Universidade de Aveiro
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Departamento de Ambiente e
Ordenamento

**MARIA CRISTINA
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Dissertation submitted to the University of Aveiro to fulfill the requirements for the degree of Master of Environmental Management and Policy, held under the scientific supervision of Professor Maria Helena Gomes de Almeida Gonçalves Nadais, Assistant Professor, Department of Environment and Planning, University of Aveiro and co-supervision of Dr. Miguel Tiago Cantiga Lopes de Oliveira from the Lisbon Oceanarium.

Dissertação apresentada à Universidade de Aveiro para cumprimento dos requisitos necessários à obtenção do grau de Mestre em Gestão e Políticas Ambientais, realizada sob a orientação científica da Professora Doutora Maria Helena Gomes de Almeida Gonçalves Nadais, Professora Auxiliar do Departamento de Ambiente e Ordenamento da Universidade de Aveiro e coorientação do Dr. Miguel Tiago Cantiga Lopes de Oliveira, do Oceanário de Lisboa.

O júri

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Palavras chave ISO 14001, análise custo-benefício, economia ambiental, gestão ambiental, Oceanário de Lisboa.

Resumo A ISO 14001 estabelece as diretrizes básicas para o desenvolvimento de um sistema de gestão ambiental numa organização, sendo uma de suas condições a melhoria continua do desempenho ambiental. No entanto, embora existam menções ao assunto na literatura e no próprio referencial normativo, não existem muitos dados acerca da eficiência dos Sistemas de Gestão Ambiental no contexto económico das organizações e da viabilidade económica dessa melhoria ambiental.

Com o objetivo de contribuir para este tema e analisar a rentabilidade da melhoria ambiental, nessa dissertação foi aplicada uma análise custo-benefício retrospectiva ao sistema de gestão ambiental do Oceanário de Lisboa (uma organização certificada com a ISO 14001 desde 2003), mais especificamente das medidas aplicadas para reduzir os consumos de água e energia. Essa analise contabiliza os custos dos investimentos e os benefícios derivados da poupança de água e energia durante o período 2003-2012, e analisa a relação entre esses investimentos, os consumos correspondentes e o seu aumento ou a sua redução. Para esse fim, foi efetuada uma pesquisa bibliográfica que abrangeu artigos científicos, livros e relatórios institucionais para a parte teórica da tese, e quatro análises dos dados fornecidos pelo Oceanário de Lisboa. Cada uma das análises representa uma opção: investimento em medidas de redução de água e energia (opção real), nenhum investimento, investimentos para a redução só dos consumos de água e investimentos para a redução só dos consumos energia.

O trabalho permitiu conhecer que as opção mais rentáveis e económica é a opção real, na que medidas de redução dos consumos de água e energia são aplicadas.

Key words ISO 14001, cost-benefit analysis, environmental economy, environmental management, Oceanário de Lisboa.

Abstract ISO 14001 establishes the basic guidelines for the development of an environmental management system in an organization, being one of its conditions the continuous improvement of the environmental performance of the organization. However, although there are some references to the subject in the literature and in the standard itself, there are only few data about the effectiveness of the standard in the economic framework of companies, which ends up reflected in a lack of information on the revenues from the system implementation.

In order to clarify this issue, this work has executed a retrospective cost-benefit analysis on the investments to reduce water and energy consumption in the Oceanário de Lisboa, a company certified with ISO 14001 since 2003. Using investment costs and benefits from saving operating costs, this analysis studies four different options: the actual one, in which water and energy consumption reduction measures were applied, a second option in which no investments were made, a third option in which only water consumption reduction measures were taken, and a fourth option in which only energy consumption reduction measures were applied. To this end, an academic research was also performed using academic papers, books and institutional reports to cover the theoretic part of the thesis, and the analysis was performed using the data provided by the Oceanário de Lisboa for the period 2003-2012.

The work allowed to confirm that the most cost-effective option was the actual one in which energy and water consumption reduction measures were applied.

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LIST OF ACRONYMS AND ABBREVIATIONS

ACRONYM	MEANING
AENOR	Agencia Española de Normalización
ATU	Air Treatment Units
CBA	Cost-Benefit Analysis
CEA	Cost-Effectiveness Analysis
CRA	Cost-Risk Analysis
DDT	Dichlorodiphenyltrichloroethane
EIA	Environmental Impact Assessment
EMAS	Eco-Management and Audit Scheme
EMS	Environmental Management System
EPA	Environmental Protection Agency
FP	Floor Pump
GATT	General Agreement on Tariffs and Trade
HHA	Health-Health Analysis
HPM	Hedonic Pricing Method
HVAC	Heating, Ventilation, and Air Conditioning
IRR	Internal Rate of Return
ISO	International Organization for Standardization
LCA	Life Cycle Analysis
MCA	Multi-criteria Cost Analysis
MIT	Massachusetts Institute of Technology
NEPA	National Environment Policy Act
NPV	Net Present Value
OCT	Ozone Contact Tower
PDCA	Plan–Do–Check–Act
PV	Present Value
QOV	*Quasi* Option Value
RBA	Risk-Benefit Analysis
RRA	Risk-Risk Analysis

SAGE	Strategic Advisory Group on Environment
SS	Strong Sustainability
SSP	Stainless Steel Pump
TAG	Technical Advisory Group
TC	Technical Committee
TCM	Travel Cost Method
TEV	Total Economic Value
UNCED	United Nations Conference on Environment and Development
VOSL	Value of Statistical Life
WG	Work Group
WS	Weak Sustainability
WTA	Willingness to Accept
WTP	Willingness to Pay
WWII	World War II

GLOSSARY

Benefit-Cost Ratio	A ratio representing the benefits of a project or investment compared to its cost. The BCR may be a strictly financial ratio, comparing the expected return to the cost of investment, or it may account for approximations of qualitative measurements.
Cash Flow	In investments, cash flow represents earnings before depreciation, amortization, and non-cash charges. Sometimes called cash earnings. Cash flow from operations (called funds from operations by real estate and other investment trusts) is important because it indicates the ability to pay dividends.
Internal Rate of Return	Discount rate at which net present value (NPV) of an investment is zero. The rate at which a bond's future cash flows, discounted back to today, equal its price.
Macroeconomics	Analysis of a country's economy as a whole.
Marginal Cost	In economics and finance, marginal cost is the change in total cost that arises when the quantity produced changes by one unit. That is, it is the cost of producing one more unit of a good.
Microeconomics	Microeconomics is a branch of economics that studies the behavior of how the individual modern household and firms make decisions to allocate limited resources Typically, it applies to markets where goods or services are being bought and sold. Microeconomics examines how these decisions and behaviors affect the supply and demand for goods and services, which determines prices, and how prices, in turn, determine the quantity supplied and quantity demanded of goods and services.
Monopoly	A situation in which the seller side of the market is dominated by a single producer.
Net Present Value	In finance, the net present value (NPV) of a time series of cash flows, both incoming and outgoing, is defined as the sum of the present values (PVs) of the individual cash flows. In the case when all future cash flows are incoming and the only outflow of cash is the purchase price, the NPV is simply the PV of future cash flows minus the purchase price (which is its own PV).
Normative Economics	The branch of economics that is concerned with evaluating the desirability of alternative resource allocations. It is concerned with "what ought to be."
Opportunity Cost	The net benefit forgone because the resource providing the service can no longer be used in its next-most-beneficial use.

Ordinal Utility	Ordinal utility theory states that while the utility of a particular good or service cannot be measured using a numerical scale bearing economic meaning in and of itself, pairs of alternative bundles (combinations) of goods can be ordered such that one is considered by an individual to be worse than, equal to, or better than the other.
Positive Economics	Positive economics is the branch of economics that concerns the description and explanation of economic phenomena. It focuses on facts and cause-and-effect behavioral relationships and includes the development and testing of economics theories.
Present Value	The current discounted value of a stream of benefits and/or costs over time.
Property Rights	A bundle of entitlements defining the owner's rights, privileges, and limitations for use of the resource.
Shadow Prices	The calculated price of a good or service for which no market price exists.
Welfare Economics	The aspects of economic theory concerned with the welfare of society and priorities to be observed in the allocation of resources.

CHAPTER I

INTRODUCTION

1.1. Contextualization of the subject of dissertation

The environment is an issue that is increasingly important nowadays and worldwide for several reasons. Tougher laws concerning environmental impacts and the raise of societies awareness to environmental issues challenge companies to show their environmental concerns, true or just for image purposes, to the outside world and, therefore, to their potential and current customers.

To help dealing with the environmental performance within a company and to create a globally recognized standard, the ISO 14001 – Environmental Management Systems (EMS) is, according to the International Organization for Standardization (2004), "a framework that helps a company to achieve its environmental goals through consistent control of its operations. The assumption is that this increased control will improve the environmental performance of the company…"

The ISO 14001 establishes the basic guidelines for the development of an environmental management system in an organization, being one of its conditions the continuous improvement of the environmental performance of the company. However, although there are some references to the subject in the literature and in the standard itself, there are not many data about the effectiveness of the standard in the economic context of a company, which ends up reflected in the lack of information on the revenues from the system's implementation and its cost-effectiveness.

In order to clarify this issue, this work develops a retrospective cost-benefit analysis of the environmental management system of the Oceanário de Lisboa for the period 2003-2012. A cost-benefit analysis is a basic tool that is used to take effective decisions from the calculation of the costs and benefits that result when developing a policy, a project or a system.

In the case of this study, although the Oceanário de Lisboa applies its environmental management system to several areas (waste, management, human resources, consumable items, energy and water), due to data accessibility only the improvements in energy and water consumption were taken into account for the analysis.

This thesis has been performed through an academic research of scientific papers, books and institutional reports; and performing an analysis of the recorded energy and water consumption and expenditure data that were provided by the Oceanário de Lisboa.

1.2 Objectives and structure

This study intends to quantify the economic benefits and costs of the implementation of an Environmental Management System according to ISO 14001:2004 Standard, and the efficiency of the investments made on continuous improvement approach.

This dissertation has been divided in six main chapters: Introduction; ISO 14001:2004 and Continuous Improvement; Cost-Benefit Analyses and the Environment; Case Study – Oceanário de Lisboa: Report on CBA evaluation for water and energy consumption improvements; Conclusion; and Bibliography. Every chapter may be also divided in subsections that intend to better explain all theories and practices that were considered essential to understand the discussed issues, their history and their importance.

1.3 Methodology

This work has been divided in two main parts: theoretical and practical. The theory on ISO 14001:2004, Continuous Improvement, Cost-Benefit Analyses and Environment has been first developed to understand better how environmental management systems, standardization and environmental economics work, and the role that continuous improvement has in those areas. The Cost-Benefit Analysis (CBA), core theme of this work, has been performed with the energy and water consumption and investments data that were provided by the Oceanário de Lisboa for the period 2003-2012.

Outcomes of the analyses are expressed as the Net Present Value looking prospectively from the first year of the project and as the Benefit-Cost Ratio. Total costs are investment costs and opportunity costs resulting from the lack of investments. Benefits have been calculated assuming a scenario of no investments in which relative energy and water consumption remains constant from 2005 onwards, and calculating the benefits of the investment scenarios by comparison.

To ensure consistent monetary quantities all monetary values have been converted to 2012 Euros (noted 2012€) using the general Consumer Price Index available from the Portuguese National Institute of Statistics.

CHAPTER II

ISO 14001:2004 AND CONTINUOUS IMPROVEMENT

2.1 History of Environmental Awareness

The term ecology was first coined by Ernest Haeckel as *oecology* in 1866. Haeckel was a German disciple of Darwin that described this concept as “the science of relations between organisms and their environment” [Haeckel in Hannigan, 1995]. Although Worster (1997) observes that the concept of ecology is much older than the word, it was only one century after the apparition of the word that it became a cornerstone of the contemporary environmental movement that began at the end of the 19^{th} Century and that had a major transformation after World War II [Hannigan, 1995].

According to some environmental historians [Hamblin, 2013], World War II did not only began because of ideological and geopolitical factors, but also because of factors that were related to the power over resources. Ironically wartime exigencies always require resource exploitation and destruction that tend to end up in scarcity, while leading to an idealization of the nature that represents the traditional values of family, work and the countryside. Nevertheless World War II caused as well great environmental impacts that were further aggravated by the intense use of the technologies that were developed during the War, especially in the chemical and mining industry. For example, mercury mining in United States provoked serious conditions to mine workers, and it was not until the 1950s that individuals and associations began to demand more responsibility from the decision makers and started to work in order to guarantee health and safety for workers and, by extension, the environment. This was the beginning of the environmental movement expressed as an activism.

According to Hannigan (1995), during the 1960s the United Farm Workers and the publication of Silent Spring [Rachel Carson, 1962] spoke out health related problems that were originated by pesticides such as DDT (dichlorodiphenyltrichloroethane), a substance that had insecticidal properties and was widely used to control malaria among civilians and troops during the second half of the World War II. Paul Müller, who discovered the insecticidal properties of the DDT, won the Nobel Prize in Physiology or Medicine in 1948 for his discovery, but DDT was banned in 1972 for causing cancer and being a thread to wildlife.

During the same decade, in 1968, several important people in the fields of science, politics and business founded the Club of Rome. Eventually, they requested from the Massachusetts Institute of Technology a report on growth that was based on mathematical models. It was published in 1972 and was called Limits to Growth. On that report, most of the foreseen scenarios resulted in the continuous growth of population and economy until 2030. At that point, growth experimented a turning point that arose the concern about the limits of Earth exploitation and the risks of an economic growth based on limited resources [Hannigan, 1995].

Scientists also started to establish cause relationships between some problems and the environment, as happened with acid rain, a phenomenon first described by British chemist Robert Angus Smith in 1852 and that, one century later, became one of the first environmental problems that required international agreed solutions. Indeed, after the United Nations Conference on Human Environment was held in Stockholm in 1972, industrialized countries began to structure environmental institutions and environmental laws were created with regard to pollution control [Hannigan, 1995].

In the 1970s industrialized countries faced petroleum shortages and the increase of the cost of oil during the so-called “energy crises of the 1970s”. Those events arose awareness about the rationalization of energy and provoked the search of less polluting fuels and renewable energy sources. In fact, the concept of sustainable development started to be developed because of petroleum, the first acknowledged-extinguishing natural resource [Hannigan, 1995].

According to the same author, in 1978 the concerns of the German’s society provoked the appearance of the first ecological seal, Blue Angel, in order to label those products that were produced with environmental friendly processes.

During the 1980s the general public started to be aware of environmental problems on account of serious environmental accidents such as those occurred in Seveso (Italy, 1976), Bhopal (India, 1984), Chernobyl (Former Ukrainian Soviet Socialist Republic, 1986) and in Alaska (USA, 1989). In 1987 the increased awareness with regard to the ozone depletion in the ozone layer caused the ban of CFCs (chlorofluorocarbons) at the Montreal Protocol.

By then, the United Nations World Commission on Environment and Development was already concerned about how nations were dealing with serious environmental problems, relegating them to just “environmental issues” and pretending they could be separated from human “actions, ambitions and needs” [Brundlandt, 1987]. In 1987 the Commission published the Brundlandt Report (in reference to the Commission's Chairman Gro Harlem Brundlandt), also known as “Our Common Future”. The report tries to establish a “global agenda for change” and is focused on sustainable development, a concept defined then as the “development that meets the needs of the present without compromising the ability of future generations to meet their own needs”.

Finally toxic pollution met the ethical concern for nature [Hannigan, 1995] and in the 1990s environmental justice became a form of social justice for minorities. In 1992 the United Nations tried to put into practice a “global agenda”, creating the Agenda 21 during the Conference on Environment and Development, also called Earth's Summit, that was held in Rio de Janeiro in 1992 [UN, 1992].

2.2 Past and present of ISO 14001:2004

Standardization is a well-established system that mainly began in 1906 with the creation of the International Electrotechnical Commission. Later on, in 1926, the International Federation of the National Standardizing Organizations was created. This organization was suspended during World War II and reappeared in 1946 under the name of the International Standardization Organization (ISO). Its first standard, in place in 1951, was on temperature for industrial length measurement [Mendel, 2001].

Since then, standardization has proved to make communication and production more efficient in an increasingly globalized world, to ease the international exchange of goods and services, and to avoid that environment, as well as quality or occupational health, related measures are used as pretexts for trade barriers [Arriaza, 1995].

The ISO has a complex structure that is organized in national standard bodies and technical committees (TCs), subcommittees (SCs) and working groups (WGs) that are constituted by delegates of ISO national groups. These national groups may also form the Technical Advisory

Groups (TAGs) that develop national positions on standards and coordinate the participation in TCs and SCs. Furthermore TAGs may be subdivided in sub-TAGs in order to address different aspects of a certain standard [Arriaza, 1995].

As of November 2013, ISO has created over 19,500 International Standards in the fields of engineering, goods production, technology, materials, tourism and entertainment, environment, corporate procedures, and health and safety, among others [ISO, 2013]. Those standards are regularly reviewed. In fact, and in relation with this thesis, this year they started to review the standard ISO 14001:2004 and it is planned that a new version will appear in 2015: the ISO 14001:2015.

According to Arriaza (1995), until the 1980s ISO Standards were limited to technical fields, but after the mistaken pollution policies of the 1970s, the 1990s introduced the concept of prevention and it started to be developed together with the need of a voluntary approach, since the public law system needs enormous resources to fulfill functions of application, compliance or assurance, among others. Moreover, multinational companies started to avoid environmental soft laws and legally binding treaties moving their environmental impacting activities to countries where supervision was less severe. This is why the ISO 14000 series were created as an alternative that promotes prevention, reducing pollution at the source "through changes in production inputs and distribution processes". The ISO standards are intended to avoid multiple registration, inspections, certifications, labels and conflicting requirements and provide a single system for global organizations that can be implemented anywhere they operate.

Arriaza (1995) establishes 5 events that made the publication of the 14000 standard series possible:

- The European Community developed technical regulation together with other European initiatives in eco-labelling and environmental audits and started to ban certain products for environment related reasons.
- The negotiation of the Uruguay Round of the General Agreement on Tariffs and Trade (GATT) along with the emerging controversy about the role of trade agreements in

environmental protection raised questions about the harmonization of standards.

- Since uncoordinated corporate environmental quality programs and eco-labelling schemes proliferated, business and consumer policy groups asked ISO to study them in order to avoid consumer misinterpretation.
- The success of the ISO 9000 series on Quality Control and Management.
- A number of documents of the Preparatory Committee for the United Nations Conference on Environment and Development referred to the need of international standards. In response, the ISO and the IEC established an *ad hoc* Strategic Advisory Group on Environment (SAGE). According to the founders, SAGE's main objective was "to assess the needs for future international standardization work in order to promote world-wide application of the key elements embodied in the concept of sustainable industrial development, including but not limited to consumer information and eco-labeling; the use of transport of resources, specially raw materials and energy; and environmental effects during production, distribution, use of products, disposal and recycling".

2.3 ISO 14001 Development

In October 1992 the SAGE advised for the urgent creation of a formal TC known today as the TC207. The urgency came from the work being done by the European Committee for Standardization (CEN) on environmental auditing and management. ISO wanted its standards to be in place before the European regulation on the same subject would become effective by the end of 1994, and in order to do that shortened its standard approval time from six to three months. According to Arriaza (1995), this time was enough to show the differences between Europe and USA approaches in relation to the Standard.

In Europe discovery rules are more protective and the threat of a large scale liability or criminal prosecutions is more remote. While regulatory compliance of potential liability drives environmental management and auditing standards in USA, Europe takes a more pro-active approach in which showing to the public that a company is taking seriously its environmental responsibilities, is a major motivation to establish environmental auditing standards.

In the debates of the TC207 the USA position was generally to seek less substantive and more procedural and flexible behaviors that protected management privileges and corporate secrecy. Those terms were usually supported by delegations that were concerned about how restrictive standards would affect trade activities in their countries. Other source of disagreement between Europe and non-European delegations was the extent of improvement on environmental performance. European representatives wanted the ISO standard to comply with the EMAS regulation and that required, in addition to continuous improvement, to list areas of mandatory evaluation and improvement, including the use of energy, water and other resources; waste avoidance, recycling and reuse; transport and disposal; selection of new production processes and changes to existing ones; product planning; and the environmental performance and practices of contractors, subcontractors and suppliers. USA and other participants rejected a fixed set of mandatory improvements, favoring a flexible management approach.

In the end USA's positions prevailed and the standards were based on the lowest common denominator. They mainly addressed the environmental impacts of densely populated, highly industrialized societies. Small businesses, consumers, NGOs and less developed countries were basically underrepresented and alternatives to compliance, such as extended timetables and financial and technical assistance, were not discussed [Arriaza, 1995].

2.4 General definition of the Standard

The ISO 14001:2004 - *Environmental management systems – Requirements with guidance for use* is a standard that was created by the International Standardization Organization, and an update of the first ISO 14001 published in 1996. It is part of the ISO 14000 family addressing several aspects of the environmental management, and nowadays it is implemented by over 250,000 certified organizations in 155 countries worldwide [ISO, 2013].

The ISO 14001 and the Environmental Management System are the core of the ISO 14000 series. Management may be here defined as "the tool that shall designate responsibility for achieving targets, and set the resource allocations and timeframes for both new and existing activities" [Arriaza, 1995] and it is useful in order to provide human and financial resources that are essential to the implementation; periodic monitoring; and corrective or preventive actions in case of nonconformance that avoid legal actions against organizations.

The ISO 14001:2004 Standard is based on a PDCA (Plan, DO, Check, Act) strategy, a modified version of the classical scientific method that is meant to promote the continuous improvement of processes and products. The 2004 version clarifies the first edition and improves its compatibility with the ISO 9001 Standard [ISO 14001:2004].

This International Standard does not establish specific requirements for environmental performance beyond the commitment to comply with the certified organization's environmental policy and the applicable legal regulation and other subscribed requirements; to prevent pollution; and to drive continuous improvement [ISO 14001:2004].

According to AENOR (2013), the Spanish Agency for Standardization, the ISO 14001:2004 Standard systematizes environmental management through the following phases:

- Policy:
  - Defining an environmental policy
- Planning:
  - Identifying environmental aspects and legal requirements
  - Definition of goals, targets and programs
- Implementation:
  - Resources, duties, responsibility and authority
  - Competition, training and awareness
  - Communication
  - Documentation and document control
  - Operational control
  - Emergency preparedness and response
- Verification:
  - Monitoring and measuring

    - Legal compliance assessment
    - Non conformity. Corrective and preventive actions.
    - Registries' control
    - Internal audit
- Review:
    - Review by top management

Therefore, any organization intending to certify its EMS shall establish, document, implement, maintain and continually improve an environmental management system in accordance with the requirements of the ISO 14001:2004 Standard, and determine how these requirements will be fulfilled. Organizations shall also define and document the scope of its environmental management system [ISO 14001:2004].

The ISO 14001:2004 Standard is the only standard of the 14001 series that has requirements that can be objectively audited in order to certify, register or serve as self-declaration. In addition there are other Standards that supplement it: the ISO 14004 – *Environmental Management Systems - General guidelines on principles, systems and support techniques;* the ISO 14031:1999 – *Environmental Management – Environmental performance evaluation*; and the ISO 14032:1999 – *Environmental management - Examples of environmental performance evaluation.*

2.5 Implementation and technical aspects

2.5.1 General procedures to achieve certification

- *Initial assessment and definition of purpose*: definition of the changes, upgrades and implementations that should be done and with what purpose, taking into account any environmental impact the company may have. According to Kuhre (1995), an initial assessment can be done by an external consultant or by in-house workers, and shall include: all requirements of the ISO 14001:2004 Standard; major applicable regulations, current environmental controls, needed additional activities and areas to be covered, and the estimated costs and benefits of the implementation.

- *Policy preparation*: a policy that address environmental impacts and regulations and that must be supported by senior management. It must be communicated to all employees and stakeholders.
- *Obtaining necessary resources*: financial, organizational and trained human resources should be identified and arranged with anticipation.
- *Preparation of procedures for identification of impacts and requirements*: procedures for identification, assembly, and analysis of environmental impacts and regulations into the organization's systems are necessary and should be prepared.
- *Objectives and targets:* objectives and targets should be prepared in order to establish a clear policy statement. Targets should be specified for each established objective and goal.
- *Utilization of existing documents and resources:* the company should use all documents and resources that already comply with the ISO 14001 specifications.
- *Preparation of new operating procedures and action plans:* all procedures and action plans in environmental management systems should be written down. An environmental management manual should be set up and contain all different procedures and standards, and a copy of the company's policy.
- *Implementation of programs:* in order to implement effective programs, the implementation of the environmental management system should be economically sound.
- *Ongoing auditing, management reviews, correction and follow-up:* an essential step to the proper functioning of the system and to guarantee the continuous improvement of the EMS.
- *Internal ISO Standard audit:* helps to identify corrections that need to be done.
- *External audit:* credibility uses to be greater when auditors are independent and perform a third-party audit. However, auditors may not have much knowledge about the particular industry being audited. For that reason, a good relationship with the auditors and providing them with all useful information they may need is essential.
- *Certification:* certification can be executed by an outside independent auditing firm, involving contracted suppliers or by self-certification.

- ***Continuous improvement**:* an integral part of every step that will help to maintain the cost-effectiveness of the system. Continuous improvement is essential for the implementation of the ISO 14001. Although there is not any strict requirement on this issue, it is a requirement for certification and organizations that want to be certified must establish annual plans with objectives and targets that will help to improve the environmental management system and the efficiency of the organization's processes in terms of environmental impacts (see ANNEX I for a detailed list of the objectives and targets of the Oceanário de Lisboa).

2.5.2 Operational control procedures

According to Kuhre (1995), the necessary operational control procedures are:

- *Procurement and vendor controls*: they are essential for environmental management. Suppliers shall be asked whether their products can be recycled and special care has to be taken if suppliers' services involve environmental services or chemicals or hazardous waste services. Data to be asked for are: product composition data, data concerning chemicals used in manufacturing process, information on product life cycle, and environmental programs. Suppliers should be encouraged or required to implement an environmental management system that is equivalent to the EMS of the primary company.
- *Process, equipment and chemical products approval and tracking*: before implementing any process or using any equipment or chemical product, the environmental department should review drawings, plans and designs to ensure compliance with policy statements, targets, objectives and in force regulations. If a potential problem is identified, it would be easier to correct before implementation has taken place. Reviews should include the following considerations :
    - Use of chemical products in the process or in the cleaning or maintenance of processes or equipment.
    - Any discharge to the air, water or soil.
    - Generation of hazardous waste.
    - Generation of solid waste such as paper, aluminum, glass or plastic.
    - Use of considerable quantities of energy, water or other natural resources.

- *Procedure for tracking chemicals*: it is necessary to know which chemicals are planned, purchased, stored and used, and which ones would become hazardous waste. In order to track chemicals, a responsible individual should be designated, an inventory of the chemical should be done, and any other important information should be added to the software system that manages these data.

2.5.3 Emergency procedures

According to the ISO guidelines, under the Emergency Preparedness and Response requirement, "the organization is required to establish procedures for identifying potential emergency and accident situations". The ISO 14001 Standard specifies five steps that must be executed in order to meet this requirement:

- Identify the potential for emergency situations and accident of all kinds.
- Pay particular attention to the potential environmental impacts of accidents and emergency situations, identify how the organization can prevent and mitigate associated adverse environmental impacts.
- Determine how the organization and its employees should respond to emergency situations and accidents.
- Periodically simulate emergency situations to test response capabilities.
- Review and revise procedures based on experience derived from actual and simulated emergency situations and accidents.

The emergency plan should be prepared by trained workers and specialists on the field. Related specific requirements from local and regional institutions should be incorporated. Moreover, emergency procedures should be updated periodically, contributing to the continuous improvement of the environmental management system.

2.5.4 Audits, reviews and verifications

According to the ISO guidelines and to Kuhre (1995), in order to check the effectiveness of the environmental management system, organizations should verify several aspects of their operations:

- Monitoring and measurement of the organization's operations in order to obtain, collect and analyze relevant data and information. The information obtained can be used to implement corrective and preventive actions.
- Evaluation of compliance with identified legal requirements, such as applicable permits or licenses. The organization should be able to demonstrate that it has evaluated its compliance with all identified requirements it has subscribed to.
- Verification of nonconformity and execution of the corresponding corrective or preventive actions in order to accomplish them with a minimum of formal planning.
- Control of records, including complaint records; training records; process monitoring records; inspection, maintenance and calibration records; pertinent contractor and supplier records; incident reports; records of tests for emergency preparedness; audit results; management review results; external communication decisions; records of applicable legal requirements; records of significant environmental aspects; records of environmental meetings; environmental performance information; legal compliance records; and communications with stakeholders.
- Internal audits of environmental management systems may be performed by workers within the organization or by selected external specialists. Auditors must be competent, impartial and objective. ISO 19011:2012 for quality and environmental management systems provides guidance on this field.

2.5.5 Records and document control

According to Kuhre (1995), "all the environmental management procedures, plans and targets […] would be considered documents requiring control". All those documents need to be stored in one place in a logical way.

The first thing for document control is to identify what kind of documents needs to be retained for regulatory and business reasons, and for how long. Then, the logical sequence of actions is: collection, indexing, filling and storing. Obsolete files need to be removed as well. As required for ISO 9001 certification, all documents must have issue date, retention time and revision numbers. If the document is related to another document, it must be cross-referenced.

2.6 Benefits

According to literature [Arriaza, 1995, Kuhre, 1995; Cagnin, 2000; Bansal and Hunter, 2003] and ISO publications, the implementation of the ISO 14001 Standard is related to the following economic and non-market benefits:

- *Protection of the environment:* the ISO 14001:2004 Standard aims to be a guide of environmental accountability for corporate activities, especially in issues related to waste problems and emissions limits. According to Arriaza (1995), other environmental problems (such as loss of habitat, loss of biodiversity and desertification) that usually affect less developed countries are underrepresented by the denomination of "other environmental impacts" more likely because less developed countries and NGOs did not have a strong representation during the creation of the standard.
- *Competitive advantage*: national and international competitive advantage through innovation and efficiency, and the possibility to enter new markets.
- *Compliance with regulation:* auditing and corrective measures help to comply with national and international laws.
- *Establishment of effective management systems:* effective management keeps an organization viable.
- *Reduced cost*: an effective implementation of the standard may result in saving costs by:
  - Reducing raw material/resource use
  - Reducing energy consumption
  - Improving process efficiency
  - Reducing waste generation and disposal costs
  - Utilizing recoverable resources
- *Reduced injuries*: the implementation of the standard may reduce health and safety risks by reducing on-site chemical and hazardous wastes and materials.
- *Improved community relations:* regular people do care about environment. Reducing environmental impacts, or even involving the community in doing so, will increment their confidence in the organization and their acceptance.
- *Improved customer trust and satisfaction:* as in the case of the community, customers will have a clear idea of what is actually done for the environment in any certified

company, for it will be documented and proved true.

- *Improved upper management attention:* ISO 14001 standard directly involves the top management, assuring that policies and measures are approved at all levels of the company.

The ISO 14001:2004 is a Standard that aims to promote the implementation of Environmental Management Systems that are suitable for all organizations. It has come a long way to be in place and to have a role in the environmental history but, for now, it has to be flexible and adaptable in order to be accepted and implemented. In any case it is a cornerstone of the corporative environmental management and provides an opportunity to all companies willing to certificate their processes, so they can be more efficient, environmentally friendlier, and renovate their image and behavior.

2.7 Continuous improvement

Continuous improvement is an essential requirement for the implementation of ISO 14001:2004. The bottom line of this concept with regard to the environment is ensuring that the environmental performance of the organization this year is better than it was last year, defining better environmental performance as the result of less environmental negative impacts and more environmental positive impacts [Briley et al., 2000].

The successful implementation of a continuous improvement system can be considered an organizational renewal process that is reached by introducing new behaviors and ideologies, especially with regard to managerial practices [Savolainen, 1999]. Furthermore, since the foundation of continuous improvement is based on production system models such as Total Management, Lean Production and World Class Manufacturing, the continuous improvement proves to be an important tool that increase competitiveness in organizations [Marín-García et al., 2008].

Kaye and Anderson (1998) describe five phases of the continuous improvement in relation to quality that are equivalent to the environmental field, since quality is the main context in which the concept of continuous improvement was developed and that eventually was applied to the environment (ISO 14001 is strongly based on ISO 9001 on Quality Management Systems). These five areas are:

1. Inspection
2. Statistical control
3. Assurance
4. Strategic management

During the first three phases, quality was a problem to be solved within the internal operations of the organization. In the 1980s it was seen for first time as a competitive opportunity and organizations started to focus on customers, and the anticipation of the needs of the latter or the market.

Nowadays phase 4 is inadequate to meet a fast changing business environment that is characterized by uncertainty and unpredictability. Therefore a new phase started: the phase of competitive continuous improvement in which the main concerns are flexibility, responsiveness, and the ability to adapt quickly to changes. Therefore, specific expectations and the use of appropriate measurements, metrics and accurate data are essential to any continuous improvement process [Briley et al., 2000; Bondurant, 2009].

Kaye and Anderson (1998) and Bessant et al. (2001) describe ten essential criteria to achieve an improvement that is continuous, self-generating and sustained over time:

1. Senior management commitment and involvement.
2. Leadership and active commitment to continuous improvement demonstrated by managers at all levels.
3. Focusing on the needs of the environment.
4. Integrating continuous improvement activities into the strategic goals across the whole organization, and across boundaries at all levels and functions of the organization.
5. Understanding the concepts of continuous improvement, establishing a culture for continuous improvement, and encouraging high involvement innovation.
6. Developing continuous improvement by involving people and focusing on people.
7. Focusing on critical processes and creating procedures that support continuous improvement activities.

8. Standardizing achievements in a documented Environmental Management System.
9. Establishing measurement and feedback systems.
10. Learning from continuous improvement results and the automatic capturing and sharing of knowledge.

There are some best practice's elements within some of these criteria that have been identified too by Kaye and Anderson (1998).

In the integration of continuous improvement, the organization's strategic aims and objectives should be used to identify and prioritize continuous improvement throughout the organization and across functional boundaries at all levels. Furthermore, self-assessment techniques using a recognized framework should be considered in order to help identifying improvement areas within the organization, and to promote a holistic approach towards continuous improvement.

With regard to criterion 5, in order to generate a culture of continuous improvement all employees should be made aware through appropriate induction and training of the general concepts of environment and sustainability as they apply to them and their particular tasks in the organization. Continuous improvement must be encouraged by the organization and the idea that everyone has something to contribute must be part of the culture of the organization. In addition managers should continuously reinforce the culture for continuous improvement by regularly checking and raising the awareness and understanding of employees; additionally, multi-disciplinary teams should be established in order to focus on environmental improvement issues.

Finally, effective communication systems should be established in order to ensure that appropriate and timely information flows horizontally and vertically from the top to lower levels, and vice versa at all levels. It is fundamental to considerate related actions such as information audits, employees surveys, employees newsletters, the use of emails, the use of improvement teams, staff briefing meetings, and staff review and appraisal systems.

Continuous improvement is a mean of innovation and so it is the implementation of the ISO 14001 Standard. Innovation has proved to be an essential tool for competition and differentiation. Therefore investments to implement ISO 14001 and its continuous improvement measures can be seen as a way to help organizations to stand out from their competitors [Cagnin, 2000].

The environmental continuous improvement is closely linked to the spirit of the ISO 14001 and is an essential part of a company sustainability, defining sustainability this time as “the capability of an organization to transparently manage its responsibilities for environmental stewardship, social wellbeing and economic prosperity over the long term while being held accountable to its stakeholders” [Pojasek, 2012 in Okongwu et al., 2013]

CHAPTER III

COST-BENEFIT ANALYSIS AND THE ENVIRONMENT

3.1 Introduction

In economics, the environment is considered as an asset that provides a number of services. In Figure 1 there is a representation of the relationship between the economic system and the environment through inputs and outputs [Tietenberg, 2011].

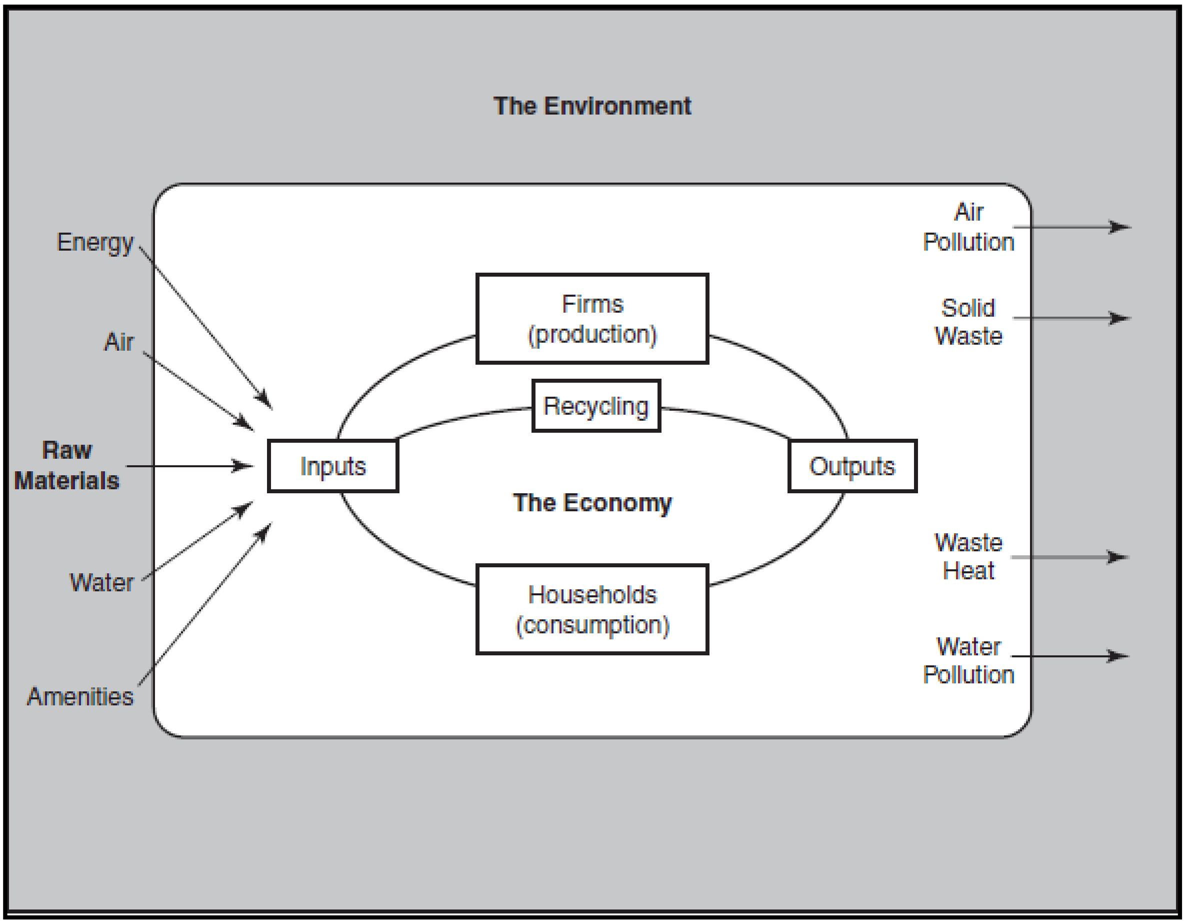

Figure 1 - The economic system and the environment – Source: Tietenberg, 2011

The environment provides raw materials and energy that are transformed in consumer products through industrial processes. It also provides direct services to consumers such as food, drink, shelter, clothing or air. In addition, the environment may provoke feelings and sensations that can be seen as benefits.

According to Tietenberg (2011), there are two types of economic theories that can be applied to understand the relationship between the economic system and the environment:

- *Positive economics:* attempts to describe past, present and future facts.
- *Normative economics:* tries to deal with what ought to be and involves value judgments.

The above approaches are useful in description and guidance, respectively. The normative approach helps to choose projects and policies where benefits are greater than costs. It can be used to know the efficiency of a project or policy before it is put into place; or it can help to evaluate how an implemented program has worked out in practice. Cost-Benefit Analysis is part of the normative economics and it is used to evaluate choices.

3.2 Cost-Benefit Analysis

3.2.1. History

The history of cost-benefit analysis (CBA) can be dated back in France to the 19th century when it was used in infrastructure appraisal [PEARCE et al., 2006]. Yet the United States Federal Water Agencies were among the first to use CBA in their evaluations and by 1808, Albert Gallatin already recommended the comparison of cost and benefits in water-related projects [Hanley, 1993]. According to the OECD (2006), the theory of welfare economics was developed along with the "*marginalist*" revolution in microeconomic theory during the last part of the 19th century, and culminated in Pigou's Economics of Welfare in 1920. Pigou's work further formalized the notion of divergence between private and social costs. In 1930 Pareto, Kaldor and Hicks developed the so called "new welfare economics" [PEARCE et al., 2006], which reconstructed welfare economics only on the basis of ordinal utility. These analytic efforts that were performed during the first half of the 20th century served as stimulation to research the use of economics in budget allocation decisions in a number of fields.

After World War II there was a need for "efficiency in government" to ensure that public funds were efficiently utilized in major public investments. This resulted in the beginning of the fusion of the new welfare economics, which was essentially cost-benefit analysis, and the practical decision-making. As Hanley (1993) states, during this era water quantity was the primary concern, but after dam construction began to slow, the public attention started to focus in other issues such as water quality.

Since environmental resources can offer non-market benefits that could count in cost-benefit analyses, theories in this regards started to be developed. In 1966, Clawson and Knetsch already included an early development of the travel cost method, emphasizing the methods and data required for measuring the benefits of environmental improvement in relation with recreational uses.

In the 1970s and 1980s the importance of non-use values was recognized. In 1969, the US National Environment Policy Act (NEPA) required Environmental Impact Assessments, and in 1981 the Presidential Executive Order No. 12291 of that year explicitly required the application of CBA to new regulations [Hanley, 1993].

3.2.2. Theoretical foundations of Cost-Benefit Analysis

Cost-Benefit Analysis (CBA) is a normative criterion. Since economists suggest that any action has both benefits and costs, if benefits exceed the costs, then the action is desirable. On the other hand, if costs exceed benefits then the action is not desirable. This means that:

Being B the benefits and C the cost of an action: If B > C or if B/C > 1, then support the project because it is feasible.

In general terms, benefits can be defined as increases in human wellbeing, they are positive impacts and utilities. According to Hanley (1993), they mean more quality and quantity of goods that generate positive utilities or a reduction in the price at which they are supplied. Meanwhile costs would be reductions in human wellbeing, negative impacts that mean less quantity or quality of such goods, or increases in their prices.

Figure 2 displays a graphical representation of an example of the relationship between environmental costs and benefits: in this case when preserving miles of a river. The intersection point R represents the optimized result in which benefits are maximized (the net benefit area is maximized) and costs are minimized (the total cost area is minimized), while M, N, T, U are examples of non-optimized options. MC and MB are marginal costs and marginal benefits, respectively, that means the costs or benefits of preserving one more mile.

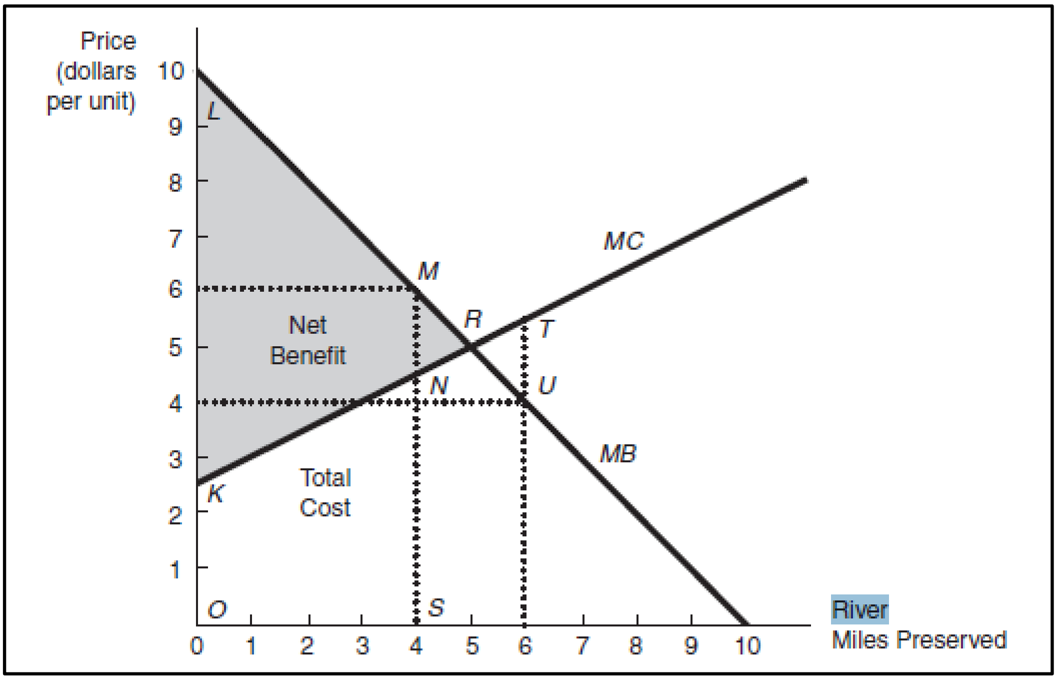

Figure 2 - Derivation of net benefits – Source: Tietenberg, 2011

Here benefits are measured as the relevant area under the demand curve and total costs are measured by the relevant area under the marginal cost curve [Tietenberg, 2011]. CBA, as the relationship between costs and benefits, helps to evaluate the desirability of any action, project or policy.

CBA can also be private or social. A private CBA is a financial analysis of a given project in the future (appraisal) or in the past (evaluation). In this situation only the benefits and costs of the project that accrue to the company itself and affect its profitability are taken into account. The project may have wider implications (such as environmental impacts or employment effects) but if these do not affect the company's commercial profitability, they are omitted from the analysis. Social CBA takes into account those wider implications that affect the society (social benefits and social costs). In those cases, profitability is not the only criterion in order to accept or reject a project or a policy [Campbell & Brown, 2003].

3.2.3 Important concepts when performing a CBA

According to the related literature [Campbell & Brown, 2003; Myers, 2003; Brent, 2006; Tietemberg, 2011], there are some important concepts that shall be used when performing a CBA. These are, among others:

- **Benefit Cost Ratio:** BCR calculates the relationship between present benefits and present costs with the formula BCR= PV (benefits)/PV (costs) [Campbell & Brown, 2003].
- **Capital costs:** generally, there are two forms of investment or capital costs: fixed investment and working capital. Fixed investment refers to all those capital goods such as land, buildings, plant and machinery; and working capital refers to stocks of goods that any business or project needs to hold in order to operate.
- **Cash flows:** they play a central role in the development and appraisal of almost any investment project. They are a summary presentation of all costs and benefits expected to accrue over the project's life.
    - <u>Incremental or relative cash flows</u>: the main objective of a proposed additional investment is to improve the net cash flow of decreasing costs or/and increasing benefits. The improvement of the net cash flow is called incremental cash flow. It is the difference between the net benefit flow with the new investment and the net benefit flow without this investment. In any case, in many projects it is extremely difficult to establish an accurate scene of the with and without situations, then the only alternative may be to directly estimate the improvement (incremental cash flow) that is expected to result from the project.
- **Discounting:** Time is a factor and discounting is the process of assigning a lower weight to a unit of benefit or cost in the future than to that unit at the present time. The discount rate takes into account not just the time value of money, but also the risk or uncertainty of future cash flows; the greater the uncertainty of future cash flows, the higher the discount rate, that means that a higher discount rate favors short-term benefits, while lower discount rates benefit long-term approaches.

- **Inflation:** Inflation is a process that results in the nominal prices of goods and services raising over time. In project evaluation, in order to compare costs and benefits of different years when looking a project's performance in retrospect, it is important to deflate or inflate prices by an appropriate rate such as de Consumer Price Index (CPI) in order to convert nominal cash flows into real cash flows [Campbell & Brown, 2003].
- **Interest charges:** although most CBAs are usually performed before financing, another issue in capital costs is the interest paid on money borrowed. All cash inflows and outflows relating to the debt financing of the project need to be incorporated into the cash flow. Furthermore, interest charges are a legitimate deductible cost, so when calculating taxes and the net cash flow after taxes, it is necessary to include any interest as a project cost.
- **Internal Rate of Return:** The IRR is the discount rate which reduces the project NPV to zero. Although widely used, there are some cases in which the IRR should not be used and that are of special relevance for this thesis. First is the use of IRR in mutually exclusive projects due to a phenomenon called "switching", in which the IRR a project with the higher NPV could be lower than the IRR of a project with a lower NPV [Campbell & Brown, 2003].The second criterion for not using the IRR is that it can be only if a reasonable rate of return can be calculated. Due to the nature of the IRR as a root of a polynomial, in case of some special cash flows patterns, this may be not possible [Brown, 2006 in Kahloefer, 2010].
- **Net Present Value:** the NPV of a project expresses the difference between the discounted PV of future benefits and the discounted PV of future costs. A positive NPV for a given project means that benefits are greater than costs. The NPV is the most reliable decision rule in a CBA and it should prevail above the others [Campbell & Brown, 2003].

3.2.4 Stages of Cost-Benefit Analysis

According to Hanley (1993), CBA is structured in the following stages:

- ***Stage 1 - Definition of the project***
    - Reallocation of resources being proposed.
    - Gainers and losers to be considered (referent group analysis). Aggregation of costs and benefits.

- ***Stage 2 - Identification of project impacts (in private CBA, this may be useful for legal, marketing, reputation, government-related purposes)***
  - Resources used.
  - Effects on unemployment.
  - Impacts on traffic movements.
  - Effects on local property prices.
  - Impacts on the local quality of landscape.

- ***Stage 3 – Which impacts are economically relevant?***

- ***Stage 4 – Physical qualification of relevant impacts***
  - Qualification of physical amounts of cost and benefit flows for a project, and identifying when in time they will occur. All calculations should be performed under varying levels of uncertainty. This can be done by attaching probabilities to uncertain events and calculating an "expected value".

- ***Stage 5 – Monetary valuation of relevant effects***
  - In CBA money serves as common unit. Quoting Hanley (1993), "it is merely a device of convenience, rather than an implicit statement that money is all that matters". As markets generate the relative values of all traded goods and services as relative prices, the latter are very useful to compare different kind of things and carry valuable information. In this stage it would be also necessary to predict prices for value flows extending into the future; to correct market prices where necessary; and to calculate non-existing prices. Shadow prices should be calculated if imperfect competition exists; if the government intervenes in the market (taxes and subsidy equivalents); or in the case of the absence of a market (here techniques such as the contingent valuation, the travel-cost method, or hedonic pricing shall be used).

- ***Stage 6 – Applying discount rates and inflation of cost and benefit flows***
  - Cost and benefit flows expressed in monetary amounts shall be converted in present value (PV) terms because of the time value of money. In order to do that, as it was previously stated, an interest rate and inflation shall be applied to all cost

and benefit flows [Hanley, 1993].

- ***Stage 7 – Applying the Net Present Value test***
    - This test establishes if the sum of discounted gains exceeds the sum of discounted losses and, therefore, the efficiency of any project. The formula for calculating the NPV can be written as

$$NPV = C_0 + C_1/(1+ r) + C_2/(1 + r)^2 + ... + C_T/(1 + r)^T$$

In this formula, C_0 is the cash flow at time 0 and r is the discount rate that has been applied. Already mentioned alternatives to this method are the Internal Rate of Return (IRR) and the benefit-cost ratio (BCR), although always the NPV decision method should prevail above the latter, since they can lead to inconsistencies.

- ***Stage 8 – Sensitivity analysis***
    - Recalculation of NPV when the values of certain key parameters (as the interest rate; physical quantities and qualities of inputs and of outputs, shadow prices of these inputs and outputs; and project life span) are modified, in order to know to which parameters the NPV outcome is most sensitive.

3.3 Methods for calculation of non-market costs and benefits

Although in the analysis of this work non-market costs and benefits have not been taken into account, they are an important part of environmental projects and policies and the methods to calculate non-market costs and benefits should be therefore explained.

The total economic value (TEV) is the sum of all values that may derive from a project. It may be divided in use and non-use values. The former relate to actual use, planned use or possible use of a good, while the latter refer to goods even if they do not have actual use, planed use or possible use. The non-use value could be classified as existence value, altruistic value, or bequest value.

The notion of the total economic value provides an all-encompassing measure of the economic value of any environmental asset, and does not encompass other kinds of values, such as intrinsic values, which are usually defined as values residing within the asset and that are unrelated to human preferences or perception [Tietenberg, 2011]. The following diagram (Figure 3) shows the mechanism that allow the measurement of environmental assets that do not have a price in the market, and the relationship between them.

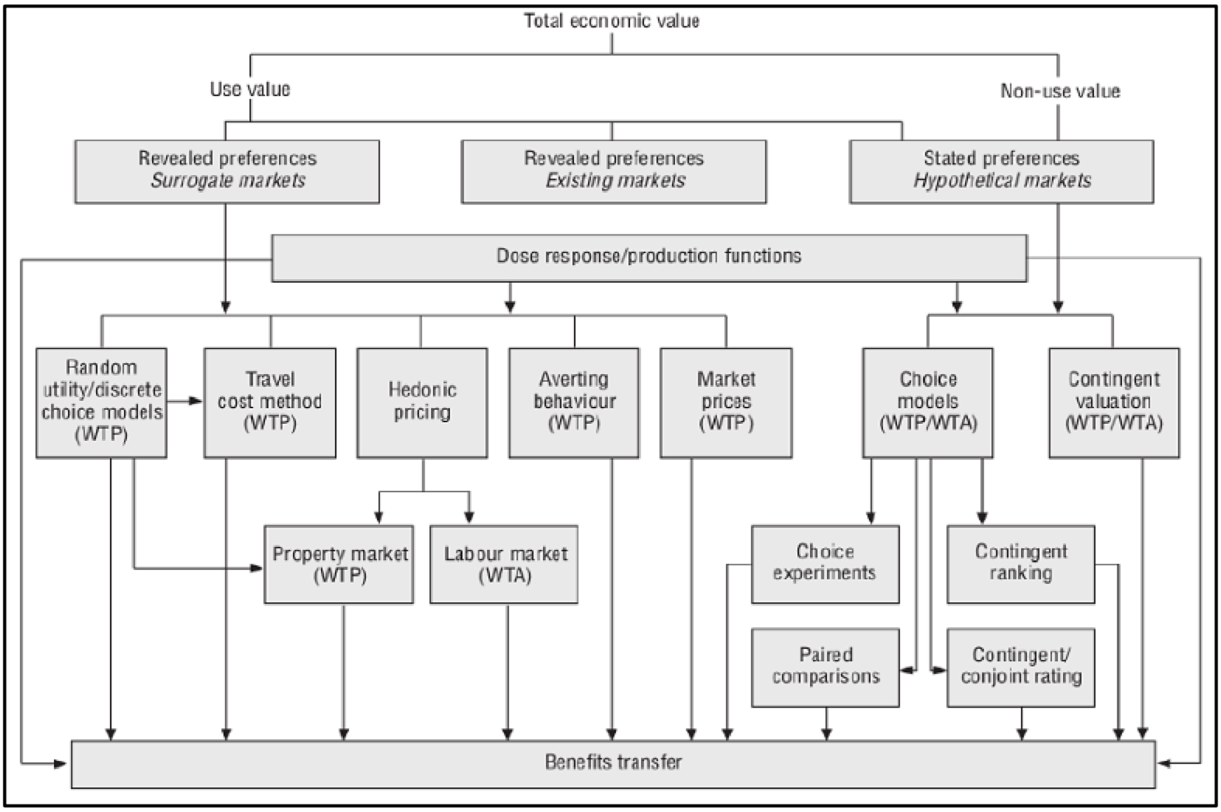

Figure 3 - Total Economic Value – Source: Tietenberg, 2011

3.3.1. Revealed preference methods for valuing non-market impacts

Since benefits cannot always be translated into a market price or a consumption level, revealed preference methods were created in order to value non-market goods:

- ***<u>Hedonic pricing method</u>***
  HPM estimates the value of a non-market good by observing the behavior in the market for a related good, especially in property and labor markets. In the first case, the HPM isolates the contributions of each significant determinant of house prices in order to identify marginal willingness to pay for each housing characteristic. This involves

collecting large amounts of data on prices and characteristics of properties in an area and applying statistical techniques to estimate a "hedonic price function". This function is a point of equilibrium prices for the sample of houses, and these prices result from the interaction of buyers and sellers in the property market in question. If the array of housing characteristics in the market is approximately continuous, then it can be assumed that buyers will choose levels of each characteristic so that its marginal implicit price is just equal to buyers' valuation of the characteristic. Therefore, the slope of the hedonic price function with respect to each characteristic is equal to the implicit price [PEARCE et al., 2006].

Hedonic studies of the property market have been used to identify the value of non-market goods such as road traffic and aircraft noise, air pollution, water quality, proximity to landfill sites and planning restrictions on open spaces in and around urban areas. The HPM has also been used to estimate the value of avoiding risk of death or injury. This has been done by looking for price differentials between wages in jobs with different exposures to physical risk. Employers must therefore pay more to induce workers to undertake jobs entailing higher risk. This extra payment provides an estimate of the market value of small changes in injury or mortality risks [Kolstad, 1999].

- ***<u>Travel Cost Method</u>***

  The travel cost method (TCM) has been developed to value the use of non-market goods in geographical areas and locations used for recreational purposes. For example, in natural areas that, for a number of reasons, typically have not a price in the market and need to find alternative means of assessing their value.

  The basis of the TCM is the recognition that individuals produce recreational experiences through the input of a number of factor inputs [PEARCE et al., 2006]. Amongst these factors are the recreational area itself, travel to and from the recreational area and, in some cases, overnight stays at the location. Typically, the recreational area itself is an unpriced good, while many of the other factors that are employed in the generation of the recreational experience have market prices.

The TCM derives from the observation that travel and the recreational area are complements such that the value of the recreational area can be measured with reference to the values expressed in the market for trips to the recreational area. To estimate the TCM, therefore, information is required as the number of trips that an individual or household takes to a particular recreational area over the course of a year; and how much it costs for that individual or household to travel to the recreational area.

- ***Averting behavior and defensive expenditure***

  Their approaches are similar to the previous two, but differ in that they refer to individual behavior to avoid negative intangible impacts. Therefore, people might buy goods such as safety helmets to reduce accident risk, and double-glazing to reduce traffic noise, revealing their valuation of those negative impacts. However, again the situation complicates by the fact that these market goods might have more benefits than simply that of reducing an intangible negative impact.

- **Cost of illness method and lost output calculations**

  They are based on the observation that intangible impacts can ultimately have measurable economic impacts on market quantities (for example, medical costs) through an often complex pathway of successive physical relationships. The difficulty with these approaches is often the absence of reliable evidence, not on the economic impacts, but on the preceding physical relationships.

3.3.2 Stated preference methods

- ***Contingent Valuation Methods***

  Contingent valuation methods construct and present a hypothetical market to questionnaire respondents. A detailed description of a good, how it will be provided, and the method and frequency of payment are usually highlighted. Following this, questions are posed in order to infer a respondent‘s Willingness To Pay or Willingness To Accept. These valuation questions can be presented in a number of different formats as open ending, bidding game, payment card, or dichotomous choice elicitation. The responses to these questions are typically used to model the determinants of stated valuations and to identify invalid and protest valuations.

The key outcome of the analysis of the responses is an estimate of the average WTP across the sample of people surveyed. If the sample is representative of the target population, then this estimate can be aggregated to obtain an estimate of the total value of the outcome or good [Fujiwara, 2011].

- ***Choice modeling methods***

Most non-market goods can be described by their characteristics. Choice modeling methods focus on goods' characteristics and their values [Fujiwara, 2011]. In order to find out the valuation estimates, choice modeling questionnaires present respondents with a series of alternative descriptions of a good. The alternative descriptions are constructed by varying the levels of the good's attributes. Depending on the specific choice modeling method adopted, respondents are either then asked to rank (contingent ranking), chose (choice experiments), rate (contingent rating), or choose then rate (paired comparisons) the presented descriptions [Hanley et al., 2001 in Fujiwara, 2011].

For these methods, as long as cost or price is included as an attribute, statistical techniques can be used to recover Willingness to Pay estimates for the other attributes of the good.

- **Quasi Option Value**

The Quasi Option Value (QOV) is "the difference between the net benefits of making an optimal decision and one that is not optimal because it ignores the gains that may be made by delaying a decision and learning during the period of delay" [Hanley, 1993]. Usually QOV is related to irreversibility. The formula for the Quasi Option Value is:

$$QOV = EW - max(ED, EP)$$

In the above formula, EW is the expected value obtained by waiting, ED are the development benefits, and EP is the expected value of preservation benefits.

- **Willingness to Pay and Willingness to Accept**

Although literature has focused mainly on Willingness to Pay (WTP), according to the OECD guidelines on this matter (2006), economists have been fairly indifferent about the welfare measure to be used for economic valuation: WTP and Willingness to Accept (WTA) have both been acceptable. Now, the development of stated preference studies has repeatedly discovered differences between WTA and WTP. These differences would not matter if the nature of property rights regimes was always clear: WTP in the context of a potential improvement is clearly linked to rights of the *status quo*. Similarly, if the context is one of losing the *status quo*, then WTA is used, since that loss is the relevant measure. In general, environmental policies or projects tend to deal with improvements rather than with deliberated degradation of the environment, so WTP is assumed as the right measure. The problems arise when it is thought that individuals can have some right to a future state of the environment. If that right exists, their WTP to secure that right seems inappropriate as a measure of welfare change, whereas their WTA to forgo that improvement seems more relevant. In practice, the policy or project context may well be one of a mixture of rights.

3.4. Considerations to add non-market prices into a CBA

3.4.1. The value of ecosystem services

Ecosystems are biological communities of interacting organisms and their physical environment. They generate multiple products and services that may be private or public. According to the OECD (2006), ecosystems provide:

- ***Purification services:*** water and air pollution filtration through, for example, wetlands and forests.
- ***Ecological cycling and storage:*** for example, growing vegetation takes in carbon dioxide and stores it in their biomass until it dies, then the carbon is transferred to soil. Since carbon dioxide is a greenhouse gas, growing biomass reduces those gases in the atmosphere.

- ***Regulation:*** natural systems regulate themselves through natural processes that involve the interaction of species. Ecosystems may regulate watershed and weather behavior, reducing risk of floods.
- ***Habitat provision:*** habitats are stores of biological diversity that helps to reduce the risks of ecosystem collapse, even apart from providing food, scientific information, recreational and aesthetic value.
- ***Regeneration and production:*** ecosystems may grow biomass by converting light, energy and nutrients. This biomass provides food, raw materials and energy to humans and other species. Ecosystems ensure that pollination and seed dispersal take place, ensuring that the systems are themselves renewed.
- ***Information and life support:*** ecosystems are products of evolution and embody millions of years of information. This information has scientific value but is also a source of wonder and life support.

In order to valuate an ecosystem it is necessary to:

- Identify the ecosystem services and products.
- Focus on marginal or discrete changes, not the value of the "total ecosystem".
- Determine the degree of irreversibility in ecosystem change.
- Establish the geographical scale of the benefits generated.
- Establish the property rights regime for the resource in question.
- Value the products and services as if they are independent of each other.
- Try to analyze the interactions between services to see how this might modify the sum of independent values outlined in the following table.

It is also necessary to take into account that ecosystems have interactive processes, whose functioning is usually uncertain, irreversible and non-linear; and that the value of the whole system is usually higher than the value of the sum of its parts, complicating the execution of a CBA. Summarizing, the economic responsibility with regard to ecosystems is to measure what is being lost when parts of a given ecosystem are lost or degraded.

3.4.2 Health and Life Risks

Environmental policies reduce environmental risks to lives and, therefore, mortality. They also may improve the health of people suffering conditions (morbidity) and improve mental health. Figure 5 is a graphical representation of the relationship between the marginal willingness to pay for safety (MWTP) and the risk level.

Furthermore, the value of statistical life (VOSL) was developed in order to value life risks. It reflects the sum of individual's WTP for fatal risk reduction and therefore, the economic value to society to reduce the statistical incidence of premature death in the population by one [He and Wang, 2010].

3.4.3. Distribution of benefits and costs

Conventional CBA does not take into account population distribution or equity in decisions. That is because it focuses in efficiency. Nevertheless, if distribution is to be incorporated, as it tends to do in the newest literature, that implies the identification and possible weight of costs and benefits on individuals and groups on the basis of differences in interest [PEARCE et al., 2006]. In other words, and according to the US Environmental Protection Agency, distributional analysis "assesses changes in social welfare by examining the effects of a regulation across different sub-populations and entities". According to the OECD (2006), Kristöm's hierarchy would be a useful way of understanding the demands of distribution in CBA. These hierarchic levels consist of the following steps:

- First, there is the task of assembling and organizing raw data of the distribution of costs and benefits of a project.
- Second, these data could then be used to ask the weight or distributional adjustment that must be placed on the net benefits and net costs of a group of interest for a given project proposal in order to pass or fail a distributional cost-benefit test.
- Third, explicit weights reflecting judgment about society's preferences, towards distributional concerns can be assigned and net benefits can be estimated on this basis.

3.4.4. Sustainability

CBA and shadow prices are just a part in understanding intergenerational consequences of a project selection. Since the Brundtland Report (1987) stated that sustainable development is the “development that meets the needs of the present without compromising the ability of future generations to meet their own needs", a landmark definition of the concept; economists have defined sustainability as a requirement to follow a development path where human well-being (per capita) does not decline over time [PEARCE et al., 2006]. From that concept two main lines of thought have been developed:

- ***The weak sustainability approach***: Weak sustainability (WS) emphasizes the changes of the real value of wealth in the aggregated population. It means that any change in the real value of total wealth should not be negative in the aggregate in order to be sustainable.
- ***The strong sustainability approach***: Strong sustainability (SS) also emphasizes the conservation of critical natural capital, especially natural capital without substitutes.

3.5 Limitations of CBA and other decision-making procedures

Since CBA has advantages and disadvantages, several objections to CBA have arose with regard to the latter [Norden, 2007]:

- ***Credibility:*** costs and benefits of an action, and their economic value are often highly uncertain. Wynne (1992) in Norden (2007) distinguishes four types of uncertainty: risk, uncertainty, ignorance and indeterminacy. According to the latter, risks occur if the possible outcomes can be defined and their probabilities can be assigned in a meaningful way. If the possible outcomes are identifiable but their probabilities cannot be determined, that is uncertainty. Ignorance is when we do not know that we do not know. And indeterminacy is used to describe situations in great complex systems in which the relevant parameters and their relationships are not known.
- ***Moral objections:*** CBA is based in the assumption that all type of negative effects can be compensated by positive effects [Norden, 2007]. That is not true when negative effects include the loss of assets that have not substitutes (like human lives, or depletable resources). As a result, it is recommended to complement any CBA with the identification of negative and positive impacts that are difficult to compensate by other

effects.

- ***The efficiency focus:*** the objective of a CBA is to assess the efficiency of an action when implemented in the current economic, technological and social context. However, policies and projects often have other objectives such as fairness, equity, long-term sustainability, competitiveness, employment, regional balance, etc.
- ***Participation:*** CBA has been usually accused of not involving relevant stakeholders and presenting one-dimensional results that avoid debate.
- ***Skills:*** some expertise is necessary on the fields of economics and natural sciences in order to perform an environmental CBA or use and judge its results.

In order to take more educated decisions, there are alternatives to CBA that help to compensate the disadvantages of the latter. The following decision making procedures are usually used:

- ***Environmental Impact Assessment –*** EIA collects and measures environmental impacts of projects or policies. Impacts may become inputs in a CBA.
- ***Strategic Environmental Assessment –*** SEA is similar to an EIA but it considers entire programs of investments or policies. It looks at the synergies between individual projects and policies and evaluates alternatives in a more comprehensive manner.
- ***Life Cycle Analysis –*** LCA is also similar to an EIA, but it looks at the whole "life cycle" of impacts.
- ***Risk Assessment –*** RA collects and measures environmental and/or health risks of products, processes, projects or policies.
- ***Comparative Risk Assessment –*** CRA analyzes risks for several alternative projects or policies.
- ***Risk-Benefit Analysis –*** RBA is similar to a CBA where the risks are costs in terms of money.
- ***Risk-Risk Analysis –*** RRA looks at the behavioral responses to regulation and analyses the risks in the execution of a project or the implementation of a policy; and the risks without that execution or implementation.
- ***Health-Health Analysis –*** HHA compares the change of risks from a policy with the risks associated with the expenditure of the policy with regards to life saving.
- ***Cost-Effectiveness Analysis -*** CEA frequently involves an optimization procedure that is

defined as a systematic method for finding the lowest-cost means of accomplishing the objective. It is important to remark that all efficient measures are cost-effective, but not all cost-effective measures are efficient [Tietenberg, 2011].

- ***Multi-criteria Analysis -*** MCA is similar in many respects to CEA but involves multiple indicators of effectiveness.

CHAPTER IV

<u>CASE STUDY: OCEANÁRIO DE LISBOA</u>

REPORT ON CBA EVALUATION FOR WATER AND ENERGY CONSUMPTION REDUCTION MEASURES

4.1 Introduction to the Study Case

The Oceanário de Lisboa S.A., a Portuguese company, has been certified with the ISO 14001 since 2003. In order to comply with the continuous improvement that is required in this standard, in nine years the organization has invested €281,159 (2012€) in order to reduce its water and energy consumption, since they are its greatest environmental impact [Oceanário de Lisboa, 2011].

In order to confirm if these investments have been economically cost-effective, a retrospective cost-benefit analysis has been performed with regard to the investments in water and/or energy saving measures and the consumption savings of energy and/or water for the period 2003-2012. Therefore this analysis considers the following options:

- Option 1: No investments in water NOR energy saving measures
- Option 2: Investments in water saving measures
- Option 3: Investments in energy saving measures
- Option 4: Investments in water AND energy saving measures

Using cost-befit analysis, each option can be ranked according to their cost-effectiveness from an economic perspective.

Based on the data of the analysis, Options 1 and 2 can be clearly rejected since they are ranked last and both have negative net present values for all discount rates. Additionally Option 1 offers no environmental or social benefits. With regard to Option 2, it would be environmentally desirable to save water but there are better options.

Option 3 would be an efficient solution to be used only in case of budget restrictions on investments and Option 4 ranks first from the economic perspective and offering the best environmental and social results.

4.2 Oceanário de Lisboa

The Oceanário de Lisboa is an aquarium located in Parque das Nações, in Lisbon - Portugal. It was built and formally inaugurated in 1998 as the centerpiece of the World Fair Expo '98: The Oceans, a Heritage for the future.

The Oceanário de Lisboa complex consists of three adjacent buildings. The *Edifício dos Oceanos* was designed by a team from Cambridge Seven Associated, led by the American architect Peter Chermayeff (see Figure 4), who took into account the geographical areas represented in the inside for the orientation of the building, benefiting from sunlight, even if it is adjusted by layers of filtering materials. It is the house of the permanent exhibition.

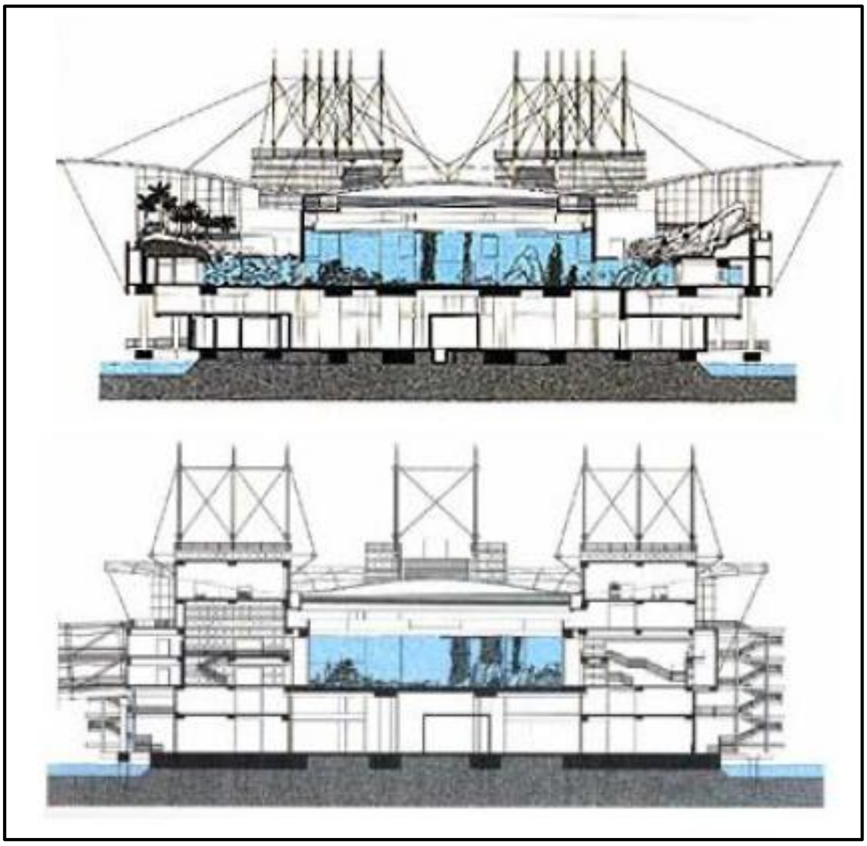

Figure 4 - The Oceanário de Lisboa by Peter Chermayeff

Source: Oceanário de Lisboa, 2013

The Support Building houses the offices, the shops, the Education Program rooms, and other support services. In 2011 the Portuguese architect Pedro Campos Costa led the building and design of the *Edifício do Mar*. This new building is intended to expand the offer of the Oceanário de Lisboa and consists of a number of spaces for temporary exhibits and customer services, a restaurant and an auditorium.

The aquarium itself retains 7,500,000 liters of salt water and 500 different species. The total area of the installation is of 20,000 square meters [Oceanário de Lisboa, 2011]. The permanent exhibition is a representation of the different ecosystems existing in the World Ocean and displays four habitats that represent the North Atlantic, the Antarctic, the tempered Pacific and the tropical Indian Ocean.

The Oceanário de Lisboa states that its mission is “to promote knowledge of the Oceans, educating visitors and the public about the necessity of protecting Natural Resources, through changing their daily habits”; to contribute to the survival of the existing biodiversity, fighting the causes of biodiversity reduction; and to have an environmentally efficient management of the aquarium. The Oceanário de Lisboa is certified with ISO 9001 and ISO 14001 since 2003, and with EMAS since 2005. It is a recognized institution in Portugal and worldwide for its efforts to promote environmental practices and attitudes, either through supporting research and educational projects, or offering bikes and public transport passes to their approximately 50 employees in order to promote environmentally friendlier transport options.

Those attitudes match the last world trends in aquariums, which lately have focused more and more in social and environmental related issues that provide them with a good image and increase the likelihood of getting grants, contracts and sponsorships. In this context, according with Martin and Kazlas (2008), aquariums are a growing industry and “...proven education, conservation, entertainment and economic development institutions in their communities...” Additionally, in order to be economically sound and sustainable, aquariums have to take into account eleven keys to success: being established on a sound financial basis; a good location and site; critical mass of attraction elements; strong thematic focus; depth of visitor experience offered; length of stay attraction content; outstanding exhibits and programs; serving residents and visitors; broad audience mix; offering multiple visit opportunities and opportunities to spend money and relax.

The following Chart 1 shows how sources of revenues have changed in the last 30 years, showing as well how the role of aquariums has also changed during that period.

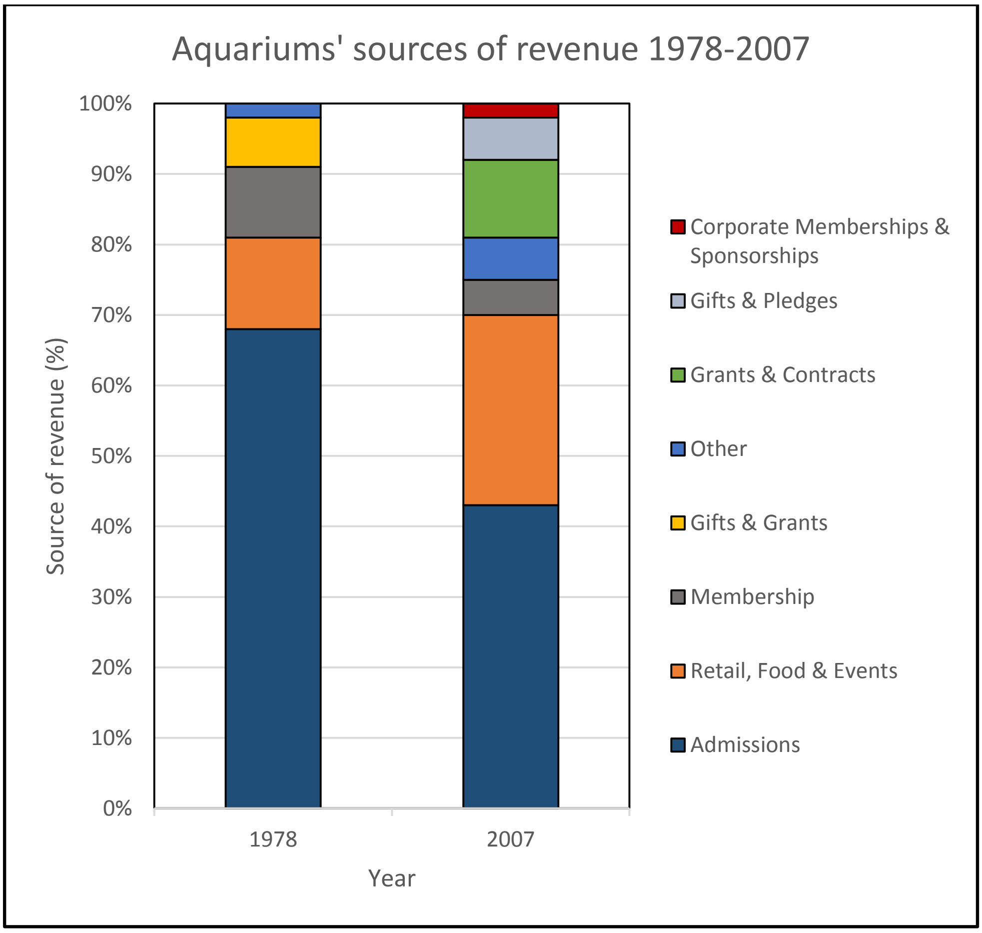

Chart 1 - Sources of revenue in aquariums -- Source: Adapted from MARTIN & KAZLAS, 2008

4.2.1. Improvement plans: objectives and targets

Continuous improvement is an essential part of the implementation of the ISO 14001 standard and a requirement to maintain the certification. To that end organizations must establish objectives and targets that improve the current environmental performance of the organization, and record their corresponding failures and successes every year. A detailed description of the Oceánio's objectives and targets for the period 2004-2011 can be found in ANNEX I. Most of those objectives and targets are focused on reducing resources consumption and waste generation, or on improving and increasing the role of the Oceanário as an environmentally responsible organization.

4.2.2. Energy and water consumption and operating costs at the Oceanário de Lisboa

4.2.2.1. Energy

Energy is an important and growing global issue. It is essential for the western way of life and it has also become an essential part of the functioning of any industrial society. Nowadays and for the whole 20th century, societies have been using and depleting fossil fuels. They are now more difficult and more expensive to extract and their intensive use has been extended to other emerging and strong economies like China, India or Brazil. These events and those seen in Chapter II have contributed to the raise of the awareness of the need of efficient uses of energy.

At the Oceanário de Lisboa energy is used for general use and to maintain the functionality of life support systems (animal's recreated ecosystems). The facility consumes three sorts of energy: electrical energy, energy originated from fuels (natural gas at the boilers and diesel fuel at the emergency generator) and thermal energy (heat transfer for air-conditioning). The Oceanário de Lisboa is considered an intensive energy consumer that undergoes periodical energy audits and has established five-year energy rationalization programs.

The Oceanário de Lisboa's supply of electrical energy is performed from a medium-voltage grid of 10kV that transforms power in three dry transformer stations (lower environmental impact): two of 1250 kVA and one of 630 kVA. The biggest energy consumers are the animal's ecosystems, or life support systems, (65.5% consumption); the HVAC system (11.5%); and the general uses (13.3%) [Oceanário de Lisboa, 2011].

In the following table 1 the consumption of energy is reflected in absolute and relative terms. After the tables there are examples of applied consumption reduction measures that were recorded and accessible for this work.

- *Energy consumption and operating costs*

TABLE 1 – ENERGY CONSUMPTION AND OPERATING COSTS 2003-2012

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Visitors	914,694.00	918,752.00	910,910.00	966,578.00	1,037,750.00	1,019,684.00	968,873.00	951,543.00	952,580.00	952,581.00
Thermal energy (cooling)										
Absolute Consumption (MWh)	5,237.00	5,880.00	6,152.00	5,782.00	5,204.00	5,121.00	4,573.00	4,573.00	6,147.00	5,539.00
Relative Consumption (MWh/1000 visitors)	5.73	6.40	6.75	5.98	5.01	5.02	4.72	4.81	6.45	5.81
Absolute operating costs (current €)	195,916.15	219,970.80	245,305.76	277,131.26	259,835.72	255,025.80	257,597.09	272,539.41	342,756.72	314,393.64
Relative operating costs (current €/1000 visitors)	214.19	239.42	269.30	286.71	250.38	250.10	265.87	286.42	359.82	330.04
Calculated price (current €/MWh)	37.41	37.41	39.87	47.93	49.93	49.80	56.33	59.60	55.76	56.76
Calculated price (2012 €/MWh)	47.01	45.55	47.42	55.64	56.21	54.73	60.34	64.37	59.40	58.33
Absolute operating costs (2012 €)	246,201.37	267,806.68	291,736.94	321,704.57	292,529.57	280,248.36	275,927.44	294,376.36	365,108.25	323,102.34
Thermal energy (heating)										
Absolute Consumption (MWh)	2,061.00	2,004.00	2,051.00	1,542.00	1,232.00	1,198.00	1,061.00	1,616.00	1,681.00	1,674.00
Relative Consumption (MWh/1000 visitors)	2.25	2.18	2.25	1.60	1.19	1.17	1.10	1.70	1.76	1.76
Absolute operating costs (current €)	70,939.62	64,969.68	70,882.56	67,369.98	56,228.48	53,898.02	55,034.07	75,257.12	86,033.58	87,349.32
Relative operating costs (current €/1000 visitors)	77.56	70.72	77.82	69.70	54.18	52.86	56.80	79.09	90.32	91.70
Calculated price (current €/MWh)	34.42	32.42	34.56	43.69	45.64	44.99	51.87	46.57	51.18	52.18
Calculated price (2012 €/MWh)	43.25	39.47	41.10	50.72	51.38	49.44	55.56	50.30	54.52	53.63
Absolute operating costs (2012 €)	89,147.48	79,098.29	84,299.13	78,205.65	63,303.43	59,228.64	58,950.24	81,287.02	91,643.92	89,768.90

- *Energy consumption and operating costs (continuation)*

TABLE 1 – ENERGY CONSUMPTION AND OPERATING COSTS 2003-2012 (continuation)

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Electricity										
Absolute Consumption (MWh)	6,790.00	6,634.00	6,776.00	6,780.00	6,418.00	6,404.00	6,773.00	6,915.00	7,313.00	6,994.00
Relative Consumption (MWh/1000 visitors)	7.42	7.22	7.44	7.01	6.18	6.28	6.99	7.27	7.68	7.34
Absolute operating costs (current €)	410,914.00	377,065.00	389,226.00	445,071.00	486,826.00	508,099.00	497,745.00	485,978.00	630,151.00	707,215.00
Relative operating costs (cur-rent €/1000 visitors)	449.24	410.41	427.29	460.46	469.12	498.29	513.74	510.73	661.52	742.42
Calculated price (current €/MWh)	60.52	56.84	57.44	65.64	75.85	79.34	73.49	70.28	86.17	101.12
Calculated price (2012 €/MWh)	76.05	69.20	68.31	76.20	85.40	87.19	78.72	75.91	91.79	103.92
Absolute operating costs (2012 €)	516,382.09	459,063.33	462,898.23	516,655.44	548,080.93	558,351.00	533,164.02	524,916.50	671,243.81	726,804.86
Energy										
Absolute energy consumption (MWh)	14,088.00	14,518.00	14,979.00	14,104.00	12,854.00	12,723.00	12,407.00	13,104.00	15,141.00	14,207.00
Relative energy consumption (MWh/1000 visitors)	15.40	15.80	16.44	14.59	12.39	12.48	12.81	13.77	15.89	14.91
Absolute energy operating costs (current €)	677,769.77	662,005.48	705,414.32	789,572.24	802,890.20	817,022.82	810,376.16	833,774.53	1,058,941.30	1,108,957.96
Absolute energy operating costs (2012 €)	851,730.94	805,968.30	838,934.29	916,565.66	903,913.93	897,828.01	868,041.70	900,579.88	1,127,995.97	1,139,676.10

As it can be seen in the previous table, energy consumption increases from 2003 until 2005, decreases from 2005 to 2010 and increases again in 2011, the year in which the *Edifício do Mar* was built. More specifically table 5 shows that from 2003 to 2012 absolute energy consumption increases only in 0.84%, even with the construction of a new building. From 2005 to 2012 absolute energy consumption was reduced in 5.15%. Relative energy consumption from 2003 to 2012 was reduced in 3.18%, while from 2005 to 2012 it was reduced in 9.31%. From 2003 to 2005 both absolute and relative energy consumption increase.

- ***Documented measures to reduce energy consumption:***

  - **Year 2003**
    - Eight speed shifters (22 kW) were installed at the pumps of the main tank
    - Initiation of the application of thermal isolation at “cool” and “heat” pipes, and in Life Support Systems
  - **Year 2004**
    - Substitution of regular lamps with halogen lamps
    - Lighting circuits monitoring with presence detectors
    - Completion of the application of thermal isolation at “cool” and “heat” pipes, and in Life Support Systems
    - Initiation of the installation of speed shifters in the pumping systems of the galleries
  - **Year 2005**
    - Optimization of the HVAC systems automatic monitoring
    - Gradual installation of electronic ballasts at the Oceanário de Lisboa's floors
    - Initiation of the installation of speed shifters in the main tank systems
    - Completion of the installation of speed shifters in the pumping systems of the galleries
    - More efficient management of the lighting and air condition schedules

- **Year 2006**
  - Optimization of the HVAC systems automatic monitoring
  - Gradual installation of electronic ballasts at the Oceanário de Lisboa's floors
  - Initiation of the installation of speed shifters in the main tank systems
  - Completion of the installation of speed shifters in the pumping systems of the galleries
  - Initiation of the installation of speed shifters in the pumping systems of the ozone contact towers (OCT). SSP pumps
  - More efficient management of the lighting and air condition schedules
- **Year 2007**
  - Optimization of the HVAC systems automatic monitoring
  - Gradual installation of electronic ballasts at the Oceanário de Lisboa's floors
  - Initiation of the installation of speed shifters in the main tank systems
  - Installation of speed shifters in the pumping systems of the ozone contact towers (OCT). SSP pumps
  - More efficient management of the lighting and air condition schedules
  - Optimization of flow rates in life support systems
- **Year 2008**
  - Modification of temperature control parameters in tank 1
  - Verification of the correct operation of FP pumps in tank 1, quadrant B
- **Year 2009**
  - Adjustment of the temperature control of tank 1
  - Substitution/ reparation of some temperature probes in air treatment units
  - Closing of the manual water-inlet valve into the boilers
  - Installation of movement/presence detection cells to control lighting according with presence
- **Year 2010**
  - Installation of an electronic speed shifter in “TB1 FP” pumps at the quarantine sector

4.2.2.2. Water

Water is an essential resource for life and for many industrial processes, but it is also a limited resource. According to UN Water (2013), the total volume of water on Earth is about 1.4 billion km^3 and the volume of freshwater is around 35 million km^3, or what is the same: about 2.5% of the total volume. In Portugal, agriculture consumes 87% of the total volume, urban purposes consume 5% of the total volume and industries consume 8% of the total volume, but what is more important is that those segments respectively waste 42%, 42%, and 29%, of the consumed water [INAG, 2013] at great economic and environmental expenses.

The water used by the Oceanário de Lisboa is supplied by the public supply. Approximately 16% of the water is used for salt-water production; and 84% is used for household-type uses, cleaning of technical areas and habitats, automatic cleaning of proteins skimmers and distilled water production [Oceanário de Lisboa, 2011].

Table 2 shows the water consumption and operating costs at the Oceanário de Lisboa. From 2003 to 2012 relative water consumption has been reduced in 25.22%, while absolute water consumption reduced in 22.13%. From 2005 to 2012 relative water consumption has been reduced in 43.90% and absolute consumption in 41.34%. From 2003 to 2005 both relative and absolute water consumption increase.

Table 3 - Water consumption and operating costs

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Visitors	914,694.00	918,752.00	910,910.00	966,578.00	1,037,750.00	1,019,684.00	968,873.00	951,543.00	952,580.00	952,581.00
Water										
Absolute Consumption (m3)	30,509.00	36,771.00	40,503.00	30,436.00	26,724.00	28,204.00	26,763.00	24,669.00	27,540.00	23,757.00
Relative Consumption (m3/1000 visitors)	33.35	40.02	44.46	31.49	25.75	27.66	27.62	25.93	28.91	24.94
Absolute operating costs (current €)	55,221.00	68,356.00	76,693.00	60,111.00	54,847.00	59,728.00	58,220.00	54,979.00	61,640.00	54,957.00
Calculated price (current €/m3)	1.81	1.86	1.89	1.97	2.05	2.12	2.18	2.23	2.24	2.31
Calculated price (2012 €/m3)	2.27	2.26	2.25	2.29	2.31	2.33	2.33	2.41	2.38	2.38
Relative operating costs (current €/1000 visitors)	60.37	74.40	84.19	62.19	52.85	58.58	60.09	57.78	64.71	57.69
Absolute operating costs (2012 €)	69,394.41	83,221.02	91,209.36	69,779.15	61,748.13	65,635.22	62,362.88	59,384.14	65,659.61	56,479.31

4.3. Methodology

The cost-benefit analysis methodology is designed to provide information about the level of costs and benefits of each identified alternative. In this case, the performed retrospective analysis values all investments that are related to energy and water consumption reduction measures at private market prices (does not include taxes, loan interests, etc.), calculates the resulted benefits from those investments, and determines if they are cost-effective.

4.3.1 Discounted cash flows and net present values

Each of the four options has been assessed using cash flows to which different discount rates (4%, 8% 12%, 16% and 20%) have been applied. Cash flows has been also converted to constant values (2012) using the Consumer Price Index in Portugal for the period 2003 to 2012. The different discount rates allow to undertake a sensitivity analysis of the net present values (NPVs). If the former are greater than zero, then the project is worth undertaking for the corresponding interest rate.

The internal rate of return (IRR) has been also tried to be determined for each component of the analysis but due to the nature of the cash flows it led to invalid results.

4.3.2 Key variables

Key variables in this report are the existence or absence of investments in water and/or energy saving measures. In Option 1 there is a scenario of no investments, so there is not reduction of consumption and the relative consumption used is maintained from 2005 forward (2005 is the year in which it is actually observed a continuous reduction of water and energy consumption). In this option the lack of savings are counted as costs, and the lack of investments as benefits.

In Options 2 and 3 only one type of investment (in water or in energy) has been taken into account.

In Option 4 there are investments in both areas (actual scenario), so those investments are the costs, and the benefits are the savings that resulted from those investments.

4.3.3 Assumptions

Any benefit-cost analysis need to make a number of assumptions. For this report, the following key assumptions have been made:

4.3.3.1 Operating costs from 2005 onwards

Actually the investments were made from 2003 to 2012 and they achieved a reduction of the consumption of energy and water. The scenarios where no investments were made assume that the relative consumption (MWh/ 1000 visitors or m^3/1000 visitors) from 2005 to 2012 remains constant in order to be able to calculate the potential costs of not reducing energy and/or water consumption. The selection of the year 2005 as a reference is due to the fact that in all cases consumption from 2005 to 2012 decreases and from 2003 to 2005 increases, so it has been considered the year of inflexion in which the reduction measures started to be effective.

4.3.3.2 Missing costs

There was not information about other costs such as labor costs, training costs, taxes costs, risk and insurance costs, and loan costs among others. All missing costs have been omitted from the analyses.

4.3.3.3 Missing benefits

Missing benefits such as partnerships and sponsorships that may have resulted from the improved environmental performance have been omitted because of the lack of information. Environmental benefits per se are not part of the analysis.

4.4 Analysis

This CBA has been performed using a spreadsheet to assure the accuracy of the calculations and it reproducibility.

The following Table 3 shows the Consumer Price Index (CPI) in Portugal for the period 2003-2012 and the resulting inflation rate that has been used to calculate the constant costs of 2012 (2012 Euros).

TABLE 3 – CPI and Inflation rate in Portugal for 2003-2012 (Instituto Nacional de Estatísticas)

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
CPI	3.22	2.37	2.45	3.11	2.45	2.59	-0.83	1.4	3.65	2.77
INFLATION RATE	1.0322	1.0237	1.0245	1.0311	1.0245	1.0259	0.9917	1.014	1.0365	1.0277

Table 4 shows the investments costs for water and energy in current and constant values that will be used in the analysis.

TABLE 4 – Energy and Water investment costs for 2003-2012 – Source: Oceanário de Lisboa

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Energy										
Energy investment costs (current €)	0.00	0.00	6,147.00	9,694.00	4,927.00	534.00	4,966.00	15,569.00	110,149.00	0.00
Energy investment costs (2012 €)	0.00	0.00	7,310.50	11,253.17	5,546.94	586.81	5,319.38	16,816.45	117,331.93	0.00
Water										
Water investment costs (current €)	44,808.00	44,081.00	2,281.00	3,599.00	12,485.00	10,587.00	28.00	11,304.00	0.00	0.00
Water investment costs (2012 €)	56,308.74	53,667.06	2,712.74	4,177.86	14,055.93	11,634.08	29.99	12,209.72	0.00	0.00
Energy & Water										
Energy & Water investment costs (current €)	44,808.00	44,081.00	8,428.00	13,293.00	17,412.00	11,121.00	4,994.00	26,873.00	110,149.00	0.00
Energy & Water investment costs (2012 €)	56,308.74	53,667.06	10,023.24	15,431.02	19,602.87	12,220.89	5,349.37	29,026.17	117,331.93	0.00
TOTAL										
Total investment costs (2012 €)	318,961.29									

Table 5 calculates benefits (money saved by reducing consumption), taking into account the increasing prices of water and energy and the assumption that if measures had not been taken, the relative consumption would be that of 2005.

Table 5 – Benefits from consumption reduction measures for 2003-2012

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Visitors	914.694,00	918.752,00	910.910,00	966.578,00	1.037.750,00	1.019.684,00	968.873,00	951.543,00	952.580,00	952.581,00
Water										
Assumed consumption (m3/1000 visitors)	33,35	40,02	44,46	44,46	44,46	44,46	44,46	44,46	44,46	44,46
Calculated price (current €/m3)	1,81	1,86	1,89	1,97	2,05	2,12	2,18	2,23	2,24	2,31
Assumed operating costs w/o investments (current €)	55.221,00	68.356,00	76.693,00	84.881,88	94.701,29	96.016,22	93.716,48	94.294,30	94.800,77	97.981,72
Actual operating costs (current €)	55.221,00	68.356,00	76.693,00	60.111,00	54.847,00	59.728,00	58.220,00	54.979,00	61.640,00	54.957,00
Calculated benefits (current €)	0,00	0,00	0,00	24.770,88	39.854,29	36.288,22	35.496,48	39.315,30	33.160,77	43.024,72
Calculated benefits (2012 €)	0,00	0,00	0,00	28.754,99	44.868,96	39.877,19	38.022,38	42.465,40	35.323,22	44.216,50
Thermal energy (cooling)										
Assumed consumption (MWh/1000 visitors)	5,73	6,40	6,75	6,75	6,75	6,75	6,75	6,75	6,75	6,75
Calculated price (current €/MWh)	37,41	37,41	39,87	47,93	49,93	49,80	56,33	59,60	55,76	56,76
Assumed operating costs w/o investments (current €)	195.916,15	219.970,80	245.305,76	312.885,32	349.941,27	342.953,95	368.593,32	382.998,78	358.727,84	365.161,65
Actual operating costs (current €)	195.916,15	219.970,80	245.305,76	277.131,26	259.835,72	255.025,80	257.597,09	272.539,41	342.756,72	314.393,64
Calculated benefits (current €)	0,00	0,00	0,00	35.754,06	90.105,55	87.928,15	110.996,23	110.459,37	15.971,12	50.768,01
Calculated benefits (2012 €)	0,00	0,00	0,00	41.504,68	101.443,09	96.624,42	118.894,61	119.309,81	17.012,61	52.174,28
Thermal energy (heating)										
Assumed consumption (MWh/1000 visitors)	2,25	2,18	2,25	2,25	2,25	2,25	2,25	2,25	2,25	2,25
Calculated price (current €/MWh)	34,42	32,42	34,56	43,69	45,64	44,99	51,87	46,57	51,18	52,18
Assumed operating costs w/o investments (current €)	70.939,62	64.969,68	70.882,56	95.084,37	106.642,07	103.293,21	113.154,88	99.775,71	109.772,09	111.917,03
Actual operating costs (current €)	70.939,62	64.969,68	70.882,56	67.369,98	56.228,48	53.898,02	55.034,07	75.257,12	86.033,58	87.349,32
Calculated benefits (current €)	0,00	0,00	0,00	27.714,39	50.413,59	49.395,19	58.120,81	24.518,59	23.738,51	24.567,71

Table 5 – Benefits from consumption reduction measures for 2003-2012 (CONTINUATION)

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Thermal energy (heating)										
Calculated benefits (2012 €)	0,00	0,00	0,00	32.171,93	56.756,89	54.280,48	62.256,63	26.483,12	25.286,52	25.248,24
Electricity										
Assumed consumption (MWh/1000 visitors)	7,42	7,22	7,44	7,44	7,44	7,44	7,44	7,44	7,44	7,44
Calculated price (current €/MWh)	60,52	56,84	57,44	65,64	75,85	79,34	73,49	70,28	86,17	101,12
Assumed operating costs w/o investments (current €)	410.914,00	377.065,00	389.226,00	471.991,78	585.550,99	601.811,59	529.651,99	497.451,53	610.588,25	716.515,65
Actual operating costs (current €)	410.914,00	377.065,00	389.226,00	445.071,00	486.826,00	508.099,00	497.745,00	485.978,00	630.151,00	707.215,00
Calculated benefits (current €)	0,00	0,00	0,00	26.920,78	98.724,99	93.712,59	31.906,99	11.473,53	-19.562,75	9.300,65
Calculated benefits (2012 €)	0,00	0,00	0,00	31.250,67	111.147,07	102.980,95	34.177,46	12.392,84	-20.838,46	9.558,27
Energy										
Calculated benefits (current €)	0,00	0,00	0,00	90.389,24	239.244,13	231.035,93	201.024,04	146.451,49	20.146,88	84.636,36
Calculated benefits (2012 €)	0,00	0,00	0,00	104.927,28	269.347,05	253.885,85	215.328,70	158.185,77	21.460,68	86.980,79
Energy & Water										
Calculated benefits (current €)	0,00	0,00	0,00	115.160,12	279.098,42	267.324,15	236.520,52	185.766,79	53.307,65	127.661,08
Calculated benefits (2012 €)	0,00	0,00	0,00	133.682,27	314.216,01	293.763,04	253.351,08	200.651,17	56.783,90	131.197,30

In Table 6, each option is analyzed separately and ranked. The development of the analysis can be seen in ANNEX II and ANNEX III.

Table 6: Project Analysis Results – NPV 2003-2012 in 2012€

	Net Present Value (Base Year 2003)			
Interest Rate	**Option 1**	**Option 2**	**Option 3**	**Option 4**
4%	-845,545.74	-703,793.49	703,793.49	845,545.74
8%	-676,783.96	-605,077.87	605,077.87	676,783.96
12%	-545,075.78	-525,357.89	525,357.89	545,075.78
16%	-441,040.72	-460,398.47	460,398.47	441,040.72
20%	-357,962.17	-407,023.02	407,023.02	357,962.17
RANK	**4**	**3**	**2**	**1**

From an economic perspective, Option 4 is preferred over the other options for 4%, 8% and 12% discount rates: it shows positive NPVs and the greatest economic results. Option 3 ranks second, being its NPVs also positive but showing weaker results for 4%, 8% and 12% discount rates. Higher discount rates show the opposite and, in this case, Option 3 overcomes Option 4 because higher discount rates prefer higher benefits at the beginning of a project. Since here continuous improvement is valuated, long-term benefits will be preferred to short-term ones. Option 1 and 2 show negative NPVs at all discount rates and economically would be disastrous options to be taken.

4.5 Conclusion

From an economic perspective, since Option 4 is the most cost-effective option, it can be said that the Oceanário took the right decision when investing in energy and water saving measures. This is mainly because of the increasing tendency of higher energy and water supply prices (Charts 2 and 3).

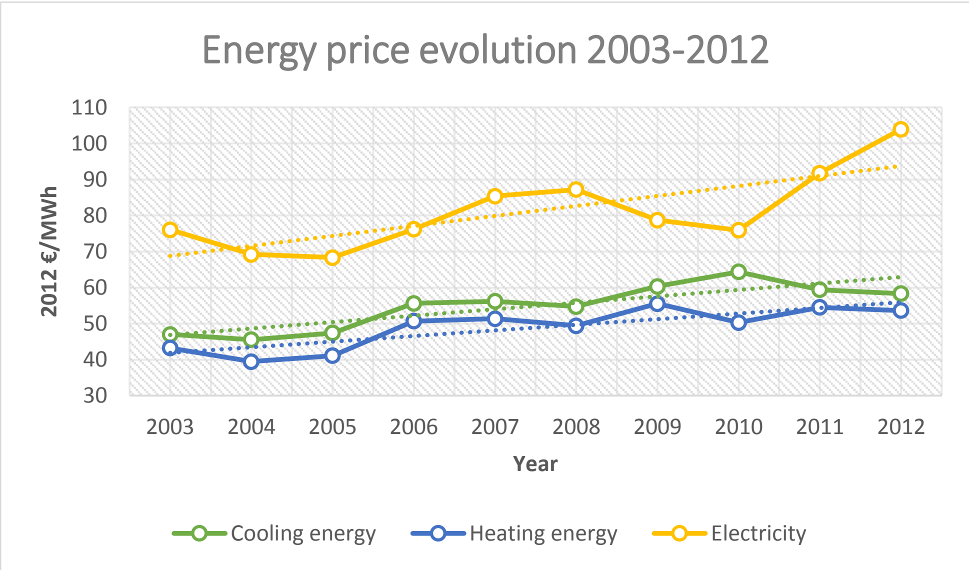

Chart 2: Energy price evolution 2003-2012 (€/MWh)

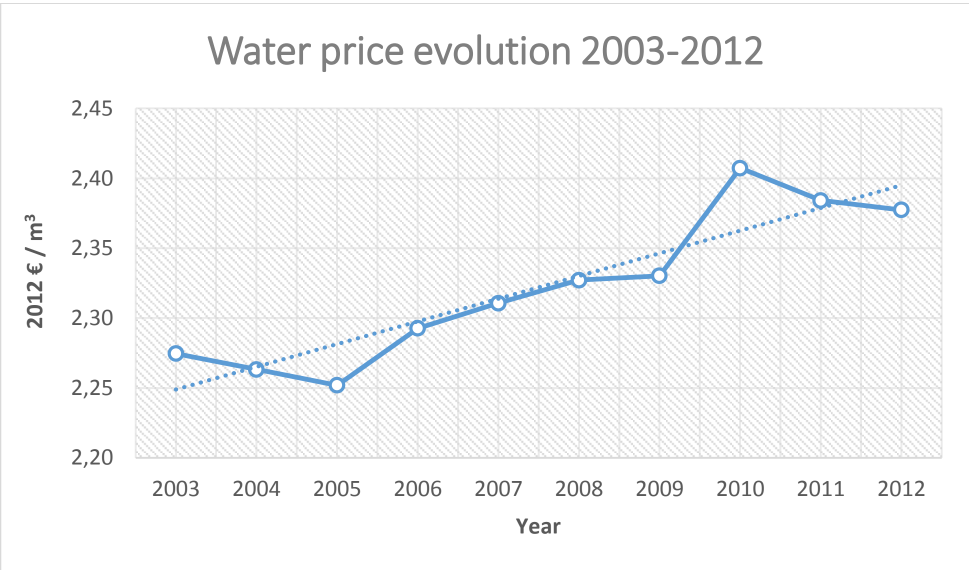

Chart 3: Water price evolution 2003-2012 (€/m³)

Charts 2 and 3 show that between 2003 and 2012, the price of cooling energy increased in 24.08%, the price of heating energy increased in 24.00%, electricity price increased in 36.65%, and the price of water increased in 4.85%. These increases are an upward trend since energy conventional sources and water are increasingly scarcer resources with always higher exploration costs. It should be noted that, since water prices increase slower than energy prices, investing in energy consumption reduction measures will be more cost-effective than investing in such measures with regard to water, as Option 3 shows for higher discount rates.

Furthermore, in order to graphically show the result of the analysis, next charts show, as an example, the cumulative cash flow (NPV) for all options at an interest rate of 12%. In ANNEX III all charts for all interest rates are included.

The following option (Option 1) that is shown in Chart 4 has not investments in energy or water saving measures and should be totally discharged, since annual NPVs (2003 NPV) are negative from 2006 onwards.

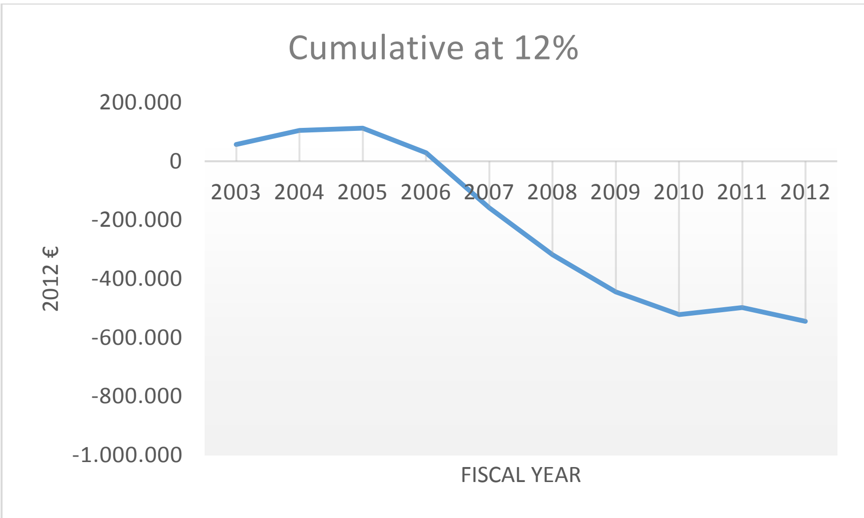

Chart 4: Option 1 at 12% discount rate

In Chart 5, annual NPVs (2003 NPV) of Option 3 (investments only in water saving measures) prove this option should be discarded since NPVs (2003 NPV) are always negative.

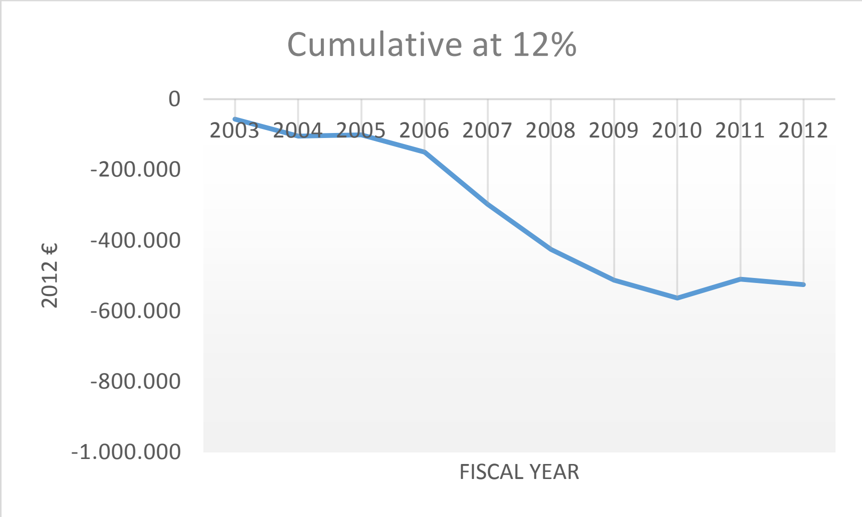

Chart 5: Option 2 at 12% interest rate

Chart 6 shows Option 3. Option 3 has positive NPVs (2003 NPV) for all discount rates but they do not reach Option 1 values for 4%, 8%, 12%. Nevertheless it should be a better option for higher discount rates and may be a good option in the case of restricted budgets.

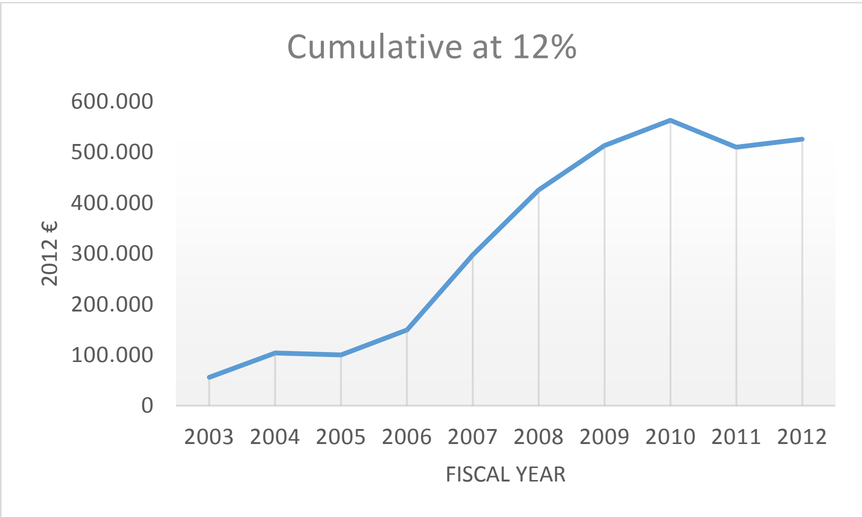

Chart 6: Option 3 at 12% discount rate

Chart 7 shows that in Option 4 investments are recouped in 2006 and the annual NPV reaches its maximum at 545,075.78 (2003 Net Present Value in 2012€) in 2012. This annual NPV chart can be also used to observe the three years payback period, that means "the number of years it takes for an investment to recover its initial cost after accounting for inflation, interest, and other matters affected by the time value of money, in order to be worthwhile to the investor" [Farlex, 2012].

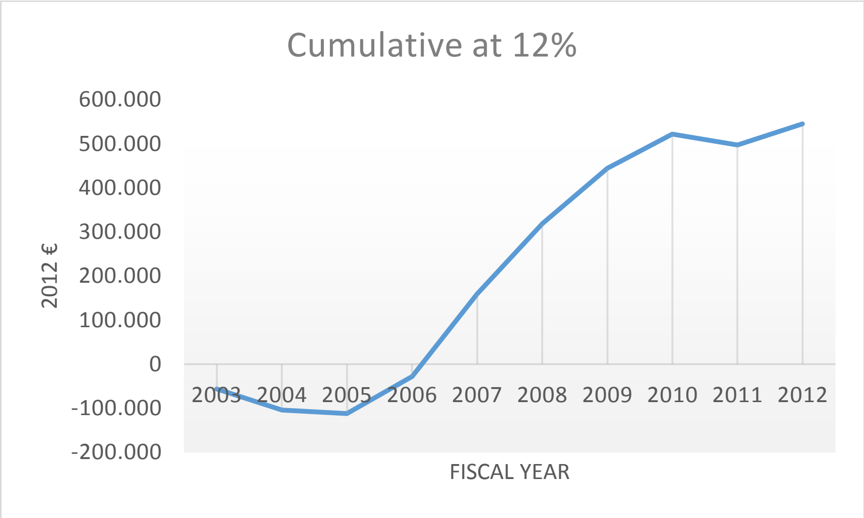

Chart 7: Option 4 at 12% interest rate

Other important data that can be drawn from the study is the consumption reduction and its relationship with investments:

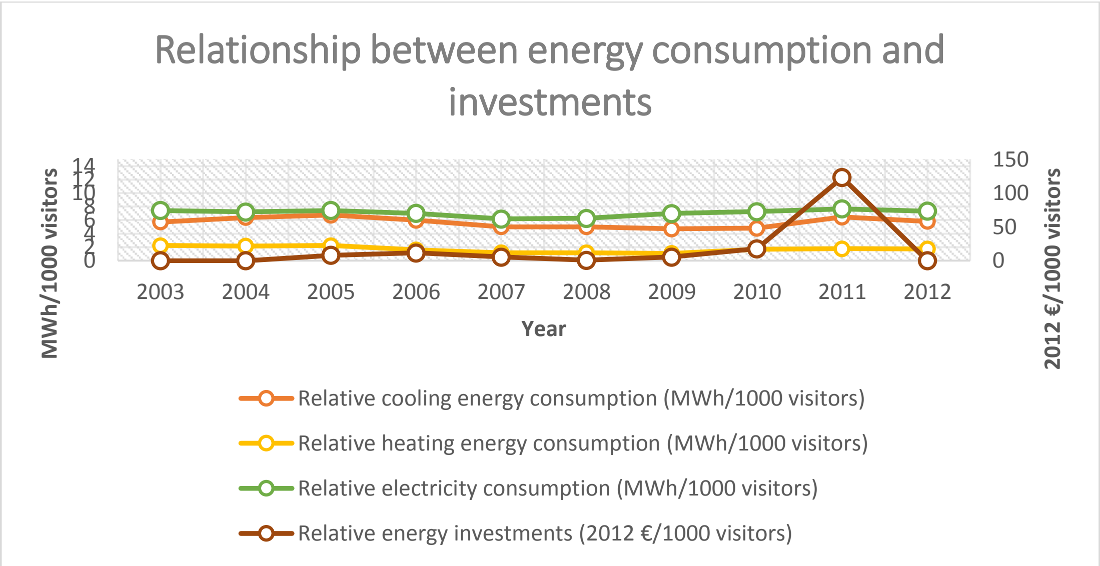

Chart 8: Relationship between energy consumption and investments 2003-2012

Chart 8 shows that specific cooling energy consumption has increased in 1.40% for the period, while specific heating energy consumption has been reduced in 21.78%, and electricity in 1.08%. Peaks in investments are followed within two years by reductions in consumption.

Chart 9 shows that water consumption has been reduced in 25.22%. This reduction is caused by a major investment in the first years that is then maintained at a low level for the rest of the period.

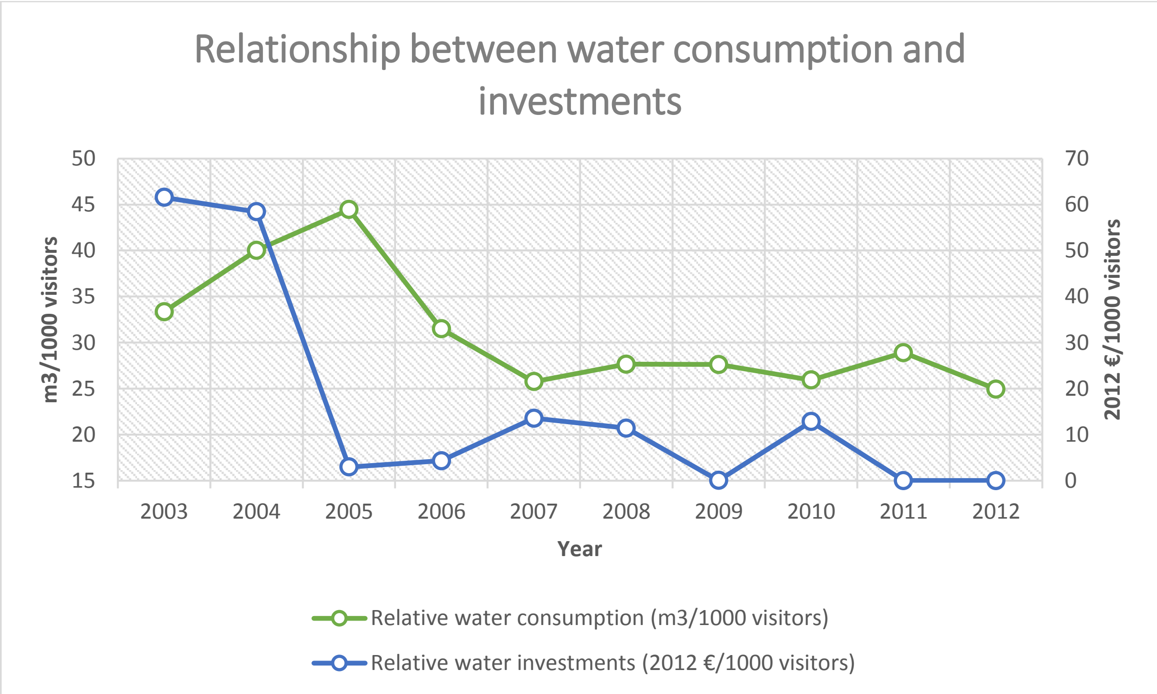

Chart 9: Relationship between energy consumption and investments 2003-2012

Furthermore, from the obtained data it is possible to forecast the future energy and water consumption and their tendency. The following figures show the linear extrapolation of the already registered water consumption in absolute and relative terms until 2017.

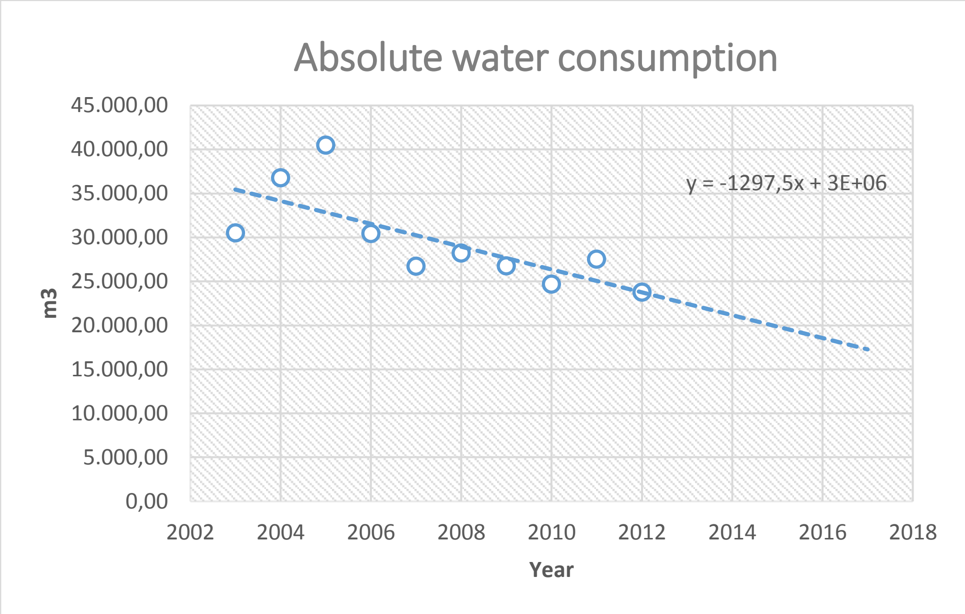

Chart 10: Absolute water consumption forecast

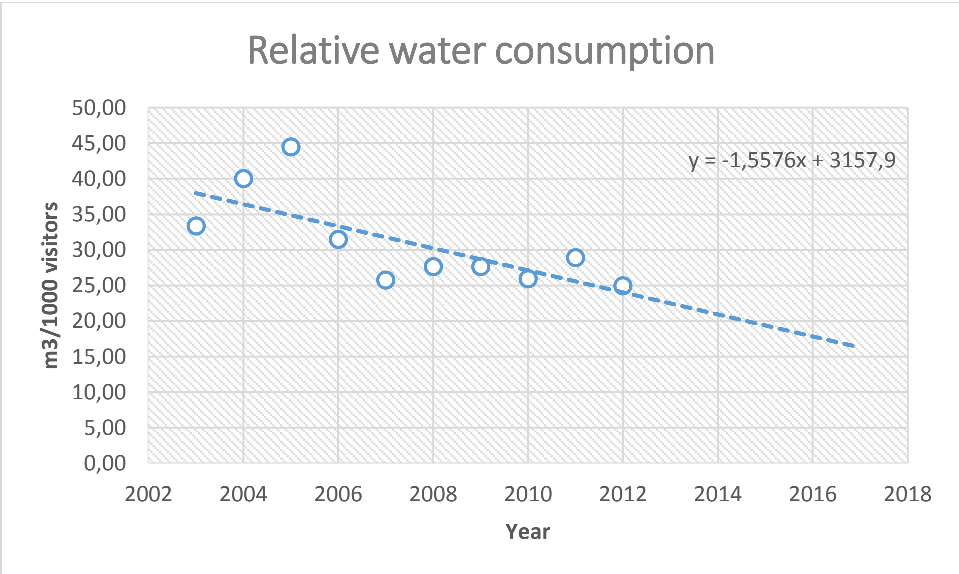

Chart 11: Relative water consumption forecast

Charts 12 and 13 show the absolute and specific energy consumption, respectively and forecast that energy consumption will be slightly reduced.

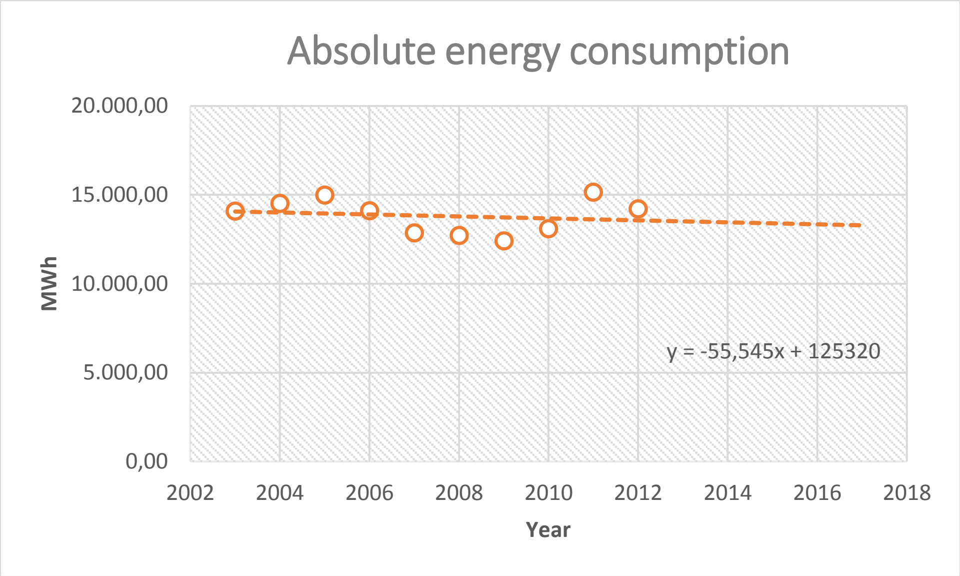

Chart 12: Absolute energy consumption forecast

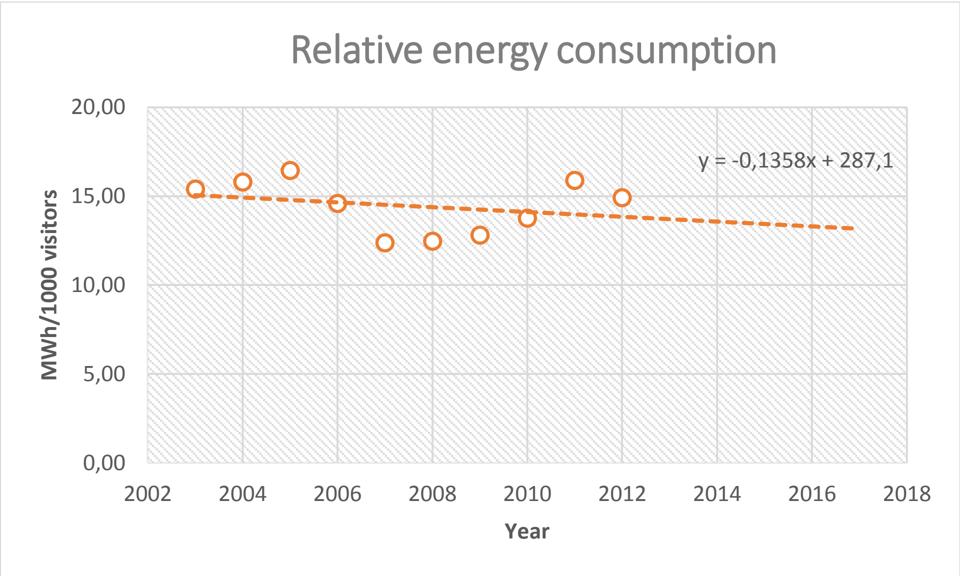

Chart 13: Relative energy consumption forecast

CHAPTER V

CONCLUSION

Chapter II addresses the importance of environment and the origin of the environmental awareness. The Environment is no longer a marginalized issue left to a few interested groups: during the last decades, waste, pollution and climate change, among others, have become major issues in society, something the general public, the media and the governments are concerned about.

Furthermore, companies and organizations, which are part of the society and responsible of most of the production and resources consumption, have seen how during this period their actions have become into focus. People, meaning customers, want to know how environmentally and socially responsible an organization is in order to consume in a responsible manner. Even consumers will start campaigns to damage an organization's image if they are unsatisfied with their environmental performance. Nowadays social media allows that individual's complaints and information reach global level just in minutes.

This second chapter also develops the concept of standardization and its origin, and the creation, development and implementation of the ISO 14001:2004. Globalization asks for homogenization and for international recognition. In this regard the ISO 14001 Standard works as a guarantee for Environmental Management Systems and serve as a tool to identify environmentally responsible organizations around the globe.

Additionally, Chapter II addresses the concept of Continuous Improvement and its central role in the ISO 14001 and in the today’s industrial world. Continuous improvement is innovation and allows companies to gain advantage over their competition. It also works as a mean of adaptation in a time of constant changes and demands, and as a mean of reaching effectiveness, efficiency and Excellency in order to survive as a company.

Chapter III covers the relationship between the environment and economics and how the latter has been developing tools in order to quantify the value of the first. The analyses of this thesis quantify the monetary value of the reduction measure investments because it is performed from a private point of view, yet saving water and energy has also other benefits that do not have a price in the market but have a value that can be eventually calculated and monetized. This third chapter also explains how a cost benefit analyses is performed (in this case in retrospective) and why it is an important tool to take decisions about the feasibility of a project, an essential part of a sustainable development that must be social, environmental and economic. Cost-Benefit Analysis should not be the only tool to make decisions but when outcomes are positive, as in this case, it may encourage companies to take environmental actions.

Finally, Chapter IV performs a retrospective cost-benefit analysis in order to assess the cost-effectiveness of the Oceanario's investments on water and energy consumption reduction measures in the framework of the ISO 14001 and its required continuous improvement. To that end four possible scenarios were displayed: Option 1 – No investments in water NOR energy consumption reduction measures; Option2 – Investments in water consumption reduction measures; Option 3 – Investments in energy consumption reduction measures; and Option 4 – Investments in water AND energy consumption reduction measures.

The results of the analysis show that Option 1 (no investments) is the worst possible scenario, registering in 2012 a loss of €-357,962.17 (2003 NPV in 2012€) at its best (interest rate at 20%) and of €-845,545.74 (2003 NPV in 2012€) at its worst (interest rate at 4%). In third place is Option 2 (investments only in water reduction), registering at the end of the studied period a loss of €-407,023.02 (2003 NPV in 2012€) at its best (interest rate at 20%) and of €-703,793.49 (2003 NPV in 2012€) at its worst (interest rate at 4%). Meanwhile Option 3 (investments only in energy reduction) registers benefits between €703,793.49 (2003 NPV in 2012€ at 4%) and €407,023.02 (2003 NPV in 2012€ at 20%). Option 3 is the best option when discount rates are high (16% and 20%), since at the beginning of the period investments costs are low, so it should be taken at those discount rates or when having budget restrictions. The fact that energy prices increase faster than water prices should be also taken into account.

Finally, as Chart 14 shows for discount rate 12%, the best case scenario is Option 4 and investing in both energy and water consumption reduction measures. For this option benefits are for amounts between €845,545.74 (2003 NPV at 4%) and €357,962.17 (2003 NPV at 20%). The outcomes show how cost-effective environmental measures and continuous improvement can be in the long-term (lower interest rates) and how they contribute not only to the environment but to make companies more efficient and competitive over time and helping the socio-economic fabric of a society.

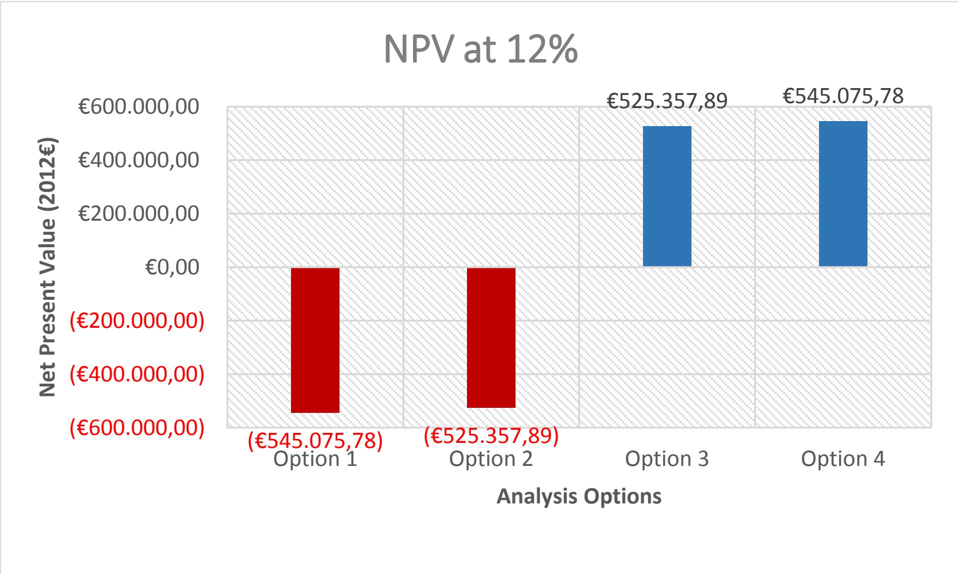

Chart 14 – Net Present Values in 2012 at interest rate 12% (the intermediate interested rate)

The analyses also proves other points such as the graphical direct relationship between investments and consumption and the time the investments need to be effective, showing how the consumption decreases approximately two years after an investment was made. In the case of the water, a big investment at the beginning of the period was enough to maintain a decreasing consumption with small investments. The case of the energy is different in part because of the construction of the *Edifício do Mar,* but the big investment made in 2011 has already is already showing some results.

Additionally, the analyses shows the steady growth trend of water and energy prices, so it is expected that the implementation of consumption reduction measures will become increasingly important in the years ahead, especially when developing countries and population are growing fast and the resources demand is always increasing.

Turning to another issues, this thesis has also served to point out the need of environmental accounting implementation or, at least, of a better organization of investments and costs related to the environment and the environmental management.

For example, the use and implementation of Environmental Accounting defined as “the study of environmental assets (property, rights and environmental obligations) of companies, that is intended to provide to internal and external users information about environmental events that cause changes in the financial situation, as well as identifying and measuring them” [Bergamini Jr., 2000] would have been extremely useful to perform this retrospective cost-benefit analyses, and it could ease the process of quantifying the benefits of environmental-related investments in order to assess the cost-effectiveness of an environmental management system. Better organization and data registering could be also essential in order to develop an optimized continuous improvement approach.

Other issues that could serve to further develop this work are:

- The adaptation to the future ISO 14001:2015, identifying the differences with the previous versions and how it has been adapted to the present times.
- The calculation of non-market environmental benefits regarding the implementation of the ISO 14001 and using the methods that were explained in this work.
- The identification of other environmental performance indicators such as the water and energy footprints of the Oceanário de Lisboa in order to identifying more areas of improvement in this regard.
- The implementation of an environmental accounting system and the performing of a retrospective cost-benefit analyses that includes other environmental related costs in addition to the energy and water consumption reduction measures.
- A cost-benefit analyses with budgetary information on future investments for the period 2013-2018.

CHAPTER VI

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ANNEX I

OCEANÁRIO DE LISBOA’S ENVIRONMENTAL PERFORMANCE IMPROVEMENT:

OBJECTIVES AND TARGETS

Table 1 - Objectives and targets for 2004

Environmental Factor	Environmental Impact	Objectives and targets
WASTE		Objective: Improving reduction, selective collection and waste valuation/disposal.
Hazardous waste		
Used oil	Environmental impacts related to hazardous waste transport and recycling (fuel consumption, noise and gases generation)	
Used batteries		Target: waste reduction in 3% (relative to 2003 values). Not applicable to Urban Waste
Ink cartridges		
UV and fluorescent lamps		
Waste for incinerating		
Health care waste	Environmental impacts related to waste transport and incineration (pollutants emissions in recycling industrial facilities)	
Recycling material		
Paper	Environmental impacts related to waste transport and recycling (fuel consumption, noise and gases generation)	Target: 3% waste reduction (relative to 2003 estimated values).
Packages		
Metallic waste, plastics and PVC		
ENVIRONMENTAL EDUCATION		
Environmental education programs integrated with school programs	Raising public awareness about environmental problems	Objectives and targets were not established.
Ocean conservation dissemination		
Allowing and enabling flora observation at the tropical area		

Table 2 - Objectives and targets for 2005

Environmental Factor	Environmental Impact	Objectives and targets
WASTE		
Hazardous waste		
Used oil	Environmental impacts related to hazardous waste transport and recycling (fuel consumption, noise and gases generation)	
Used batteries		This year, objectives and targets were not established.
Ink cartridges		
UV and fluorescent lamps		
Waste for incinerating		
Health care waste	Environmental impacts related to waste transport and incineration (pollutants emissions in recycling industrial facilities)	
Recycling material		
Paper	Environmental impacts related to waste transport and recycling (fuel consumption, noise and gases generation)	This year, objectives and targets were not established.
Packages		
Metallic waste, plastics and PVC		
NATURAL RESOURCES CONSUMPTION		Objective: Consumption reduction
Water (public supply)		
Salt-water production	Water depletion	Target: Maintaining 2004 consumption levels
Washing and cleaning		
Toilets		
Electrical power		
Energy consumption in air conditioning, life support systems and lighting		Target: Maintaining 2004 consumption levels increase under 3%
Liquid emissions		
Rain water and waste-water		This year, objectives and targets were not established.
ENVIRONMENTAL EDUCATION		
Environmental education programs integrated with school programs	Raising public awareness about environmental problems	This year, objectives and targets were not established
Ocean conservation dissemination		
Allowing and enabling flora observation at the tropical area		

Table 3 - Objectives and targets for 2006

Environmental Factor	Environmental Impact	Objectives and targets
WASTE		
Hazardous waste		
Used oil	Environmental impacts related to hazardous waste transport and recycling (fuel consumption, noise and gases generation)	
Used batteries		This year, objectives and targets were not established.
Ink cartridges		
UV and fluorescent lamps		
Waste for incinerating		
Health care waste	Environmental impacts related to waste transport and incineration (pollutants emissions in recycling industrial facilities)	
Recycling material		
Paper	Environmental impacts related to waste transport and recycling (fuel consumption, noise and gases generation)	This year, objectives and targets were not established.
Packages		
Metallic waste, plastics and PVC		
NATURAL RESOURCES CONSUMPTION		Objective: Consumption reduction
Water (public supply)		
Salt-water production	Water depletion	Target: Maintaining 2005 consumption levels
Washing and cleaning		
Toilets		
Electrical power		
Energy consumption in air conditioning, life support systems and lighting		Target: Reducing 2005 consumption levels in 1%
Liquid emissions		
Rain water and waste-water		This year, objectives and targets were not established.
ENVIRONMENTAL EDUCATION		
Environmental education programs integrated with school programs	Raising public awareness about environmental problems	This year, objectives and targets were not established.
Ocean conservation dissemination		
Influencing positively suppliers environmental performance	Improving suppliers environmental performance	Disseminating good environmental practices and auditing 3 major suppliers

Table 4 - Objectives and targets for 2007

Environmental Factor	Environmental Impact	Objectives and targets
WASTE		
Hazardous waste		
Used oil	Environmental impacts related to hazardous waste transport and recycling (fuel consumption, noise and gases generation)	
Used batteries		This year, objectives and targets were not established.
Ink cartridges		
UV and fluorescent lamps		
Waste for incinerating		
Health care waste	Environmental impacts related to waste transport and incineration (pollutants emissions in recycling industrial facilities)	
Recycling material		
Paper	Environmental impacts related to waste transport and recycling (fuel consumption, noise and gases generation)	This year, objectives and targets were not established.
Packages		
Metallic waste, plastics and PVC		
NATURAL RESOURCES CONSUMPTION		Objective: Consumption reduction
Water (public supply)		
Salt-water production	Water depletion	Target: n/a
Washing and cleaning		
Toilets		
Electrical power		
Energy consumption in air conditioning, life support systems and lighting		Target: n/a
ENVIRONMENTAL EDUCATION		
Environmental education programs integrated with school programs	Raising public awareness about environmental problems	This year, objectives and targets were not established.
Ocean conservation dissemination		
Influencing positively suppliers environmental performance	Improving suppliers environmental performance	Target: n/a

Table 5 - Objectives and targets for 2008

NUMBER	DESIGNATION
OBJECTIVE 1	NATURAL RESOURCES REDUCTION
Target 1.1	Maintaining 2007 water consumption levels
Target 1.2	Reducing 2007 energy consumption levels in 2%
OBJECTIVE 2	GASES EMISSIONS REDUCTION
Target 2.1	CO2 emissions reduction
OBJECTIVE 3	COMPLIANCE OF Oceanário de Lisboa MISSION
Target 3.1	Implementation of a system to promote research
	Oceanário-Gulbenkian Award
Target 3.2	Improving Oceanário de Lisboa's reputation in teaching on ocean's sustainability
	Certification as training institution
OBJECTIVE 4	DISSEMINATING GOOD ENVIRONMENTAL PRACTICES TO PARTNERS
Target 4.1	Raising awareness of stakeholders

Table 6 - Objectives and targets for 2010

NUMBER	DESIGNATION
OBJECTIVE 1	CONTRIBUTING TO MAINTAIN EXISTING BIODIVERSITY
Target 1.1	Supporting 3 conservation projects
Target 1.2	IN AQUA National Geographic/Oceanário de Lisboa Fund
Target 1.3	Oceanário de Lisboa / Gulbenkian Foundation Award
OBJECTIVE 2	FIGHTING BIODIVERSITY REDUCTION CAUSES
Target 2.1	“Water – a vital resource” Campaign
Target 2.2	Promoting society behavior changes
OBJECTIVE 3	ECO-EFFICIENT MANAGEMENT OF EQUIPMENT
Target 3.1	Reducing 2009 water consumption levels in 1%
Target 3.2	Reducing 2009 electricity consumption levels in 5.5%
Target 3.3	Targeting maximum consumption levels of cooling and heating energy in 5,100 MWh and 1,000 MWh, respectively
Target 3.4	Energy certification of Oceanário de Lisboa's buildings

Table 7 - Objectives and targets for 2011

NUMBER	**DESIGNATION**
OBJECTIVE 1	CONTRIBUTING TO MAINTAIN EXISTING BIODIVERSITY
Target 1.1	Supporting 3 in-situ conservation projects
Target 1.2	IN AQUA National Geographic/Oceanário de Lisboa Fund
Target 1.3	Oceanário de Lisboa's Earth Keepers – Individual grants for on-site conservation projects
OBJECTIVE 2	FIGHTING BIODIVERSITY REDUCTION CAUSES
Target 2.1	"Plastic – consumption reduction" Campaign
Target 2.2	Promoting society behavior changes
OBJECTIVE 3	ECO-EFFICIENT MANAGEMENT OF EQUIPMENT
Target 3.1	Maintaining 2010 water consumption levels increase under 15%
Target 3.2	Maintaining 2010 electricity consumption levels increase under 20%
Target 3.3	Targeting maximum consumption levels of cooling and heating energy in 6,400 MWh and 1,840 MWh, respectively
Target 3.4	Energy certification of Oceanário de Lisboa's buildings

Table 8 - Objectives and targets for 2012

NUMBER	DESIGNATION
OBJECTIVE 1	CONTRIBUTING TO MAINTAIN EXISTING BIODIVERSITY
Target 1.1	Supporting 3 in-situ conservation projects
Target 1.2	IN AQUA National Geographic/Oceanário de Lisboa Fund 2012
OBJECTIVE 2	FIGHTING BIODIVERSITY REDUCTION CAUSES
Target 2.1	"Plastic – consumption reduction" Campaign
Target 2.2	Promoting society behavior changes
OBJECTIVE 3	ECO-EFFICIENT MANAGEMENT OF EQUIPMENT
Target 3.1	Reducing 2011 water consumption levels in 1%
Target 3.2	Reducing 2011 electricity consumption levels in 5%
Target 3.3	Reducing 2011 cooling and heating energy consumption levels in 5%
Target 3.4	Energy certification of Oceanário de Lisboa's buildings

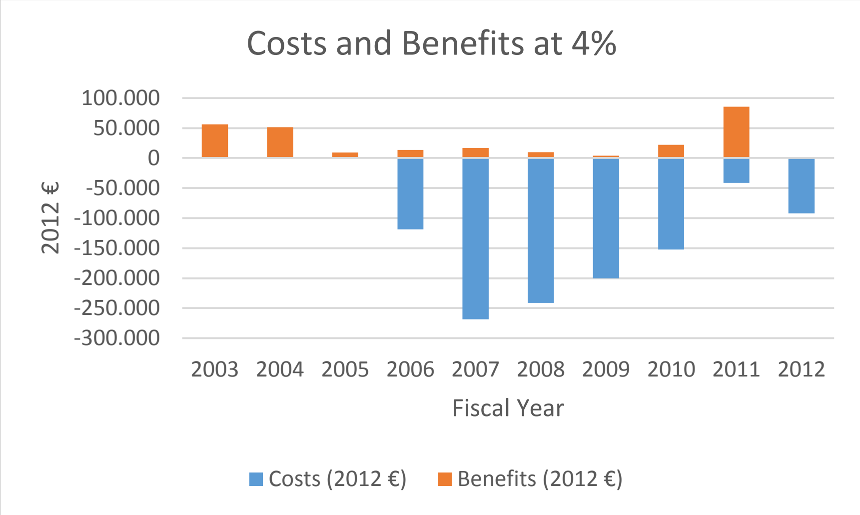
ANNEX II

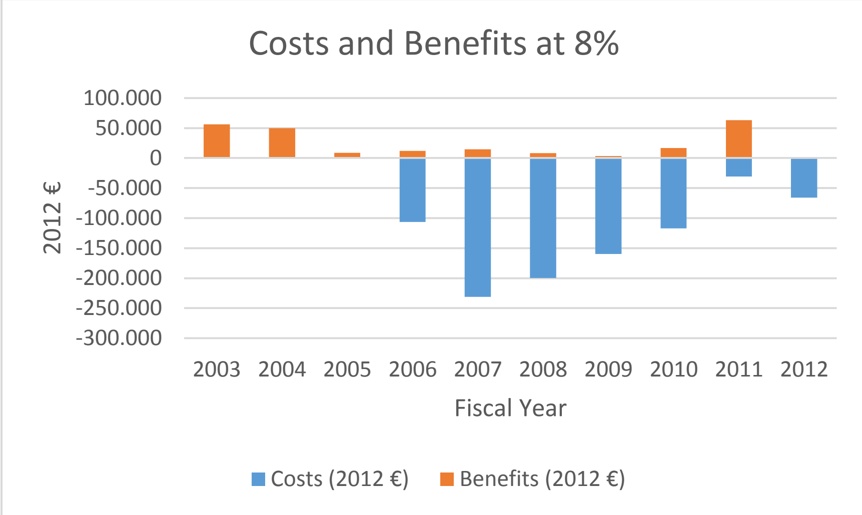
<u>COST-BENEFIT ANALYSIS</u>

OPTION 1

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Cash Flows w/o Discount										
Costs (2012 €)	0,00	0,00	0,00	-133.682,27	-314.216,01	-293.763,04	-253.351,08	-200.651,17	-56.783,90	-131.197,30
Benefits (2012 €)	56.308,74	53.667,06	10.023,24	15.431,02	19.602,87	12.220,89	5.349,37	29.026,17	117.331,93	0,00
Net Cash Flow (2012 €)	56.308,74	53.667,06	10.023,24	-118.251,25	-294.613,14	-281.542,15	-248.001,71	-171.625,00	60.548,03	-131.197,30
Base Year	2003									
Year Index	0	1	2	3	4	5	6	7	8	9
Discount rate	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Discount factor	1	0,96153846	0,92455621	0,88899636	0,85480419	0,82192711	0,79031453	0,75991781	0,73069021	0,70258674
Cash Flows at 4%										
Costs (2012 €)	0,00	0,00	0,00	-118843,05	-268593,16	-241451,81	-200227,04	-152478,40	-41491,44	-92177,48
Benefits (2012 €)	56308,74	51602,94	9267,05	13718,12	16756,61	10044,68	4227,68	22057,51	85733,29	0,00
Net Cash Flow (2012 €)	56308,74	51602,94	9267,05	-105124,93	-251836,55	-231407,13	-195999,35	-130420,89	44241,85	-92177,48
Cumulative (2012 €)	56308,74	107911,68	117178,73	12053,80	-239782,74	-471189,87	-667189,22	-797610,12	-753368,26	-845545,74
2003 NPV (2012 €)	-845.545,74 €									
Discount rate	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%
Discount factor	1	0,92592593	0,85733882	0,79383224	0,73502985	0,6805832	0,63016963	0,5834904	0,54026888	0,50024897
Cash Flows at 8%										
Costs (2012 €)	0,00	0,00	0,00	-106121,30	-230958,14	-199930,19	-159654,15	-117078,03	-30678,57	-65631,31
Benefits (2012 €)	56308,74	49691,72	8593,31	12249,64	14408,69	8317,33	3371,01	16936,49	63390,79	0,00
Net Cash Flow (2012 €)	56308,74	49691,72	8593,31	-93871,65	-216549,45	-191612,86	-156283,14	-100141,54	32712,22	-65631,31
Cumulative (2012 €)	56308,74	106000,46	114593,78	20722,12	-195827,33	-387440,19	-543723,33	-643864,87	-611152,65	-676783,96
2003 NPV (2012 €)	-676.783,96 €									

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Discount rate	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%
Discount factor	1	0,89285714	0,79719388	0,71178025	0,63551808	0,56742686	0,50663112	0,45234922	0,40388323	0,36061002
Cash Flows at 12%										
Costs (2012 €)	0,00	0,00	0,00	-95152,40	-199689,95	-166689,04	-128355,54	-90764,40	-22934,06	-47311,06
Benefits (2012 €)	56308,74	47917,02	7990,47	10983,50	12457,98	6934,46	2710,16	13129,97	47388,40	0,00
Net Cash Flow (2012 €)	56308,74	47917,02	7990,47	-84168,90	-187231,98	-159754,58	-125645,38	-77634,43	24454,34	-47311,06
Cumulative (2012 €)	56308,74	104225,76	112216,22	28047,32	-159184,66	-318939,23	-444584,62	-522219,05	-497764,72	-545075,78
2003 NPV (2012 €)	-545.075,78 €									
Discount rate	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%
Discount factor	1	0,86206897	0,7431629	0,64065767	0,5522911	0,47611302	0,41044225	0,35382953	0,30502546	0,26295298
Cash Flows at 16%										
Costs (2012 €)	0,00	0,00	0,00	-85644,57	-173538,70	-139864,41	-103985,99	-70996,31	-17320,53	-34498,72
Benefits (2012 €)	56308,74	46264,71	7448,90	9886,00	10826,49	5818,52	2195,61	10270,32	35789,23	0,00
Net Cash Flow (2012 €)	56308,74	46264,71	7448,90	-75758,57	-162712,21	-134045,88	-101790,38	-60725,99	18468,69	-34498,72
Cumulative (2012 €)	56308,74	102573,45	110022,35	34263,78	-128448,44	-262494,32	-364284,70	-425010,69	-406542,00	-441040,72
2003 NPV (2012 €)	-441.040,72 €									
Discount rate	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Discount factor	1	0,83333333	0,69444444	0,5787037	0,48225309	0,40187757	0,33489798	0,27908165	0,23256804	0,1938067
Cash Flows at 20%										
Costs (2012 €)	0,00	0,00	0,00	-77362,43	-151531,64	-118056,78	-84846,76	-55998,06	-13206,12	-25426,91
Benefits (2012 €)	56308,74	44722,55	6960,58	8929,99	9453,54	4911,30	1791,49	8100,67	27287,66	0,00
Net Cash Flow (2012 €)	56308,74	44722,55	6960,58	-68432,44	-142078,10	-113145,48	-83055,27	-47897,39	14081,54	-25426,91
Cumulative (2012 €)	56308,74	101031,29	107991,87	39559,44	-102518,66	-215664,13	-298719,41	-346616,79	-332535,25	-357962,17
2003 NPV (2012 €)	-357.962,17 €									


Costs and Benefits at 4%
100.000
50.000
0
-50.000
-100.000
-150.000
-200.000
-250.000
-300.000
2012 €
2003 2004 2005 2006 2007 2008 2009 2010 2011 2012
Fiscal Year
Costs (2012 €)
Benefits (2012 €)


Costs and Benefits at 8%
100.000
50.000
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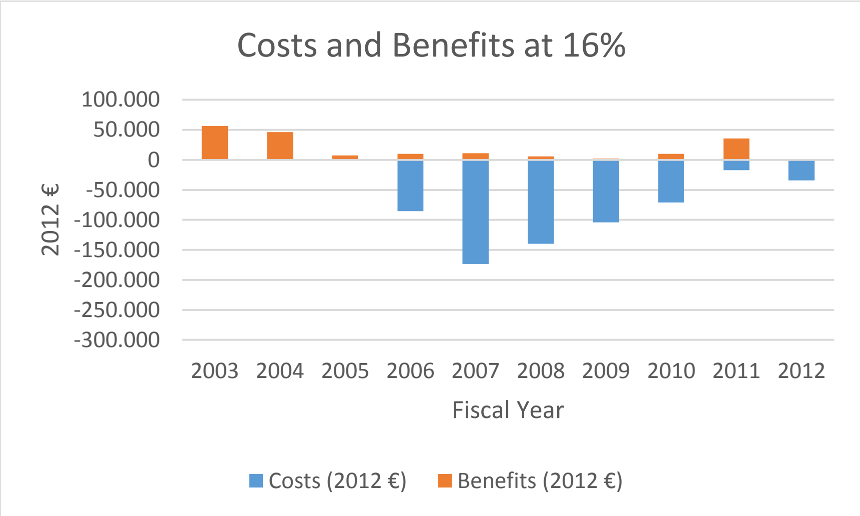
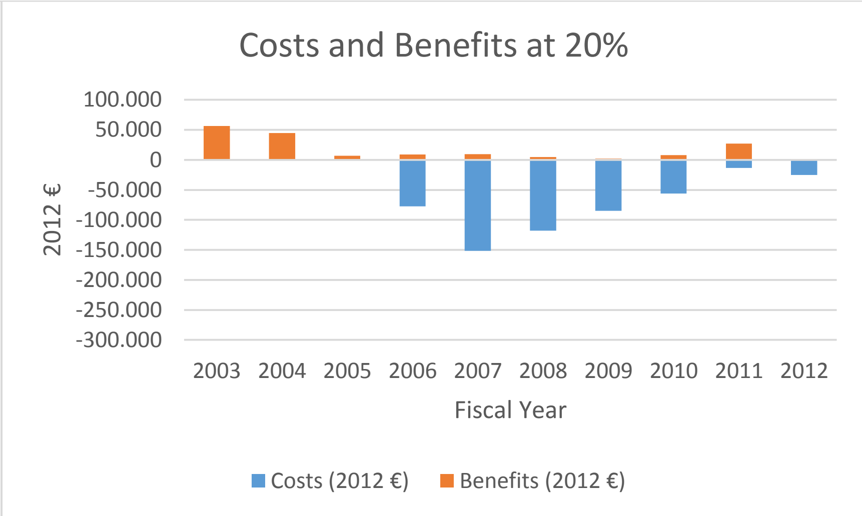
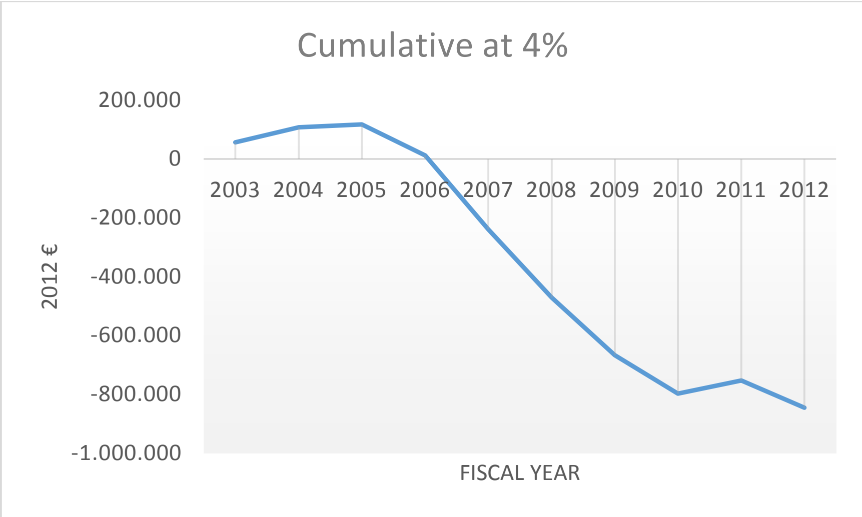
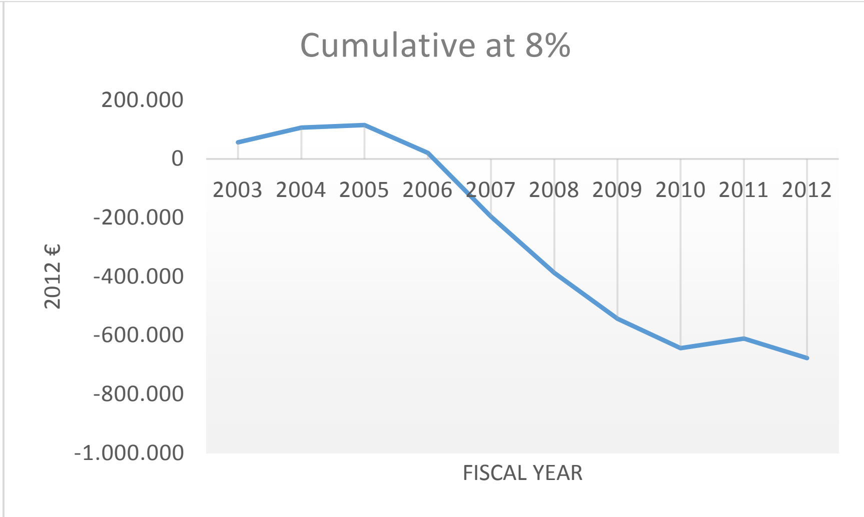
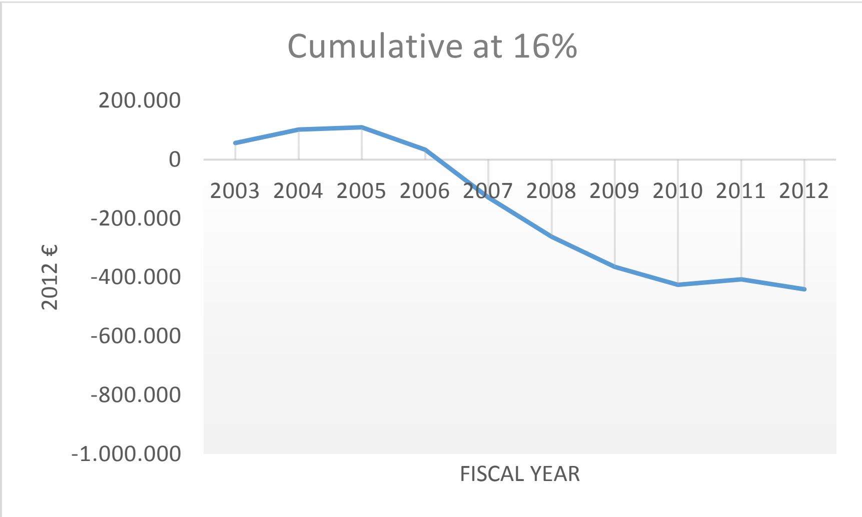
-50.000
-100.000
-150.000
-200.000
-250.000
-300.000
2012 €
2003 2004 2005 2006 2007 2008 2009 2010 2011 2012
Fiscal Year
Costs (2012 €)
Benefits (2012 €)

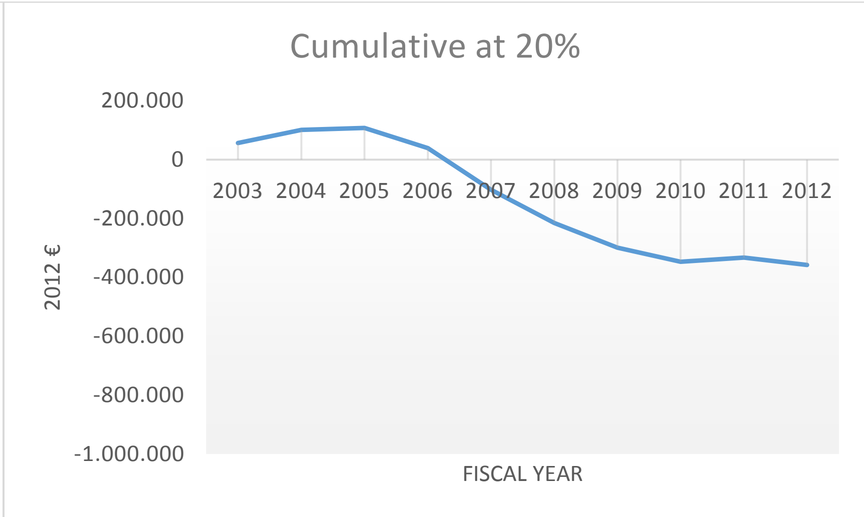

Costs and Benefits at 16%
100.000
50.000
0
-50.000
-100.000
-150.000
-200.000
-250.000
-300.000
2012 €
2003 2004 2005 2006 2007 2008 2009 2010 2011 2012
Fiscal Year
Costs (2012 €)
Benefits (2012 €)


Costs and Benefits at 20%
100.000
50.000
0
-50.000
-100.000
-150.000
-200.000
-250.000
-300.000
2012 €
2003 2004 2005 2006 2007 2008 2009 2010 2011 2012
Fiscal Year
Costs (2012 €)
Benefits (2012 €)


Cumulative at 4%
200.000
0
-200.000
-400.000
-600.000
-800.000
-1.000.000
2012 €
2003 2004 2005 2006 2007 2008 2009 2010 2011 2012
FISCAL YEAR


Cumulative at 8%
200.000
0
-200.000
-400.000
-600.000
-800.000
-1.000.000
2012 €
2003 2004 2005 2006 2007 2008 2009 2010 2011 2012
FISCAL YEAR

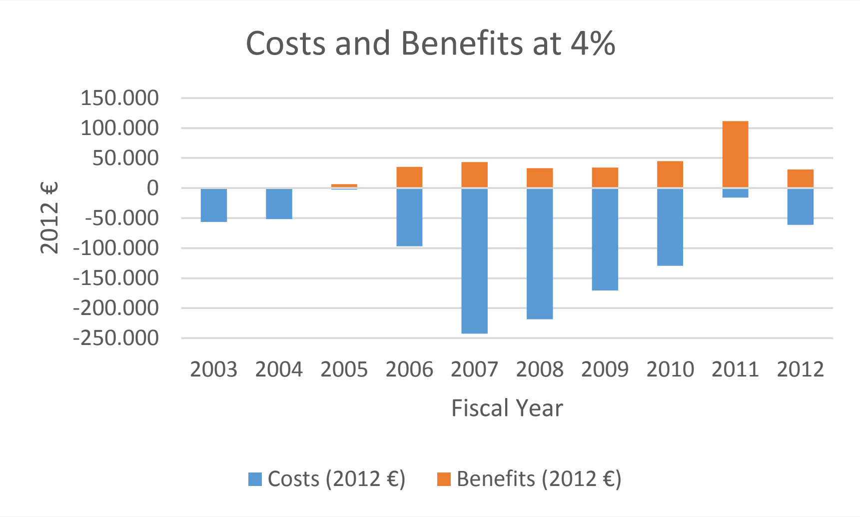

Cumulative at 16%
200.000
0
-200.000
-400.000
-600.000
-800.000
-1.000.000
2012 €
2003 2004 2005 2006 2007 2008 2009 2010 2011 2012
FISCAL YEAR

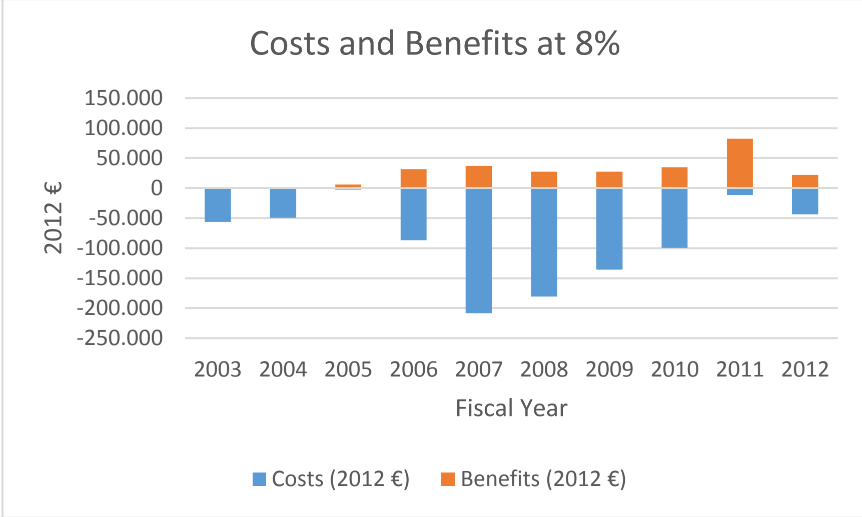

Cumulative at 20%
200.000
0
-200.000
-400.000
-600.000
-800.000
-1.000.000
2012 €
2003 2004 2005 2006 2007 2008 2009 2010 2011 2012
FISCAL YEAR

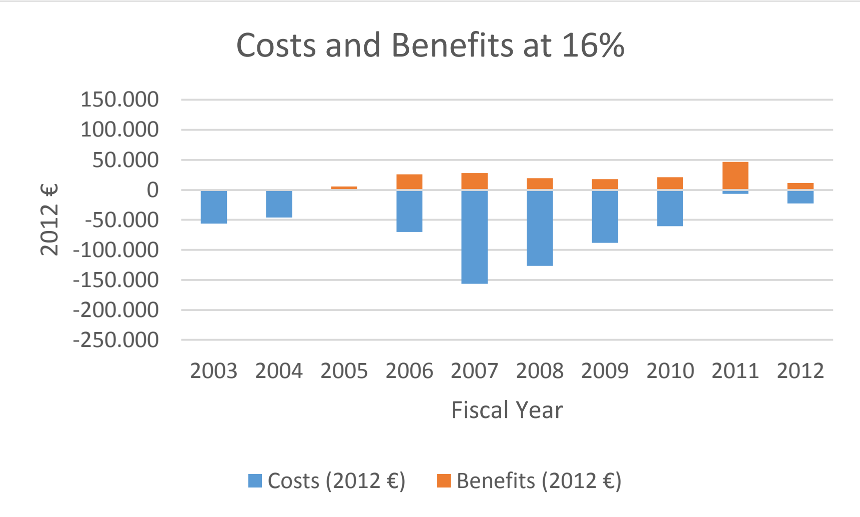
OPTION 2

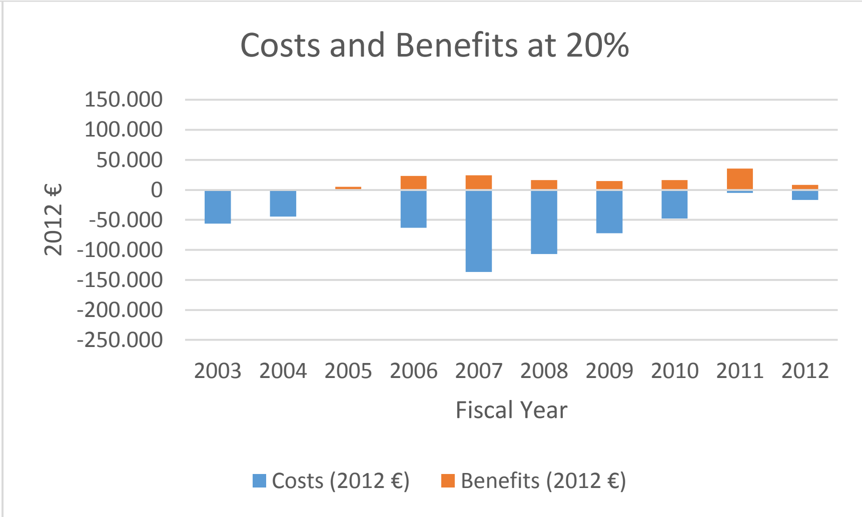
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Cash Flows w/o Discount										
Costs (2012 €)	-56.308,74	-53.667,06	-2.712,74	-109.105,14	-283.402,98	-265.519,92	-215.358,69	-170.395,49	-21.460,68	-86.980,79
Benefits (2012 €)	0,00	0,00	7.310,50	40.008,15	50.415,90	40.464,01	43.341,75	59.281,85	152.655,15	44.216,50
Net Cash Flow (2012 €)	-56.308,74	-53.667,06	4.597,75	-69.096,99	-232.987,08	-225.055,91	-172.016,94	-111.113,64	131.194,48	-42.764,29
Base Year	2003									
Year Index	0	1	2	3	4	5	6	7	8	9
Discount rate	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Discount factor	1	0,96153846	0,92455621	0,88899636	0,85480419	0,82192711	0,79031453	0,75991781	0,73069021	0,70258674
Cash Flows at 4%										
Costs (2012 €)	-56308,74	-51602,94	-2508,09	-96994,07	-242254,05	-218238,02	-170201,10	-129486,57	-15681,11	-61111,55
Benefits (2012 €)	0,00	0,00	6758,97	35567,10	43095,72	33258,47	34253,62	45049,33	111543,63	31065,93
Net Cash Flow (2012 €)	-56308,74	-51602,94	4250,88	-61426,97	-199158,33	-184979,56	-135947,49	-84437,24	95862,52	-30045,62
Cumulative (2012 €)	-56308,74	-107911,68	-103660,80	-165087,77	-364246,10	-549225,66	-685173,15	-769610,38	-673747,87	-703793,49
2003 NPV (2012 €)	-703.793,49 €									
Discount rate	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%
Discount factor	1	0,92592593	0,85733882	0,79383224	0,73502985	0,6805832	0,63016963	0,5834904	0,54026888	0,50024897
Cash Flows at 8%										
Costs (2012 €)	-56308,74	-49691,72	-2325,74	-86611,18	-208309,65	-180708,40	-135712,51	-99424,13	-11594,54	-43512,05
Benefits (2012 €)	0,00	0,00	6267,57	31759,76	37057,19	27539,12	27312,66	34590,39	82474,83	22119,26
Net Cash Flow (2012 €)	-56308,74	-49691,72	3941,83	-54851,42	-171252,46	-153169,27	-108399,85	-64833,74	70880,29	-21392,79
Cumulative (2012 €)	-56308,74	-106000,46	-102058,63	-156910,05	-328162,50	-481331,78	-589731,63	-654565,37	-583685,08	-605077,87
2003 NPV (2012 €)	-605.077,87 €									

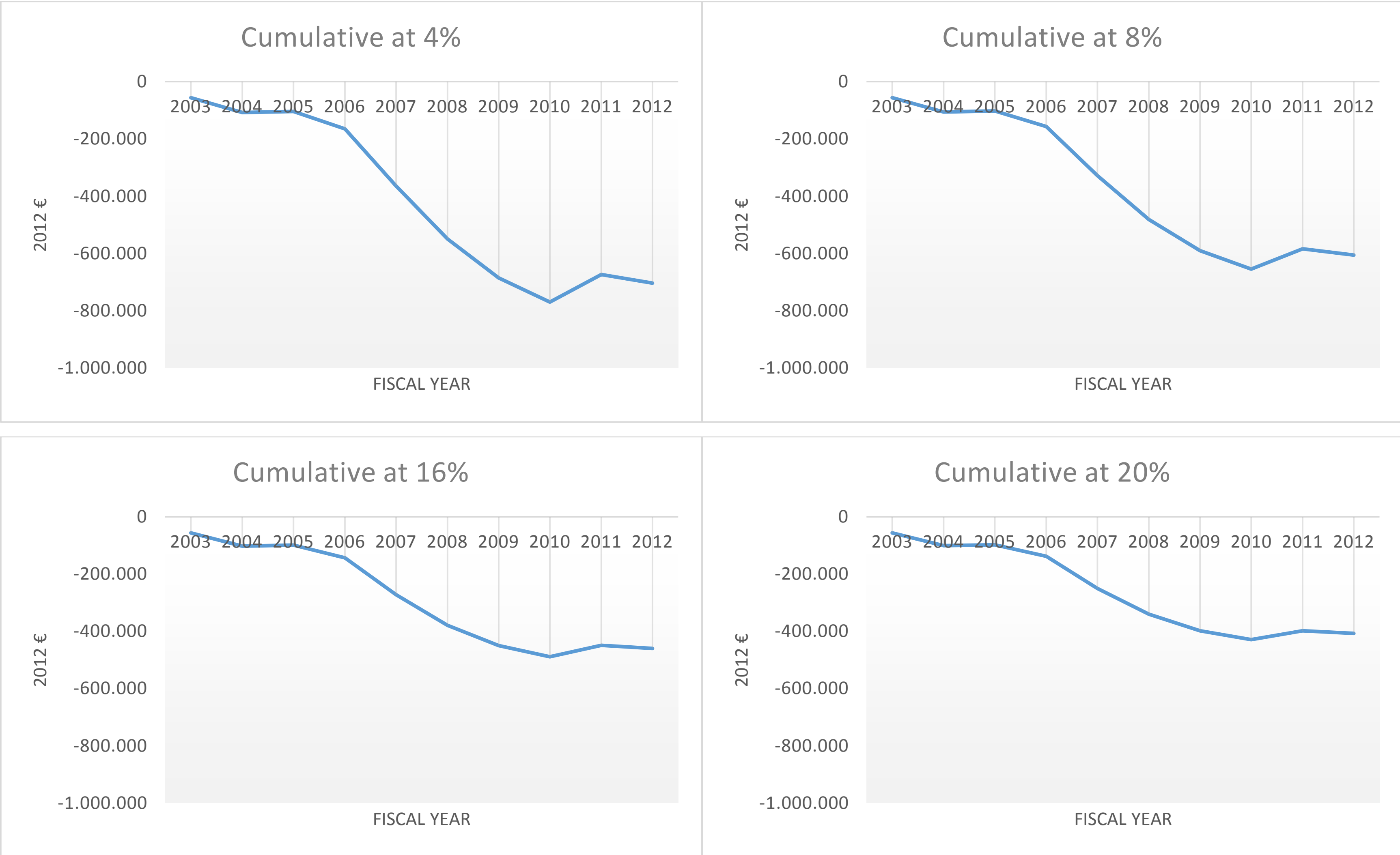
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Discount rate	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%
Discount factor	1	0,89285714	0,79719388	0,71178025	0,63551808	0,56742686	0,50663112	0,45234922	0,40388323	0,36061002
Cash Flows at 12%										
Costs (2012 €)	-56308,74	-47917,02	-2162,58	-77658,88	-180107,71	-150663,13	-109107,42	-77078,27	-8667,61	-31366,15
Benefits (2012 €)	0,00	0,00	5827,88	28477,01	32040,21	22960,36	21958,28	26816,10	61654,86	15944,91
Net Cash Flow (2012 €)	-56308,74	-47917,02	3665,30	-49181,87	-148067,50	-127702,77	-87149,14	-50262,17	52987,25	-15421,23
Cumulative (2012 €)	-56308,74	-104225,76	-100560,46	-149742,33	-297809,83	-425512,60	-512661,73	-562923,90	-509936,65	-525357,89
2003 NPV (2012 €)	-525.357,89 €									
Discount rate	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%
Discount factor	1	0,86206897	0,7431629	0,64065767	0,5522911	0,47611302	0,41044225	0,35382953	0,30502546	0,26295298
Cash Flows at 16%										
Costs (2012 €)	-56308,74	-46264,71	-2016,01	-69899,05	-156520,94	-126417,49	-88392,31	-60290,96	-6546,05	-22871,86
Benefits (2012 €)	0,00	0,00	5432,89	25631,53	27844,25	19265,44	17789,29	20975,67	46563,71	11626,86
Net Cash Flow (2012 €)	-56308,74	-46264,71	3416,88	-44267,51	-128676,69	-107152,05	-70603,02	-39315,29	40017,65	-11245,00
Cumulative (2012 €)	-56308,74	-102573,45	-99156,57	-143424,08	-272100,77	-379252,82	-449855,84	-489171,13	-449153,48	-460398,47
2003 NPV (2012 €)	-460.398,47 €									
Discount rate	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Discount factor	1	0,83333333	0,69444444	0,5787037	0,48225309	0,40187757	0,33489798	0,27908165	0,23256804	0,1938067
Cash Flows at 20%										
Costs (2012 €)	-56308,74	-44722,55	-1883,85	-63139,55	-136671,96	-106706,50	-72123,19	-47554,25	-4991,07	-16857,46
Benefits (2012 €)	0,00	0,00	5076,73	23152,87	24313,22	16261,58	14515,07	16544,48	35502,71	8569,45
Net Cash Flow (2012 €)	-56308,74	-44722,55	3192,88	-39986,68	-112358,74	-90444,92	-57608,13	-31009,78	30511,64	-8288,01
Cumulative (2012 €)	-56308,74	-101031,29	-97838,41	-137825,09	-250183,83	-340628,75	-398236,88	-429246,65	-398735,01	-407023,02
2003 NPV (2012 €)	-407.023,02 €									


Costs and Benefits at 4%
150.000
100.000
50.000
0
-50.000
-100.000
-150.000
-200.000
-250.000
2012 €
2003 2004 2005 2006 2007 2008 2009 2010 2011 2012
Fiscal Year
Costs (2012 €)
Benefits (2012 €)


Costs and Benefits at 8%
150.000
100.000
50.000
0
-50.000
-100.000
-150.000
-200.000
-250.000
2012 €
2003 2004 2005 2006 2007 2008 2009 2010 2011 2012
Fiscal Year
Costs (2012 €)
Benefits (2012 €)


Costs and Benefits at 16%
150.000
100.000
50.000
0
-50.000
-100.000
-150.000
-200.000
-250.000
2012 €
2003 2004 2005 2006 2007 2008 2009 2010 2011 2012
Fiscal Year
Costs (2012 €)
Benefits (2012 €)

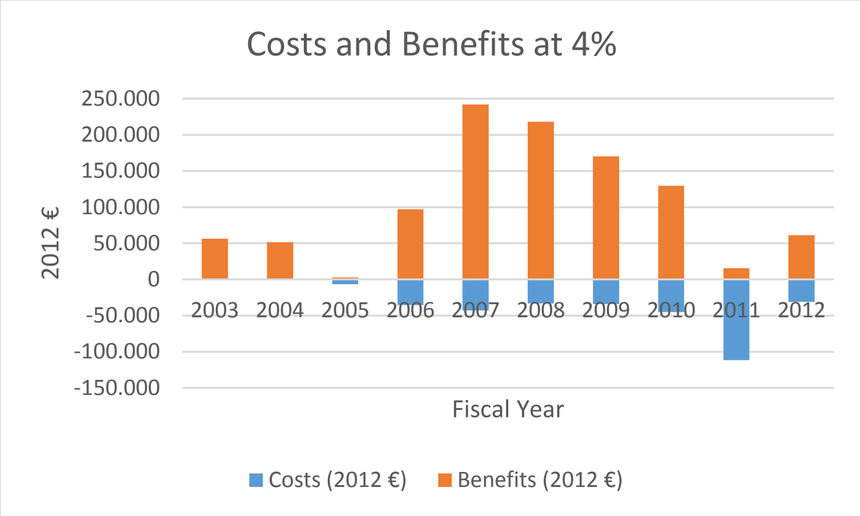

Costs and Benefits at 20%
150.000
100.000
50.000
0
-50.000
-100.000
-150.000
-200.000
-250.000
2012 €
2003 2004 2005 2006 2007 2008 2009 2010 2011 2012
Fiscal Year
Costs (2012 €)
Benefits (2012 €)

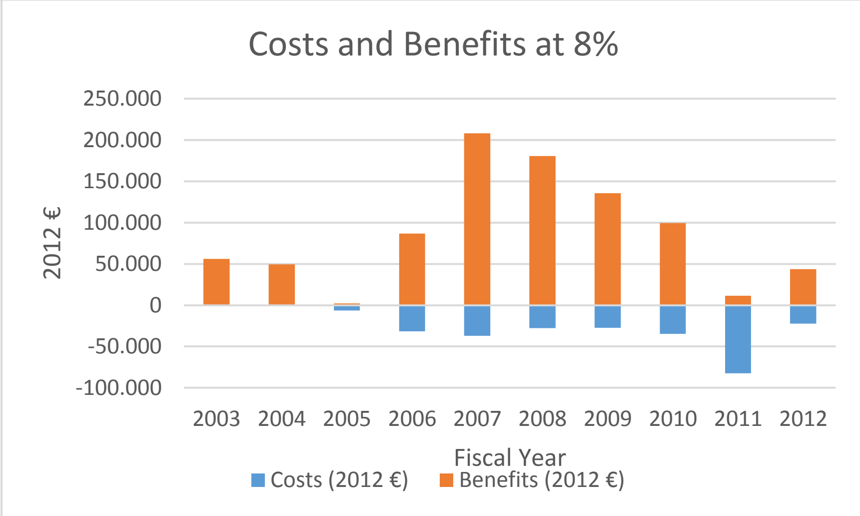

Cumulative at 4%
0
-200.000
-400.000
-600.000
-800.000
-1.000.000
2012 €
2003 2004 2005 2006 2007 2008 2009 2010 2011 2012
FISCAL YEAR
Cumulative at 8%
0
-200.000
-400.000
-600.000
-800.000
-1.000.000
2012 €
2003 2004 2005 2006 2007 2008 2009 2010 2011 2012
FISCAL YEAR
Cumulative at 16%
0
-200.000
-400.000
-600.000
-800.000
-1.000.000
2012 €
2003 2004 2005 2006 2007 2008 2009 2010 2011 2012
FISCAL YEAR
Cumulative at 20%
0
-200.000
-400.000
-600.000
-800.000
-1.000.000
2012 €
2003 2004 2005 2006 2007 2008 2009 2010 2011 2012
FISCAL YEAR

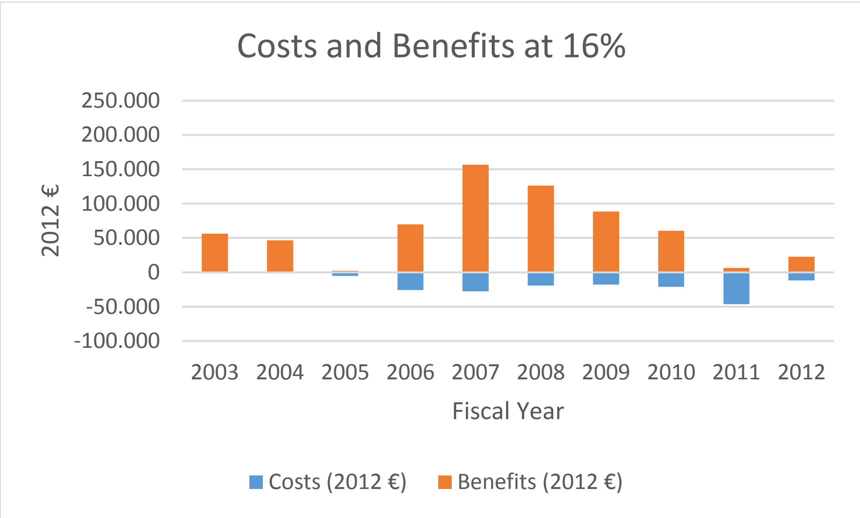
OPTION 3

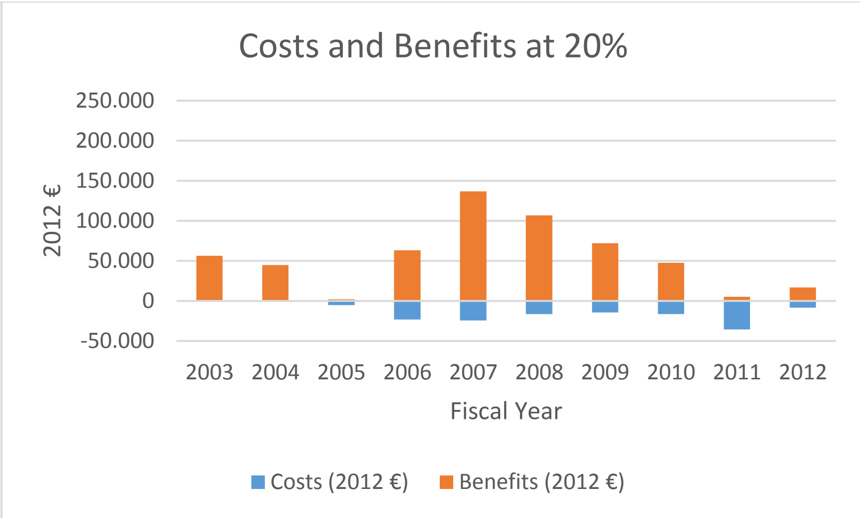
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Cash Flows w/o Discount										
Costs (2012 €)	0,00	0,00	-7.310,50	-40.008,15	-50.415,90	-40.464,01	-43.341,75	-59.281,85	-152.655,15	-44.216,50
Benefits (2012 €)	56.308,74	53.667,06	2.712,74	109.105,14	283.402,98	265.519,92	215.358,69	170.395,49	21.460,68	86.980,79
Net Cash Flow (2012 €)	56.308,74	53.667,06	-4.597,75	69.096,99	232.987,08	225.055,91	172.016,94	111.113,64	-131.194,48	42.764,29
Base Year	2003									
Year Index	0	1	2	3	4	5	6	7	8	9
Discount rate	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Discount factor	1	0,96153846	0,92455621	0,88899636	0,85480419	0,82192711	0,79031453	0,75991781	0,73069021	0,70258674
Cash Flows at 4%										
Costs (2012 €)	0,00	0,00	-6758,97	-35567,10	-43095,72	-33258,47	-34253,62	-45049,33	-111543,63	-31065,93
Benefits (2012 €)	56308,74	51602,94	2508,09	96994,07	242254,05	218238,02	170201,10	129486,57	15681,11	61111,55
Net Cash Flow (2012 €)	56308,74	51602,94	-4250,88	61426,97	199158,33	184979,56	135947,49	84437,24	-95862,52	30045,62
Cumulative (2012 €)	56308,74	107911,68	103660,80	165087,77	364246,10	549225,66	685173,15	769610,38	673747,87	703793,49
2003 NPV (2012 €)	703.793,49 €									
Discount rate	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%
Discount factor	1	0,92592593	0,85733882	0,79383224	0,73502985	0,6805832	0,63016963	0,5834904	0,54026888	0,50024897
Cash Flows at 8%										
Costs (2012 €)	0,00	0,00	-6267,57	-31759,76	-37057,19	-27539,12	-27312,66	-34590,39	-82474,83	-22119,26
Benefits (2012 €)	56308,74	49691,72	2325,74	86611,18	208309,65	180708,40	135712,51	99424,13	11594,54	43512,05
Net Cash Flow (2012 €)	56308,74	49691,72	-3941,83	54851,42	171252,46	153169,27	108399,85	64833,74	-70880,29	21392,79
Cumulative (2012 €)	56308,74	106000,46	102058,63	156910,05	328162,50	481331,78	589731,63	654565,37	583685,08	605077,87
2003 NPV (2012 €)	605.077,87 €									

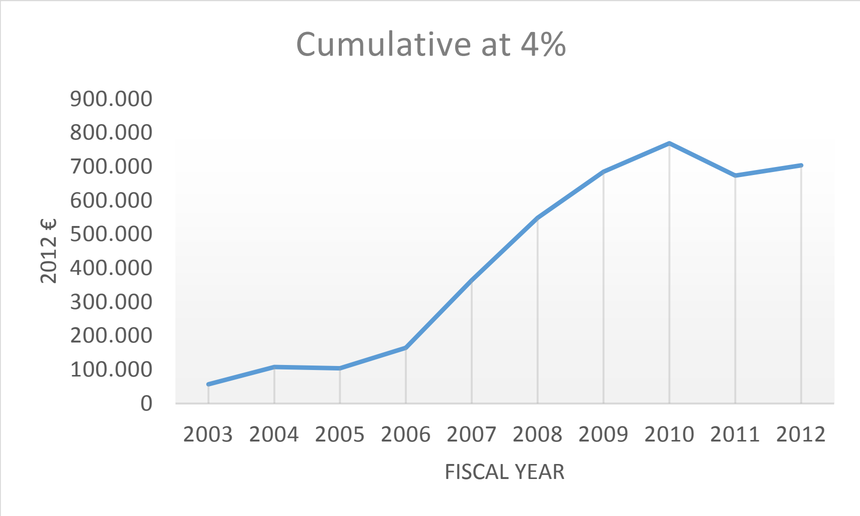
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Discount rate	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%
Discount factor	1	0,89285714	0,79719388	0,71178025	0,63551808	0,56742686	0,50663112	0,45234922	0,40388323	0,36061002
Cash Flows at 12%										
Costs (2012 €)	0,00	0,00	-5827,88	-28477,01	-32040,21	-22960,36	-21958,28	-26816,10	-61654,86	-15944,91
Benefits (2012 €)	56308,74	47917,02	2162,58	77658,88	180107,71	150663,13	109107,42	77078,27	8667,61	31366,15
Net Cash Flow (2012 €)	56308,74	47917,02	-3665,30	49181,87	148067,50	127702,77	87149,14	50262,17	-52987,25	15421,23
Cumulative (2012 €)	56308,74	104225,76	100560,46	149742,33	297809,83	425512,60	512661,73	562923,90	509936,65	525357,89
2003 NPV (2012 €)	525.357,89 €									
Discount rate	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%
Discount factor	1	0,86206897	0,7431629	0,64065767	0,5522911	0,47611302	0,41044225	0,35382953	0,30502546	0,26295298
Cash Flows at 16%										
Costs (2012 €)	0,00	0,00	-5432,89	-25631,53	-27844,25	-19265,44	-17789,29	-20975,67	-46563,71	-11626,86
Benefits (2012 €)	56308,74	46264,71	2016,01	69899,05	156520,94	126417,49	88392,31	60290,96	6546,05	22871,86
Net Cash Flow (2012 €)	56308,74	46264,71	-3416,88	44267,51	128676,69	107152,05	70603,02	39315,29	-40017,65	11245,00
Cumulative (2012 €)	56308,74	102573,45	99156,57	143424,08	272100,77	379252,82	449855,84	489171,13	449153,48	460398,47
2003 NPV (2012 €)	460.398,47 €									
Discount rate	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Discount factor	1	0,83333333	0,69444444	0,5787037	0,48225309	0,40187757	0,33489798	0,27908165	0,23256804	0,1938067
Cash Flows at 20%										
Costs (2012 €)	0,00	0,00	-5076,73	-23152,87	-24313,22	-16261,58	-14515,07	-16544,48	-35502,71	-8569,45
Benefits (2012 €)	56308,74	44722,55	1883,85	63139,55	136671,96	106706,50	72123,19	47554,25	4991,07	16857,46
Net Cash Flow (2012 €)	56308,74	44722,55	-3192,88	39986,68	112358,74	90444,92	57608,13	31009,78	-30511,64	8288,01
Cumulative (2012 €)	56308,74	101031,29	97838,41	137825,09	250183,83	340628,75	398236,88	429246,65	398735,01	407023,02
2003 NPV (2012 €)	407.023,02 €									

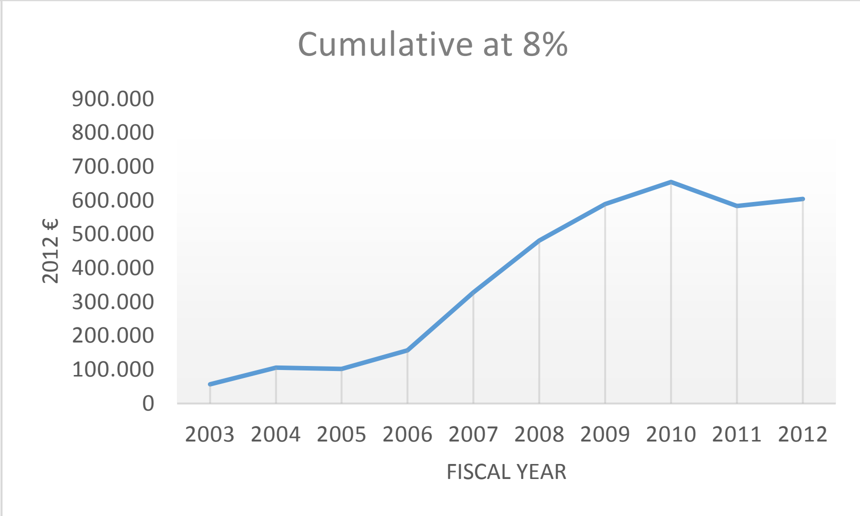

Costs and Benefits at 4%
250.000
200.000
150.000
100.000
50.000
0
-50.000
-100.000
-150.000
2012 €
2003 2004 2005 2006 2007 2008 2009 2010 2011 2012
Fiscal Year
Costs (2012 €)
Benefits (2012 €)

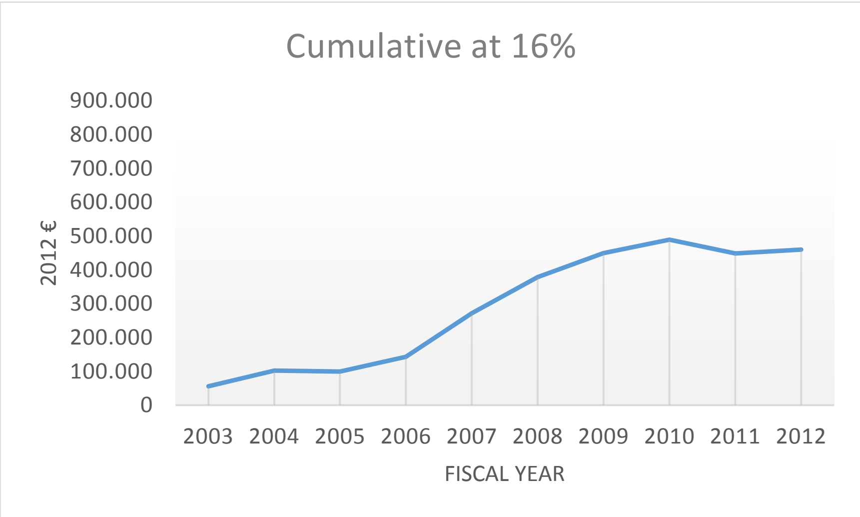

Costs and Benefits at 8%
250.000
200.000
150.000
100.000
50.000
0
-50.000
-100.000
2012 €
2003 2004 2005 2006 2007 2008 2009 2010 2011 2012
Fiscal Year
Costs (2012 €)
Benefits (2012 €)

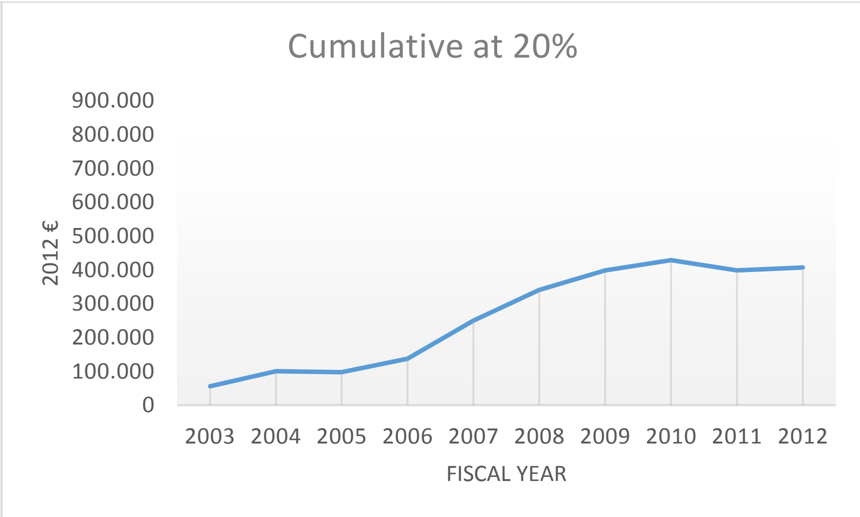

Costs and Benefits at 16%
250.000
200.000
150.000
100.000
50.000
0
-50.000
-100.000
2012 €
2003 2004 2005 2006 2007 2008 2009 2010 2011 2012
Fiscal Year
Costs (2012 €)
Benefits (2012 €)


Costs and Benefits at 20%
250.000
200.000
150.000
100.000
50.000
0
-50.000
2012 €
2003 2004 2005 2006 2007 2008 2009 2010 2011 2012
Fiscal Year
Costs (2012 €)
Benefits (2012 €)


Cumulative at 4%
900.000
800.000
700.000
600.000
500.000
400.000
300.000
200.000
100.000
0
2012 €
2003 2004 2005 2006 2007 2008 2009 2010 2011 2012
FISCAL YEAR


Cumulative at 8%
900.000
800.000
700.000
600.000
500.000
400.000
300.000
200.000
100.000
0
2012 €
2003 2004 2005 2006 2007 2008 2009 2010 2011 2012
FISCAL YEAR

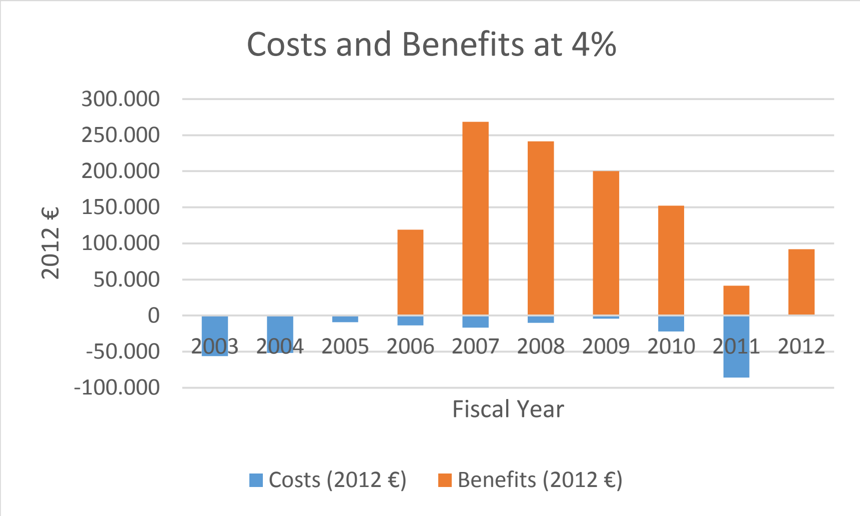

Cumulative at 16%
900.000
800.000
700.000
600.000
500.000
400.000
300.000
200.000
100.000
0
2012 €
2003 2004 2005 2006 2007 2008 2009 2010 2011 2012
FISCAL YEAR

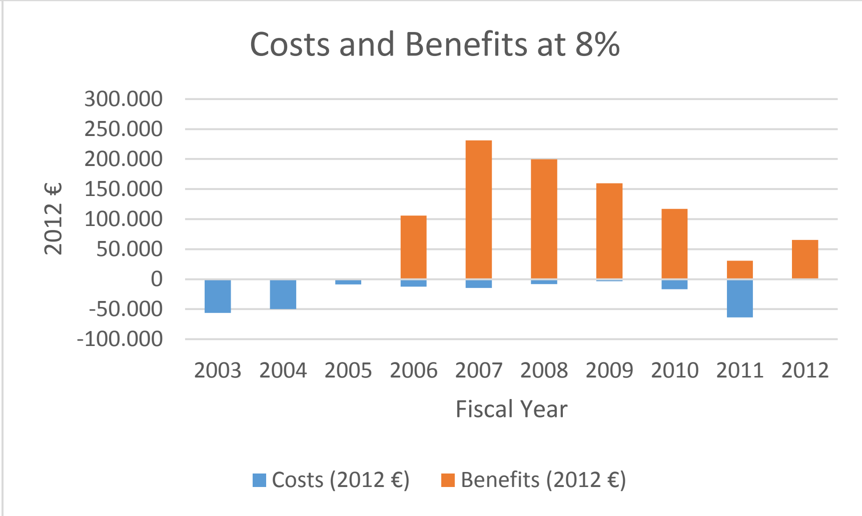

Cumulative at 20%
900.000
800.000
700.000
600.000
500.000
400.000
300.000
200.000
100.000
0
2012 €
2003 2004 2005 2006 2007 2008 2009 2010 2011 2012
FISCAL YEAR

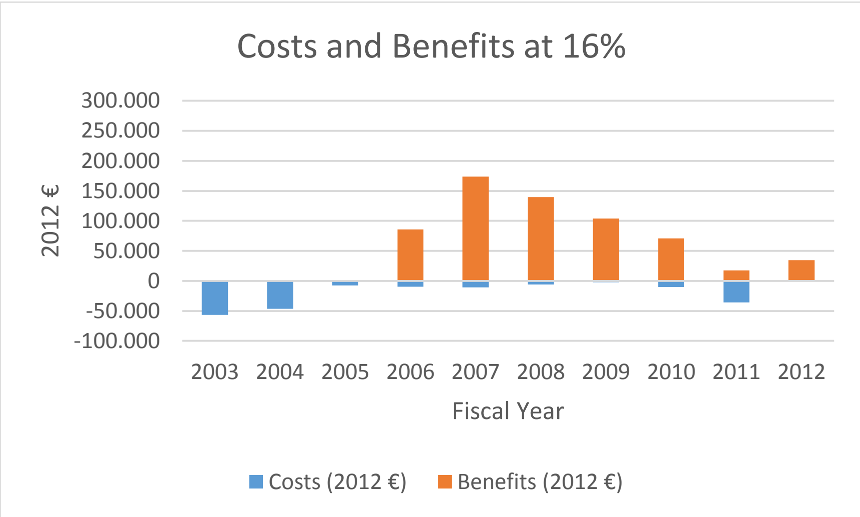
OPTION 4

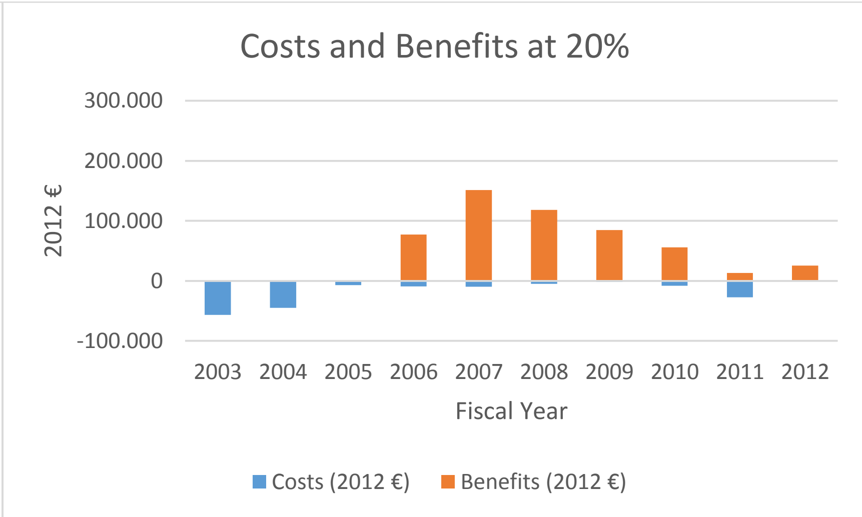
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Cash Flows w/o Discount										
Costs (2012 €)	-56.308,74	-53.667,06	-10.023,24	-15.431,02	-19.602,87	-12.220,89	-5.349,37	-29.026,17	-117.331,93	0,00
Benefits (2012 €)	0,00	0,00	0,00	133.682,27	314.216,01	293.763,04	253.351,08	200.651,17	56.783,90	131.197,30
Net Cash Flow (2012 €)	-56.308,74	-53.667,06	-10.023,24	118.251,25	294.613,14	281.542,15	248.001,71	171.625,00	-60.548,03	131.197,30
Base Year	2003									
Year Index	0	1	2	3	4	5	6	7	8	9
Discount rate	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Discount factor	1	0,96153846	0,92455621	0,88899636	0,85480419	0,82192711	0,79031453	0,75991781	0,73069021	0,70258674
Cash Flows at 4%										
Costs (2012 €)	-56308,74	-51602,94	-9267,05	-13718,12	-16756,61	-10044,68	-4227,68	-22057,51	-85733,29	0,00
Benefits (2012 €)	0,00	0,00	0,00	118843,05	268593,16	241451,81	200227,04	152478,40	41491,44	92177,48
Net Cash Flow (2012 €)	-56308,74	-51602,94	-9267,05	105124,93	251836,55	231407,13	195999,35	130420,89	-44241,85	92177,48
Cumulative (2012 €)	-56308,74	-107911,68	-117178,73	-12053,80	239782,74	471189,87	667189,22	797610,12	753368,26	845545,74
2003 NPV (2012 €)	845.545,74 €									
Discount rate	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%
Discount factor	1	0,92592593	0,85733882	0,79383224	0,73502985	0,6805832	0,63016963	0,5834904	0,54026888	0,50024897
Cash Flows at 8%										
Costs (2012 €)	-56308,74	-49691,72	-8593,31	-12249,64	-14408,69	-8317,33	-3371,01	-16936,49	-63390,79	0,00
Benefits (2012 €)	0,00	0,00	0,00	106121,30	230958,14	199930,19	159654,15	117078,03	30678,57	65631,31
Net Cash Flow (2012 €)	-56308,74	-49691,72	-8593,31	93871,65	216549,45	191612,86	156283,14	100141,54	-32712,22	65631,31
Cumulative (2012 €)	-56308,74	-106000,46	-114593,78	-20722,12	195827,33	387440,19	543723,33	643864,87	611152,65	676783,96
2003 NPV (2012 €)	676.783,96 €									

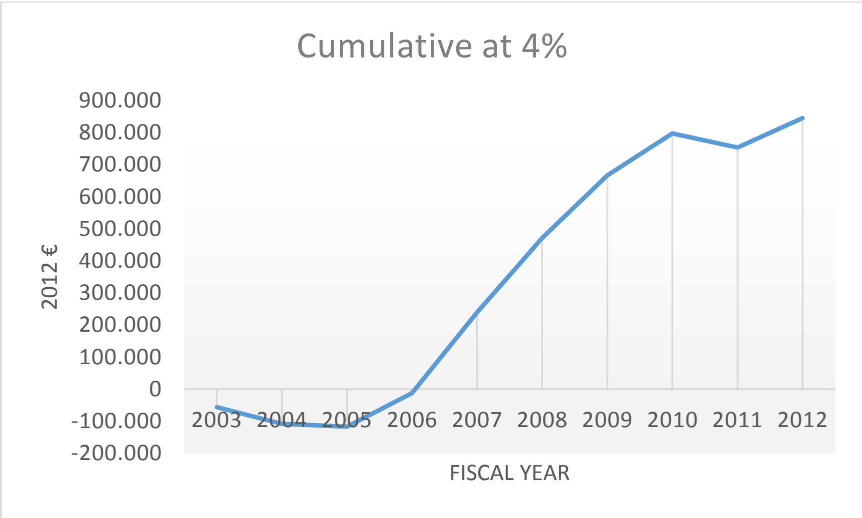
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Discount rate	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%
Discount factor	1	0,89285714	0,79719388	0,71178025	0,63551808	0,56742686	0,50663112	0,45234922	0,40388323	0,36061002
Cash Flows at 12%										
Costs (2012 €)	-56308,74	-47917,02	-7990,47	-10983,50	-12457,98	-6934,46	-2710,16	-13129,97	-47388,40	0,00
Benefits (2012 €)	0,00	0,00	0,00	95152,40	199689,95	166689,04	128355,54	90764,40	22934,06	47311,06
Net Cash Flow (2012 €)	-56308,74	-47917,02	-7990,47	84168,90	187231,98	159754,58	125645,38	77634,43	-24454,34	47311,06
Cumulative (2012 €)	-56308,74	-104225,76	-112216,22	-28047,32	159184,66	318939,23	444584,62	522219,05	497764,72	545075,78
2003 NPV (2012 €)	545.075,78 €									
Discount rate	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%
Discount factor	1	0,86206897	0,7431629	0,64065767	0,5522911	0,47611302	0,41044225	0,35382953	0,30502546	0,26295298
Cash Flows at 16%										
Costs (2012 €)	-56308,74	-46264,71	-7448,90	-9886,00	-10826,49	-5818,52	-2195,61	-10270,32	-35789,23	0,00
Benefits (2012 €)	0,00	0,00	0,00	85644,57	173538,70	139864,41	103985,99	70996,31	17320,53	34498,72
Net Cash Flow (2012 €)	-56308,74	-46264,71	-7448,90	75758,57	162712,21	134045,88	101790,38	60725,99	-18468,69	34498,72
Cumulative (2012 €)	-56308,74	-102573,45	-110022,35	-34263,78	128448,44	262494,32	364284,70	425010,69	406542,00	441040,72
2003 NPV (2012 €)	441.040,72 €									
Discount rate	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Discount factor	1	0,83333333	0,69444444	0,5787037	0,48225309	0,40187757	0,33489798	0,27908165	0,23256804	0,1938067
Cash Flows at 20%										
Costs (2012 €)	-56308,74	-44722,55	-6960,58	-8929,99	-9453,54	-4911,30	-1791,49	-8100,67	-27287,66	0,00
Benefits (2012 €)	0,00	0,00	0,00	77362,43	151531,64	118056,78	84846,76	55998,06	13206,12	25426,91
Net Cash Flow (2012 €)	-56308,74	-44722,55	-6960,58	68432,44	142078,10	113145,48	83055,27	47897,39	-14081,54	25426,91
Cumulative (2012 €)	-56308,74	-101031,29	-107991,87	-39559,44	102518,66	215664,13	298719,41	346616,79	332535,25	357962,17
2003 NPV (2012 €)	357.962,17 €									

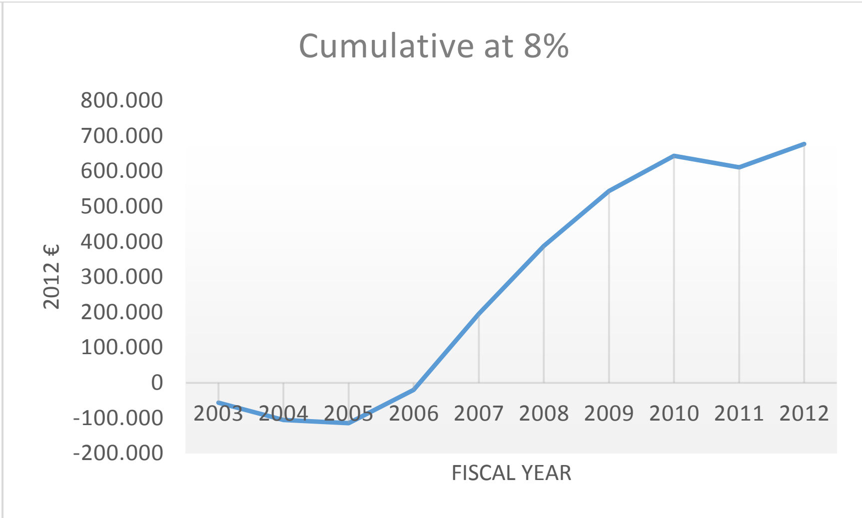

Costs and Benefits at 4%
300.000
250.000
200.000
150.000
100.000
50.000
0
-50.000
-100.000
2012 €
2003 2004 2005 2006 2007 2008 2009 2010 2011 2012
Fiscal Year
Costs (2012 €)
Benefits (2012 €)

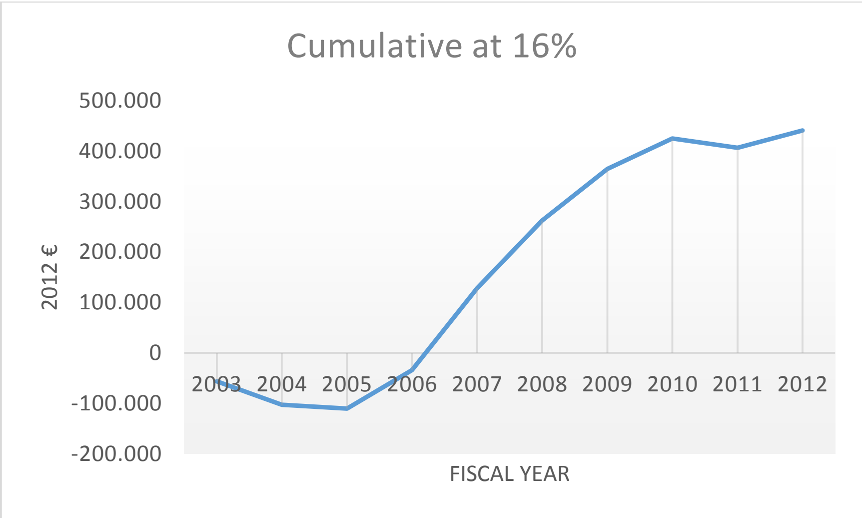

Costs and Benefits at 8%
300.000
250.000
200.000
150.000
100.000
50.000
0
-50.000
-100.000
2012 €
2003 2004 2005 2006 2007 2008 2009 2010 2011 2012
Fiscal Year
Costs (2012 €)
Benefits (2012 €)

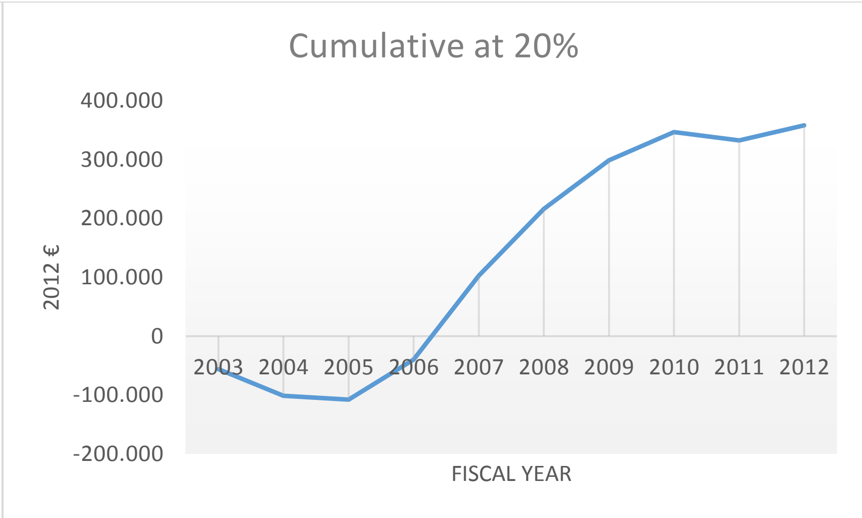

Costs and Benefits at 16%
300.000
250.000
200.000
150.000
100.000
50.000
0
-50.000
-100.000
2012 €
2003 2004 2005 2006 2007 2008 2009 2010 2011 2012
Fiscal Year
Costs (2012 €)
Benefits (2012 €)


Costs and Benefits at 20%
300.000
200.000
100.000
0
-100.000
2012 €
2003 2004 2005 2006 2007 2008 2009 2010 2011 2012
Fiscal Year
Costs (2012 €)
Benefits (2012 €)


Cumulative at 4%
900.000
800.000
700.000
600.000
500.000
400.000
300.000
200.000
100.000
0
-100.000
-200.000
2012 €
2003 2004 2005 2006 2007 2008 2009 2010 2011 2012
FISCAL YEAR


Cumulative at 8%
800.000
700.000
600.000
500.000
400.000
300.000
200.000
100.000
0
-100.000
-200.000
2012 €
2003 2004 2005 2006 2007 2008 2009 2010 2011 2012
FISCAL YEAR


Cumulative at 16%
500.000
400.000
300.000
200.000
100.000
0
-100.000
-200.000
2012 €
2003 2004 2005 2006 2007 2008 2009 2010 2011 2012
FISCAL YEAR


Cumulative at 20%
400.000
300.000
200.000
100.000
0
-100.000
-200.000
2012 €
2003 2004 2005 2006 2007 2008 2009 2010 2011 2012
FISCAL YEAR

ANNEX III

CALCULATIONS

This ANNEX aims to ease the understanding of the calculations that were made in this thesis through the examples of some of the calculations.

1. **INFLATION**: Calculation of the inflation rate for 2012.

	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
CPI	3.22	2.37	2.45	3.11	2.45	2.59	-0.83	1.4	3.65	2.77
Inflation rate	1.0322	1.0237	1.0245	1.0311	1.0245	1.0259	0.9917	1.014	1.0365	1.0277

- Inflation rate 2003 = 1 + 3.22/100 = 1.0322

2. CONSTANT VALUES (2012€):

	2003	2004	2005
Visitors	914,694.00	918,752.00	910,910.00
Water			
Absolute Consumption (m3)	30,509.00	36,771.00	40,503.00
Relative Consumption (m3/1000 visitors)	33.35	40.02	44.46
Absolute operating costs (current €)	55,221.00	68,356.00	76,693.00
Calculated price (current €/m3)	1.81	1.86	1.89
Calculated price (2012 €/m3)	2.27	2.26	2.25
Relative operating costs (current €/1000 visitors)	60.37	74.40	84.19
Absolute operating costs (2012 €)	69,394.41	83,221.02	91,209.36

- ***Absolute operating costs 2003 = 69,394.41 € (constant 2012)***

  = 55,221 x (1.0322 x 1.0237 x 1.0245 x 1.0311 x 1.0245 x 1.0259 x 0.9917 x 1.014 x 1.0365 x 1.0277)
- ***Absolute operating costs 2004 = 83,221.02 € (constant 2012)***

  = 68,356 x (1.0237 x 1.0245 x 1.0311 x 1.0245 x 1.0259 x 0.9917 x 1.014 x 1.0365 x 1.0277)

3. CALCULATED PRICE (current €/m^3)

- Calculated price 2003 = absolute operating costs / absolute consumption = 55,221 current € / 30,509 m3 = 1.81 current €/m^3

4. RELATIVE CONSUMPTION (m^3/1000 visitors)

- Relative water consumption 2003 = 30,509/914,694.00 x 1000 = 33.35 m^3/1000 visitors

5. BENEFITS

	2003	2004	2005	2006
Visitors	914,694.00	918,752.00	910,910.00	966,578.00
Water				
Assumed consumption (m3/1000 visitors)	33.35	40.02	44.46	44.46
Calculated price (current €/m3)	1.81	1.86	1.89	1.97
Assumed operating costs w/o investments (current €)	55,221.00	68,356.00	76,693.00	84,881.88
Actual operating costs (current €)	55,221.00	68,356.00	76,693.00	60,111.00
Calculated benefits (current €)	0.00	0.00	0.00	24,770.88
Calculated benefits (2012 €)	0.00	0.00	0.00	28,754.99

- **Assumed operating costs w/o investments 2006 (current €)**

  = 44.46 x 1.97 x 966,578 / 1000 = 84,658.89 (in Excel the result is slightly different because it uses more decimal figures when calculating the calculated price. See point 3).

- **Calculated benefits = Actual operating costs – assumed operating cost**

6. COST-BENEFIT ANALYSIS

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Cash Flows w/o interest										
Costs (2012 €)	-56,308.74	-53,667.06	-10,023.24	-15,431.02	-19,602.87	-12,220.89	-5,349.37	-29,026.17	-117,331.93	0.00
Benefits (2012 €)	0.00	0.00	0.00	133.682.27	314.216.01	293.763.04	253.351.08	200.651.17	56.783.90	131.197.30
Net Cash Flow (2012 €)	-56,308.74	-53,667.06	-10,023.24	118,251.25	294,613.14	281,542.15	248,001.71	171,625.00	-60,548.03	131,197.30
Base Year	2012									
Year Index	9	8	7	6	5	4	3	2	1	0
Interest rate	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Interest factor	0.702586736	0.73069021	0.75991781	0.79031453	0.82192711	0.85480419	0.88899636	0.92455621	0.96153846	1
Cash Flows at 4%										
Costs (2012 €)	-39,561.77	-39,214.00	-7,616.84	-12,195.36	-16,112.13	-10,446.47	-4,755.57	-26,836.33	-112,819.17	0.00
Benefits (2012 €)	0.00	0.00	0.00	105,651.04	258,262.65	251,109.88	225,228.18	185,513.28	54,599.90	131,197.30
Net Cash Flow (2012 €)	-39,561.77	-39,214.00	-7,616.84	93,455.68	242,150.52	240,663.41	220,472.62	158,676.96	-58,219.26	131,197.30
Cumulative (2012 €)	-39,561.77	-78,775.77	-86,392.61	7,063.07	24,9213.60	489,877.01	710,349.62	869,026.58	810,807.32	942,004.61
NPV (2012 €)	942,004.61 €									

- **Costs**: - Investment costs converted to constant values (See point 2).
- B**enefits**: Calculated in point 5 and converted to constant values (See point 2).
- **Net Cash Flow:** Costs + Benefits. When costs are left as positives values, then: Benefits – Costs.
- **Base Year:** See Glossary.
- **Year Index:** Base Year – Current Year. Year index 2003 = 9 = 2012 - 2003
- **Interest rate:** 4% = 0.04

- **Interest factor:** 1/ (1+interest rate) ^Year Index. Interest factor 2003 = 1/(1+0.04)^9 = 0.702586736
- **Cash flows at 4%:**
  - Costs at 4%: Costs x interest factor
  - Benefits at 4%: Benefits x interest factor
- **Cumulative 2004** = Cumulative 2003 + Net Cash Flow 2004 = -39,214.00 + (-39,561.77) = -78,775.77
- **Net Present Value** = $_{(n > i=1)} \sum (\text{values})_I / (1 + \text{rates})^I$ (See Cumulative)