 10% of the new demand and claiming that the whole of South Africa was out in search of alternative energy due to the crisis, Hickey (electronic comm. 24 February 2009) responded that there was no real increase in the demand for solar water heaters in recent years. On the other hand Cawood (electronic comm. 29 April 2009) reported that there was a great impact arising from the rebate programme as indicated by a sharp rise in production and consequently, sales of solar water heating in 2008. This view was supported by Mundy (electronic comm. 20, 29 April 2009).

Despite this optimism, the project failed to take off at the predicted scale because of weakened choice architecture demonstrated by a lack of awareness among consumers and presumably also the dynamics of other related prospect theory heuristics and biases. Many building industry professionals interviewed in early

2009 were not even aware of the gazette notice requiring that solar water heaters be installed in all new houses valued at R750,000 or larger than 300sq.m by 2013 (Republic of South Africa, 2008). Some had heard of the Eskom programme but did not know the details on how to access the rebates and their attitude in such cases, as always, was that when all information is not available, you do not take chances. Many professionals therefore exhibited a sceptical approach to the programme.

According to Holm and SolaSure (2005), international experience has demonstrated that subsidies paid to manufacturers and suppliers are counterproductive because they have no inbuilt incentives to improve quality and performance. But Eskom had ensured that their programme incorporated SABS quality control and accreditation of installing companies. Furthermore subsidies were paid to the consumer rather than the supplier. Although the programme was driven and funded by government, it had been observed that government was not setting a good example as most departments continued to install electric geysers for water heating requirements in new staff housing projects.

There were problems with the rebate programme even at the time of this study. The buy-in by key stakeholders was slow and sceptical. There was neither evidence of involvement of professionals from the building industry, their associations and educational institutions, nor the vigour expected from suppliers of solar water heating appliances. The promotion of the programme was weak. For example advertisements in the media only started appearing late in 2010, and even though various Eskom rebate programme webpages (such as http://www.eskom.co.za/c/56/eskom-solar-water-heating-programme/ and http://www.eskomidm.co.za/residential/residential-technologies/solar-water-heating-supplier-list) were informative, they were not accessible to many potential beneficiaries of the programme who had no access to the internet.

There was an extremely low level of consultation and information sharing during the planning and roll-out stages of the programme, and the implementation phase

maintained a top-down approach. Some of the government departments which would have been beneficiaries of the programme did not seem aware of the benefits. Others were either sceptical or left the decision to individual project officers who would then make their decision based on personal experiences and persuasion towards environmental issues. Apart from Cape Town and Nelson Mandela, there was a general lack of interest from other municipalities. Johannesburg, Durban and Tshwane, (as examples of cities which suffered high impacts from load-shedding) had not shown any co-ordinated response to the crisis.

The rebate programme was characterised by a rational-agent approach to transition which resulted in unrealistic strategies especially when stakeholder considerations were absent or inadequate (Gazheli, 2012:1). In order to counter the forces of *status-quo bias, endowment effect* and technology lock-in that prejudice new technologies, transition in technologies needs to be designed, planned and executed in a framework that recognises and integrates into the co-evolutionary process in which it operates. This entails identifying and recognising the change agents that play a catalysing role in the transition including choice architecture, where to apply it and when. Regarding regulatory interventions that target altruistic responsibility such as concern for the environment and ecological diversity, Gazheli (2012:8) notes that rewards and punishment can be counterproductive if they crowd out or fail to tap into community oriented aspirations.

The rebate programme failed to capture the reality of decision making in prospect theory perspective particularly the bounded rationality constraint and the role of System-2 heuristics. In failing to recognise the effect of bounded-rationality-based nudges and choice architecture in decision making, the methods adopted ended up being overwhelmed by *inertia* and associated heuristics. For example the failure to involve the key stakeholders in the planning and implementation process made the process too complex for System-1 to capture and get attracted to as a viable option. Promotion methods failed to relate the solar water heating option with the

electricity bill which is closer to the System-1 computation and *mental accounting* of the consumer. In the minds of the consumers therefore, there was very limited mental linkage between the rebate programme and the eventual high electricity tariff increases starting from 2010.

4.8 Conclusion

In this Chapter, the study set out to demonstrate how decision making within the solar water heating sector in South Africa is characterised by contradictions between rational-agent model assumptions and the reality of boundedly rational behaviour model as explained by prospect theory. It is clear from the events presented here that in most cases, *irrational* prospect theory heuristics drive decision making even where rational and structured decision making is anticipated. But evidently, there is neither consistency nor any standard, replicable behaviour pattern in decision making at both institutional and individual level in the sector case study reviewed. In all cases, there was a variety of contradictory and unpredictable decision making patterns with equally contradictory and unpredictable decision outcomes. There was also no distinction between institutional and individual behaviour patterns in decision making. Decision making featured an ad hoc mix of informal cost-benefit analysis, sustainability assessment and prospect theory heuristics.

In terms of prospect theory, the period before the electricity crisis in South Africa was characterised by heuristics that maintained the status-quo such as *loss aversion, status-quo bias, endowment effect, procrastination, inertia* and tendency towards the *default option*. In addition, there was *induced blindness* especially among professionals, electricity suppliers and government officials tasked with decision making. Most of the decision making biases were based on perceptions, which were not supported by any scientific studies or facts but mainly based on impressions and *post-rationalisation* (Table 3.2).

The period during the crisis was characterised by reactive behaviour including denial and attempts to justify the previous position. The various measures introduced to deal with the crisis were characterised by economic-based rational-agent model techniques such as market interventions to cause shift in the supply and demand dynamic. In response, consumers either ignored the interventions or acted irrationally and contrary to expected behaviour. The nudge mechanisms did not seem to register as priority in the minds of the consumers or else they were too complicated and confusing for System-1 thinking and were therefore either ignored or delayed.

The period after the onset of the crisis was characterised by expedited revisions of previous positions at both institutional and individual levels. As noted in the US studies, previous biases can be transformed into acceptable decision and choice behavioural heuristics under different circumstances. The previous view of solar water heating as immature technology subjected to a technological lock-out by electric geysers was revised in light of escalating electricity tariffs. This is a common example of a shift in reference point from *inertia, affect heuristic and defective forecasting* to *availability heuristic*. This chapter has highlighted the prominence of *status-quo bias, inertia, procrastination* and *post-rationalisation* as key heuristics in choice and decision making on the one hand and revision of position or *anchor* following the electricity crisis.

Chapter 5

Prospect theory and decision making for solar water heating projects in southern Africa

5.1 Introduction

The patterns of decision making that promote and entrench the status-quo outcomes in conventional cost-benefit analysis (CBA) thus prejudicing the goals and principles of sustainability can also be demonstrated at the scale/level of specific solar water heating projects as argued in this chapter. The chapter adopts a more focused approach to the analyses of decision making patterns in specific projects, using a framework derived from attributes that define the link between CBA evaluation and the principles of sustainability, and similarly interpreted for prospect theory heuristics or irrationalities. It is from this analysis that we can establish whether and how decision making in the selected solar water heating projects demonstrate patterns of prospect theory heuristics and *irrational* behaviour rather than formal/rational CBA evaluation and sustainability assessment methods. The attributes were introduced in Sub-section 2.7.1 and discussed in more detail in Sub-sections 2.7.2 to 2.7.5, while the framework was introduced in Section 3.2.

This analysis departs slightly from the comparative approach in Chapter 4, where decisions to install or not to install solar water heaters are presumed to be competing with the use of electricity as an alternative. Since this section deals mainly with institutional projects, the alternative to solar water heaters come in the form of electric geysers or fuel-based boilers. However, the focus of the surveys in this chapter is on the key reasons that influence the decision to install or not to install solar water heaters rather than on the alternative technology that was adopted. For this reason, the analysis in this chapter indicates a clearer link between the key attributes and the key heuristics in prospect theory. The comparison between solar water heaters and electrical, fuel-based, or other

alternative installations is therefore implied rather than being used directly as the primary analytical approach.

5.2 Data overview

As mentioned earlier, data in the following sections are those that tell the story of decision making in solar water heating projects (Section 3.3). The study collected and analysed data from case studies of the following solar water heating projects in South Africa and Botswana:

- Case Study 1: Solahart Botswana (interview 18 May 2007) – A supplier of solar water heaters from Botswana. The version of interview questions relevant to this category is found in Appendix 3. The responses to the interview are found in Appendix 4.
- Case Study 2: University of Botswana Student Hostels, Gaborone (interview 21 May 2007) – A long-time user of solar water heating. The version of interview questions relevant to this category is found in Appendix 5 and the responses in Appendix 6.
- Case Study 3: Deutshes Senioren Wohnheim (DSW), Pretoria (interview 18 June 2007) – A completed solar water heating project. The version of interview questions relevant to this category is found in Appendix 5 and the responses in Appendix 7.
- Case Study 4: University of Pretoria Student Hostels (interview 28 June 2007) – A solar water heating project in progress at the time of the survey in June 2007. The version of interview questions relevant to this category is found in Appendix 5 and the responses in Appendix 8.
- Case Study 5: Tshwane University of Technology (interview 30 July 2007) – An institution where the solar water heating option was not taken. The version of interview questions relevant to this category is found in Appendix 9 and the responses in Appendix 10.

The responses to the interviews for the surveys are summarised in Tables 5.1-5.4. In Sub-sections 2.7.1 to 2.7.4, we identified the key status-quo attributes that define the common objectives and shape the status-quo framework for evaluation in CBA and sustainability assessment. These are re-stated as follows:

(i) The ***time-related attributes*** are life-cycle costs, generational equity , accruing of benefits, immediate gratification, project feasibility and payback periods for the project.

(ii) The ***scope and stakeholder attributes*** relate to scope of beneficiaries, monetisation, impacts of the project in the area where it is located, participatory process, stakeholdership, inclusion vis-à-vis exclusion and attitude to future generations.

(iii) The ***attitudes and perceptions-related attributes*** are attitude to risks, intrinsic vis-à-vis economic value and the irreversibility and preventative principle.

The interview questions were designed to lead the discussion towards an understanding of how decisions are made in solar water heating projects. The merits of these types of interviews are discussed in Section 3.2. The people who were interviewed in this survey are referred to as interviewees to distinguish them from the term respondents used in Chapter 4 to refer to surveys done through questionnaires. The questions were varied slightly to reflect the status of the projects.

In each case, the interviewee was contacted through telephone and requested for an interview after careful introductory protocols. The appointment was thereafter confirmed through electronic communication. In addition, the respective questions were sent to the interviewee in advance. All interviews were conducted in the respective interviewee's office. The interviewees were allowed to fully express themselves without digressing too far from the question.

Among the four institutions surveyed with regard to the reason for attraction to the solar water heating option the three that had installed the systems cited expected economic benefits in form of reduced electricity costs for water heating (cost saving). Solahart, the supplier and installer of solar water heaters in Botswana alluded to compliance with government policy as an additional reason in that country. Both the government and University of Botswana (UB) already had policies that required that solar water heaters be installed in their building projects. No feasibility studies were required to defend this policy or project-decisions and consultants employed in government and university projects just complied. UB's policy was perhaps the most progressive among the institutions surveyed. All of the 56 hostels accommodating 4083 students were on solar water heating. The buildings were appropriately oriented to maximise on solar radiation indicating the solidity of the policy and thereby solving the 'structural problem' discussed in Section 4.2.

Senioren Wohnheim (DSW) in Pretoria, South Africa was equally decisive in choosing the solar water heating option. A feasibility study would not have changed their opinion and had therefore been deemed unnecessary . Similarly, the University of Pretoria carefully considered the options and chose to install solar water heating in their new hostels although a formal feasibility study on solar water heating was yet to be completed and would, according to the interviewee, only be used to make a decision regarding retrofitting of existing hostels.

Tshwane University of Technology (TUT) which is located in the same city as University of Pretoria (UP) had considered the solar water heating option but there was no administrative (referred to as political) support and approval to proceed. A study commissioned by the university to determine the feasibility of the solar water heating option was not considered. In response to later questions, the decision not to adopt solar water heating at TUT was attributed to the perception that solar water heating was not economically viable, had long payback periods and was therefore not a priority in view of the university's limited capital budget.

In all cases therefore the primary benefit identified from installation of solar water heating was economic. In exceptional cases as in UP, the institution's responsibility towards the national energy management was cited as a reason for adopting solar water heating. Solahart in Botswana mentioned the environmental responsibility and reduction of carbon emissions which can be addressed through solar water heating.

The question of payback time was crucial in determining the value decision makers placed on solar water heating. The results reflected the attitudes of each of the institutions surveyed. DSW, the most optimistic institution in terms of adopting solar water heating regarded a fifteen-year payback period as acceptable. Solahart, UB and UP who all showed a good understanding of the benefits of solar water heating considered a payback period of 4-5 years as reasonable while TUT regarded a 2-3 year payback period as satisfactory but would only consider funding the project if it delivered a 6-month payback period.

The question regarding the scope of beneficiaries revealed the economic bias that most people had regarding solar water heating and the environment. Where the institutions were cited as the beneficiaries, the most important benefit was almost always the reduced cost on the electricity bill. Even when Eskom or the global community were cited as beneficiaries, the benefits translated to economic values such as reduced electricity costs and reduced power demand (demand-side management), but rarely were environmental benefits mentioned. Only the DSW interviewee mentioned the nation as a beneficiary of solar water heating.
The majority of interviewees mentioned the inability to heat water adequately during cloudy days as a negative factor associated with solar water heating technologies. This translates to the need for a back-up alternative such as electrical or other heating-energy source. Poor maintenance was also frequently mentioned, indicating a perception of lack of technical capacity in the solar water heating market. For most of the institutions, the time period in which a solar water heating system operates and the quantity of hot water that is available determines

the efficiency of the systems. One interviewee mentioned the aesthetic effects of a solar water heating installation on the roof of a house as a minor negative factor. These problems could lead to a bias against solar water heating installations even when a market transformation appeared imminent.

The interviewees from Solahart described a fragmented supply side in which each party acts alone and activities to promote solar water heating are not coordinated. Governments adopt a top down procurement process which does not recognise, accommodate or encourage stakeholdership. UB reported a functional stakeholdership with consultative procedures such as infrastructure committees and report back forums, in place while DSW had a committee which based its decision on advice from a technical team. There was no need for lengthy discussions in DSW and dissenters were easily persuaded into accepting the solar water heating option. The UP stakeholder consultation process was very technical and not as refined, only seeking approval from senior administration and the university council for purposes of financing. On the other hand TUT had a very clearly defined decision making process with several stakeholder groups represented at the various stages.

In all the institutions, there was concern about the maintenance risks of solar water heating installations. Unreliability during cloudy days resulted in perceptions of poor performance of the system while reliance on electricity back-up was seen as a sign of weakness or confirmation of unreliability. But there were also signs of a good experience with the system at UB, which was due to responsive and efficient maintenance procedures. Whereas DSW showed absolute confidence in the technology, TUT could not be convinced on the viability of the technology for hot water needs in their student hostels (under closely similar conditions).

In the following sections, the decision making patterns are analysed and interpreted for characteristics of prospect theory heuristics or similar boundedly rational behaviour. The identification of such heuristics will be interpreted as

demonstration that decision making in the selected projects is not premised on the rational-agent model considerations assumed in CBA evaluation and sustainability assessment. This will lead to conclusions on how the prevailing evaluation approaches and tools undermine the transformation to sustainable production and consumption lifestyles through reinforcing of the status-quo outcomes (Section 1.11 and Chapter 6).

5.3 Time-related factors in choices and decision making for solar water heating projects

Undoubtedly, the main consideration solar water heating option in the case-study projects surveyed was the economic benefit expected from the technology. There was an indication or prior perception that solar water heating had become more economically viable in recent years. But there was no indication that formal contemporary evaluation studies such as cost-benefit analysis (CBA) had been done to support this perception. There is evidence however that the decision to install solar water heating was heavily influenced by the perceived economic benefits. There was also the implied perception that the prices of electricity would rise sharply especially after 2008 in response to the electricity crisis especially arising from the need to recoup the cost of additional generating capacity by Eskom.

Consistently across all the case-studies covered, neither formal evaluation in CBA nor sustainability assessment methods, or any other formal feasibility studies were done to justify decisions. Even where such studies had been done or were in progress, a decision to install or not to install solar water heating had already been made regardless of the study outcomes or findings. In DSW, there was such a high level of conviction that solar water heating is sustainable in all aspects that no feasibility studies were required. According to von Luttichau (Interview, 18 June 2007), "there were no facts, no figures, just logic". Even though installation costs for solar water heating were higher than the alternative electric geyser system by as much as R300 000, it was still decided to install solar water heating. On the

other hand, there was a perception among decision-makers at TUT that solar water heating was not viable regardless of the outcome of a CBA. In the case of University of Pretoria (UP), a hostel under construction in June 2007 was designed to have solar water heating while in parallel a study had been commissioned to assess the feasibility of solar water heating in the old hostels. There was pressure at the time to reduce dependence on electricity for water heating.

The recommendations of a similar study at Tshwane University of Technology (TUT) in 2007 had been shelved because solar water heating was not seen as a priority by the capital budgeting allocation authorities. The outcome of the study in this case was irrelevant to the decision made regarding solar water heating installation. An issue of particular interest is that both institutions are located in Pretoria, South Africa and that both are involved in the same business, presumably with similar if not identical issues regarding supply of hot water to resident students. During the same time period, both made distinctly divergent decisions on the system to use.

The pattern which emerges from these institutions is that decisions were not made exclusively on the basis of the outcome of formal feasibility evaluations. Instead, decision making was more in line with prospect theory heuristics (Sections 1.3, 2.5 and 2.7). Contrary to expectations, decision processes did not follow the predictable, conventional pattern where the outcome of a feasibility study dictates the decision to be taken. The decision making patterns described were thus characterised more by a combination of *mental accounting* and several instances of *post-rationalisation* of choices and decisions which appear to have been arrived at intuitively based on bounded rationality heuristics (Section 1.3 and Table 3.2).

To a limited extent, government projects are influenced by policy which leans more towards the principles of sustainability than the economic prospects. The governments of Botswana and South Africa are signatories to various international environmental treaties and they therefore deliberately put in place

policies that project them in a compliant light. In such cases, economic feasibility could be overridden by sustainability policy compliance. However, in implementing such policies, governments tend to focus more on domestic than institutional solar water heating. On the other hand, it is among institutions, such as University of Botswana and DSW in Pretoria, where solar water heating appears to be more readily accepted for its sustainability performance than among individual home owners.

Although issues of environmental and social responsibility were well articulated among most of the interviewees, these tended to be at individual rather than institutional level. In such cases, other sustainability-related issues such as global warming and concern for the environment were acknowledged by the interviewees and well-articulated in discussions even though no overall institutional policies were alluded to as the reference point for the sustainability opinions.

Equally, there was a very strong element of individual influence in decision-making for solar water heating projects even in large institutions. Decisions to install or not to install solar water heating were often initiated by a staff member, usually in the maintenance or property department, who was already familiar with and well aware of the benefits of solar water heating. These individuals were usually sympathetic to environmental issues on which they had a reasonable level of awareness. Their opinions and perceptions were highly regarded within their respective institutions and no studies were necessary to substantiate their recommendations. From a prospect theory perspective, these individuals created a reference point or anchor for institutional decision making by *framing* the information in particular ways. The assumption that the selected institutions make decisions on solar water heating within an objective corporate decision making framework, which records proceedings of meetings and relies on technical, scientific studies cannot be supported.

Initially, consumers in South Africa did not appear to be affected or bothered by the prospects of higher electricity tariffs. There was no evidence of consumer reaction to prior warnings or predictions of such increases. Similarly, authorities such as government, municipalities and Eskom only reacted in response to crisis. There was no incentive to take any action and hence in consistence with prospect theory, consumers took the *default option* to do nothing. It is further noted that under these circumstances, people are likely to deal with an immediate challenge rather than a predicted one. Furthermore, the *status-quo bias* means that risks are taken on the basis of the current position. Human beings are also naturally risk or *loss averse*, preferring assured outcomes over a gamble or uncertain outcomes. According to this pattern of decision making, the earliest that people will recognise the need for action is when the signs of a crisis start appearing even though the action itself will most likely be delayed until the crisis strikes. This pattern is often seen in the last-minute rush to renew licences, to pay bills and such other obligations with expiry dates or deadlines. There is often a misplaced hope that the prediction is wrong, that the event could have been averted or that an expiry date or deadline can be extended. There is a common behaviour pattern of optimism and the overconfidence effect regarding uncertain future outcomes.

When benefits were assessed, they were almost always financial (economic). Social and environmental benefits were secondary and only mentioned in some public institutions in terms of support and compliance with government policy rather than important elements of a fulfilling lifestyle and wellbeing. Secondary benefits were not considered in most of the institutions. There was little independent evaluation regarding social and environmental benefits of solar water heating in these institutions outside the need to support or comply with government policy. The structured ‘rational-agent model’ of assessment was often discarded. In System-1 and prospect theory thinking, the structure is complicated and therefore simplified in System-1 to the more familiar financial parameters, which are determined through *mental accounting*. Alternatively, the complexity of the problem leads to *inertia* and *procrastination*.

There was a consistent tendency to view and therefore calculate payback periods in terms of economic life and rarely in lifespan or life-cycle terms. Most of the surveys conducted indicate that there was little understanding of the concept of life-cycle costing for solar water heaters. The "immediate benefit" logic was prevalent in all cases studied. Payback periods approaching five years were considered not viable even when it was acknowledged that the solar water heating systems have a lifespan of 15-20 years. This logic is closely tied to the perception that associates solar water heating with quality and maintenance problems. Surprisingly, an interviewee who had used solar water heating in his house for 30 years considered institutional solar water heating to have too long paybacks and reckoned that a 2-3 year period was ideal for any water heating system. A six-month payback was suggested as likely to attract funding from the institution's financial managers. There are elements of the *optimism and over-confidence effect* as well as *loss aversion* in this reasoning.

The payback argument sets solar water heating in direct competition with electric geysers in the consumer's *mental accounting* application. The standard used to determine reasonable payback periods for solar water heaters is weighed against that of electric geysers. In *mental accounting*, the 15-20 year lifespan for a solar water heater does not immediately translate into a viable benefit when considered against the five year payback period. The risk of a lesser lifespan for an electric geyser is relatively underweighted in comparison to 2-3 year payback period for solar water heating technologies.

The institution, the country, the electricity utility and the residents were considered to be the key beneficiaries of solar water heating, but only in the immediate future rather than the life-cycle. Negative impacts are viewed mainly from a maintenance and reliability perspective which is tied to the economic life of the solar water heating installation. This amounts to 15-20 years, which is a very short time period in relation to generation time periods. Again *mental accounting* is applied with similar outcomes as discussed above.

The *immediate-benefit logic* can be identified as the informal combination of *mental accounting* and immediate gratification in prospect theory (Section 1.3, Section 2.5 and Sub-section 2.7.2). The introduction of time-declining discount rates in evolved in CBA evaluation is one way of responding to this deficiency (Section 1.5 and sub-section 2.7.5). The individual mindset or self-centredness has created a myopic view of generational time spans which in turn reduces the understanding of and commitment to obligations that the current generation have to future generations. This is further reinforced by the immediate benefit mentality attributed to *loss aversion, status-quo bias* and associated heuristics, which drives escalation in over-consumption and bio-capacity overshoot, thus undermining sustainability.

5.4 Scope and stakeholder-related factors in choices and decision making for solar water heating projects

There is no consensus regarding the sustainability principle of recognition of beneficiaries in the selected solar water heating projects and opinions vary widely among the institutions surveyed. Some have a few beneficiaries while others have a wider scope. In the University of Botswana (UB), only students are regarded as the primary beneficiaries of solar water heating in the hostels. The reliability of solar water heating is seen as the main benefit and this is transferred to users who are the students. Similarly, the residents of DSW Pretoria are regarded as beneficiaries although savings on energy are added as a benefit to the nation.

At TUT (which decided not to install solar water heating), only the institution as an entity is regarded as a potential beneficiary of such an installation. Students are not recognised as beneficiaries because, as it is argued, they would not really care what system is used to heat the water in the hostels as long as it is available at the right temperature as and when needed. It is in the University of Pretoria (UP) however where a wider scope of beneficiaries are recognised. The institution is seen as the primary beneficiary from an economic perspective, with Eskom the electricity supplier and the global community regarded as secondary beneficiaries.

However, a pattern emerges where primary beneficiaries are recognised in most of the institutions.

According to the *mental accounting* heuristic applied in this case, the benefits of solar water heating are weighted primarily from an economic perspective rather than concern for the environment. Economic and individual benefits are easily recognised in System-1 and over-weighted while the social-environmental and collective benefits remain abstract and therefore tend to be under-weighted.

It is clear that there are conflicting interpretations and perceptions regarding the sustainability principle of inclusion of a wide scope of beneficiaries in the four institutions. If the rational-agent rationale were to be applied, the interpretations would be similar in all the institutions surveyed because the parameters especially for DSW, TUT and UP would be similar. However, as can be seen here, there is no rational pattern of decision making in these institutions. Intuition and individual preferences prevail over institutional structures and decision making frameworks.

It emerges that suppliers of solar water heating were much better informed on scoping issues (Sub-section 2.7.1). They articulated admirably and in a balanced way the issue of beneficiaries consistent with the principles of sustainability as well as in CBA evaluation perspective even though financial savings were once again cited as the most important benefit of solar water heating. The tourism sector was for example mentioned as increasingly influential in the adoption of solar water heating in the hotel industry, making both of them beneficiaries in different ways.

Most of the interviewees regarded impacts as only negative effects. The question of impacts of solar water heating was therefore usually seen only from a negative perspective as to indicate failures. However, most of the interviewees gave approval to solar water heating as having no negative impacts. Sometimes disadvantages of solar water heating were confused with negative impacts. The

few disadvantages mentioned were cited as causes of negative attitudes towards solar water heating. However the approval did not necessarily translate to adequate weighting in *mental accounting* to cause adoption and installation of solar water heaters. At that level, the *anchoring* effect, *status-quo bias* and *procrastination* prevailed.

The most commonly cited disadvantage was the unreliability of solar water heating during cloudy days and its reliance on electricity as back-up. In DSW and UP where the solar water heating installations were relatively new, negative impacts were anticipated whereas UB had experienced maintenance challenges that however seemed to be outweighed by the undeniable high level of confidence in solar water heating. Similar arguments were presented even where solar water heating had not taken off.

In UP, students were cited as the main party affected by any impacts of solar water heating. Whereas the university, Eskom and the global community were cited as the beneficiaries and inconvenience of bathing times regarded as a disadvantage of solar water heating, the residents (students) were viewed as the affected parties. The views of the interviewees indicate a limited appreciation of the principle of inclusion in sustainability. These views were largely influenced by economic considerations where the primary financial investor is the principal and sometimes only beneficiary of the outcome. In other words the one who pays gets disproportionately more benefits while the negative impacts of the investment were shared by all.

There was a very narrow perspective of costs and benefits of solar water heating installations in the institutions investigated. Only impacts that are direct, immediate and accruing to the institutions were appreciated and mainly in terms of benefits only. While primary impacts were acknowledged and appreciated, secondary impacts were either hazy, were considered too distant and therefore inconsequential or just simply ignored. The time perspective plays a crucial role in this attitude. As stated earlier, the future is too abstract to attract any attention or

priority in the decision making hierarchy of System-1, and impacts accruing to future generations are difficult to perceive. Also, any beneficial impacts that may be realised in the future are regarded as uncertain and consequently under-weighted in decision making hence assured gains are more likely to be over-weighted compared to abstract and uncertain future outcomes.

The issue of tangible and intangible impacts did not arise in the responses (Sub-section 2.7.3). A closer look however indicates that only tangible and easy-to-cost impacts were accounted for albeit in an informal manner. The process of valuing intangible impacts appears in the category of complex System-1 problems and was therefore often ignored in decision making. In all cases, impacts were localised to the extent that there were distinctly varied and conflicting outcomes from DSW, TUT and UP and all in the same city in South Africa. Although there was no formal evaluation in CBA in any of these institutions, the studies that had been commissioned had no impact on the final decision. Such inconsistency or *irrationality* (intuitively/sub-consciously emergent versus rationally motivated choices) is consistent with what one would expect from a prospect theory paradigm rather than rational-agent model of behaviour.

The aesthetics of solar water heating installations featured as a possible negative impact. Although this is a value-laden observation, it could have an overwhelming impact on the upscaling of solar water heating. According to one interviewee, solar water heating installations are regarded by some as ugly and unsightly features on roofs (Appendix 10-B2). The main concern is the design of the installation especially the storage container component and the angle at which solar water heaters are installed, which is almost always different from the roof profile and therefore requiring to be propped up with a secondary-support structure. Significantly, and in a value-laden contradiction, no such negative comments were made regarding for example channel television satellite dishes or antennae which have comparable features and aesthetic effect when similarly installed on roof tops. This is another clear demonstration that solar water heating

is not regarded as an aspirational technology particularly in developing countries (Sections 1.9, 4.2, 4.3 and 4.4).

The participatory process is one of the key principles of sustainability. It advocates consultation and participation of stakeholders in decision-making processes. This analysis focuses on the levels of involvement of parties or stakeholders and recognition of the need for such a process in solar water heating projects. The ever present difficulty of balancing a participatory process and expediting decisions was evident in all the institutions surveyed. In UB, consultation was extensive even though the project initiator, being the technical advisor, had more significant influence on the final decision. In any case, the final decision was heavily influenced by both the government's and university's environmental policy and by extension their compliance-approach towards solar water heating.

DSW Pretoria had a building committee of six people. Again the decision was heavily influenced by the technical members of the committee who already had a higher awareness of the benefits of solar water heating and would eventually prevail on any dissenters. In this project, proposals were obtained from suppliers to back up what was regarded as "common sense". Even when the installation initially failed to function as smoothly as expected, the management was still convinced that this was only a technical problem which the suppliers could easily fix. Although all institutions surveyed had a formal decision making structure for projects, decisions were eventually determined, as observed earlier in this section, on the basis of intuition and individual preferences. *Post-rationalisation, mental accounting, optimism and over-confidence effect, induced blindness* and elements of *sunk-cost fallacy* prevailed.

According to Solahart (Appendix 4), there was very little consultation with stakeholders, especially prospective users, in government projects. This could have been partly attributed to the tendering process in government where the contractor, supplier or developer for example only became recognised as a

stakeholder or party to the project after winning a tender. Prior reference or involvement at planning stages of the project was discouraged and often considered to be unprocedural and inconsistent with transparency. The building environment technical department of government made all decisions. However, government projects still went through a long bureaucratic process mainly to comply with procurement regulations. The decision on whether to install solar water heaters or not depended on whether there was such a policy or regulation and whether there was political will to enforce the regulation. Otherwise, the same prospect theory heuristics exercised by the influential individual and technical professionals involved in the project prevailed.

UP and TUT had elaborate decision making processes for their development projects. Whereas many of the stakeholders were involved in the process, students were for example excluded. Even where 'users' were represented as happened in TUT, the term referred to the residence administration, who became the eventual owners of the completed hostel project, rather than the students. The parties involved in decision making and stakeholders of solar water heating projects in UP and TUT were predominantly from administrative structures of the institution. In a university situation, the turnover of residents reduced the impact of the student body as stakeholders in the project unlike those in DSW Pretoria. Tenure, and by extension time, became an important factor in deciding who was to be included as a stakeholder.

5.5 Attitudes and perceptions-related factors in choices and decision making for solar water heating projects

The perception of inadequate and high performance-risk for solar water heating was a recurrent theme among interviewees in the institutional surveys. Even where guarantees were provided by the manufacturer, and the solar water heating technology having greatly improved over the last few years, the impact of past faulty installations and consequent negative stories about experiences with their unreliable performance was far greater. This narrative caused individuals and

institutions to lose confidence in the system and easily influence others in this regard.

Although failed solar water heating installations in specific institutions were cited in the same way as successful ones, it is the story of the failed ones that seemed to linger on and create a greater impact in decision making. These are identified as patterns of evaluation based on impressions, which are prevalent in decision making whereby empirical valuation and objective calculations are under-weighted and thus ignored (Sections 4.4, 5.6, 6.4; Sub-section 2.5.4). The history of poor performance translates to higher risk which in this case counts against the decision to opt for solar water heating in a manner consistent with Damasio's 'somatic-marker' hypothesis (Section 1.8). A number of heuristics in prospect theory can be identified in this behaviour pattern. Evaluation based on impressions is identified as the *default option* used to justify and maintain the status-quo (Sub-section 2.5.4). There is also evidence of the *availability affect* and *induced blindness* arising from such incidents of malfunctioning solar water heaters (Section 1.3, Table 3.2).

In UB, presumably because of the magnitude of the installation, maintenance was a very important consideration in making decisions for solar water heating projects. The lifespan of the system and the attendant maintenance challenges also became important considerations. The use of electric back-up for solar water heating created a perception of unreliability as indicated by the response from TUT. In all cases, and especially in UP and TUT, the lack of technical information on the performance of solar water heating was evident. There were fears that for such large institutions, unless electrical back-up was used, there might not be adequate supply of hot water at the right time and temperature for hostel residents when only solar water heating is used. Such negative *framing effects* caused or influenced a *status-quo bias* against solar water heating.

In some institutions such as UB however, all these risks and challenges were overridden by the requirement to comply with institutional or government policy

on solar water heating. In such institutions therefore, there was a pre-determined default option regardless of the risks and challenges. In DSW, there was a similar pre-determined outcome and the prior conviction regarding the performance of solar water heating far outweighed the risks and challenges. In DSW and TUT, both in Pretoria, the feasibility studies were of no consequence as decisions were already made for and against solar water heating respectively. These three sets of conflicting choice- and decision-outcomes confirm the bounded rationality approach of satisficing rather than meticulous and comprehensive or thorough rational-agent approach in choices and decisions in solar water heating projects. This contrasts significantly with what would be expected out of the rational-agent model often assumed in formal CBA evaluations.

It is quite clear from the responses that economic values dominated over social and environmental values in assessing solar water heating projects. UB was primarily attracted to solar water heating by the expected savings in the cost of heating water compared to other methods. In DSW Pretoria, a committee decided to install solar water heating in order to save costs of heating water using electricity which was predicted to become more expensive in future. Even though UP was not implementing solar water heating purely due to expected savings, reduced costs was one of the envisaged benefits. UP however also regarded national energy management as an important benefit. One interesting observation from UB was that users of hot water in institutions do not really care what system is used to heat the water. This argument is an indication that there was still little awareness of the social and environmental benefits of solar water heating among the public. It might also imply a lack of stakeholder or participatory engagement through the decision making processes in a way which would embed such awareness.

None of the interviewees appeared to be aware of the concept of either the irreversibility or the preventative principles of sustainability. These principles relate to the attitude of instant gratification where the current generation demands and expects immediate results and accrued benefits without any conscious

consideration of the future consequences of the consumption activities and the related processes they engage in (Section 2.7.2). Similarly, the preventative principle has little or no impact on decisions in which economic values dominate. Interviewees conceptualise their responsibility within a very limited scope. In most cases, generational perceptions are limited to grandchildren and relate to an individual's lifetime. This conflict in perceiving the future is a pattern of decision making that is consistent with modern decision theory. The patterns of contradiction with key principles of sustainability indicate a conflict between the formal sustainability assessment framework premised on the rational-agent model and the reality of decision making based on prospect theory heuristics.

5.6 Conclusion

From the foregoing analysis, a pattern of conflict between the formal evaluation in CBA and sustainability assessment–oriented decision making and prospect theory heuristics is evident. Prospect theory decision making heuristics are routinely applied in decision making for the selected solar water heating projects where the expected approaches would have been formal evaluation in CBA and sustainability assessment. In some cases, the formal evaluation methods were applied with the intention of informing the subsequent decision process, only to be ultimately over-ruled through prospect theory decision making heuristics.

The key prospect theory decision making heuristics identified in this chapter as prevalent in the selected solar water heating projects are:

- *Status-quo bias*
- *Mental accounting*
- *Optimism and over-confidence effect*
- *Anchoring*
- *Framing effects*
- *Loss aversion*
- *Post-rationalisation*
- *Procrastination*

- *Availability affect*
- *Induced blindness*

In addition, various irrationalities which may not fit the descriptions of the prospect theory heuristics as discussed in Section 1.3 are prevalent. For example, the behaviour described as the *immediate-benefit logic* associated with economic influence and instant gratification in modern society is entrenched in decision making. In prospect theory, the *immediate-benefit logic* is closely related to *mental accounting*, while valuation based on impressions leads to or justifies *status-quo bias*, *default option*, *procrastination* and *inertia*.

In this chapter, the formal sustainability assessment framework emerges more prominently as a contradiction to the prospect theory decision making heuristics than evaluation in CBA. As stated in Section 5.1, responses to the solar water heating surveys are summarised in Tables 5.1-5.4.

Table 5.1: Summary of the time-related responses from interviews

	CASE STUDY 1 SUPPLIERS OF SOLAR WATER HEATING : SOLAHART, BOTSWANA	CASE STUDY 2 LONG-TIME USERS OF SOLAR WATER HEATING: UB, GABORONE, BOTSWANA	CASE STUDY 3 COMPLETED SOLAR WATER HEATING PROJECT: DSW, PRETORIA, S.AFRICA	CASE STUDY 4 SOLAR WATER HEATING PROJECT IN PROGRESS: UP, S.AFRICA	CASE STUDY 5 SOLAR WATER HEATING OPTION NOT TAKEN: TUT, PRETORIA, S.AFRICA
Time-related questions	**Time-related responses**				
1. What attracted you/your customers to the solar water heating option?	Cost saving: most of their clients are attracted to solar water heating by economic reasons and the some literature on savings. Most of the institutional projects Solahart has been involved in are owned by the government which has its own policy on use of solar water heating.	Cost saving: UB was attracted to solar water heating to reduce costs incurred in electricity consumption.	Cost saving: a building committee decided to install solar water heating in the new building because electricity was predicted to become more expensive and to save future costs.	The University of Pretoria has never addressed the issue of solar water heating until recently. A solar water heating system will be installed in the hostel that is under construction. An engineering consultant has been commissioned to evaluate the existing hostels for similar installation. A positive report will result in replacement of the existing heat pump system with solar water heating.	
2. Have you ever considered the solar water heating option for your institutional hot water supply system?					Yes, TUT has, in the past, considered the solar water heating option.
3. How do/did you arrive at the decision to/not to install solar water heating in your institution(s)	The government department that deals with building development projects makes independent decisions to install or not to install solar water heating in its institutions. The users or institution managers are	Interviewee was not quite sure how the decision to install solar water heating was arrived at. Generally there was a casual assessment of the amount of solar energy available in Botswana and the likely	There was a discussion in the building committee. The idea originated from two engineers in the building committee. For a building of this size, the long term savings on electricity are worth the	The criteria used to make a decision will be energy consumption, maintenance, reliability and temperature delivery of the hot water.	The decision not to install solar water heating has been influenced by a number of factors. The biggest barrier according to the interviewee was the merger between the 3 institutions, which took a lot of time and much

	therefore not involved in decision making regarding the installations. Solahart as a supplier is usually only brought into the project by the building or mechanical engineering contractors at the installation stage when the buildings are complete and all services are in place. There is no early input from solar water heating suppliers in public projects. In some few cases, Solahart approaches institutions and "sensitizes" them on the benefits of solar water heating.	benefits especially since the North orientation for the student hostels had already been decided and implemented (all hostels have their long facades facing north/south).	investment.		politics resulting in the indefinite postponement of a decision on a study carried on solar water heating.
4. How did you/they determine the viability or feasibility of solar water heating/alternative system?	The feasibility or viability of the public projects is determined by the government. The interviewees observe that there is very little knowledge in the building industry about solar water heating even among professionals. Professionals have very little faith and many project the perception that solar water heating does not work. This perception has a great influence on clients. Many clients are ill advised especially if they have had a bad first-time experience with the solar water heating	The interviewee was not sure whether any feasibility of solar water heating was done but would be surprised if this was not done. Other reports indicate however that there was no such study.	No formal feasibility was done. Different firms were contacted and discussions held with them regarding the viability. Expected savings gave the breakthrough even though the installation cost compared to the geyser system is R300,000 more. "There were no facts, no figures, just logic."	The consultant is expected to also do a feasibility analysis.	There is a perception within TUTs decision-making levels that future savings are not substantial to make solar water heating viable especially due to the high capital costs. Discounted savings are too far in the future. The University operates a highly competitive capital budgetary process in which solar water heating is not a high priority.

	technology. This has happened to the Gaborone City Council. (Value systems influenced by technological failure of the system in the past. Faith in solar water heating eroded by this technical failure.)				
5. What do you envisage to be the benefits of solar water heating?	The main benefits of solar water heating are financial savings of up to 80%, possibly more on water heating costs. For Solahart, the side effects of some of the alternative energy sources are cause for concern. The effects of carbon emission and its long-term implication on global environment are reasons to opt for renewable sources of energy.	The benefits of solar water heating are (i) savings on energy for the university and the country and (ii) diversification for the university and the country in terms of energy usage. The university is an example to other institutions and households. It is however noted that the benefits may not be as great for domestic installation as they would be for institutions. For domestic usage, the peak period for solar radiation takes place during the day when most of the occupants are away and therefore conflicts with evening domestic usage peaks. A solar water heating system is operational from 0600-1800hrs while electric backup is used from 1800-0600hrs.	The benefits of solar water heating were not known at the beginning. It just seems to make sense. There were also the neighbouring Flower Foundation and Pretorius Street (Rosendal Retirement Centre) examples which we visited. Both were very positive about the project.	Benefits of solar water heating include cost effectiveness. The University will want to play a part in national energy management in view of the imminent energy crisis. The driving force for the decision to install solar water heating in the new hostel and to consider changing the system used in the existing is the national need to reduce the power grid supply, and cost savings.	
6. Is payback time considered? What is the envisaged payback time frame?	The payback time given for most domestic installations is five years against a twenty-year lifespan of the system. It is rare that clients	Payback time is reasonable at 5 years.	Payback time is expected to be 15 years. The figures we are getting are rather higher than those projected by the suppliers. Pumping	Payback time will definitely be considered. A 4-year payback period for the new building is reasonable. The University expects to apply	Payback time should ideally be 2-3 years for any water heating option adopted at TUT. It is the opinion of the interviewee that solar water

	demand guaranteed payback periods. In one case, a mining company requested for a cost-benefit analysis and eventually determined that the payback time was too long given the lifespan of the mining operation. Solahart unfortunately did not take depreciation and inflation into account when calculating the payback time and the estimates turned out to be too conservative. Solahart advises that solar water heating should be incorporated into the project as a capital investment rather that an add-on installation. Professional advice can be influential.		costs for two blocks is high (the tanks are on the ground).	for a government rebate (incentive) for the installation.	heating has longer (too long) payback periods and maintenance for the systems begins soon after. A six-month payback period would have a possibility of attracting the capital layout required.

Table 5.2: Summary of the scope-related responses from interviews

	CASE STUDY 1 SUPPLIERS OF SOLAR WATER HEATING : SOLAHART, BOTSWANA	CASE STUDY 2 LONG-TIME USERS OF SOLAR WATER HEATING: UB, GABORONE, BOTSWANA	CASE STUDY 3 COMPLETED SOLAR WATER HEATING PROJECT: DSW, PRETORIA, S.AFRICA	CASE STUDY 4 SOLAR WATER HEATING PROJECT IN PROGRESS: UP, S.AFRICA	CASE STUDY 5 SOLAR WATER HEATING OPTION NOT TAKEN: TUT, PRETORIA, S.AFRICA
Scope-related questions	**Scope-related responses**				
1. Who do you see as the beneficiaries of the solar water heating installation?	For institutions the most important benefits of installing a solar water heating system are financial savings. Environmental consciousness is rarely the driving factor but a few institutional clients also have an environmental policy that advocates use of renewable energy as much as practically possible. The tourism sector is increasingly influencing institutions frequented by tourists, especially hotels, to adopt sustainability principles by among other practices installing solar water heating systems. Savings by institutions translate to national benefits in form of savings on the energy bill.	The main beneficiaries of the solar water heating installation are the students. The problem of hot water supply in the hostels, undersized storage tanks is common even with electric back-up.	The main beneficiaries of the solar water heating installation are the residents and the nation as a whole (savings on energy).	The main beneficiary of the solar water heating installation is the University of Pretoria. A reduction in electricity and water bills is expected. Other beneficiaries will be Eskom which will have a reduced supply load, due to a decrease in use of the grid, the global community will benefit from a reduced use of coal to generate electricity.	The main beneficiary of the solar water heating installation is the institution (TUT) because the students do not really care what system is used to heat their water as long as it is available at all times at the right temperature.
2. Do you know or foresee any negative impacts from solar water heating? Who are the affected	With an increasing shift to the solar water heating option caused by rapid electricity price increases,	Negative impacts: Poor maintenance from service providers/suppliers causes people to have a negative	There are no negative impacts. Energy tariffs keep going up.	Negative impacts: None are foreseen but the administration may have to institute bathing times	Negative impacts: Currently electricity is used for 99% of hot water needs while a solar water heating pilot

parties?	some unscrupulous suppliers want to cash in on the "boom" leading to sub-standard equipment. There are no negative impacts from the system itself. However, it has been criticised for being dependent on sunny days and requiring electric back-up during cloudy days or winter days with low radiation.	impression of solar water heating. Lower efficiency in terms of hot water provision (water not hot enough when required). In domestic supply, hot water is mostly required in the morning and evening when occupants are at home whereas solar radiation is maximised during the daytime resulting in conflict of usage time.		depending on the system's ability to cope with peak demands for hot water for bathing. The affected parties are mainly the residents.	project with electric back-up constitutes the remaining 1%. These realises a saving during the "maximum demand" periods. There are however advantages of using solar water heating to save on "lower maximum demand". There are no real negative impacts although the aesthetics of the building would be adversely affected by the solar water heating installation but not very significantly.

Table 5.3: Summary of the stakeholder-related responses from interviews

	CASE STUDY 1 SUPPLIERS OF SOLAR WATER HEATING : SOLAHART, BOTSWANA	CASE STUDY 2 LONG-TIME USERS OF SOLAR WATER HEATING : UB, GABORONE	CASE STUDY 3 COMPLETED SOLAR WATER HEATING PROJECT: DSW, PRETORIA	CASE STUDY 4 SOLAR WATER HEATING PROJECT IN PROGRESS: UP, S.AFRICA	CASE STUDY 5 SOLAR WATER HEATING OPTION NOT TAKEN: TUT, PRETORIA, S.AFRICA
Stakeholder-related questions	**Stakeholder-related responses**				
1. Who was involved in the decision-making process? What was the process of involving any other parties?	Solahart is not involved at the inception of the building project. Few contractors consult Solahart when they tender for solar water heating and some end up with lower-than-market prices thereby compromising the quality of the systems installed. Clients (government officials) are usually not well-informed and do not know the difference in quality. The end consumers are not involved in decision-making. This eventually makes maintenance very difficult as users do not know how to handle the problems that arise. Manuals should be included in the contracts.	All stakeholders are involved in the decision-making process. Consultation is done extensively. The SRC is represented in the Development Committee.	There was a building committee of six people. Mostly it worked through common sense but proposals were obtained from suppliers. The committee, the developer and the architects were the main decision-makers and stakeholders. The latter two think that solar water heating is a good thing.	The Director of residence is involved in the decision-making as well as the interviewee (Mr Blackhall). The Rector's decision is also required but all will be based on the technical report. A University Council meeting also considers the proposal especially the financial implication.	The Administration Support Committee is the main decision making organ for such projects. The following procedure is followed: i) A project gets registered ii) The committee decides the feasibility iii) Capital is allocated iv) Design process and/or procurement process starts. v) An energy management committee will look at the proposal and the Executive Management Committee makes the final decision. All users of the project under consideration are represented in the process and all affected parties are consulted.
2. Who do you consider to be the key stakeholders in	The end user is the key stakeholder but is never		The building committee, the developer and the 'life-right	Key stakeholders are the Director of Residence	The key stakeholders are: i) Building and Estates

this project?	consulted in government projects. The supplier is another stakeholder who is consulted very late in the project. The contractor is another stakeholder who usually has very little technical knowledge of solar water heating but quotes without any benefit of advice from suppliers and eventually procures the equipment. The contractor being the party to the originating/main contract, is ultimately responsible to the client for the installation and provides the guarantees. The government is usually the most influential stakeholder who also provides the funding for the project. The consultants advise on the specifications for the installation but are often inadequately informed on the important/crucial technical aspects.		owners' of the flats. They buy the flats on bond with 75% of the residual re-sale proceeds going to their families and 25% to the foundation on termination of occupancy.	Affairs, the Head of Building Maintenance (Mr Blackhall) and the University Council. The final decision is made by the Director of Residence Affairs and The Head of Building Maintenance.	Department, who initiate the project ii) Residences Department, who are the clients/users and also the ones who do the budget iii) The Finance Department finances the project by providing an internal loan to the client department. All residences are independent and self-supporting financially.

Table 5.4: Summary of the attitudes and perceptions-related responses from interviews

	CASE STUDY 1 SUPPLIERS OF SOLAR WATER HEATING : SOLAHART, BOTSWANA	CASE STUDY 2 LONG-TIME USERS OF SOLAR WATER HEATING: UB, GABORONE, BOTSWANA	CASE STUDY 3 COMPLETED SOLAR WATER HEATING PROJECT: DSW, PRETORIA, S.AFRICA	CASE STUDY 4 SOLAR WATER HEATING PROJECT IN PROGRESS: UP, S.AFRICA	CASE STUDY 5 SOLAR WATER HEATING OPTION NOT TAKEN: TUT, PRETORIA, S.AFRICA
Attitudes and perceptions-related questions	**Attitudes and perceptions-related responses**				
1. What do you consider to be the risks in solar water heating? What risks did you consider in accepting solar water heating?	Clients do not usually discuss the risks before the system is installed. However, the most common problems are wrongly installed systems with the attendant pressure problems, poorly designed systems and corrosion. The cheaper the system is the more likely it is to be of lower quality.	Risks: Maintenance is the biggest risk (the system may not be working properly at all times and spare parts may not be easily available when needed). Any failure in the system will cause the back-up to be used thereby defeating the original purpose of installing the solar water heating system. Vandalism is 'very high' in the university.	The risks were not very significant in the decision-making.	Risks: The interviewee is already using a solar water heating system in his house and is already familiar with its performance. He and the Director have considered the risks to mainly be regarding cloudy days not having adequate hot water supply and relying on the electric back-up. According to the interviewee however, the greatest risk is not having enough hot water in terms of volume even during the sunny days. Client satisfaction will be determined by the amount of time it takes to heat water to the right temperature during peak usage time. Another risk is the possibility of getting a poor quality product as there is no SABS guideline or standard.	Perceived risks in solar water heating: The absence of solar radiation at times (e.g. on cloudy days) can be risky for an institution. Solar water heating is dependent on the weather, the fall-back being electricity. In South Africa, this is less of a problem as there is an abundant amount of solar radiation.

2. How did you plan to handle these risks? What plans are put in place to handle these risks?	Quality is guaranteed by the manufacturer. The distributor informs the manufacturer if there are any problems. Quality control is the responsibility of the manufacturer.	Various methods have been identified to overcome the risks. The person operating the system is identified and made accountable for security of all components.	The 'life-right owners' paid for the installation together with the other costs of the building. The solar water heating was not separated from the building costs. Two committee members were not convinced but were later won over.	No problems are foreseen provided the system is properly designed. The interviewee has confidence in the system he uses at his house. The supplier should provide a guarantee and maintain the system for a certain period after installation.	The solution is to use an electric backup. All solar water heaters use an electric backup.
3. What is your evaluation of solar water heating, after using the system for some time? What is your evaluation on solar water heating as a water heating option compared to other alternatives?		Evaluation: the system works to some extent and technology has improved over the past few years. Underestimating the capacity of the storage tanks and the size of the solar water heating panels can cause inadequate supply of hot water when required by the user in the quantity needed. The user is only interested in hot water not whether it is supplied by a solar water heating or electric system.	Evaluation: solar water heating makes sense. There were a few mistakes made which the installation firm rectified. The technology is not new but largely untested locally. The committee made a leap of faith in the system.		Evaluation of solar water heating: The interviewee has used a solar water heater in his house for 30 years. There is very little maintenance but sludge needs to be removed once in a while. When a solar water heating system is installed, people need to be trained to maintain the system on a regular basis. A measurement system needs to be installed to evaluate performance. Regular cleaning even on the panels is important. The solar water heating proposal will be re-taken through the validation process and re-evaluated for prioritising.

Chapter 6

Consolidation of findings

6.1 Overview

Arising from the preliminary theoretical analysis of evaluation in cost-benefit analysis (CBA) and the principles of sustainability in Chapter 1 and 2, several assumptions were made regarding the relationship between the two systems. The key assumptions were:

- That both evaluation in CBA and the principles of sustainability share some common objectives and seek to address shared fundamental issues but use contradictory approaches to achieve the objectives,
- That evaluation in CBA and sustainability assessment as choice and decision making tools are premised on an economic-theory-based rational-agent model while in reality choice and decision making are often based on intuitive, emotive and *irrational* (boundedly-rational) behaviour as demonstrated in neuro-economics and prospect theory.
- That policies are formulated, market decisions made and projects initiated on the basis of formal decision making processes, which are based on informed evaluation such as feasibility studies. It was assumed in particular that evaluation in CBA (in both the conventional and evolved form) and sustainability assessment are consistent, systematic and formal choice and decision making tools and protocols.

In addition to these assumptions and selected background anchor for the study, various aspects of the theoretical analysis relating to evaluation in CBA and the principles of sustainability were introduced in Chapter 1. These include the sustainability paradigm, the CBA evaluation approach (both conventional and evolving) and choice and decision making approaches under risk and uncertainty (behavioural economics, prospect theory, bounded rationality and new

perspectives from neuro-science, and especially Damasio's somatic-marker hypothesis).

The preliminary theoretical analysis led to the research question: *"how does choice and decision making through CBA evaluation influence status-quo decision outcomes relative to the goals and principles of sustainability and how does this impact on the transition to sustainability?"*

The subsequent data analysis and interpretation in Chapters 4 and 5, combined with the theoretical discussions in Chapter 1 and 2, broadly lead to the following three sets of contradictions and conflicts, which form the core of the discussion in this chapter and simultaneously respond to the research question:

(i) A present versus future conflict in choice and decision making was evident. This is linked to the time-related attributes of evaluation in CBA and sustainability.

(ii) A predominance of the individual vis-à-vis the collective conflict, which broadly refers to inclusivity and collective responsibility in choice and decision making. In addition, this section presents findings which demonstrate the complexity of judgement on what is relevant and what is not in the decision making process. Choice and decision making in general was found to be heavily influenced by individual preferences with little or no regard to the collective consequences of such decisions. In the theoretical framework, this behaviour is linked to the stakeholder and scope-related factors in CBA evaluation and sustainability.

(iii) A strong pattern of choice and decision making that is heavily influenced by attitudes and perceptions.

The concept of sustainability is aligned to change, adaptation and transition and therefore has the future as reference point while evaluation in CBA is aligned to the status-quo and has the present as reference point. In the same way, sustainability is aligned to collective welfare whereas evaluation in CBA is more

often aligned to individual preferences (at both personal and organisational scales). Although prospect theory is primarily about individual rather than institutional or collective behaviour, this study shows that institutional and collective behaviour can be *irrational* (in the bounded-rational sense) and hence demonstrate characteristics of prospect theory. Often, actions within society and its environment occur due to individual discretions exercised through choice and decision making even though they exhibit non-linear dynamics and hence cannot always be effectively explained in a cause-effect model.

Tables 6.1-6.3 summarise the conflicting and contradictory approaches to evaluation discussed in Chapter 1, the literature review and theoretical framework in Chapter 2 as well as data presentation and evaluation in Chapters 4 and 5. Sections 6.2 to 6.4 provide discussions on a selection of the key contradictions and findings as well as evaluating their implications on the relationship between CBA evaluation and the principles of sustainability. The discussions eventually lead to the substantiation of how, from a prospect theory perspective, *"choice and decision making through CBA evaluation influences status-quo decision outcomes relative to the goals and principles of sustainability and how this impacts the transition to sustainability"*. Section 6.5 summarises the findings and concludes the chapter.

Table 6.1: Summary of the time-related approaches and contradictions

Time-related approaches and contradictions				
CONVENTIONAL CBA EVALUATION	**EVOLVED CBA & EMERGING TOOLS**	**SUSTAINABILITY PRINCIPLES AND ASSESSMENT METHODS**	**PROSPECT THEORY & BOUNDED RATIONALITY HEURISTICS**	**SOLAR WATER HEATING SECTOR & PROJECTS - CASE STUDY EVIDENCE**
1. Benefits accrue as soon as possible to current generation while costs accrue as far into the future as possible.	1. Ecological footprint, MCDA and SAM have developed methods such as equity weights to facilitate for inter and intragenerational equity considerations.	1. Intergenerational and intragenerational equity i.e. future generations have equal rights and opportunity to resources as present generations. Each generation bears the costs of its activities regardless when the impacts are manifested. Uncontrolled production and consumption are not sustainable.	• Patience heuristic moderates the immediacy markers. • Low appreciation can lead to procrastination. • Mental accounting prevalent. • Individual mindset to decision making. • Human limitations of time .	• Lack of appreciation of generational issues and time. • Lack of interest in non-financial benefits of solar water heating. • Demand for short and unreasonable payback periods. • Prejudice of financial evaluators .
2. Goods and services have a limited period of economic value. Economic life need not be equal to existence period. Risk in terms of economic life-costing and financial viability translates to shorter payback period.	2. Life-cycle costing in ecological footprint, environmental accounting and SAM. Extended payback periods. Link with time-declining discount rate.	2. Unlimited existence value. Economic value only a part of total value. Applies life-cycle costing. Risk is extended to life-cycle and to impacts on future generations. No time limitation.	• Patience heuristic moderates the immediacy markers. • Can lead to procrastination. • Mental accounting. • Loss aversion • Optimism & overconfidence effect	• Demand for short and unreasonable payback periods • Prejudice of financial evaluators
3. All costs and benefits have the present as the point of reference. Instant gratification – *immediate-benefit logic*. Discounting as a method for taking	3. To be resolved primarily by time-declining discount rate and other emerging tools such as hyperbolic discounting.	3. Future as reference point. Various yardsticks being developed for specific purposes. No standard method used.	• Immediate-benefit logic • Mental accounting • Loss aversion • Status-quo bias	• US surveys • Comments from South African consumers. • Decisions on payback periods for solar water heating.

account of the future costs and benefits. Constant discount rate. Net present value (NPV).				
4. Future generations can use created capital from present generation. Future generations will be more creative and can deal with any negative impacts through innovation.	4. Ecological footprint. In transition	4. Future generations are entitled to their share of natural resources and require these resources rather than created capital.	• Affect heuristic & defective forecasting. • Optimism & over-confidence effect. • Immediate-benefit logic • 'Do nothing' heuristics (status-quo bias, inertia, procrastination). • Induced blindness.	• Irreversibility & preventative principle not addressed or not understood in decision making because it is associated with the future.
5. Future trend can be predicted by projecting present patterns and then applying probability. There is no uncertainty in the future because any implications for such uncertainty can be probabilistically costed. Aggregated costs and benefits are adjusted for assumptions, uncertainties and predictions.	5. Life-satisfaction approach indicates progress in the transition (e.g. US court ruling)	5. The future is uncertain and unpredictable and should not be gambled with. Predictions on some dangerous impacts have been proved wrong. Projects that can cause irreversible damage now or in future do not pass the sustainability test. Where irreversible damage can occur, sustainability bases its decision on the preventative principle.	• Affect heuristic & defective forecasting. • Optimism & over-confidence effect. • Immediate-benefit logic • 'Do nothing' heuristics (status-quo bias, inertia, procrastination). • Induced blindness.	• Human limitations in conceptualising future time-frames. • Human perception of generations limited to immediate life-times (one or two generations).

6. Compensation among stakeholders applies the Hicks-Kador criterion which is discretionary.	6. Ecological footprint takes into account equitable distribution of a finite bio-capacity. Time-declining discount rate ensures that current generation bears the costs of their activities.	6. Each generation bears the full compensatory costs of its activities regardless when the impacts are manifested. Payment for compensation can be enforced through legislative and regulatory instruments e.g. taxes. Projects with irreversible impacts are not approved and no amount of compensation is considered adequate.	• Affect heuristic & defective forecasting. • Optimism & over-confidence effect. • Immediate-benefit logic • 'Do nothing' heuristics (status-quo bias, inertia, procrastination). • Induced blindness.	• Not clearly demonstrated in solar water heating

Table 6.2: Summary of the scope and stakeholder approaches and contradictions

Scope and stakeholder approaches and contradictions				
CONVENTIONAL CBA EVALUATION	**EVOLVED CBA & EMERGING TOOLS**	**SUSTAINABILITY PRINCIPLES AND ASSESSMENT METHODS**	**PROSPECT THEORY & BOUNDED RATIONALITY HEURISTICS**	**SOLAR WATER HEATING SECTOR & PROJECTS - CASE STUDY EVIDENCE**
1. The first step in CBA involves a hierarchical limitation of scope. There is a selection of impacts that are discarded as inconsequential (mindset of linear model of simple cause-effect relationships).	1. MCDA, SAM and European Regional Policy provide evolutionary methods.	1. Sustainability advocates inclusion of all impacts be they primary or secondary; first, second or any other level; economic, social or environmental.	• Cognitive limitations. Issues too complex so not priority for System-1. • Bounded rationality constraints. • Assumed or unconscious blindness to scale, location and time in decision making.	• Recognition of sustainability principles in UB, UP & DSW Pretoria. • Eskom's efforts to keep prices of electricity as low as possible and exclude externalities. • Institutions only took action

2. A tendency for exclusion where impacts or streams cannot be easily defined or measured in monetary terms.	2. MCDA, SAM and European Regional Policy provide evolutionary methods.	2. Sustainability advocates inclusion of all impacts be they primary or secondary; first, second or any other level; economic, social or environmental.	• Recency and experiential heuristics for prioritising choice and decision making. • Affect heuristic & defective forecasting. • Status-quo bias. • Inertia. • Procrastination. • Optimism & over-confidence effect.	towards promoting solar water heating and sustainability for compliance not because they get rationally convinced on its merits. • Institutions relegate of collective responsibility to government.
3. First step is to decide whose benefits and costs should be counted. Benefits only accrue to direct stakeholders. Tendency for benefits to accrue to individual and costs to collective.	3. SAM emphasises participatory process and wider scope for benefits and costs.	3. Sustainability is emphatic on the participatory process and spread of benefits and costs (all inclusive).		
4. Limitation of stakeholders in order to reduce costs and maximise benefits.	4. Decision conferencing in MCDA emphasises robust stakeholder participation.	4. All stakeholders are to be involved in the decision-making process.	• Status-quo bias • Loss aversion • Induced blindness • Gut-rule (intuitive/emotive decision making)	• The individual mindset in the conduct of research. • Behaviour of municipalities & developers
5. Future, absent generations cannot make choices and so cannot be stakeholders in CBA.	5. Intergenerational equity in Ecological footprint.	5. Future generations can be represented and compensated through trusts and investment funds.	• 'Do nothing' heuristics (status-quo bias, inertia, procrastination). • Cognitive limitations. Issues too complex so not priority for System-1. • Assumed or unconscious blindness to scale, location and time in decision making.	• Human limitations in conceptualising future time-frames. • Human perception of generations limited to life-times.

6. All impacts are often localised and subject to geographical limitations. Stakeholdership covers or focuses on limited geographical area.	6. Ecological footprint, MCDA and SAM adopt wide geographical scope and emphasise unlimited boundaries – extent of impacts dictate scope. CIEL considers cross-boundary impacts.	6. Sustainability does not exclude or discriminate any stakeholder on the basis of any prejudice whatsoever. Stakeholdership can be extended beyond local, regional and trans-national boundaries. Trans-boundary impacts are assessed. Global potential impacts are included in the assessment.	-	-

Table 6.3: Summary of the attitudes and perceptions approaches and contradictions

Attitudes and perceptions approaches and contradictions				
CONVENTIONAL CBA EVALUATION	**EVOLVED CBA & EMERGING TOOLS**	**SUSTAINABILITY PRINCIPLES AND ASSESSMENT METHODS**	**PROSPECT THEORY & BOUNDED RATIONALITY HEURISTICS**	**SOLAR WATER HEATING SECTOR & PROJECTS - CASE STUDY EVIDENCE**
1. CBA is a product of society's prevailing attitudes and perceptions, where for example money and other economic tools are dominant.	1. Recognition that conventional CBA was too 'econocentric' is a transformation in attitudes and perceptions.	1. Sustainability recognises intrinsic value for goods whose true value cannot be monetised.	• Technological lock-in • Induced blindness • Endowment effect • Status-quo bias • Post-rationalisation • Inertia • Procrastination • Anchoring (frost damage). • Anchoring (choice architecture).	• Technical prejudices (e.g. satellite dish/antennae & swh analogy, structural problem). • DSW management conviction about solar water heating. • Eskom rebate programme. • Past experiences with solar water heating

			• Re-evaluation based on intuitive/emotive & System-1 dynamics.	
2. Formal feasibility study part of CBA process.	2. Formal feasibility studies necessary as part of the CBA process (Bias on economic aspects of a project).	2. Feasibility studies necessary (bias towards environmental and social aspects of a project)	• Impressions-based patterns • Mental accounting • Post-rationalisation • Informal valuation supersedes the formal (System-1 dynamics)	• Feasibility studies done but not factored in decision making in TUT, UP, DSW. • Eskom request for additional power stations ignored by government even though studies showed critical capacity by 2007.
3. CBA operates on the 'rational-agent model' model of neo-classical economic attitudes to natural resources and common goods. Pareto optimality and Hicks-Kador principle applied for compensation.	3. Still operating on the 'rational-agent model' model but equity weights applied. In transition.	3. Also operates on the 'rational-agent model' model. Attitudes and perceptions are identified and resolved in sustainability evaluation through stakeholder participation.	• Defective forecasting leading to unconscious blindness regarding scale, location and time in decision making. • Status-quo bias • Procrastination • Homeostatic and allostatic drivers impose pleasure and pain emoters at sub-conscious level. • Subjective attitudes and idiosyncrasies. • Operates on the 'bounded rationality' heuristics. System-1 and System-2 choice and decision making under uncertainty.	• Eskom rebate programme • Electric geyser would still prevail over solar water heating in a CBA evaluation.

4. Unit of measurement is money. All streams of costs and benefits have monetary values.	4. SAM and EU Regional Policy have developed indicators for non-monetary and difficult-to-measure effects.	4. No single yardstick or unit of measure. Some impacts are measured in descriptive terms. Intrinsic value of some resources recognised.	• Money as an emotive element leading to the individual-centred mindset. • Monetising creates an impression of value. • Choice architecture & nudge affects cause inconsistencies and distortions. • Mental accounting • Status-quo bias • Inertia • Post-rationalisation	• Responses from all interviewees in solar water heating projects. • Responses from US survey. • Eskom's introduction of solar water heating not a result of a deliberate re-think or paradigm shift.
5. Application of WTP/WTA and related valuation methods to allocate monetary values to intangible and difficult-to-measure streams of costs and benefits.	5. MCDA, life satisfaction approach and SAM: (indicators developed for non-monetary and difficult-to-measure effects).	5. Measurement is both monetised and descriptive and therefore includes the measurable and difficult-to-measure, tangible and intangible and the intrinsic valuables. Some resources, goods and services have intrinsic value. They are priceless.	• WTP/WTA disparity dilemma explained by loss aversion heuristic & endowment effect. • Shift in reference point from status-quo bias, inertia, and reversal of the affect heuristic & defective forecasting.	• Eskom rebate programme • Steady rise in demand for solar water heating from 2008 after electricity crisis.
6. Externalities and other indirect/common goods inadequately factored into costs.	6. SAM monetises externalities. Life-satisfaction approach.	6. Externalities internalised to express true value.	• Status-quo bias • Optimism and over-confidence affect. • Inertia • Satisficing • System-1 decision making dynamics.	• Low electricity prices • Electricity crisis and aftermath. • Eskom intentions in introducing solar water heating not a result of a deliberate re-think or paradigm shift.

6.2 The present versus future contradictions in decision making

The dilemma of evaluation of present vis-à-vis future production and consumption needs and activities as well as allocation of the resultant costs and benefits constitutes the key time-related conflict and contradiction in decision making for the solar water heating sector, policy, programmes and projects. In particular, the dilemma is demonstrated in determination of payback periods in CBA evaluation and the attitude towards life-cycle costing as advanced by the principles of sustainability. Various critiques cite the processes of discounting and monetising as the defining flaws of the rational-agent and evaluation in CBA approach (see for example Section 2.9). This study has presented various perspectives and illustrations to demonstrate the conflicting and contradictory time-related approaches taken by evaluation in CBA, sustainability assessment, behavioural economics, prospect theory as well as new perspectives in neuro-science.

In the conventional CBA approach, payback periods are determined by evaluation of risk, which is mitigated through discount rates, and other future-value calculation techniques such as the net present value (NPV) and the contingent valuation method (CVM) (Section 1.4, Section 2.2, Sub-section 2.5.1). Facione et al. (1978), Faber and Hemmersbaugh (1993), Clark (1995), Brent (1996), Atkinson and Mourato (2008) and Watkins (2012) among others illustrate the concept of bringing future costs to the present within the rational-agent and revealed preference model assumptions of full knowledge and predictability of future trends and outcomes.

However, as acknowledged by Conningarth Economists (2002), Bebbington et al. (2007:228) and others, the techniques have proved problematic more so from a sustainability perspective primarily because of their failure to adequately account and compensate for the needs of future generations. In order to address these concerns, new techniques such as the ‘life satisfaction approach’, time-declining discount rates and hyperbolic discounting have been introduced in what this study

refers to as evolved CBA (Section 1.5) (Weitzman, 1999; Bebbington, 2006; Bebbington et al., 2007; Atkinson and Mourato, 2008; Frame and Cavanagh, 2009; Fujiwara and Campbell, 2011). Fundamentally however, these approaches have been faulted for embracing the same rational-agent model assumptions of rational mind, infinite time and unlimited information/knowledge (Cullis and Jones, 2009:487; Tomer, 2012:2-3; Watkins, 2012).

The rational-agent model approach is often assumed in both formal and informal evaluation processes. In particular, the informal and instinctive discounting, which is driven by instant gratification and referred to as the **"*immediate-benefit logic*"** in this study, is applied in deciding payback periods for solar water heaters (Sub-sections 2.5.3 and 2.7.2). The intention and outcome of this approach is to bring benefits to the present and to postpone or relegate costs as far away into the future as possible (Section 2.7.2) (Pearce, 1983; Schmuck and Schultz, 2002:39; Boardman et al., 2006; Rangel et al., 2008:550). The approach therefore entrenches the *status-quo* (as the reference point/state), and *default option* position which according to prospect theory and bounded rationality, is the comfort zone for choice and decision making under uncertainty. This approach was evident in the responses to the United States surveys discussed in Section 4.4 and comments from some South African consumers regarding solar water heating (Appendix 11).

Prior to the electricity supply crisis in South Africa in 2006-2008, solar water heaters could not deliver a positive CBA evaluation outcome (formal or informal) against electric geysers and therefore there was no motivation for consumers to shift from the tried and tested electric geyser installations (Sections 4.4 and 4.6). In evaluating the solar water heater option, the electric geyser remained the reference point with *endowment effect* advantages (Section 1.3 and Table 3.2) (Shogren, 2012).

The evaluation of risk associated with solar water heating was expressed through a demand for shorter and relatively unrealistic payback periods. For example, although a payback period of say five years for a solar water heater with a lifespan

of 15-20 years may have sounded reasonable, this was considered not viable (Section 5.3 and Table 5.1). This position is further demonstrated by the interviewee who had used solar water heating in his house for 30 years, who nevertheless considered 2-3 years to be the ideal payback period (Section 5.3). It is instructive that the introduction of the rebate programme, which effectively reduced the upfront cost of solar water heaters, did not change this position as noted by Worthmann (Interview, 28 November 2008) (Section 4.7).

From the consumer's decision making perspective, the risk and consequent value of the solar water heater extends beyond the purchase and installation costs, performance and maintenance (Table 5.1). The *endowment effect* and *status-quo bias* present an additional risk factor which triggers other 'do nothing' heuristics such as *inertia* and *procrastination* (Section 4.6). Furthermore, the sustainability-related benefits of solar water heating are not easily quantifiable to the individual consumer in an easily recognisable unit of measurement. From a *mental accounting*, prospect theory and *loss aversion* perspective with the electric geyser as reference point, the additional immediate cost of installing a solar water heater looms larger than the promised higher benefits of such installation (Section 1.3, Sub-section 2.5.2) (Bernstein, 1996:274; Rangel et al., 2008:550; Thaler and Sunstein, 2008:33).

Higher upfront costs required for solar water heaters translate to long payback periods which are undesirable from the *immediate-benefit logic* perspective (Section 5.3). In this thinking, life-cycle costs demanded by sustainability principles are also undesirable because they delay the satisfaction obtained from benefits while high initial costs reduce the quantity of the expected immediate benefits. In the intuitive and emotive *immediate-benefit logic*, there is a clear application of *mental accounting* driven by *loss aversion* and *status-quo bias* (Section 1.3 and Table 3.2) (Fujiwara and Campbell, 2011:18; Shogren, 2012:9). Clearly, any study that would have shown solar water heaters in a favourable CBA position prior to the electricity crisis in South Africa would still have faced this entrenched *status-quo bias* position. This would be further reinforced by an

opt-in, opt-out default option dilemma justified through *post-rationalisation* (Section 1.3 and Sub-section 1.11.4).

The Eskom rebate programme failed to identify a suitable *anchor* for solar water heaters to effectively counter the electric geyser reference point (Section 1.3) (Ariely, 2008:45; Kahneman, 2011:118; Shogren, 2012:9). In the *mental accounting* of a prospective customer, the savings of R1860-R4900 were not adequate compensation for the complex qualification and payment processing procedure (Davie, 2007) or attractive enough to reverse the somatic-marker feedback conferred by the electric geyser status-quo (Section 1.8) (Damasio, 1994:174; Bechara and Damasio, 2005:339). Additionally, the requirement for a South African Bureau of Standards (SABS) quality control system, installation by only Eskom accredited installers, the processing of the rebate by Deloitte and the eight-week claim settlement period could have worked as a cognitive bias/nudge against the rebate programme (Thaler and Sunstein, 2008:34).

The individual perception of time is very different from the collective perception (Sub-section 2.7.2). This can be attributed to the significantly high influence of the individual mindset as opposed to concerns for the collective good in decision making, and also human limitations in perception of time periods and relativity to the future (Section 5.3 and 6.3). The time perspective is closely related to individual lifetime periods but constrained by the *immediate-benefit logic* which as we have seen in Sub-section 2.7.2 is linked to risk, delayed gratification and immediacy markers (Rangel et al., 2008:50). This is clearly demonstrated by the attitude towards payback in the selected solar water heating projects (Section 5.3). Individuals demanded shorter and sometimes unrealistic payback periods regardless of collective impacts of the reference technology (electric geyser) , usually to justify or rationalise the already existing choice or decision thereby entrenching the prejudice against the alternative technology . From a prospect theory perspective, determination of payback periods is characterised by *mental accounting*, *loss aversion* and the *optimism and over-confidence effect* (Sections 1.3 and 5.3, Table 3.2).

Despite being a strong strategy towards sustainability, the irreversibility and preventative principle was relegated to the periphery in decision making for the selected solar water heating projects (Sub-sections 2.7.1 and 2.7.2; Section 5.5). It was not easily understood due to its association with the future which is usually perceived in relation to an individual's lifetime (Section 5.5). The *immediate benefit logic* and associated 'do nothing' heuristics such as *status-quo bias*, *inertia* and *procrastination* which are applied in decision making relegate values associated with the future to insignificance and abandonment in the weighting of future streams of costs and benefits (monetised ones and un-monetised externalities).

The failure to appreciate the irreversibility and preventative principle in decision making for solar water heating projects is linked to the argument that the individual or organisation making the decision will not have to bear the costs or consequences of such a decision individually (Sub-section 2.7.2) (Pearce, 1983; Boardman et al., 2006). This behavioural attitude which prevails in decision making as the *affect heuristic* is associated with the individual mindset and a lack of concern for the welfare of others. Here, the 'others' includes future generations. The development of methods for recognising and valuing irreversible impacts remains difficult due to the strong *status-quo bias*, *inertia* and *induced blindness* that characterises choice and decision making. Although the life satisfaction approach partially responds to this concern in CBA (Section 1.5), it remains one of the most contentious issues in decision making for sustainability. Equally, it is still prone to deficiencies in rational-agent model which assumes that all the information needed for choice-optimisation can be availed at no cost and within a suitable time.

The limited capacity to perceive generational timelines beyond a certain level (usually determined by generations of offspring) contradicts the rational agent model foundation of the principle of discounting as applied in evaluation in CBA. Under prospect theory and neuro-science, immediacy markers and the immediate-

benefit logic trigger the 'do nothing' heuristics where decision making pertaining to the 'distant' future is required. This also explains the attitude towards the irreversibility and preventative principle in sustainability, as well as the determination of payback periods in solar water heating projects.

It is the finding of this study therefore that the '*immediate-benefit logic*' which is under subconscious control of the somatic-markers (Section 1.8), is the key emotive trigger and influence in all time-related decisions, formal and informal, individual and institutional (Damasio, 1994:174; Bechara and Damasio, 2005:339). This is best exemplified in expressions regarding payback periods and life-cycle costing as well as the relegation of the irreversibility and preventative principle in decision making. Risk and payback periods are strongly and consistently linked to the *immediate-benefit logic* and are therefore subject to *irrational* or bounded-rational decision outcomes (Sections 1.3 and 5.3) expressed through behavioural heuristics such as *loss aversion*, *mental accounting* as well as the *optimism and over-confidence effect*.

6.3 The individual versus collective mindset contradictions in decision making

Economic theory and the rational agent model, bounded rationality, prospect theory and neuro-science are all premised on individual preferences and individual decision making behaviour. On the other hand, sustainability focuses on the impacts of individual as well as the cumulative impacts of collective production and consumption lifestyles (van Dieren, 1995:66-67; Jackson, 2009:3), symbiotic interdependence among species, habitats and natural systems and finiteness of the earth's regenerative and biophysical capacity (Jackson, 2009:35-48; Ekins, 2011:629-632). Choice and decision making for sustainability therefore encounters a complication in which a behavioural and biological system operating within the individual mindset is required to deliberate and choose for the collective good (Section 2.7.3).

Matters are complicated further when, due to various behavioural constraints, individual decision makers cannot separate individual decisions from the collective (Section 2.7.3). Often, the individual mentality and behavioural constraints cloud out the 'bigger picture' in choice and decision making (Pearce, 1983; Atkinson et al., 1997; Schmuck and Schultz, 2002). The contradiction is demonstrated in various examples of decision making in the solar water heating sector and selected projects. For example, the individual mentality was prevalent in the conduct of research and surveys for the solar water heating sector (Section 4.3). There was no stakeholder involvement and surveys were often done to facilitate gain in market-share (possibly undermine others) and thus justify strategies to achieve advantage over competitors even when a collective approach and sharing of information would have been beneficial for all. Significantly, this behaviour contradicts the aim of the emerging field of sustainability science to promote a transdisciplinary approach to scientific research and stakeholder engagement (Section 1.2) (de Lange et al., 2008:243).

The response from municipalities and developers towards proposals to introduce solar water heating in new housing projects can also be seen as a perpetuation of the individual mentality at institutional level (Sections 4.3). Again the lack of coordinated stakeholder participation was evident. Costs and benefits were perceived from an individual institution's perspective and each stakeholder acted independently. International and national interests concerning the environment and biodiversity were glaringly absent and thus considered inconsequential and relegated to the periphery of choice and decision making at municipality and developer level.

From a prospect theory and bounded rationality perspective, this study can now argue that the individual mindset in solar water heating is influenced by *status-quo bias*, *loss aversion* and *induced blindness* (Sections 1.3 and 1.8, Table 3.2) heuristics. When faced with a collective choice and decision task at individual level, the consequent risk assessment in System-1 is driven primarily by individual, opportunistic interest and self-preservation. People therefore make

judgements and decisions on collective issues based significantly on their individual emotions and applying the *affect heuristic* (Kahneman, 2011:139; Weber, 2006:103-105). Collective decision making is however subjected to moderation depending on the levels of individual decision-maker's interpretation of collective prospective gains from such decisions. Consequently, the collective response to a choice and decision task can be interpreted as a moderated version of the individual emotion-driven response. There was no evidence of a systematic difference in the process of individual versus institutional decision-making contexts, especially because the consultative processes were extremely limited and inadequately facilitated in institutional decisions.

The result of this behaviour pattern is that institutional and collective decision making assume the characteristics of individual decision making. Individual based gut-rule or intuitive and emotion-induced decision making behaviour can be inferred from the institutional leaders' dominance over the collective consultative processes (Section 1.8) (Damasio, 1994:173; Bechara and Damasio, 2005:352; Thaler and Sunstein, 2008:21).

Sustainability is more commonly identified with the collective rather than individual aspirations. In this regard, this study observes that it is among institutions, such as University of Botswana, University of Pretoria and DSW in Pretoria, where solar water heating appeared to be more readily accepted for its sustainability qualities than among individual home owners (Section 5.3). Government efforts to intervene in the solar water heating sector through policy and legislation can be seen as an attempt to shift and enforce the balance towards the principles of sustainability and thus optimising for collective benefits. Government and public institutions therefore ideally become the stewards of collective assets. Sometimes however, as noted in Sections 5.3 and 5.4 and demonstrated in most of the institutions which have adopted solar water heating, it is individuals who champion the objectives of the collective. By consistently demonstrating leadership in the shift from an entrenched practice (such as choosing solar water heating in place of electric geysers), the individuals could

transform the attitudes and perceptions of the society in which they live (Section 4.3).

The pattern is broken in Tshwane University of Technology (TUT) where in rejecting solar water heating, when acceptance was more common in other similar institutions, decision making was more closely aligned to the individual than the collective values (Sections 5.2, 5.3, 5.4 and 5.5; Appendix 10). In prospect theory, decision makers facing similar options may fail to act consistently and often choose contradictory courses of action, thus defying the rationally-logical choice (Section 5.5; Sub-sections 2.5.2 and 2.5.4) (Bernstein, 1996:282; Hastie and Dawes, 2001:22). This behaviour further demonstrates the opportunities and pathways for the influence of emotions and gut-rule in choice and decision making under uncertainty even at a collective/institutional level.

This study also demonstrates a significant recurrence of the individual mindset of self-preservation manifesting at institutional level. For example, in DSW, Eskom, TUT, UB and UP, decisions were made almost exclusively in the interest and self-preservation of the individual company or institution, primarily from economic benefits perspective (Section 5.5). Any other benefits that may have accrued to other parties in the process were secondary and unintended although the company or institution could claim credit if additional secondary benefits such as social responsibility happen to arise. It was in Eskom's interest (possibly arising from political motivations not to place socio-economic growth at risk) for example to keep electricity tariffs as low as possible and to exclude externalities from the pricing as much as possible (Section 4.3). Any remedial action from Eskom would only be seen as intended for compliance with regulatory requirements or in pursuit of an economic and specifically financial benefit such as the carbon credits.

In this respect and as far as Eskom was concerned, the government was regarded as the custodian of the collective interests. From economic principles perspective, institutional or individual interests in decision making are often seen in positive light as demonstration of shrewdness within a socio-cultural system where

economic standards are highly valued. The attitude of companies in this regard demonstrates the *affect heuristic and defective forecasting* in which, due to *status-quo bias* and *inertia*, the probabilities of negative events which do not affect the company directly are underweighted, even when evidence to the contrary is overwhelming.

The overwhelming prevalence of the individual mindset is again seen in discussions about distribution of costs and benefits (as key concern in sustainability) as envisaged in CBA (Section 5.3). Even though this concept is not well understood among decision makers in the selected solar water heating projects, the pattern where benefits accrue or are claimed by the individual and costs borne by the society is consistent with economic principles. The benefits accruing to the individual are always regarded and valued primarily in monetary terms while the costs are regarded in subjective non-measurable terms in the same way as environmental and social-cultural costs.

It is evident that any transformation towards sustainability in the institution does not immediately translate to transformation within the individual or vice versa (Section 5.3). The time scale, pace and intensity are different. We have seen that the introduction of regulations requiring installation of solar water heaters and launching of the rebate programme did not immediately translate to a higher demand for solar water heaters. Instead, decisions were made primarily on the basis of strong individual attitudes and perceptions and such other heuristics that promote the *status-quo bias*, which only time can change.

Stakeholder participatory processes (as one of the key principles of sustainability), were very weak in most of the projects and decision making adopted a top-down structure (Section 5.4). The principle is not popular because it contradicts the individualistic character demonstrated by decision making heuristics aligned to the immediate-benefit logic. Emerging assessment methods such as SAM and MCDA emphasise the participatory process which advocates inclusion of all stakeholders (Sub-section 2.7.3).

Throughout this study, it has been demonstrated that the dominance of economic (monetary-driven cost-benefit) value in choice and decision making emerges as the greatest barriers towards the transformation of CBA evaluation to align with the goals and the principles of sustainability. Due to the importance of this constraint towards sustainability, it has remained the focus of attention in evolved CBA and emerging assessment methods. For example, the life satisfaction approach was developed to account for non-monetary and difficult-to-measure effects, which include those with intrinsic value (Section 1.5). Similarly, the indicators developed in SAM and by the European Union recognise and propose alternative units, other than money, for measuring value (Sub-section 2.7.3). However, as systematically argued in this study, such alternative assessment methods continue to be premised on the rational-agent model which could not be empirically validated under prospect theory and bounded rationality frameworks, which this study finds to be more prevalent models of choice and decision making within the case studies.

6.4 Attitudes and perceptions contradictions in decision making

The key question that emerges from this study is how almost half a century (and thus close to two generations) of environmental and sustainability studies, research and interventions has failed to bring about the appropriate behavioural change that would cause a paradigm shift in choice and decision making regarding our consumption and production in a way which would lead us towards the transition to sustainable lifestyles. Section 1.2 discusses the ideals of sustainability which we are expected to aspire to, but have taken too long to recognise (van Dieren, 1995:104; Pearson, 2000; Weber, 2006:103; Jackson, 2009:35-48; Ekins, 2011:629-632; Sekerka and Stimel, 2012:195). It is clear that past approaches for promoting sustainable lifestyles have failed to recognise the immense constraining force effect of bounded rationality, emotions and prospect theory heuristics in human behaviour regarding choice and decision making (Section 1.3 and 1.8) (Damasio, 1994:173; Bechara and Damasio, 2005).

In this study, the empirical evidence of such constraining forces within the context of solar water heating versus electrical geysers has been systematically argued to be the basis of the contradictions between the growing sustainability-shift awareness versus our stubborn disinterest/commitment to make the shift (Section 1.8, Forester, 1984:23; Bechara and Damasio, 2005:337). The reality in which attitudes and perceptions significantly influence the emotion/intuitive trigger mechanisms for *'irrational'* choice and decision making have been used to substantiate the role of these constraints (Selten, 1999; Ariely, 2008; Cullis and Jones, 2009; Kahneman, 2011).

The empirical findings arising from this study seem to suggest that past theoretical approaches (especially those based on the rational-agent model) have over-rationalised and idealised the choice and decision making process, thereby making it too complex and misaligned with the human decision making mechanism as substantiated by empirical studies under behavioural economics, prospect theory, cognitive psychology and neuroscience (Section 1.3, 1.5 and 1.8) (Ariely, 2008; Thaler and Sunstein 2008; Kahneman, 2011; Shogren, 2012; Tomer, 2012:2-3 among many others). Emerging evaluation approaches such as environmental accounting, SAM, MCDA and CIEL are equally unlikely to make any impact because they are either based on the same flawed rational-agent model or are too idealistic in their assumptions of high-level, comprehensive and sophisticated cognitive mechanisms to support the rational-agent model in choice and decision-making. Others such as the ecological footprint are too complex to arouse interest in the *satisficing*, *procrastinating* and *inertia*-prone System-1 decision making process (Sub-section 2.7.5).

There is no doubt that the attitudes and perceptions towards solar water heating in South Africa changed considerably over the period 2001-2008 especially following the World Summit for Sustainable Development in 2002 (Sections 1.10 and 4.5). But this was not significant enough to cause a shift towards solar water heating. The change was not compelling enough in the consumer's

emotive/intuitive choice and decision making system to trigger any real re-assessment of the value and risk associated with solar water heaters (Sections 1.3 and 1.8). The marginal increases in electricity tariffs during this period only served to further justify and entrench the *status quo* and associated heuristics/biases.

In addition, the economic value indicated by the buying price of solar water heaters did not change significantly (Section 4.5). Nevertheless, solar water heating became more acceptable than previously, indicating a steady rise in its economic rather than intrinsic value. This was a significant shift in the reference point from *status-quo bias* and *inertia,* and also a reversal of the *affect heuristic and defective forecasting* (Section 4.6). Due to *loss aversion* and the *endowment effect* and as demonstrated by the willingness-to-pay (WTP) and willingness-to-accept (WTA) discrepancy, people do not always value intrinsically (in Damasio's somatic-marker sense) or with the same intensity what they value economically or vice versa (Sections 1.3, 1.5 and 2.2; Sub-section 2.7.2) (Sienden et al., 2006:60-61; Cullis and Jones, 2009:489; Shogren, 2012:9).

The electricity supply crisis in South Africa during the period 2006-2008 can therefore be argued to be the outcome of such contradictions between the ideal rational-agent-model-based approach and the reality of subjective bounded rationality, prospect theory heuristics and emotion/intuition in choice and decision making (Sections 1.2 and 1.3) (de Lange et al., 2008; Rangel et al., 2008; Gordon, 2011; Kahneman, 2011; Tomer, 2012). The crisis (and its subsequent effect on the economics of electricity in South Africa) may therefore have precipitated or accelerated the beginning of a paradigm shift which could lead to a transformation from extreme dependency on coal-generated-electricity consumption and towards long-term sustainable energy practices.

On the other hand, the crisis can be seen as the key towards elevated emotional trigger needed for the revision of attitudes and perceptions towards alternative water heating technologies at a time when electricity tariff increases remained low

and the economic cost of solar water heating technologies remained high. The System-1 mental accounting exercise and satisficing evaluations could then (after the onset of the crisis and subsequent tariff escalations) return a reversal under the loss aversion heuristic for solar water heating and thus induce positive informal CBA evaluation outcomes. It is however observed that the riskiness or value attached to solar water heaters in both scenarios (before and after the crisis onset) was determined primarily by economic considerations and only secondarily by sustainability principles.

The Solahart Botswana case study confirms that formal evaluation in CBA, sustainability assessment and other feasibility studies are rarely carried out to motivate decisions in the solar water heating projects. Tshwane University of Technology (TUT), University of Pretoria (UP) and Deutshes Senioren Wohnheim (DSW) case studies in Sections 4.4 and 5.3 clearly demonstrate that even when such studies are conducted, they are consistently ignored in reaching the decision or used to rationalise a decision that has already been made through the System-1 satisficing processes (Section 1.3 and 1.8).

Further, the studies are evaluated through the same satisficing process where they are subjected to the *irrational*, *mental accounting* and first impressions-based behavioural heuristics that characterise and influence decision making under risk and uncertainty in prospect theory (Sections 2.5). This behaviour confirms the views in Zajonc (1980:157) and Quartz (2009:209) to the effect that we are not easily moved to reverse our initial impressions and perceptions because we trust that they accurately represent our rational judgement but more often unaware of their sub-conscious origin from an internal emotion-driven, "gut-feel" state or condition (Section 1.8).

How did the evaluation process among consumers allocate a higher value or weighting to satellite dishes and TV antennae and a lower value to a solar water heater, although all have similar features when mounted on the rooftop or façade of a building (Section 4.4)? Was the evaluation outcome in favour of the satellite

dish and antennae a rational assessment of aesthetic value or a mere post-rationalisation exercise to justify the bias against solar water heaters? This study finds that the evaluation and decision making process was influenced by a combination of decision making heuristics such as *induced blindness, endowment effect, status-quo bias, inertia* and *procrastination* (the 'do nothing' heuristics).

Combined with inadequate information about the benefits of solar water heating, this decision process leads to technological lock-in, which relegates solar water heating and elevates satellite dishes and antennae. In this regard therefore, the function of the satellite dish, TV antenna and solar water heater as a provider of entertainment and hot water respectively, rather than the installation itself and its aesthetics, becomes the *reference point*. This behaviour is consistent with the role of decision making heuristics discussed in Section 1.3 (Gilovich et al., 2002:xv; Marx and Weber, 2009:10; Gordon, 2011:4; Kahneman, 2011:98).

When the majority of respondents in the United States survey of 1999 cited high initial costs, uncertainty on maintenance and nature of guarantee as the main disadvantages of solar water heating, they were engaging in a similar evaluation process as discussed above (Section 4.4). They were compiling their own streams of costs and benefits and attaching values according to their own assessment which was based on their attitudes and perceptions. The most likely scenario is that they had already formed an overall opinion influenced by those impressions and cited the disadvantages to justify or rationalise this opinion the same way the interviewee in Deutshes Senioren Wohnheim (DSW), Pretoria rationalised the management's belief in the efficiency of solar water heating (Section 5.3 and Appendix 7).

The subsequent US study in 2008 suggests that increased awareness caused a shift in attitudes and perceptions towards solar water heating (Section 4.4). While saving money was by far the most commonly cited advantage of installing a solar water heater in 1999, this position had changed by 2008 when energy savings became the most important consideration followed closely by environmental

concerns. This revision of the *reference point* or *anchor* demonstrates the dynamism (in a co-evolutionary and complex systems context) of decision making and the indication that the desire for a transition to more sustainable production and consumption lifestyles is achievable. Attitudes and perceptions can be revised and items or effects that were relegated in the past can be elevated and vice versa. For example, various forces could play the role of choice architecture and present the option for solar water heating in a more favourable frame, thereby causing a *mental accounting* revision of risk levels, even when a formal evaluation in CBA or sustainability assessment might produce a negative decision outcome. The revision of risk levels could make similar or subsequent post-rationalisation start to work in favour of sustainability.

The rebate programme was initiated on the basis of an economic theory approach and the 'rational comprehensive position' modelled on rational-agent assumptions described in Section 1.8 (Forester, 1984:23; Bechara and Damasio, 2005:337). In CBA evaluation for solar water heating, the rebate would be a tangible monetised stream easily factored among the benefits while electric geysers would be considered among the costs (Sections 1.4 and 1.5). This was an attempt by Eskom to formalise the informal values and therefore create the transformation that recognises solar water heating as a viable alternative from a conventional economics, rational-agent perspective. The rebate therefore targeted the key disadvantages associated with solar water heating namely initial costs and maintenance (Section 4.7), but failed to recognise the overriding influence of emotions/intuition and bounded-rational decision making heuristics/biases demonstrated in prospect theory.

As seen in the results whereby the uptake of solar water heaters was evidently slow despite the rebate incentive (Section 4.7), people do not always regard formal values as more valuable unless or until the formal valuation is taken through an informal evaluation process. In this satisficing process and in order to break down complex problems into simpler System-1-friendly tasks, people have to assign value informally before they can value formally (Forester, 1984:24;

Muramatsu and Hanoch, 2005:209; Tomer, 2012:3). As already mentioned, a number of prospect theory and bounded-rational behavioural patterns are applied in the satisficing process. Principal among them are mental accounting and 'valuation based on personal, subjective impressions rather than empirical valuation and objective calculation' (Sections 4.4, 5.5 and 5.6; Sub-section 2.5.4).

At the current rate in the evolutionary and transitional process, it could take time for the bias against solar water heating and sustainability to be replaced by positive attitudes and perceptions. Following on Thaler and Sunstein (2008) and Gazheli et al. (2012, the rebate programme could be seen as a form of choice architecture or *nudge* targeting choice and decision making among consumers. The weakness in the rebate programme can therefore be attributed to failure to recognise and apply the bounded rationality approach and appropriate framing effects (Kahneman, 2003:1458; Kahneman, 2011:363-374). The background to the rebate programme discussed in Section 4.7 further demonstrates Eskom's rational-agent model approach and subsequent contradictions with the *irrationality* of the decision making processes of their target consumers.

It must be emphasised again that Eskom's intentions had always been to maintain demand for electricity at levels that were commensurate with production to avoid interruptions and ensure security of supply. As noted in Sub-section 1.10, even though South Africa was one of the largest emitters of carbon dioxide (van Horen, 1996; Karekezi and Ranja, 1997), such externalities had never been adequately factored in the pricing of electricity. Eskom's involvement in solar water heating was therefore primarily a measure to stabilise peak demand and only secondarily to promote environmental stability. In addition, there was the supplementary benefit of carbon credits accruing from the rebate programme which could significantly benefit Eskom financially. Eskom's attitude and decision favoured the action that would, at the foremost, maximise expected economic values from an informal CBA/satisficing and bounded rationality perspective.

The observation by Worthmann (Interview, 28 November 2008) that electric geysers would prevail over solar water heating in a conventional feasibility study in spite of the rebate programme is indicative of the *status-quo bias* which is supported by rational-agent-model evaluation tools (Section 4.7). Although evolved CBA has significantly transformed the formal evaluation tool towards the principles of sustainability, its continued grounding on the economic rational-agent model continues to contradict the reality that choice and decision making is predominantly informal and grounded in satisficing as argued under bounded rationality and other intuitive/emotive prospect theory-based heuristics. This misalignment between formal choice and decision making tools such as evaluation in CBA and sustainability assessment on one side and informal bounded rationality and other intuitive/emotive prospect theory-based heuristics on the other, places significant transition barriers towards sustainable consumption and production, and threatens current and future welfare of humanity and other species.

We have seen in Sections 4.4 and 5.3 that there was a consistent absence of formal CBA evaluation or sustainability assessment to inform decision making in the solar water heating sector and selected projects. There was however overwhelming influence from informal valuation with a strong pattern of application of economic principles and a particular focus on financial benefits consistent with the monetising practice of evaluation in CBA. The prevalence of the informal *mental accounting* and *post-rationalisation* behaviour pattern which is premised on impressions and perceptions rather than empirical valuation and objective calculation, contradicts both the formal CBA evaluation and sustainability assessment processes (Section 1.8) (Zajonc, 1980; Quartz, 2009:209).

The prevalence of *loss aversion* in decision making was evident in the solar water heating sector, hence the hesitation to adopt the system. In addition, decisions were strongly influenced by attitudes and perceptions especially pertaining to negative past experiences. Recent improvements in technology and performance

of solar water heating technologies did not systematically translate into a positive image (possibly a reflection of finite information processing as argued under bounded rationality). This perception was used to undervalue the benefits of solar water heating and increase the riskiness to the detriment of transformation towards sustainability. Informal decision making tools picked up these biases in the evaluation process, which resulted in a negative evaluation outcome, which in turn perpetuated the original perceptions and the resultant technological lock-out. The overwhelming influence of perceptions in decision making only served to escalate the extent of stakeholder biases against solar water heating and hence against the transition towards sustainability (Section 4.3).

6.5 Conclusion

Several key contradictions in choice and decision making for the solar water heating sector and selected projects emerge from the analysis in this chapter. These contradictions are observed within and across the decision making approaches discussed in this study. These approaches are CBA evaluation, sustainability, bounded rationality, prospect theory and related behavioural economics and the new insights from neuro-science (with the key role of emotions and feelings as the new salient insights).

The contradictions with regard to the issues of payback periods vis-à-vis lifecycle costing for solar water heating provide a perfect example of the way risk and time value are determined in conditions of uncertainty. As demonstrated in Sections 4.4, 4.7, 5.2, 5.3 and 6.2 and Sub-section 2.7.2, the conventional approach to risk and uncertainty in decision making and cost-benefit analysis (CBA) evaluation adopts the rational-agent model, in which the present becomes the reference point and future values are brought to the present and valued accordingly.

In CBA evaluation, risk and uncertainty is primarily driven by the *immediate-benefit logic* (and thus echoes contemporary societal values), and calculated through revealed-preference oriented methods such as the net present value (NPV)

and the contingent valuation method (CVM). However, those methods have been challenged and found to be inadequate, hence emerging evaluation tools such as MCDA, SAM and environmental accounting have introduced the life satisfaction approach, time-declining discounting and hyperbolic discounting (Section 1.5). Nevertheless, these emerging evaluation tools apply variations of the same flawed rational-agent model methods. This creates a contradiction within the conventional and emerging approach to choice and decision making through CBA evaluation.

On the other hand, the sustainability approach adopts the future as the reference point and therefore advocates intrinsic value and life-cycle costing to ensure equitable distribution of resources as well as continued well-being and survival of species, habitats and natural systems (Weber, 2006:103; Sekerka and Stimel, 2012:195). However, current sustainability assessment methods including emerging ones such as the ecological footprint and CIEL (Sub-section 2.7.5, Appendix 2) have adopted the rational-agent model which has been proven to have no empirical merits. This creates further contradictions between the goals and principles of sustainability (Section 1.2) and sustainability assessment methods.

There is therefore no fundamental paradigm shift in the emerging and evolving formal evaluation and assessment approaches because they are still premised on the rational-agent model and driven by the *immediate–benefit logic* with the present as the reference-state. To compound the contradictions further, it emerges from the case studies that in reality, risk, uncertainty and other time-related decisions are subject to emotive/intuitive drivers and the System-1 satisficing process which intuitively (and often subconsciously) determine the urgency and risk levels. In the case of sustainability interventions and initiatives, such decision judgements often arouse ‘do nothing’ heuristics such as *inertia, procrastination* and *post-rationalisation* (Sections 1.3, 1.8 and 6.2). Such ultimate decision outcomes reinforce the status-quo which entrenches current production and

consumption activities and lifestyles (thus contradicting the principles of sustainability) and thus forestalling the transition towards sustainable lifestyles.

Similar contradictions are observed with regard to other time-related choice and decision making attributes such as human cognition limitations to perception of time and the inability to instinctively weight for the irreversibility and preventative principle, especially with an understanding of risk and uncertainty as the common factor in time-related attributes of choice and decision making.

In Section 6.3, this study highlighted the dilemma and contradiction resulting from the inability to distinguish between individual and collective decision making on one hand and between the individual and institution on the other. Whereas the rational-agent model, bounded rationality, prospect theory and neuro-science frameworks are premised on the individual as the primary entity for decision making, sustainability focuses on the impacts and consequences of such decisions from a collective point of view. Sustainability also emphasises the symbiotic interrelationship between humanity and biodiversity and cautions that unrestrained production and consumption lifestyles will result in disastrous consequences for humanity (van Dieren, 1995:104; Weber, 2006:103; Jackson, 2009:35-48; Ekins, 2011:629-632; Sekerka and Stimel, 2012:195). This position is however compromised by the prevalence of the individual mindset, *affect heuristic* and *gut rule* in choice and decision making, especially due to the limited cognitive capacity to consciously process complex information which would require a non-linear dynamics approach.

The individual mindset and consequent contradiction is demonstrated in examples such as the lack of stakeholder collaboration in the conduct of research and the attitude of municipalities and developers to solar water heating (Sections 5.4 and 6.3). The individual mindset which is primarily conditioned to promote individual interests and opportunities in choice and decision making frustrates the common good. The observation in Section 6.3 that individual and opportunistic interests are often overweighted at the expense of the collective good and that people make

judgements and decisions on collective issues by consulting their individual emotions and applying the *affect heuristic* is an indication of the overwhelming constraints to the transition to sustainability.

In addition, decisions and choices are often made on an ad hoc, unpredictable basis, but heavily influenced and driven by personal attitudes, perceptions and preferences. A number of examples from this study demonstrate this contradictory behaviour. In the past, research projects had recommended legislative and market interventions to upscale solar water heating. But these interventions often failed to achieve the expected results mainly because they were premised on an economic, rational-agent model approach, whereas the target consumer are directed by *irrational* biological mechanisms and behavioural economics drivers which are rarely sensed at a conscious level (Section 1.3, 1.8, 4.6 and 6.4).

Following on Ariely (2008), Thaler and Sunstein (2008), Kahneman (2011) and Shogren (2012) among others, the past interventions were not successful in reconfiguring the choice architectures. The interventions completely missed out on the role of economic gains and money in particular as triggers for emotions and feelings, and mental accounting as a key satisficing heuristic in choice and decision making (Sub-sections 2.5.3 and 2.74; Sections 4.4, 5.3 and 6.4) (Ariely, 2008:75). Instead of recommending interventions or emerging evaluation techniques that attempt to diminish the prominence of money as the medium of valuation, perhaps we should accept and recognise money as an emotive element or trigger in choice and decision making capable of triggering subconscious processes which can bias any attempts by rational-agent approaches to evaluating options in choice and decision-making.

Similarly, the passive response from consumers to threats of higher electricity prices clearly demonstrates that consumers do not act on the external stimulus until the trigger mechanisms and internal systems have evaluated the risks through mental accounting and the satisficing process, and then determined the course of action (Section 4.5). The individual evaluates the threats of increases, takes into

account past threats and their outcomes, and might conclude that the current threat is equally of no consequence.

The response from consumers after the electricity crisis in South Africa during the period 2006-2008 contradicts the pre-crisis position, yet previous studies and the literature have not explained the process that triggered such revision of the reference point or anchor from the 'do nothing' heuristics.. Similarly, it is not clear from the United States studies what triggered the revision of anchor regarding solar water heating. Both behaviours are viewed in this study as demonstrations of the *availability affect* heuristic in which the effects of dramatic and personal experience of the electricity shortages and the eventual prospects of increased electricity tariffs triggered a satisficing process in which the new risk was reassessed, countering the *status-quo bias*, *inertia* and *procrastination* and thus opening the opportunity for unlocking the *endowment effect* and *loss aversion* (which are now reversed into risk-seeking behaviour as would be expected under prospect theory when one is faced with loss-scenarios of choice).

This study demonstrates how the effects of the electricity crisis aroused responses from the *default option* and *status-quo* position because it touched on a key emotive trigger for action – money and economic gains. The reality of increased electricity tariffs eventually triggered the emotions that eventually initiated the paradigm shift that years of research, studies and reports, legislative instruments, market interventions and pilot projects had failed to achieve.

What then is the value of such interventions, formal feasibility studies and other rationalised informed decision processes? This study does not imply that interventions and feasibility studies are worthless or that an intelligent and analytical approach in decision making is not necessary. After all we desire that our decision outcomes appear to be rational even when we are not (Forester, 1984:23; Bechara and Damasio, 2005:337). The study rather demonstrates that over-rationalised and idealised or complex approaches have not been successful in popularising solar water heaters and the principles of sustainability. It also

demonstrates that bounded rationality, prospect theory heuristics and biological mechanisms such as emotions, feelings and intuition play a much more significant role in choice and decision making than previously allowed for. It must however be emphasised here, as indicated in Forester (1984:24) and Tomer (2012:3), that these *irrational* approaches are not merely flimsy subjective, elementary decision making processes but rather the outcome of well-founded, biologically-evolved decision making mechanisms strongly attuned for survival-fitness in the past, and thus predating human consciousness (Section 1.8).

The study therefore finds that feasibility studies and other interventions in their current structure do not attract much attention in emotive/intuitive trigger mechanisms or the subsequent satisficing process. Such studies are therefore much more likely to either be flagged down at System-1 level as too complicated or only appropriate (good enough) to motivate for a decision outcome in the process of post-rationalisation. Examples from TUT, UP DSW and the US studies effectively demonstrate this finding (Section 4.4, 5.3 and 6.4).

Table 6.4 below summarises the key findings discussed in this chapter, their respective cross-references and the literature sources from previous chapters. These findings provide a clear demonstration of the manner in which choice and decision making in CBA evaluation reinforces status-quo decision outcomes, thereby contradicting the goals and principles of sustainability, and thus constraining the transition to sustainability.

The key highlights from the findings can now be summarised as follows:

- Reference to CBA evaluation (principles and practice) and its rational-agent model was not systematically observed in the empirical context of the case studies covered in this study.
- Reference to sustainability assessment methods and their rational-agent model approach was not systematically observed in the empirical context of the case studies either.

- Bounded rationality and prospect theory informed heuristics were the predominant patterns of choice and decision-making in the case studies.
- The approaches observed are more closely aligned with informal CBA evaluation than sustainability assessment methods.

In view of the above core findings, both CBA evaluation and sustainability assessment methods suffer a significant degree of absence in the empirical practices of choice and decision-making as observed from the case-study data of this study. Sustainability assessment methods and CBA evaluation in its pure/formal form suffer the highest level of absence.

The overall finding can therefore be captured as follows: Bounded rationality and prospect theory heuristics conspire to privilege a highly informal and adaptable/flexible form of CBA evaluation which is more biologically-rooted and driven (as argued in neuro-science and neuro-economics) while undermining/disadvantaging the rationally derived methods and techniques crafted out of a recently literate culture and civilisation based on a transcendental-mind/cognition. The study therefore indicates that attempts towards sustainability transitions should engage with this dilemma and ensure a more reciprocal alignment to such System-1 processes rather than solely counting on rational-agent approaches. The concept of choice architecture (as substantiated in prospect theory and bounded rationality) seems to be the promising gateway for such an alignment. Further substantiation of these highlights and related recommendations are presented in the next chapter.

Table 6.4: Summary of the key contradictions and findings

RESEARCH ISSUE	SECTION COVERING THE ISSUE	RELATED CBA LITERATURE	RELATED SUSTAINABILITY LITERATURE	RELATED BOUNDED RATIONALITY LITERATURE	RELATED PROSPECT THEORY AND BEHAVIOURAL ECONOMICS LITERATURE	RELATED EMOTIONS, FEELINGS AND NEURO-SCIENCE LITERATURE	KEY CONTRADICTIONS AND FINDINGS
Time and risk in decision making (determination of payback periods, discounting, life-cycle costing, perception of time/future, irreversibility and preventative principle)	1.3, 1.4, 1.5, 1.11.4, 2.2, 2.5.1, 2.5.2, 2.5.3, 2.7.1, 2.7.2, 2.7.5, 3.2, 4.4, 4.6, 4.7, 5.2, 5.3, 5.5, 6.1, 6.2, Table 3.2, Table 5.1, Appendix 11	Facione et al. (1978); Pearce (1983); Farber & Hammersbaugh (1993); Perkins, 1994; Clark (1995); Brent (1996); Weitzman (1999); Beder, (2000); Conningarth Economists (2002); Attfield, (2003; Bebbington (2006); Boardman et al. (2006); Bebbington et al. (2007); Artkinson & Mourato (2008); Frame & Cavanagh (2009); Watkins (2012);	Pearce (1983); Armstrong & Botzler (1993); Costanza & Pattern (1995); Wackernagel, & Rees (1996); Costanza et al. (1997); Heal (1997); Attfield (1999); Beder (2000); Mawhinney (2002); Padilla (2002); Bechara & Damasio (2005); Hossay (2006)	Zajonc (1980); Forester (1984); Hedborg (1996); Selten (1999); Kahneman (2003); Muramatsu & Hanoch (2005; Ariely (2008); Cullis & Jones (2009); Polic (2009); Quartz (2009); Kahneman (2011); Tomer (2012)	Bernstein (1996); Ariely (2008); Rangel et al. (2008); Thaler & Sunstein (2008); Cullis & Jones (2009); Fujiwara & Campbell (2011); Kahneman (2011); Fischer (2012); Shogren (2012); Tomer (2012); Watkins (2012)	Zajonc (1980); Forester (1984); Damasio (1994); Kaufman (1999); Selten (1999); Bechara & Damasio (2005); Weber (2006); Ariely (2008); Rangel et al. (2008); Thaler & Sunstein (2008); Quartz (2009); Crompton (2010); Weber (2010); Fujiwara & Campbell (2011); Kahneman Tomer (2012)	(i) The attitude to **risk and uncertainty** is key to choice and decision making and the transition process. (ii) In CBA evaluation and emerging evaluation methods, **risk and uncertainty** (hence payback periods for solar water heating for example) is driven by the ***immediate-benefit logic***, which is structured to promote, entrench and maintain the status-quo rather than transition and change. iii) Any evaluation method premised on the ***immediate-benefit logic*** ends up promoting these outcomes. iv) There is no fundamental paradigm shift in emerging evaluation methods whether for CBA evaluation or sustainability assessment.

RESEARCH ISSUE	SECTION COVERING THE ISSUE	RELATED CBA LITERATURE	RELATED SUSTAINABILITY LITERATURE	RELATED BOUNDED RATIONALITY LITERATURE	RELATED PROSPECT THEORY AND BEHAVIOURAL ECONOMICS LITERATURE	RELATED EMOTIONS, FEELINGS AND NEURO-SCIENCE LITERATURE	KEY CONTRADICTIONS AND FINDINGS
The individual vis-à-vis collective in decision making (broadly related to inclusivity and collective responsibility)	1.3, 1.8, 2.5.4, 2.7.1, 2.7.3, 3.2, 4.3, 4.6, 4.7, 5.2, 5.4, 5.5, 6.1, 6.3, Table 3.2, Table 5.2, Table 5.3	Anderson & Settle (1974); Dasgupta & Pearce (1978); Pearce (1983); Clark (1995); Willis & Corkindale (1995); Brent (1996); Boardman et al. (2006); Baumol & Blinder (2011)	Pearce (1983); Armstrong & Botzler (1993); van Dieren (1995); Artkinson et al. (1997); Beder (2000); George (2000); Pearson (2000); Mawhinney (2002); Padilla (2002); Schmick & Schultz (2002); Hossay (2006); de Lange et al. (2008); Jackson (2009); Ekins (2011); Masur & Posner (2011)		Benstein (1996); Hastie & Dawes (2001); Kahneman (2003); Weber (2006); Ariely (2008); Weber (2010); Kahneman (2011); Tomer (2012)		The individual mindset/mentality and self-preservation are the underlying drivers of both individual and institutional decision making. This principle is supported by the ***immediate–benefit logic,*** prospect theory and bounded rationality, and related choice and decision making mechanisms.

RESEARCH ISSUE	SECTION COVERING THE ISSUE	RELATED CBA LITERATURE	RELATED SUSTAINABILITY LITERATURE	RELATED BOUNDED RATIONALITY LITERATURE	RELATED PROSPECT THEORY AND BEHAVIOURAL ECONOMICS LITERATURE	RELATED EMOTIONS, FEELINGS AND NEURO-SCIENCE LITERATURE	KEY CONTRADICTIONS AND FINDINGS
Attitudes and perceptions in decision making	1.3, 1.4, 1.7, 1.8, 1.9, 1.10, 2.5.4, 2.7.4, 2.7.5, 3.2, 4.2, 4.3, 4.4, 4.5, 4.6, 5.5, 6.1, 6.4, Table 3.2, Table 5.4	Perkins (1994); Beder (2000); Attfield (2003); Boardman et al. (2006); Davie (2007); Gowdy (2007); Fujiwara & Campbell (2011)	van Dieren (1995); Wackernagel & Rees (1996); Pearson (2000); EDRC (2003); Weber (2006); Jackson (2009); Pringle (2010); Williams (2010); Ekins (2011); Stanton & Bueno (2011); Sekerka & Stimel (2012)		Selten (1999); Gilovich et al. (2002); Sienden et al. (2006); Ariely (2008); Thaler & Sunstein (2008); Cullis & Jones (2009); Marx & Weber (2009); Gordon (2011); Kahneman (2011); Gazheli et al. (2012); Shogren (2012); Tomer (2012)		(i) In choice and decision making, economic gains and money in particular are prime triggers for emotions and feelings that prompt mental accounting, the satisficing process and other decision making mechanisms. (ii) The current structure of feasibility studies for solar water heating and other interventions does not trigger the emotions and feelings which can drive a paradigm shift in the attitudes and perceptions towards solar water heating and the ideals of sustainable production and consumption lifestyles. (iii) Lessons can be learned in this regard from the South Africa's electricity crisis of 2006-2008.

Chapter 7

Conclusions and recommendations

7.1 Summary and conclusions

This chapter summarises the implications of the key findings from Chapter 6 and contextualises those findings in the context of the research question and objectives of the study. These conclusions therefore demonstrate how choice and decision making in CBA evaluation reinforces status-quo decision outcomes thereby contradicting the goals and principles of sustainability and thus constraining the transition to sustainability.

This study begins from the position that evaluation tools based on the classical economics and rational-agent model are flawed and cannot therefore be justified from a prospect theory, bounded rationality and neuro-science perspective. The study however recognises that CBA evaluation and the concept of sustainability have evolved over the last two decades in a co-evolutionary process, in response to various forces. In several key areas, CBA evaluation has shown responsiveness to concerns emanating from the principles of sustainability, regarding certain valuation methods that are perceived to promote status-quo decision outcomes and bias against the principles of sustainability. Evolved CBA and other emerging assessment methods have therefore developed valuation techniques which focus on some key areas of conflict such as (i) monetisation of non-market impacts, (ii) application of constant discount rates, (iii) recognition and appropriate valuation of intrinsic goods (iv) recognition of impacts with irreversible consequences.

However, whereas CBA evaluation, sustainability assessment and other emerging tools may be recognised as invaluable approaches for objective and scientific choice and decision making, they inevitably become subjected to the irrational brain/mind information processing constraints of day-to-day decision making. In this process, the faster System-1 process takes primacy over the slower but more

computational System-2, which often comes in to rationalise choices and decisions arrived at sub-consciously in System-1. It is due to this mind/brain processes that several of our choices and decisions manifest as irrational at the worst or post-rationalisation at their best. Contrary to expectations from the rational-agent behaviour model, and as demonstrated in the findings of this study, facts do not speak for themselves. Instead, as corroborated by scientific findings in prospect theory, bounded rationality and neuro-science among other fields of scientific enquiry, such facts and scientific knowing are subjected to similar irrational brain/mind mediations.

Among the findings of this study, the following were found to influence choice and decision making more significantly:

(i) The attitude to risk and uncertainty is a key element in choice and decision making and the transition process.

(ii) In CBA evaluation and emerging evaluation methods, risk and uncertainty (hence payback periods for solar water heating for example) is driven by the immediate-benefit logic, whose major logic is to promote, entrench and maintain the status-quo rather than instigating transition, change and adaptive behaviour.

(iii) Any evaluation method premised on the immediate-benefit logic ends up reinforcing these outcomes.

(iv) There is no fundamental paradigm shift from the rational-agent model in emerging evaluation methods whether for CBA evaluation or sustainability assessment and they thus continue to ignore bounded rationality cognitive imperatives.

(v) The individual mindset/mentality and self-preservation are the underlying drivers of both individual and institutional decision making. This principle manifests in the immediate–benefit logic, prospect theory and bounded rationality heuristics as well as related choice and decision making mechanisms.

(vi) In choice and decision making, economic gains and money in particular are prime triggers for emotions and feelings that prompt mental

accounting, the satisficing process and other similar decision making mechanisms.

(vii) The prevailing approach in viability evaluations for solar water heating and other sustainable energy interventions does not evoke the fundamental emotions and feelings which can trigger a paradigm shift in the attitudes and perceptions towards solar water heating and the ideals of sustainable lifestyles (as manifested in our production and consumption choices).

(viii) In the absence of adequately attuned evaluation tools/techniques, default to status-quo can persist till a crisis jolts stakeholders out of an econiche that was previously satisficing but has gradually eroded or degraded to an unfit/unsatisficing state. The electricity scenario in South Africa prior to and during the 2006-2008 crisis demonstrates such an unsensed shift/degradation even though it was rationally/explicitly anticipated as is evident from a variety of previous studies (several of which have been appraised within this study).

It is demonstrated in this study that the assumption that rationally informed tools/methods such as CBA evaluation, sustainability assessment and other similar rational-agent model-based tools can form the basis for interventions to modify behaviour towards a paradigm shift in favour of sustainable production and consumption lifestyles is most likely unwarranted. Even though evaluation in CBA does play a significant role in entrenching the status-quo bias against transition to sustainability, the adoption of the same rational-agent model of human behaviour in the emergent sustainability transition interventions fails to recognise and deal with inadequacies of the assumed models.

This study also highlights the role of economic gains in general and money in particular as prime triggers for emotions and feelings that prompt mental accounting, satisficing and other choice and decision making heuristics. From the findings of this study, it is conceivable that beyond its economic value, especially its utility as a medium of valuation, money primarily serves as an emotive and

biological stimulus whose significance in choice and decision making has been grossly underestimated. In prospect theory for example, the probability of loss of money is overweighted. The emotion triggered by prospects of monetary gain or loss is a key factor in choice and decision making regarding sustainable production and consumption. In particular, the non-monetary benefits of solar water heaters are always underweighted while initial costs in monetary terms are overweighted.

In designing interventions for sustainability therefore, we need to develop choice architectures aligned with actual emotive trigger mechanisms. Choice architectures must discover and recognise what arouses the System-1 mechanism to action. For example, the biological and autonomic choice and decision making mechanisms which were activated before, during and after the electricity crisis in South Africa in 2006-2008 should be explored in greater detail to assist in formulating choice architectures for future interventions for sustainability transitions. It is crucial that we understand how the electricity crisis managed to effect a shift, what role money plays in such a shift and what other situations trigger similar emotions. Sustainability science (the emergent research/studies in sustainability), must incorporate interdisciplinary collaboration especially with behavioural economics, neuro-science and market researchers, as well as communication experts to design choice architectures that are relevant to the reality of choice and decision making that we aspire to for sustainability.

Returning to the poser at the beginning of this study, the sudden switch to solar water heating as a result of the electricity crisis in South Africa in 2006-2008 must be seen as a combination of various co-evolutionary and non-linear systems dynamics. It could therefore also be, as is the nature of such forces, an ad hoc market reaction to the crisis which can equally be reversed with the commissioning of Eskom's new power stations and surplus power scenarios re-emerge. In addition, the switch provides one of the best examples of the *irrationality* and complexity of human choice and decision making mechanisms at both individual and institutional level. It demonstrates how the *affect heuristic and*

defective forecasting can quickly turn into an *availability affect* in which the crisis inserts itself as the recent/new dramatic event and hence starts to serve as the new reference point. Under rational-agent model, one is unlikely to factor in the crisis-experience/distress in the evaluation matrix because that would be the exact outcome one would be rationally aiming to avoid through systematic choice and decision-making. It would therefore remain in the background as an implicit driver, possibly captured under the concept of risk.

Nevertheless, if the switch is a seed in the long-term paradigmatic shift towards sustainability, it needs to be nurtured through sensitively-managed increases in electricity tariffs as one strategy and the commitment from all role players in order to maintain the opportunistic momentum and goodwill cultivated after the crisis, and to turn around the attitudes and perceptions regarding solar water heaters. Any lapse in this regard could shift the momentum or at the very worst return the sector to the pre-crisis level. In this regard, the new building regulations in South Africa if adequately enforced could serve as one major component in choice architectures that could reverse and shift the advantages of *loss aversion, status-quo bias* and *endowment effect*, currently enjoyed by electric geysers, towards solar water heaters.

In addition and more generally, individual and collective benefits of sustainable lifestyles must be framed as prospects of individual gain in order to capture the reality of the human choice and decision making mindset. Choice architects must shift emphasis to individual gains and create individual value in sustainable production and consumption lifestyles, because this is what attracts the emotive/intuitive triggers for choice and decision making that can result in a paradigm shift in favour of sustainability. Persisting solely or predominately on the rationally constructed collective benefits is unlikely to achieve the desired transitions within reasonable time frames for avoiding crisis and catastrophes.

On whether the sudden switch represented a selfish or rational economic response, this study has demonstrated that most decisions are significantly driven by the

following considerations: (i) economic gains (ii) money as a key emotive driver (iii) the immediate-benefit logic and (iv) self-preservation. Any paradigmatic shift towards sustainability will most likely evolve or emerge as a by-product of self-preservation rather than from a rationally understood firm belief in sustainability. It is therefore clear from the case-study findings of this study that the switch represents a significantly selfish economic response. This would be the outcome of a natural decision making process which can be coherently explained within the theoretical perspectives applied to underpin this study.

This study demonstrates that it is what people do (behaviour) rather than what they say, which is the key to understanding choice and decision making under risk and uncertainty. It is shown that due to cognitive limitations, people are often inclined to say one thing but then find themselves acting to the contrary. In this regard, rational-agent model-based evaluation tools and processes such as CBA should re-appraise their techniques (such as the WTP/WTA) in order to address their discrepancies relative to contemporary understanding of choice and decision-making arising from cognitive psychology, behavioural economics and neuro-science. As an example, the brain imaging methods of neuro-science provide more accurate mapping of real-time neurological signals which are linked to specific choice and decision making heuristics, tasks and outcomes, thus making visible both the sub-conscious as well as the conscious processes and neural-pathways involved in choice and decision-making for normal functioning brains.

Risk and uncertainty which are found to be key factors of choice and decision making are primarily evaluated within the immediate-benefit logic which has a bias for and therefore promotes, entrenches and maintains status-quo (even sometimes to a highly risky and catastrophic level) rather than transition and change. Any evaluation method or tool premised on the immediate-benefit logic only ends up escalating the probability of similar outcomes rather than mitigating their likelihood. It is noted that there is no fundamental paradigm shift in emerging CBA evaluation and sustainability assessment methods and tools. The

individual mentality/mindset and self-preservation, supported by the immediate-benefit logic, prospect theory, bounded rationality and related heuristics are the underlying drivers of both individual and institutional choice and decision making processes, and not the rationally accessed knowledge or information which, in the most optimistic of scenarios, gets co-opted through post-rationalisation of an intuitively sensed choice/decision which would be most likely System-1 engineered.

The sustainability paradigm is neither unrealistic nor utopian. It is premised on a deeply-sensed biological rationale of (i) a symbiotic inter-relationship for all species including human beings and nature (ii) recognising the finiteness of life-supporting resources (iii) acknowledging impending threats to continued human well-being and survival on the planet and (iv) controlling and limiting wasteful production and consumption lifestyles. Despite increasing evidence of impending threats due to climate change for example, humanity has either been nonchalantly slow or shown dogmatic resistance to change. Alternatively, society is not adequately motivated and therefore fails to prioritise the transition process while continuing to practice unsustainable production and consumption lifestyles (the status-quo bias).

This study demonstrates that when the sustainability agenda in its current form (rational-agent model formulation) encounters the intrinsic/biologically-evolved choice and decision making mechanism, it stands little chance of attracting any attention in the System-1 process due to biologically/culturally entrenched biases. This manifests in the form of conflicting human choice and decision making practises/outcomes, which this study coherently explains in terms of prospect theory and bounded rationality, behavioural heuristics, triggered by emotive/intuitive biological mechanisms. The outcome of this process entrenches the status-quo bias which induces inertia and procrastination, and frustrates any prospects for a scaled-up transition to sustainability.

Considering the findings of this study and particularly the challenges to the transition process, one of its key new insight is the substantiation of the link between CBA and other emerging evaluation tools based on the rational-agent model on the one hand versus bounded rationality, prospect theory and neuro-economics and the ideal of a transition to sustainable lifestyles (production and consumption choices) on the other.

In conclusion, it follows from the foregoing implications of the key findings that within the context of the case-study scenario, the study has conclusively and adequately demonstrated how choice and decision making in CBA evaluation reinforces status-quo decision outcomes thereby contradicting the goals and principles of sustainability and thus constraining the transition to sustainability. However, given that this context is inadequate to warrant generalisation into other choice and decision-making scenarios, it offers concrete motivation for further studies in different scenarios so as to pave a pathway towards assessing the validity of such a generalisation.

Further, the key findings and conclusive answer to the research question support the working hypothesis that: *'From a behavioural economics perspective and particularly prospect theory and neuro-economics, CBA-oriented evaluation processes (formal or informal) place an opt-out bottleneck in favour of status-quo and consequently an opt-in bottle-neck against the goals and principles of sustainability, thus impeding the transition to more sustainable lifestyles (production and consumption choices) for individuals and collectives'*. However, the study also substantiates how a rational-agent model based approach to sustainability undermines its access to System-1 decision-making resources (thinking/cognition) thus significantly denying itself access to the emotive forces it requires to effect its desired transition within reasonable time frames.

7.2 Recommendations for further research

Following on the findings and conclusions of this study, it is evident that decades of research, studies and reports, legislative instruments, market interventions and pilot projects have failed to trigger the level of choice and decision emotions, hence a possible paradigm shift towards sustainability, that was achieved by the electricity crisis of 2006-2008. The slow transformation to sustainability especially as observed in the solar water heating sector in South Africa calls for a new approach and change of direction in this regard. This study therefore provokes further debate regarding the weaknesses of previous approaches to evaluation and towards identifying specific areas in which further research is required.

This study identifies choice architecture as the entry point in influencing the decision making process to recognise and prioritise behaviour that promotes the principles of sustainability and the transition process. Following on the view and motivation that rational-agent model-based evaluation tools such as CBA evaluation, sustainability assessment and emerging tools are inadequate for effecting the transition to balanced sustainable consumption and production lifestyles, further research to identify new models for assessing the feasibility of projects and programmes is required. Such models should simulate the reality of human decision making processes as empirically demonstrated in this study. The evaluation tools that evolve from such research should be aligned to prospect theory, behavioural economics and neuro-economics as well as the elements that define the principles of sustainability.

Further research to develop a strategy on transformation of society's attitudes and perceptions towards the environment in general and solar water heating in particular is required. Primarily, the research should target the attitudes and perceptions that diminish and undervalue solar water heating. For example, and on a more practical level, there is need to transform solar water heating into an aspirational technology. In this regard researchers should create and design more aesthetically acceptable solar water heating appliances. In addition, further

research should be directed towards a more systematic understanding of the 'structural problem' associated with solar water heaters in the context of choice architecture and thus allow for effective nudges. Solar water heaters should be easy to install and maintain just like satellite dishes and TV antennae. They should not present themselves within a choice architecture which makes them to be sensed as too expensive compared to electric geysers and other alternatives.

Another key area of concern is the effect of electricity tariffs on the solar water heating market. Further research on the trend of electricity tariffs vis-à-vis solar water heating costs and demand profiles is recommended. In particular, the impact of the rebate programme and other such interventions need to be documented and disseminated to all stakeholders. In addition, the research should cover the impacts of a likely increase in electricity supply capacity on the emerging market transformation for solar water heaters as Eskom's new power stations near completion and commissioning.

Finally, even though the findings of this study seems to allude to an inevitability of crisis (the coupling of external manifestation of the crisis to internal distress/dissonance) in one form or another (at individual and collective level) for adaptive transitions, time and resources could not allow for even a preliminary exploration of this dimension within this study based on a prospect theory and neuro-science perspective. However, the significant absence of reference to crisis within rational-agent model of choice and decision-making literature reviewed in this study could be read as a glaring omission given the significant transition-effect demonstrated from the 2006 – 2008 electricity crisis. But how can one factor this into rational-agent based choice and decision-making models where avoidance of such an undesirable outcome constitutes the overarching rationale of the whole evaluation exercise? Was there a way in which the distress (individual and collective) from South Africa's electricity crisis could have been authentically factored into the numerous CBA-oriented evaluations (formal or informal) undertaken before the onset of the crisis in 2006 – 2008? Does the pathway of risk, uncertainties, probabilities and sensitivity analysis as factored into such

evaluations actually carry the sensed component of the distress? Could Damasio's *somatic-marker hypothesis* (from neuro-science) be a possible pathway for establishing the required distress-component into CBA-evaluations for sustainability? It is therefore recommended that future research be directed towards a better understanding which would help us re-contextualise a crisis in our formulation of tools and mechanisms of sustainability transitions. This could facilitate for a tangible effect to the common slogan: *never allow a "good crisis" go to waste.* Some countries such as Germany and Denmark (Gichia, 2003) have emerged as global leaders in sustainable energy transitions primarily due to their full and sustained exploitation of the infamous *oil-crisis* of the early 1970s which shocked all global economies but became forgotten as quickly in most countries when the OPEC-led oil-embargo ceased and supplies returned to normal.

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Appendix 1

STEP-BY-STEP PROCEDURES FOR CONVENTIONAL AND EVOLVED COST-BENEFIT ANALYSIS EVALUATION

The following 8-step procedure for evaluation in conventional CBA is adapted for this study from Stewart et al. (1997) and Conningarth Economists (2002):

1) Define the purpose of the CBA and specification of project alternatives. In this study the alternatives for solar water heating will be electricity, oil and gas.
2) Identify all impacts, costs and benefits, generated by each alternative.
3) Quantify the impacts in monetary values, wherever and in as many of the impacts as possible using the recognised approximation techniques such as shadow pricing, surrogate prices and others where necessary.
4) Impacts that are difficult to measure can be recorded in qualitative terms and then weighted appropriately. These could be:
   i) Effects such as incomes distribution, population groups/cultural considerations or geographical regions,
   ii) Welfare costs and benefits, and
   iii) Creation of job opportunities.
5) Discount the project costs and benefits for each of the alternatives to present values.
6) Calculate the net present value (NPV) and benefit to cost ratio (B/C ratio).
7) Perform a sensitivity analysis. This means assessing which outcomes will for example be more likely to reflect reality and which incomes or weights and discount rates most accurately reflect society's preference or clients' objectives. Perman et al. (2003:373) describe sensitivity analysis as, "…examining the effect on a decision of variations around a central estimates/assumptions employed in the analysis".
8) Interpret and report the results of the analysis.

The 5-step procedure for evolved evaluation in CBA from European Union Regional Policy (2008:47):

- Conversion of market to accounting prices
- Monetisation of non-market impacts
- Inclusion of additional indirect effects (if relevant)
- Discounting of estimated costs and benefits
- Calculation of the performance indicators (net present value, internal rate of return or economic rate of return and benefit to cost ratio).

Appendix 2

OVERARCHING FRAMEWORK FOR SUSTAINABILITY ASSESSMENT

The following generic criteria for measuring sustainability is developed from George (2000:69), Gichia (2003) and Holcim Foundation (2004). The criteria is grouped according to the three basic foundations sustainability (environmental, economic and social) and an additional technological grouping. Some of the criteria may overlap within the groups. Each criterion is weighted according to its overall effect on the project and the importance of its contribution to the principles of sustainability. The project is assessed using a scoring system within the range of 1-5 where a score of one indicates non-compliance while a score of 5 indicates full compliance with the criteria. Non-compliance by one group can veto the entire project.

A Environmental criteria

1. Has an environmental impact assessment been published and made available to all members of the public?
2. Were any potentially critical ecosystem factors affected by the project identified and remedial measures put in place?
3. Were any risks of serious or irreversible environmental damage arising from the project assessed?
4. If the risks of serious or irreversible damage were significant, or if the project added to an already significant risk, were the impacts fully mitigated such that there were no further significant residual impacts?
5. Has the natural capital (natural resources) which the project converted into other forms of capital been identified?
6. Does the assessment quantify any natural habitat that was lost, that was important for species conservation?
7. Does the project emit any greenhouse gases? Have any steps been taken to mitigate the emissions?

B Economic criteria

8. Has the viability, cost-effectiveness or profitability of the project been established?
9. Are the components of the installation manufactured with consideration for economy of resources and low levels of embodied energy?
10. Is the technology easily available and does the project offer flexible financial terms for installation?

C Social criteria

11. Were all groups or individuals affected by the project identified and were the impacts on them assessed using a full social impact assessment where appropriate?
12. Were all stakeholders (users, client, financiers, local authorities and manufacturers) given the opportunity to comment on the project and were their views taken into account before any decisions were made?
13. If any minority groups were affected, was suitable provision made for their participation in project decisions?
14. Were all potential global social-economic impacts considered? Has an appropriate social-economic appraisal been carried out?
15. Have all local, regional, national or global impacts been assessed where appropriate, with the participation of the affected parties and have appropriate compensatory and mitigating measures been put in place?
16. Have any specific groups or individuals adversely affected by the impacts of the project expressed satisfaction with the compensation offered, or has any dispute been satisfactorily resolved?
17. Is the project consistent with national policy on the environment?
18. Is the project consistent with national plan and policy regarding energy efficiency and renewable energy?
19. Is the project shown to contribute significantly to development at the national level and within the community in which it is built?

20. Does the project contribute to increased employment and poverty alleviation at local, regional and national level?
21. Does the manufacturing and installation process observe good labour practices and ethics?
22. Does the project create positive responsiveness among the beneficiaries in particular and the stakeholders in general at local, regional, national and global level?
23. Has the project created a positive impact at local, regional, national and global level?
24. Has the project raised awareness among the beneficiaries, stakeholders and community?
25. Does the project promote intragenerational and intergenerational equity?
26. Did the project procurement and implementation process follow the principles of transparency?

D Technological criteria

27. Was a post-implementation monitoring and evaluation programme put in place?
28. Can this type of project be replicated in other regions of the same country and in other parts of the world?
29. Is the technology technically adaptive to any building type and has the installation been compatible with existing building components, thereby minimising major alterations to existing buildings?
30. Does the installation enhance the aesthetic value of the building?
31. Does the project offer services in a sustained manner by ensuring a continued efficient performance at all times?
32. Does the project include a life-time maintenance guarantee that ensures reliable services and puts responsibility for the maintenance on the supplier?

Appendix 3

INTERVIEW QUESTIONS: SUPPLIERS IN SOLAR WATER HEATING PROJECTS

A

1. What attracted your clients to the solar water heating option?
2. How do they arrive at the decision to install solar water heating?
3. How do they determine the viability or feasibility of solar water heating?
4. What are the envisaged benefits of solar water heating?
5. Is payback time considered? What is the envisaged payback time frame?

B

1. Who are the beneficiaries of the solar water heating installation?
2. Are there any negative impacts from solar water heating? Who are the affected parties?

C

1. Who is involved in the decision-making process? What was the process of involving any other parties?
2. Who do you consider to be the key stakeholders in these projects?

D

1. What risks are considered in accepting solar water heating?
2. What plans are put in place to handle these risks?
3. What is your evaluation on solar water heating as a water heating option compared to other alternatives?

Appendix 4

CASE STUDY 1:
SUPPLIERS OF SOLAR WATER HEATERS: SOLAHART BOTSWANA

Interviewees:	-Felix Chavaphi (Managing Director, Solahart Botswana). -Simon Mmonatau (Sales/Operations Director, Solahart Botswana).
Type of interview:	Face-to-face
Date of interview:	18 May 2007, 0930hrs

Felix and Simon are the owners of the Solahart franchise in Botswana. Their company supplies and installs solar water heating equipment.

A

1. According to Felix and Simon, most of their clients are attracted to solar water heating by economic reasons and the literature on savings. Most of the institutional projects Solahart has been involved in are owned by the government which has its own policy on use of solar water heating.

2. The government department that deals with building development projects makes independent decisions to install or not to install solar water heating in its institutions. The users or institution managers are therefore not involved in decision making regarding the installations. Solahart as a supplier is usually only brought into the project by the building or mechanical engineering contractors at the installation stage when the buildings are complete and all services are in place. There is no early input from solar water heating suppliers in public projects. In some few cases, Solahart approaches institutions and "sensitizes" them on the benefits of solar water heating.

3. The feasibility or viability of the public projects is determined by the government. Felix and Simon observe that there is very little knowledge in the

building industry about solar water heating even among professionals. Professionals have very little faith and many project the perception that solar water heating does not work. This perception has a great influence on clients. Many clients are inadequately advised especially if they have had a bad first-time experience with the solar water heating technology. This has happened to the Gaborone City Council

4. The main benefits of solar water heating are financial savings of up to 80%, possibly more on water heating costs. For Solahart, the side effects of some of the alternative energy sources are cause for concern. The effects of carbon emission and its long-term implication on global environment are reasons to opt for renewable sources of energy.

5. The payback time given for most domestic installations is five years against a twenty-year lifespan of the system. It is rare that clients demand guaranteed payback periods. In one case, a mining company requested for a cost-benefit analysis and eventually determined that the payback time was too long given the lifespan of the mining operation. Solahart unfortunately did not take depreciation and inflation into account when calculating the payback time and the estimates turned out to be too conservative. Solahart advises that solar water heating should be incorporated into the project as a capital investment rather than an add-on installation. Professional advice can be influential.

B

1. For institutions the most important benefits of installing a solar water heating system are financial savings. Environmental consciousness is rarely the driving factor but a few institutional clients also have an environmental policy that advocates use of renewable energy as much as practically possible. The tourism sector is increasingly influencing institutions frequented by tourists, especially hotels, to adopt sustainability principles by among other practices installing solar water heating systems. Savings by institutions translate to

national benefits in form of savings on the energy demand and loading of the grid. .

2. With an increasing shift to the solar water heating option caused by rapid electricity tariff escalation , some unscrupulous suppliers want to cash in on the “boom” leading to sub-standard equipment. There are no negative impacts from the system itself. However, it has been criticised for being dependent on sunny days and requiring electric back-up during cloudy days or winter days with low solar radiation.

C

1. Solahart is not involved at the inception of the building project. Few contractors consult Solahart when they tender for solar water heating and some end up with lower-than-market prices thereby compromising the quality of the systems installed. Clients (government officials) are usually not well informed and do not know the difference in quality. The end consumers are not involved in decision-making. This eventually makes maintenance very difficult as users do not know how to handle the problems that arise. Manuals should be included in the contracts.

2. The end user is a key stakeholder who is never consulted in government projects. The supplier is another stakeholder who is consulted very late in the project. A third is the contractor who usually has very little technical knowledge of solar water heating but quotes without any benefit of advice from suppliers and eventually procures the equipment. The contractor being the party to the originating/main contract, is ultimately responsible to the client for the installation and provides the guarantees. The government is usually the most influential stakeholder who also provides the funding for the project. The consultants advise on the specifications for the installation but are often inadequately informed on the important/crucial technical aspects.

D

1. Clients do not usually discuss the risks before the system is installed. However, the most common problems include wrongly installed systems with the attendant pressure problems, poorly designed systems and corrosion. The cheaper the system is the more likely it is to be of lower quality.

2. Quality is guaranteed by the manufacturer. The distributor informs the manufacturer if there are any problems. Quality control is the responsibility of the manufacturer.

3. Clients rarely ask for cost-benefit analysis and Solahart rarely provides such analysis. In Felix's opinion, cost-benefit analysis would give institutions a much better picture of their investment and may encourage them to go for the solar water heating option. However, CBA is based on an ideal situation and the service and maintenance may not measure up.

Appendix 5

INTERVIEW QUESTIONS: COMPLETED INSTITUTIONAL SOLAR WATER HEATING PROJECTS

(*Domestic solar water heating project question variations in brackets)*

A

1. What attracted you to the solar water heating option?
2. How did you arrive at the decision to install solar water heating in your institution? (How did you arrive at the decision to install solar water heating in your home?)
3. How did you determine the viability or feasibility of solar water heating? (How did you determine the viability or feasibility of the solar water heating alternative?)
4. What do you envisage to be the benefits of solar water heating?
5. What is your envisaged payback time frame? (Is/Was payback time considered? What is/was the envisaged payback time frame?)

B

1. Who do you see as the beneficiaries of the solar water heating installation?
2. Do you know or foresee any negative impacts from solar water heating? Who are the parties affected by these impacts?

C

1. Who was involved in the decision-making process? What was the process of involving any other parties? (Who was involved in the decision-making process?)
2. Who do you consider to be the key stakeholders in this project?

D

1. What risks did you consider in accepting solar water heating?

2. How did you plan to handle these risks? (How did you plan to handle these risks or how have you handled these risks?)
3. What is your evaluation on solar water heating, after using the system for some time? (What is your evaluation of solar water heating, after using the system for some time? What is your evaluation on solar water heating as a water heating option compared to other alternatives?).

Appendix 6

CASE STUDY 2:
LONG-TIME USERS OF SOLAR WATER HEATING: THE UNIVERSITY OF BOTSWANA STUDENT HOSTELS

Interviewee:	Mr R M Frank (Deputy Director, Campus Services, University of Botswana, Gaborone).
Type of interview:	Face-to-face
Date of interview:	21 May 2007, 0900hrs

As early as more than 20 years ago, the University of Botswana (UB) made a deliberate decision to install solar water heating (swh) in the student hostels. At the main campus in Gaborone, there are 56 hostel units of various sizes accommodating a total of 4083 students. All the hostels use solar water heating technology for the supply of hot water. This is a large scale application of solar water heating by any standards.

A

1. The University of Botswana was attracted to solar water heating to reduce costs incurred in electricity consumption.

2. Mr Frank is not quite sure how the decision to install solar water heating was arrived at. Generally there was a casual assessment of the amount of solar energy available in Botswana and the likely benefits, especially as the North orientation for the student hostels had already been decided upon and implemented (all hostels have their long facades facing north/south).

3. The interviewee was not sure whether any feasibility of solar water heating was done but would be surprised if this was not done. Other reports indicate however that there was no such study.

4. The benefits of solar water heating are (i) savings on energy for the university and the country and (ii) diversification for the university and the country in terms of energy usage. The university is an example to other institutions and households. It is however noted that the benefits may not be as great for domestic installation as they would be for institutions. For domestic usage, the peak period for solar radiation takes place during the day when most of the occupants are away and therefore conflicts with evening domestic usage peaks. A solar water heating system is operational from 0600-1800hrs while electric backup is used from 1800-0600hrs.

5. Payback time is reasonable at 5 years.

B

1. The main beneficiaries of the solar water heating installation are the students. The problem of hot water supply in the hostels, and undersized storage tanks is common even with electric back-up.

2. Negative impacts: Poor maintenance from service providers/suppliers causes people to have a negative impression of solar water heating. Lower efficiency in terms of hot water provision (water not hot enough when required). In domestic supply, hot water is mostly required in the morning and evening when occupants are at home whereas solar radiation is maximum during the daytime resulting in conflict of usage time.

C

1. All stakeholders are involved in the decision-making process. Consultation is done extensively.

2. The Student Representative Council is represented in the Development Committee.

D

1. Risks: Maintenance is the biggest risk (the system may not be working properly at all times and spare parts may not be easily available when needed). Any failure in the system will cause the back-up to be used thereby defeating the original purpose of installing the solar water heating system. Vandalism is ‘very high’ in the university.

2. Various methods have been identified to overcome the risks. The person operating the system is identified and made accountable for security of all components.

3. Evaluation: the system works to some extent and technology has improved over the past few years. Underestimating the capacity of the storage tanks and the size of the solar water heating panels can cause inadequate supply of hot water when required by the user in the quantity needed. The user is only interested in hot water not whether it is supplied by solar water heating or electric system.

Appendix 7

CASE STUDY 3:
COMPLETED SOLAR WATER HEATING PROJECT: DEUTSHES SENIOREN WOHNHEIM (DSW), PRETORIA, SOUTH AFRICA

Interviewee:	Dr. von Luttichau (Chairman, Management Committee, Deutshes Senioren Wohnheim -DSW). 71A Oates St., Groenkloof, Pretoria, South Africa
Telephone:	+ 27 12 4249131
Type of interview:	Face-to-face
Date of interview:	18 June 2007, 1030hrs

The Deutshes Senioren Wohnheim (DSW) in Pretoria, South Africa is more commonly known as the German home for the elderly. It has 73 flats accommodating a total of 89 residents. The first group of residents took occupancy in November 2005. The building was designed and built to incorporate solar water heating.

A

1. A building committee decided to install solar water heating in the new building because electricity was predicted to become more expensive and to save future costs. The idea originated from two engineers in the building committee.

2. There was a discussion in the building committee. For a building of this size, the long term savings on electricity are worth the investment.

3. No formal feasibility was done. Different firms were contacted and discussions held with them regarding the viability. Expected savings gave the breakthrough even though the installation cost compared to the geyser system is R300,000 more. “There were no facts, no figures, just logic.”

4. The benefits of solar water heating were not known at the beginning. It just seemed to make sense. There were also the neighbouring Flower Foundation and Pretorious Street (Rosendal Retirement Centre) examples which we visited. Both were very positive about the project.

5. Payback time is expected to be 15 years. The figures we are getting are rather higher than those projected by the suppliers. Pumping costs for two blocks is high (the tanks are on the ground).

B

1. The main beneficiaries of the solar water heating installation are the residents and the nation as a whole (savings on energy).

2. There are no negative impacts. Energy tariffs keep going up.

C

1. There was a building committee of six people. Mostly it worked through common sense but proposals were obtained from suppliers. The committee, the developer and the architects were the main decision-makers and stakeholders. The latter two think that solar water heating is a good thing.

2. In addition are the 'life-right owners' of the flats. They buy the flats on bond with 75% of the residual re-sale proceeds going to their families and 25% to the foundation on termination of occupancy.

D

1. The risks were not very significant in the decision-making.
2. The 'life-right owners' paid for the installation together with the other costs of the building. The solar water heating was not separated from the building costs. Two committee members were not convinced but were later won over.

3. Evaluation: solar water heating makes sense. There were a few mistakes made which the installation firm rectified. The technology is not new but largely untested locally. The committee made a leap of faith in the system.

Appendix 8

CASE STUDY 4:
SOLAR WATER HEATING PROJECT IN PROGRESS: UNIVERSITY OF PRETORIA STUDENT HOSTELS

Interviewee:	Mr Alec Blackhall (Head: Building Maintenance University of Pretoria, South Africa).
Type of interview:	Face-to-face
Date of interview:	28 June 2007, 12:14hrs

The University of Pretoria (UP) accommodates 7000 students in 25 hostels. An additional hostel is under construction while another is to be bought to increase the number to 27. According to the interviewee, there is a lot of underutilised solar energy but electricity tariffs have been reasonably low. Recently however, prices of delivery have risen.

A

1. The University of Pretoria has never addressed the issue of solar water heating until recently. A solar water heating system will be installed in the hostel that is under construction. An engineering consultant has been commissioned to evaluate the existing hostels for similar installation. A positive report will result in replacement of the existing heat pump system with solar water heating.

2. The criteria used to make a decision will be energy consumption, maintenance, reliability and temperature delivery of the hot water.

3. The consultant is expected to also do a feasibility analysis.

4. Benefits of solar water heating include cost effectiveness. The University will want to play a part in national energy management in view of the imminent

energy crisis. The national need to reduce the power grid supply, and cost savings, are the driving forces for the decision to install solar water heating in the new hostel and to consider changing the system used in the existing one.

5. Payback time will definitely be considered. A four-year payback period for the new building is reasonable. The University expects to apply for a government rebate (incentive) for the installation.

B

1. The main beneficiary of the solar water heating installation is the University of Pretoria. There is expected to be a reduction in electricity and water bills. Other beneficiaries will be Eskom which will have a reduced supply load, due to a decrease in use of the grid, and the global community which will benefit from a reduced use of coal to generate electricity.

2. Negative impacts: None are foreseen but the administration may have to institute bathing times depending on the system's ability to cope with peak demands for hot water for bathing. The affected parties are mainly the residents.

C

1. The Director of residence is involved in the decision-making as well as the interviewee (Mr Blackhall). The Rector's decision is also required but all will be based on the technical report. A University Council meeting also considers the proposal, especially the financial implication.

2. Key stakeholders are the Director of Residence Affairs, the Head of Building Maintenance (The interviewee) and the University Council. The final decision is made by the Director of Residence Affairs and The Head of Building Maintenance.

D

1. Risks: The interviewee is already using a solar water heating system in his house and is already familiar with its performance. He and the Director have considered the risks to be mainly regarding cloudy days when hot water supply is inadequate and the electric back-up has to be relied on. According to the interviewee however, the greatest risk is not having enough hot water in terms of volume even during the sunny days. Client satisfaction will be determined by the amount of time it takes to heat water to the right temperature during peak usage time. Another risk is the possibility of getting a poor quality product as there is no SABS guideline or standard.

2. No problems are foreseen provided the system is properly designed. The interviewee has confidence in the system he uses at his house. The supplier should provide a guarantee and maintain the system for a certain period after installation.

Appendix 9

INTERVIEW QUESTIONS: SOLAR WATER HEATING NOT CONSIDERED

A

1. Have you ever considered the solar water heating option for your institutional hot water supply system?
2. If no, how did you arrive at the decision not to install solar water heating in your institution?
3. How did you determine the viability or feasibility of the alternative methods of heating water?
4. What are the comparative payback time frames between the system you are using and solar water heating?

B

1. Who do you see as the beneficiaries of the solar water heating installation?
2. What do you envisage to be the advantages of the system you are using and what are the disadvantages of the solar water heating system? Do you know or foresee any negative impacts from solar water heating? Who are the affected parties?

C

1. Who was involved in the decision-making process? What was the process of involving any other parties?
2. Who do you consider to be the key stakeholders in this project?

D

1. What risks did you consider in accepting the system you are using? What do you consider to be the risks in solar water heating?
2. How did you plan to handle these risks?

3. What is your overall evaluation of your system compared with solar water heating?

Appendix 10

CASE STUDY 5:
SOLAR WATER HEATING OPTION NOT TAKEN: TSHWANE UNIVERSITY OF TECHNOLOGY, PRETORIA

Interviewee:	Mr Pieter Engelbrecht (Chief Director of Buildings and Estates, Tshwane University of Technology, Pretoria, South Africa).
Type of interview:	Face-to-face
Date of interview:	30 July 2007, 10:00hrs

Tshwane University of Technology (TUT) was established in January 2004 following the merger of three institutions; Technikon Northern Gauteng, Technikon North-West and Technikon Pretoria. It currently has a student population of approximately 60000 of which about 10500 are accommodated in 40 hostels (each hostel accommodates 250 students) making it the largest residential higher education institution in southern Africa (Tshwane University of Technology, 2007). All the residences are supplied with hot water on a daily basis for 24 hours.

A

1. Yes, TUT has, in the past, considered the solar water heating option.

2. The decision not to install solar water heating has been influenced by a number of factors. The biggest barrier according to the interviewee was the merger between the 3 institutions, which took a lot of time and much politics resulting in the indefinite postponement of a decision on a study carried on solar water heating.

3. There is a perception within TUTs decision-making levels that future savings are not substantial to make solar water heating viable especially due to the

high capital costs. Discounted savings are too far in the future. The University operates a highly competitive capital budgetary process in which solar water heating is not a high priority.

4. Payback time should ideally be 2-3 years for any water heating option adopted at TUT. It is the opinion of the interviewee that solar water heating has longer (too long) payback periods and maintenance for the systems begins soon after. A six-month payback period would have a possibility of attracting the capital layout required.

B

1. The main beneficiary of the solar water heating installation is the institution (TUT) because the students do not really care what system is used to heat their water as long as it is available at all times at the right temperature.

2. Negative impacts: Currently electricity is used for 99% of hot water needs while a solar water heating pilot project with electric back-up constitutes the remaining 1%. This realises a saving during the "maximum demand" periods. There are however advantages of using solar water heating to save on "lower maximum demand". There are no really negative impacts although the aesthetics of the building would be adversely affected by the solar water heating installation, albeit not very significantly.

C

1. The Administration Support Committee is the main decision making organ for such projects. The following procedure is followed:
    i) A project gets registered
    ii) The committee decides the feasibility
    iii) Capital is allocated
    iv) Design process and/or procurement process starts.
    v) An energy management committee will look at the proposal and the Executive Management Committee makes the final decision.

All users of the project under consideration are represented in the process and all affected parties are consulted.

2. The key stakeholders are:
    i) Building and Estates Department, who initiate the project
    ii) Residences Department, who are the clients/users and also the ones who do the budget
    iii) The Finance Department finances the project by providing an internal loan to the client department. All residences are independent and self-supporting financially.

D

1. Perceived risks in solar water heating: The absence of solar radiation at times (e.g. on cloudy days) can be risky for an institution. Solar water heating is dependent on the weather, the fall-back being electricity. In South Africa, this is less of a problem as there is an abundant amount of solar radiation.

2. The solution is to use an electric backup. All solar water heaters use an electric backup.

3. Evaluation of solar water heating: The interviewee has used a solar water heater at his house for 30 years. There is very little maintenance but sludge needs to be removed once in a while. When a solar water heating system is installed, people need to be trained to maintain the system on a regular basis. A measurement system needs to be installed to evaluate performance. Regular cleaning even on the panels is important. The solar water heating proposal will be re-taken through the validation process and re-evaluated for prioritising.

Appendix 11

COMMENTS TO INTERNET ARTICLES ON SOLAR WATER HEATING

Source:
http://www.engineeringnews.co.za/article/eskom-hopes-to-accelerate-swh-rollout-as-it-doubles-rebates-2010-01-13. Accessed 24/02/2010.
Note: The spelling of the words in italics has been corrected.

SOLAR WATER HEATING
Eskom hopes to accelerate SWH roll-out as it doubles rebates

By: Chanel Pringle
13th January 2010

Edited by: Marian Webb

READERS COMMENTS

If they really want to make it work, they will include the combination of current electrical water cylinders (where applicable) with solar panels. I have a 6 months old geyser with excellent insulation. I do not need a new one - only to combine with panels. I am sure there are many households like that.
Carel Venter on 14 Jan 10

I do not think that solar heating is the solution although it is a very good system. The bigger problem is within the *manufacturing* and agricultural sectors. Higher electricity prices means that the input costs of products/food will go up to absorb the electricity price, thus we all pay more for everyday items, pushing up inflation. The solar heating system *installation* rebate is a once *off* saver. Repairs and replacements will be done by the client with moneys saved from using a cheaper energy source. A solution will have to be found for the industry sectors. Whichever way you look at it, the fact still is that Eskom is guilty of neglect and *incompetence* for providing a basic service. Competent leaders and workers should be employed, disregarding skin colour.
Grobler on 14 Jan 10

I agree with Carl. Eskom advised you to puncture a brand new geyser or *pre-feed* it from solar heated geyser. Why not assist the homes that *have* a year old geyser with a *sacrificial* anode monitor to encourage people to care more about the non-solar geyser. This monitor will indicate when the anode has to be replaced and thereby your geyser will last longer. Many geyser installations are just not up to standard and this is the major issue. How many properly trained solar hot water installers are out there? There are geysers available on the market with a ten year

warranty -this is another option to encourage so that standards are encouraged at all times.
anwar arnold on 14 Jan 10

Consider a Hot Water Heat Pump as an alternative to a Solar Water Heater. It is generally cheaper and more efficient than an electric element assisted solar system. It works day and night and does not rely on the sun. Does not require the installation of solar panels.
SIRAC on 14 Jan 10

For those who are considering heat pumps as an alternative to solar water heating, contact the Sustainable Energy for Africa organization who have done an economic comparison between heat pumps and solar systems. Solar have a clear advantage in South Africa. *It's* still not clear why the government *has* not implemented a law requiring every new house to install a solar water heater by default. This is the solution to significantly increase uptake of solar.
Anonymous on 17 Jan 10

Source:

http://www.fin24.com/articles/default/display_article.aspx?Channel=News_Home&ArticleId=1518-25_2576072&IsColumnistStory=False (13th April 2010)

Solar heater boom to drive economy

Mar 16 2010 09:17 **Francois Williams**

Add your comment

(No bad language or hate speech, please)

Jim Van Damme
Mar 17 2010 13:40 Report this comment
I've had a homemade solar water heater on our house for 20 years. It supplies about half our hot water in a cold, cloudy climate (44 degrees North). Forget all this photovoltaic stuff until costs go down. Hot water is low tech and cheap.

Jim
Mar 17 2010 13:13 Report this comment
Amazing how we are going backwards in this country. we pay more and more to get less and less.

Mr Pv
Mar 16 2010 15:35 Report this comment
I have actually looked into this and tried it on a small scale.Biggest issue is cost! Minimal power usage for a household is 10'000Watts per day.Most use way more than this daily.Considering a 70Watt PV panel cost R2000+/- and you would need 70Watts x 6 full sun hours per day = 350Watts per panel per day.So 10000Watts/350Watts per panel per day and you need 30 of these! R60'000 for all the panels with no labour,batteries,solar regulators yet.Cost would be R250'000 or more to get off the grid!

aj
Mar 16 2010 14:45 Report this comment
If muncipalities had any clue, they would allow for NET metering so that those who can can contribute to the grid. This would bring down overall cost of household PV as one would not require expenive battery systems for storage.

Fred Basset
Mar 16 2010 13:35 Report this comment
@Huh? - There is another way - handouts from the West

Huh?
Mar 16 2010 12:35 Report this comment
Power will be provided to the masses at no cost (or it will be stolen) and someone will pay for it. Hey Mr taxpayer, on or off the grid, you WILL ultimately pay. There is no other known successful way in Africa to achieve this.

Saffer
Mar 16 2010 12:04 Report this comment
It would be helpful if people could publish the contact details of local companies who install photovoltaic systems for residential clients. The only local services/products I can find are way too technical for the average joe soap to understand or purchase. Overseas businesses (China, Dubai, USA, UK) offer user-friendly all-in-one photovoltaic packages.

Ant K
Mar 16 2010 10:23 Report this comment
I fully agree with Get Off. I approached the Durban Metro last year and was surprised to find they would actually entertain buying surplus power during peak periods if I generated an excess. However they do insist on certain standards of quality. They also explained that power was only in short supply during peak periods am and pm. Outside of these, there is actually no power supply problem.

Fred Basset
Mar 16 2010 10:19 Report this comment
@ GET OFF THE GRID I agree 100%. And if you have the space, try to harvest your own water too. Clean water is soon going to become expensive for the 'privileged' as money will have to be spent on a grand scale to rehabilitate our dilapidated water treatment infrastructure. HDI's will get free / subsidised water and you know who will end up bearing the brunt of the cost. Whitey the benevolent benefactor!

Insider Oil INdustry
Mar 16 2010 09:59 Report this comment
@ Get off the grid: I agree with u, now imagine if all the people with disposable income do this- I mean these guys use the most amount of electricty per hoousehold and thus pay the most among residential users- if u go off the grid we will no longer support, and subsidise the thieves, then where will they get their extra hidden taxes for their extragavagent lifestyles. go off the grid, dont give them more money to waste and spend as they please. viva solar power viva

GET OFF THE GRID!!!
Mar 16 2010 09:32 Report this comment
To ALL South African's with a 'decent/fair' disposable income - GET YOUR HOMES OFF THE GRID AS SOON AS HUMANLY POSSIBLE!!!! And by that, I mean Solar Geysers, Photovoltaic Panels, Wind Turbines, THE WORKS!!!! Make your home SELF SUSTAINABLE!!!! Dip into the equity you have hopefully built up over the last 3-5yrs (amounts you have been paying EXTRA into your bond) and go ALL OUT!!! Trust me, you do not want to be 'hanging around' 10yrs from now still relying on EKS'DOM for energy!!!

Appendix 12

ESKOM-CONSUMER COMMUNICATION

(Source: KwaZulu Natal Department of Public Works, Project Files, 2008)

Eskom
Distribution

Date:

16 May 2008

DEPARTMENT OF HEALTH
P.O.BOX 750
RICHARDS BAY
3900

Enquiries:
Patricia Mnguni
Ref No:PO12140326

Dear R Bonfa

APPLICATION FOR NEW SUPPLY

PROPERTY DETAILS :MBOZA CLINIC
PROJECT No. :PO12140326
TRANSFORMER No. : «n/a»

We thank you for your application for a supply for the above mentioned property.

However, our Reticulation Analyst has requested that your application be placed on hold due to network constraints on the Makhathini Network Breaker 43 line. We are currently not in a position to confirm possible dates where we can accept new connections on this network as negotiations for further capacity have not gone according to plan.

Once this situation improves, Eskom will communicate to the community and stakeholders alike. It will be at this stage when we can accept new applications.

Therefore, we request that you reinitiate your project once this communication has been done, by reapplying at the Contact Centre on the share call number 0860037566, quoting the project number mentioned above.

We apologise for this inconvenience but these measures are necessary to ensure that Eskom's present customers are not adversely affected in terms of the Electricity Supply Act.

Yours sincerely

For: LINDA MKHOMBE
CUSTOMER SERVICE AREA MANAGER EMPANGENI

Eastern Region (Empangeni Area)
Customer Service
26 Turnbull Street Empangeni 3880 Private Bag X20051 Empangeni 3880 SA
tel +27 35 902 4488 Fax +27 35 772 4261 www.eskom.co.za

Directors: RJ Khoza (Chairman) TS Gcabashe (Chief Executive) MF Baleni Dr BH Cleaver (United Kingdom) SE Funde
LG Josefsson (Sweden) WE Luckhoff PM Makwana JRD Modise V Mohanlal Ranjee AJ Morgan
SA Mpambani TN Msomi B Ngwababa* SV Zilwa *Executive Director Company Secretary: M Adam
Eskom Holdings Limited Reg No 2002/015527/06

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HEALTH
KwaZulu-Natal

INFRASTRUCTURE DEVELOPMENT

191 Peter Kerchhoff Street, Pietermaritzburg, 3201
Private Bag X9051, Pietermaritzburg, 3200
Tel.: 033 341 7000, Fax.: 033 345 4370
www.kznhealth.gov.za

Reference: PS 4/6/3/1
Enquiries: Mr. Robin Westwood
Telephone: (033) 341 7038

17 October 2008

Mr TA Mdadane : General Manager Opérations
Department of Works
PIETERMARITZBURG

Fax: 033 3555509

Dear Mr. Mdadane

NEW MBOZA CLINIC AND 5 HOUSES: WCS 026615: ZNT 77693 W:
CONTRACT COST R6,717,000-00:
PROVISION OF ELECTRICAL SUPPLY

Kindly be advised that the clinic and five houses mentioned above are currently under construction with an expected due completion in December 2008.

The provision of an electrical supply from Eskom has proved to be problematic as they have a total moratorium on new supplies on this network due to a lack of electrical capacity. Please see attached letters from Eskom in this regard.

After extensive communication and meetings with Eskom they have agreed to provide an electrical connection to the clinic provided the Department makes an effort to reduce the total electrical demand.

Investigations have been carried out and it has been agreed by both parties that if solar water heating is installed instead of electrical geysers this would enable Eskom to provide the electrical connection with a lower electrical demand.

Eskom are in the process of surveying the line in order that they can provide a cost for this new electrical connection.

A further incentive is that Eskom will provide a monetary rebate for each solar water heating system installed and this would be credited to the Clinic's electrical account when they are connected.

It is therefore requested that solar panels, 1 x 200 litres be installed at each of the five houses and 1 x 200 litres be installed at the clinic.

The estimated cost of R90,000-00 is approved for this work.

Your assistance in providing this service will be greatly appreciated.

2008/10/20

Z NDLELA
GENERAL MANAGER: INFRASTRUCTURE DEVELOPMENT AND CLINICAL SUPPORT

Cc: Ms M. De Goede: Department of Works

Appendix 13

LIST OF INTERVIEWEES

Name	Contacts	Type of interview	Date of interview
Blackhall, Alec	Head: Building Maintenance University of Pretoria South Africa.	Face-to-face	28/06/2007
Cawood, Will	willandlorraine@telkomsa.net	e-mail	29/04/2009
Chavaphi, Felix	Managing Director Solahart Botswana	Face-to-face	18/05/2007
Engelbrecht, Pieter	Chief Director of Buildings & Estates Tshwane University of Technology Pretoria, South Africa	Face-to-face	30/07/2007
Frank, R M	Deputy Director, Campus Services University of Botswana, Gaborone.	Face-to-face	21/05/2007
Hickey, Jim	Solahart SA jim@solahart.co.za	e-mail	24/02/2009
Mmonatau, Simon	Sales/Operations Director, Solahart Botswana	Face-to-face	18/05/2007
Mundy	solarbeam@netactive.co.za	e-mail	20/04/2009 29/04/2009
von Luttichau, Dr.	Deutshes Senioren Wohnheim (DSW), 71A Oates St., Groenkloof, Pretoria, South Africa Telephone: + 27 12 4249131	Face-to-face	18/06/2007
Worthmann, Cedric	Renewable Portfolio Manager Eskom Energy Services Cedric.Worthmann@eskom.co.za	Face-to-face	28/11/2008

Appendix 14

ILLUSTRATION OF STANDARDIZATION AND DISCOUNT RATE

Standardization is a statistical method used to compare values of different time frames and ranges by adopting a common baseline. The baseline for Table 4.1 is 1996. Standardization also makes the results of a variety of statistical techniques entirely independent of the ranges of values or the units of measurements (Urdan, 2010; StatSoft Electronic Statistics Textbook, 2011). Standardization is therefore simply the percentage deviation of any variable in relation to the baseline. The baseline standard equals 100 and variables exceeding the baseline have a percentage above 100 while those below the baseline have a percentage below 100. For example, the standards for 2001 are calculated as follows:

Tshwane residential: $26.43 \div 20.20 \times 100 = 130.84$
Eskom Residential: $30.90 \div 19.44 \times 100 = 158.95$
Solar water heater: $5700 \div 4500 \times 100 = 126.67$

The discount rate in principle indicates the future cost of capital or the time value of money (Vishwanath, 2007; Garger, 2010), (Sub-section 2.7.2). Since the discount rate effectively represents the riskiness of the asset, the higher the discount rate the higher the risk associated with the asset and therefore the lower the demand for that asset. The formula for calculating a discount rate is as follows:

$$r = [FV \div PV]\ 1/n - 1$$

where r is the discount rate (%), FV is the future value, PV is the present value (baseline value), and n is the number of periods (years) from the baseline year (Garger, 2010).