Implementing sustainability initiatives in business processes

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Abstract

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ABSTRACT OF DISSERTATION submitted by **Bruno Teixeira Luz Foresti Gallotta** for the degree of Doctor of Philosophy and entitled 'Implementing sustainability initiatives in business processes'.

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Purpose – The sustainability topic has been receiving a growing importance in the corporate environment in recent years. More and more companies are adopting sustainability practices in all their organisational levels, operations and business process as a whole, however, they have still failed to achieve the anticipated goal. Existing roadmaps, frameworks and systems do not comprehensively support sustainable business transformation. This research proposes a four phases framework, based on BPM, to help organisations to implement sustainability practices in the organisation business processes and has verified it with industry/academic specialists and validated it in a local organisation focused on sustainability initiatives.

Design/methodology/approach – A conceptual framework has been created, verified and validated. The framework is based on Business Process Management (BPM) principles, which was chosen because due its capability to work in a cross process way while providing the full control of the process performance. It was then verified using a Delphi study held with 21 specialists in Sustainable Operations Management from both academia and industry and validated using an action research study on a biomass company focused in the development of sustainable energy technologies that wished to improve the implementation of sustainability initiatives in its business processes and operations.

Findings – It was identified that organisations still struggle to succeed the implementation of sustainability projects. The research outlined that the business process management (BPM) approach can be used as way to implement sustainability practices in an organisation's business processes by using the conceptual framework. The benefits from this approach are the enablement of continuous process improvement, improvement of process quality; cost reduction; increase in the customer satisfaction; and better control

over process performance, which can be directly linked to the improvement of the sustainability improvement.

Research limitations/implication – The main limitation of this research is the application of the framework in only one real-life scenario, which was expected due the research method chosen to validate it. Future work aims to apply the framework in different scenarios, in organisations with different sizes, different maturity level, different sector, and different locations. Further research will also investigate the symbiosis of the BPM approach with other management approaches, such as lean/green manufacturing, project management, green supply chain and carbon footprint. In addition, in a further moment, once companies are familiarised with the project methodology, it is possible to create a centre of excellence (an area within the organisation with the best practices/ processes of the industry) in terms of sustainability bringing even more value, improving continuously and generating more innovation by the form of green reference process models.

Practical implications – The proposed framework uses a Business Process Management (BPM) approach, which provides a systemic solution for the organisations adopt sustainability practices in their business processes.

Keywords – Business Process Management, Sustainability, Sustainability Implementation, Sustainable Operations Management

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Dedication

For those who have strong thinking, the impossible is only a matter of opinion (Alexandre Abrao). This dissertation is dedicated to my family for being always for me when I needed their support and guidance. This dissertation is particularly dedicated to my friends and family, who always supported me in this long journey.

Acknowledgement

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Chapter 1 - Introduction

1.1. Introduction

This chapter presents an overview of the research project. It starts by providing the background, as well as a general overview and description of how it was developed. Then, the aim and objectives of this research project are presented. Finally, the research questions that guide this project, importance and motivation of the research, as well as the dissertation structure are also included in this chapter.

1.2. General Overview of the Research and problem statement

The sustainability topic has been receiving growing importance in the corporate environment in recent years. The motivation factors can be related to social aspects, regulation aspects, customer requirements, among others (Epstein et al., 2010). Many organisations are committed to transforming their business processes and have taken sustainability initiatives. However, many of them have yet failed to achieve the anticipated goals (Gallotta et al., 2016 and Ahmed and Sundaram, 2012). Every sustainability project involves changes in the organisation, from the most basic ones (e.g. replacing disposal plastic cups with individual ceramic mugs) up to drastic changes in the way in which a company operates. However, according to Burnes (2003), a large percentage of these change initiatives fail due to different factors that may include the lack of management support, lack of proper communication, lack of stakeholder engagement, among others.

In summary, organisations face various challenges when trying to implement change initiatives to become sustainable. If organisations are unable to overcome a particular challenge, this might result in the failure of the initiative. Some authors (e.g. Epstein and Buhovac, 2010; vom Brocke et al., 2012; and Giunipero et al., 2012) have studied and identified the most common challenges/barriers organisations face when implementing sustainability initiatives. **Table** 1 represents a summary of some of these challenges.

Table 1 Summary of some challenges found in the literature to implement sustainability initiatives

References	Challenges
Epstein et al (2010)	Setting clear and measurable goals
	Dealing with financial incentive pressures
	Comprehending Stakeholder reactions
Seidel et at (2012),	How to consider sustainability aspects in the management of an organisation's processes
Giunipero et al (2012)	Lack of consensus at the CEO level
	Costs of sustainability and economic conditions;
	Lack of sustainability standards and appropriate regulations
	Misalignment of short term and long term strategic goals.
Ahmed & Sundaram (2012)	Existing roadmaps, frameworks and systems do not comprehensively support sustainable business transformation
	Existing systems do not allow decision makers to explore interrelationships and influences between the sustainability dimensions
	Sustainability concept continues to be applied unsystematically
Poveda ET al (2014)	Select the right sustainability Indicators
	Define the proper measurement method
	Align indicators to goals and objectives
Frandsen et al (2013)	How to embed sustainability to the organisation.
Stewart eT AL (2016)	The barriers are categorised in (1) internal, such as financial and other resource constraints, managerial and employee attitudes, poor communication and past practices and (2) external, such as capital costs, competitive pressures, industry regulation, technical information, green market opportunities and technical solutions.

Besides the above challenges, another factor suggested by Ahmed and Sundaram (2012) as a possible reason for sustainability initiatives to fail is that existing roadmaps, frameworks and systems do not comprehensively support a sustainable business transformation nor do they allow decision makers to explore interrelationships and influences between the sustainability dimensions. Hence, because the sustainability concept continues to be applied unsystematically, practising organisations experience considerable difficulties in realising their goals of achieving a full sustainability status. This is due to a lack of understanding and support for the design, development and implementation process, and a lack of proper procedural and technological support for decision making for sustainability management.

According to Slack et al. (2013), whenever a business attempts to satisfy the needs of its customers, it will use various processes in both its operations and other functions. Each of these processes will contribute to fulfilling its customers' needs. Once an organisation

decides to reorganise its operations, each product is created from a starting point passing through processes, which contain the necessary elements for the production, to reach a final stage. This concept is called 'end-to-end' process. These end-to-end processes usually cut across conventional organisational boundaries (Gallotta et al. 2016)

'Process' refers to the conversion of inputs (resources) into outputs (goods and services) (Armistead and Machin, 1997). Although the literature provides numerous definitions for 'business processes', all of these reflect, more or less, the same ontology, that a business process is a series of continuous or intermittent cross-functional activities that are naturally connected with work flowing through these activities for a particular outcome/purpose (Hammer and Champy, 1993; Zairi, 1997; Slack et al. 2013; Harmon, 2010). What seems to make the business process approach so distinct is that it not only focuses on activities, i.e. what is done and/or how they are done, but it also places emphasis on how these activities are interconnected and how workflows through these activities to produce efficient and effective results (Bititci et al., 2011). The critical point is that transformed resources (e.g. materials and information) originate from outside the boundaries of the organisation, whereas outputs in the form of goods and/or services leave the boundaries of the organisation.

Nonetheless, many sustainability implementation initiatives have focused in one specific department of the organisation, e.g. IT (Uddin and Rahman, 2012), warehouse (Tan et al., 2010; Tan et al., 2008), logistics (Rossi et al., 2013), etc. They, however, do not consider that those departments work along with other departments into an end-to-end process. According to Porter's (1985) model, products pass through activities of a chain in order, and at each activity, the product gains some value. Similarly, we can consider that the 'product' (in the case of a product based industry) gains some 'sustainability impact' in each activity. Therefore, a more refined analysis would consider the whole process interaction to evaluate the full status of the sustainability implementation.

In this perspective, the research project was undertaken with the aim to help organisations to adopt sustainability practices in their business processes, transforming their regular business processes into sustainability business processes (or green business processes) following a systemic approach. Several approaches can be used to improve business processes, such as DMAIC (Define, Measure, Analyse, Improve and Control), PDCA (Plan, Do, Check and Act), lean manufacturing and Six Sigma. For the matters of this

research, it was employed the Business Process Management (BPM) approach. BPM has evolved as a holistic management practice for managing and transforming organisational operations (Hammer, 2010). According to Gartner: "BPM refers to a set of management disciplines that accelerate effective business process improvement by blending incremental and transformative methods. BPM's management practices provide for the governance of a business process environment toward the goal of improving agility and operational performance. BPM is a structured approach that employs methods, policies, metrics, management practices and software tools to manage and continuously optimise an organisation's activities and processes" (Hill et al. 2007; Gallotta, 2016). It provides adequate techniques for the design, execution, controlling as well as the analysis of business processes in order to improve value creation within single organisations as well as in inter-organisational value networks – their supply chain (van der Aalst, ter Hofstede, & Weske, 2003).

The working methodology for this research project was based on an inductive approach in which a conceptual framework has been created, verified and validated. The framework is based on Business Process Management (BPM) principles, which was chosen because due its capability to work in a cross process way while providing the full control of the process performance, and contains four main phases: (1) 'Analyse Phase'; (2) 'Design Phase'; (3) 'Implement Phase'; and (4) 'Monitor & Control Phase'. It was then verified using a Delphi study held with 21 specialists in Sustainable Operations Management from both academia and industry and validated using an action research study on a biomass company focused in the development of sustainable energy technologies that wished to improve the implementation of sustainability initiatives in its business processes and operations. The research methodology can be observed in **Figure 1**.

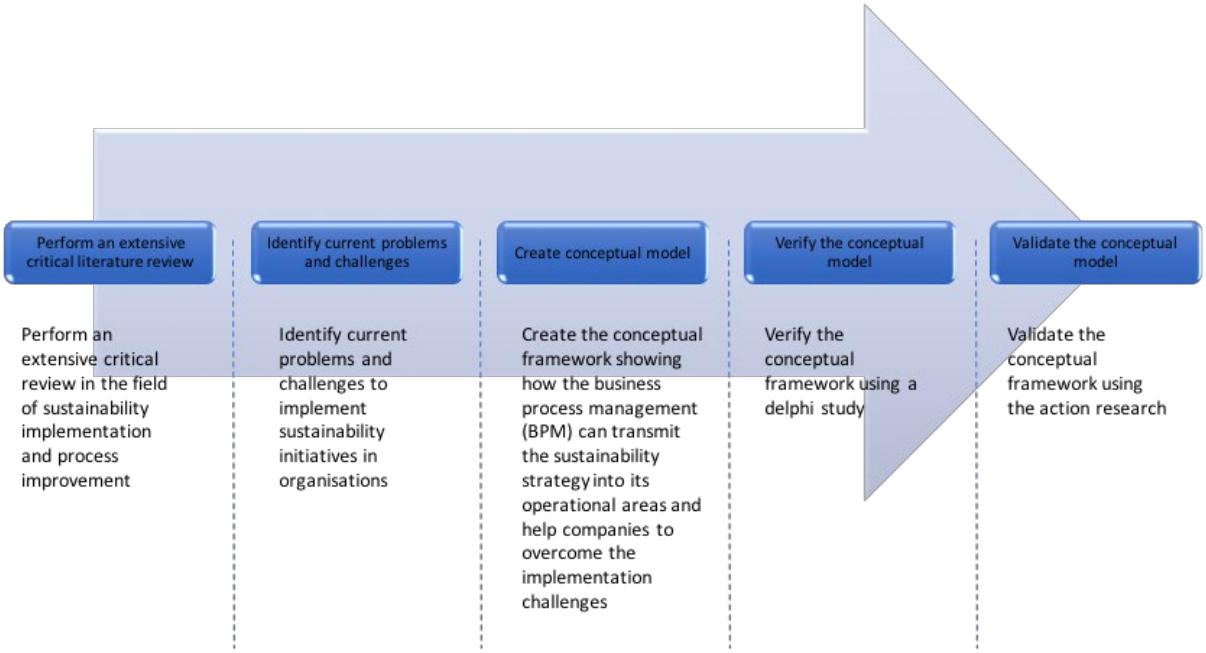

Figure 1 Research Methodology

1.3. Research Aim and Objectives

This research aimed to provide a full lifecycle solution for the implementation of sustainability initiatives in business processes by Analysing, Designing, Implementing and Monitoring & Controlling current (or eventual new) processes in one organisation. It provided systematic methods for this implementation, aiming to realise the goals of full sustainability status. The implementation can result in cost reduction, process optimisation, innovation generation, energy/water consumption reduction, waste generation reduction, customer satisfaction improvement, employee turnover improvement, among other benefits to the organisation. The proposed aim was achieved through the following objectives:

1. Identify what are the current problems/barriers to implementing sustainability initiatives;
2. Identify and critically review the current sustainability implementation frameworks found in the literature;
3. Create a framework to effectively implement sustainability practices in organisations;
4. Identify key persons in sustainable operations management and obtain their feedback regarding the framework;
5. Employ the framework in a real-world scenario and obtain the feedback;

1.4. Research Questions

The research questions of this research are:

- How can an organisation adopt sustainability practices in their business processes?
- What are the benefits to adopt sustainability initiatives in the business processes?
- What are the main challenges to adopt sustainability initiatives in the business processes?
- What is the most efficient way to adopt sustainability initiatives in the business processes?

1.5. Motivations, importance and rationale of the research

As a Business Consultant, the author is interested in the Business Process Management (BPM) topic because it helps organisations to become process-centric and to manage and control their business processes. On the other hand, there is the sustainability topic, which is considered by many the 'challenge of the century', how organisations can become more respectful to the environment in which it is located.

The rationale of this research consists on the benefits that Business Process Management can bring to the sustainability topic in the organisations, and present a framework to help them to implement sustainability projects in their business processes, transforming their regular business processes into sustainability business processes.

This research fits into that perspective as academic knowledge, in the forms of sustainable operations management and industrial engineering concepts and principles.

1.6. Structure of the dissertation

The following section describes the dissertation's layout with a brief description of each chapter.

Chapter One: Introduction

This chapter presents a general overview of this research project. In particular, it provides the research's background, overview, aim and objectives. The chapter then outlines the research question, motivations, importance and rationale for undertaking this project, and finally, the structure of this dissertation.

Chapter Two: An overview of Sustainability, Sustainability Implementation and how it relates to Business Processes

This chapter starts presenting the Sustainability topic, providing a few definitions and the evolution of the topic. The chapter then outlines why organisations need to adopt

sustainability practices in their business and how these initiatives can be implemented. More than adopting sustainability initiatives in their business processes. Finally, this chapter also discusses what are the problems and challenges of implementing sustainability initiatives.

Chapter Three: Literature Review on Business Process Management

This chapter presents the Business Process Management (BPM) approach. The chapter begins presenting the evolution of concepts that lead to the development of the BPM methodology, ever since Adam Smith's division of labour, passing to the Toyota Production System, Lean Manufacturing, Total Quality Management approach, Six Sigma, Business Process Reengineering, and finally the Business Process Management. Then, the chapter goes deep into the concepts of BPM showing the benefits, success factors and the typical implementation phases. Finally, the chapter brings the relation between Business Process Management and the sustainability topic. It starts by reviewing the sustainability role in the current corporate environment and provides arguments to corroborate that BPM can be used as a tool to enable the implementation of Sustainability Initiatives in the organisation processes.

Chapter Four: Research methodology and approach

This chapter presents an overview of the methodological aspects of the research and the manner it was conducted. The first step was to classify the research concerning purpose, process, logic and outcome. Then, it defines the research methodology used in this research, aligning it to the aims, objectives and research questions. Finally, the chapter presents the research methods used and presents the methods for data collection.

Chapter Five: Sustainability Implementation Framework for Business Processes

This chapter presents the creation of the framework to implement sustainability initiatives in the business processes. It is initially presented the framework with the four main phases: (Analyse Phase; Design Phase; Implement Phase; and Monitor & Control Phase) followed by the description of each step contained in the phases. The chapter also identifies enablers for the framework.

Chapter Six– Framework Verification using Delphi study

This chapter presents the verification of the Sustainability Implementation Framework using the Delphi method. It is initially presented the concept of the Delphi technique, after this, it shows the manner to select the participants and how to classify them as specialists. The chapter then explores the modus to create the questionnaire. Finally, the chapter provides the results of the study (both first round and second round).

Chapter Seven – Framework Validation using Action Research

This chapter presents the validation of the Sustainability Implementation Framework using the action research method. It is initially presented the concept of the action research method, after this, it describes the project, presents the timeline and justifies the use of the framework to solve the specific problem. The chapter then explores the phases of the framework, going through the phases: 'Analyse', 'Design', 'Implement', and 'Monitor and Control'. Finally, it proposes adequate recommendations to improve the process' and sustainability's elements investigated

Chapter Eight - Conclusions and recommendations

This chapter presents a summary of the results obtained from the research study, the study limitations and future research opportunities. Finally, it draws the final conclusions of this project and the final comments.

Chapter 2 – An overview of Sustainability, Sustainability Implementation and how it relates to Business Processes

2.1 Introduction

Sustainability is a term with multiple meanings, so this chapter starts by bringing the concepts of Sustainability, providing a few definitions and the evolution of the topic. After that, it is justified the importance of sustainability in the Operations Management scenario and then how the sustainability initiatives can be adopted. More than adopting sustainability initiatives in their business and operations, organisations need to implement in their business processes. Current Systems do not address all the aspects of the sustainability implementation. Thus, finally, this chapter also discusses the problems and challenges related to the current ways to implement sustainability initiatives.

2.2 What is Sustainability

The word sustainability has multiple meanings, and the meanings often differ depending on whether you are from another culture, you are from the world of multinational corporations, you are a small business owner, or you are an individual trying to **figure** out what a sustainable lifestyle looks like (McNall et al., 2011). However, defining this concept is not straightforward, and a number of different and contested meanings can be identified. According to Agyekum-Mensah et al. (2012) and Adams (2006), the idea of sustainability is relatively recent and can be traced back to a conference held in the 1970s. Adams (2006) and Kamara et al. (2006) argues that the concept of sustainability emerged from the UN conference on the human environment – (UNEP, 1972). The most widely used definition of sustainable development is the "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987).

Ever since the United Nations held conferences to discuss topics related to sustainable development. In 1992, the United Nations Conference on Environment and Development (UNCED) succeeded in raising public awareness of the need to integrate environment and development. One of the outcomes of the conference, the Agenda 21 addresses the pressing problems of today and also aims at preparing the world for the challenges of the next century. It reflects a global consensus and political commitment at the highest level on development and environment cooperation. Its successful implementation is first and foremost the responsibility of Governments. National strategies, plans, policies and processes are crucial to achieving this (United Nations, 1992). Other outcomes of the

conference include the United Nations Framework Convention on Climate Change (UNFCCC) – a climate change agreement that led to the Kyoto Protocol and the United Nations Convention to Combat Desertification (UNCCD) (United Nations, 2014).

In 2002 the World Summit on Sustainable Development brought together tens of thousands of participants, including heads of State and Government, national delegates and leaders from non-governmental organisations (NGOs), businesses and other major groups to focus the world's attention and direct action toward meeting difficult challenges, including improving people's lives and conserving our natural resources in a world that is growing in population, with ever-increasing demands for food, water, shelter, sanitation, energy, health services and economic security United Nations (2002).

In 2012, the United Nations Conference on Sustainable Development resulted in a focused political outcome document (Future we want) which contains clear and practical measures for implementing sustainable development. In Rio, Member States decided to launch a process to develop a set of Sustainable Development Goals (SDGs), which was built upon the Millennium Development Goals and converge with the post-2015 development agenda United Nations (2012).

In 2015, the United Nations Sustainable Development Summit provided a plan of action for people, planet and prosperity. It also seeks to strengthen universal peace in larger freedom. In this report, it is recognised that the most significant challenge is to eradicate the poverty, including extreme poverty, and that it is an indispensable requirement for sustainable development. It presents the 17 Sustainable Development Goals, as can be observed in **Figure 2**. They seek to build on the Millennium Development Goals and complete what these did not achieve. They are integrated and indivisible and balance the three dimensions of sustainable development: the economic, social and environmental United Nations (2015).

Figure 2 Sustainable Development Goals. Source: http://www.un.org/sustainabledevelopment/sustainable-development-goals/ - content removed for copyright reasons

Figure 3 represents the United Nations Conferences timeline.

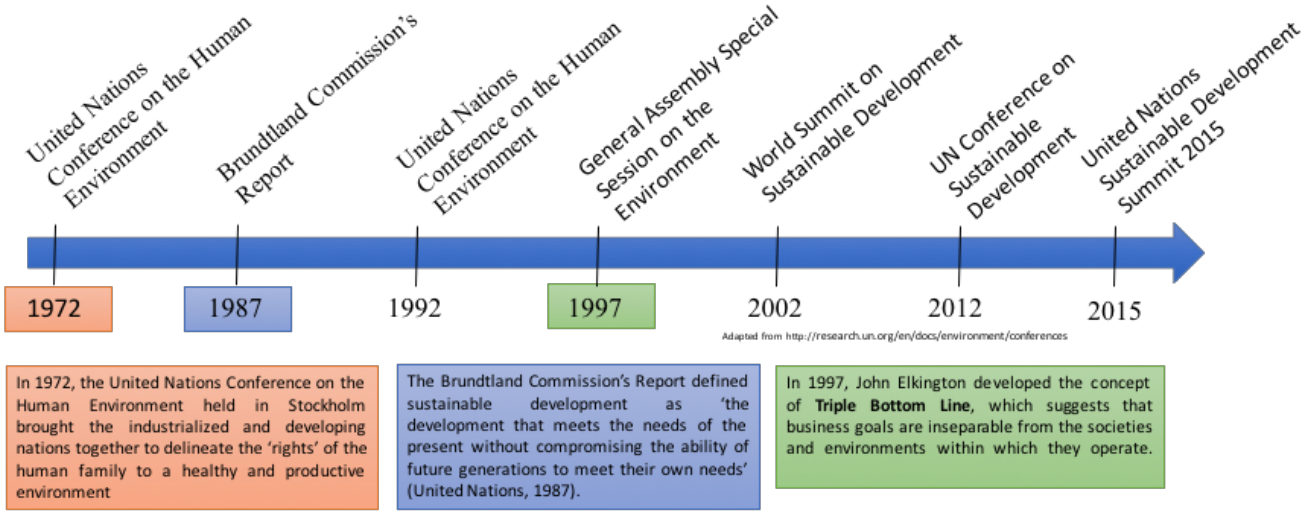

Figure 3 represents UN Sustainability Conferences Timeline

In 1997, the concept of the Triple Bottom Line was developed by Elkington (1997), which suggests that business goals are inseparable from the societies and environments within which they operate. Sustainability can be defined as a multi-dimensional concept composed by three distinct dimensions: economic, environmental, and social; often referred to as the "triple bottom-line" (Elkington, 1997; Magon et al.2018). The economic dimension of sustainability is the ability to generate enough capital flow to ensure

liquidity and produce a persistent return for the long-term (Vachon and Mao, 2008; Steurer and Konrad, 2009). Environmental sustainability is obtained if a company consumes natural resources at an inferior pace than the natural regeneration and generates limited waste and emissions (Vachon and Mao, 2008). Social sustainability is obtained when the organisation actively supports the preservation and creation of skills as well as the capabilities of current and future generations, promotes health and supports equal and democratic treatments within and outside its borders (McKenzie, 2004).

Sustainable businesses aim to deliver balanced and integrated performances in the three sustainability dimensions. According to Slack et al. (2013), sustainable business creates an acceptable profit for its owners, but minimises the damage to the environment and enhances the existence of the people with whom it has contact. In other words, it balances economic, environmental and societal interests. This gives the organisation its 'licence to operate' in society. **Figure 4** illustrates some of the issues involved in the Triple Bottom Line.

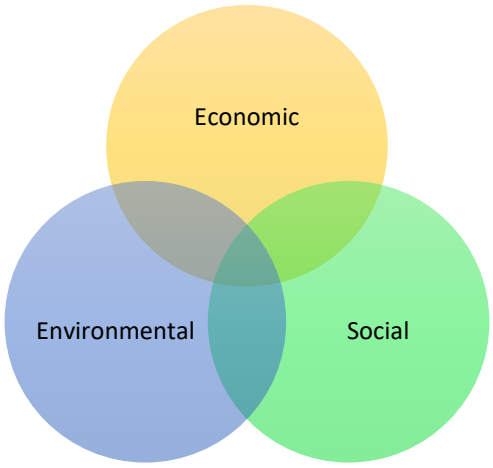

Figure 4 - Triple Bottom Line. Adapted from Elkington.(1997)

According to Gallotta (2016) and Hubbard (2009), some organisations have tackled the challenge of measuring their TBL environmental performance by adopting internationally recognised, industry certified environmental management systems (EMSs). These systems help them develop, implement and communicate environmental policies, set objectives and targets for reducing environmental impacts and monitor performance against these targets. The leading EMS system, ISO (International Organisation for Standardisation) 14001, certifies that an organisation has a particular type of EMS in place; it signals the firm's intention to manage its environmental impacts. However, it does not say anything about how the system is performing (Bansal, 2002). In 1999, the

ISO 14031 (performance measurement system) was introduced to complement ISO 14001, but there are still no internationally recognised benchmarks for acceptable levels of performance (Dowell et al., 2000; Litten, 2005). Despite that, the social aspect of the TBL does not have any official standard certification (the closest to that are the rankings of 'best employer', 'best company to work' and so on).

2.3. Sustainability and Operations Management

Sustainability has been receiving growing importance in the corporate environment in recent years. Whether the motivation is the concern for society and the environment, government regulation, stakeholder pressures, or economic profit, most managers recognise the importance of developing sustainability strategies and activities (Epstein et al., 2010). According to Gunasakaran et al. (2015), Sustainable Operations Management (SOM) has started receiving attention from both operations management and management science researchers. SOM includes topics such as green supply chain (e.g., Linton et al., 2007; Darnall et al., 2008), green manufacturing (e.g. Ma, et al., 2018), circular economy (e.g. Kirchherr et al.2017), lean/green manufacturing (e.g. Mittal et al.2017), green procurement (e.g., Seuring and Müller, 2008; Walker et al., 2009) and reverse logistics (RL) (e.g., Dowlatshahi, 2005; Srivastava, 2008). SOM has a potentially vital role to provide solutions for the complex sustainability challenges faced by many organisations (Kleindorfer et al., 2005; White and Lee, 2009).

Bringing sustainability to the OM field, Kleindorfer et al. (2005) and Magon et al. (2018) define sustainable OM as "the set of skills and concepts that allow a company to structure and manage its business processes to obtain competitive returns on its capital assets without sacrificing the legitimate needs of internal and external stakeholders and with due regard for the impact of its operations on people and the environment." According to Buil et al. (2016), sustainability is "the transformation of an organisation's management model towards the achievement of economic goals in a socially and environmentally responsible manner". Gunasekaran and Spalanzani (2012) argue, "Sustainability concepts should be considered as operations strategies similar to agile manufacturing, lean production and business process reengineering.

The Sustainability topic is important in the current business scenario once the potential benefits to a company that implement sustainability projects include cost reduction, process optimisation, innovation generation, lower consumption of natural resources, brand enhancement and competitive advantage increases. According to Ambec & Lanoie

(2008) Sustainability also enables greater innovation by encouraging learning and inquiry among employees, offering access to alternative markets and opportunities to differentiate products while reducing risk management and agency costs and providing access to cheaper capital and improved labour costs. Both researchers and practitioners recognise the importance of SOM as a key strategic component in the development of cost-effective and sustainable global supply chains to meet the increasing needs of customers in terms of flexibility, responsiveness and cost while safeguarding natural resources for future generations

The last twenty years have seen growing pressure on businesses to pay attention to the environmental and resource consequences of their products and processes (Kleindorfer et al., 2005), which has resulted into the increase of Sustainable Operations Management (SOM) research (Walker, 2014). In the 1990s, there was a focus on resource productivity, and the need to reduce the consumption of resources and to use them more efficiently. The underlying concern was that if we continue to consume resources at current rates, we would need over three planets worth of resources (Weizsacker et al., 1997). An interest in resource productivity was typified by the desire to be green and competitive, to make a profit or gain a competitive advantage by improving environmental performance (Porter and Van de Linde, 1995). Interest in environmental performance has continued, with a focus on green products and processes, reducing waste and CO_2 emissions, recycling and reverse logistics or closed-loop supply chains.

Starik and Marcus (2000) state two common explanations of the emergence and study of ‘‘greening organisations’’ are: (1) this development was the evolving outcome of the environmental and social movements that received considerable attention in the 1960s and 1970s; and (2) the perception that organisational entities have or could have significant impacts on their respective ecosystems became widely held, providing various motivations for organisational change. One aspect of these overall themes is green supply chain management issues and how organisations can maximise the potential of their suppliers to adopt green supply chain management practices (Walker et al., 2008).

2.4 Adoption of Sustainable Initiatives

Growing interest in sustainability has been found in both academia and industry (Linton et al., 2007). According to Stoughton et al. (2012), there are two approaches to adopt sustainability, (1) top-down approach and (2) catalytic approach.

A top-down approach is a long-term approach in which leaders "build momentum for change and promote coordinated movement on multiple fronts" (Mirvis and Manga, 2010). In this approach, leadership creates a precise definition of organisational sustainability values, which is consistently communicated and reinforced throughout the organisation.

In the catalytic approach, sustainability initiatives are introduced and implemented by middle managers (Mirvis and Manga, 2010, Stoughton et al., 2012). These middle managers often operate within different functional areas of the organisation and develop their own values and beliefs towards sustainability based on their education and enculturation into their subculture (Linnenluecke and Griffiths, 2010). As a result, managers within a given subculture are expected to behave similarly to sustainability opportunities and challenges, while managers in differing subcultures are expected to behave differently.

According to Gallotta (2016), several authors have investigated the sustainability implementation through different perspectives, such as Human aspect (Robinson et al., 2006 and Vora, 2013); Sustainability Indexes/Reporting facet (Tan et al., 2010; and Ahmed & Sundaram, 2012); Project Management side (Silvius & Nedeski, 2011; Silvius, Schipper and Nedesky, 2012; Agyekum-Mensah et al., 2012); Operations aspect (Thies et al., 2012; Uddin & Rahman, 2012; and Tan et al., 2008) and circular economy;

In this perspective, sustainability implementation can be considered the term to design the adoption of any sustainability initiative, with direct or indirect effect. Examples of Sustainability Implementation projects are: Replacing outdated equipment with new energy-efficient ones; replacing outdated equipment with new water efficient ones; virtualising IT data centre devices; among others. Similarly, to the concept of sustainability, a few researchers considers the three aspects of the triple bottom line (such as Silvius and Nedeski, 2011; Thies et al., 2012; and Sanchez 2014) while others only consider only the environmental aspect (such as Uddin & Rahman et al.2012, Houy et al.2012). The local and global external contexts significantly affect the choices a corporation makes regarding the formulation and implementation of sustainability actions and product characteristics. For example, manufacturing companies may focus more on environmental and health issues, while service-oriented companies may emphasise the social aspects of sustainability (Epstein et al., 2010). This can be justified since most manufacturing companies have a more significant carbon impact when compared with service-oriented organisations. More than that, regulations (such as ISO 14000 and ISO

9000 family standards) have a higher impact on manufacturers when compared with service-oriented organisations.

Human Aspect:

Concerning the Human aspect Robinson et al. (2006) consider the role of knowledge management (KM) in promoting corporate sustainability in the construction industry context. Vora (2013), on the other hand, makes a case for achieving business excellence through sustainable change management. In this research work, the author breakdowns change management into leadership, project management and talent management as pillars and provide insights into how sustainable change is achieved to propel an entity toward business excellence. Muja et al. (2014) presented a review of recent findings relevant to sustainability and change management in order to develop a better understanding of factors that may hinder corporate adoption of sustainability, the role of sustainability in transformational change, and the change management challenges involved in integrating sustainability within the corporate culture.

Sustainability Indexes/Reporting

Considering the Sustainability Indexes/Reporting aspect, Tan et al. (2010) implemented a system to control and manage one warehouse in sustainability terms. The economic indicators page provides the decision maker with more economic indicators to help monitor and assess the situation. The three main social indicators consist of average processing time/pallet, hours/person/month and job satisfaction. The main environmental indicators page shows the number of trees that have been planted as well as the number of trees ready to be sold, the carbon credits required to offset current cumulated emission levels, the current vehicle emissions and minimum vehicle emissions. However, this study was focused only in the warehouse scenario and evaluates only a few metrics of the triple bottom line, revenue, income and expenses (Economic), average processing time/pallet, hours/person/month and job satisfaction (Social) and Carbon Emission (Environmental). Ahmed & Sundaram (2012), on the other hand, proposes and implements a generic sustainable business transformation roadmap, which is supported by a framework and architecture for integrated sustainability modelling and reporting. This research proposes an SBT Roadmap as a procedural framework and a generic domain-independent SMART framework and architecture as a technological infrastructure for realising the SBT roadmap phases and steps.

Project Management

Regarding the Project Management aspect, Silvius & Nedeski (2011) investigated the implementation of Sustainability practices in on Information System (IS) Project. This research studied one project to develop a Remote Application to control lighting, air condition, entertainment equipment, and other electrical devices in the average home that usually requires many separate remotes (and batteries). Silvius, Schipper and Nedesky (2012) analysed 56 case studies on the integration of the concepts of sustainability in the way organisations initiate, develop and manage projects. Agyekum-Mensah et al. (2012) proposed a framework to achieve sustainability in the construction industry, covering the whole lifecycle project, from the planning phase until the deconstruction phase. Silvius & Schipper (2014) report a literature-based analysis of the coverage of the competencies required for considering sustainability aspects, in the standards of project management competencies. The study aims to specify the competence gap of project managers with regards to sustainability and to provide guidance on how to close this gap.

Operations

Considering the Operations side, Rossi et al. (2013) explored the innovative strategies undertaken by Logistics Service Providers (LSPs – companies which service portfolio includes performing partially or entirely the logistics operations) in the eco-efficiency arena and the logistics and learning capabilities needed to achieve eco-efficiency in supply chains; Uddin & Rahman (2012), on the other hand, studied energy efficiency and low carbon enabler green IT framework for data centres in IT departments. To perform this work, the authors developed an implementation roadmap comprising five phases: Planning Phase; Identification & Categorisation phase; Recycling, low carbon enabler policy; Implementation Plan; and Analysis phase. Tan et al. (2008) studied sustainable enterprise modelling and simulation in a warehousing context. The authors used a specific modelling software tool (iThink 9.0.2, from iSee Systems) to model and simulate processes and scenarios. The model analyses the triple bottom line perspectives (social, economic and environmental).

Operations Management concerns the creation of the products and services and all organisations produce some mixture of services and products, whether that organisation is large or small, manufacturing or service, for profit or not for profit, public or private (Slack et al., 2013). Operations Management (OM) also has an impact on the sustainability perspective, according to Drake & Spinler (2013) at the micro-level, firms' operational decisions determine the production and distribution technologies and system design that they employ. These, in turn, determine how efficiently (and which) materials

and energy are consumed as well as the type and intensity of waste injected into ecosystems. Sustainable OM, therefore, potentially has an important role to play in contributing to solutions for the sustainability challenges that we currently face.

Circular economy

The Circular Economy (CE) is not a new concept, but the term was first used in the literature in the early nineties by Pearce and Turner (1990). Other authors, such as Ormazabal et al. (2018), Park et al. (2010), Prieto-Sandoval et al. (2018), Geng et al., (2012), (Yuan et al., 2006), Velenturf et al. (2017) have also investigated the circular economy concept. According to the Ellen MacArthur Foundation (2018), looking beyond the current "take, make and dispose" extractive industrial model, the circular economy is restorative and regenerative by design. It entails gradually decoupling economic activity from the consumption of finite resources, and designing waste out of the system. Underpinned by a transition to renewable energy sources, the circular model builds economic, natural, and social capital.

Prieto-Sandoval et al. (2018) proposed that the CE can be understood through four specific components:

- The recirculation of resources and energy, the minimization of resources demand, and the recovery of value from waste.
- A multi-level approach due to its implementation at the micro (enterprises and consumers) (Park et al., 2010), meso (economic agents integrated in symbiosis) (Geng et al., 2012) and macro (city, regions and governments) levels (Yuan et al., 2006).
- Its importance as a path to achieve sustainable development (Prieto-Sandoval et al., 2017, Velenturf et al., 2017).
- Its close relationship with the way society innovates (Prieto-Sandoval et al., 2018).

As well as creating new opportunities for growth, a more circular economy aims to reduce waste, drive greater resource productivity (obtain the maximum value of the resources), deliver competitive economy, and reduce the environmental impacts of production and consumption of goods

2.5 Companies need to implement sustainability initiatives in their Business Processes

According to Slack et al. (2013), whenever a business attempts to satisfy its customers' needs it, will use many processes, both in its operations and its other functions and each of these processes will contribute some part to fulfilling customer needs. Once the organisation decides to reorganise its operations, each product is created from a starting point passing through processes (which contains the necessary elements for the production) to reach a final stage. This concept is called 'end-to-end' process, which fulfils the customer needs. These end-to-end processes usually cut across conventional organisational boundaries.

"Process" refers to the conversion of inputs (resources) into outputs (goods and services) (Armistead et al., 1997). Although the literature provides numerous definitions for "business processes", all of these reflect, more or less, the same ontology, that a business process is a series of continuous or intermittent cross-functional activities that are naturally connected together with work flowing through these activities for a particular outcome/purpose (Davenport and Short, 1990; Hammer and Champy, 1993; Davenport, 1993; Ould, 1995; Zairi, 1997; Slack et al., 2013, Harmon, 2010). What seems to make the business process approach so distinct is that it not only focuses on activities, i.e. what is done and/or how they are done, but it also places emphasis on how these activities are interconnected and how workflows through these activities to produce efficient and effective results (Bititci et al.2011).

According to Armistead et al. (1997), Operations should be viewed as one example of a business process. The critical point is that transformed resources (such as materials and information) originate from outside the boundaries of the organisation and that outputs in the form of goods and services leave the boundaries of the organisation. It is this "end to end" property which should be used to distinguish business processes. They start with inputs to the business boundary and finish with outputs from the business boundary.

Nonetheless, several sustainability implementation initiatives focus in one specific department of the organisation (IT sector in Uddin & Rahman (2012)'s study, warehouse in Tan et al. (2008) and Tan et al. (2010) studies, Logistics in Rossi et al. (2013)' study). They, however, do not consider that those departments work along with other departments into an end-to-end process (systemic view). According to Michael Porter (1985) model, products pass through activities of a chain in order, and at each activity, the product gains

some value. Similarly, we can consider that the "product" (in the case of a product based industry) gains some 'sustainability impact' in each activity. Therefore, a more refined analysis would consider the whole process interaction to evaluate the full status of the sustainability implementation.

According to Houy et al. (2012) taking resource scarceness, increasing pollution and the debate on global warming into consideration, more and more organisations recognise the upcoming need to improve the sustainability of their business processes. The matter gains increasing importance in the business context and drives organisations to put more effort into enhancing resource efficiency and reducing the production of waste materials in the context of their business activities. According to Thies et al. (2012), most large enterprises regularly assess their emission inventories, set reduction targets, and report on their improvements to various stakeholders (Seuring & Muller, 2008). However, leading enterprises are even going beyond static sustainability reporting by incorporating environmental and social activities into their core business processes. Organisations increasingly realise the importance of sustainability, and many are trying to design or redesign their business processes so that their activities are more environmentally friendly (Klassen & Vachon, 2003). Such companies have in particular understood the value of improving their processes to achieve environmental excellence; the same way they collaborate with others to improve their supply chains with respect to time, quality, flexibility, agility and total cost (Handfield, Sroufe, & Walton, 2005; Sharfman, Shaft, & Anex, 2009).

2.6 Sustainability Implementation Problems

Many organisations are committed to transforming their business processes and have taken sustainability initiatives. However, they have still failed to achieve the anticipated goal (Ahmed & Sundaram 2012). Every sustainability project involves changes in the organisation, from the most basic ones (like replacing disposal plastic cups for individual ceramic mugs) up to changes in the company operations. However, according to Burnes (2003) between 40 and 70 percent of these change initiatives still fail. Those initiatives fail due to many different reasons, either the lack of management support, lack of proper communication, lack of stakeholder engagement, among others.

However, the reasons behind the initiatives' failure might be in the challenges to implement sustainability initiatives. Once an organisation does not overcome a particular challenge, it might result in the failure of this initiative. A few authors (such as Epstein et

al., 2010; Frandsen et al.2013, Seidel et al., 2012; and Giunipero et al., 2012) have studied those barriers. According to Epstein et al. (2010), the challenges of implementing sustainability initiatives are setting clear and measurable goals, dealing with financial incentive pressures; and comprehending Stakeholder reactions. Seidel et al. (2012), on the other hand, considers that the challenge arises on how sustainability considerations (such as carbon footprint, renewable energy consumption, wastage production, and other environmental performance indicators) can be considered in the management of an organisation's processes. Frandsen et al. (2013), proposes that the main challenge is within embed sustainability into the organisation. According to Poveda et al. (2014), the challenge lies in the sustainability indicators, specifically in selecting the right indicators, identifying the measurement method and aligning them to the goals and objectives of the project. To Giunipero et al. (2012) the main barriers to the sustainability adoption are (1) lack of consensus at the CEO level; (2) costs of sustainability and economic conditions; (3) lack of sustainability standards (covering all the three aspects from the Triple Bottom Line) and appropriate regulations; and (4) misalignment of short term and long term strategic goals.

Ahmed & Sundaram (2012) go even beyond the presented challenges, according to the authors existing roadmaps, frameworks and systems do not comprehensively support a sustainable business transformation nor do they allow decision makers to explore interrelationships and influences between the sustainability dimensions. However, because the sustainability concept continues to be applied unsystematically, these practising organisations experience considerable difficulties in realising their goals of full sustainability status. This is due to a lack of understanding and support for the design, development and implementation process, and lack of proper procedural and technological support for decision making for sustainability management.

Stewart et al. (2016) categorises the barriers in (1) internal barriers, such as financial and other resource constraints, managerial and employee attitudes, poor communication and past practices and (2) external barriers, such as capital costs, competitive pressures, industry regulation, technical information, green market opportunities and technical solutions. **Table 2** represents the summary of some challenges found in the literature to implement sustainability initiatives.

Table 2 - Summary of some challenges found in the literature to implement sustainability

initiatives

References	Challenges
Epstein et al. (2010)	Setting clear and measurable goals
	Dealing with financial incentive pressures
	Comprehending Stakeholder reactions
Seidel et al. (2012)	How to consider sustainability aspects in the management of an organisation's processes
Giunipero et al. (2012)	Lack of consensus at the CEO level
	Costs of sustainability and economic conditions;
	Lack of sustainability standards and appropriate regulations
	Misalignment of short term and long term strategic goals.
Ahmed & Sundaram (2012)	Existing roadmaps, frameworks and systems do not comprehensively support sustainable business transformation
	Existing systems do not allow decision makers to explore interrelationships and influences between the sustainability dimensions
	Sustainability concept continues to be applied unsystematically
Poveda et al. (2014)	Select the right sustainability Indicators
	Define the proper measurement method
	Align indicators to goals and objectives
Frandsen et al. (2013)	How to embed sustainability to the organisation.
Stewart et al. (2016)	The barriers are categorised in (1) internal, such as financial and other resource constraints, managerial and employee attitudes, poor communication and past practices and (2) external, such as capital costs, competitive pressures, industry regulation, technical information, green market opportunities and technical solutions.

2.7 Chapter Summary and conclusions

The sustainability concept is quite recent and has several meanings. However, the most common, presented in the Brundtland Commission's Report, defines sustainability as the development that meets the needs of the present without compromising the ability of future generations to meet their own needs'. Sustainability integrated into operations management provides benefits to the organisations since it provides new opportunities to grow, develop new business practices, and drive innovation while being ecologically, socially and economically correct.

Organisations' motivation to adopt sustainability practices can be related to compliance, customer requirements, economic profit, among others. Sustainability implementations can be studied from different angles (such as regarding the Project Management aspect, the Human aspect, the Operations aspect) and there are still problems and challenges associated with these implementations. Some challenges found in the literature consists in defining measurable goals, selecting the right sustainability Indicators, considering sustainability aspects in the management of an organisation's processes. Therefore, any sustainability initiative must comprehend those challenges and provide a solution that could overcome them. More than the challenges and barriers to implementing sustainability initiatives, several approaches focus on one specific department of the organisation. They, however, do not consider that those departments work along with other departments into an end-to-end process (systemic view). Therefore, a more refined analysis would consider the whole process interaction to evaluate the full status of the sustainability implementation.

Chapter 3 – Literature Review on Business Process Management

3.1. Introduction

Chapter 2 outlined that a more refined analysis needs to consider the whole process interaction to evaluate the full status of the sustainability implementation and Business Process Management (BPM) emerges as a right approach. This chapter presents the Business Process Management (BPM) approach. It starts showing the evolution of concepts that lead to the development of the methodology, ever since Adam Smith's division of labour, passing to the Toyota Production System, Lean Manufacturing, Total Quality Management approach, Six Sigma, Business Process Reengineering, and finally the Business Process Management. It goes deep in the concepts of BPM showing the benefits, success factors and the typical implementation phases. Finally, the chapter brings the relation between Business Process Management and the sustainability topic. It starts by reviewing the sustainability role in the current corporate environment and provides arguments to corroborate that BPM can be used as a tool to enable the implementation of Sustainability Initiatives in the organisation processes.

3.2. Process Management Origin and Evolution

Business Process Management (BPM) may be a new label, although the ideas leading to business process management are old. The process management concept started in the Scientific Management era; the concept was followed by the Toyota Production System; Lean Manufacturing; Total Quality Management; Six Sigma; Business Process Reengineering; and, finally, Business Process Management. According to Smith & Fingar (2003), the Process Management concept can be divided into four phases: industrial age; Process Improvement; Process Reengineering; and Business Process Management. The BPM timeline in **Table 3** presents the three waves of process evolution since industrial revolution concept (Gallotta, 2016). The timeline illustrates that the shaping of BPM into its present state is the result of significant business drivers, business tools, organisation development methodologies, key technological developments, technology and measurement tools, standards, and related controls (Lusk et al., 2005).

Table 3 - Three Waves of Process Evolution. Adapted from .Lusk et al. (2005)

Phase	Time	Focus	Business	Technology	ToolsEnablers
Industrial Age		Specialisation of Labour	Functional Hierarchies	Mechanisation	Scientific Management

	1750 - 1960s	Task Productivity Cost Reduction	Command & control Assembly line	Standardisation Record-keeping	PDCA improvement Cycle Financial modelling
Information Age					
1st wave - process improvement	1970s - 1980s	Quality management Continuous flow Task efficiency	Multi-industry enterprises Line of business organisation Mergers & acquisitions	Computerized automation Management systems MRP	TQM Statistical Process Control Process improvement methods
2nd wave - Process reengineering	1990s	Process Innovation Best practices Better, faster, cheaper Business via internet	Flat organisation End-to-end processes value propositions - speed to market, customer intimacy, operational excellence	Enterprise architecture ERP CRM Supply Chain Management	Activity-based costing Six Sigma Buy vs build Process redesign/ reengineering methods
3rd wave - Business	2000 +	Assessment, adaptability & agility	Networked organisation	Enterprise application integration	Balanced scorecard

Process Management		24X7 global business Continual transformation	Hyper competition Market growth driven Process Effectiveness over resource efficiency Organisational efficiency over operational efficiency	Service Oriented Architecture	Self-service & Personalisation Outsourcing, co-sourcing, in-sourcing BPM methods

3.2.1. Scientific Management

According to Snabe et al. (2008), the foundation for process management can be traced back to Adam Smith, who wrote the groundbreaking book: "An Inquiry into the Nature and Causes of the Wealth of Nations (1776)". While at its core Smith's book focused on answering the question "Why are some nations rich and others poor?" his ideas and conclusions have broad applicability and are especially relevant to contemporary management. Adam Smith was the first to realise that specialisation and the division of labour were the primary sources of productivity, and he was the first to conceptualize the "invisible hand principle" demonstrating the tendency for self-interested individuals to be guided towards undertaking activities valued by the whole of society in a free market system governed by the rule of law and market prices. (Crowley et al., 2010).

The next stage in the evolution is the scientific management movement, initiated by Frederick Winslow Taylor at the end of the XIX century. Taylor's work titled "The Principles of Scientific Management" brought a revolution in shaping the early twentieth-century factory system (Jaffee, 2001). In this book, he formalised the replacement of the rule of thumb for scientific methods. Taylor focuses his argument on the work efficiency, which involved making the tasks most intelligently with the most effort economy (Taylor,

1911). According to Uddin et al. 2015), Taylor through his scientific analysis of finding inefficiency in traditional organised businesses established the point that, each motion of work should be executed under maximum capacity of workers with a predetermined method of work under specific training format, ensuring high profit and resulting good worker manager relationship (Caldari, 2007). Taylor thus introduced a clear vision for the division of labour depending on responsibilities and rank and introduced science in the labour selection process in organisation management. (Uddin et al. 2015).

The final stage in the evolution of the scientific management movement was initiated by Ford's mass production factory, which represented a revolution in the sense that the application of these principles significantly improved productivity by organising manufacturing processes differently (Snabe et al., 2008). Ford adopted the principles of Scientific Management from 1908 to 1914, resulting in promoting Ford and his modified methodology of Fordism internationally (Waddell, et al.2013).

In the scientific field, the methods and mathematical tools were used to organise and manage processes. According to Slack et al. (2013), the vital thing to remember about scientific management is that it is not particularly 'scientific' as such, although it certainly does take an 'investigative' approach to improve operations. Perhaps a better term for it would be 'systematic management'. During this period, two fields of study had a significant role: the method study and the work measurement (Gallotta, 2016).

3.2.2. Toyota Production System

The next industrial engineering paradigm was the Toyota Production System. According to Ohno (1988), the initial step of the Toyota Production System is to identify waste. According to the author the waste can be classified into: waste of overproduction; waste of time on hand (waiting time); waste of transportation; waste of processing; waste of inventory; waste of movement; and waste of making defective products (Gallotta, 2016). The next issue Ohno addressed was Supply. Probably the most critical and essential aspect of the Toyota production system is the just-in-time production concept. Just-in-time production is exactly what it says, production of a part, component or subassembly must occur just in time, not any earlier nor any later, reducing in-process inventory and inventory produced by parts or component suppliers to a considerable and significant extent (Pegels 1984).

In manufacturing, just-in-time means that a later process gets only what it needs from an earlier process. The earlier process immediately produces what was required with no delays. To improve the process flow, Ohno (1988) decided that instead of putting the

machines of one process together and having to carry parts between processes, he would design the plant layout according to the operation flow. This system increased production efficiency by two to three times over "one operator, one process", which mass production required (Gallotta, 2016).

3.2.3. Lean Manufacturing

Following the evolution of the concepts of Toyota Production System, there is the rising of the Lean Manufacturing approach, which is an integrated socio-technical system whose main objective is to eliminate waste by concurrently reducing or minimising supplier, customer, and internal variability (Shah and Ward, 2007). While just-in-time manufacturing is focused on efficiency, lean manufacturing is focused on using efficiency to add value for the customer. The main practices that support lean manufacturing objectives are continuous flow; Just in Time; Reduction in setup time; Total production maintenance (TPM); Employee involvement; Continuous improvement; and Supplier development (Shah and Ward, 2003, 2007; Bhasin and Burcher, 2006; Pettersen, 2009; Agus and Hajinoor, 2012; Gallotta, 2016). According to Krajevski et al. (2012), the goals of a lean system are to eliminate the waste (MUDA), produce services and products only as needed, and to continuously improve the value-added benefits of operations. The eight type of wastes are: overproduction, inappropriate processing, waiting, transportation, motion, inventory, defects and underutilization of employees.

In recent years, lean practices have been linked to green practices by several authors (eg. Cruz-Machado & Leitner, Zhu et al., 2008, Duarte & Machado, 2017). According to Duarte & Machado (2017), the lean management paradigm involves continuous improvement in quality, productivity and time by reducing cost and waste across all operations (Cruz-Machado & Leitner, 2010) and the green paradigm is intended to reduce environmental risks and negative environmental impacts while improving the ecological efficiency and eliminating environmental waste in organisations (Zhu et al., 2008). Therefore, it is possible to conclude that both paradigms aims to reduce the waste across the operations and, consequently, to the organisations. The Environmental Protection Agency (EPA, 2009) mentions that green and lean professionals often operate in parallel universes, using different languages and involving different people, despite having similar goals and using some similar tools (EPA, 2009). Their strategies focus on waste reduction, efficient use of resources and customer value (Carvalho et al., 2011).

Several authors have related lean and green subjects to manufacturing processes (Pampanelli et al., 2014, Kurdve et al., 2014, Jabbour et al. 2013, Chiarini, 2014, Verrier

et al., 2016). Jabbour et al. (2013) found evidence that Lean management has a positive impact on environmental management, which itself has a positive impact on operational performance and Chiarini (2014) underlines interesting links between specific basic lean tools and their consequences on environmental performance. However, according to Verrier et al. (2016), only few studies proposed Lean and Green models but most confirmed the ability of a joint Lean and Green philosophy to reduce the usage of resources and increase cost benefits.

3.2.4. Total Quality Management

The next step in the process management concept is the Total Quality Management (TQM). According to Fotopoulos & Psomas (2009), making the step towards TQM was much more difficult as there was widespread confusion about the components of TQM and how they could be implemented. They argue that Deming's 14 points and cycle (plan, do, check, act - PDCA), Juran's quality trilogy (planning, control and improvement), Crosby's absolutes of quality management (conformance to requirements, prevention, zero defects and cost of quality), Garvin's quality dimensions, Ishikawa's cause and effect diagram, Feigenbaum's three steps to quality (quality leadership, modern quality technology and organisational commitment) and Taguchi's advice to companies to turn to statistical process control and design of experiments constitute the most critical aspects of the TQM framework that quality gurus have recommended (Gallotta, 2016). Deming confirmed that improving product quality should not be dependent on mass inspection. Quality comes not from inspection, but from the improvement of the production process (Deming, 1986).

For Ahire et al. (1996), TQM works on the belief that the overall quality of products can be enhanced by improving the quality of the processes directly or indirectly related to them. Dale (2003), on the other hand, mentioned that, according to TQM approach, the achievement of the highest level of quality involves the application of quality management principles to all aspects of the organisation, including customers and their integration with the key business process (Gallotta, 2016).

3.2.5. Six Sigma

TQM led to another approach called Six Sigma. Six Sigma is a series of practices developed by Motorola at the 1980s. According to Linderman et al. (2003), Six Sigma is "an organised and systematic method for strategic process improvement and new product and service development that relies on statistical methods and the scientific method to

make dramatic reductions in customer-defined defect rates". It uses an improvement procedure generally known under the acronym DMAIC (Define, Measure, Analyse, Improve and Control) de Mast et al. (2012). DMAIC is similar in function to its predecessors in manufacturing problem solving, such as Plan-Do-Check-Act and the Seven-Step method of Juran and Gryna (Balakrishnan et al., 1995).

3.2.6. Business Process Reengineering (BPR)

At the beginning of the 1990s, it was developed the concept of Business Process Reengineering (BPR). According to Radhakrishnan & Balasubramanian (2008), Business Process Reengineering (BPR) is the redesigning of business processes, associated systems and organisational structures to achieve substantial improvements in business performance. The business reasons for making such changes could include poor financial performance, external competition, market share loss, or emerging market opportunities. BPR is the examination and change of the following business components: strategy; processes; technology; organisation; and culture. Successful BPR implementation can result in cost reductions or cycle time reduction. It can also potentially create substantial improvements in quality, customer service, and other parameters of business performance. According to Hammer and Champy (1993), BPR is the "fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical, contemporary measures of performance, such as cost, quality, service and speed" (Gallotta, 2016).

According to Hammer (1993), the principles of reengineering process are: 1. Organise around outcomes, not tasks; 2. Have those who use the output of the process perform the process; 3. Subsume information processing work into the real work that produces the information; 4. Treat geographically dispersed resources as though they were centralised; 5. Link parallel activities instead of integrating their results; 6. Put the decision point where the work is performed, and build control into the process; 7. Capture information once and at the source.

Radhakrishnan & Balasubramanian (2008) justifies that BPR is fundamental because in reengineering business people need to ask questions such as: 'why do we do what we do?' and 'why do we do it the way we do?' Asking these fundamental question forces the organisation to look at the unspoken rules and assumptions that underline the way they conduct their business and find opportunities for change. It is radical because the radical redesign implies in getting to the root of things (not a superficial assessment); radical redesign means disregarding all existing structures and procedures, and inventing

completely new ways to accomplish work, reengineering is about business re-invention (not necessarily b business improvement). It is dramatic because Reengineering is not about making incremental improvements, but about achieving quantum leaps in performance (significant changes). Moreover, it relates to processes because processes define how an organisation can develop a new product, how it can perform in a better way, how can the organisation do the same work at a lower cost and, mainly, why does the company do what it does at all (Gallotta, 2016).

According to Hammer and Champy (2004), the seven principles for Business Process Reengineering are: Organising around results and outcomes (not tasks); Having those who use the output of the process perform the process; Subsuming information-processing work into real work that produces the information; Treating geographically dispersed resources as though they were centralised; Linking parallel activities instead of integrating their results; Putting the decision point where the work is performed, and build control into the process; and capturing information once and at the source (Gallotta, 2016).

3.3. Defining Business Process Management (BPM)

BPM has evolved as a holistic management practice for managing and transforming organisational operations (Hammer, 2010). BPM is built on several management approaches, embracing aspects of the total quality management (TQM) approach from the 1980s and the business process re-engineering (BPR) approach from the 1990s (Rosemann et al.2010).

BPM can be defined as a paradigm that includes methods, techniques, and tools to support the design, enactment, management and analysis of operational business processes (Meidan et al. 2017). According to Hill et al. (2007): "BPM refers to a set of management disciplines that accelerate effective business process improvement by blending incremental and transformative methods. BPM's management practices provide for governance of a business process environment toward the goal of improving agility and operational performance. BPM is a structured approach that employs methods, policies, metrics, management practices and software tools to manage and continuously optimise an organisation's activities and processes".

Business Process Management (BPM) has gained importance over the last decades and many organisations today focus their attention on identifying and documenting business processes, defining key performance indicators (KPIs) for measuring and monitoring

process performance, and implementing means for continuous process improvement and innovation (vom brocke, Gartner, 2013; Rosemann, 2014; vom Brocke & Rosemann, 2015; Zairi, 1997). It provides adequate techniques for the design, execution, controlling as well as the analysis of business processes in order to improve value creation within single organisations as well as in inter-organisational value networks (van der Aalst, ter Hofstede, & Weske, 2003). According to Seidel et al. (2012) in their efforts to manage and improve business processes, BPM enables business benefits concerning costs, flexibility, time savings, quality, or, indeed, sustainable practices (Gallotta, 2016).

According to Jeston & Nelis (2006), historically, process literature has suggested that there are three critical aspects to a process improvement project: process, people, and technology. The BPM approach considers those three aspects comprehensively since process design needs to be linked to the company strategy and aiming to reach the process objectives; people are key to implement the proposed processes, they are the agents of change; and technology means the tools that support processes and people, not necessarily means a BPM software or application (even though it could be) (Gallotta, 2016).

The BPM discipline calls for organisations to see themselves as a collection of highly integrated processes instead of a mere set of functions and departments (McCormack and Johnson, 2001). BPM, therefore, is a comprehensive management approach to align business processes with corporate strategy, to analyse, optimise and implement best-in-class processes.

3.3.1. BPM Benefits

Rudden (2007) identified that the organisation that incorporates successfully the BPM philosophy gains benefits in terms of Efficiency; Effectiveness; and Agility.

Efficiency usually is the first benefit to be observed by an organisation that deploys a BPM initiative. According to the author, most processes have significant waste because of manual effort, poor hand-offs between departments and a general inability to monitor overall progress. The initial deployment of a BPM solution eliminates these problems and the benefit is typically expressed in full-time equivalent time saved. The efficiency can also be identified in the elimination of manual data entry, reduction of process cycle time and reduction of manual analysis. BPM tools may be pressed into roles beyond providing do-more-with-less efficiency. BPM tools offer the potential for greater business agility, as workflow apps can be quickly rolled out and modified to deal with shifting business trends or changes in the regulatory environment. Besides, some customers are looking to deploy BPM to improve customer-facing processes as well as back-office tasks.

Once an organisation has realised the necessary efficiencies that a more controlled process brings, they will often focus on making the process more effective. The returns are typically expressed in the context of making better decisions. One telecommunication service provider found that by better controlling their billing disputes process they were able to reduce by $3 million the amount they were paying out each quarter (approximately 10%). Their BPM deployment helped them identify duplicate issues, research disputes more throughly, and enforce more consistent payout policies. The effectiveness can also be identified in handling exceptions faster and better and in making a more consistent execution of tasks.

According to Rudden (2007), the third key benefit that BPM provides is agility. In the world of Process Management, the ability to change quickly is essential. The driver for change can be internal or external, new opportunities can arise, customers may change their demands. BPM provides a platform to change the organisation processes in a faster and controlled way. The agility can be identified in faster regulatory compliance and in supporting new business models.

Other authors (such as Jeston & Nelis, 2008; Scheer, 2006; Snabe et al., 2008) identify other benefits obtained from BPM implementations, such as enablement of continuous process improvement; improvement of process quality; cost reduction; increase in the customer satisfaction; and better control over process performance.

According to (Škrinjar & Trkman 2013), BPM is an approach for increasing Business Process Orientation (BPO), improving the process maturity level and leading to better performance. **Figure 5** represents the BPM contribution.

Figure 5 Source Škrinjar & Trkman (2013) - content removed for copyright reasons

Ittner & Larcker (1997) highlight that some BPM practices and techniques improve profitability, while others have little effect on financial performance.

3.3.2. BPM Success Factors

According to Jeston & Nelis (2008), BPM projects are usually complex. This type of project has the potential to cross departments and, increasingly, organisation boundaries, as clients, vendors and partners become more involved. It will involve many diverse and complex stakeholder relationships both inside and outside the organisation. According to the authors, this type of initiatives has the following success factors: Leadership; Project Management alignment; Linkage to organisation strategy; Structured approach to implement BPM initiatives; People change management; People and empowerment; and Value Realisation (Gallotta, 2016).

Today, it is observed more and more organisations considering BPM in various business contexts (Harmon & Wolf, 2014), although it is also observed more and more organisations reporting on project failure. Thus, much research has been conducted to examine success factors for BPM in general (Ravesteyn & Batenburg, 2010; Trkman, 2010) and how these factors influence the different stages of BPM adoption (Buh, Kovačič, & Indihar Štemberger, 2015). According to Benner & Tushman (2003) one reason for the frequency of BPM project failure is the lack of knowledge about how to sufficiently address the different contexts in which BPM is applied; or, in other words,

BPM approaches, methods and models are not sensitive enough to diverse business contexts (Brocke et al. 2016)

3.4. Business Process Management (BPM) Phases

The literature provides numerous approaches to implement Business Process Management concepts in an organisation. Morais et al. (2014) compared thirty-one (31) different models to implement BPM projects with the model proposed by ABPMP (Association of Business Process Management Professionals). Scheer (2006), for instance, proposed a four steps implementation roadmap (Strategy, Design, Implementation, and Controlling presented in **Figure 6**); Netjes et al. (2006), on the other hand, proposed a five phases implementation steps (design, configuration, execution, control, and diagnosis, providing – **Figure 7**) and Houy et al. (2010) proposed a cycle perspective of BPM with six phases (Strategy development, definition and modelling, implementation, execution, monitoring and control, optimisation and improvement – presented in **Figure 8**).

Figure 6 - BPM implementation. Adapted from Scheer, (2006) - content removed for copyright reasons

Figure 7 - BPM implementation. Netjes et al. (2006) - content removed for copyright reasons

Figure 8 - BPM implementation cycle. Houy et al., 2010) - content removed for copyright reasons

According to ABPMP (2009), the management practice of BPM may be characterised as a continuous lifecycle of integrated BPM activities. While several variations of BPM lifecycles are recognised, most lifecycles can be summarised by an iterative, phased set of activities including: (1) Planning; (2) Analysis; (3) Design and Modelling; (4) Implementation; (5) Monitoring and Control; and (6) Refinement (Gallotta, 2016). As business processes move through the lifecycle, they are enabled or constrained by a variety of factors including the four primary factors of Leadership, Values, Culture and Beliefs.

Figure 9 shows the model of the BPM lifecycle proposed by ABPMP (2009). In the cycle, the analysis step adds activities aimed at aligning business objectives with their processes, whether to establish them or update them, and based on the scope, techniques are applied to map the business context through interviews, documental analysis, simulations or other instruments of prospection. The design of business processes involves the creation of new specifications for them, their activities and tasks, rules and definitions for exchanging information among functional groups (handoffs), physical design and IT infrastructure. Management during implementation should be viewed as an "orchestration" activity and it involves training, metric policies and performance evaluation, strategic alignment evaluation and risk analysis and monitoring. The monitoring and control of processes deal with adjustments of resources to ensure process objectives through performance measurements and evaluation. The refining step is associated with organisational change, continuous improvement and optimisation activities in search of the efficiency and effectiveness of processes implemented in the organisation.

Figure 9 - BPM Lifecycle - ABPMP (2009) - content removed for copyright reasons

Morais et al. (2014) study indicates a moderate convergence of Business Process Management (BPM) models in literature with the ABPMP reference model, essentially in the models' intermediate steps: for the analysis, design and modelling, implementation and monitoring and control phases, the activities of studied models were mapped to the ABPMP (2009) BPM lifecycle, so that each step of the studied

models corresponds to two or more steps of the ABPMP model or various steps of a studied model correspond to a step of the reference model.

As it was discussed in chapter 2, the sustainability implementation success is directly related to the alignment of the strategy and business processes in an explicit manner. This way, it was proposed a four phases framework (Analyse, Design; Implement; and Monitor & Control), in which the Analyse phase has broken down the elements from the "process planning & strategy" into the identification of business scenario, determination and prioritisation of processes, identification of project stakeholders, definition of project objectives, definition of metrics, record enterprise map, record baseline values and sustainability maturity assessment. The four phases framework also can be related to Deming's PDCA cycle, which might facilitate the implementation of the sustainability initiatives.

3.4.1. Analyse

The 'Analyse' phase is critical to evaluate the strategy, business environment and processes identifying business goals and defining requirements. This phase provides structure and direction for continued customer-centric process management. It lays a foundation for a holistic BPM approach to ensure the alignment with organisational strategy and the integration of strategy, people, processes, and systems across functional boundaries. This phase sets the strategy and direction for the BPM process. It also identifies appropriate BPM organisational roles and responsibilities, executive sponsorship, goals, and expected performances measures and methodologies. (ABPMP, 2009). After this phase, the project should have the current process design (as-is situation), the concrete process goals and the initial process ownership definition (Gallotta, 2016).

3.4.2. Design

In the 'Design' phase there is the designing of potential process alternative; identification of potential changes in the current design; modelling the process alternatives, mapping the proposed alternatives (to-be) to existing systems/applications; and defining the implementation strategy. According to ABPMP (2009) Process design activities focus on the design of how end-to-end work occurs to deliver value to customers. The sequence of activities, including the design of what work is performed, at what time, in what location, by what process actors using what methodology is documented. Design defines what the organisation wants the process to be and answers the what, when, where, who and how

questions of how end-to-end work is executed. An essential component of the design is also ensuring that the proper management controls and metrics are in place for compliance and performance measurement. In an iterative BPM lifecycle, first designing activities may look at standardising or automating current ad hoc activities, while more mature design activities may look at redesign or radically reminding a process, or incremental improvements designed for optimisation. After this phase, the project should have the project scope; the expected process designs (to-be situation), and the implementation plan (Gallotta, 2016).

3.4.3. Implement

According to ABPMP (2009), process transformation implements the output of the iterative analysis and design cycle. It addresses organisational change management challenges and is aimed at continuous improvement and process optimisation. In this context, "optimised processes" are those that consistently achieve predefined goals in terms of both efficiency and effectiveness. During the 'Implement' phase there is the process transformation (following up activities, monitoring the realisation progress, performing roll-out & change management activities and designing a support concept); and the process execution (solution go-live) (Gallotta, 2016).

3.4.4. Monitor & Control

Finally, in the 'Monitor & Control' phase, there is the measurement of the project performance. Measurement of the process performance; and the analysis of the results. According to ABPMP (2009), continuous measuring and monitoring of business processes provide the information necessary for process managers to adjust resources to meet process objectives. In the context of the BPM lifecycle, measuring and monitoring also provides critical process performance information through key measurements related to goals and value to the organisation. The analysis of process performance information may result in improvement, redesign or reengineering activities (Gallotta, 2016).

3.5. Relating Business Process Management (BPM) and Sustainability

According to vom Brocke et al. (2012), business process management to date has not explicitly focused on sustainability as a change objective or driver. Although, approaches relating BPM and Sustainability already exist, e.g. (Ghose et al.2009; Hoesch-Klohe et al. 2010; Houy et al.2012; Seidel et al.2012. According to Opitz et al. (2014), green BPM is the sum of all management activities that help to monitor and reduce the environmental impact of business processes in their design, improvement, implementation, or operation

stages, as well as lead to cultural change within the process lifecycle. The intention behind Green BPM is the incorporation of environmental objectives into the management of business processes. To achieve this objective, BPM has to be extended by ecologically oriented complements, as are the consideration of environmental strategy as a part of the process strategy, or the awareness for energy consumption and pollution (Houy et al.2012)).

According to Levina (2015) the majority of the sustainability initiatives focus on reducing the general resource usage (such as electricity), cost savings was the second exclusive goal mentioned by the enterprises, implying that the environmental benefits that result from the accordant activities are considered as a by-product of lean or optimisation actions rather than the goal itself, while providing a unique proposition to gain customers and market share. Process management techniques, especially techniques for process optimisation, are also shown to result in environmental benefits, i.e. resource usage or waste reduction, without being explicitly focused on designing green processes. As various industries are present in the study sample, indications about favoured managing techniques for green initiatives among the industries can deviate. It was observed that manufacturing companies tend to adopt lean and sustainable benefits but also that service-oriented enterprises financially and environmentally benefit from conscious resource usage by applying and adopting the same techniques. According to Houy et al. (2012) Green BPM methods are still in the early stages and so far, only a few approaches exist.

Seidel et al. (2012), for example, created a framework for Green BPM Research and Practice by building on a model of BPM capabilities (de Bruin & Rosemann, 2007; Rosemann & vom Brocke, 2010) (presented in **Figure 10**). Essentially, the model describes a set of six capability areas that are key to the management of business processes in an organisation: Strategic Alignment is the continual tight linkage of business process management to organisational priorities and processes, enabling achievement of business goals; Governance establishes relevant and transparent accountability and decision-making processes to align rewards and guide actions in business process management; Methods are the approaches and techniques that support and enable consistent business process management actions and outcomes; Information Technology is the software, hardware, and information management systems that enable and support business process management activities; People are the individuals and groups who continually enhance and apply their business process management-related expertise and knowledge; and

Culture is the collective values and beliefs that shape business process management-related attitudes and behaviours (Gallotta, 2016).

Figure 10 - The BPM capability areas and underlying factors (de Bruin & Rosemann, 2007) - content removed for copyright reasons

Reiter, Fettke, and Loos (2014) introduce a combined approach of IT and BPM for efficient energy use in a process. The authors used a three-layer view that aims to introduce an integrated view of business processes, their related applications and the corresponding IT components. Later on, they evaluated the energy consumption from the sample business process. **Figures 11** and **12** represents the sample business process and related energy consumption.

Figure 11 Sample business process and related local applications. Source Reiter, Fettke, and Loos (2014) - content removed for copyright reasons

activity	application	energy consumption (application)	energy consumption (display)	energy consumption (static)	energy consumption (total)
extract order data	**sub total**	**68 Ws**	**1,003 Ws**	**3,097 Ws**	**4,168 Ws**
	e-mail client	57 Ws	459 Ws	1,416 Ws	1,931 Ws
	pdf reader	8 Ws	246 Ws	761 Ws	1,015 Ws
	spreadsheet 1	4 Ws	298 Ws	920 Ws	1,221 Ws
create shipping note and invoice	**sub total**	**15 Ws**	**766 Ws**	**2,366 Ws**	**3,148 Ws**
	word processor	7 Ws	399 Ws	1,232 Ws	1,639 Ws
	spreadsheet 2	8 Ws	367 Ws	1,134 Ws	1,509 Ws
pass to logistics supplier	**sub total**	**101 Ws**	**265 Ws**	**819 Ws**	**1,185 Ws**
	browser	101 Ws	265 Ws	819 Ws	1,185 Ws
total		**184 Ws**	**2,034 Ws**	**6,282 Ws**	**8,501 Ws**

Figure 12 Energy consumption of the sample business process. Source Reiter, Fettke, and Loos (2014

Recker et al. (2011), in turn, created a notation for the documentation of carbon footprint information in a process model. Then, they applied the modelling approach to a real-world company and started measuring carbon footprints of the business processes. However, this research only focused in one particular stage of the business process lifecycle (actually two distinct, considering the case studies), more than that the study only focused in selected emission drivers and emission sources, it was only assessing Carbon footprint, not the whole sustainability status (Gallotta, 2016). **Figure 13** shows the notation and **Figure 14** the application of the notation in the business processes.

Figure 13 - Notation extensions. Recker et al. (2011) - content removed for copyright reasons

Figure 14 - E.g. of a BPMN model using the sustainability notation. Recker et al. (2012)- content removed for copyright reasons

Houy et al. (2012), on the other hand, assessed and demonstrated both organisational and technological opportunities and challenges of Green BPM for the improvement of the sustainability of business activities. According to the authors in Green BPM every business activity in a process model can be annotated with an adequate ratio representing the consumption of resources and the production of waste materials. By accumulating the annotated values, the total consumption of needed resources or the total production of waste materials in a process can be measured and controlled. This method facilitates an optimised organisation of activities in a process and the controlling of the ecological impact of its execution. To investigate the organisational as well as technological opportunities of Green BPM (Gallotta, 2016). **Figure 15** shows one sales process represented by an Event-driven Process Chain (EPC) with the respective resource consumption

Figure 15 - E.g. of a process at the activity level using EPC notation with the sustainability rations per activity. Houy et al. (2012) - content removed for copyright reasons

According to Houy et al. (2012) future research should further develop concepts for Green BPM; e.g. in the form of green reference process models or procedure models for the implementation of green processes. Furthermore, adequate techniques and tools for the realisation of Green BPM potentials in inter-organisational scenarios throughout the whole business process lifecycle can considerably contribute to more sustainable business activities.

Therefore, this research aims to provide a full lifecycle solution for improvement of business processes into sustainability business processes by Analysing, Designing, Implementing and Monitoring & Controlling current (or eventual new) processes in one organisation to transform them in sustainable processes, optimised processes. (Gallotta, 2016)

3.6. Chapter Summary and conclusions

By definition, Business Process Management (BPM) is a management approach to align business processes with the corporative strategy to analyse, optimise and implement the best processes into an organisation. However, BPM is more than one methodology, it is a concept that involves several areas within the organisation. It relates people, strategy, governance, methods, Information Technology and culture with processes and operations. Chapter 2 has demonstrated that current management models do not address the sustainability challenges fully, so it is crucial to develop new approaches to overcome this situation. In this scenario, Business Process Management rises as an excellent approach to be used as an enabler, due to its capacity to organise the companies in processes structures, helping them to understand those processes and change them according to the current sustainability requirements. Chapter 4 will present the methodological aspects involved in the research, and chapter 5 will provide the framework that was developed for the research.

Chapter 4 - Research methodology and approach

4.1. Introduction

This chapter presents an overview of the methodological aspects of the research and the manner it was conducted. The first step was to classify the research regarding purpose, process, logic and outcome. Then, it defines the research methodology used in this research, aligning it to the aims, objectives and research questions. Finally, the chapter presents the research methods used and presents the methods for data collection.

4.2. Type of research

According to Hussey and Hussey (1997), it is essential to know and classify the research to clearly understand what the researcher is doing. **Table 4** shows the different classifications of research.

Table 4 Different classifications of research. Adapted from Hussey and Hussey (1997)

Type of research	Basis of classification
Exploratory, descriptive, analytical or predictive	Purpose of research
Quantitative or qualitative	Process of the research
Deductive or inductive	Logic of the research
Applied or basic	Outcome of the research

Based on this classification and their characteristics, the research carried out in this project can be classified, according to its purpose, as exploratory. This is due to the lack of studies successfully combining business process management and sustainability implementation detailed in chapter 2. Furthermore, the present investigation will not only describe the research process but also analyse it, propose changes and evaluate accordingly.

According to Robson (2002), an exploratory study is a valuable means of finding out 'what is happening; to seek new insights; to ask questions and to assess phenomena in a new light'. Shields (2013) states that exploratory research is intended to study a problem in a more transparent way, in order to establish priorities, develop definitions and improve the research design. For Dudovskiy (2016) the main advantages of the exploratory research are the flexibility and adaptability to change and the effectiveness to lay the groundwork for future studies. According to the author, the main disadvantages are the generation of qualitative information (leading the interpretation of the information

subjected to bias), and the lower number of samples generated by the study.

Concerning process, this research is qualitative as the success of sustainability implementation is an intangible concept. For Walliman (2010), qualitative data cannot be accurately measured and counted, and are generally expressed in words rather than numbers. The research evaluates sustainability implementation in an interpretive way, demonstrating its application in a small environment. According to Atieno (2009), the main disadvantage of qualitative methods is that their findings cannot be extended to broader populations with the same degree of certainty that quantitative analyses can. This is because the findings of the research are not tested to discover whether they are statistically significant or due to chance.

Concerning logic, the research can be classified as inductive since a theoretical framework was developed and then verified and validated. According to Goddard & Melville (2004), the inductive approach starts with the observations and theories are proposed towards the end of the research process as a result of observations. This goes in the same direction as this research, since the research questions.

Thus, the rationale of this research consists on the benefits that Business Process Management can bring to the sustainability topic in the organisations, and present a framework to help them to implement sustainability projects in their business processes, transforming their regular business processes into sustainability business processes.

Finally, since the framework proposed in this research was tested in a real-world scenario, it can be classified as applied. According to Kothari (2008), applied research "aims at finding a solution for an immediate problem facing society, or an industrial/business organisation, whereas fundamental research is mainly concerned with generalisations and with the formulation of a theory". For Dudovskiy (2016), "the advantages and disadvantages of applied and fundamental research mirror and contrast each other. On the positive side, applied research can be helpful in solving specific problems in business and other settings. Nevertheless, on the negative side, findings of applied research cannot be usually generalised. In other words, the applicability of the new knowledge generated as a result of applied research is limited to the research problem".

4.3. Research Methodology

As it was defined in **Chapter 1**, this research project aims to provide a full lifecycle solution for the implementation of sustainability initiatives in business processes by Analysing, Designing, Implementing and Monitoring & Controlling current (or eventual new) processes in one organisation. In order to complete this work, the proposed methodology, presented in **Figure 16**, was carried out.

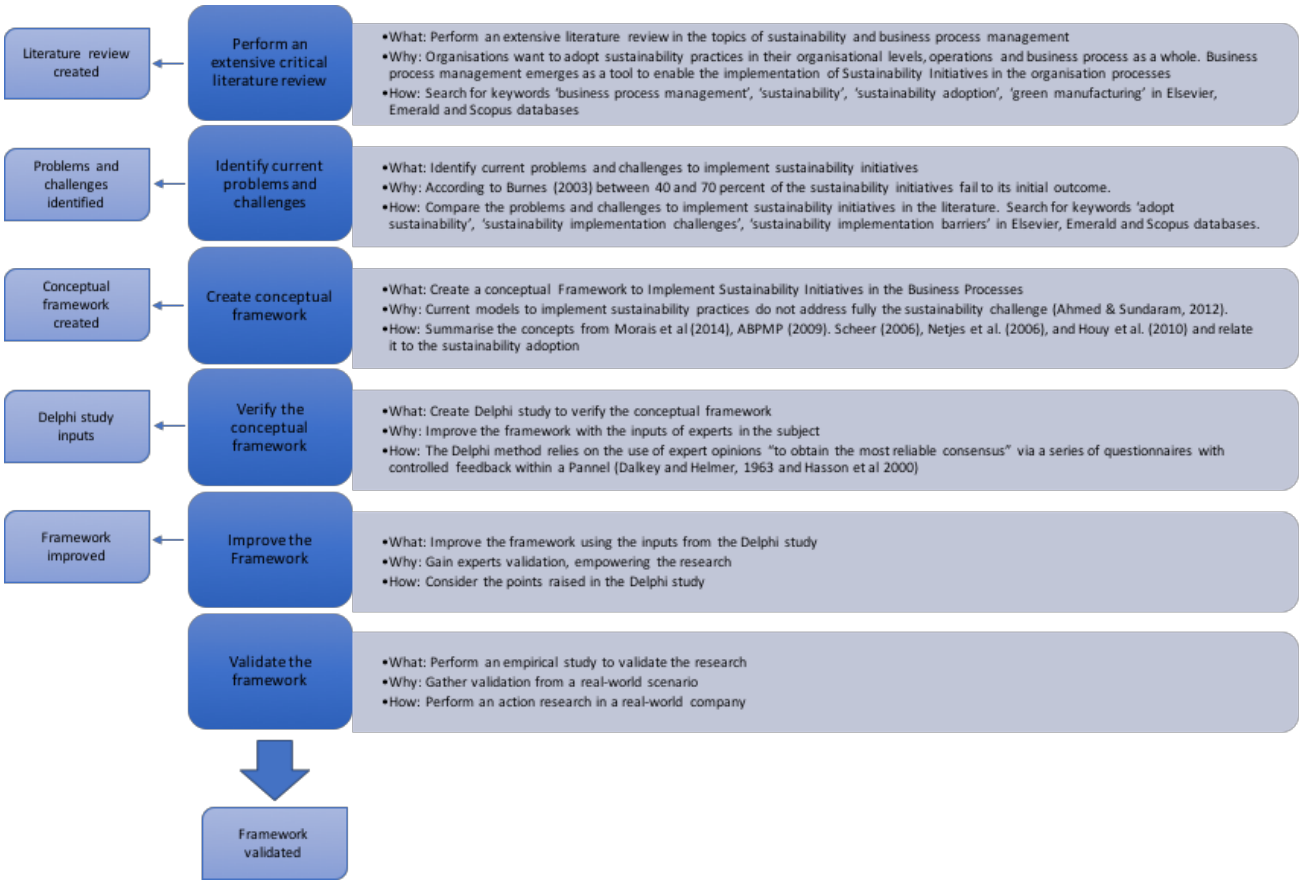

Figure 16 – Research Methodology

The initial step of the research was to perform an extensive critical literature review in the field of sustainability and business process management. Chapter 2 demonstrates that currently, companies want to adopt sustainability practices in their organisational levels, operations and business process as a whole. However, these organisations have still failed to reach the sustainability level they wished at the beginning of the project. Moreover, despite the existence of some standards (such as ISO 14000, ISO 14001 and ISO 26000), current models to implement sustainability practices do not address the sustainability challenge fully (Ahmed & Sundaram, 2012). Chapter 3 brings the relationship between business process management and sustainability and provides arguments to corroborate

that BPM can be used as a tool to enable the implementation of sustainability initiatives in the organisation processes.

The second step, then, was to identify what were the current problems and challenges to implementing sustainability in organisations. Some challenges found in the literature consists in defining measurable goals, selecting the right sustainability Indicators, considering sustainability aspects in the management of an organisation's processes. More than the challenges and barriers to implementing sustainability initiatives, several approaches focus on one specific department of the organisation. They, however, do not consider that those departments work along with other departments into an end-to-end process (systemic view). Therefore, a more refined analysis would consider the whole process interaction to evaluate the full status of the sustainability implementation. The systemic view is observed in the business process management approach; thus, it justifies the use of the methodology.

After identifying the problems and challenges to implement sustainability in organisations, it was developed the conceptual framework showing how the business process management method can transmit the sustainability strategy into operation areas and help companies to overcome the implementation challenges. The framework summarises the concepts from Morais et al. (2014), ABPMP (2009). Scheer (2006), Netjes et al. (2006), and Houy et al. (2010) and relate it to the sustainability adoption. Chapter 5 provides the details of the framework.

In order to verify the conceptual framework, a Delphi study was performed. The study was held between June 2016 and August 2016 and contained the participation of twenty-one specialists in the field of sustainable operations from both academia and industry and their feedback was evaluated. In total, there were fourteen researchers from the academia and seven from the industry. The participants were based in six different countries (Brazil, Germany, UK, Mexico, Sweden and Netherlands) and it was used online based questionnaires to gather the data. Chapter 6 provides the details of the Delphi study.

Finally, the research validated the framework in a real-world scenario by using the action research method. The study was held between August 2016 and January 2017 and was held on a biomass company focused in the development of sustainable energy technologies that wished to improve the implementation of sustainability initiatives in its business processes and operations. Chapter 7 provides the details of the action research study

4.4. Research Methods

The research used two methods: Delphi Study and Action research. The Delphi method was used to verify the framework proposed in chapter 5 and the Action research to validate it, testing it in a real-life scenario.

4.4.1. Delphi Study

According to Linstone & Turoff (2002), the Delphi method may be viewed as one of the spinoffs of defence research. "Project Delphi" was the name given to an Air Force-sponsored Rand Corporation study, starting in the early 1950's, concerning the use of expert opinion. The objective of the original study was to "obtain the most reliable consensus of a group of experts ... by a series of intensive questionnaires interspersed with controlled opinion feedback.". The intent of the Delphi, as it was initially conceived, was to create a method, using expert opinions, to forecast long-range trends related to the military potential of future science and technology and their effects on political issues (Gordon, 1994; Linstone & Turoff, 1975).

Sackman (1974) identified the following as the characteristics of a conventional Delphi:

- A formal and structured questionnaire is used.
- Questionnaire items may be generated by the moderator, the panellists, or both.
- Either quantitative or qualitative scales may be used.
- The process consists of two or more rounds.
- Questionnaires may or may not include open-ended questions.
- Feedback from each round is in the form of statistical feedback, usually involving some measure of central tendency and some measure of dispersion.
- Feedback from each round may include selected textual information.
- Individual responses to items are kept anonymous.
- Iteration with feedback continues until consensus is reached, as determined by the moderator.
- Participants do not meet face to face and may be geographically dispersed.
- Outliers (i.e. upper and lower quartile) may be asked to justify their responses in writing

According to Sommerville (2008), the Delphi method has some advantages, such as: information can be gathered from participants in different geographical locations, participants have anonymity (reducing halo effects associated with their opinion); and the specialists time to consider carefully their responses before replying (Adams & O'Brien,

2004; Garrod, 2004; Gordon, 1994). According to Sommerville (2008), one disadvantage of the Delphi method is the high attrition rate. Since the method requires lengthy responses in the early rounds of the process and the active participation of participants over several weeks, the potential for a high drop-out rate of panellists exists (Borg & Gall, 1983).

Therefore, it is possible to consider that the Delphi method is suitable to verify the framework since it gathers the opinions of specialists in sustainable operations management from several locations over the proposed framework. Other approaches that could have been used for the verification would have been the use of surveys or even focus groups. However, even though fact that a survey would have a higher number of respondents, the reliability of the responses would be lower, and it would lack the interaction between the panellists and the researcher. Using a focus group, on the other hand, would be interesting due to the high level of commitment of the participants, however, the fact that the specialists in the topic are in different geographical locations would make this option inviable.

4.4.1.1. Methods for data collection

For the Delphi study, the method for data collection was the use of a questionnaire. In the research, the questionnaire term is used as a general term to include all techniques of data collection in which each person is asked to respond to the same set of questions in a predetermined order (de Vaus 2001).

In a general view, it was identified eight groups of questions. 1) Sustainability, 2) Process Improvement, 3) Process Improvement & Sustainability, 4) Analyse phase, 5) Design phase, 6) Implement phase, 7) Monitor & control phase, and 8) Enablers of the implementation.

Saunders (2012) identifies five types of questionnaires: Internet meditated, via a portal, via delivery and collection, via telephone, in a structured interview. Since the specialists were spread all over the World, the study was performed via internet, using the Google forms web application. The advantages of using this application were: it provides enough techniques for the creation of the questionnaire, it is a freeware application, it provides electronic control of the respondents and it provides automatic data analysis. More than that, it provides reliability for the study, since all the registers are kept recorded online. The main disadvantages found in this approach was the low level of response rate (29.16%) and the time took to complete (each phase of the study had about one month of duration).

4.4.2. Action Research

According to Maestrini et al. (2016), Action research can be defined as an emergent investigation process that integrates theory and action to couple scientific knowledge with existing organisational knowledge and to address real organisational problems together with the people of the system under inquiry (Coghlan, 2011, Shani and Pasmore, 1985, Rapaport, 1970 and Lewin, 1947). It is a participatory and collaborative approach and is aimed at bringing change to organisations, developing competencies, and contributing to scientific knowledge through a co-inquiry cyclical process (Coghlan and Shani, 2014, Reason and Bradbury, 2008 and Shani and Pasmore, 1985). According to van der Hoorn (2016), Gibson (2004) and Newton (2006), Action research can be described as a process that considers a situation (the dependent variables); brings an intervention to the situation (action/independent variable); and then reassesses the situation (reflection on the intervention or effect of the independent variable on the dependent variable). **Figure 17** represents this cycle.

Figure 17 Adapted from: (Baskerville & Pries-Heje 1999, p. 4). - content removed for copyright reasons

According to Mapotse (2017), Kurt Lewing was the first to coin the term “Action Research” in 1944. In his 1946 paper "Action Research and Minority Problems" he described action research as "a comparative research on the conditions and effects of various forms of social action and research leading to social action" that uses "a spiral of steps, each of which is composed of a circle of planning, action and fact-finding about the result of the action".

Therefore, it is possible to consider that the Action Research method is suitable to validate the framework. The selection of the action research method relies on the intervention to a situation (a problem faced by the organisation) and the study that was seeking to assess the outcomes (using the sustainability implementation framework). The action research was suitable because it enabled mutual benefits to both the organisation and the research itself. Besides that, there was an alignment between the research method and the research study context. There is a constant feedback process held during the project execution with the ongoing research. The empirical study goes beyond merely reporting observations, it provides an environment to improve the framework and validation from a real-world context.

Another approach that could have been used for the validation of the framework would have been the use of case studies. However, the case study has an impersonal character and the researcher only observes the situation from an outside point of view. According to Bryman & Bell (2011), in action research, the investigator virtually becomes part of the arena being studied with the purpose of solving organisational problems. This orientation appears to involve a surrendering of detachment, and it is not surprising that many practitioners display concern about the ethical bases of their enterprise. However, action research is explicitly concerned to develop findings that can be applied in organisations, a position that contrasts with the peripheral relevance to organisations that much organisational research exhibits.

4.4.2.1. Methods for data collection

For the Action Research, the collection of data was made based on the observation and action to a specific problem. The study was held on a biomass company focused in the development of sustainable energy technologies that wished to improve the implementation of sustainability initiatives in its business processes and operations. Due to legal requirements, some information of the organisation was omitted in the study description. The study was held between August 2016 and January 2017. In that period, the researcher went to the company three days a week (Mondays, Wednesdays and Fridays) between 7 am and 4 pm to collect the data. The study followed the four phases of the framework (Analyse, Design; Implement; and Monitor & Control) and was aimed to provide a solution to the generation of an excess of a particular residue (tar) from the organisation. More details of the action research can be found in chapter 7.

4.5. Chapter summary and conclusions

This chapter has presented the research methodology and approach followed. It briefly reviewed the different classification in which research can be defined, and based on that, it classified the actual research as exploratory (purpose), qualitative (process), inductive (logic) and applied (outcome). The chapter then presents the research methodology that was carried out. Finally, the chapter presents the research methods (Delphi method and action research) and their methods for data collection. Next chapter will provide the framework proposed by the research.

Chapter 5 – Sustainability Implementation Framework for Business Processes

5.1. Introduction

Chapter 2 has highlighted the lack of attention paid to the implementation of Sustainability in business processes. This chapter presents the framework that is developed to facilitate the implementation of sustainability initiatives in the business processes. The chapter initially presents the framework, which is based on Business Process Management principles (described in Chapter 3), containing four main phases: (Analyse Phase; Design Phase; Implement Phase; and Monitor & Control Phase). Then, the chapter describes each step contained in the phases (Identify Business Scenario; Identify Project Stakeholders; Define Project Objectives; Define Metrics; Record enterprise map - AS-IS Situation; Record baseline values; Perform Sustainability Maturity Assessment; Define Scope; Identify improvement opportunities; Design TO-BE Process; Record predicted metric values; Define implementation strategy; Transform Business Processes; Execute the new Processes; Monitor and analyse organisational performance; Monitor and analyse process performance; Monitor metrics; Realise value; and Identify optimisation opportunities). The chapter also identifies enablers for the framework's implementation (governance, strategy, methods, information technology, change management, leadership, and culture) and discuss their roles.

5.2. Conceptual framework for Sustainability Projects Implementation

Initially, the framework would demonstrate how the Business Process Management (BPM) combined with Project Management methodologies (Silvius & Schipper, 2010, Silvius & Nedeski, 2011, PMI, 2004); balanced scorecard tools (Sanchez, 2014), among other management tools can transmit the sustainability corporate strategy into its operational area and help companies to overcome the implementation challenges.

Who and Why

The main stakeholders in this Project are:

- Shareholders – internal aspect
- Employees – internal aspect
- Customers – external aspect
- Community – external aspect

Figure 18 represents the relation between the stakeholders and the triple bottom line and **figure 19** represents the balanced scorecard.

Figure 18 Relation between the stakeholders and the triple bottom line

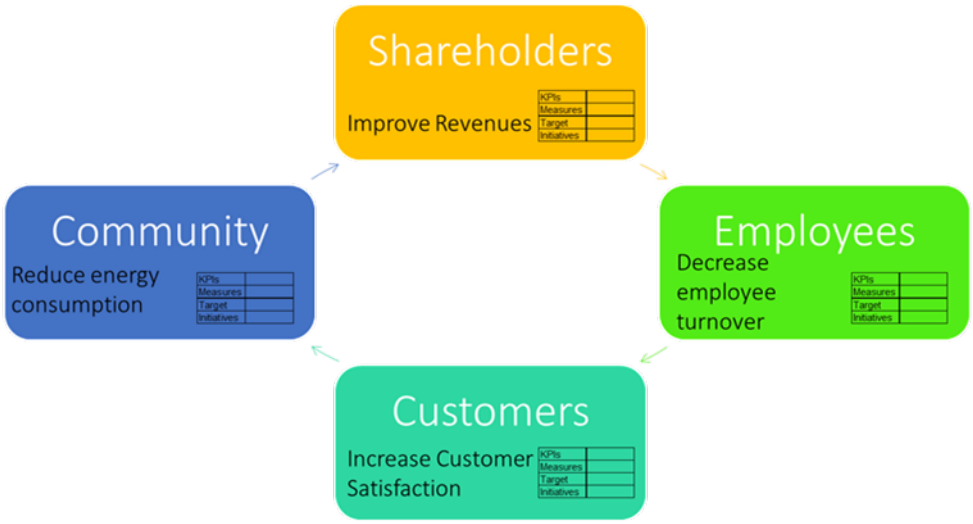

Figure 19 Balanced scorecard for the sustainability implementation

How and when?

The implementation would be defined as a project, following the PMI (2004) guidelines. **Figure 20** represents the project plan.

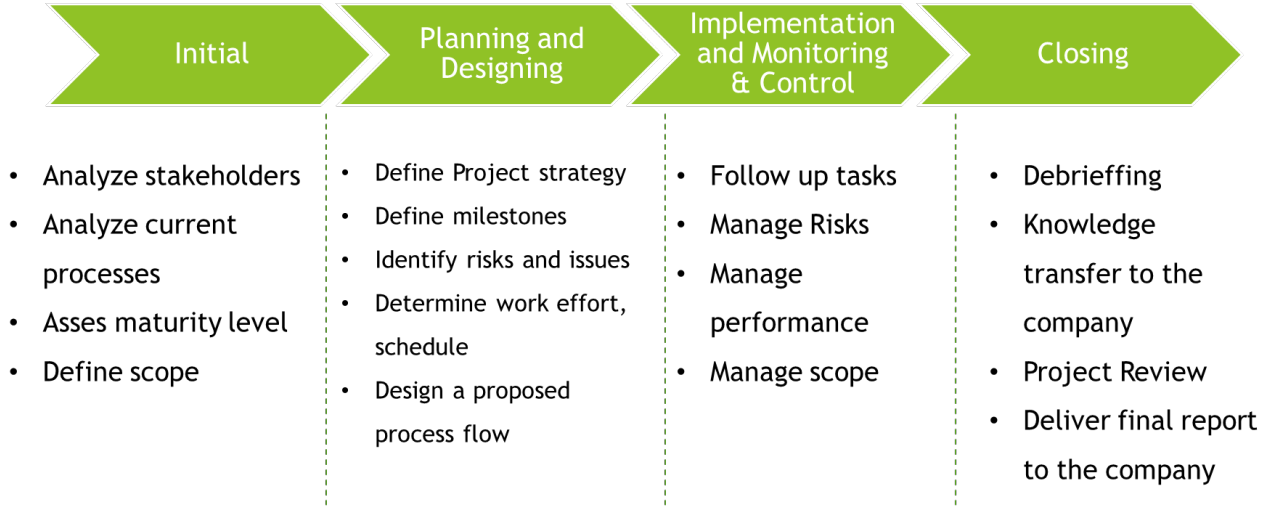

Figure 20 Project plan

The process modelling would evaluate the process design in three levels of details: Process Landscape, Process and Activities. Ranging from the strategic level to the operations level**. Figure 21** represents the process design, from the strategy to operations.

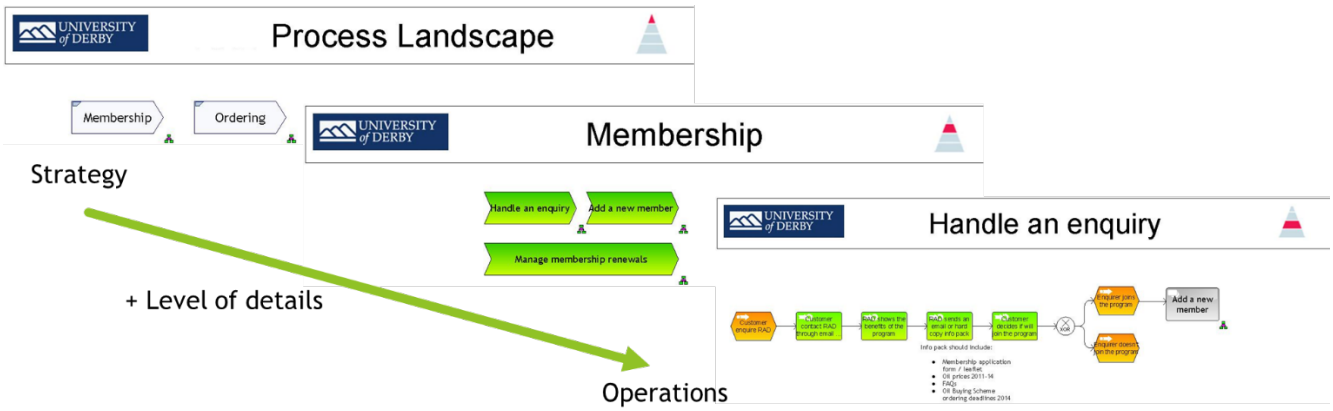

Figure 21Process design - Strategy to operations

The initial framework was represented by **figure 22** and aimed to demonstrate the relation between strategy and operations. In this approach, the project management would be an enabler for the implementation of sustainability initiatives.

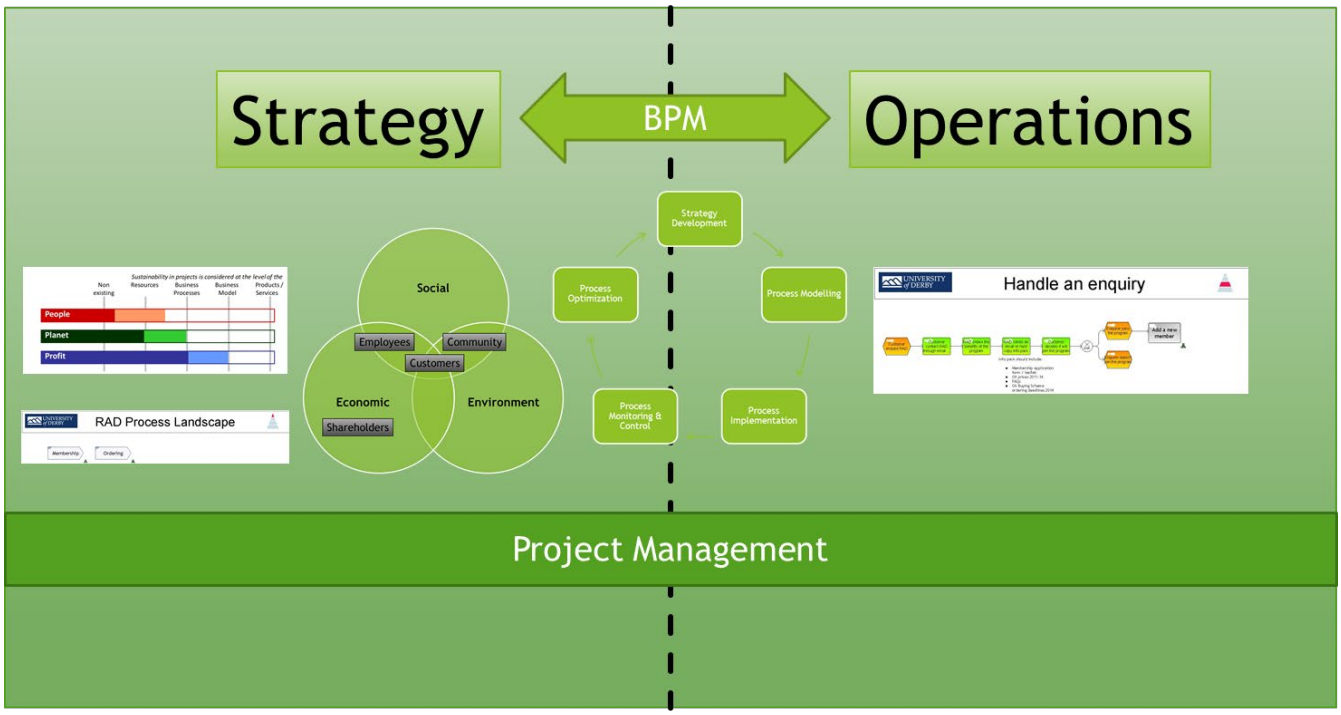

Figure 22Initial framework

As it was explained in Section **3.4**, according to ABPMP (2009) the management practice of BPM may be characterised as a continuous lifecycle of integrated BPM activities. While several variations of BPM lifecycles are recognised, for the matters of this research, in order to integrate the sustainability topic into BPM, a four phases methodology (Analyse, Design; Implement; and Monitor & Control) was carried out. These four phases were chosen because they represent the BPM approach with stages analogues to the ones presented in other sustainability implementation frameworks (such as the models from Ahmed & Sundaram, 2012 – with the phases of 'Discover & Learn'; 'Strategize'; 'Design'; 'Transform'; and 'Monitor & Control' – and from Uddin & Rahman, 2012 - with the phases 'Planning'; Identification & Categorisation; Recycling & Low Carbon Enabler; Implementation; and Analysis). 'Analyse' phase contains the steps of 'Identify Business Scenario', 'Identify Project Stakeholders', 'Define Project Objectives', 'Define Metrics', 'Record enterprise map - AS-IS Situation', 'Record baseline values', and 'Perform Sustainability Maturity Assessment'; Design phase contains the steps of 'Define Scope', 'Identify improvement opportunities', 'Design TO-BE Process', 'Record predicted metric values', and 'Define implementation strategy'; Implement phase contains the steps of 'Transform Business Processes', and 'Execute the new Processes'; and Monitor & Control phase contains the steps of 'Monitor and analyse organisational

performance', 'Monitor and analyse process performance', 'Monitor metrics', 'Realise value', and 'Identify optimisation opportunities'). **Figure 23** presents the detailed information of the main implementation phases and its sub-activities suggested to be carried out in each phase.

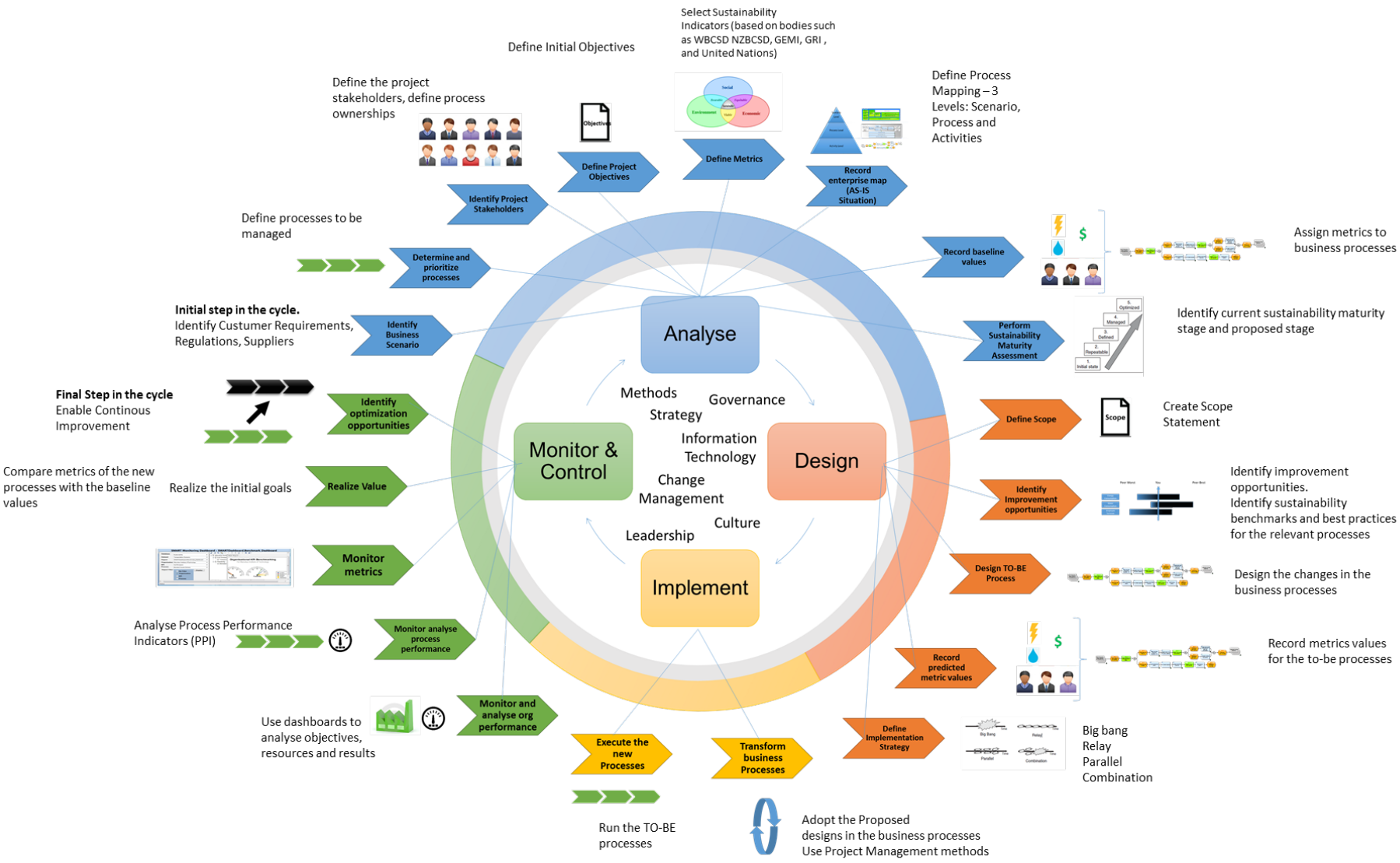

Figure 23 – Conceptual Framework to Implement Sustainability Initiatives in the Business Processes

5.2.1. Analyse

Socrates' famous quote 'Know thyself' can have many philosophical meanings; one possible meaning is that by knowing yourself, it is possible to know your role in the World. In the case of the business environment, in order to understand the role in the market, it is required to comprehend the inner aspects of the organisation fully. To understand these aspects, the analytical capability is fundamental. Regarding the implementation framework, the 'Analyse' phase aims to assess and evaluate all the relevant aspects related to the sustainability implementation in the business processes (Gallotta, 2016).

The first step in the Analyse phase is to identify the current business scenario, identifying the customer's requirements, supplier's requirements and current regulations that may affect the project. Once this assessment is concluded, it is defined and prioritised the processes to be considered in the project, the stakeholders are identified and the primary project objectives. After this, the metrics are defined (aligned to the project objectives), the enterprise map (current situation) is created, the baseline values are recorded and, finally, the sustainability maturity assessment is performed (Gallotta, 2016). **Figure 24** shows the breakdown of the steps in this phase.

In terms of sustainability, the main aspects of this phase regarding sustainability are the definition of metrics related to water management, energy management, employee satisfaction or any other triple bottom line metric and the sustainability maturity assessment. The outcome of the Analyse phase is the definition of the current sustainability status and the identification of the future stage.

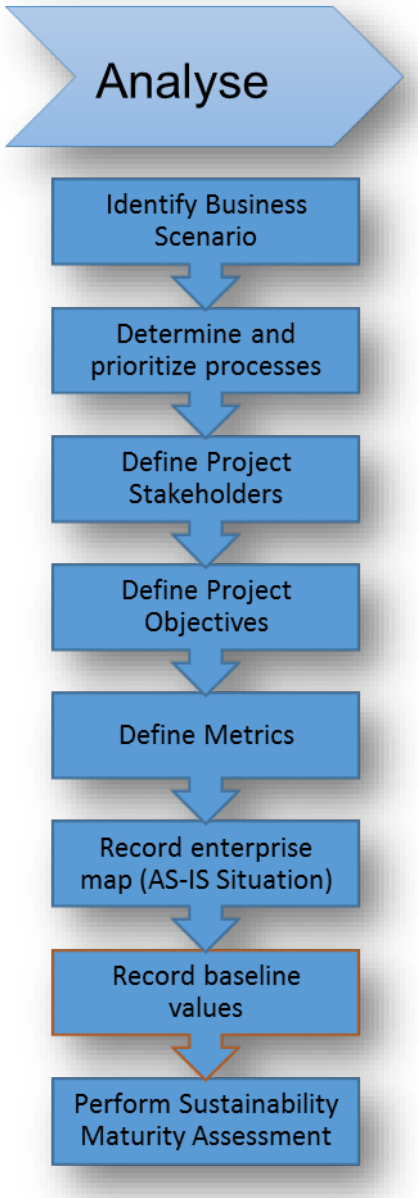

Figure 24 - Breakdown of the Analyse phase

5.2.1.1. Identify Business Scenario

The purpose of this stage is for the project team members obtain sufficient understanding of the current business environment to enable further project phases. The step analyse comprises all the factors which may affect the project during its lifecycle. It comprises factors related to the current regulatory needs, the external business environment (customers and suppliers needs) and the internal environment (organisation cultural aspects).

Examples of regulatory impacts in the business can be found in Japan. According to Debnath (2015), after 2011 Fukushima nuclear power plant accident, Japan Nuclear

Regulatory Commission set the new regulation standards of the nuclear power plant. The new regulations forced electric power companies to increase the investment in a coastal barrier to meet the new standard. Besides that, current policymakers are now discussing the possibility of complete switching from the nuclear power plants to other means for electricity (Gallotta, 2016).

Another Japanese example of the impact of regulations was the Kyoto Protocol. According to Debnath (2015) in 2001, Japan was able to reduce CO_2 emissions to 8.2% below 1990 levels (one of the proposals of the Kyoto Protocol). The Japanese example is significant once this initial commitment might have helped Japanese organisations to connect Corporate Social Responsibility (CSR) activities with the products by making them environment-friendly (examples of those initiatives are: Toyota Prius, Nissan Leaf and Panasonic Eco Navi).

The American automobile industry demonstrates the changes in customer needs. Before 1973 the American market was dominated by 'muscle cars' (such as Chevrolet Corvette, Ford Mustang, and Chevrolet Camaro). The 1970's changed this business scenario due to the oil crises (1973 and 1979), in which the oil barrel price jumped from U$3 (before the first crisis) to nearly U$40 (after the second crisis). The increase in oil price forced consumers to seek alternatives in smaller cars. One company which benefited from this situation was Toyota since this company's cars were smaller than the American ones and had a lower fuel consumption.

Regarding the organisational culture, some researchers have suggested that while the tools, techniques and change strategies may be present, failure occurs because the fundamental culture of the organisation remains the same (Cameron & Quinn, 2006). Linnenluecke & Griffiths (2010) suggest that the successful implementation of culture change for corporate sustainability might be mostly dependent on the values and ideological underpinnings of an organisation's culture and that these, in turn, affect how corporate sustainability is implemented and the types of outcomes that can be observed. This means that would be easier to find successful sustainability implementation cases in organisations that have Sustainability as their inner DNA (Gallotta, 2016).

5.2.1.2. Determine and prioritise processes

After identifying the current business scenario, the organisation needs to define the processes to be managed and studied along the project. It is essential to prioritise because mapping the whole enterprise might implicate in the consumption of a lot of effort (or time) (Gallotta, 2016).

5.2.1.3. Define Stakeholders

After determining and prioritizing the processes to be studied, the relevant stakeholders are identified. Stakeholders are the individuals or groups affected by the project. The level of participation of stakeholders in analysis can vary considerably from passive consultation to active engagement. The level of participation of stakeholders in analysis can vary considerably from passive consultation to active engagement. Categorisation methods follow either top-down analytical categorisations or bottom-up reconstructive methods. Finally, some methods have been developed to investigate the relationships that exist between stakeholders in the context of the issue of interest. Examples include actor linkage matrices and social network analysis (Sanchez, 2014).

During this step, it will be defined the key stakeholders in the project and their goals. At the end of the project, it will be evaluated if the stakeholders have achieved their project goals defined in this phase (Gallotta, 2016).

5.2.1.4. Define Project Objectives

After defining the project stakeholders, the objectives are set. According to Slack et al. (2013) objectives help to provide a definition of the endpoint which can be used to monitor progress and identify when success has been achieved. Traditionally projects are considered in terms of cost, time and quality (Gallotta, 2016). **Figure 25** shows the 'project objectives triangle' with these three types of project marked. However, a few authors such as Reijers & Mansar, 2005, Seidel et al. 2012, Agyekum-Mensah 2012) also suggest objectives in terms of flexibility and sustainability. With the emergence of environmental sustainability as an additional dimension of organisational performance, the classical process imperatives are increasingly subjected to critical scrutiny. This is because they do not appropriately reflect environmental objectives such as "minimise energy consumption", "reduce carbon footprint," or "provide ecologically sustainable solutions." (Seidel et al. 2012)

Figure 25 - The project objectives triangle (Slack et al., 2013) - content removed for copyright reasons

5.2.1.5. Define Metrics

After defining the project objectives, the relevant metrics are defined. The metrics definition is one critical aspect in the Sustainability Implementation Project since it is related to a few challenges to implementing those kinds of initiatives (Select the right sustainability indicators, define the proper measurement method and align indicators to goals and objectives). According to Silvius et al. (2012), elaborating on the three perspectives of the triple bottom line concept, several organisations developed frameworks of indicators that would allow organisations to evaluate the sustainability aspects of different policies and projects, as well as to monitor progress. In fact, the literature on these models is a veritable jungle of different approaches and numerous case studies (Olsson et al., 2004). A widely-used framework in sustainability reporting is the Sustainability Reporting Guidelines (SRG) by the Global Reporting Initiative (GRI). Companies can use the SRG to indicate to shareholders and consumers their economic, social and environmental performance. GRI's objective is to facilitate sustainability reporting for companies and thereby stimulate them to operate more sustainably. The SRG framework consists of an extensive set of indicators, from which companies can select a set that is relevant to their operations or industry (Silvius et al. 2012).

GRI has indicators to provide information on the economic, environmental and social performance. According to GRI (2013) the economic dimension of sustainability concerns the organisation's impacts on economic conditions of its stakeholders, and on economic systems at local, national, and global levels; the environmental dimension of sustainability concerns the organisation's impact on living and non-living natural systems, including land, air, water and ecosystems; the Environmental Category covers impacts related to inputs (such as energy and water) and outputs (such as emissions, effluents and waste). In addition, it covers biodiversity, transport, and product and service-related impacts, as well as environmental compliance and expenditures; and the social dimension of sustainability concerns the impacts the organisation has on the social systems within which it operates. According to the GRI (2013), there are 91 indicators (as can be viewed in **table 5, table 6 and table 7**) and many of them can be used as metrics and evaluate the performance in the business processes, e.g. 'direct economic value generated and distributed', 'proportion of spending on local suppliers at significant locations of operation', 'energy consumption within the organisation', 'reduction of energy consumption', 'direct Greenhouse Gas (GHG) emissions (scope 1)', 'operations

with significant actual and potential negative impacts on local communities' (Gallotta, 2016)..

Table 5 - GRI Economic Indicators. Adapted from GRI (2013) - content removed for copyright reasons

Table 6 - GRI Environmental Indicators. Adapted from GRI (2013) - content removed for copyright reasons

Table 7 - GRI Social Indicators. Adapted from GRI (2013) - content removed for copyright reasons

At the 2010 IPMA Expert Seminar 'Survival and Sustainability as Challenges for Project" (Knoepfel, 2010), one of the goals was to 'translate' the concepts of sustainability to practically applicable tools for project management professionals. Based on the SRG, the participants of the seminar developed a 'Sustainability Checklist' for projects and project managers. **Table 8** provides this Sustainability Checklist (Silvius et al. 2012).

Table 8- A checklist for integrating sustainability in projects and project management (Knoepfel, 2010). - *content removed for copyright reasons*

Sanchez (2014) has also provided a 'Sustainability Checklist' for projects relating the goals, the metrics (Measure column) and the group to be beneficiated from the initiative (**Figure 26)**.

Figure 26 - Sustainability Checklist (Sanchez, 2014) - content removed for copyright reasons

So, depending on what are the goals of the project, different metrics can be adopted. For example, a company can define 'Increase flexibility', 'reduce water consumption', 'reduce energy consumption' and 'increase health and safety standards' as metrics to be measured along the project. All those metrics will be evaluated and associated with relevant processes or activities and later will be monitored along the project. The intention to that is to be possible to assess the performance of those metrics in the beginning and comparing it to the final stage, displaying the evolution of the metrics and showing the sustainability impact of the project (Gallotta, 2016).

5.2.1.6. Record Enterprise Map (AS-IS situation)

After defining the metrics, it is recorded the enterprise map with the current process situation. An enterprise map is the modelling representation of the hierarchy of business

processes of an organisation. Scheer, (2006), for instance, defined three levels to create process mapping. A first level, called 'Scenario' level which comprises all the macro processes in the company (or the ones in the project scope); a second level, 'Process' level which encompasses the processes within the macro process; and, finally, an 'Activity' level which represent the process steps from the specific process (**Figures 27, 28 and 29** represents one example of the three design levels).

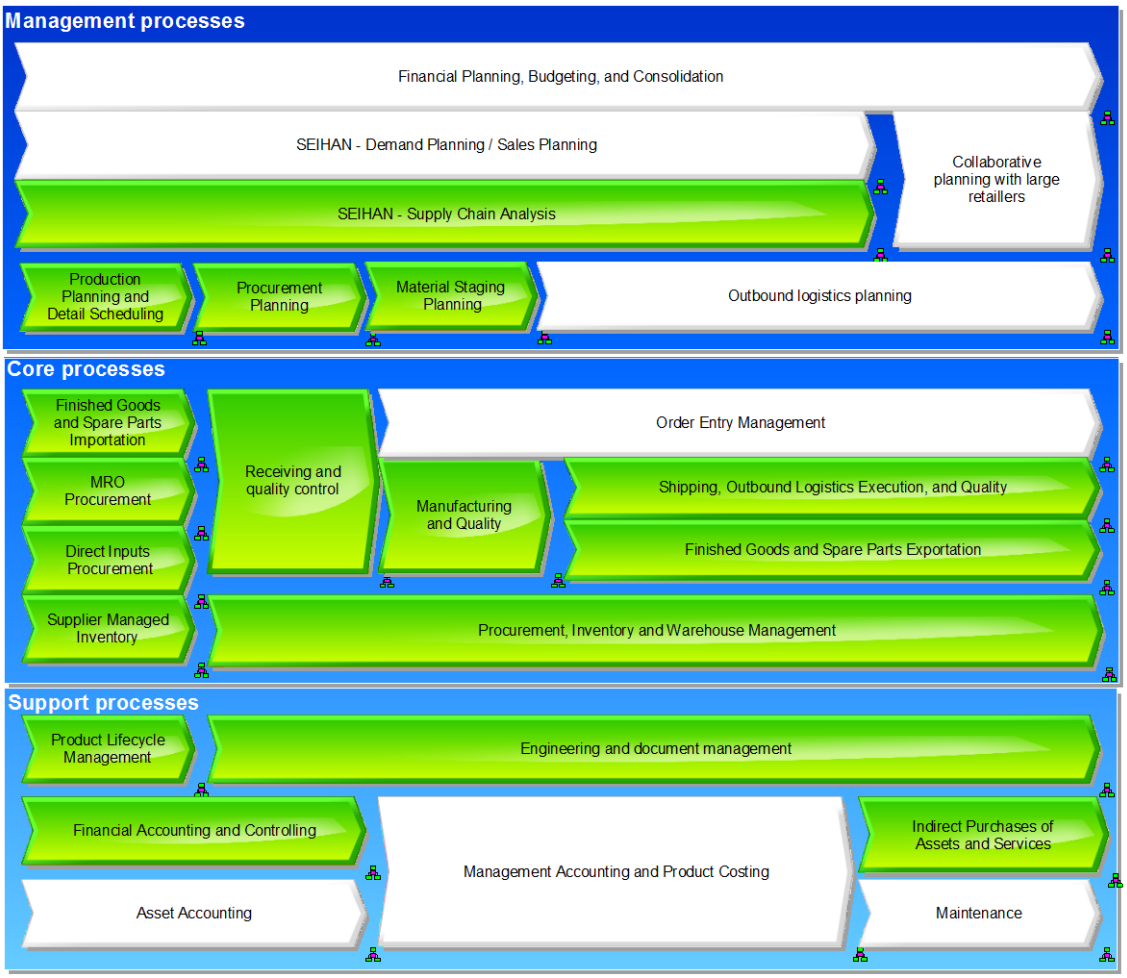

Figure 27 - Example of Process Design using EPC methodology - Scenario Level

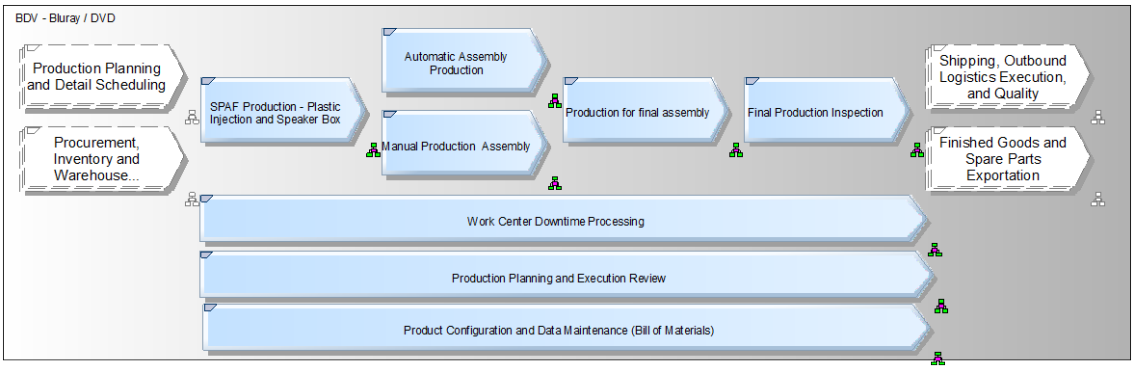

Figure 28 - Example of Process Design using EPC methodology - Process Level

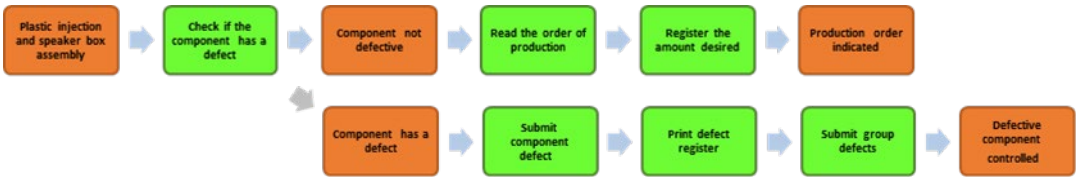

Figure 29 - Example of Process Design using EPC methodology – Activity Level

It is called process mapping (or enterprise mapping) due to the analogy to a world map (**Figure 30**). In this representation, observing the processes at the 'scenario level' would be the same as observing a world map in the broadest way, in this case the countries are analogues to the macro-processes; drilling down to the process level, it is observed the processes, which can be related to the cities of a country; and in the third level, the activities can be related to the streets of a particular city (Gallotta, 2016).

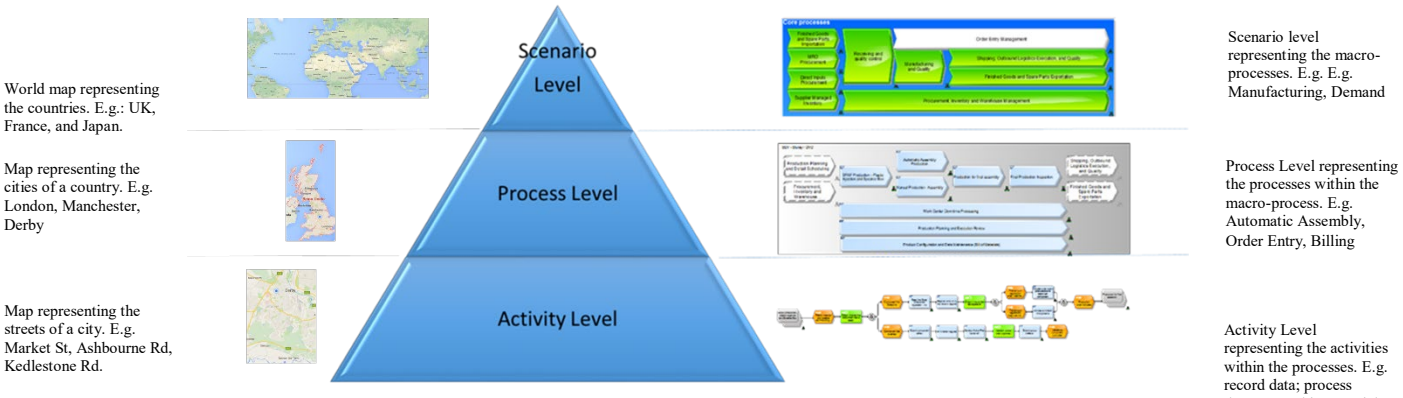

Figure 30 - Process Design Hierarchy

According to ABPMP (2009), Process modelling combines a set of processes and skills which provide insight and understanding of business process and enable analysis, design and performance measurements. "Business Process Modelling" is the set of activities involved in creating representations of an existing or proposed business process. During business modelling, it is essential to be able to describe the business processes on different

levels (Gale & Eldred, 1996). According to Davenport (1993), business processes are divided into core processes, supporting processes, and management processes. Core Processes represents the key processes in the organisation, the processes that add primary value to an output, they represent the essential activities an organisation performs to fulfil their mission (E.g. Manufacturing, Quality Management, Order Entry Management); Supporting Processes gives support to the core processes, usually managing resources and/or infrastructure required by the core processes and not bringing direct delivery value to the business (E.g. Financial Accounting, Maintenance, Technical Support); and Management Processes, which are the processes responsible for managing, monitoring and controlling business activities ensuring that core process address operational, financial, regulatory and legal goals, they also to do not bring direct value to the business (E.g. Financial Planning, Demand Planning) (Gallotta, 2016).

According to Smith and Fingar (2003), Hammer and Champy once observed that "hardly any company contains more than ten or so principal processes". Davenport likewise advised that the "fewer and broader the processes, the greater the possibility for innovation… and the greater the understanding measuring the change". Principal processes mainly exist in the rarefied environment of the corporate strategy office, far away from the "engine and cog" processes that actually run the business. Principal processes require hundreds of tangible supporting processes (observed in **Table 9**) and thousands of distinct process variants, all of which are needed and all of which need to be managed. The supporting processes include many unique internal processes, industry best practices, and sub-processes to ensure compliance with standards, legal requirements, and regulatory guidelines.

Table 9 Subset of enterprise process. Adapted from Smith and Fingar (2003)

Account Management	**Organisational Learning**
Advance Planning & Scheduling	Payroll Processing
Advertising	Performance Management
Assembly	Performance Monitoring
Asset Management	Performance Review
Benefits administration	Physical Inventory
Branch Operations	Planning and Resource Allocation
Budget Control	Post-Sales Service

Build to Order	Problem/Resolution Management
Call Centre Service	Process Design
Capacity Reservation	Procurement
Capital Expenditures	Product Data Management
Check Request Processing	Product Design, Development
Collateral Fulfilment	Product/Brand Marketing
Collections	Production Scheduling
Commissions Processing	Program Management
Compensation	Promotions
Component Fabrication	Property Tracking/Accounting
Corporate Communications	Proposal Preparation
Credit Request/Authorization	Publicity Management
Customer Acquisition	Real Estate Management
Customer Inquiry	Recruitment
Customer Requirements Identification	Returns & Depot Repairs
Customer Self Service	Returns Management
Customer/Product Profitability	Sales Channel Management
Demand Planning	Sales Commission Planning
Distribution / VAR Management	Sales Cycle Management
Financial Planning	Sales Planning
Financial Close/Consolidation	Service Agreement Management
Hiring/orientation	Service Fulfilment
Installation Management	Service Provisioning
Integrated Logistics	Shipping
Internal Audit	Site Survey & Solution Design
Inventory Management	Six Sigma
Investor Relations	Sourcing
Invoicing	Strategy Development
IT Service Management	Succession Planning
Knowledge Management	Supply Chain Planning

Manufacturing	Supply Planning
Manufacturing Capability Development	Test
Market Research & Analysis	Time & Expense Processing
Market Test	Timekeeping/Reporting
Materials Procurement	Training
Materials Storage	Treasury/Cash Management
Order Dispatch & Fulfilment	Warehousing
Order Fulfilment	Warranty Management
Order Management	Zero-Based Budgeting

Other important aspects are the modelling standards and notations. According to ABPMP (2009) some of the benefits of using a standards-based approach include: common symbology, language, and technique which facilitate communication and understanding; standards-based models provide common and consistently defined processes definitions which eases the process of design, analysis and measurement and facilitates model reuse; an ability to leverage modelling tools based on common standards and notations; and an ability to import and export models created in various tools for reuse in other tools. Currently, there are several modelling techniques in use, such as Event-driven Process Chains (EPCs), Yet Another Workflow Language (YAWL), diagrams offered by the Unified Modelling Language (UML) and Business Process Model and Notation (BPMN). However, to deal with business processes, there is a prominence of the use of EPCs and BPMNs (Gallotta, 2016).

According to ABPMP (2009), Business Process Model Notation (BPMN) is a relatively new standard created by the Business Process Management Initiative. BPMN appears to be emerging as the most extensive, most widely accepted business process modelling notation in the industry. It provides a simple, yet robust, symbology for modelling all aspects of business processes. According to Ottensooser et al. (2012), the Business Process Modelling Notation (BPMN) depicts the flow of a business process as a graph. Activities are the dominant type of nodes in such a graph (captured as rounded boxes) while the arcs define temporal and logical order. Activities are usually annotated with short text labels following a Verb, as for instance “place order” (Mendling et al., 2010). There are also diamond-shaped routing elements for describing decisions based on certain

conditions or parallel execution. Actors are represented as so-called swim lanes, in which activities can be placed (Gallotta, 2016). **Figures 31** and **32** provide examples of the BPMN notation to describe a business process.

Figure 31 - Example of a BPMN model. Source Appel et al. (2014) - content removed for copyright reasons

Figure 32 - Example of a BPMN model. Source: ABPMP (2009) - content removed for copyright reasons

Event-driven Process Chains (EPC), on the other hand, are very similar to activity diagrams regarding the addition of events or outcomes of tasks. An EPC is an ordered sequence of events and functions that provides various connectors that allow alternative and parallel execution of processes. The tasks (activities) are followed by outcomes (events) of the task, developing a very detailed process model. A significant strength of EPC is claimed to be its simplicity and easy-to-understand notation. This makes EPC a widely accepted technique to denote business processes (ABPMP, 2009)

According to Reijers et al. (2009), the Event-driven process chains (EPC) language was developed in 1992 at the Institute for Information Systems in Saarbrücken. The primary goal behind this development was to allow business users to describe processes on the level of their business logic in a form that is easily understandable (Gallotta, 2016). A specific EPC model (or simply EPC) consists of the following building blocks:

- Functions: The basic building blocks are functions. A function corresponds to an activity (task, process step) which needs to be executed.
- Events: Events describe the situation before and/or after a function is executed. An event corresponds to the postcondition of the function it succeeds (if any) and

to the precondition of the function it precedes (if any).

- Logical connectors: Connectors can be used to show the different paths the process can take. Through the use of connectors, paths can be split and joined. There are three types of connectors. ∧ (and), XOR (exclusive or) and ∨ (inclusive or).
- Arcs: Functions, events and connectors are connected by directed arcs.

Figure 33 shows the representation of these building blocks.

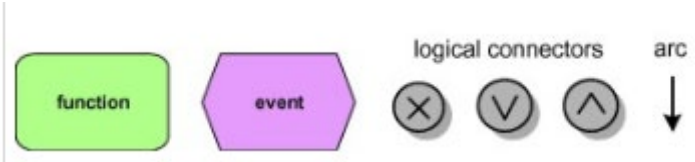

Figure 33 The building blocks of an Event-driven Process Chain. Source: Reijers et al. (2008)

Figure 34 represents the same process described in figure **27**, with the EPC nomenclature.

Figure 34 – Example of an EPC model. Adapted from ABPMP (2009) - *content removed for copyright reasons*

Houy et al. (2012) used Event-driven Process Chains (EPC) and Business Process Modelling Notation (BPMN) to represent process flows and to use the principles of the Green BPM. According to the authors, by accumulating the annotated values of the sustainability metrics, the total consumption of needed resources or the total production of waste materials in a process it can be measured and controlled. This method facilitates an optimised organisation of activities in a process and the controlling of the ecological impact of its execution (Gallotta, 2016).

According to Houy et al. (2012) in Green BPM every business activity in a process model can be annotated with an adequate ratio representing the consumption of resources and the production of waste materials. By accumulating the annotated values, the total

consumption of needed resources or the total production of waste materials in a process can be measured and controlled. This method facilitates an optimised organisation of activities in a process and the controlling of the ecological impact of its execution. In order to investigate the organisational as well as technological opportunities of Green BPM (Gallotta, 2016). **Figure 35** shows one sales process represented by an Event-driven Process Chain (EPC) with the respective resource consumption.

Figure 35 - Sales process (EPC) annotated with relevant sustainability ratios. Adapted from Houy et al. (2012) - *content removed for copyright reasons*

Using the example data, it is possible to identify the total electric consumption, the total fuel consumption and the total CO_2 production (or other metrics, depending on the case) of a particular process and in a further moment propose a new design, showing the potential savings in a comprehensive way. Using the three-level approach, defined in section **3.3.1.3. Record enterprise map**, it is possible to evaluate the metrics in the Scenario level, Process level and Activities level. This means a full identification of the sustainability footprint along all the scoped business unity (Gallotta, 2016). **Figure 36**

shows the Process Design Hierarchy, every metric that is evaluated in the activity level is accumulated at the process level which is accumulated to the Scenario Level.

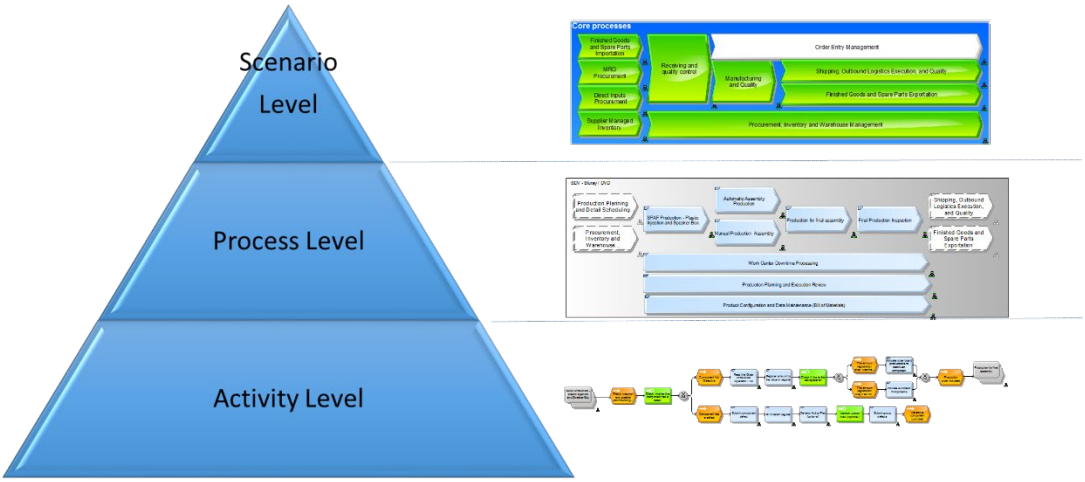

Figure 36 – Process Design Hierarchy

5.2.1.7. Record baseline values

After recording the enterprise map, the consumption values are associated with the processes.

5.2.1.8. Perform Sustainability Maturity Assessment

After recording the baseline values, it is possible to perform the sustainability maturity assessment. In this stage, it will be evaluated formally at the current level of sustainability awareness and the desired stage. Generically, Maturity Assessment is a practical way to 'translate' complex concepts into organisational capabilities and to raise awareness for potential development (Silvius & Schipper, 2010). They provide guidance for action plans and allow organisations to monitor their progress (Dinsmore, 1998). Most maturity models are derived from the Software Engineering Institute's Capability Maturity Model (Carnegie Mellon Software Engineering Institute, 2002) and thereby based on the maturity of processes.

Jeston & Nelis. (2006), for instance, proposed a BPM maturity model which shows the different maturity levels and the characteristics of low maturity and high maturity levels (Gallotta, 2016). This maturity model framework is observed in **Figure 37.**

Figure 37 - Comparison of low and high maturity and the five maturity stages (Jeston.& Nelis, 2006) - *content removed for copyright reasons*

According to the authors, companies that are in the 'Initial' stage have either no or unstructured attempts towards BPM (some characteristics of this type of organisations: Individual efforts; minimal employee involvement; low reliance on external BPM expertise; and high levels of manual interventions and workarounds); organisations in the 'Repeatable' stage are starting to build BPM capabilities and are increasing the number of employees that are seeing the organisation with the process perspective (some characteristics of this type of organisations: first documented processes; Recognition of the importance of BPM; Increased involvement of executives and top management; and increased reliance on external BPM expertise); companies in the 'Defined' stage have the BPM even more developed and almost all the employees possesses the process view (some characteristics of this type of organisations: focus on the management of the early phases of the process lifestyle; use of elaborate process modelling tools; comprehensive and formal BPM training sessions; and less reliance on external expertise); organisations in the 'Managed' stage have already implemented the BPM along the whole organisation and is starting to enjoy the benefits of having the BPM aligned to the company strategy (This kind of organisations has some of this characteristics: an established Process Management Centre of Excellence that maintains standards; Exploration of business process controlling methods and technologies; formal, designated process management positions; Continuous extension and consolidation of process management initiatives; and Minimal reliance on external expertise); and companies in the 'Optimised' stage are

enjoying the benefits of having the BPM entrenched as a core part of both strategic and operational management within the organisation (this kind of organisations has some of this characteristics: Process management is a part of managers' activities, accountabilities and performance measurements; wide acceptance and use of standard methods and technologies; and incorporates customers, suppliers, distributors and other stakeholders (Gallotta, 2016).

However, the potential use of the maturity assessment tool is not exclusive to Management or BPM, some researchers (such as Ness et al., 2007; Singh et al., 2012; Silvius and Schipper, 2010) have already proposed sustainability maturity assessments (Gallotta, 2016).

According to Ness et al. (2007) "The purpose of sustainability assessment is to provide decision-makers with an evaluation of global to local integrated nature–society systems in short and long-term perspectives in order to assist them to determine which actions should or should not be taken in an attempt to make society sustainable". According to Singh et al. (2012), there are many sustainability assessment methodologies for evaluating the performance of companies, such as The World Business Council for Sustainable Development (WBCSD), the Global Reporting Initiative (GRI) and Organisation for Economic Co-operation and Development (OECD). According to the author, indicators or metrics can be used to assess and evaluate performance; provide trends on improvement as well as warning information on declining trend for the various dimensions of sustainability; and provide information to decision-makers to formulate strategies and communicate the achievements to the stakeholders.

Silvius and Schipper (2010) developed a maturity model to assess, monitor, and improve the incorporation of the principles and concepts of sustainability in projects. The model comprises a series of questions to cover aspects of the respondent, the project that is assessed, the organisational context of the project and the actual assessment questions. The model assesses the level (resources, business process, business model, products/services) on which the different aspects of sustainability are considered in the project. The sustainability aspects are grouped into economic aspects, environmental aspects and social aspects. Presenting the project's maturity separately on these three pillars of sustainability (Gallotta, 2016). **Figure 38** shows the conceptual model of the assessment.

Figure 38 - Reporting format showing actual levels (dark colours) and desired levels (light colours) of integration of sustainability aspects (Silvius & Schipper, 2010) - content removed for copyright reasons

According to Silvius & Schipper (2010), the approach indicates that sustainability can be realised in different levels: (1) level of the resources, (2) level of the business processes, (3) level of the business model, and (4) level of project

The first level is the level of the resources used in the project. For instance, selecting different resources to reach the same functionality while being less harmful to the environment, (e.g. using hybrid cars instead of regular fuelled cars). These actions can, for example, reduce the environmental impact of the project. They reduce the negative impact of the project but do not take away the cause of non-sustainability.

The second level is related to the business processes. A more sustainable process takes away the cause of non-sustainable effects instead of just limiting or compensating them. For example, using teleconferencing for project meetings, instead of travelling to the meeting location.

The third level of consideration is looking at the business model in which the project is delivered. For instance, changing the contract for a project from just the construction phase to the full lifecycle may have favourable effects on the project delivery because of the emphasis on the full lifecycle of the project and the project deliverable.

The fourth and final level of consideration takes into account the result or deliverable of the project. This connects the consideration of sustainability in project management to the sustainability of the project itself. It demonstrates how the project contributes to a more sustainable society.

Spohn (2004), on the other hand, evaluated the maturity level differently way. The author proposed a five steps approach (presented in **Figure 39**), in which organisations that are in the first level are only committed to the compliance aspects (just following the current

regulations); in the second level, organisations start to care about the materials use and start to use performance indicators; in the third level the organisation uses facility effect indicators; in the fourth level the organisation start to use indicators in the supply-chain and product lifecycle; and in the fifth and last level, the organisation start to use sustainable system indicators to monitor the performance (Gallotta, 2016).

Figure 39 - Sustainability maturity assessment. Source Spohn (2004) - content removed for copyright reasons

Therefore, in this phase, the organisation will assess which is the current level of sustainability in their processes and evaluate what is the desired level. This is a crucial element in the framework since it provides guidance to it (Gallotta, 2016).

5.2.2. Design Phase

The 'Design' phase aims to propose the changes in the business processes, design the expected situation. The first step in the 'Design' phase is to define the project scope and the improvement opportunities, by conducting collaborative meetings aiming at designing the new processes. After this new design, the metrics are assigned to the related activities and the implementation strategy is defined. This phase relates the process changes to the sustainability impacts, demonstrating the direct effects of the process changes into the metrics defined during the Analyse phase. **Figure 40** shows the breakdown of the steps in this phase.

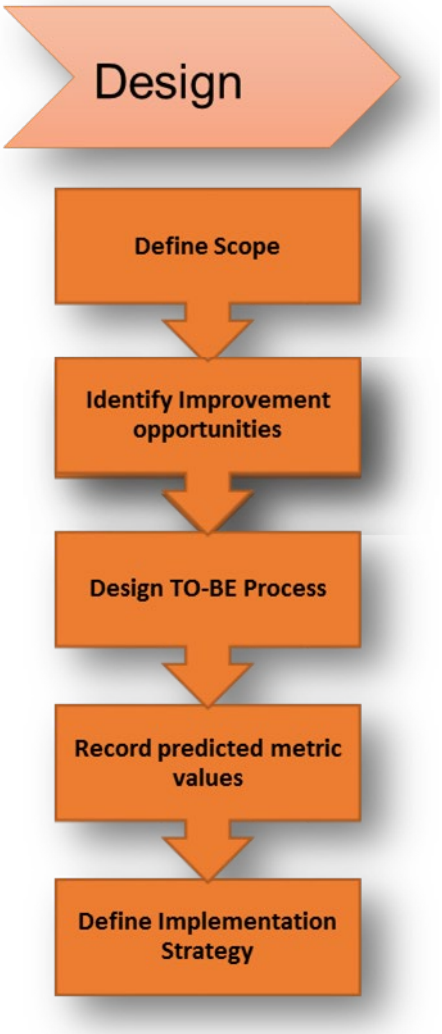

Figure 40 - Breakdown of Design Phase

5.2.2.1. Define Scope

The first stage in the Design Phase is the 'Define Scope'. According to the PMI (2004), the project scope statement describes, in detail, the project's deliverables and the work required to create those deliverables. The project scope statement also provides a common understanding of the project scope among all project stakeholders and describes the project's major objectives. It also enables the project team to perform more detailed planning, guides the project team's work during execution, and provides the baseline for evaluating whether requests for changes or additional work are contained within or outside the project's boundaries. Usually, those aspects are recorded in a table (Gallotta, 2016). **Table 10** represents a model of a Project Scope Statement.

Table 10 - Project Scope Statement model

Project Scope Statement	
Project Name	
Date	
Project Justification	
Project Description	
Project Deliverables	
Out of Scope items	
Project Objectives	
Constraints	
Assumptions	

5.2.2.2. Identify Improvement opportunities

After recording the Enterprise Map and defining the project scope it is required to identify the improvement opportunities. These improvement opportunities can have different sources, such as sustainability benchmarks (internal and external) and best practices for the relevant processes. In this phase, the collaboration character is fundamental, ethical practice of work is to organise the meetings or workshops with people affected by the business processes (not only the ones responsible for the specific business process but with people from connected processes as well). E.g. if the organisation is studying the process 'Order Entry' and it relates to the process 'Outbound Logistics', the meeting must contain the business owners and business analysts from 'Order Entry' process and at least one person representing the 'Outbound Logistics' process (preferably the business owner or someone with full understanding on the process) (Gallotta, 2016).

According to Scheer, A. (2006) for each meeting, for example, an invitation including an agenda must be sent to all colleagues concerned. After the meeting, the minutes of the meeting must be sent to all participants within 24 hours. All work processes must be designed efficiently and any form of waste avoided. These processes are documented and are transparent to each employee. It is the aim to guarantee a constant, uniform process flow and assure high quality.

5.2.2.3. Design TO-BE process

After identifying the improvement opportunities, the TO-BE process (expected) is designed. A good work practice in this particular step is to keep the process designs in a shared folder, or shared space within the organisation so everyone could be able to check and make sure that the proposed design reflects the best-case scenario for the proposed processes (Gallotta, 2016).

5.2.2.4. Record predicted metric values

After designing the new to-be process, the metrics are recorded to the new processes predicting the new metric values per process (Gallotta, 2016).

5.2.2.5. Define Implementation Strategy

The final stage in the Design phase is to define the implementation strategy. There are four types of Implementation scenarios that can be conducted in project implementation: 'Big Bang', 'Parallel', 'Relay' and a combination of one or more strategy. According to Jeston & Nelis (2006) in the 'Big Bang' approach the proposed change is introduced in one major overhaul; in the 'Parallel' method the proposed change is introduced step by step (e.g. by location or business unit), with the next roll-out starting before the previous one is finished; in the 'Relay' approach the proposed change is introduced step by step, with each roll-out only starting once the previous one has been completed; and the last scenario is a combination of the abovementioned implementation approaches (Gallotta, 2016).

According to the authors, 'Big Bang' has the advantage of being fast to implement, although the risk of disruption to the business is high; 'Parallel' method provides a relatively fast implementation and the ability to make use of lessons learned from preceding implementations is valuable, even though additional resources will be required to assist with overlapping implementations, and the coordination of these simultaneous roll-outs will be high and potentially complex; in the 'Relay' approach lessons learned from the preceding roll-out(s) can be fully taken into account and the same implementation team can be used, the negative aspect from this technique is that it involves lack of speed, as this implementation could, depending upon the circumstances, take some time to complete; and the 'Combination' approach provides the organisation with the benefits of tailoring the roll-out to the specific situation; flexible and yet still manageable (Gallotta, 2016).

5.2.3. Implement Phase

The 'Implementation' phase is when the project is in fact implemented, when the technical execution happens, so it is when the business processes will be transformed to 'green business processes' (strong commitment with Project Management and Change Management aspects) and further executed, incorporated by the organisation day by day routine (go-live scenario). During this phase, the tasks need to be followed up and if changes are required, they need to be recorded in a change request form that should be addressed and incorporated (or not, depending on the decision of the project committee) in the project scope. The changes aim to improve the sustainability performance, represented by the metrics. **Figure 41** shows the breakdown of the steps in this phase.

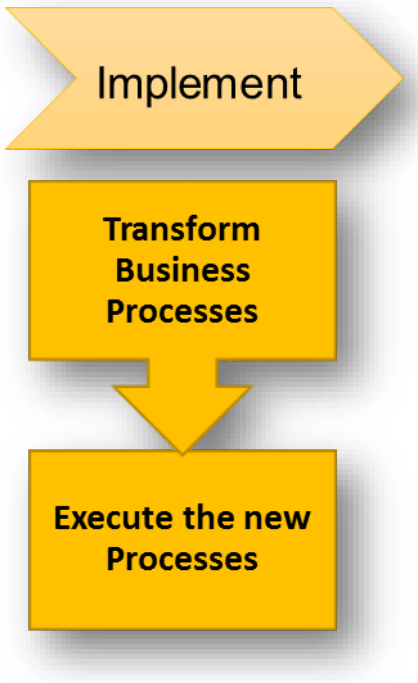

Figure 41 - Breakdown of Implement Phase

5.2.3.1. Transform Business Processes

The executing phase brings the transformation of the business processes. In this step, all the proposed designs come to life concerning business processes. According to Jeston and Nelis (2008) projects often fail because the implementation is merely restricted to being one of the closing steps of the project, and is mainly centred on one-way communication to inform the users and other stakeholders of the benefits of the new solution for the organisation. Moreover, most activities are focused on ensuring that users can use the new solution (e.g. training), and not on whether they want to use it (e.g. motivation of

staff). The best way to ensure smooth implementation is to start considering implementation issues at the initiation of the project, by adopting Project Management guidelines (Gallotta, 2016).

Before defining Project Management, it is essential to define the concept of Project. According to Slack et al. (2013) a project is a set of activities with a defined start point and a defined end state, which pursues a defined goal and uses a defined set of resources. Technically many small-scale operations management endeavours, taking minutes or hours, conform to this definition of a project.

The Association of Project Management Body of Knowledge (APM BoK), defines Project Management as, "the planning, organisation, monitoring and control of all aspects of a project and motivation of all involved to achieve the project objectives safely and within agreed time, cost and performance criteria" (Association of Project Management (APM), 1995). The Project Management Institute (2004), on the other hand, defines Project Management as the application of knowledge, skills, tools and techniques to project activities to meet project requirements. Project management is, therefore, the accomplished of a specific work through the application and integration of the project management processes of initiating, planning, executing, monitoring and controlling, and closing. Managing a project involves identifying requirements; establishing clear and achievable objectives; balancing the competing demands for quality, scope, time and cost; and adapting the specifications, plans, and approach to the different concerns and expectations of the various stakeholders (Gallotta, 2016).

Several studies, such as Box & Platts, (2005), Margherita (2014) and Lee & Dale (1998) have linked successfully Project Management and Business Process Management. According to Box & Platts (2005) creating and maintaining alignment of purpose for change initiatives in the business processes requires an understanding of the environment in which the change is being made, good leadership and effective project management. Margherita (2014) states that project management system of the organisation can support its process management system by providing a structure and method of the process as a set of parts which can be conceived as "micro-work packages" or "micro-projects". More than that, the process management can support project management by providing the method for implementing lifecycle, state of advancement and work modelling. According to Lee & Dale (1998), Effective project management plays a critical operational, and sometimes strategic, role in BPM implementation and in handling organisational change (Gallotta, 2016).

However, the project management itself does not ensure the success of the implementation. Other aspects have a crucial role, such as leadership and change management. According to Epstein et al. (2010), leading corporations such as Nike, P&G, The Home Depot Inc., and Nissan Motor Co. are successful in implementing their sustainability initiatives primarily because of committed leadership, organisational culture and people. Moreover, though sensitive to stakeholder concerns and impacts, these leading companies are internally committed to improving corporate sustainability performance. All four companies incorporate sustainability issues into their corporate strategies; they have specific sustainability strategies and aligned organisational structures; performance measurement systems with some social and environmental metrics are also in place. However, leadership and organisational culture have been found to be the critical determinants of successful management of the various trade-offs middle managers face when they try to simultaneously manage social, environmental, and financial performance (Gallotta, 2016).

5.2.3.2. Execute the new Processes

After transforming the business processes, the organisation starts to adopt the new practices in the routine, by executing these new processes. This adoption depends on the type of implementation defined in the step **5.2.2.5. Define Implementation Strategy.** Usually, before the 'go-live' of the solution, organisations make some tests, dry runs (or pilot). A similar example is found in the television industry, in which the studios prepare 'pilots' of TV shows and, depending on the acceptance of the audience, they carry on with other episodes. In organisations, these dry runs may occur in small business unities or with small control groups and, only after that, the solution has the official 'go-live' (Gallotta, 2016).

5.2.4. Monitor & Control Phase

The 'Monitor & Control' phase contains the steps to evaluate the status of the sustainability implementation. In this phase, it is initially monitored the organisational performance (using dashboards to analyse objectives, resources and results). After this step, the process performance (based on the Process Performance Indicators) is monitored and the metrics are monitored. Afterwards, once the value is fully realised (all the objectives are realised, the comparison between actual metric values with initial and predicted ones) the sustainability implementation project is formally closed. However, since the sustainability requirements (from the market, customers, and regulations) are

always changing, it is essential to have a step to identify optimisation opportunities, giving a cyclic characteristic to the framework. **Figure 42** shows the breakdown of the steps in this phase.

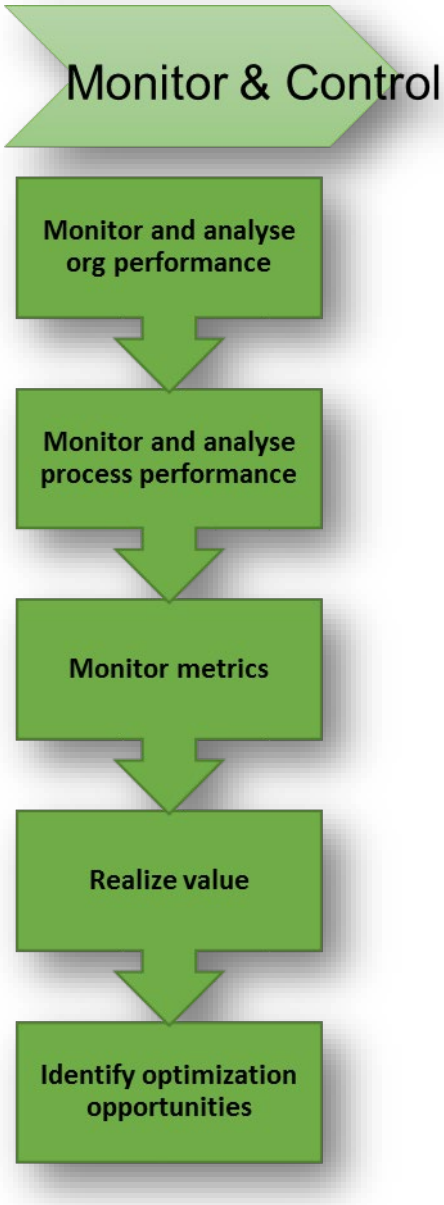

Figure 42 - Breakdown of Monitor & Control Phase

5.2.4.1. Monitor and analyse organisational performance

The first step in the 'Monitor & Control Phase' is to 'Monitor and analyse the organisational performance'. According to Draghicia et al. (2014), performance assessments and audits define the system/organisation perspective that incorporates the complexities of various dynamic and interacting processes of modern organisations.

Linkage (2013), proposed a framework (**Figure 43**) to provide a practical structure for organisational analysis, framing the right questions as focused on each of the five key elements: (1) Strategy: Does my organisation know where it is headed (quantitative and qualitative data)? (2) Execution: What are the issues around getting things done? (3) Systems: What is blocking my organisation in terms of process, structure, etc.? (4) Growth: Where is my organisation's growth going to come from? (5) Culture: What does my organisation stand for? What type of change is the organisation (and its people) currently experiencing? The general tendency of the organisational performance approach takes into consideration different organisational dimensions (customers and stakeholders satisfaction, human resources performance, definition of key performance indicators, continuous improvement, and most economical and financial indicators, all aspects integrated into the strategic management system) (Brudan, 2010).

Figure 43 - Organisational performance framework (Linkage, 2013) - content removed for copyright reasons

Draghicia et al. (2014), on the other hand, proposed a model for the organisational performance management (focus on the evaluation, analysis and monitor activity) in the context of the actual trends in the field. The proposed framework (**Figure 44**) takes into consideration three organisational determinants: objectives, resources and results. The relation between them defines three critical organisational characteristics: efficiency (described in our approach from the perspective of intellectual capital management), effectiveness and pertinence (diagnosis from the perspective of organisational and manager/leader behaviour) (Gallotta, 2016).

Figure 44 – Framework to monitor organisational performance. Adapted from Draghici (2014) - content removed for copyright reasons

5.2.4.2. Monitor and analyse process performance

After monitoring and analysing the organisational performance, the organisation need to monitor and analyse the process performance. According to del-Río-Ortega et al. (2013) to improve processes, it is essential to evaluate their performance, since it helps the organisation to define and measure progress towards their goals. Performance requirements on business processes can be specified by means of Process Performance Indicators (PPIs), a particular case of KPIs. PPIs can be defined as quantifiable metrics that allow evaluating the efficiency and effectiveness of business processes. They can be measured directly by data that is generated within the process flow and are aimed at the process controlling and continuous optimisation (Rosenberg et al. 2011).

According to del-Río-Ortega et al. (2013) and Franceschini et al. (2007) four requirements for the definition of PPIs can be established: expressiveness (the definition should be unambiguous and complete); understandability (PPIs should be comprehended and accepted by process managers and employees); traceability with the business process (enabling to maintain coherence between both assets, Business Process models and PPIs); and possibility to be automatically analysed (allowing thus not only to gather the

information required to calculate PPI values, but also to infer knowledge on which are the business process elements related to PPI) (Gallotta, 2016).

After monitoring and analysing the organisational performance, it is required to monitor and analyse the process performance. del-Río-Ortega et al. (2013) proposes a PPINOT model, which allows a definition of PPIs (Process Performance Indicators) and correlates them with business processes. After modelling the process, the first step is to define the PPIs that are necessary to evaluate it; Once PPIs are defined, the next step is to decide how to calculate them from the data that is generated during the execution of the process; After deciding how measures are obtained, they must be actually gathered during the execution of the process so that the values of the PPIs can be calculated based on them; and Finally, PPIs can change because of an evolution of the business process and, hence, they should be updated accordingly, or they can also change independently of the business process (Gallotta, 2016).

5.2.4.3. Monitor Metrics

After monitoring and analysing process performance, the organisation will monitor the metrics in the new processes. Ahmed and Sundaram (2012) developed a system that supports the monitoring and controlling of the organisational, sustainability metrics using various dynamic dashboards available through a number of reporting sub-systems such as Ad-hoc Reports, Organisation Benchmark Report, Organisation Performance Indicators, Strategic Performance Indicators, Process Benchmark Report, Ad-hoc Report Documents, Strategy Documents, Design Documents, Transform Documents, metrics Report, Monitor and Control Report and All Saved Reports. The dashboards are easy to use monitoring and controlling devices which have rich dynamic runtime features, as shown in (Gallotta, 2016). The dashboards (**Figure 45**) allow filtering using any or all of the attributes, namely organisation, metrics, and business process. It displays a list of databases and datasets associated through configuration.

Figure 45 - Example of a Monitoring Dashboard. Adapted from Ahmed and Sundaram (2012) - content removed for copyright reasons

5.2.4.4. Realise value

After monitoring the metrics, it is possible to evaluate the actual state of the sustainability implementation. According to Jeston & Nelis (2008), a project is only complete once the reason for its existence has been achieved and it has been handed over to the business in such a way that the business can now sustain the project outcomes. If the initial goals are not fully realised, it is necessary to investigate the reasons and start the cycle in the missing point (e.g. the problem was during the 'implement' phase, so an action plan is required to overcome this problem) (Gallotta, 2016).

5.2.4.5. Identify optimisation opportunities

Some optimisation techniques for improvement found in the literature include 'scatter diagrams', cause-effect diagrams', 'Pareto diagrams', and 'why-why analysis'. According to Slack et al. (2013), 'scatter diagrams' provide a quick and simple method of identifying whether there is evidence of a connection between two sets of data. This type of graph only identifies the existence of a relationship, not necessarily the existence of a cause–effect relationship. According to Slack et al. (2013), 'cause–effect diagrams' are a particularly effective method of helping to search for the root causes of problems. They do this by asking what, when, where, how and why questions. Cause–effect diagrams (which are also known as 'Ishikawa diagrams') have become extensively used in improvement programmes. This is because they provide a way of structuring group brainstorming sessions. Often the structure involves identifying possible causes under the (rather old-fashioned) headings of: machinery, workforce, materials, methods and money. Pareto's mathematical model, on the other hand, has become linked with the "80/20" rule "which states that 20 percent of the known variables will account for 80 per cent of the

results" (Basile, 1996). Juran labelled 'Pareto' the principle of the 'vital few and trivial many'. It is a shorthand name for the phenomenon that in any population which contributes to a common effect, a relative few of the contributors account for the bulk of the effect" (Juran, 2001). According to Juran (1954), "in any series of elements to be controlled, a selected small fraction, in terms of numbers of elements, always accounts for a significant fraction in terms of effect. In other words, it helps the organisation to identify what are the areas causing more difficulty in the business.

According to Slack et al. (2013), 'why–why analysis' starts by stating the problem and asking why that problem has occurred. Once the reasons for the problem occurring have been identified, each of the reasons is taken in turn and again the question is asked why those reasons have occurred, and so on. This procedure is continued until either a cause seems sufficiently self-contained to be addressed by itself or no more answers to the question 'Why?' can be generated.

According to Jeston & Nelis (2008), the continuous improvement approach from BPM is an amalgam of the ones from Lean Six Sigma, TQM and BPR, however, it does not focus heavily on statistical process control or bottom-up experimentation, but addresses the basics of process improvement and change.

5.3. Roadmap Enablers

The phases and steps described above might not be enough to ensure the success of the implementation of the Sustainability Initiatives in the business processes. Other aspects are relevant for this implementation and should be considered along with the project. These aspects are viewed as enablers to the implementation (they facilitate their implementation), they are: Governance, Strategy, Methods, Information Technology, Change Management, Leadership, and Culture.

5.3.1. Governance

Corporate governance involves a set of relationships between a company's management, its board, its shareholders and other stakeholders. Corporate governance also provides the structure through which the objectives of the company are set, and the means of attaining those objectives and monitoring performance are determined (OECD, 2004). According to ABPMP (2009) in order to discover and manage key processes, it is essential to have the organisational discipline to utilise methodologies to document, store, manage and continuously improve the business processes, particularly those that make up the value chains (Gallotta, 2016).

According to Jeston & Nelis (2008), there are two levels of impact of governance into BPM initiatives: the impact on the processes and the impact on the management of the processes. According to the authors, the impact on the process refers to the increasing rules and regulations applying to processes. The best way to address this is to ensure that governance is included within the process architecture (which is the foundation for the design of new processes in the 'design TO-BE process' phase and the reviewing and assessment of the existing processes in the 'design AS-IS processes'). The Impact on the management of the business processes refers to the fact that governance forces organisations to take all the necessary measures to ensure that the processes are managed and under control and that they are appropriately administered (Gallotta, 2016).

Good governance is vital in every sphere of the society whether it be the corporate environment or general society or the political environment. According to Aras & Crowther (2008) a growing number of researchers have recognised that the activities of an organisation impact upon the external environment and have suggested that such an organisation should therefore be accountable to a broader audience than merely its shareholders. Those suggestions probably first arose in the 1970s (Ackerman, 1975) and a concern with a broader view of company performance is taken by some writers who evince concern with the social performance of a business, as a member of society at large. This concern was stated by Ackerman (1975) who argued that big business was recognising the need to adapt to a new social climate of community accountability, but that the orientation of business to financial results was inhibiting social responsiveness.

5.3.2. Strategy

'Strategy' is not an easy term to define. According to Slack et al. (2013) linguistically the word derives from the Greek word 'strategos', which means 'leading an army'. Moreover, although there is no direct historical link between Greek military practice and modern ideas of strategy, the military metaphor is powerful. Both military and business strategy can be described in similar ways, and include some of the following: setting broad objectives that direct an enterprise towards its overall goal; planning the path to achieve these goals; stressing long-term objectives; dealing with the total picture rather than stressing individual activities; and being detached from, and above, the confusion and distractions of day-to-day activities (Gallotta, 2016).

In Operations, according to Slack et al. (2013) strategy concerns the pattern of strategic decisions and actions which set the role, objectives and activities of the operation. According to ABPMP (2009) in BPM, the alignment between business process objectives

and enterprise strategy is essential to realise fully the BPM benefits. Customer requirements must drive business strategy, metrics, objectives and organisation. Precise definition of end-to-end business processes with process owners should include extended business processes and more detailed business activities (or work packages) (Gallotta, 2016). According to Wijethilake (2017), theoretically, proactive sustainability strategy1 improves corporate sustainability performance through efficient use of resources, increased cost advantage, reduced waste and discharge, promotion of social reputation, improved customer preferences, and generation of new innovative capabilities (Banerjee, 2001, Bhupendra and Sangle, 2015, Christmann, 2000, Judge and Douglas, 1998, Sharma and Vredenburg, 1998).

5.3.3. Methods

According to Jeston & Nelis (2008), methods, in the context of BPM, have been defined as the approaches and techniques, which support and enable consistent process actions. Distinct methods can be applied to principal, discrete stages of the process lifecycle. An advantage of associating the method capability with a specific process lifecycle stage is the resultant ability to assess methods that serve a particular purpose, rather than purely all methods relating to BPM. For instance, it is possible to evaluate specific methods for designing processes as distinct from those used for improving processes. This form of analysis is considered to be particularly beneficial, given the common practice of methods being developed, marketed and implemented to meet the needs of a specific process lifecycle stage. Process methods can be observed in several moments of the implementation: for the process design and modelling; for the process implementation and execution; for the monitoring & control (e.g. use of dashboards); and in process improvement.

5.3.4. Information Technology

According to Jeston & Nelis (2008) Information technology (IT) refers to the software, hardware and information management systems that support and enable process activities. Similarly, to the methods maturity assessment, the IT components focus on the specific needs of each process lifecycle stage and are evaluated from viewpoints such as customizability, suitability of automation and integration with related IT solutions. IT solutions can be observed in several moments of the implementation: for the process design and modelling; for the process implementation and execution; for the monitoring & control (e.g. use of dashboards); and in process improvement (Gallotta, 2016).

According to ABPMP (2009), once a process has been designed, putting that process into operation may involve a number of information technology support applications. The use of systems to support the execution of BPM in an organisation's internal operations and activities involving interactions with trading partners and customers may considered in the following categories: Electronic Document Management Systems (EDMS) that capture, organise and provide information required for the execution of steps in a process; electronic forms for information capture and distribution; workflow routing and management; and workgroup collaboration. The integration of management systems allows organisations to be simultaneously coherent and consistent in satisfying the demands of sustainability in an optimal way (Vivanco et al., 2018, Rebelo et al., 2016, Salomone, 2008).

5.3.5. Change Management

Since every implementation project involves changes in the organisation, Change Management aspects need to be considered in the project. According to Slack et al. (2013) refers to the need for the implementation team to formally prepare a change management programme and be conscious of the need to consider the implications of such a project. One vital task is to build user acceptance of the project and a positive employee attitude. This might be accomplished through education about the benefits and need for the new processes. Part of this building of user acceptance should also involve securing the support of opinion leaders throughout the organisation (Gallotta, 2016).

According to BPMNP (2009), change management for BPM initiatives should directly address the five S aspects (strategy, structure, system, staffing and shared values) aligned with organisation strategy, structure, and environment. This holistic approach helps the organisation achieving intended objectives and minimising unintended consequences (Gallotta, 2016). According to Doppelt (2003), implementing sustainable business practices is about much more than the technical, financial, or political. It is about the human factors. Doppelt found that the critical missing ingredient in the adoption of sustainability measures is organisational and cultural change. Sustainability measures require a paradigm shift from the traditional linear "take-make-waste" economic model to a circular "borrow-use-return" system. These fundamental changes in operations and organisational design often require substantial changes in culture.

5.3.6. Leadership

According to ABPMP (2009) the role of executive leadership is critical to business process management initiatives. The executive leader sets the vision, tone and pace of business process improvement. He determines the direction and strategy of BPM, focusing the enterprise on its broader objectives. He is the responsible for allocating resources and reward success. He may unify the various missions and groups throughout the enterprise, appoint and empower process owners or other individuals playing key roles in the management of business processes. Executive leaders may even be process owners themselves, owning and institutionalising the process of process management. They could act as 'champions' inspiring the enterprise to change, sometimes by creating a sense of urgency to overcome scepticism and resistance. To do this, they must communicate the case for process management and remove obstacles, which may impede progress toward the goal. They are responsible for creating the environment for success, sometimes through influence and persuasion, other times by resolving conflicts and removing barriers. The critical role for leadership in sustainability is to encourage the introduction and reflective consideration of deeper contextual information (ecological, social, cultural, and geographic) into the field of salience for collective meaning making: helping to develop a 'biosphere consciousness' (Kurucz et al., 2017; Rifkin, 2009).

5.3.7. Organisational Culture

According to Slack et al. (2013), an organisation's culture is usually taken to mean its shared values, ideology, and pattern of thinking and day-to-day ritual. Different organisations will have different cultures stemming from their circumstances and their history. According to ABPMP (2009), every organisation has a culture that impacts and is impacted by the internal and external processes of that organisation. That culture includes how the work is performed and what motivates the members of the organisation to do the work. By changing the process, the culture may also change. This may lead to unintended consequences as new processes are put into place. Part of the 'Analyse' phase is to ask questions that will help the analysis team understand the culture of the organisation and those unwritten rules that determine how and by who work is really accomplished. The goal of these discussions is to understand what will happen to the organisation when the process is changed.

Several studies have pointed to internal organisational pressures for the adoption of sustainability practices, such as staff turnover due to decreasing firm loyalty and

workplace satisfaction (Wilkinson, Hill, & Gollan, 2001, Linnenluecke & Griffiths, 2010). These studies identify internal organisational factors, such as top management support, human resource management, environmental training, employee empowerment, teamwork and reward systems, as important aspects for achieving corporate sustainability (Daily and Huang, 2001, Wilkinson et al., 2001). On a value level, the adoption of corporate sustainability principles takes place through changes in employees' values and beliefs towards more ethical and more responsible values (Crane, 2000).

5.4. Discussion

Table 11

Table 11Discussion

Phase	Sustainability impact
Analyse	Metrics definition
Design	
Implement	
Monitor and control	
Enablers	

5.5. Chapter summary and conclusions

Chapter 2 has demonstrated that current ways to implement sustainability initiatives do not address all the aspects of the sustainability implementation and chapter 3 presented how BPM can be used as a tool to perform this job. This way, this chapter presented the development of the conceptual framework based on the BPM approach to implementing sustainability initiatives in the business processes and relating it to the sustainability initiatives implementation. It has initially presented the four main phases of the model then it described all the steps in each phase and, finally, the enablers for the framework adoption. Chapter 6 will provide a Delphi study that was used to verify the framework, chapter 7 will provide an Action research study that was used to validate the framework in a real-world scenario.

Chapter 6 – Framework Verification using Delphi Study

6.1. Introduction

Chapter 5 presented the development of the conceptual framework based on the BPM approach to implementing sustainability initiatives in the business processes. This chapter presents the verification of the framework using the Delphi method. The Delphi technique seeks to obtain consensus on the opinions of experts, termed panel members, through a series of questionnaires. As part of the process, the responses from each round are fed back in summarised form to the participants who are then given an opportunity to respond again to the emerging data. This chapter explains the method. After this, it shows the manner to select the participants and how to classify them as specialists. The chapter then explores the modus to create the questionnaire. Finally, the chapter provides the results of the study (both round 1 and round 2).

6.2. The Delphi method

The Delphi method relies on the use of expert opinions "to obtain the most reliable consensus" via a series of questionnaires with controlled feedback within a Panel (Dalkey and Helmer, 1963 and Hasson et al.2000), According to Linstone and Turoff (1975), the Delphi technique is " a method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem". The purpose of this technique is either forecasting/issue identification or concept/framework development (Okoli and Pawlowski, 2004 and Schmiedel et al.2013). The Delphi method was originated in the 1950s by the RAND Corporation (Linstone and Turoff, 1976), became highly popular from the mid-90s (Habibi et al.2014) and according to McKenna (1994), the Delphi method has been used in over 1,000 published research projects.

According to Krigsholm, et al. (2017) there are several variants of the method, but all Delphi studies have some key elements in common. First, a Delphi study consists of multiple rounds of formal questionnaires, and the respondents are anonymous to one another. Second, a Delphi study builds upon iterative, controlled feedback. That is, after each round experts can revisit and rethink their answers in the light of the information provided. Third, a Delphi study presents a statistical summary of the group's responses.

The literature presents a scattered view of the number of participants in the study. Hogarth (1978) claims that between six and twelve members are the ideal number of participants for the Delphi study, according to Clayton (1997), if a mixture of experts with different

specialties is used, between five and ten members are enough. According to Habib et al. (2014) while some Delphi studies considered less than 10 members in their panels (such as Malone et al.2005 and Strasser et al.2005), other studies included more than 100 participants (such as Kelly et al.2005 and Meadows et al. 2005). The Delphi panel is obtained with the participation of the specialists. The specialists are individuals with knowledge and expertise of the study subject.

Figure 46 presents the methodology that was carried out for this study.

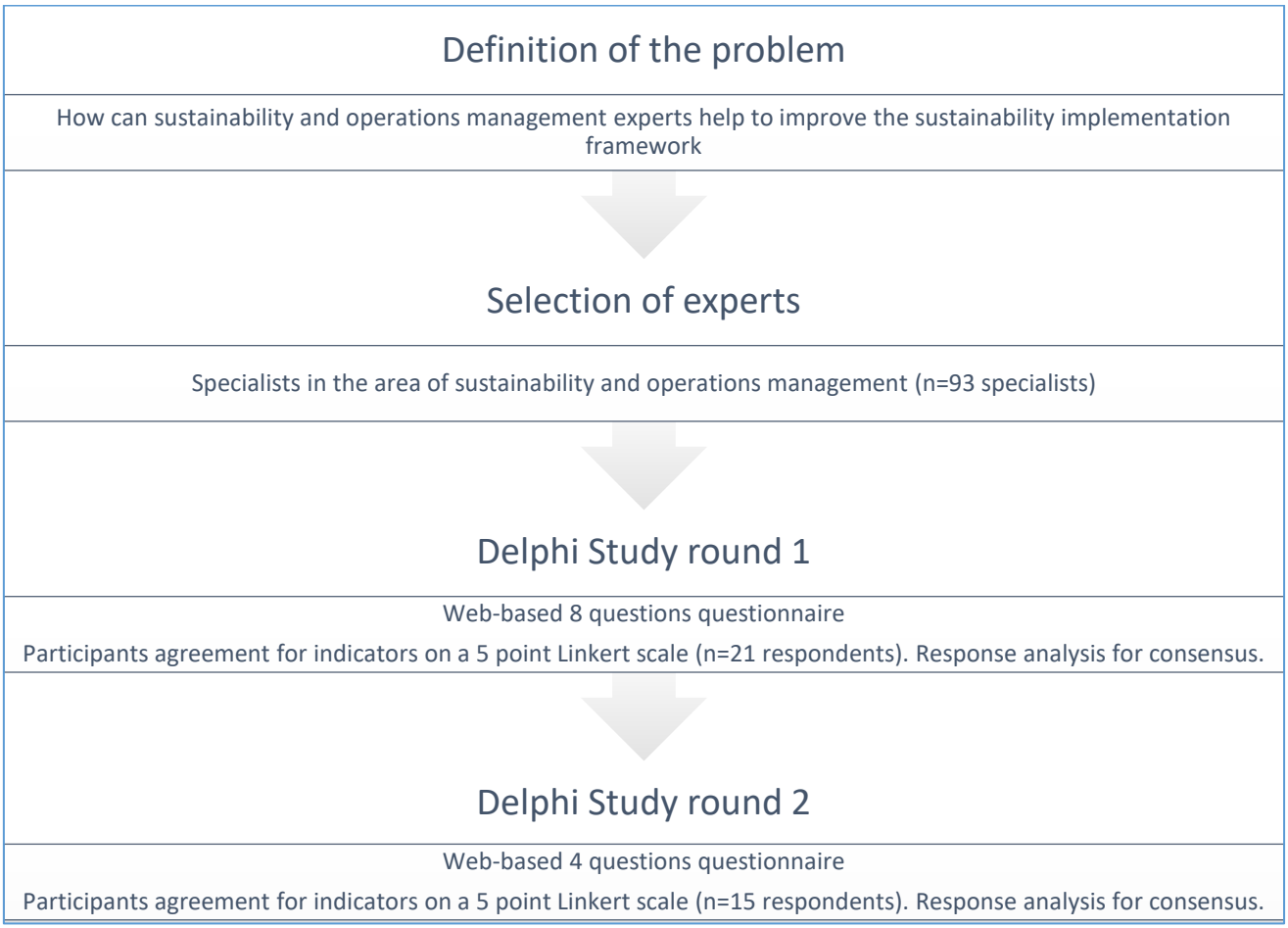

Figure 46 Delphi study method

In order to quantify the expert's opinions, it was used the Likert scale. According to Wadagave et al. (2016), Likert scale is a psychometric response scale primarily used in questionnaires to assess subject's perception. Most commonly seen as a 5-point scale (Ordinal data), each level on the scale is assigned a numeric value (Jamieson, 2004).

For the maters of this study, it was used the following definition:

1 = strongly disagree

2 = somewhat disagree

3 = neither disagree or agree

4 = somewhat agree

5 = strongly agree

Therefore, the average response value is defined by the following formula:

$$Average = \frac{\sum_0^n response\ index}{n}$$

In order to convert this average into percentage, it was used the following formula:

$$Percentage = \frac{Average}{5}$$

*5 because it is the maximum numeric value of the scale. If it were defined a 7-point scale, the denominator would be equals to n x 7.

Exemplifying:

If a particular question had the following answers

Somewhat Disagree
Somewhat Agree
Strongly Agree
Somewhat Agree
Neither agree or disagree

The answers, in numeric ways would be:

Somewhat Disagree	2
Somewhat Agree	4
Strongly Agree	5
Somewhat Agree	4
Neither agree or disagree	3

The average would be:

$$Average = \frac{\sum_0^6 response\ index}{6}$$

$$Average = 3.66$$

The percentage would be:

$$Percentage = \frac{3.66}{5}$$

$$Percentage = 73.33\%$$

Since the main objective of the Delphi study is to obtain consensus, it is important first to define the concept of consensus. A consensus is in essence, a general agreement, a unanimity, the majority of opinion of a determined group. Some authors have suggested the level of consensus for the Delphi study: Loughlin and Moore (1979) suggest it should be set at 59% agreement amongst respondents, McKenna (1994) suggests 51%, and Orton (1981) suggested a level of 55%. Robert and Schermers, et al. (2011) consider different types of majority, such as greater than one half (more than 50%), three fifths (60%), two thirds (66%) and three quarters (75%). Therefore, any question with a score of acceptance higher than 75% was considered as a consensus.

After checking the agreement level, if the question has a score lower than 75% it is flagged for the second round. If the score is higher than 75%, the comments were analysed using the textalyser tool to identify the prominent keywords. Finally, the keywords are analysed and discussed. **Figure 47** represents the analysis method employed by the Delphi study. For the qualitative questions, the initial step is to check whether the recommendation should be considered. If so, the comments were analysed using the textalyser tool to identify the prominent keywords. Finally, the keywords are analysed and discussed.

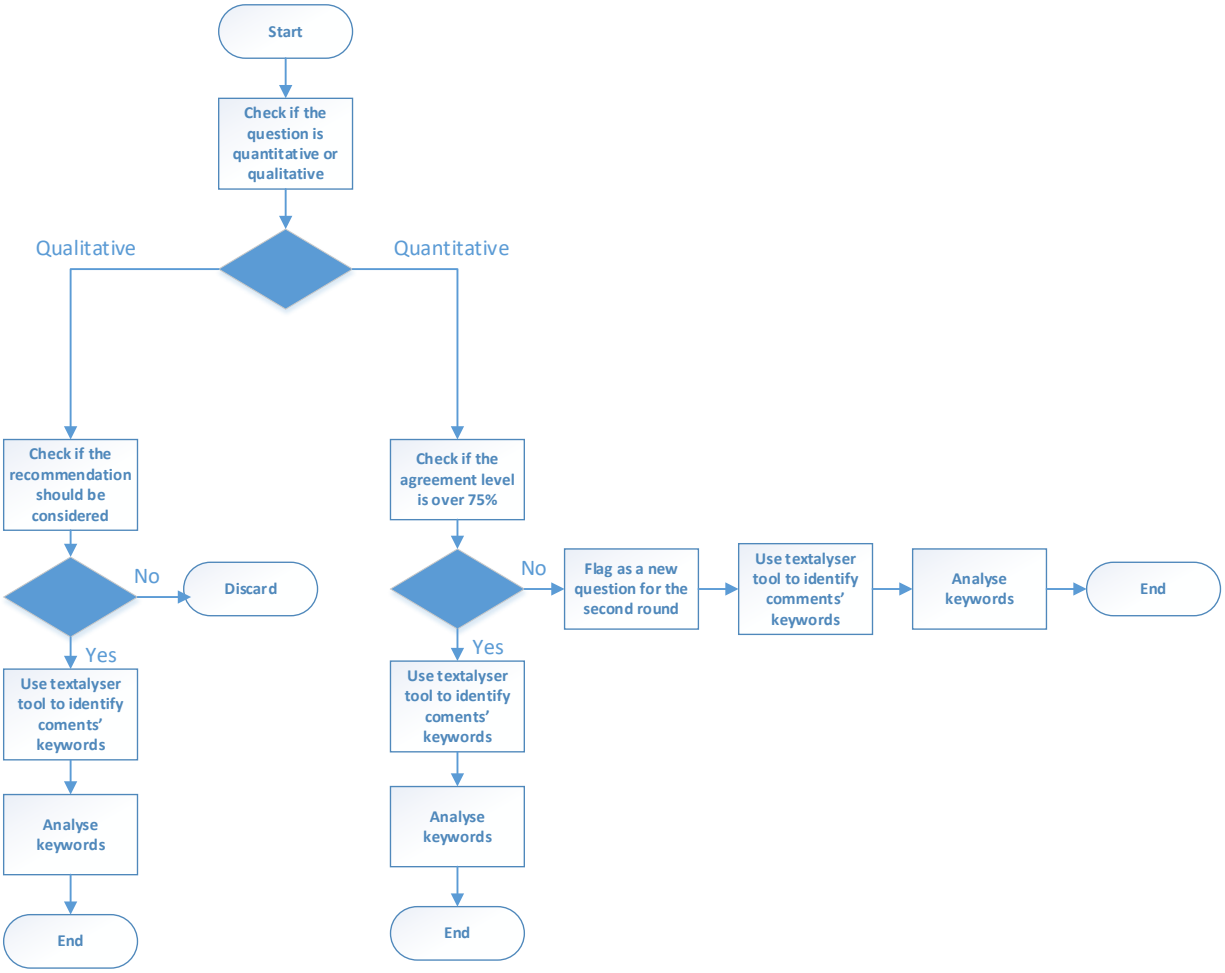

Figure 47Method to analyse the responses of the Delphi study

6.3. Participants

Some researchers argue that an expert is "any individual with relevant knowledge and experience of a particular topic" (Cantrill et al. 1999ˆ). The participants for this study were found on Linkedin, Research gate, conference publications, and universities websites. In order to be considered a specialist, the person should occupy 1) Industry: Experience with leadership positions (such as Manager, Director, position) with more than 3 years of experience in Sustainability and operations management or 2) Academia: Involvement with sustainability and operations management for at least 3 years and publications of the topic. After this, 93 people were identified as potential participants for the study. Appendix A list the 93 specialists identified.

Since the participants were spread around the globe (Brazil, US, UK, Mexico, etc), the questionnaire was sent through the following e-mail. In the e-mail, it was explained the reasons for the study, a brief explanation of the method and the expected time to complete

the survey. **Figure 48** represents the e-mail that was sent. The e-mails were sent on the 22nd of June 2016 and defined a one-month deadline for completion (first round).

Dear researcher,

I am writing to invite you to participate in a Delphi study to support the research **A framework for the implementation of sustainability business processes**

What is a Delphi study? The Delphi technique seeks to obtain consensus on the opinions of experts, termed panel members, through a series of questionnaires. As part of the process, the responses from each round are fed back in summarised form to the participants who are then given an opportunity to respond again to the emerging data. The Delphi is, therefore, an iterative multi-stage process designed to combine opinion of specialists into group consensus

This research aims to provide a complete solution to implement sustainability initiatives using the Business Process Management tool.

As an established expert in this field, we are keen to gain your views on how to construct an 'expert consensus' implementation framework. This will then be validated using the data of other researchers from the same field of study. It is envisaged that this should take between 10-15 minutes to complete. After validating the framework, it will be empirically tested using the case study tool.

Your expertise would be extremely beneficial to develop a credible sustainability implementation framework and I would be very grateful if you would consider participating in this Delphi study. Please access the questionnaire through the following link
http://goo.gl/forms/91fD20YsLtcrMGAz1

Kind regards

Figure 48 - e-mail sent to the specialists

From the total of 93 people contacted, 21 responded to the e-mail and agreed to take part in the study, representing a total of 29.16% response rate (**Figure 49**).

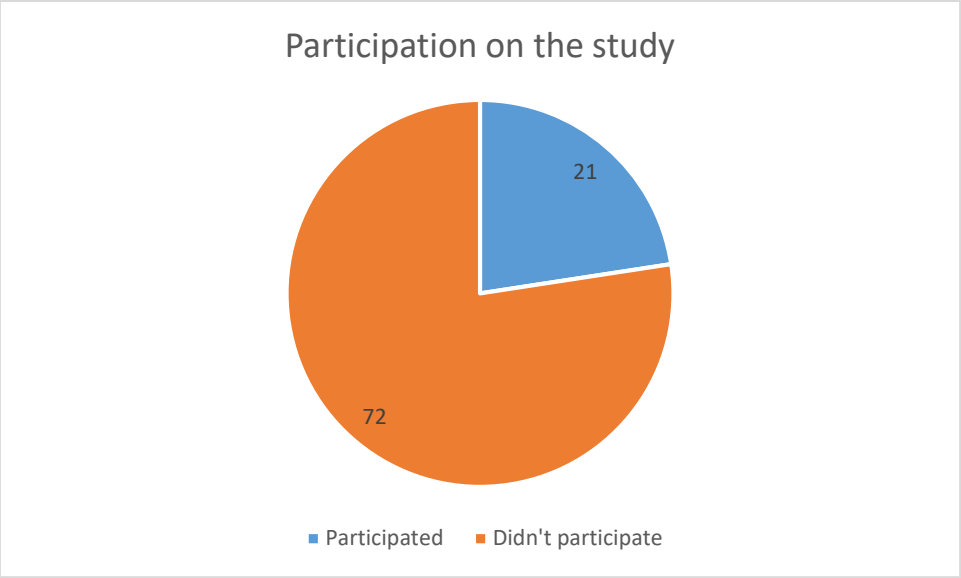

Figure 49 - Participation of the study chart

Among the participants, there were people from different job positions, such as Researchers, Lecturers, Professors, Managers, Directors and CEOS from different organisations in several countries.

In total, there were fourteen researchers from the academia and seven from the industry. The participants were based on six different countries (Brazil, Germany, UK, Mexico, Sweden and Netherlands). The specialists comprised nine different job positions (Green developer, management partner, researcher, lecturer, senior lecturer, professor, manager, sustainability VP and sustainability consultant). **Table 12**, **figure 50, 51 and 52** represent the participants' information.

Table 12 - - Participants information

Position	**Institution**	**Country**	**Focus**
Researcher	USP	Brazil	Academic
Professor	UFBA	Brazil	Academic
Researcher	USP	Brazil	Academic
Lecturer	Senac	Brazil	Academic
Researcher	Instituto de Pesquisas Energéticas e Nucleares - IPEN	Brazil	Academic
Professor	UFSC	Brazil	Academic
Researcher	UNIP	Brazil	Academic
Managing Partner	SYSTEMICA	Brazil	Industry
Professor	Uni Autonoma	Mexico	Academic

Sustainability Consultant	BASF	Brazil	Industry
Manager	Nestle	Brazil	Industry
Sustainability VP	Corbetti Geothermal plc	Brazil	Industry
Sustainability Consultant	SAP	Germany	Industry
Senior Lecturer	Instituto Politécnico Nacional	Mexico	Academic
Green developer	GREENDEV	Netherlands	Industry
Researcher	Volvo	Sweden	Industry
Researcher	Cranfield University	UK	Academic
Senior Lecturer	Brighton	UK	Academic
Professor	Coventry University	UK	Academic
Professor	University of Northampton	UK	Academic
Lecturer	Surrey	UK	Academic

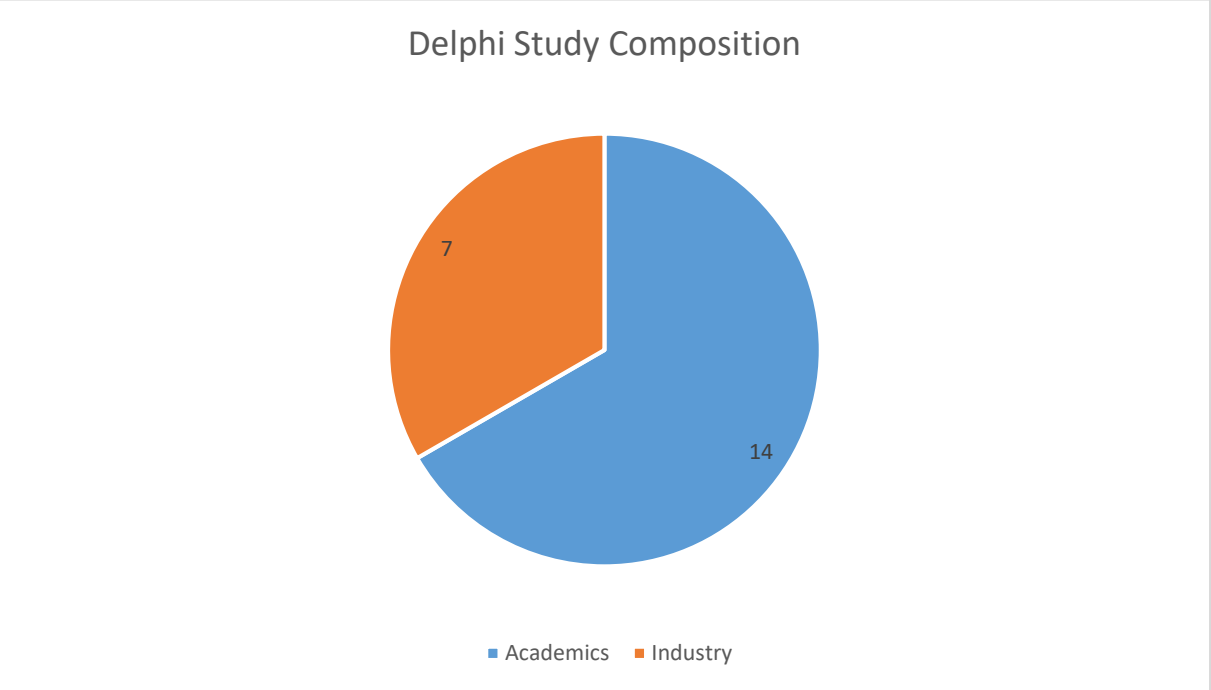

Figure 50 - Delphi study composition

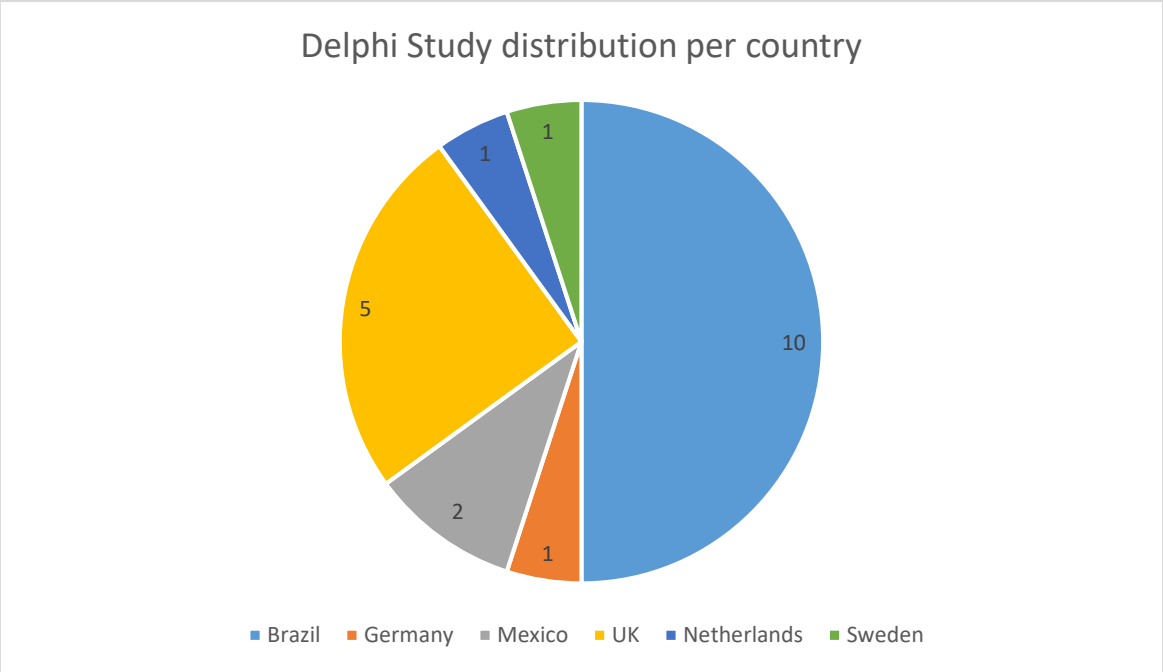

Figure 51 - Delphi study distribution per country

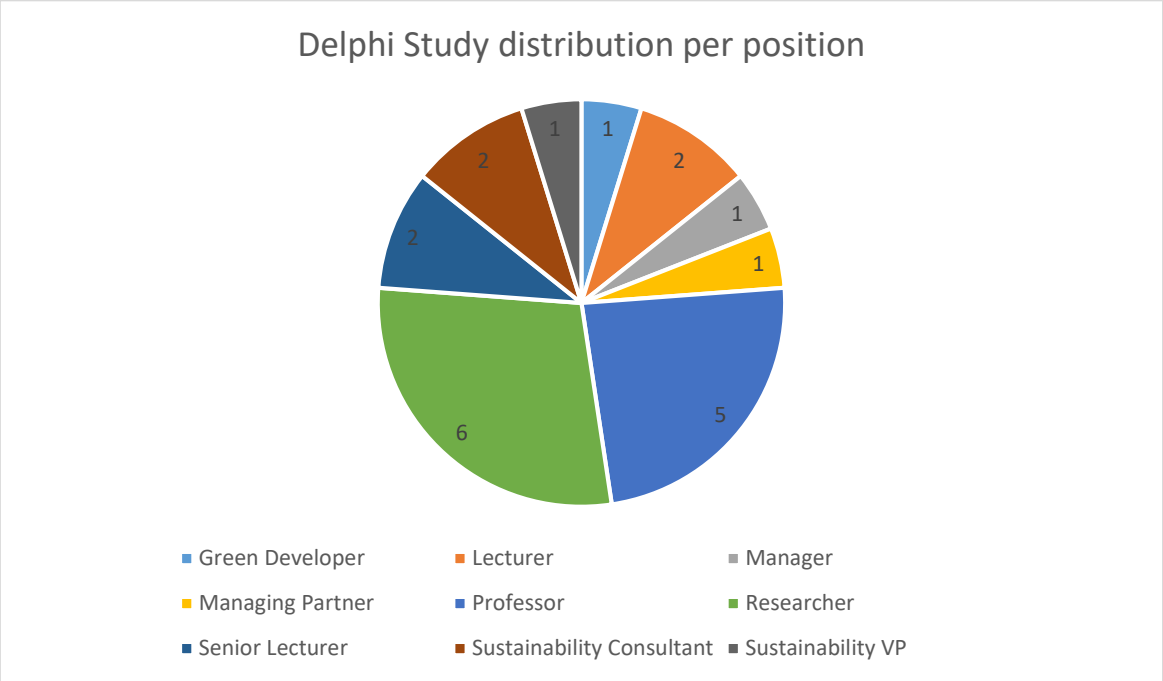

Figure 52 - Delphi study distribution per position

6.4. The Delphi study

6.4.1. Questionnaire creation

The initial challenge to create the questionnaire relies on how to define the appropriate questions in order to obtain the most accurate and valuable results from the respondents. The questions need to be concise, direct and should have a logical connection. It should

englobe all the required information, but in the interim, it should not consume much time from the respondents.

In a general view, it was identified 8 groups of questions. 1) Sustainability, 2) Process Improvement, 3) Process Improvement & Sustainability, 4) Analyse phase, 5) Design phase, 6) Implement phase, 7) Monitor & control phase, and 8) Enablers of the implementation. **Table 13** identifies the groups of questions for the questionnaire.

Table 13 - Groups of questions for the questionnaire

Sustainability Process Improvement Process Improvement & Sustainability	
Analyse	Identify Business Scenario Determine and prioritise processes Define stakeholders Define project objectives Define Metrics Record enterprise map Record baseline values Perform Sustainability maturity assessment
Design	Define Scope Identify Improvement Opportunities Design to-be process Record predicted metrics values Define Implementation Strategy
Implement	Transform Business Processes Execute new processes
Monitor & Control	Monitor and analyse organisational performance Monitor and analyse process performance Monitor Metrics Realise value Identify optimisation opportunities

Process Improvement	Relate with	Governance Strategy Methods Information Technology Change Management Leadership Culture

The questionnaires for the first and second rounds are available in the Appendix section.

6.4.2. Test round

Before submitting the questionnaire to the participants, it was conducted a test round as a form of a pilot with 10 English native speaking participants. These participants did not have any education or work experience with sustainability and or operations management. The non-biased participants were chosen, so the questionnaire was clear, coherent and did not have any grammar errors. The pilot test started on the 17th of June 2016 and lasted until the 23rd of June 2016.

6.4.3. Delphi Study first round

After concluding the test round, the outputs from the participants were evaluated and considered to the questionnaire to be sent to the specialists. Appendix B displays the questionnaire used for the first round of the Delphi study.

Results and Discussion

6.4.3.1. Is Sustainability implementation directly linked to Process Management?

Figure 53 displays the graph with the results for the question and **table 14** displays the comments provided by the specialists.

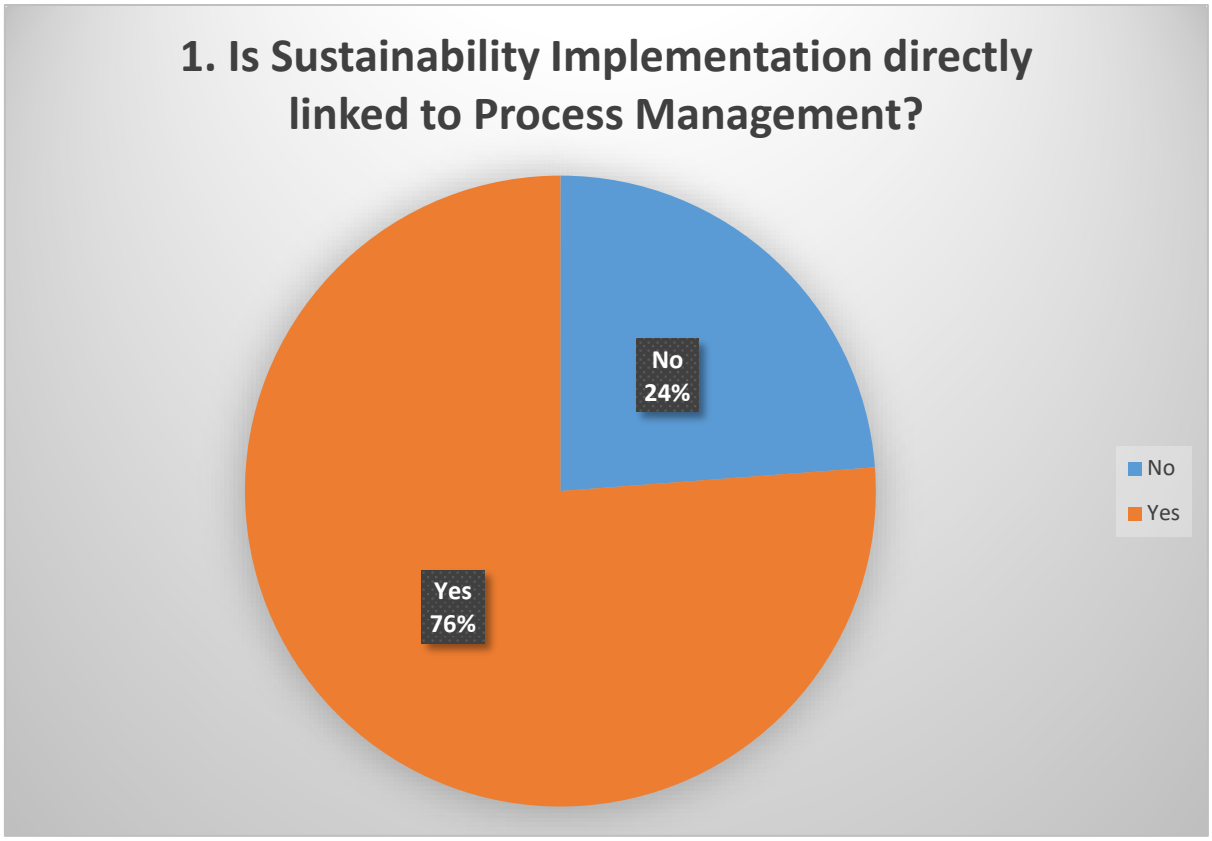

Figure 53 - Is Sustainability implementation directly linked to Process Management?

Comments

Table 14 Comments on the question –'Is Sustainability implementation directly linked to Process Management?'

It is not something indispensable, but the process view helps in the sustainability adoption.
Sustainability is a wider concept related to the environment, social, and economic issues.
I want to answer both; I think the sustainability implementation takes several ways into the organisation. Sometimes the initiative of people is created before any intent of changing the process and procedures.
In my point of view, when we approach sustainability, we definitively have to rethink our process (inbound and outbound). That´s why sustainability is linked to process management
Sustainability is linked to business processes results in several ways. There are business processes that directly affect sustainability results, such as product development and manufacturing; and some business processes can influence business sustainability, for example, the strategic planning and human resource management processes.
The process should be sustainable in any stage (waste, energy and ultimately reworkable)
If you do not have sustainable processes, how can you talk about sustainability in a company?

There is a need to create changes, new approaches to sustainability, in the core processes of companies.
For any implementation, it is more efficient to link with process management, to reduce waste of materials and waste of time, for example.
I believe that sustainability must be part of the process as a whole. In addition, not that it should be implemented as separate processes and actions that already exist in the business.
In my view, the implementation activity is a process in itself, which has to be adequately managed.
It can be linked. However, you also can implement a Process Management without using the sustainability issues.
It is one part of sustainability implementation but it is the part that will realise many of the benefits operationally.
Life itself is made of processes. They are everywhere, not only on manufacturing places. thus, sustainability can be related to every scope of our lives

Table 15 was obtained using the text analyser software and it contains the keywords of the responses. **Figure 54** represents the keywords distribution.

Table 15 Keywords list

Word	Occurrences	Frequency	Rank
sustainability	14	8.4%	1
process	9	5.4%	2
processes	8	4.8%	3
business	5	3%	4
management	4	2.4%	5
implementation	4	2.4%	5
linked	3	1.8%	6
view	3	1.8%	6
part	3	1.8%	6
you	3	1.8%	6

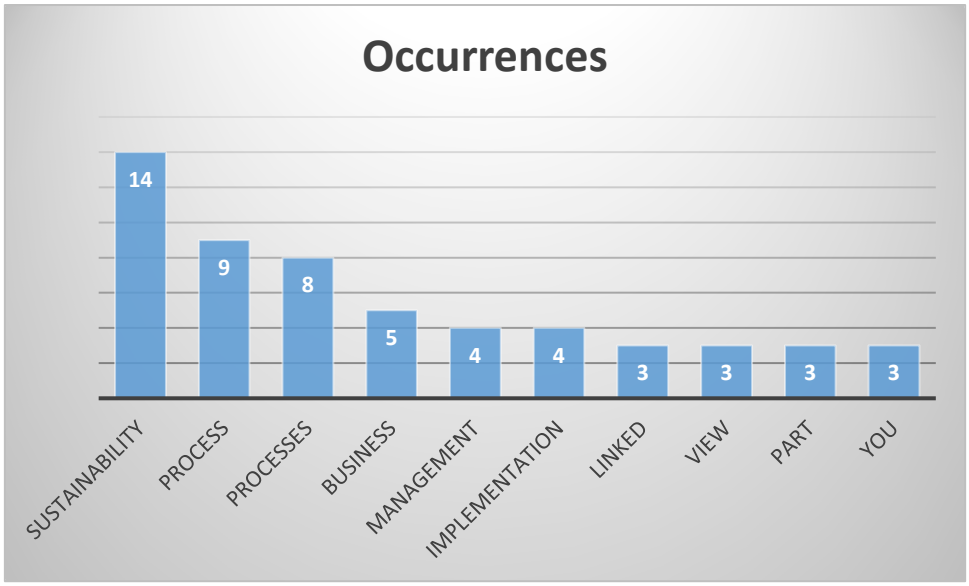

Figure 54Keywords distribution

Sustainability and processes ("process" and "processes") were the most cited keywords, with 14 and 17 occurrences, respectively, representing a total of 18.6% frequency. This makes sense since the question was regarding the linkage between "sustainability" and "process management".

6.4.3.2. If Sustainability implementation is related to Process Management, is it justified to use the Business Process Management (BPM) approach?

Figure 55 displays the graph with the results for the question and **table 16** displays the comments provided by the specialists.

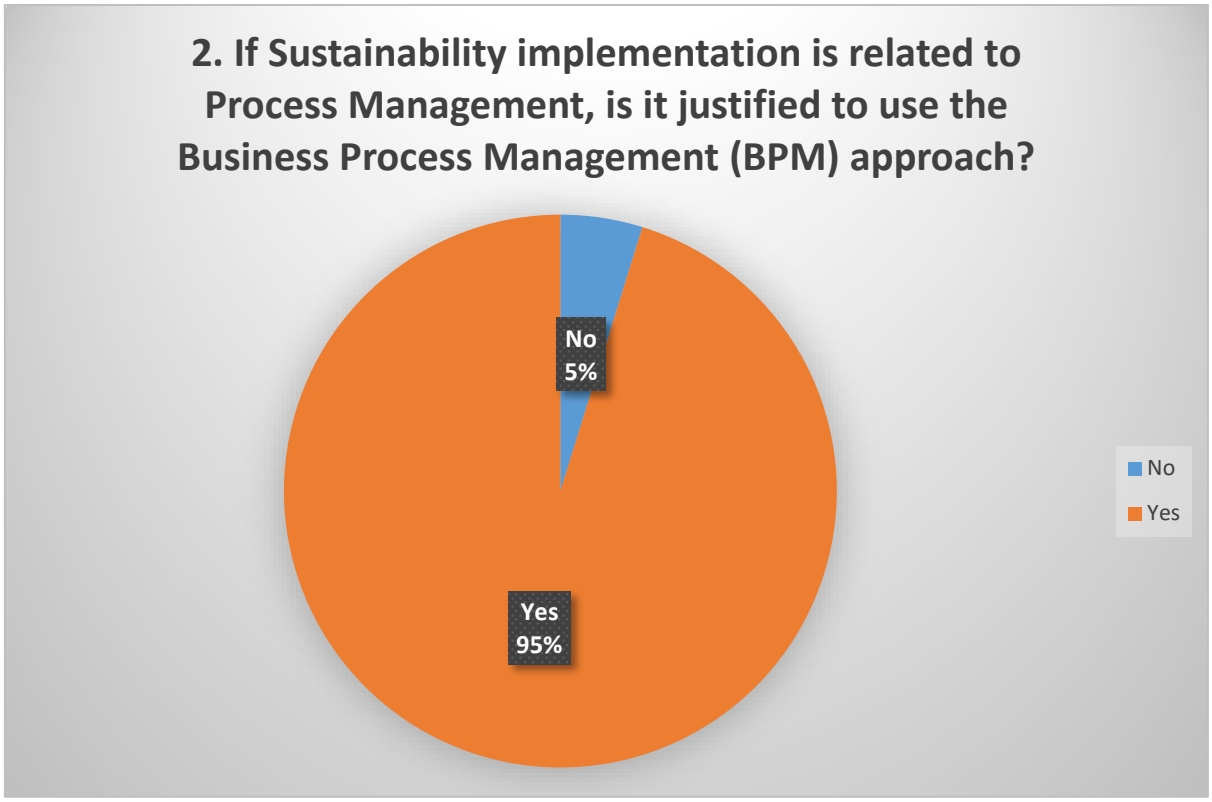

Figure 55 - If Sustainability implementation is related to Process Management, is it justified to use the Business Process Management (BPM) approach?

Comments

Table 16 Comments to the question 'If Sustainability implementation is related to Process Management, is it justified to use the Business Process Management (BPM) approach?'

It could be a process level. Some processes may help to support key strategies.
I consider it important to integrate the sustainability into the management system yes, but that also depend on how and in which extent the BPM is applied. That could differ in organisations.
All company has business processes, but most of them do not explicitly adopt BPM. Furthermore, there are companies which adopt BPM and have problems in its implementation and execution. Therefore, if all company has business processes and these business processes result in corporate sustainability, BPM can contribute to sustainability implementation.
BPM is about efficiency and cost not about sustainability
You can only verify the success of a sustainability implementation if you have data to measure, monitor, and control sustainability issues linked to the strategic goals of a organisation

it provides a holistic view of the company's core processes
If with BPM you can manage the process, it is the way to have information and control of the system, so it is the way to manage sustainability implementation.
Yes, the inclusion of the sustainability issue should be part of the end-to-end process. It makes no sense to apply sustainability separately, because this complicates the understanding and the application on a daily basis.
Yes, I think you can use a BPM approach to manage processes properly.
Although I say yes, this is because of the alignment with strategic goals. It may be that more flexibility is required for sustainability implementation including trial and error and so parts of it should be used.
You may use the BPM to make the process lean and improve the sustainability of a process by eliminating unnecessary things that may be identified with the BPM

Table 17 was obtained using the text analyser software and it contains the keywords of the responses. **Figure 56** represents the keywords distribution.

Table 17 keywords list

Word	Occurrences	Frequency	Rank
sustainability	11	7.4%	1
bpm	9	6%	2
processes	6	4%	3
you	5	3.4%	4
implementation	5	3.4%	4
process	5	3.4%	4
may	4	2.7%	5
yes	4	2.7%	5
business	3	2%	6
manage	3	2%	6

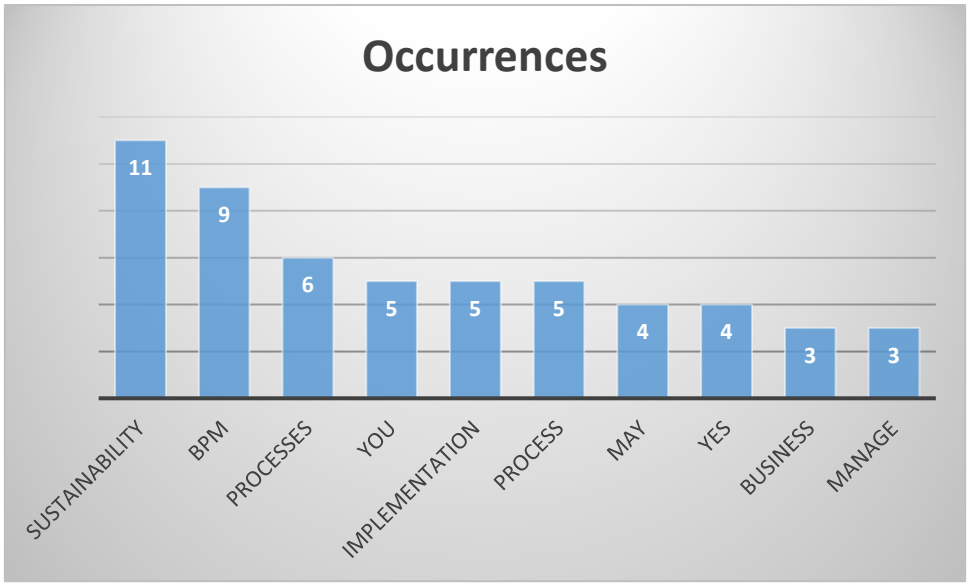

Figure 56 Keywords distribution

Sustainability, bpm and processes were the most cited keywords, with 11, 9 and 6 occurrences, respectively, representing a total of 17.4% frequency. This makes sense since the question was regarding the use of BPM in over the sustainability topic.

6.4.3.3. Considering the BPM frameworks from **Figure** 1, **Figure** 2 and **Figure** 3, is it justified to represent the implementation of Sustainability initiatives using the BPM tool as the framework from **Figure** 4 suggests?

Figure 57 displays the graph with the results for the question and **table 18** displays the comments provided by the specialists.

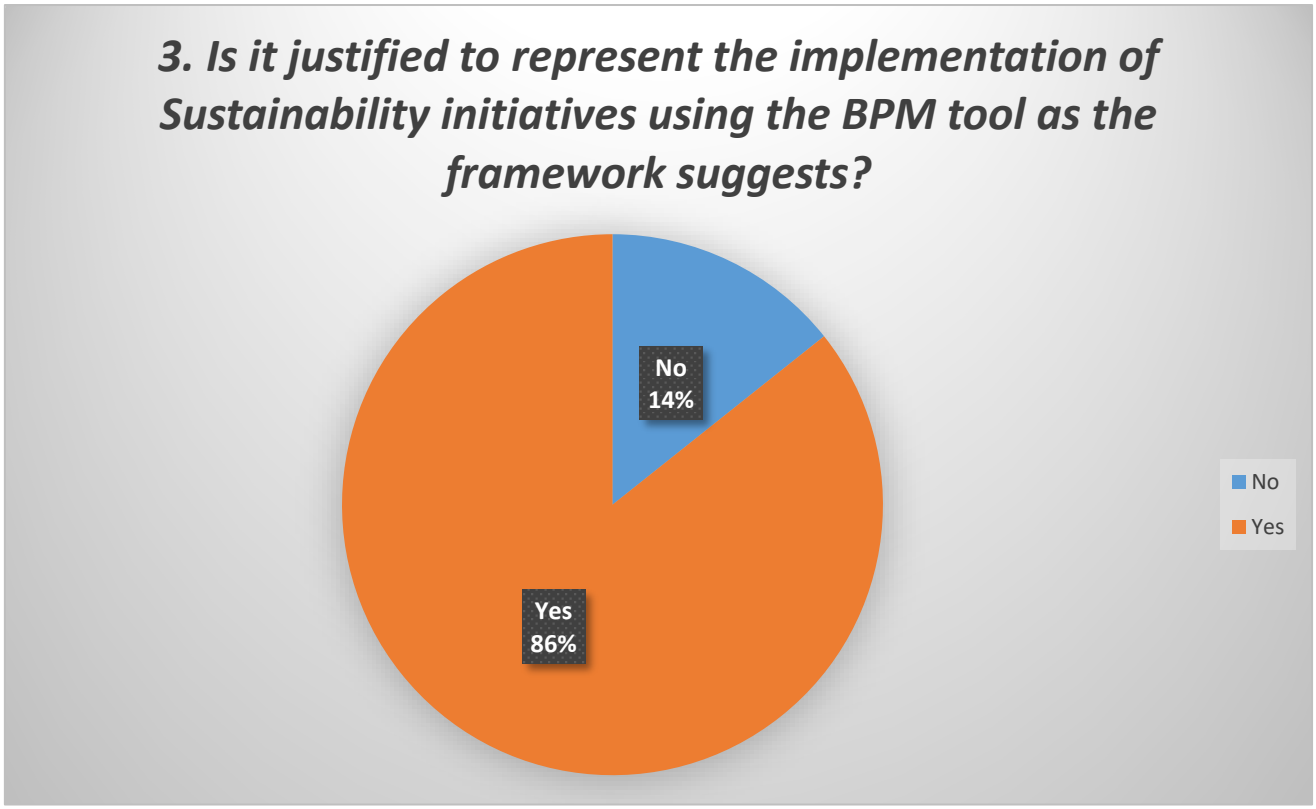

Figure 57 - Is it justified to represent the implementation of Sustainability initiatives using the BPM tool as the framework suggests?

Comments

Table 18 Comments to the question '- Is it justified to represent the implementation of Sustainability initiatives using the BPM tool as the framework suggests?'

It is not possible to read all the items from the figure. They are really small.
It looks a bit complex in Figure 4, but core activities in the middle looks fine.
I believe that you should be careful with 1) analysis and design steps need to be more re ned in order to avoid overlaps. 2) not clear how to taken into consideration policies or strategies already implemented, such as environmental policy or code of ethics, or value map, like materiality, which have been hugely used by lead rms.
Yes, it seems ok, but I think this is a leading question:-) And it doesn't consider the current state of the organisation, such as culture, other strategies etc. I think that would influence how well the process can be followed.
The inclusion of sustainability in BPM lifecycle is crucial for sustainable business processes. Nowadays, when we talk about corporate sustainability it is essential mentioning the product lifecycle perspective and its value chain. Some business processes determine the value chain and most of the environmental and social impacts occurs along the product lifecycle.

Therefore, BPM has to promote the inclusion of lifecycle thinking into business process. One suggestion is to include this concept in the middle of your conceptual framework as a discipline (e.g. lifecycle management).
sustainability should be part of the design
Actually, I would prefer something simpler than that.
it contains the specific actions to the desired implementation
Figure 4 is more complete related to sustainable process since the initial part of the program (for example Analyse: Perform Sustainable Maturity Assessment), but Fig 4 is also a "mix" in most of other processes compared to Figs 1, 2 and 3.
I believe it makes sense to apply this process in the implementation of sustainability. It seemed a complete process and tying the initiative.
I think Fig. 4 captures well aspects from Fig. 1 & 2. I am not very sure if it links well with Fig. 3. The design covers many of the ideas from BPM.

Table 19 was obtained using the text analyser software and it contains the keywords of the responses. **Figure 58** represents the keywords distribution.

Table 19 Keywords list

Word	Occurrences	Frequency	Rank
lifecycle	5	2.8%	1
process	5	2.8%	1
fig	4	2.3%	2
sustainability	4	2.3%	2
think	3	1.7%	3
well	3	1.7%	3
bpm	3	1.7%	3
processes	3	1.7%	3
business	3	1.7%	3
sustainable	3	1.7%	3

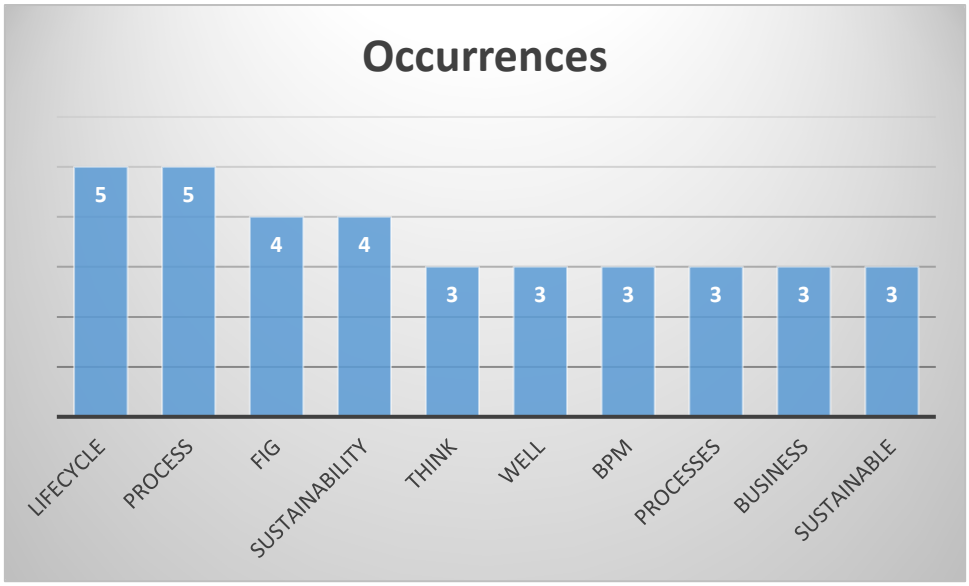

Figure 58 Keywords distribution

This question had a more scattered level of responses. The most cited words were "process(es)" with 7 occurrences and "lifecycle" and "fig" with 4 occurrences. This makes sense since the question was regarding the use of the framework to implement sustainability initiatives in a lifecycle way.

6.4.3.4. Which of the steps would be mandatory to an Analyse phase?

Figure 59 displays the summary of the questions for the Analyse phase, **table 20** displays the analyse phase acceptance rates and **table 21** displays the comments provided by the specialists.

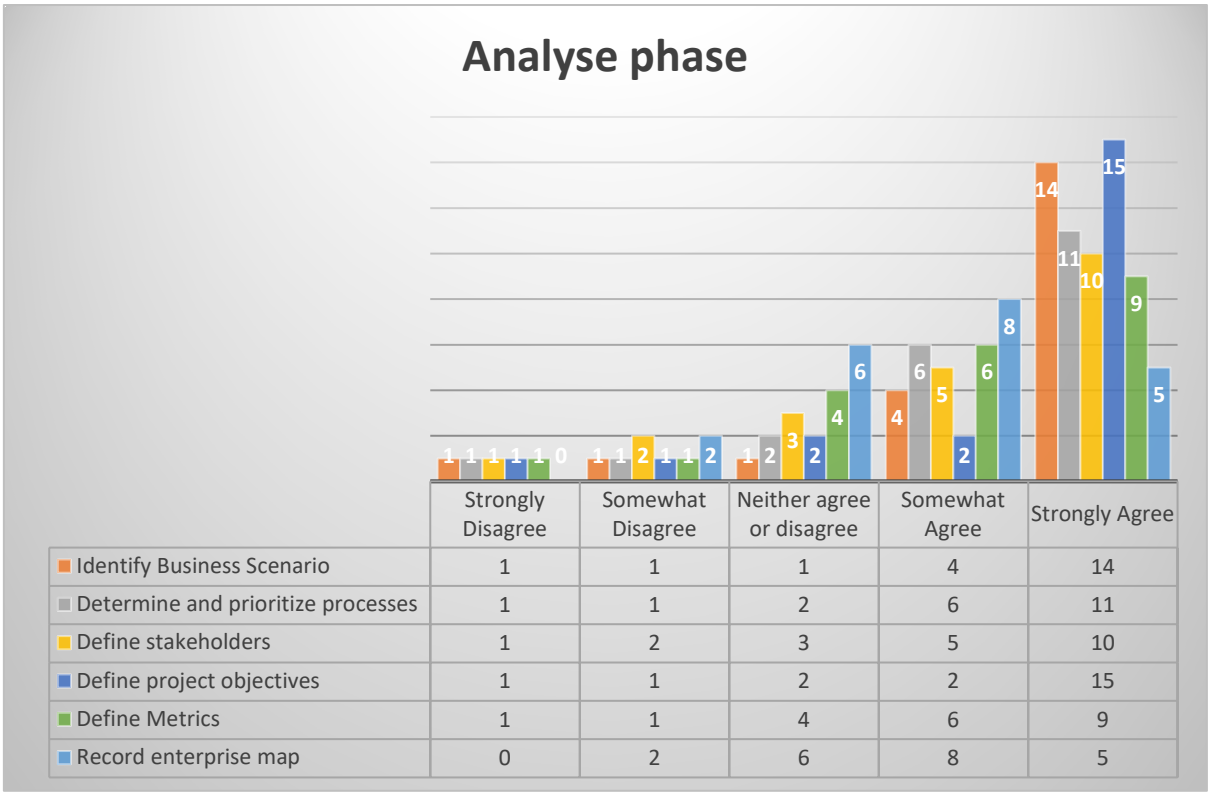

Figure 59 Analyse phase consolidated

Table 20 0 Analyse phase acceptance (in percentage)

Identify Business Scenario	87.62%
Determine and prioritise processes	83.81%
Define stakeholders	80.00%
Define project objectives	87.62%
Define metrics	80.00%
Record enterprise map	75.24%
Analyse phase	**82.38%**

Comments

Table 21 Comments regarding the Analyse phase

I think this stage could be a pre-diagnosis step - where is the firm?
One of the issues with Environmental and social metrics is that these seem harder and more complicated to be defined as metrics.
Does the step "define project objectives" makes reference to business processes improvements projects or the BPM project? If the response is about the business processes

improvement projects maybe it may more sense to include this step in the beginning of Design phase.
I think the base of an analyse phase is to identify the business scenario. The other statements are not proper in this phase
Metrics depend on the objectives previously defined. All steps have to be in the process.

Table 22 was obtained using the text analyser software and it contains the keywords of the responses. **Figure 60** represents the keywords distribution.

Table 22 Keywords list

Word	Occurrences	Frequency	Rank
metrics	3	5%	1
phase	3	5%	1
step	3	5%	1
business	3	5%	1
objectives	2	3.3%	2
think	2	3.3%	2
processes	2	3.3%	2
projects	2	3.3%	2
project	2	3.3%	2
defined	2	3.3%	2

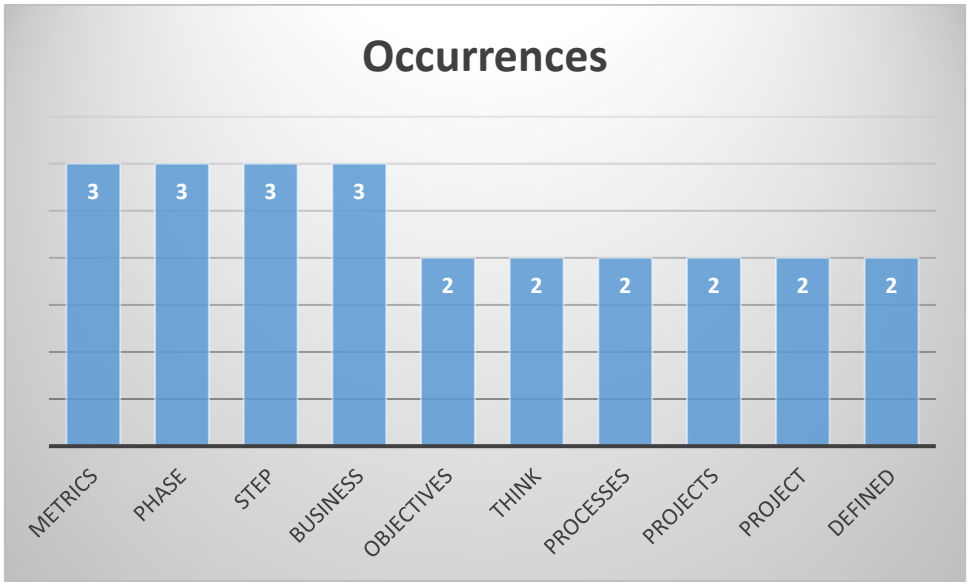

Figure 60 Keywords distribution

Metrics, phase, step and business were the most cited keywords, with three occurrences each, representing a total of 20% frequency.

6.4.3.5. Which of the steps would be mandatory to a Design phase?

Figure 61 displays the summary of the questions for the Design phase, **table 23** displays the design phase acceptance rates and **table 24** displays the comments provided by the specialists.

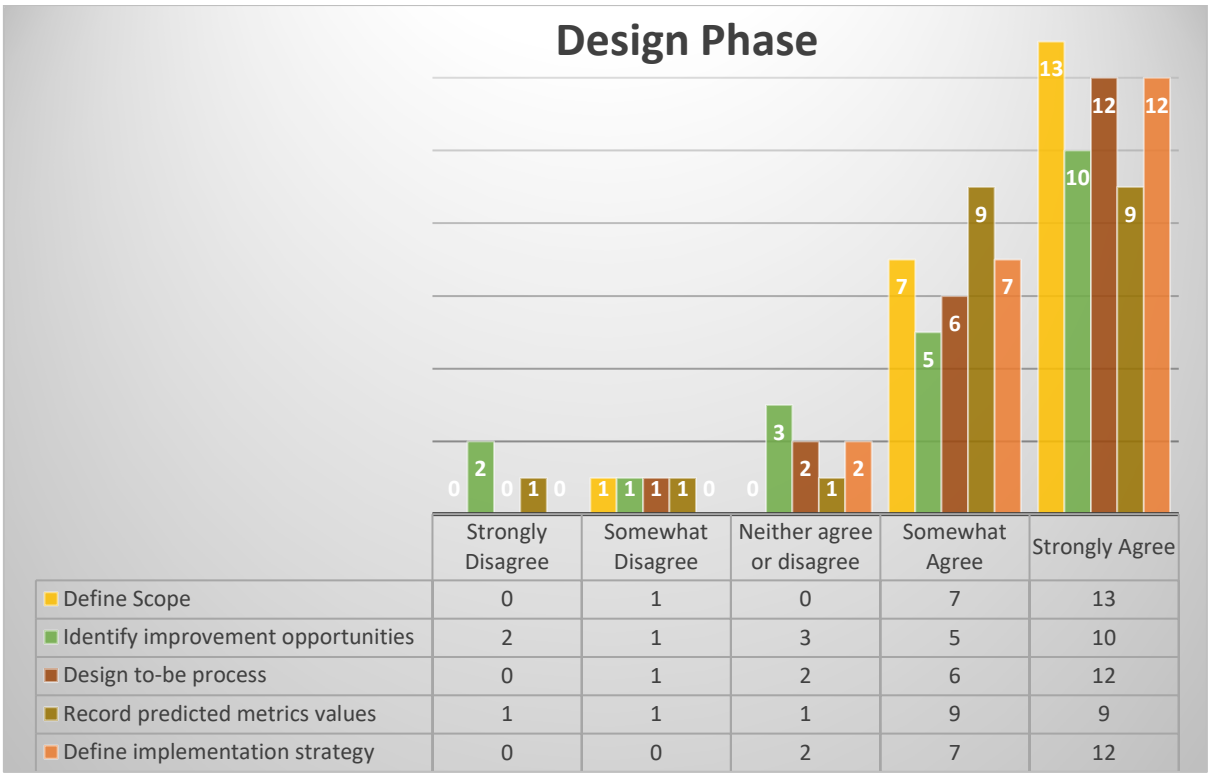

Figure 61 - Design phase consolidated

Table 23 - Design phase acceptance i(in percentage)

Define scope	80.00%
Identify improvement opportunities	84.76%
Design to-be process	90.48%
Record predicted metrics values	79.05%
Define Implementation strategy	87.62%
Design phase	**85%**

Comments

Table 24 Comments regarding the Design phase

Element ticked as strongly disagree at the former item, I suggest to you to consider at the design phase. The topic 2 should be included at the phase 1.
Sometimes the process to innovation is unknown and not linear. And for a company that is perhaps the largest gains of sustainability.
identify improvement opportunities is in the analyze phase. I would put "de ne metrics values" in this phase I think Identify Improvement Opportunities would t better the Monitor & Control phase
I think Identify Improvement Opportunities would t better the Monitor & Control phase

Table 25 was obtained using the text analyser software and it contains the keywords of the responses. **Figure 62** represents the keywords distribution.

Table 25 Keywords list

Word	Occurrences	Frequency	Rank
phase	6	12%	1
opportunities	3	6%	2
improvement	3	6%	2
identify	3	6%	2
better	2	4%	3
control	2	4%	3
monitor	2	4%	3
think	2	4%	3
perhaps	1	2%	4
company	1	2%	4

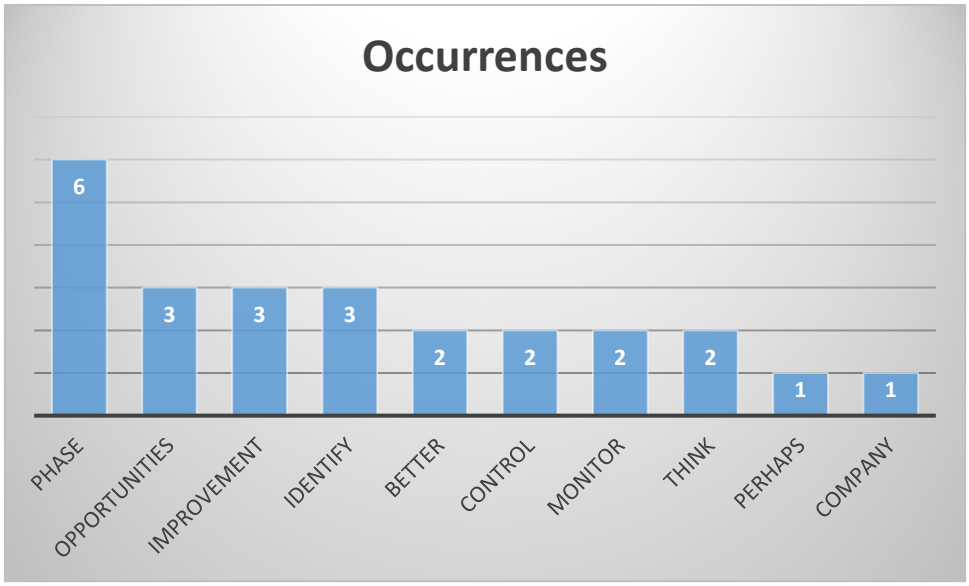

Figure 62Keywords distribution

"Phase", "opportunities" and "improvement" were the most cited keywords, with 6, 3 and 3 occurrences, respectively, representing a total of 24% frequency.

6.4.3.6. Which of the steps would be mandatory to an Implement phase?

Figure 63 displays the summary of the questions for the Implement phase, **table 26** displays the implement phase acceptance rates and **table 27** displays the comments provided by the specialists.

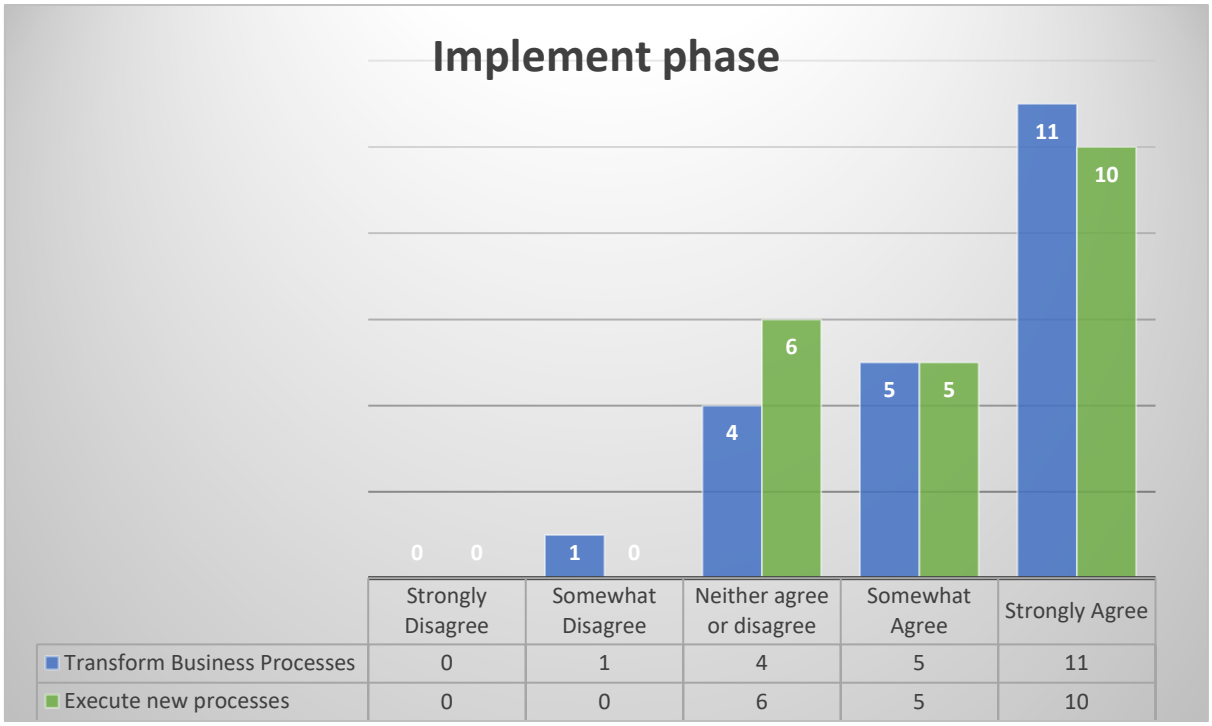

Figure 63 - Implement phase consolidated

Table 26 - Implement phase acceptance (in percentage)

Transform business processes	82.86%
Execute new processes	89.52%
Implement phase	**87.14%**

Comments

Table 27 Commment regarding Implement phase

What about capabilities

6.4.3.7. Which of the steps would be mandatory to a Monitor and Control phase?

Figure 64 displays the summary of the questions for the Monitor and Control phase, **table 28** displays the monitor and control phase acceptance rates.

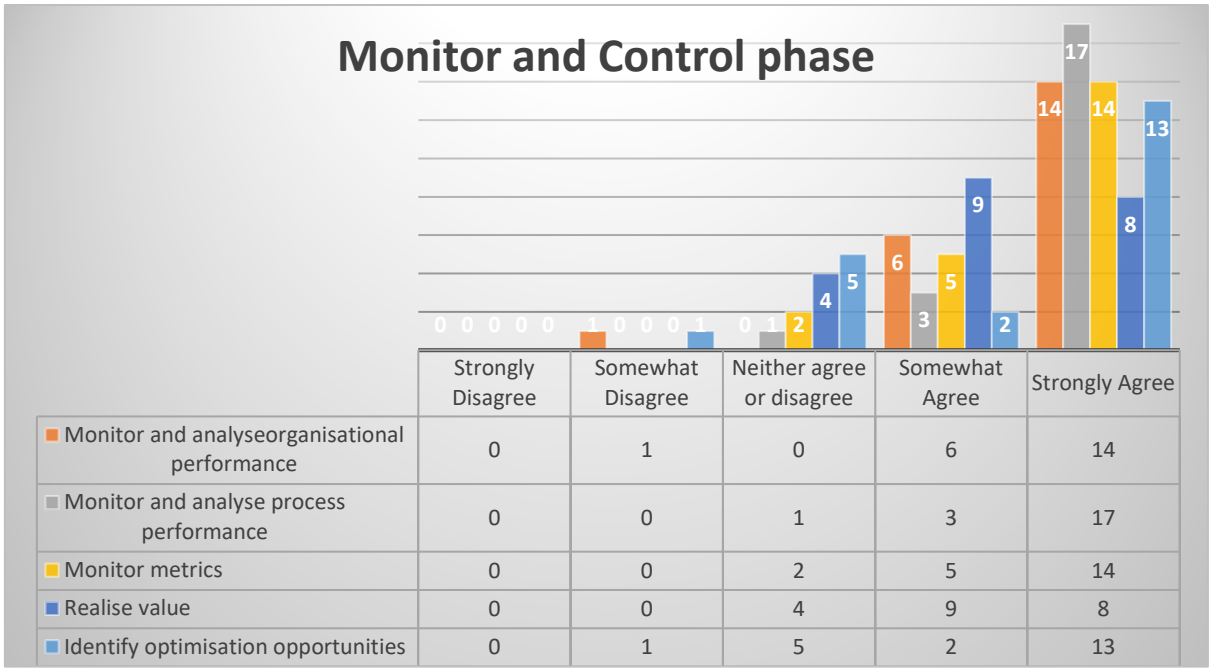

Figure 64 - Monitor and control phase consolidated

Table 28 - Monitor and control phase acceptance (in percentage)

Monitor and analyse organisational performance	91.43%
Monitor and analyse process performance	95.24%
Monitor metrics	91.43%
Realise value	83.81%
Identify optimisation opportunities	86.67%
Monitor and control phase	89.71%

No comments for this question.

6.4.3.8. Which of these options can be viewed as enablers to the implementation of sustainability projects?

Figure 65 displays the graph with the results for the enablers to the implementation fo sustainability projects and **table 29** displays the comments provided by the specialists.

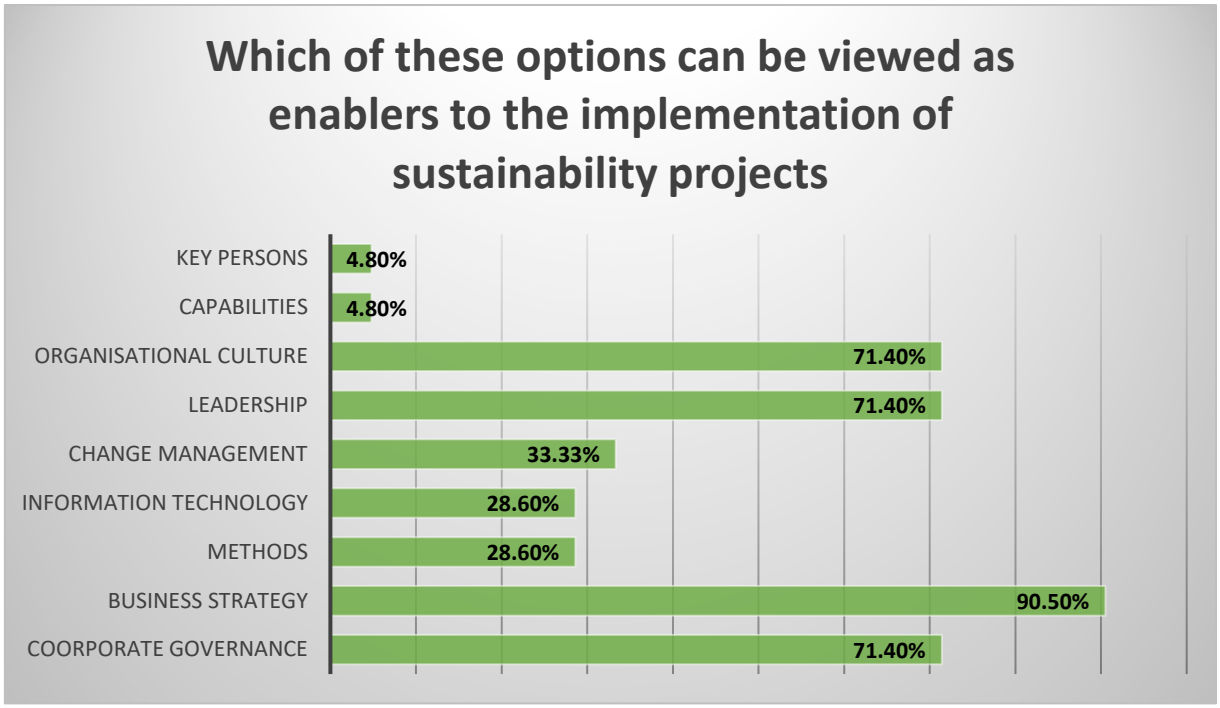

Figure 65 - Enablers of the framework

Comments

Table 29 Comments regarding the enablers for the framework

My main concern is the difference between your model and management system standards, such as ISO 14001:2015, which has been updating process, including elements like leadership or 26000.
I am not sure what you mean by methods - do you mean implementation methods and if so, what do these include?

6.4.3.9. Number of daily responses

Figure 66 represents the number of responses over the time.

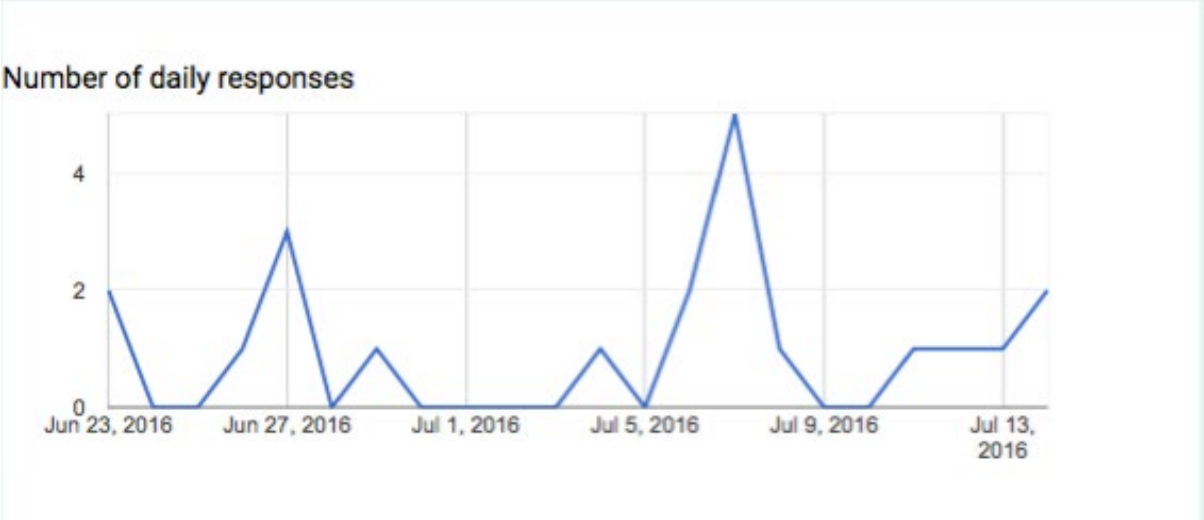

Figure 66 - Number of daily responses to the first round of the Delphi Study

6.4.3.10. Discussion

The lowest acceptance rates were found in the items '**Record enterprise map**' (75.24%), '**Is Sustainability Implementation directly linked to Process Management?**' (76.19%), '**Design to-be process**' (81.67%). While the highest acceptance rates were found in the items '**is it justified to use the Business Process Management (BPM) approach**' (95.24%), '**Monitor and analyse process performance**' (95.24%) and '**Monitor metrics'** (91.67%). The steps of the framework have received the following rates: Analyse (82.38%), Design (85%), Implement (87.14%), and Monitor and Control (89.71%). Regarding the framework enablers, Business Strategy had the highest acceptance rate (90.5%), whilst Methods and Information Technology received only 28.6%. **Table 30** summarises the results of the study.

Table 30 - Summary of the responses

Is Sustainability implementation directly linked to Process Management?	76.19%
is it justified to use the Business Process Management (BPM) approach?	95.24%

Is it justified to represent the implementation of Sustainability initiatives using the BPM tool as the framework suggests?		85.71%	
Analyse phase	Identify Business Scenario	87.62%	**82.38%**
	Determine and prioritise processes	83.81%	
	Define stakeholders	80.00%	
	Define project objectives	87.62%	
	Define metrics	80.00%	
	Record enterprise map	75.24%	
Design phase	Define scope	80.00%	**85%**
	Identify improvement opportunities	84.76%	
	Design to-be process	90.48%	
	Record predicted metrics values	79.05%	
	Define Implementation strategy	87.62%	
Implement phase	Transform business processes	82.86%	**87.14%**
	Execute new processes	89.52%	
Monitor and control phase	Monitor and analyse organisational performance	91.43%	**89.71%**
	Monitor and analyse process performance	95.24%	
	Monitor metrics	91.43%	
	Realise value	83.81%	
	Identify optimisation opportunities	86.67%	

Therefore, it was concluded that there was a consensus in all of the questions, since all of them had an accepting rating of over than 75%, as it was defined on the topic 6.5.

Regarding the enablers for the framework, there was a scattered opinion on its applicability. The conceptual framework proposed the following enablers: Organisational

Culture, Leadership, Change Management, Information Technology, Business Strategy and Corporate Governance. **Table 31** represents the level of agreement of the enablers

Table 31 Summary of the enablers level of agreement

Organisational Culture	71.4%
Leadership	71.4%
Change Management	33.33%
Information Technology	28.6%
Methods	28.6%
Business Strategy	90.5%
Corporate Governance	71.4%

Considering the level of consensus defined in section 6.5, Organisational Culture, Leadership, Business Strategy and Corporate Governance were considered as the framework enablers.

6.4.4. Delphi Study second round

After concluding the first round, another questionnaire was used. Appendix C displays the questionnaire used for the second round of the Delphi study.

Since the consensus regarding the steps of the framework was obtained during the first phase of the Delphi study, the second phase was used to assess other aspects of the framework.

The second phase of the study had only four questions:

1. In your opinion, what are the main challenges to implement sustainability initiatives in organisations?
2. In your opinion, how is it possible to assess all the sustainability dimensions (social, environmental and economic) in terms of Business Processes?
3. Considering the framework from Figure 1, would you change the order of the steps or suit it in a different phase?
4. How would you improve the framework? Feel free to add any other comment.

Questions 1 and 2 had a more generic character in order to improve the rationale of the research based on the experience of the specialists. E.g. of one output: The multiple factors a company needs to consider parallel with sustainability, such as other factors coming from global competition (e.g. profitability, conditions compared to low-cost

countries), meeting different customer demands, legislative and not, as well as just responding to other future trends such as digitalisation, flexibility, etc."

Questions 3 and 4 were related to the framework, more specifically to its organisation, display, and if they would change anything to improve the framework. E.g. of one output: "In my opinion, the framework could include an initial step or a pre-activity to develop and to clarify the concept of sustainability. This activity could also be included in the first step "identify business scenario", but the important is to provide criteria or perspectives for assessing performance operation against the chosen definition. This definition can be included into bpm policy as mission and vision to be seen and diffused across the whole organisation."

Results and discussion

6.4.4.1. In your opinion, what are the main challenges to implement sustainability initiatives in organisations?

Table 32 provides the comments for the question and lists the keywords found on every response.

Table 32 Comments on the question 'In your opinion, what are the main challenges to implement sustainability initiatives in organisations?'

Comment	Keywords
Dealing with resistance from individuals, the result and costs/resources involved.	**Cost**
I think that the main challenge is to create awareness of the importance of sustainability in terms of value added for the whole organisation and its supply chain. Another point we have to stress is that organisations have to perceive that being sustainable means to be cost- efficient.	**Awareness; cost**
The biggest challenges are the people; enable them to be ready; and resources: human, financial and time.	**People; cost; time**
The multiple factors a company needs to consider parallel with sustainability, such as other factors coming from global competition (e.g. profitability, conditions compared to low-cost countries), meeting different customer demands, legislative and not, as well as just responding to other future trends such as digitalisation, flexibility, etc.	**Costs; customer demands; regulations**

Cost, leadership buy-in, employee knowledge, unaware of benefits (or risk of not doing so) Redesign processes, implement change, and manage related costs.	**Cost; people; processes**
cost	**Cost**
Management of change	**Change management**
to expand understanding about sustainability and roles in the company Leadership compromised	**Leadership**
Change the leadership team the mind-set.	**Leadership**
In my opinion, the main challenge to implement sustainable practices in organisation is related to organisational culture. In general, many companies see sustainability as additional cost or legal requirements. There are many sustainable business practices but most companies have not yet adopted them.	**Organisational culture**
Most of the times the organisations are not willing to make changes towards a sustainable performance due to decreases in their monetary performance. The short-term profit overcomes the long-term goal of sustainability.	**Costs**
The main challenge is to change the mind-set of the leaders and bring sustainability for the main aspect, more important than sales.	**Leadership**

Table 33 and **Figure 67** summarises the main challenges to implement sustainability initiatives.

Table 33 - Summary of the challenges to adopt sustainability initiatives

Keywords	Recurrence	Statistics
Cost	7	54%
Leadership	3	23%
Awareness	1	8%
People	1	8%
Customer demands	1	8%
Regulations	1	8%

Change management	1	8%
Processes	1	8%

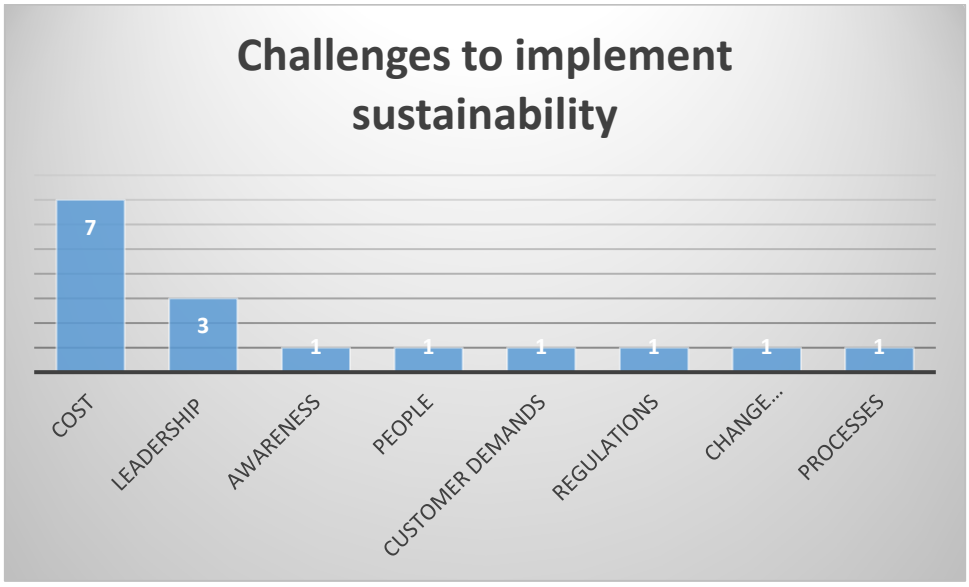

Figure 67 Challenges to implement sustainability initiatives

Thus, leadership and cost were identified as the main challenges related to the sustainability adoption by the organisations ("cost" was mentioned by 54% of the specialist and "Leadership" by 23%). According to one specialist, "the multiple factors a company needs to consider parallel with sustainability, such as other factors coming from global competition (e.g. profitability, conditions compared to low-cost countries), meeting different customer demands, legislative and not, as well as just responding to other future trends such as digitalisation, flexibility, etc.". Another specialist related the sustainability implementation with the organisational culture, "in my opinion, the main challenge to implement sustainable practices in organisation is related to organisational culture. In general, many companies see sustainability as additional cost or legal requirements. There are a lot of sustainable business practices, but most companies have not yet adopted them".

6.5.2.2. In your opinion, how is it possible to assess all the sustainability dimensions (social, environmental and economic) in terms of Business Processes?

Table 34 provides the comments for the question and lists the keywords found on every response.

Table 34 Comments on the question 'In your opinion, how is it possible to assess all the sustainability dimensions (social, environmental and economic) in terms of Business Processes?'

Comment	Keywords
Quantifying the different aspect, using indicators	**Indicators**
It is very difficult to assess all three dimensions in one single scale.	-
I think that the main point is to link all these three dimensions form the triple bottom line. A holistic view of the triple botton line is crucial to achieve and assess sustainability in terms of Business Processes. Unfortunately, it´s my perception that sustainability is something vague and mostly related to strategic level of organisations. So, one must create a bridge between strategy and operations to assess sustainability.	**Triple bottom line**
the company needs to implement a policy that considers the TBL.	**Triple bottom line**
Hard question, I think business process management is one of the parts to reach sustainability, it is like the map how to drive and measures on the way, but it cannot work without having the people (driver), the organisation (the vehicle) and the systems (surroundings) to work and understand where to go.	**People, organisations and systems**
Clear KPIs/benchmarks so they must be addressed, even if the plan is to address in the future	**Indicators**
You need to contextualise process outcomes within in the specific dimensions, and relate their potential impact on social, environmental and economic aspects.	**Triple bottom line**
leadership	**Leadership**
Specific scorecard like balanced scorecard	**Balanced scorecard**
In my opinion, it is necessary a maturity of the field, more motivation of actors, and a series of indicators to measure	**Indicators**

these three dimensions, while balancing the achievement of competing interests.	
It is necessary a global vision and indicators that complete all process in parallel.	**Indicators**
Apply for training and consultancy in order to have the advantages for the 3BL (triple bottom line - social, environmental and economic)	**Training**
In order to assess all the sustainability dimensions in terms of business processes it is important to identify how and what the business processes influence each dimension, which activities and aspects are relevant, and which are the hotspots for each dimension in order to allow companies to prioritise the activities and aspects with highest potential for improvement in terms of sustainability. Thus, companies could develop and implement performance indicators on business process, but it is still a challenge to solve trade-offs between the three dimensions.	**Indicators**
Using eMergy or Lifecycle Assessment approaches.	**Lifecycle Assessment**
there is a tool called lifecycle assessment that can calculate all the impacts for evaluation	**Lifecycle Assessment**

Table 35 and **Figure 68** summarises the ways to assess all the sustainability dimensions

Table 35 Summary of the ways to assess all the sustainability dimensions

Keyword	Recurrence	Statistics
Indicators	5	36%
Triple bottom line	2	14%
Lifecycle assessment	2	14%
Organisations	1	7%
Systems	1	7%
Leadership	1	7%
Balanced scorecard	1	7%
Training	1	7%
People	1	7%

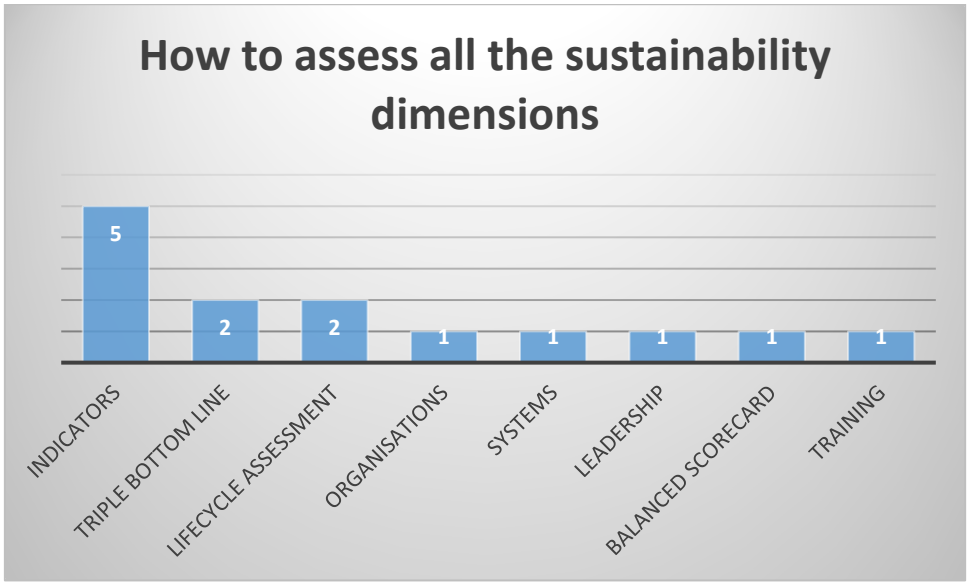

Figure 68 Summary on how to assess al the sustainability dimensions

Therefore, indicators, Lifecycle assessment (LCA) and triple bottom line (TBL) were the most cited keywords (respectively with 36%, 14% and 14% of the respondents). According to one specialist, "the main point is to link all these three dimensions form the triple bottom line. A holistic view of the triple bottom line is crucial to achieve and assess sustainability in terms of Business Processes. Unfortunately, it´s my perception that sustainability is something vague and mostly related to strategic level of organisations. So, one must create a bridge between strategy and operations to assess sustainability." and also related business processes with the sustainability dimensions. Another specialist stated that "In order to assess all the sustainability dimensions in terms of business processes it is important to identify how and what the business processes influence each dimension, which activities and aspects are relevant, and which are the hotspots for each dimension in order to allow companies to prioritise the activities and aspects with highest potential for improvement in terms of sustainability. Thus, companies could develop and implement performance indicators on business process, but it is still a challenge to solve trade-offs between the three dimensions".

6.5.2.3. Considering the framework from Figure 1, would you change the order of the steps or suit it in a different phase?

Figure 69 displays the graph with the results for the question and **table 36** displays the comments provided by the specialists.

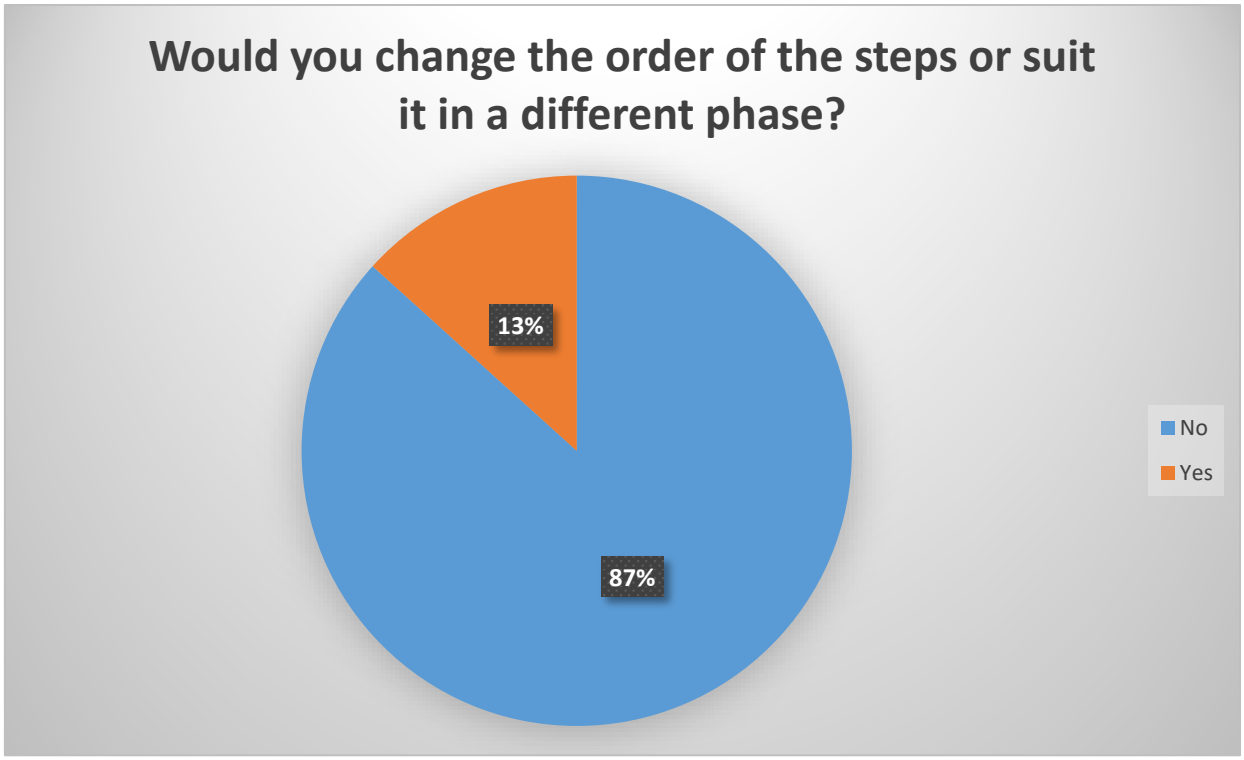

Figure 69 - .Considering the framework from Figure 1, would you change the order of the steps or suit it in a different phase?

Comments

Table 36 Comments on the question' Considering the framework from Figure 1, would you change the order of the steps or suit it in a different phase?'

Comment	**Yes or No**	**Keyword**
Sustainability maturity should be part of monitor and control depending on individual situation	N	**Sustainability maturity**
In my opinion, the framework is broad in terms of scope and adoption. Therefore, I am satisfied with the way the framework is conceived.	Y	
The order is fine.	Y	
It makes sense to have them in that order, but I am considering the factors in the middle to also influence a lot if this wheel will work. In addition, what other dominant strategies and focuses the organisation have. Are they aligned?	N	**Enablers**
Detailed enough at that level	Y	

The framework seems to follow a logical managerial sequence.	Y	
That's the way it works	Y	
It's fine	Y	
it seems to integrate the necessary actions to create and act on improvement areas for sustainability I think that it is ok	Y	
I think this is a reasonable correct order.	Y	
The steps are well structured and make sense in terms of logic.	Y	
I'd not change	Y	
I think its fine	Y	

Question 3 was intended to observe if the order of the steps on the framework were correct and logic. Most of the specialists agreed on the order (87%). Most of the specialists stated that the framework "was fine", but one stated that "Sustainability maturity should be part of monitor and control depending on individual situation", this was considered to the final version of the framework, but it was clarified on chapter 5 that the framework is flexible and might change according to the situation. Another specialist made another observation, "It makes sense to have them in that order, but I am considering the factors in the middle to also influence a lot if this wheel will work. Moreover, what other dominant strategies and focuses the organisation have. Are they aligned?" which relates the framework with the proposed enablers, justified on the first round of the Delphi study,

6.5.2.4.How would you improve the framework? Feel free to add any other comment.

Table 37 provides the comments for the question and lists the keywords found on every response.

Table 37 Comments on 'How would you improve the framework'

Comment	**Keyword**
see 3	
hard to say, depending on the appropriateness according to the situation	
No improvements	
I believe it is OK.	

The alignment to other objectives and goals would be the suggestion for improvement. More detail - what do these steps mean to someone without business experience?	**Goals; objectives**
It seems ok as it is.	
no clue	
Add delegation and identification of key deliverables	**Deliverables**
The centre of the model looks a bit messy, no clear position of elements.	
No comments	
No additional suggestion.	
In my opinion, the framework could include an initial step or a pre-activity to define and clarify the concept of sustainability. This activity could also be included in first step "identify business scenario", but the important is to provide criteria or perspectives for assessing performance operation against the chosen definition. This definition can be included into bpm policy as mission and vision to be seen and diffused across the whole organisation.	**Define sustainability**
I'd not	
Monitor & Control: I suggest to include "indicators review / metrics review"	**Indicators**

Question 4 was intended to obtain final comments regarding the framework. Most of the answers were “it looks fine”, but some specialists mentioned other aspects, such as “appropriateness”, “identification of key deliverables”, “alignment to other objectives and goals”, “metrics review” (which is already as the step “monitor metrics”) and “the creation of an initial step to define the concept of sustainability”.

6.5.2.5.Number of daily responses

Figure 70 represents the number of responses over the time.

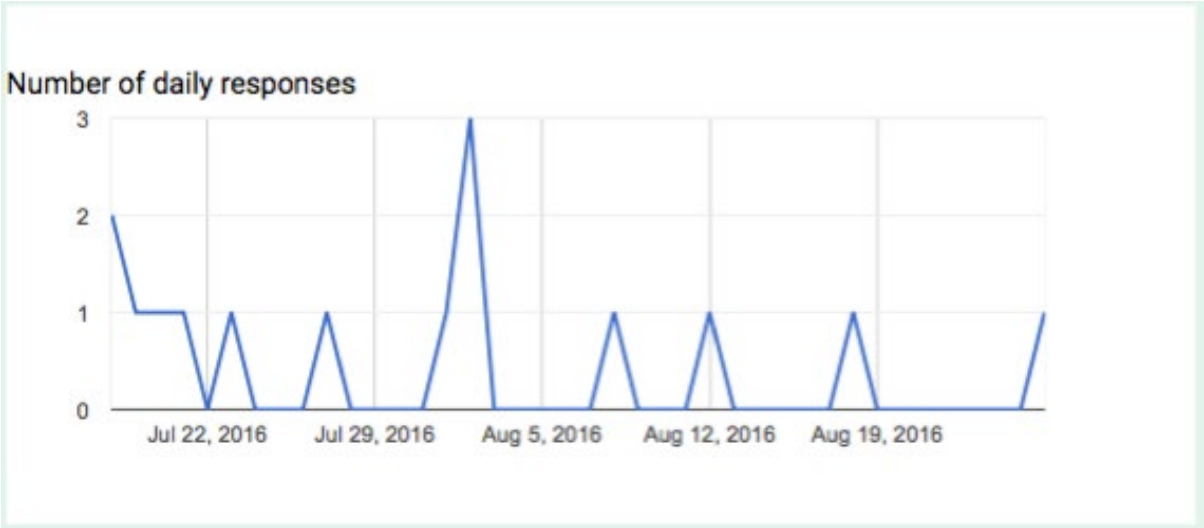

Figure 70 - Number of daily responses for the second round of the Delphi study

6.5. Final Discussion

The first round of the Delphi Study identified a level of agreement of the phases of the framework as follows (**table 38**):

Table 38 Level of agreement of the framework phases

Analyse phase	82.38%
Design phase	85%
Implement phase	87.14%
Monitor and Control phase	89.71%

Therefore, there were no change regarding the phases of the framework.

The second round of the Delphi Study identified that the steps of the framework are in the correct order (87% level of agreement). Therefore, there was no changes regarding the order of the steps to be followed by the framework.

After the verification of the framework by the specialists using the Delphi Study, the main change was regarding the enablers. The conceptual framework proposed the following enablers: Organisational Culture, Leadership, Change Management, Information Technology, Business Strategy and Corporate Governance. After the experts' feedback, the verified framework contained the enablers: Organisational Culture, Leadership, Business Strategy and Corporate Governance. **Figure 71** represents the verified framework

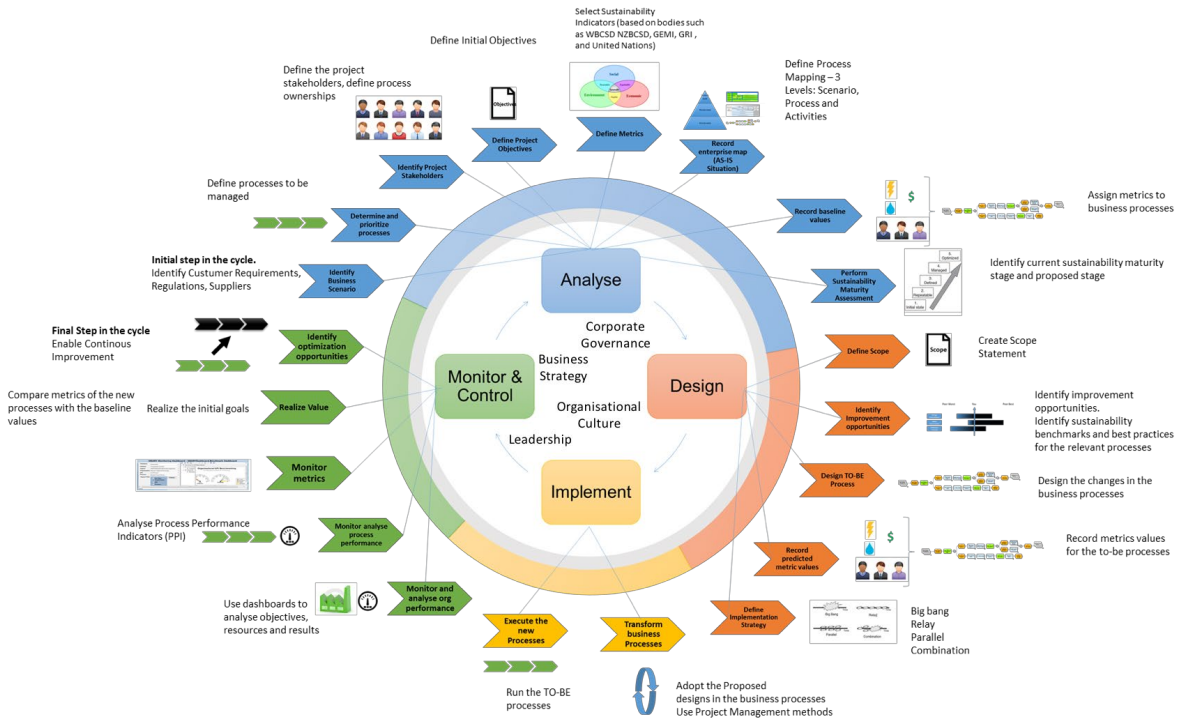

Figure 71 – Verified Framework

6.6. Chapter Summary and conclusions

The chapter provided a Delphi study to verify the framework to implement sustainability initiatives in the business processes. The study successfully obtained a consensus in the phases and steps of the conceptual framework and provided feedback from the specialists. According to them, leadership, people and cost were identified as the main challenges related to the sustainability adoption by the organisations and key performance indicators (KPIs), Lifecycle assessment (LCA) and triple bottom line (TBL) were identified as the main methods to assess al the sustainability dimensions in terms of business processes. After the verification of the framework by the experts, the main change was regarding the enablers. The chapter summarises the results of the study and presents the verified framework. Next chapter will provide the validation of the framework using the Action Research method.

Chapter 7 – Framework Validation using Action Research

7.1. Introduction

Chapter 6 presented the verification of the conceptual framework based on the BPM approach to implementing sustainability initiatives in the business processes proposed in chapter 5. This chapter presents the validation of the framework using the action research method. Action research is a comparative research to solve an immediate problem led by individuals working in partnership with other teams whilst conducting research. This chapter starts providing an overview of the study, and it explores the phases of the framework, going through the phases: 'Analyse', 'Design', 'Implement', and 'Monitor and Control'.

7.2. Study Overview

Biomass represents approximately 10% of the energy sources in the World (2010 World Energy Council). The most common use of biomass for energy is direct combustion, gasification, carbonisation and pyrolysis. In this perspective, torrefaction emerges as a thermal biomass pre-treatment method that can reduce the significant limitations of biomass (such as heterogeneity and lower energy density). However, one of the outputs from the torrefaction process is the generation of tar. Tar is brown or black liquid composed of hydrocarbons which, in long exposure, can cause cancer. This study was performed in a biomass power generation company that was producing an excess of tar. In order to provide a solution to the excess of tar generated, it was used the framework to implement sustainability business processes using the Business Process Management (BPM) approach.

7.3. Study timetable

The study was held between August 2016 and January 2017. **Figure 72** represents the project Gantt chart that was used for the project.

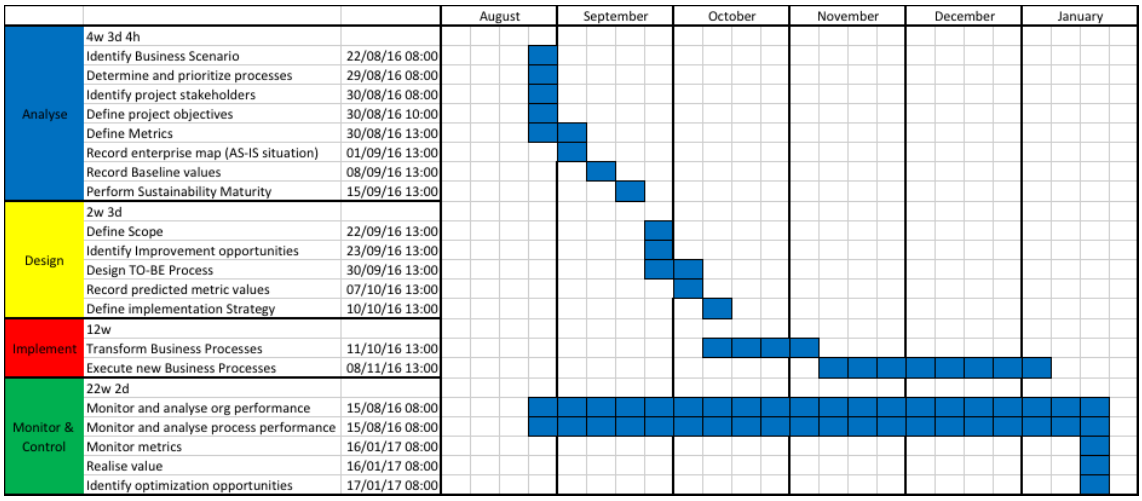

Figure 72 Project Gantt chart

The framework contains four phases (Analyse, Design; Implement; and Monitor & Control). 'Analyse' phase contains the steps of 'Identify Business Scenario', 'Identify Project Stakeholders', 'Define Project Objectives', 'Define Metrics', 'Record enterprise map - AS-IS Situation', 'Record baseline values', and 'Perform Sustainability Maturity Assessment'; Design phase contains the steps of 'Define Scope', 'Identify improvement opportunities', 'Design TO-BE Process', 'Record predicted metric values', and 'Define implementation strategy'; Implement phase contains the steps of 'Transform Business Processes', and 'Execute the new Processes'; and Monitor & Control phase contains the steps of 'Monitor and analyse organisational performance', 'Monitor and analyse process performance', 'Monitor metrics', 'Realise value', and 'Identify optimisation opportunities'). This section presents the validation of the proposed framework for the implementation of sustainability initiatives.

7.4. Analyse Phase

7.4.1. Identify Business Scenario

7.4.1.1. The company

Company A is a biomass power generation company. The organisation defines itself as an energy innovation company and uses torrefaction to transform wood into bio-coal.

The primary focus of the company is to develop sustainable energy technologies, implement technology into renewable energy production plants, license technology to third parties and develop state-of-the-art torrefaction technology. This commitment to sustainability was the main reason to select Company A as one of the participants of the Action Research.

7.4.1.2. Biomass

According to the 2010 World Energy Council, 10% of the energy in the World is generated from Biomass. According to the Digest of United Kingdom Energy Statistics (DUKES) 2016, in 2015 25.3% of the renewable energy fuel use was originated from (plant) Biomass sources. According to the study, 24.6% of the energy consumption in the UK came from renewable sources. Thus, it is possible to conclude that (plant) Biomass energy represents 6.22% of the energy consumption in the UK. This represents an amount of 5196,81 GWh.

Biomass is a versatile energy resource that could be used as a sustainable energy resource in solid, liquid and gaseous form of energy sources (Nhuchhen et al.2014). According to Basu (2010), Biomass has a unique appeal in environmental aspect because it makes no net contribution of CO_2 to the atmosphere. Regulations for making biomass economically viable are in place in many countries. E.g. if biomass replaces fossil fuels in a power plant, that power plant could earn carbon credits – sold in the market for additional revenue in countries where such trades are in practice.

According to Basu (2010), the most common use of biomass for energy is direct combustion, followed by gasification, carbonisation and pyrolysis. In this perspective, torrefaction emerges as a thermal biomass pre-treatment method that has an ability to reduce the significant limitations of biomass (such as heterogeneity, lower bulk density, lower energy density, hygroscopic behaviour, and fibrous nature). Torrefaction aims to produce high-quality solid biomass products (Nhuchhen et al.2014).

According to Basu (2010), torrefaction is a thermochemical process where biomass is slowly heated to within a specified temperature range and retained there for a stipulated time such that is results in near complete degradation of its hemicellulose content while maximising mass and energy yield of solid product. The torrefacation process converts biomass, steam and N2 into biochar (and wood, ash, water, tar and gases CO, CH_4 and H^2 as byproducts). **Figure 73**, represents the transformation process.

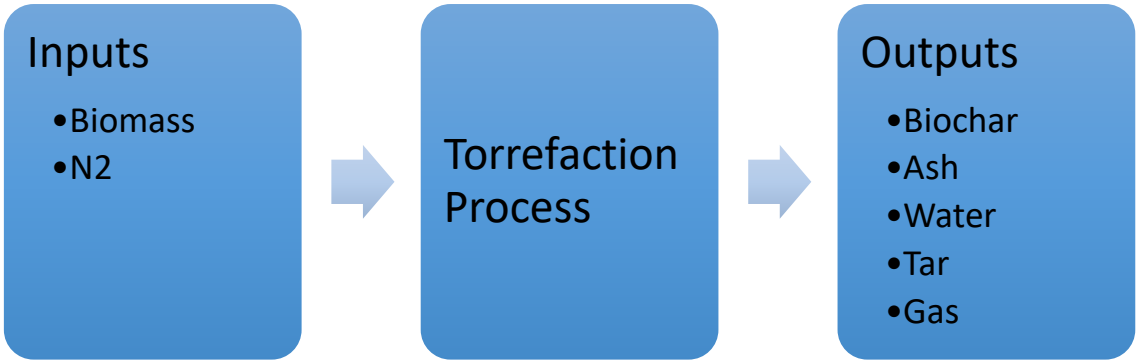

Figure 73 Transformation Process

7.4.1.3. The current problem

Currently, the plant is producing an excess of tar. Tar can be defined as hydrocarbons with a molecular weight higher than benzene (Manattis et al., 2010) constituted by polycyclic aromatic components with a high boiling point (Eriksson, 2012). They are formed during gasification in a series of complex reactions (Milne et al., 1997). When cooled down, tars can condense while increased temperatures can result in the formation of more complex compounds with higher boiling points (Edinger et al., 2016). This can cause clogging and fouling of pipes, heat exchangers or particulate filters. As a result, tar formation and its control are still considered as one of the major challenges in the implementation of biomass gasification technology (Ruiz et al., 2013). Tar is listed at number 19999 from United Nations' list of dangerous goods (United Nations, 2015).

According to the Occupational Safety and Health Administration (OSHA), the legal limit (permissible exposure limit) for tar pitch volatiles exposure in the workplace as 0.2 mg/m^3 benzene-soluble fraction over an 8-hour workday. The National Institute for Occupational Safety and Health (NIOSH) has set a recommended exposure limit (REL) of 0.1 mg/m^3 cyclohexane-extractable fraction over an 8-hour workday. At levels of 80 mg/m^3, coal tar pitch volatiles are immediately dangerous to life and health (CDC, 2016). According to the CDC (2016), the long exposure to tar can cause lung, kidney and skin cancer.

Organisation A classifies the tar into two categories: weak tar (approximately 93%) and heavy tar (approximately 7%). According to the organisation tests, weak tar is composed of 86% water and 14% organic compounds (alcohols, acids, phenols, benzene, ether, and aldehyde); and heavy tar is composed of 23% water, 55% organic compounds (alcohols, acids, phenols, benzene, ether, and aldehyde) and 22% of char.

Another problem with the tar is the final destination. Currently, the weak tar is being collected by a third party company that charges £190 per 1000 L (1 IBC – 1m^3). According to the organisation, in 2015, approximately 95 IBCs of weak tar were disposed, which represents a cost of £18,050. Currently, the tar problem is still bearable. However, considering that the company is not still working in full production and it is also deploying a new production line, the amount of tar generated will increase significantly in the next few years and this might become a big problem. Therefore, the initial idea of the project is to try to either: use the tar in the process, dispose it down the drain or sell it to other companies.

7.4.1.4. What has been done

The responsible chemical engineer had already tested a few approaches to treat the tar. The tests already done are as follow: solvent extraction, filtration with activated carbon, neutralisation, and vacuum distillation.

1- Solvent Extraction

The solvent extraction test aims to remove tar (organic compounds) from weak tar. This was done with five different solvents (Dichloromethane, MEK, N-butanol, MIBK and MEKP) at a different volume.

Results: The mixing of each of these solvents with weak tar formed two separate layers. The volume of weak tar and solvent used for each test did not generally change after mixing. This indicates that no extraction was achieved, probably because of the complex nature of weak tar.

2- Filtration with activated carbon

The filtration with activated carbon test aims to remove phenols from weak tar. Activated carbon was used as a filter in this case.

Results: No change in colour and pH of weak tar was observed. The test was not done properly and will be repeated.

3- Neutralisation

The neutralisation test aims to change the pH of weak tar from three to seven - nine in order to meet the requirements needed to dispose it off down the drain. This was done using a base such as sodium hydroxide.

Results: The test was successful, but by changing the pH using sodium hydroxide, we increased the total dissolved solids and COD in weak tar making it unsuitable to be disposed of down the drain.

4- Vacuum distillation

The vacuum test aims to remove water from weak tar under vacuum to lower the boiling point of chemicals and prevent the formation of solid tar which tends to occur when high temperatures around 140C are reached.

Results: From 100ml weak tar, 50ml concentrated weak tar and approximately 25ml clear liquid were produced. The clear liquid which is also known as distillate has a pH of 3. Water removed from weak tar will always be mixed with low boiling compounds such as acetic acid, acetone etc. The sugars can be the ones responsible for weak tar brown colour

7.4.1.5. What can be done?

The chemical engineer was still trying to find alternatives to provide treatment to the tar. One of the approaches is the Reverse Osmosis, which aims to remove impurities in weak tar and hopefully produce clean water with a reduced number of organic compounds in it.

Another possibility is the utilisation of the tar back into the process. Weak tar can be converted to heavy tar by distilling off the water. The heavy tar produced can be mixed with biochar, sulphur and moisture; under pressure and heat (90C) this mixture will form strong bonds in pellets. However, this approach might have a few problems, such as causing pipe blockage. There could be a possibility to transform heavy tar into solid, mill and add it in the pellet line in powder form. Apart from that, in order to reuse the tar, it will be needed to redesign the process

Another possible solution would be selling the tar to other companies. By analysing the composition of the weak tar, it was identified that it has a similar composition of something that is called 'wood vinegar'. According to the Food and Fertilizer Technology Center for the Asian and Pacific Region (2005), wood vinegar is a by-product from charcoal production that improves soil quality, eliminates pests and controls plant growth, but is slightly toxic to fish and very toxic to plants if too much is applied. It accelerates the growth of roots, stems, tubers, leaves, flowers, and fruit. In some instances, it may hold back plant growth if the wood vinegar is applied at different volumes. Wood vinegar

is safe to living matters in the food chain, especially, insects that help pollinate plants. Therefore, one way to capitalise with tar would be to sell it to agriculture companies.

Therefore, any chosen solution would involve changes in the current process structure. In this scenario, the BPM methodology would be very suitable, since it will provide methods for the successful implementation of those changes aiming to improve the process performance, a better use of resources, and the transformation of expenses into revenue and enablement of innovation.

7.4.2. Determine and prioritise processes

Since the purpose of the action research was to validate empirically the framework **for the implementation of sustainability business processes,** the selected processes needed to have a significant impact in terms of sustainability. Since resources and time are scarce, it was defined to only study one business scenario of Company A, the energy generation. This business scenario is composed of 4 processes: Torrefaction, Syngas Cleaning, Syngas Combustion, and Pelletization. For the matters of this project, it was decided to only focus on the processes of Torrefaction, Syngas Cleaning, and Pelletization. This decision was taken because they are the processes affected by the tar generation and that might need process change. The process of Syngas Generator is only a technical process that collects the syngas for combustion, in order to generate green electricity. In the future, Company A aims to reuse the syngas generated as an input of the process of Torrefaction (currently it uses natural gas)

7.4.3. Define Project Stakeholders

7.4.3.1. Internal Stakeholders

Company A has 14 internal stakeholders: one Operations Manager, one Mechanical Engineer, one Chemical Engineer, one Employed Contractor, one Site Supervisor, six Plant Operator, and three Temporary Staff.

7.4.3.2. External Stakeholders

Currently, Company A is not operating on a full scale, it is still in the ramp-up stage, so there are only potential customers. In that case, the potential customers are coal-fired power stations, companies in the Energy sector. Other external stakeholders are suppliers. Company A uses mainly timber suppliers, originated in the forestry industry.

Company A is a joint venture company with financial partners from the Netherlands and United States of America. Regarding legal and governmental entities, since Company A

is located in the United Kingdom, it needs to follow the standards and requirements of the United Kingdom Policies.

7.4.4. Define Project Objectives

The project objective was to perform an Action Research to help Company A find a solution to the tar generated through the conversion of biomass in energy. The current process generates large amounts of weak tar that can be hazardous to the employees, so it needs to be dealt with appropriately.

7.4.5. Define Metrics

The Global Reporting Initiative (2015) defines the following categories (**Figure 74**) of Economic, Environmental and Social metrics (indicators). It was discussed with the responsible for Company A, and the following aspects were selected to be monitored: Economic Performance (Economic); Materials, Water, Effluents and Waste (Environmental); and Occupational health and safety (Social).

Figure 74 Categories of Sustainability Indicators (Global Reporting Initiative, 2015) - content removed for copyright reasons

According to the GRI (2015), the economic performance can be measured in terms of direct economic value generated; Financial implications and other risks and opportunities for the organisation's activities due to climate change; Coverage of the organisation's defined benefit plan obligations; and Significant financial assistance received from the government. For the project, the most adherent would be the direct economic value generated, in the form of operating costs.

According to the organisation, the materials performance can be measured in terms of Materials used by weight or volume; and Percentage of materials used that are recycled input materials. For the project, the most adherent would be the amount of materials consumed.

According to Global Reporting Initiative (2015), the water performance can be measured in terms of Total water withdrawal by source; Water sources significantly affected by the withdrawal of water; and Percentage and the total volume of water recycled and reused. For the matters of the project, it was selected the percentage of water reused by the process.

According to GRI (2015), the Emissions, Effluents, and Waste performance can be measured in terms of total direct and indirect greenhouse gas emissions by weight; Other relevant indirect greenhouse gas emissions by weight; Initiatives to reduce greenhouse gas emissions and reductions achieved; Emissions of ozone-depleting substances by weight; NO, SO, and other significant air emissions by type and weight; Total water discharge by quality and destination; Total weight of waste by type and disposal method; Total number and volume of significant spills; Weight of transported, imported, exported, or treated waste deemed hazardous; Identity, size, protected status, and biodiversity value of water bodies and related habitats significantly affected by the reporting organisation's discharges of water. For this project, the most relevant indicator was the total weight of waste by type (tar) and disposal method.

According to the organisation, the Occupational Health and Safety performance can be measured in terms of Injury rate (IR); Occupational disease rate (ODR); Lost day rate (LDR); and Absentee rate (AR). For this study, it was only assessed the Injury Rate. More than that, it will also be assessed the health and safety related training per employee (and furthermore relate them to the Injury rate).

In terms of process, Slack et al., (2013) define that the process performance can be measured in terms of Cost, Time and Quality. For this project, it was considered the production cost per ton (cost); cycle time per ton; and percentage of products (biochar

pelletized) under specification (quality). Therefore, **Figure 75** summarises the metrics to be measured in the project.

Economic	Environmental	Social	Process Performance
Direct economic value generated	Materials	Occupational health and safety	Cost
Operating Costs	Materials used by weight or volume	Injury rate (IR)	Production Cost per ton (Pct)
	Water	Training	Time
	Percentage and total volume of water reused	Health and safety trainings per employee	Cycle time per ton (Ct)
	Emissions, effluents, and waste		Quality
	Total weight of waste by type and disposal method - tar		Percentage of products (pellet) under specification (Pus)

Figure 75 Project Metrics - summary

7.4.6. Record enterprise map (AS-IS Situation)

BPMN (Business Process Management Notation) was used to design the enterprise map (process mapping).

In this representation, **Figure 76** represents the symbols that were used:

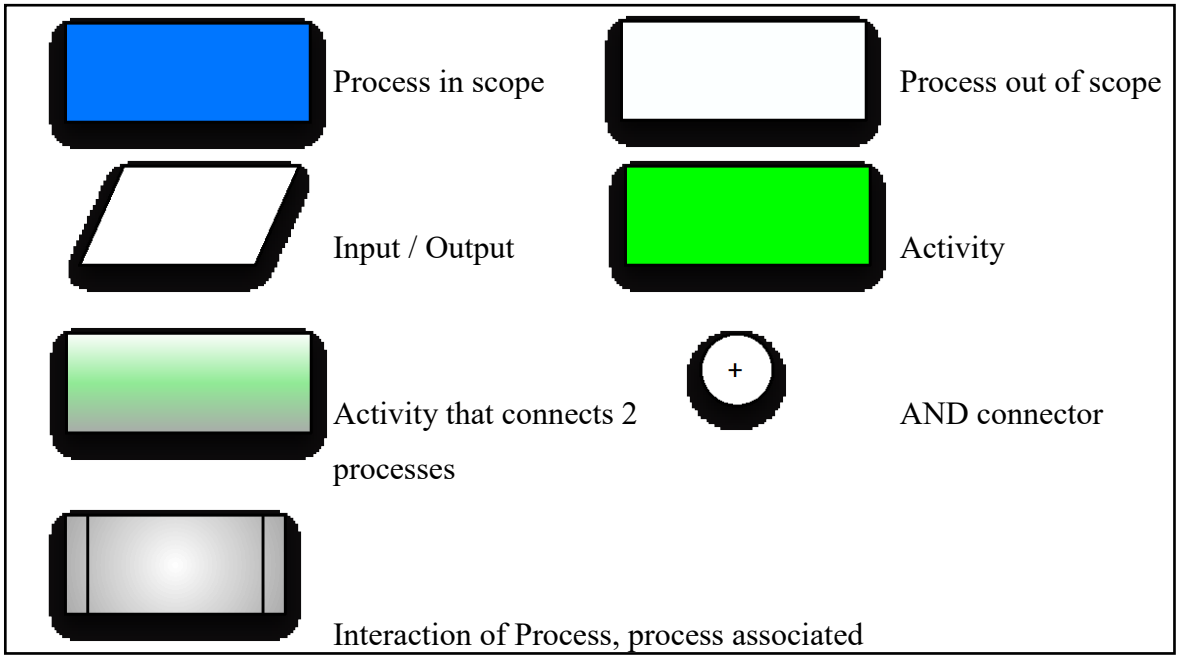

Figure 76 BPMN symbols

Company A works with two (2) levels of process (level of Process and level of Activities). The Energy Generation business Scenario contains four Processes, Torrefaction, Syngas cleaning, Syngas generator and Pelletization. This project studied only the processes of Torrefaction, Syngas cleaning and Pelletization. They were chosen because they are the ones that affect the tar generation. Syngas combustion is currently is only a technical process that collects the syngas for combustion, in order to generate green electricity. In the future, Company A aims to reuse the syngas in the process of Torrefaction (currently Company A uses natural gas to trigger the operation). **Figure 77** represents the Energy Generation Business Scenario.

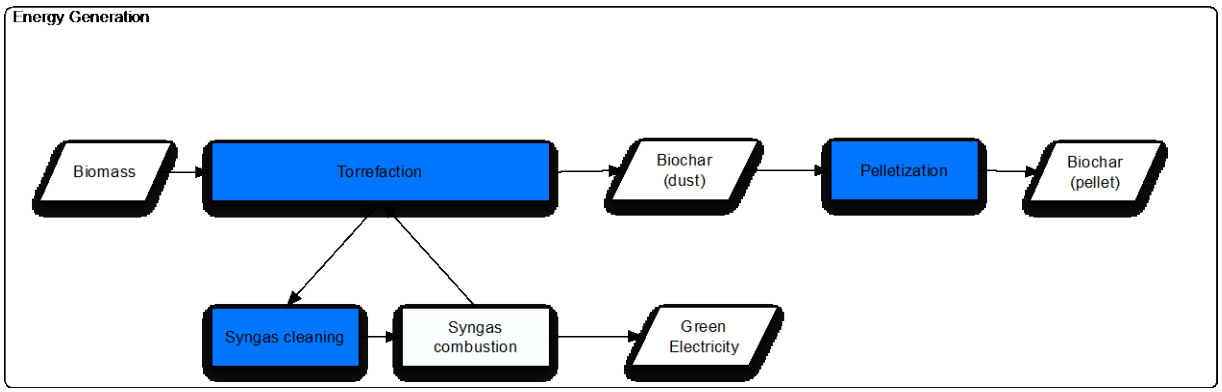

Figure 77 Energy Generation business scenario

Torrefaction is a thermochemical process that involves the conversion of biomass to biochar. The process uses biomass as primary input. In this process, the reactor uses the heat power of the hot exhaust gas (natural gas) to trigger the operation (no contact with the biomass). Later on, once the biochar is generated, it is cooled down by cooling water from cooling tower. The process has biochar (dust) and syngas (with Organic Volatiles) as outputs. **Figure 78** represents the Torrefaction Process.

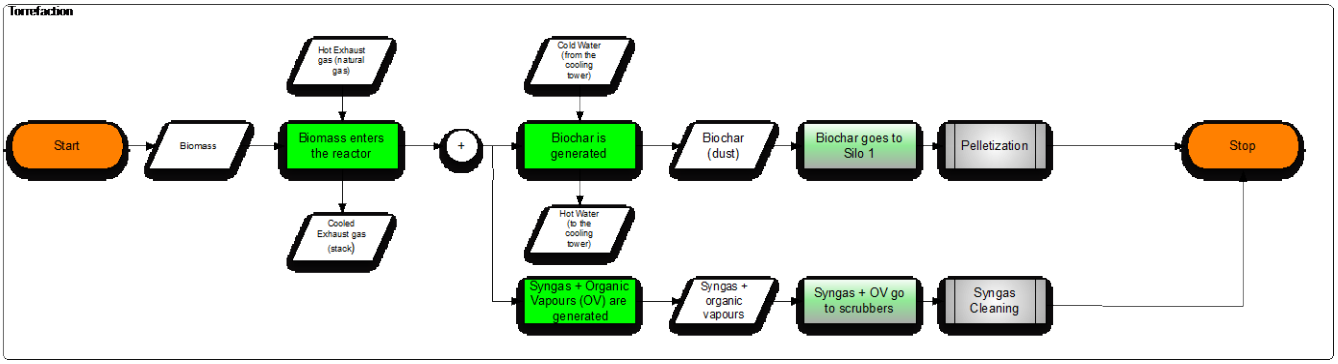

Figure 78 Torrefaction process

Syngas cleaning is the process to clean the gas that is generated by the Torrefaction Process. This is the process most affected by the tar since it is where the tar is generated. In this process, the tar is separated into weak tar and heavy tar. **Figure 79** represents the Syngas Cleaning Process

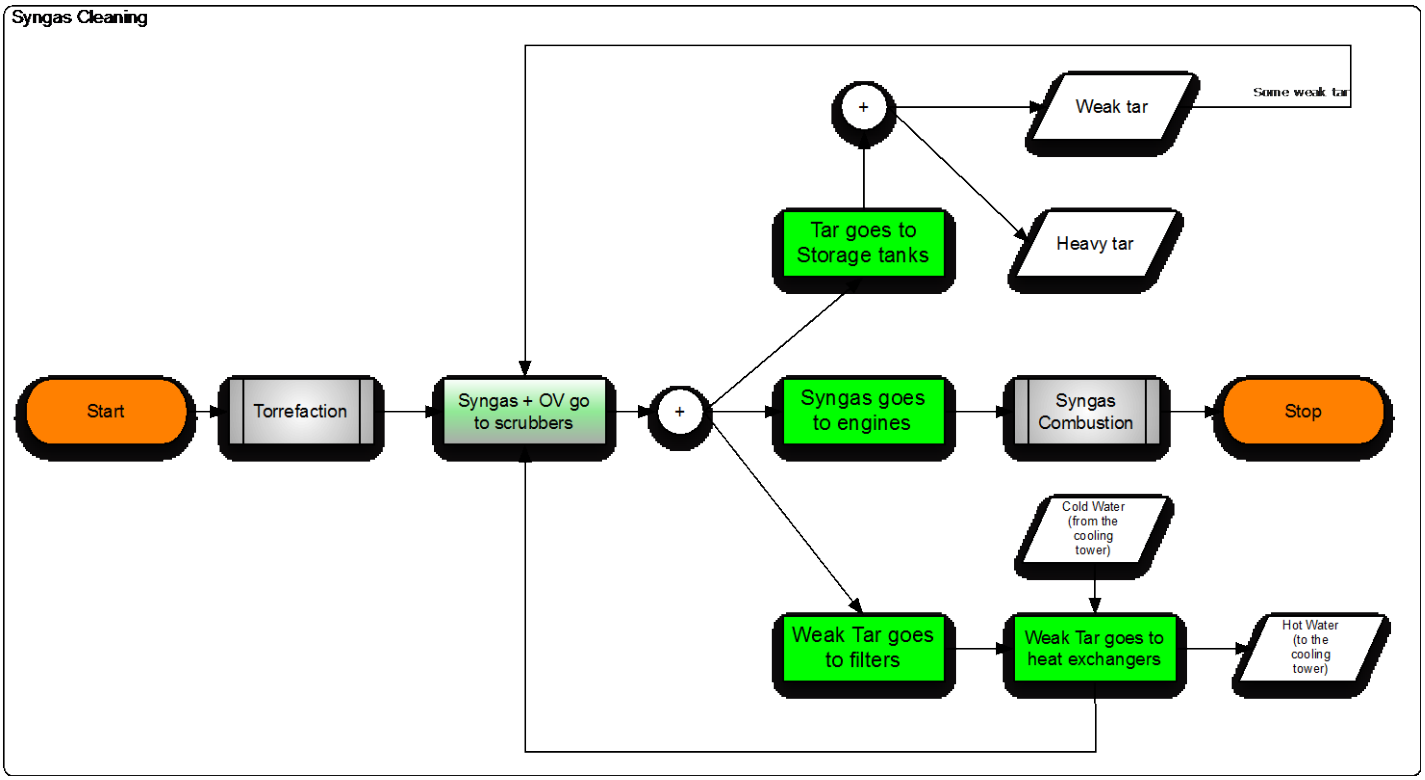

Figure 79 Syngas cleaning process

The Pelletization process is the process to pelletize the biochar (dust). The process combines the biochar dust with lubricant, water and binder in order to produce biochar pellets. **Figure 80** represents the Pelletization process.

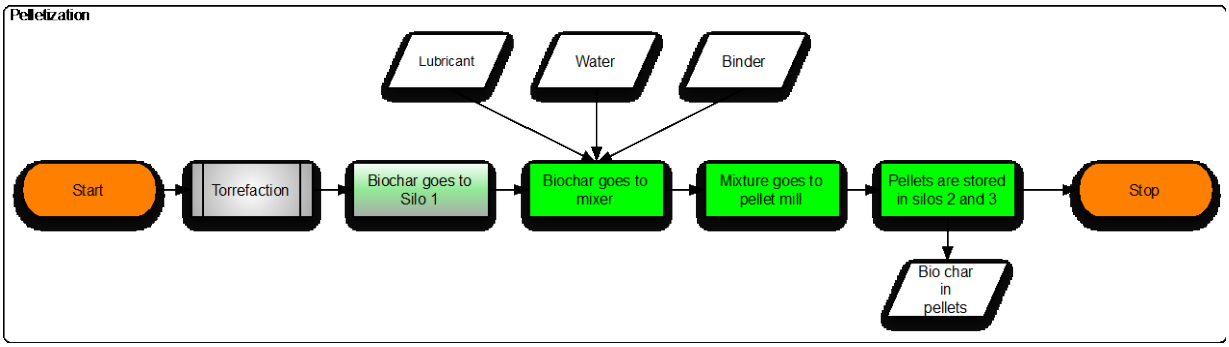

Figure 80 Pelletization Process

7.4.7. Record baseline values

Some metrics were obtained through the access of information provided by Company A, others were obtained through observation of the current process performance, and others were obtained through calculations. Some of the metrics (such as the occupational health and safety) were only evaluated in a scenario level due to the lack of information on the process level. **Figure 81** represents the sustainability performance metrics calculation method and **Figure 82** the process performance indicators**.**

	Sustainability performance			
				Calculation method
Dimensions	Economic	Direct economic value generated	Operating Costs	Obtained from Company A reports
	Environmental	Materials	Materials used by weight or volume	Obtained from Company A reports
		Water	Percentage and total volume of water reused	Mass balance between: capacity of the water tower, amount of water evaporated, amount of water drained, water obtained from the rain and water obtained from the mains
		Emissions, effluents, and waste	Total weight of waste by type and disposal method - tar	Obtained from Company A reports
	Social	Occupational health and safety	Injury rate (IR)	$IR = \frac{Total\ \#\ of\ injuries}{Total\ hours\ worked} x\ 200{,}000$
			Occupational diseases rate (ODR)	$ODR = \frac{Total\ \#\ of\ Occupational\ disease\ cases}{Total\ hours\ worked} x\ 200{,}000$
			Lost day rate (LDR)	$LDR = \frac{Total\ \#\ of\ lost\ days}{Total\ hours\ worked} x\ 200{,}000$
			Absentee rate (AR)	$AR = \frac{Total\ \#\ of\ missed\ (absentee) days\ over\ the\ period}{Total\ \#\ of\ workforce\ days\ worked\ for\ same\ period} x\ 200{,}000$

Figure 81 Sustainability Performance calculation methods

	Process performance	
		Calculation method
Cost	Production Cost per ton (Pct)	$Pct = \frac{Cost\ of\ production}{Amount\ of\ bio\ coal\ produced}$
Time	Cycle time per ton (Ct)	$Ct = \frac{Amount\ of\ bio\ coal\ produced(batch)}{time}$
Quality	Percentage of products (pellet) under specification (Pus)	$Pus = \frac{Amount\ of\ bio\ coal\ products\ under\ specification}{Amount\ of\ bio\ coal\ produced}$

Figure 82 Process Performance calculation methods

7.4.7.1. Operational costs

Table 39 represents the costs of production from Company A (with two production lines).

Table 39 Production Costs

Fixed Costs	Annual cost '000 Euros
Maintenance and spare parts	286.4
Personnel costs	477.2
Engineering costs	14.0
Consultancy/temporary	14.0
Rent	50.0
General and administrative costs	20.0
Insurance	42.8
Total Fixed Costs	904.4

Variable Costs	Annual cost '000 Euros
Biomass	~ 5967.4
Electricity	~ 368.8
Start-up liquid fuel cost	~ 3
Freight cost	~ 613.6
Royalty costs	~ 200
Total Variable Costs	7152.8

Raw material expenses constitute the significant part of the Project's operating expenses. The main cost item is the cost of purchased biomass; electricity and other are minor items.

7.4.7.2. Materials used by weight or volume

According to the organisational reports, in 2015, it was used 44 tons of wood. With the full production and the two operation lines working, it is planned to produce 30, 000 tons of biochar, which represents 50,420 tons of wood. According to the report, it was also used 2 tons of binders. In full production, it will be used 1,950,000 tons of binders. Last year, it was also used 500 Kg of lubricant in the last year. In full production, it will be used 30,000 tons of lubricant.

7.4.7.3. Water reused in the process

In order to identify the water reused in the process, it was analysed the water balance of the cooling tower. **Figure 83** represents this water balance.

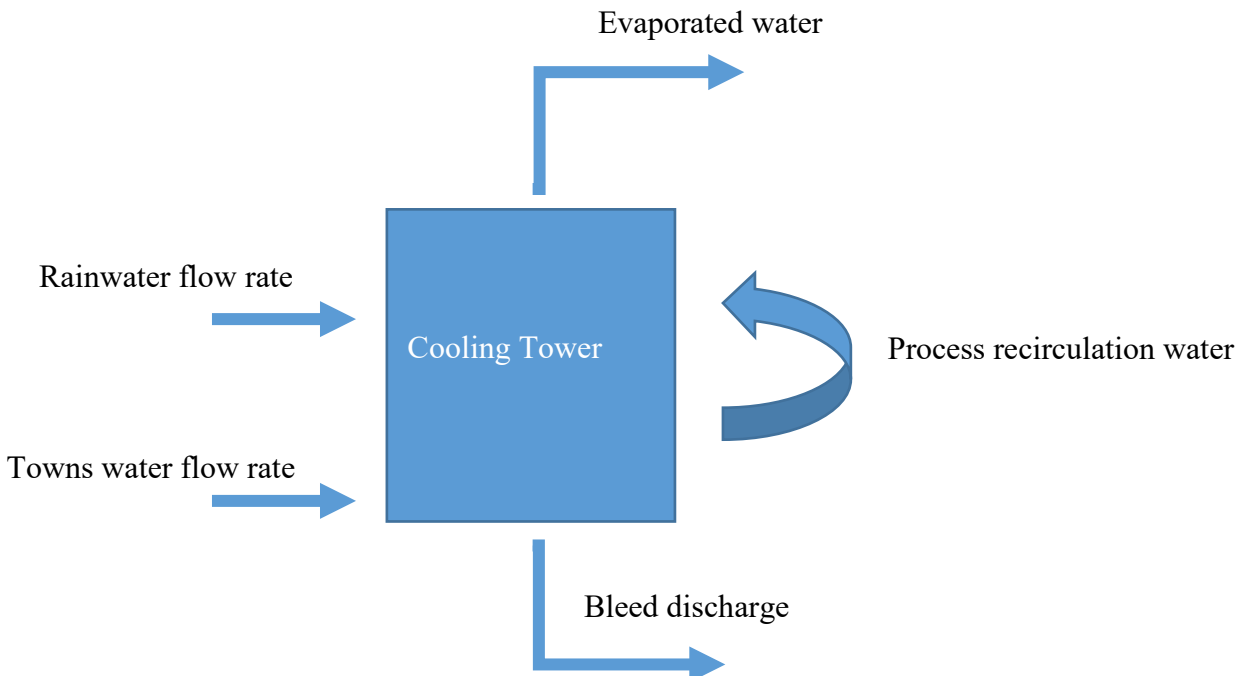

Figure 83 Water balance (cooling tower)

In order to determine the water reused in the process, it was collected four bills from one operating year. **Table 40** represents the water consumption over one year period

Table 40 Water consumed in a one year period

Month/Year	Water consumed (m^3)
Jul - Oct 2015	262
Oct - Jan 2015	242
Jan - Apr 2016	189
Apr - Jul 2016	257
Total	950

It was estimated that from that 950 m^3, 56 m^3 was used in toilet per annum and the rest (894 m^3) was used by the process. Considering that the plant is only available for 91% of the days in a year, it was considered that the flow rate consumed was 0.13 m^3/h.

Table 41 represents the formulas that were used to calculate the water used in the process.

Table 42 represents the required data to obtain the results from table 3.

Table 41 Formulas to calculate the water used in the process

Formulas	
$H_V E = mC_p \Delta T$	E is the amount of water evaporated
$BD = E/(C - 1)$	BD is the amount of water bled off and C is the cycles of concentration
$TDS = 0.67\ X\ Conductivity$	TDS is the total dissolved solids
$C = \frac{TDS\ in\ process\ water}{TDS\ in\ (mains\ water + rainwater)}$	
Make-up water $= E + BD + D + L$	D and L are water lost in drift and leaks (It is assumed to be negligible)

where:

Table 42 Required data to calculate the water used in the process

Latent heat of vaporization of water (Hv) (kJ/kg)	2257
Flowrate of warm process water (m) (kg/h)	59479.97
Specific heat capacity of water (Cp) (kJ/kg C)	4.181
Temperature difference between warm and cold streams (ΔT) (C)	4.56
Conductivity of Process water (µS)	1885
TDS in make-up water (mains water + rainwater) (mg/l)	400
TDS in process water (mg/l)	1262.95
Cycles of concentration	3.2
Heat Capacity of cooling tower (kw)	318
Evaporatio rate (l/h) /kw	1.58
E (l/h)	502.44
Number of hours the CT was on (h)	7200

Thus, **table 43** shows the summary of the flow rate of water from the cooling tower and **Figure 84** represents the water balance with the respective flow rates.

Table 43 Summary of flow rate

Flowrate of evaporated water (L/h)	502.4
Amount of water bled off (L/h)	232.9
Make-up water (L/h)	735.3

Evaporated water (m^3/h)	0.5

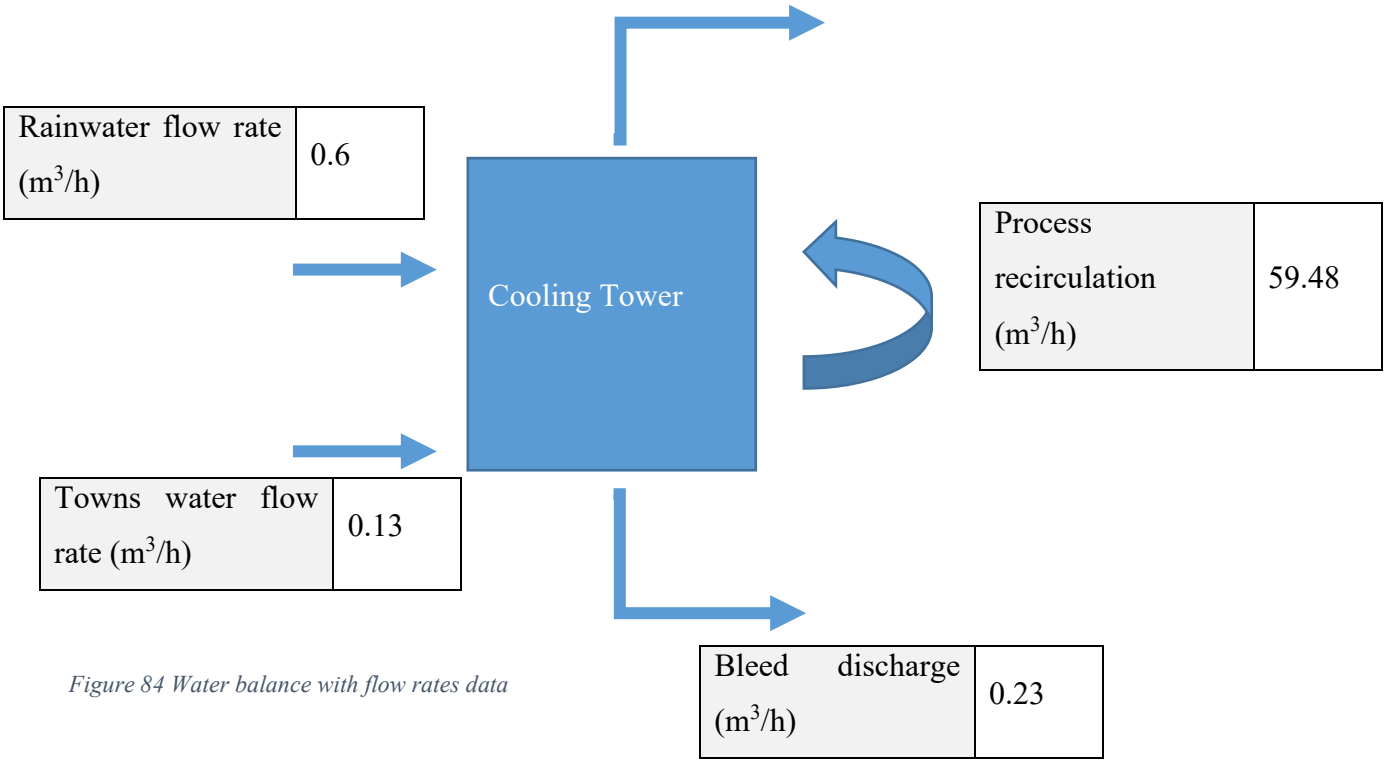

Figure 84 Water balance with flow rates data

Considering that the plant was operating for 10 months in the past year (July 2015 – July 2016), from which the reactor was working for 176 hours, it is possible to conclude that the amount of water that entered the process was 5256 m3 ([rainwater flow rate + towns water flow rate] x 7200 h) and the amount of water reused by the process was 10,468.48 m3. Thus, it is possible to conclude that the percentage of water reused in the process is 66.57% (Process recirculation / [Rainwater flow rate + towns water flow rate + process recirculation]). **Table 44** displays the calculations used to obtain this percentage.

Table 44 Calculation of the percentage of water reused in the process

Time without maintenance (months)	10
Time without maintenance (hours)	7200
Reactor working (h)	176
Rainwater (m3)	4320
Towns water consumption (m3)	936

Process Recirculation (Water in the cooling tower) (m3)	10468.48

Calculation	
Percentage of water reused by the process	$\frac{Process\ Recirculation}{Process\ Recirculation + Rainwater + Towsn\ water\ consumption}$
Percentage of water reused by the process	66.57%

7.4.7.4. Total weight of waste by type and disposal method - tar

According to the latest mass balance available in the company, in full production (with the two lines working), it will be generated an output of 8301 m3 of weak tar. However, since Company A is not working in full production yet, the actual results were different. According to the organisation, in 2015, approximately 95 IBCs of weak tar were disposed, representing an amount of 95 m^3.

7.4.7.5. Injury rate

Tables 45 and **46** display the accident records from 2015 and 2016, respectively.

Table 45 - Accident records 2015

Date	Brief description of accident	Location	Type of injury	Location of injury	First aid administered	Other treatment (eg hospital visit)
16/03/2015		Inside reactor			No	None
27/03/2015	Hacksaw slipped whilst cutting cable	Control Room 1	Cut	Finger	Yes	None
14/04/2015	Foreign body in eye from grinding works as walking past	Factory floor	Contaminate	Right eye	No	Removed at hospital
08/06/2015	Oil splashed into eye	External bund area	Contaminate	Eyes	Yes	Hospital visit for further treatment and check up
13/08/2015	Fell into hole inside open reactor	Reactor 2	Impact	Ribs	No	
25/08/2015	Removing a gasket from skip	Skips at back of units	Cut	Finger	Yes	None
27/08/2015	Caught sharp edge of chuck on drill	Control Room 2	Cut	Finger	Yes	None

Table 46 Accident records 2016

Date	Brief description of accident	Location	Type of injury	Location of injury	First aid administered	Other treatment (eg hospital visit)
16/02/2016	Spanner slipped off old bolt	Pellet mill	Impact	Above eye	No	None
19/02/2016	Walked into screw conveyor	Tar test trailer	Impact/cut	Head	Yes	None
16/03/2016	9 inch griner snapped back	Workshop	Impact	Chin	No	None
21/03/2016	Piece of steel work rolled over	Unit 1d Reactor 2	Impact/Crushing	Foot	No	None
04/04/2016	Dust into eyes	Pellet mill	Contaminate	Eye	No	None
21/04/2016	Steam from opened hatch on pellet mill	Pellet mill	Burn/Scald	Fore-arm	Yes	None
07/06/2016	Screwdriver slipped out of place	Woodstore	Puncture	Hand	Yes	Hospital visit for further treatment
20/06/2016	Sharp edge on plastic pipe	Pellet mill	Cut	Hand	Yes	None
24/06/2016	Replacing cutting disk on grinder	Workshop	Cut	Finger	Yes	None
19/07/2016	Hit thumb with hammer	Pellet mill	Impact	Thumb	Yes	None
20/07/2016	Injured back moving electrical control panel	Control Room 1	Musculoskeletal	Back	No	None
22/07/2016	Screwdriver slipped out of place	Outside front unit 1d	Puncture	Hand	Yes	Hospital visit for further treatment
22/07/2016	Touched chemical with glove then re wore gloves	Lab Area	Blanching	Finger	No	None

In order to calculate the Injury rate (IR), GRI (2015) defines the following formula:

$$IR = \frac{Total\ \#\ of\ injuries}{Total\ hours\ worked} x\ 200{,}000$$

Note: The factor 200,000 is derived from 50 working weeks, with 40 work hours per week for companies with less than 100 employees.

For 2015, the Injury rate was 70. For 2016, since it was only assessed six months, the injury rate was 130.

7.4.7.6. Health and safety training per employee

Company A has internal and external training related to health and safety. **Figures 85** and **86** represent, respectively, the internal and external training records.

Name	Emergency Procedures	Reactor Operation	Engine Operation	Start/Stop Conveyors	Genral Process Description	Process Infeed	Outfeed - Silos	Gas Cleaning Scrubber System	SCADA	Pelletmill Familiarisation	Fire Warden Training
1			3/3/16		C					C	
2					C						
3	C	C	C	C	C	C		C	C		3/23/16
4	C	C	C	C	C	C	3/23/16				
5											
6			3/14/16		C	3/15/16	3/23/16	3/21/16	3/22/16		
7		C	C	C	C	3/18/16		3/17/16			
8	C	5/27/16	7/29/16		C	5/27/16		7/27/16			
9		C	C	C	C		3/1/16	3/2/16	3/3/16	3/25/16	
10					C						
11		C	C	C	C	C		C	C		
12	C	9/13/16			C	9/13/16			3/9/16	C	
13		C	C	C	C	3/15/16		3/16/16	3/16/16		
14	C	9/13/16	7/29/16		C	9/13/16		7/27/16			
15	C	9/13/16			C	9/13/16		3/2/16			C
16					C					3/24/16	
17	C	9/13/16		C	C	C		3/2/16	3/9/16		3/23/16

Figure 85 Internal training

	TRAINING																			
Name	Emergency First Aid at Work	Risk Assessment	Work at Height	Manual Handling	Use of Fire Fighting Equipment	The Role of the Supervisor	Environmental Management Systems (ISO 14001) Awareness	Environmental Awareness	Legionella Awareness	Confined Space & Top Man Awareness	Rigging and Slinging	Telehandler	Counter Balance Forklift	KAHL Pelletizer	DSEAR Awareness	COSHH Awareness	Vehicle Movements	Abrasive Wheel Use / Selection And Hand Tool Use	PASMA Tower Scaffold	IPAF (Access Platform)
1		C	C	C	C	C		C		C	C	C	C	C					C	C
2		C	C		C								C		C				C	C
3	C	C	C	C	C	C		C	C	C	C	C				C				
4	C	C	C	C	C						C		C					C		
5	C	C	C	C	C	C				C	C	C	C						C	C
6	C	C	C	C	C						C		C					C		
7	C	C	C	C	C					C	C	C	C						C	C
8	C	C	C	C	C				C	C	C	C	C						C	C
9	C	C	C	C	C	C				C	C	C	C						C	C
10	C	APL	APL		C				APL	APL	C									
11	C	APL			C	C		C	C	C	C									
12		C			C							C	C		C					C
13		C	C	C	C					C	C	C	C		C				C	C
14		C											C							C
15	C	C	C	C	C	C	C	C	C	C	C		C			C				
16	C	C	C	C	C						C		C					C		C
17	C	C	C	C	C	C		C	C	C						C				

Completed	Accredited Prior Learning
Ongoing	High Importance Training Need

Figure 86 External training

While some of this training is specifically related to machinery, others are directly related to health and safety standards and procedures:

- Emergency Procedures
- General Process Description
- Emergency First Aid at Work
- Risk Assessment
- Work at Height
- Manual Handling
- Use of Fire Fighting Equipment
- Legionella Awareness
- Confined Space & Top Man Awareness
- Rigging and Slinging
- COSHH Awareness
- Vehicle Movements
- Abrasive Wheel Use / Selection and Hand Tool Use
- PASMA Tower Scaffold
- IPAF (Access Platform)

Some of these trainings are required for a specific task or job; however, some of them are necessary for all positions. These trainings are: Emergency First Aid at work, Risk Assessment, Work at height, and Use of firefighting equipment.

At the moment, five staff members still need to conclude the 'Emergency First aid at work' training; three staff members still need to conclude 'Work at height' training; and one still needs to conclude the 'use of firefighting equipment'. Only the 'Risk assessment' training was concluded by all the employees. **Table 47** represents the percentage of staff that concluded the trainings.

Table 47 Percentage of staff that concluded the trainings

Training	Percentage of Staff that concluded the training
Emergency First Aid at work	70.59%
Risk Assessment	100.00%
Work at height	82.35%

Use of firefighting equipment	94.12%

7.4.7.7. Production cost per ton (Pct)

Considering the last year production of 31 tons and cost of production of 4,286,000.6 euros (1 production line), the cost per ton was

$$Pct = \frac{Cost\ of\ production}{Amount\ of\ bio\ coal\ produced}$$

Pct = 97,409.1 euros/ton

7.4.7.8. Cycle time per ton (Ct)

Since the company is not working in full production, it is hard to evaluate precisely the cycle time per ton. So, in order to evaluate the cycle time, it will be used the amount of coal produced last year (31 tons) and the working time of the reactor (176 hours).

$$Ct = \frac{Amount\ of\ bio\ coal\ produced}{time}$$

Cycle time = 0.176 tons/h

7.4.7.9. Percentage of products (pellet) under specification (Pus)

$$Pus = \frac{Amount\ of\ bio\ coal\ products\ under\ specification}{Amount\ of\ bio\ coal\ produced}$$

From the total mass of biochar used in the last year to make pellets, 48% of it came out as a dust at the end of the cooler. From that 52% of produced pellets, only 6% met the criteria (3.12% of the total produced).

Figure 87 summarises the sustainability performance metrics and **Figure 88** summarises the process performance indicators.

	Sustainability performance			
				Result
Dimensions	Economic	Direct economic value generated	Operating Costs	Fixed costs: 904,000.4 euros/year Variable costs: 7,152,000 euros/year * based on 2 production lines
	Environmental	Materials	Materials used by weight or volume	44 tons of wood 2 tons of binders 500 Kg of lubricants
		Water	Percentage and total volume of water reused	66.57%
		Emissions, effluents, and waste	Total weight of waste by type and disposal method - tar	95 m3 of weak tar
	Social	Occupational health and safety	Injury rate (IR)	70 in 2015
				130 in 2016
			Health and safety trainings per employee	Emergency First Aid at work 70.59% Risk Assessment 100.00% Work at height 82.35% Use of firefighting equipment 94.12%

Figure 87 - Sustainability Performance - Summary

	Process performance	
		Result
Cost	Production Cost per ton (Pct)	97,409.1 euros / ton
Time	Cycle time per ton (Ct)	0.25 tons / h
Quality	Percentage of products (pellet) under specification (Pus)	6%

Figure 88 Process Performance - Summary

7.5.8. Perform Sustainability Maturity Assessment

A lean/green study that was held on the company prior to the action research. The study evaluated the results from a lean-green measurement based on the presence of specific process improvement tools and result of staff's opinions as regards the lean-green nature of the company.

The study uses the Verrier et al. (2016) maturity deployment model which aims to evaluate the level of lean knowledge in an organisation and thus recommend the best way to implement it. The study used a structured questionnaire to assess the lean & green level.

It was observed that although the organisation had a few lean/green tools in practice the understanding of what it was fell between the first and second levels of the maturity model that is: level1 (Initial), limited awareness of L&G issues and level 2 (Managed), Occasional basic Lean and green actions). **Figure 89** represents the level of lean & green knowledge. It is possible to observe that only 22% of the company's workforce had knowledge of lean or green manufacturing with the majority of that percentage being top management personnel.

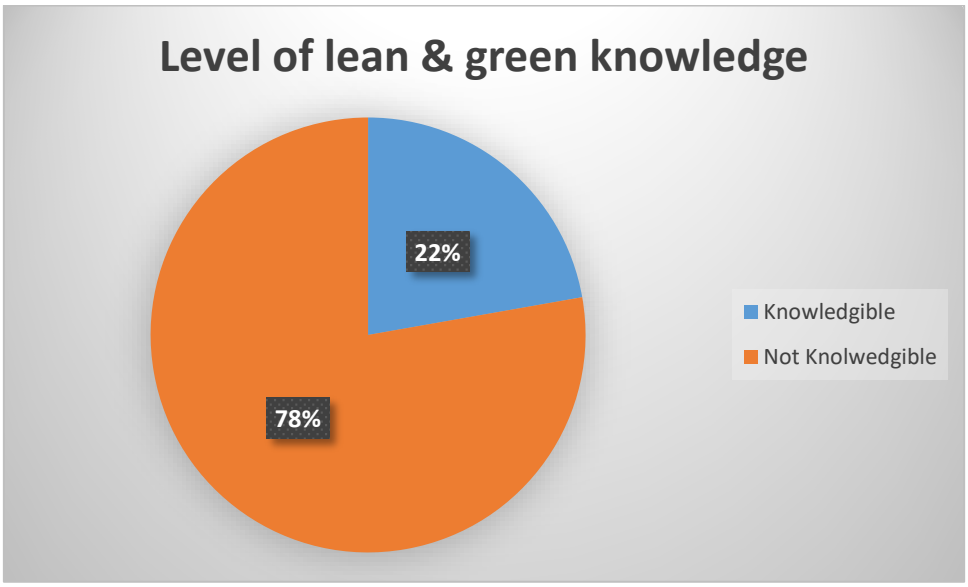

Figure 89 Level of lean/green knowledge

Another study evaluated the lean and green tools used by the organisation.

Table 48 Lean and green tools used by the organisation

Lean tools	**Weighting**	**Weighting of tools present**
Kaizen	.4	.2
5S	.2	.1
Visual Management	.2	.1
TPM	.1	.1
Standardised work	.1	.1
	Lean score	60%

A lean score of 60% was obtained based on the partial implementation of some lean tools such as the 5s which was visible on only one part of the facilities and also the kaizen

process which seems not to be fully operational with regard to employee participation and a set continuous improvement method thus it was given a presence score of .2.

Table 49 Green tools used by the organisation

Green Tools	Weighting	Weighting of Green tools present
1SO14000	.5	.2
3R'S	.3	.2
EVSM	.1	
Energy Management	.1	
	Green tools score	40%

A green tool score of 40% was obtained due to the fact that a lot of the basic green measurements such as, water usage control, or energy management, or a set framework such as the EVSM, which checks to see the effect of the firm's everyday operation on the environment seems to be missing.

One factor that might justify the lack of lean and green practices is the fact that the company is still in the ramp-up phase, and have not achieved the full production. Thus, it is possible to conclude that in terms of process management it is in the Initial stage. In terms of sustainability, it is also on the stage due to the lack of green measurements or practices. One of the outputs of this project was the creation of metrics (performance indicators). Those metrics, associated with the improvement of the process maturity level (from initial to repeatable) can help Company A to move into the level 2 of the sustainability maturity assessment framework.

7.5. Design phase

7.5.1. Define Scope

The scope of the Project was to treat the tar. The project evaluated the feasibility of using the weak tar in the process of Pelletization and to sell the remaining tar to other companies. More than that, the project can help the organisation to achieve the level 2 of the process maturity level and of sustainability maturity level. **Figure 90** represents the Project Scope Statement.

Project Scope Statement	
Project Name	Action Research
Date	Sep-16
Project Justification	Currently the plant is producing an excess of tar. In the last year approximately 95 IBCs of weak tar were disposed, which represents a cost of £18,050.
Project Description	The project will evaluate the feasibility of using the weak tar in the process of Pelletization and to sell the remaining tar to other companies. More than that, the project can help the organisation to achieve the level 2 of the process maturity level and of sustainability maturity level.
Project Deliverables	Enterprise map - High level view to all business scenarios, specific details on the processes on scope (Torrefaction, Syngas cleaning, and Pelletization)
Out of scope items	Full sustainability analysis. Full process analysis
Project Objectives	The project objective is to perform an Action Research to help Company A find a solution to the tar generated through the conversion of biomass in energy. The current process generates large amounts of tar that can be hazardous to the employees, so it needs to be dealt with properly.
Constraints	Company A is not operating in a continous way yet
Assumptions	The board of the organisation will provide full support to the project

Figure 90 Project Scope Statement

7.5.2. Identify Improvement opportunities

The main objective of the project was to provide a solution to the tar generated through the conversion of biomass in energy. The initial idea was to reutilise the tar in the process as a binder would reduce the amount of tar disposed and would also reduce the number of binders required to run the operations (reducing costs of operation). Other objectives of the project are to raise the percentage of water reused on the process, relate the injury rates with the specific process (in order to control them in a better way) and relate the injury rates with the health and safety trainings. It was identified six (6) possible solutions to solve this issue: Disposal down the drain; Sell the weak tar; Filtration using activated carbon or other chemicals; Incineration (Oxidiser) – Option 1 with weak tar in liquid form; Incineration (Oxidiser) – Option 2 with weak tar in vapour form; and Inject directly in stack

7.5.2.1. Disposal down the drain

For this solution, weak tar will have to be treated to meet the requirements in order to dispose it down the drain. The pH of weak tar is 3 and this needs to be neutralized. In that case, the TDS (Total Dissolved Solids) and COD (Chemical Oxygen Demand) will increase. Reverse osmosis can be used to remake TDS but high pressure is needed due to such thing TDS contents. This may be impossible to do on site and might require a lot more money.

7.5.2.2. Sell it

Last year, Company A spent £18,050 to dispose the tar (95 IBCS, using services of a third-party company). With the full production, the organisation will generate, theoretically, 8,301 m^3 of tar (8,301 IBCs), consisting a cost of £1,577,190 per year (if disposed in the current way).

One of the alternatives to deal with this exceeding tar would be selling the weak tar to other companies in the form 'wood vinegar' (or pyroligneous acid). Thus, theoretically, it might be possible to transform weak tar into wood vinegar.

It was found one supplier of wood vinegar that charges £1,700 for 1 m^3. Considering that last year it was produced 95 m^3 of tar (95% of weak tar – 90.25 m3), this would represent a £156,403.25 profit. Considering the values of full production (8,301 m^3 of weak tar), this could represent a £14,385,633 profit*. The remaining heavy tar produced could be used back in the process in form of binders. According to the responsible engineer, it is hard to evaluate the total savings of this approach, however, it would represent in a reduction of binders needed (1,950,000 tons of binders per year for the case of two lines, representing 1,303,924 pounds) and also it would improve the calorific power of the final product. **Figure 91** and **92** represent the weak tar profitability analysis without considering the costs of transportation. It might take a while to identify/contact potential buyers

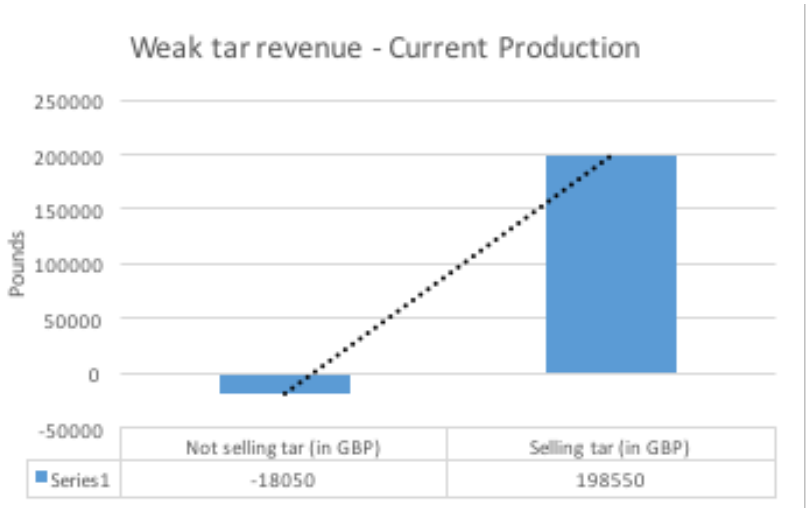

Figure 91 Weak tar profitability analysis

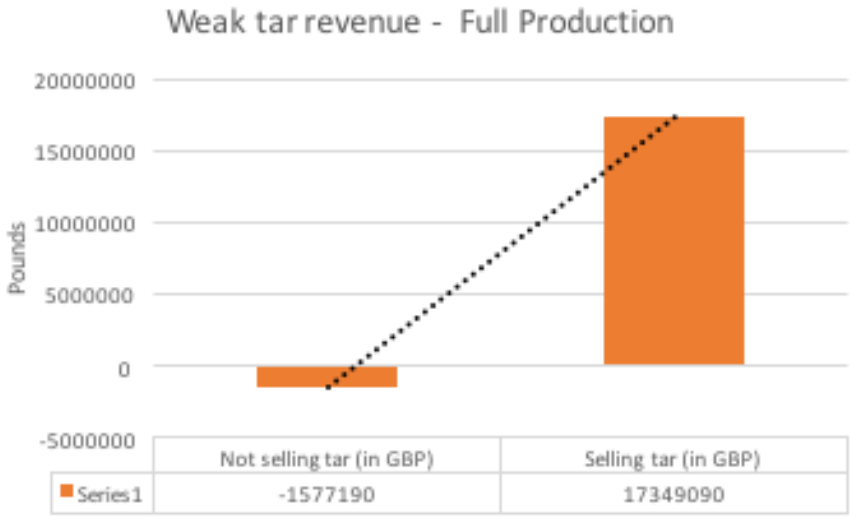

Figure 92 *Weak tar profitability analysis*

Nonetheless, this would also need a redesign of the process, the process to transform weak tar into wood vinegar and the connection between the channels of communication from Company A and the buying organisation (added to the costs to create the network, costs to transport the wood vinegar, among others).

7.5.2.3. Filtration using activated carbon or other chemicals

Activated carbon or other material can be used to clean (removing phenols from weak tar and other unwanted compounds) weak tar. However, the use of this approach would produce more waste that will need to be removed off-site, leading to higher costs.

7.5.2.4. Incineration (Oxidiser) – Option 1 with weak tar in liquid form

Weak tar needs to be atomised to make the evaporation more efficient. In this approach, VOCs (Volatile Organic Compounds) will be combusted and converted into CO_2 and H_2O, which will be released into the atmosphere. This solution has not been tested yet and needs calibration time. The process of atomization can involve other costs, which can be very costly to the organisation.

7.5.2.5. Incineration (Oxidiser) – Option 2 with weak tar in vapour form

This approach is similar to the last one, except that in this option the weak tar would be boiled and fed in a vapour phase, instead of being atomised. This process, however, is cheaper since there is already a tank.

7.5.2.6. Injected directly in the stack

This approach is to release of VOCs in the atmosphere. This represents a clear environmental problem and also might affect the local companies.

7.5.2.7. SWOT Analysis

In order to identify which solution is more adherent to the current problem, it was created a SWOT analysis, comparing the Strengths, Weaknesses, Opportunities, and Threats of the proposed solutions to the weak tar problem. **Table 50** displays the SWOT analysis.

Table 50 SWOT Analysis

Weak tar treatment solutions	SWOT analysis
Disposal down the drain	**Strenghts** - Easy to do - Doesn't involve changes in the current process **Weknesses** - Need to meet the requirements listed in the discharge permit - Might require further treatment of weak tar (high costs) - The volume of weak tar to be discharged will be limited **Opportunities** **Threats** - If not treated properly, can be a hazard to the environment

Sell it	**Strenghts** - Doesn't involve changes in the current process	**Weknesses** - Insufficient information is available to meet the requirements needed to put the product on the market - Difficulties in finding customers - Further tests will have to be done - high costs) - Need to meet the requirements listed in the discharge permit - Might require further treatment of weak tar (high costs) - The volume of weak tar to be discharged will be limited
	Opportunities Because of the value of the chemicals in weak tar, the company can make a profit by selling it	**Threats**
Filtration using activated carbon or other chemicals	**Strenghts** - Simple method - Main process will not be affected	**Weknesses** - Weak tar may require high amounts of filter media to clean it - Filter media can be re-used in the process but in order to do so it will have to be treated and this can involve high costs - Process will have to designed and changes will be made in the tar area
	Opportunities	**Threats** - Contamination of product. Filter media may increase TDS of weak tar leading to further treatment (high costs)

Incineration (Oxidiser) – Option 1 with weak tar in liquid form	**Strenghts** - There is already an oxidizer on site - VOCs in weak tar will be destroyed, therefore won't be released into the atmosphere - No odour problem	**Weknesses** - Liquid weak tar will have to be atomized before feeding it in - Sprays might be blocked with tar during operation which will affect the process - Pipework modifications around the oxidizer - Dependent on syngas produced from reactor because it will be used as fuel
	Opportunities	**Threats** - Incomplete combustion can result into VOCS emissions in the air
Incineration (Oxidiser) – Option 2 with weak tar in vapour form	**Strenghts** - There is already an oxidizer on site - VOCs in weak tar will be destroyed, therefore won't be released into the atmosphere - No odour problem	**Weknesses** - Need a tank to boil liquid weak tar and convert it to vapour - Connect tank to the oxidiser (pipework, insulation of pipe) - Instrumentation - Continuous monitoring to prevent the formation of solid tar in the tank - Dependents on syngas produced from reactor because it will be used as fuel
	Opportunities - The concentrated tar at the bottom of the tank can be pumped to the pellet line warm and be used as a binder	**Threats** - Formation of solid heavy tar at the bottom of the tank if not emptied on time - Incomplete combustion can result into VOCS emissions in the air

Injected directly in the stack	**Strenghts** - Easy to do **Weknesses** - Release of VOCs in the atmosphere - Odour **Opportunities** **Threats** - Companies nearby may complain about odours

With the SWOT analysis, it was possible to identify that the alternative 'Incineration (Oxidiser) – Option 2 with weak tar in vapour form' is the best one, since it is viable, will save material (heavy tar in form of binders) and have controllable risks.

Regarding the injury rates, it was identified that in 2015 most of the accidents were located inside the control room and in the reactor (28.57% each one). In 2016, most of the accidents were located on the Pellet line (41.66%). This might require training on the safety aspects on the pellet line. Another objective in terms of trainings would be to have 100% of the staff capacitated in the 'High Importance Training Need'.

7.5.3. Design TO-BE Process

In the new process, the tar generated in the 'Syngas Cleaning' process will be reused as moisture, binders and some of it will be stored. In this new process, after the weak tar goes to the storage tank, it will be distilled. Some of the weak tar will stay in liquid form will be stored in IBCs and some of it will be used as binders. The weak tar in vapour form will be oxidised (combusted) with the syngas from the process and the VOCs will be converted into CO_2 and H_2O. **Figure 93** represents the tar distillation and **Figure 94** the new 'Syngas cleaning' process

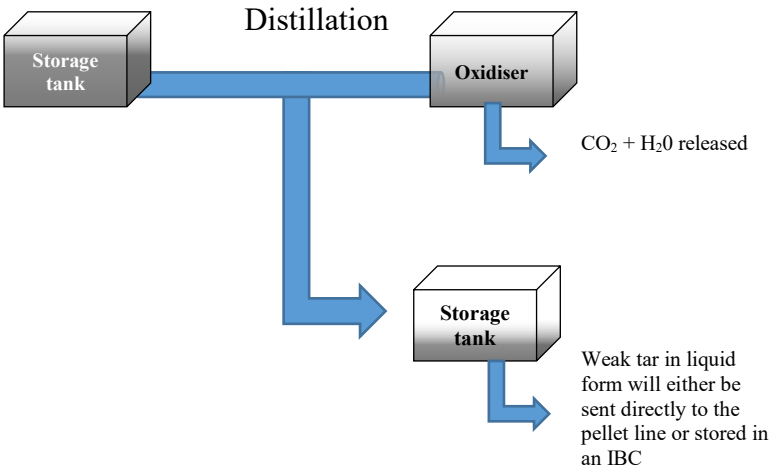

Figure 93 Tar Distillation

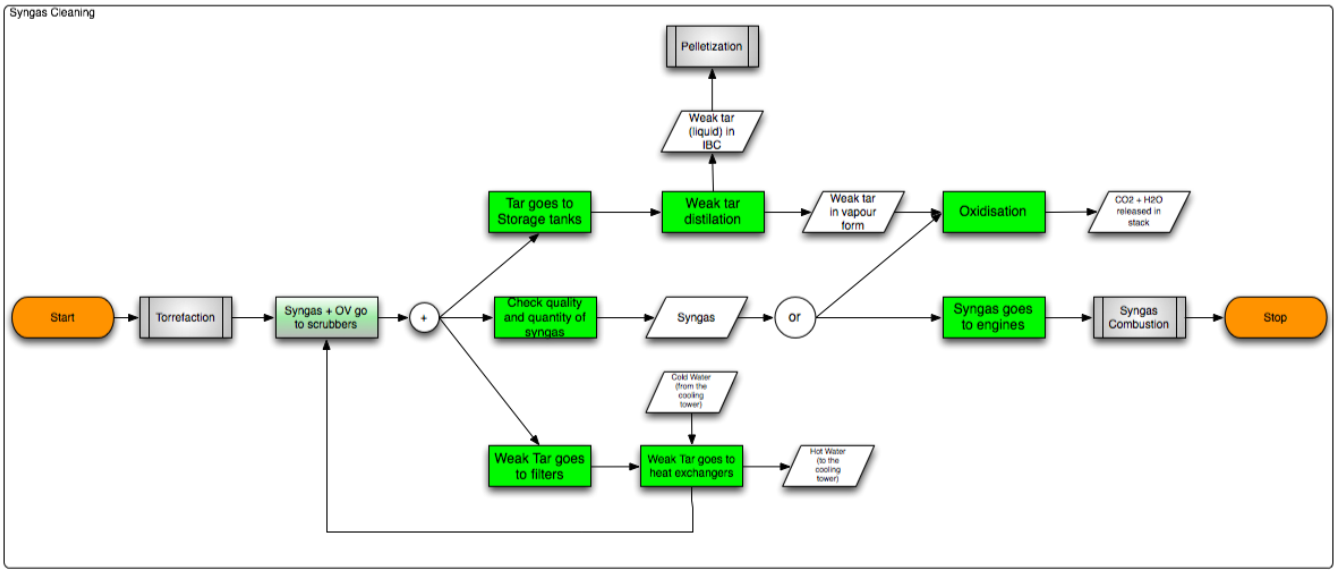

Figure 94 - New Syngas cleaning process

7.5.4. Record predicted metric values

With the new process design, theoretically, the weak tar distillation would have an efficiency of 65% (65% of the volatile composts would be combusted and transformed into $CO_2 + H_2O$). This would represent a reduction of 33.25 m^3 (representing saves of £11,732 on cost) of tar based on last year results (95 m^3) and 64.27 m^3 (representing saves of £12,212.06) based on the theoretical result of full production. Therefore it is possible

to conclude that this will cause a reduction in the operating costs, use of materials (since tar will be used as moisture), and production cost per ton.

More than that, the tool to control the process will help to control the cycle time, percentage of products under specification, percentage of water reused, injury rate and health and safety trainings.

Figures 95 and **96** display, respectively, the predicted Sustainability Performance and Process Performance.

	Sustainability performance				
				AS-IS situation	TO-BE situation
Dimensions	Economic	Direct economic value generated	Operating Costs	Fixed costs: 904,000.4 euros/year Variable costs: 7,152,000 euros/year * based on 2 production lines	↓
	Environmental	Materials	Materials used by weight or volume	44 tons of wood 2 tons of binders 500 Kg of lubricants	↓
		Water	Percentage and total volume of water reused	66.57%	↑
		Emissions, effluents, and waste	Total weight of waste by type and disposal method - tar	95 m3 of weak tar	8,301 m3 weak tar (5,646 m3 to be used as binders)
	Social	Occupational health and safety	Injury rate (IR)	70 in 2015	↓
				130 in 2016	
			Health and safety trainings per employee	Emergency First Aid at work 70.59% Risk Assessment 100.00% Work at height 82.35% Use of firefighting equipment 94.12%	100% 100% 100% 100%

Figure 95 Sustainability Performance - Predicted

	Process performance		
		AS-IS situation	TO-BE situation
Cost	Production Cost per ton (Pct)	97,409.1 euros / ton	↓
Time	Cycle time per ton (Ct)	0.25 tons / h	↓
Quality	Percentage of products (pellet) under specification (Pus)	6%	↑

Figure 96 Process performance - Predicted

The company is currently not in full production, therefore it is hard to predict precisely the values of the TO-BE situation. Thus, one proposal of this work is to establish the routine management. In order to do that, it is proposed a model with the phases of: Assign metrics/process ownership; Define regular measurements periods; Record the metrics in a specific tool; update the dashboard; and Define regular meetings.

7.5.5. Define implementation Strategy

The final stage in the Design phase was to define the implementation strategy. There were mainly four types of Implementation scenarios that can be conducted in a project implementation: 'Big Bang', 'Parallel', 'Relay' and a combination of one or more strategy. According to Jeston & Nelis (2006) in the 'Big Bang' approach the proposed change is introduced in one major overhaul; in the 'Parallel' method the proposed change is introduced step by step (e.g. by location or business unit), with the next roll-out starting before the previous one is finished; the 'Relay' approach the proposed change is introduced step by step, with each roll-out only starting once the previous one has been completed; and the last scenario is a combination of the abovementioned implementation approaches.

For this project, it was used the Parallel method, once it provides a relatively fast implementation and the ability to make use of lessons learned from preceding implementations is valuable. In that case, the two parallel initiatives will be the deployment of the Incineration (Oxidisation) with weak tar in vapour form solution and

the Occupational health and safety initiatives. In the case of the incineration, it will be needed to test the distillation method and then adapt the plant to the new procedure.

7.6. Implement phase

During the Implement phase, there were found a few problems in the Incineration (Oxidiser) – Option 2 with weak tar in vapour form. The main issue was the formation of solid heavy tar at the bottom of the tank, it was blocking the strainer, interrupting the feed. Besides that, there were other problems involved in that, such as: the need of a new tank, the need to insulate the pipes, the need of continuous monitoring, resulting in many costs. More than that, it was likely that the solution did not work due the viscosity of the tar.

Therefore, there was a management decision to change the approach, changing to a simpler solution. The approach chosen was the Oxidiser - Option 1 with weak tar in liquid form. This because there is no need to have a tank, there is no need to worry about insulation, the heavy tar turning into solid, there is a reduction on maintenance costs since there is no need to continuously monitor the process. It involves fewer costs. This approach is currently being tested by the organisation and the development will be carried over the next months.

In the future, the company aims to implement the new process, reusing the tar generated in the 'Syngas Cleaning' as moisture, binders and some of it will be stored. In this way, after the weak tar goes to the storage tank, it will be distilled. Some of the weak tar will stay in liquid form will be stored in IBCs and some of it will be used as an additive.

To help in the implementation of the project it was used the Project Management methodology. To schedule the activities, it was used a Gantt chart (or bar chart). The chart consists of a horizontal scale divided into time units - days, weeks, or months - and a vertical scale showing project work elements - tasks, activities, or work packages. (Nicholas & Steyn 2008).

According to Slack et al. (2013), the monitored measures of project performance at any point in time need to be assessed so that project management can make a judgement concerning overall performance. At the beginning of a project, some activities can be started, but most activities will be dependent on finishing. Eventually, only a few activities will remain to be completed. **Figure 97** shows an example of an S-curve. In this example, the chart represents the progress of the project (in percentage) versus the time (in days). It is possible to observe that in a few moments such as day 20 and day 80 the actual project pace was faster' than what was expected; while in others, such as day 60 it

was slower than what was expected. This is a good tool to monitor the project performance and to make sure that the 'project real status' meets the 'projected status' (or planned status) at the end of the project time. If the project is delayed and unable to reach the final project deadline, the project committee must intervene and define strategies to mitigate this issue, it can be the case of hiring new resources, negotiating a new deadline, negotiating extra-hours to the employees in the project, among other options.

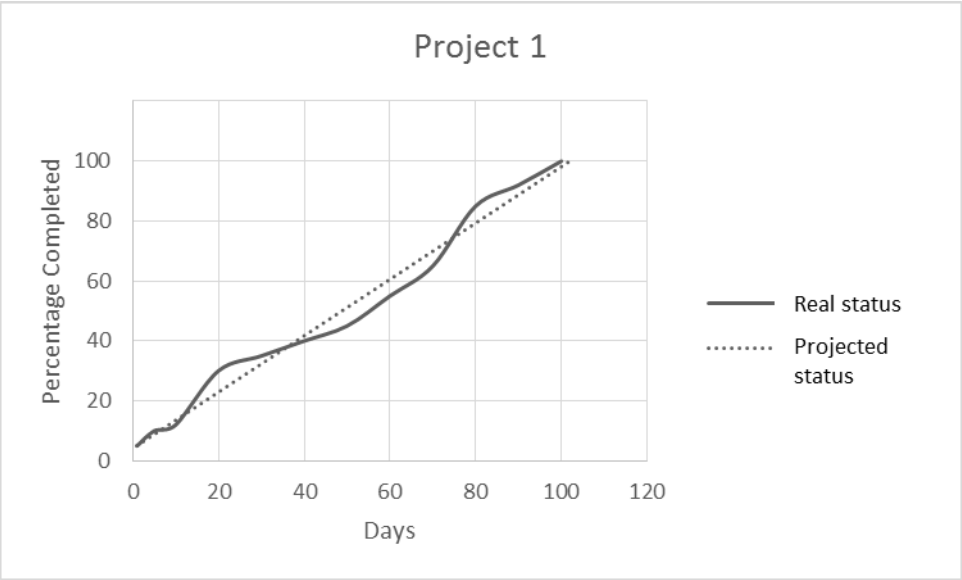

Figure 97 Example of an S-curve

7.7. Monitor & Control Phase

7.7.1. Monitor and analyse organisational performance

According to Jaafreh et al. (2013), based on a previous review, researchers adopted the measurement of organisational performance in term of customer satisfaction, where this Support by Deming (1986) confirmed the focus on quality would lead to outcomes such as employee and customer satisfaction, efficiency, and profitability. The measurement of organisational performance adopted as follows: Customer retention (Improved satisfaction of our clients) (NIST, 2010; Sila, 2007); Reliability and timely delivery of products/services reaches the customer faster (Wilson & Collier, 2000, Sila, 2007); Personalized service (Flynn et al., 1995; Sila, 2007); Value for the money spent (A reduction in the number of customer complaints and grievances) (Dean & Bowen, 1994; NIST, 2010; Sila, 2007).

According to Sila (2007), customer and employee satisfaction and streamlined processes together produce improved operational and financial results, which will eventually lead

to business excellence. A study by Wilson & Collier (2000) empirically tested the causal relationships of the MBNQA framework and overall IS quality. They found significant impact and on business results. There is growing evidence that QM implementation has improved organisations' performance and significantly affected most organisations (Dewhurst et al., 2003). Several studies showed that QMPs had the most substantial effect on the quality performance measures such as Flynn et al. (1994) and others founded positively correlated with organisational performance such as (Powell, 1995; Ahire et al., 1996; Samson & Terziovski, 1999; Agus, 2003; Rao et al., 1999; Kaynak, 2003; Prajogo & Sohal, 2003; 2006; Sila & Ebrahimpour, 2005; Zu, 2009).

7.7.2. Monitor and analyse process performance

The main aspects to be monitored in the oxidiser are the Pressure and Temperature (of the oxidiser). In order to avoid flooding the oxidiser, it is required to monitor the weak tar flow rate, which is reflected by the pressure. Thus, a pressure gauge would adequate to be used as a process control tool.

The oxidiser temperature is another critical aspect. In order to destroy all the VOCs, the temperature should be between 700 - 1000 degrees Celsius. That because temperatures below 700 degrees Celsius can cause incomplete combustion, which would release organic components to the atmosphere (the complete combustion only releases CO_2 and H_2O).

The process metrics defined in section 7.6.5. Define metrics can be monitored as follows:

Table 51 Monitor Process performance

	Process performance	
		How to monitor
Cost	Production Cost per ton (Pct)	Monitor cost of - Wood - Binders - Water
Time	Cycle time per ton (Ct)	- Monitor batch times on a weekly/monthly basis - Use of statistical tools, such as scatter plot analysis

Quality	Percentage of products (pellet) under specification (Pus)	- Monitor batch quality - Evaluate the pellets under specification over the full batch production

In addition to these monitoring techniques, regular meetings were defined in order to follow up the process performance.

7.7.3. Monitor and analyse sustainability metrics

Table 52 Monitor Sustainability performance

Sustainability performance			
			How to monitor
Economic	Direct economic value generated	Operating Costs	Monitor cost of: - Wood - Binders - Water
Environmental	Materials	Materials used by weight or volume	- Monitor the material consumption per month - Use of statistical tools, such as scatter plot analysis
	Water	Percentage and total volume of water reused	- Monitor water consumption per month - Use statistical tools, such as scatter plot analysis
	Emissions, effluents, and waste	Total weight of waste by type and disposal method - tar	- Monitor the tar waste per month - Use statistical tools, such as scatter plot analysis
Social	Occupational health and safety	Injury rate (IR)	

		Occupational diseases rate (ODR)	Monitor the occupational health and safety data
		Lost day rate (LDR)	
		Absentee rate (AR)	

In order to help to monitor and control the sustainability metrics, it was suggested routine management with the following steps:

- Assign metrics ownership

The metrics owner is someone who monitors and reports the metrics. This approach has some advantages from a complexity viewpoint:

  - It focuses attention on the key sustainability issues for the organisation
  - It splits the responsibility amongst the personnel while providing
  - It improves the awareness of the sustainability metrics in the organisation

- Define constant measurements

The constant measurements help to provide more data over time. With more data, it is possible to define trends and analyse patterns.

- Record in a Statistical Process Control chart / Create and update Dashboard

According to Silva et al. (2017), Statistical process control (SPC) is the designation of the approach, which utilises multivariable models for the purposes of process monitoring. The strategy is well documented in the literature (such as Barla et al., 2014; 2011; Kona et al., 2013; MacGregor and Cinar, 2012; Macgregor and Kourti, 1995; MacGregor et al., 2005).

In order to facilitate the view of the SPC data, it was recommended the creation of a Dashboard. A dashboard provides real-time information aggregating and extracting data from the KPIs (or metrics). It is a useful tool for analysis. For this project, it was used the software Tableau Public, an open source web application that allows the publication of the dashboard on the web, to exemplify the application of a Dashboard.

Figure 98 represents the Software view of the SPC and **Figure 99** represents the web view of the SPC.

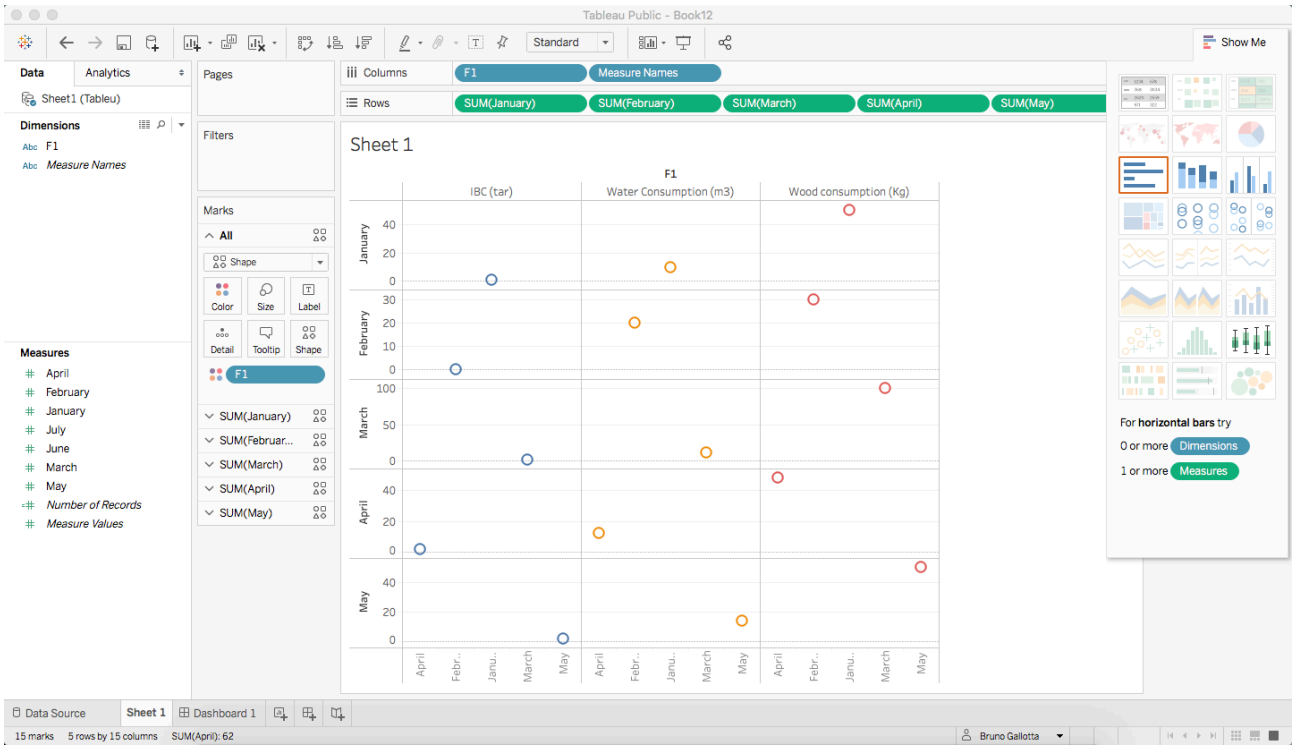

Figure 98 Tableau public screen

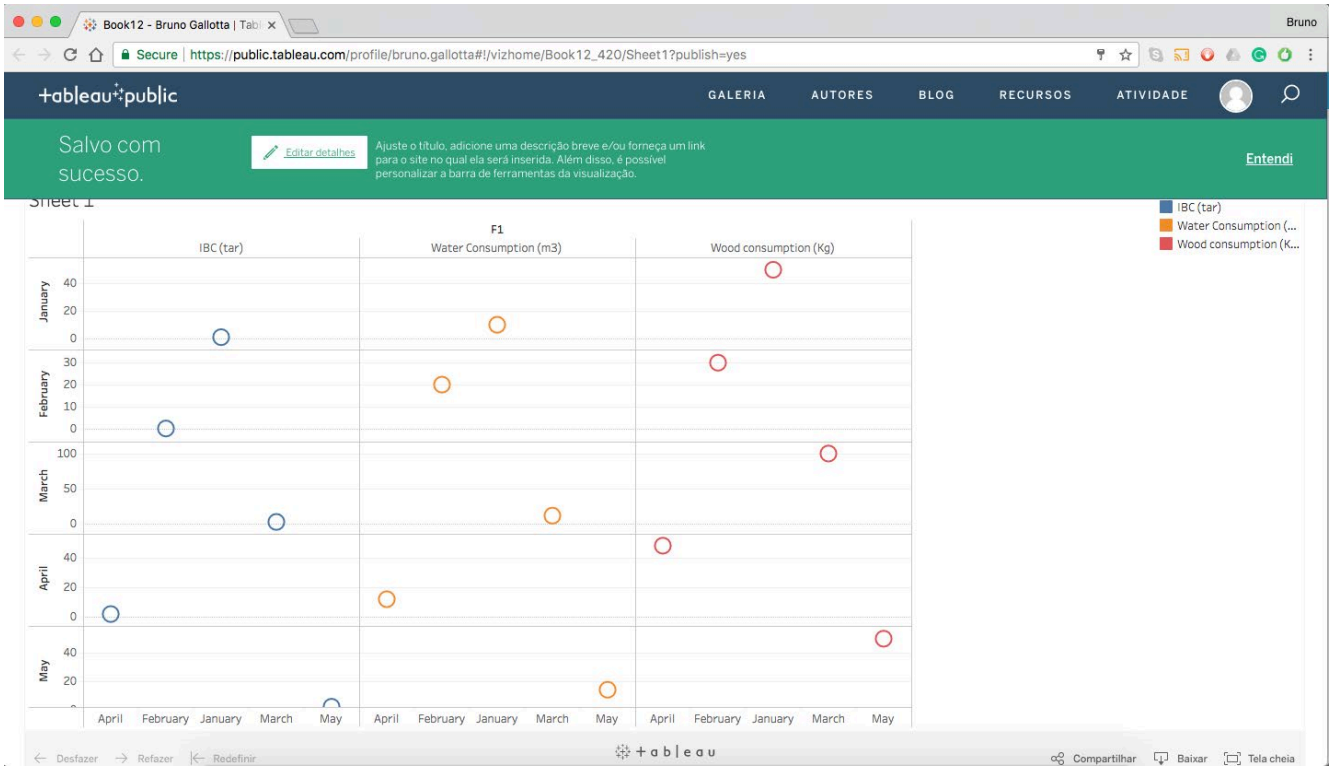

Figure 99 - Tableau web screen

- Define regular meetings for follow up

Regular meetings are helpful to make the staff aware of the current developments on the metrics. Beyond that, they help to inform and to solve potential issues faced by the organisation.

The model defined to be followed was one agile methodology, known as Scrum, which is based on principles of lean manufacturing (James, 2009). According to Scrum organisation, Scrum can be identified as a management and control process that cuts through complexity to focus on building products that meet business needs. Management and teams are able to get their hands around the requirements and technologies and deliver working products, incrementally and empirically. According to Vlietland (2015), a Scrum development lifecycle consists typically of short (2–4 weeks) iterations, which enables swift feedback from related stakeholders about the developed solution. **Figure 100** represents the Scrum framework.

Figure 100 Scrum framework. Adapted from scrum.org - content removed for copyright reasons

The primary objective of the definition of the routine is to achieve repeatability in the process.

7.7.4. Realise value

After monitoring the metrics, it is possible to evaluate the actual state of the sustainability implementation. According to Jeston & Nelis (2008), a project is only complete once the reason for its existence has been achieved and it has been handed over to the business in such a way that the business can now sustain the project outcomes. If the initial goals are not fully realised, it is necessary to investigate the reasons and start the cycle in the missing point.

7.7.5. Identify optimisation opportunities

The last step in the Monitor & Control phase and in the whole cycle is to 'Identify optimisation opportunities'. As Heraclitus would say, "the only constant in life is

change". For the sustainability topic is not different, changes are constant and they can be related to the legal requirements, the customer needs, the market new best practices. Thus, it is essential to have the concept of the continuous improvement in the framework (Gallotta, 2016).

7.8. Chapter summary and conclusion

The chapter provides an Action Research study to validate the framework to implement sustainability initiatives in the business processes presented in chapter 5. The action research has a participatory and collaborative bias and contributes mutually to the Organisation and the Research. The study represents an empirical application of the framework in a biomass company focused in sustainable energy technologies. The company is generating an excess of tar and it is currently disposing the substance using a third-party company. In order to provide a solution to the excess of tar generated, it was used the framework to implement sustainability business processes using the Business Process Management (BPM) approach. The project has concluded the Analyse and Design phases. During the Implement phase, there were found a few problems with the proposed solution and then another approach was designed. Finally, in the Monitor and Control phase, there were identified methods to measure the process performance and sustainability performance.

Chapter 8 - Conclusions and recommendations

8.1. Introduction

This final chapter develops the conclusions of this dissertation. Chapter 1 has provided the introduction of the research, outlining the problem statement, the aims, objectives, research question and rationale. Chapter 2 has presented the concepts of sustainability, how it is being implemented by organisations and what are the challenges and problems with the current ways to implement them. This chapter has identified the lack of attention paid to the implementation of Sustainability in business processes. One methodology to help the implementation of sustainability practices in business process is Business Process Management (BPM), which was detailed in Chapter 3, presenting the Process Management origin and evolution; the definition of the concept; the phases to implement the approach; and how it can be related to Sustainability. Chapter 4 has presented the Research Methodology and approach. In Chapter 5, it was developed the Conceptual Framework to Implement Sustainability Initiatives in the Business Processes. Chapter 6 verified the framework using the Delphi method. Chapter 7 has provided the validation of the framework using the action research method. Finally, chapter 8, begins with the findings from the research project. Then, it is related to the project aim and objectives. The chapter also outlines the research contribution for the sustainability topic, the practical implications, the limitations and future work. Finally, the chapter presents the final conclusions and the final comments (related to the dissertation experience).

8.2. Findings and actions in relation to the project's aim, objectives and research question

This section summarises the evidence gathered through this research project and the results obtained from the different studies performed. Its objective is to draw conclusions over the research aim and objectives presented in section 1.3 and the research questions included in section 1.4.

This research aimed to provide a full lifecycle solution for improvement of business processes into sustainability business processes in one organisation by conducting a literature review in the fields of sustainability, sustainability implementation and Business Process Management; identifying and critically review the best practices frameworks to implement sustainability projects; creating a model or framework to help organisations to implement sustainability practices in their business processes in a better way; and creating a conceptual study case using the model developed.

Conduct a literature review in the fields of sustainability, sustainability implementation and Business Process Management;

Chapter 2 has provided the literature review in the fields of Sustainability and Sustainability Implementation. 'Sustainability' has several definitions. This chapter then begins reviewing the concept of sustainability ever since the initial ideas of the topic (presented at the UN conference on the human environment in 1972). After that, the chapter discussed that organisations need to adopt sustainability practices, the current ways to implement them and what are the challenges and problems with current ways to implement sustainability initiatives. One possible approach to tackle these problems is to use the BPM approach. Chapter 3 have provided a complete literature review in the Business Process Management field, presenting definitions, the Process Management origin and evolution; the definition of the concept; the phases to implement the approach; and how it can be related to Sustainability.

Identify and critically review the best practices frameworks to implement sustainability initiatives;

Chapter 2 has identified the best practices frameworks found in the literature to implement sustainability initiatives from different angles, such as Human aspect (Robinson et al., 2006 and Vora, 2013); Sustainability Indexes/Reporting facet (Tan et al., 2010; and Ahmed & Sundaram, 2012); Project Management side (Silvius & Nedeski, 2011; Silvius, Schipper and Nedesky, 2012; Agyekum-Mensah et al., 2012); and Operations aspect (Thies et al., 2012; Uddin & Rahman, 2012; and Tan et al., 2008).

It was identified that current models to implement sustainability practices do not address fully the sustainability challenge (Ahmed & Sundaram, 2012). Beyond that, several sustainability implementation initiatives focus in one specific department of the organisation (IT sector in Uddin & Rahman (2012)'s study, warehouse in Tan et al. (2008) and Tan et al. (2010) studies, Logistics in Rossi et al. (2013)' study). They, however, do not consider that those departments work along with other departments into an end-to-end process (systemic view). Therefore, a more refined analysis would consider the whole process interaction to evaluate the full status of the sustainability implementation.

Create a model or framework to help organisations to implement sustainability practices in their business processes in a better way;

Chapter 5 has presented the Conceptual Framework to Implement Sustainability Initiatives in the Business Processes created during the MRes stage of the research, which

is based on Business Process Management principles containing four main phases: (Analyse Phase; Design Phase; Implement Phase; and Monitor & Control Phase). Then, the chapter describes each step contained in the phases (Identify Business Scenario; Identify Project Stakeholders; Define Project Objectives; Define Metrics; Record enterprise map - AS-IS Situation; Record baseline values; Perform Sustainability Maturity Assessment; Define Scope; Identify improvement opportunities; Design TO-BE Process; Record predicted metric values; Define implementation strategy; Transform Business Processes; Execute the new Processes; Monitor and analyse organisational performance; Monitor and analyse process performance; Monitor metrics; Realise value; and Identify optimisation opportunities). The chapter also identifies enablers for the framework's implementation (governance, strategy, methods, information technology, change management, leadership, and culture) and discuss their role.

Verify the conceptual model

Chapter 6 presents the verification of the framework proposed in chapter 5 using the Delphi method. The study reported a consensus in the phases and steps of the conceptual framework and provided feedback from the panellists. According to them, leadership, people and cost were identified as the main challenges related to the sustainability adoption by the organisations and key performance indicators (KPIs), Lifecycle assessment (LCA) and triple bottom line (TBL) were identified as the primary methods to assess al the sustainability dimensions in terms of business processes. After the verification of the framework by the experts, the main change was regarding the enablers, according to them, the main enablers for the framework's implementation should be: Corporate governance, business strategy, organisational culture and leadership.

Validate the conceptual model

Chapter 7 presents the validation of the framework proposed in chapter 5 using action research. The study exemplified the use of the framework in a real-world biomass company based in the UK that was having a problem with residue from its production. The study aimed to propose new processes and ways to minimise its generation. The project has faced some difficulties while implementing the proposed solution, but have concluded the Analyse and Design phases. In the Monitoring and Control phase, it was identified methods to measure the process performance and sustainability performance and it presents a list of recommendations for the organisation to improve its production and sustainability status.

The research questions were:

- How can an organisation adopt sustainability practices in their business processes?
- What are the benefits to adopt sustainability initiatives in the business processes?
- What are the main challenges to adopt sustainability initiatives in the business processes?
- What is the most efficient way to adopt sustainability initiatives in the business processes?

The research outlined that the business process management (BPM) approach can be used as a way to implement sustainability practices in an organisation's business processes by using the conceptual framework (presented in chapter 5). The benefits from this approach are the enablement of continuous process improvement, improvement of process quality; cost reduction; increase in the customer satisfaction; and better control over process performance (Gallotta, 2016), which can be directly linked to the improvement of the sustainability improvement.

8.3. Discussion

8.3.1. Sustainability Implementation

As it was discussed in chapter 2, Sustainability is already a subject relevant to the business community for a while and this concept is becoming an increasingly strategic and integrated into companies. More and more organisations are looking to adopt sustainability practices in their operations, strategy, and processes. Sustainability has been receiving growing importance in the corporate environment in recent years and Sustainable Operations Management (SOM), in particular, has started receiving attention from both operations management and management science researchers, since it has a potentially vital role in providing solutions for the complex sustainability challenges faced by many organisations (Kleindorfer et al., 2005; White and Lee, 2009).

However, adopting sustainability practices is not something trivial. The project implementation involves several elements of an organisation (such as stakeholders, culture and business environment) and has several barriers (such as setting clear and measurable goals, comprehending stakeholder reactions and selecting the right sustainability Indicators). Existing roadmaps, frameworks and systems do not comprehensively support sustainable business transformation nor allow decision makers to explore interrelationships and influences between the sustainability dimensions. More

than that, several current solutions tend to focus on one specific department of the organisation. This goes in the opposite direction of recent administration theories that considers process-centric as a key characteristic to improve the organisation's performance. Thus, a more refined analysis would consider the whole process interaction to evaluate the full status of the sustainability implementation.

Nonetheless, many sustainability implementation initiatives have focused in one specific department of the organisation, e.g. IT (Uddin and Rahman, 2012), warehouse (Tan et al., 2010; Tan et al., 2008), logistics (Rossi et al., 2013), etc. They, however, do not consider that those departments work along with other departments into an end-to-end process. According to Porter's (1985) model, products pass through activities of a chain in order, and at each activity, the product gains some value. Similarly, we can consider that the 'product' (in the case of a product-based industry) gains some 'sustainability impact' in each activity. Therefore, a more refined analysis would consider the whole process interaction to evaluate the full status of the sustainability implementation.

8.3.2. Framework

In order to develop the Conceptual Framework to Implement Sustainability Initiatives in the Business Processes, it was initially analysed current ways to implement sustainability. After that, the literature review identified what were the barriers to implementing sustainability initiatives. The next step was to identify potential methodologies to address the problem. Business process management was chosen due to its capability to work in a cross process way while providing the full control of the process performance. Chapter 5 provides the different BPM models found in the literature. As it was discussed in chapter 2, the sustainability implementation success is directly related to the alignment of the strategy and business processes in an explicit manner. This way, it was proposed a four phases framework (Analyse, Design; Implement; and Monitor & Control), in which the Analyse phase has broken down the elements from the "process planning & strategy" into the identification of business scenario, determination and prioritisation of processes, identification of project stakeholders, definition of project objectives, definition of metrics, record enterprise map, record baseline values and sustainability maturity assessment. The four phases framework also can be related to Deming's PDCA cycle, which might facilitate the implementation of the sustainability initiatives.

8.3.3. Delphi study:

The Delphi method was used to verify the framework once it gathered the opinions of specialists in sustainable operations management from several locations over the proposed framework. However, as it was more discussed in chapter 6, one disadvantage of the Delphi method is the high attrition rate. Since the method requires lengthy responses in the early rounds of the process and the active participation of participants over several weeks, the potential for a high drop-out rate of panellists exists (Sommerville, 2008; Borg & Gall, 1983). This was actually one of the issues of the study, since there was a drop out of 23% from round one to round two (from 21 to 16 respondents).

Another aspect that was observed was the low number of responses (21 from 93 people contacted), this might have two causes. One is because most of the participants identified were found on LinkedIn, Research gate, conference publications, and universities. The other cause might be related to the time of the year, since the study was held between June and August 2016, which corresponds to the European summer, time of the year that most people are out of the office for their annual leave.

8.3.4. Action research

The action research method was used to validate the framework. Company A was chosen for the study due to its commitment to sustainability practices. Company A, however, is a small enterprise with a lower level of process maturity. This aspect affected the research, once it was unable to achieve its full potential. The implementation phase identified a problem in the proposed solution for the problem and it was redesigned. The monitor and control phase was not entirely followed, the step "monitor and control organisational performance" was not relevant to the organisation and, thus, was not performed. Since the implementation was not concluded, the steps of "Realise value" and "identify optimisation opportunities" were also not able to be concluded. In several moments, the action research study faced some difficulties regarding the boundaries between the academic purposes and the business interests.

After concluding the study, an interview was held with the managing director of the company to obtain his feedback regarding the research and the framework. According to him, the initial view of the framework is "dense" and "seems too complex". However, after analysing the steps and phases, the framework reads well and "have a good flow". According to his feedback, the research is essential for new production systems but might

face difficulty to be adopted on small companies, due to its lack of process/sustainability maturity. In order to improve it, he recommended to fully understanding what is the target for this research, company size, company location and industry. Finally, he proposed the creation of best practices in terms of sustainable processes.

8.4. Research Contribution to the Sustainability Implementation Field – Theoretical Implications

Chapter 2 has identified the best practices frameworks found in the literature to implement sustainability initiatives from different angles, such as Human aspect (Robinson et al., 2006 and Vora, 2013); Sustainability Indexes/Reporting facet (Tan et al., 2010; and Ahmed & Sundaram, 2012); Project Management side (Silvius & Nedeski, 2011; Silvius, Schipper and Nedesky, 2012; Agyekum-Mensah et al., 2012); and Operations aspect (Thies et al., 2012; Uddin & Rahman, 2012; and Tan et al., 2008). It was identified that current models to implement sustainability practices do not address fully the sustainability challenge (Ahmed & Sundaram, 2012).

This research, then, provides a new approach for the implementation of sustainability initiatives in business processes, combining aspects from operations management field to the sustainability topic. According to Gunasakaran et al. (2015), Sustainable Operations Management (SOM) has started receiving attention from both operations management and management science researchers. This study provides a new step for the application of sustainability practices in the Operations Management scenario, providing tools and methods to improve the likelihood of success of those initiatives.

8.5. Practical Implications of the Research

The last twenty years have seen growing pressure on businesses to pay attention to the environmental and resource consequences of their products and processes (Kleindorfer et al., 2005), which has resulted into the increase of Sustainable Operations Management (SOM) research (Walker, 2014). According to Houy et al. (2012) taking resource scarceness, increasing pollution and the debate on global warming into consideration, more and more organisations recognise the upcoming need to improve the sustainability of their business processes. According to Thies et al. (2012), leading enterprises are even going beyond static sustainability reporting by incorporating environmental and social activities into their core business processes. Organisations increasingly realises the importance of sustainability, and many are trying to design or redesign their business processes so that their activities are more environmentally friendly (Klassen & Vachon,

2003). Such companies have in particular understood the value of improving their processes to achieve environmental excellence; the same way they collaborate with others to improve their supply chains with respect to time, quality, flexibility, agility and total cost (Handfield, Sroufe, & Walton, 2005; Sharfman, Shaft, & Anex, 2009).

The research, then, provides a framework using the Business Process Management (BPM) approach, which offers a systemic solution for the organisations adopt sustainability practices in their business processes. The advantages of the use of this methodology include: enablement of continuous process improvement; improvement of process quality; cost reduction; increase in the customer satisfaction; and better control over process performance (Gallotta, 2016). This study provides an applied overview of the topic and can be used as a handbook for managers, consultants and practitioners in the topic of sustainable operations management.

8.6. Research Limitations and further research

The main limitation of this research is the application of the framework in only one real-life scenario, which was expected due to the research method was chosen to validate it. Future work aims to apply the framework in different scenarios, in organisations with different sizes, different maturity level, different sector, and different locations. Further research will also investigate the symbiosis of the BPM approach with other management approaches, such as lean/green manufacturing, project management, green supply chain and carbon footprint. In addition, in a further moment, once companies are familiarized with the project methodology, it is possible to create a centre of excellence (an area within the organisation with the best practices/ processes of the industry) in terms of sustainability bringing even more value, improving continuously and generating more innovation by the form of green reference process models.

8.7. Final comments – dissertation experience

The author's personal experience in conducting this research project and writing his dissertation can be considered at the same time stressful, but also positive and satisfactory. As a PhD (new Route) student and Business Consultant, this research project has allowed the author to apply Business Process Management (BPM) concepts to the Sustainability topic.

Regarding the dissertation's writing process that the author went through, it was observed an improvement in the academic writing skills. The author appreciates the guidance offered by Dr Jose Arturo Garza-Reyes (dissertation's supervisor) and Dr Tony Anosike

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Appendices

The appendices section contains information that is too detailed for the thesis. Appendix A is, B, C, D ,E

Appendix A. Experts information for the Delphi study

Occupation	Institution
Adjunct Associate Professor of Operations Management	MIT
Adjunct Lecturer of Finance	Northwestern University
Affiliate Professor	HEC Paris
Assistant Professor	University of Warwick
Assistant Professor, Department of Operations, Innovation and Data Sciences	ESADE Business & Law School
Assistant Professor, Department of Operations, Innovation and Data Sciences	ESADE Business & Law School
Associate Fellow	University of Oxford
Associate Professor	University of Massachusetts Lowell
Associate Professor in Operations Management	University of Oxford
Associate Professor of Business Administration	Harvard Business School
ASSOCIATE PROFESSOR OF OPERATIONS, TECHNOLOGY AND INFORMATION MANAGEMENT	Cornell
Associate Professor of Technology and Operations Management	Insead Business School
Associate Professor, Department of Operations, Innovation and Data Sciences	ESADE Business & Law School
Business Operations & Supply Chain Expert | Consultant | Visiting Professor	Cranfield University
Business Projects Manager	B2Blue.com
CEO	Galica Lean & Galica EHSS

CEO	Global Supply and Procurement
CEO	Monsanto
Chair Professor	Universität Liechtenstein
Coffee and Sustainability Operations Manager	Nestlé Nespresso S.A.
Department of Management and Technology	Universita Bocconi
Deputy Director Operations & Utilities	University of Surrey
Director	Triple Bottom Line Ltd
Director of Corporate Sustainability	WWF
Director of Strategy and Operations	University of Cambridge
Director of Process Improvement	Willmott Dixon Interiors
Environment & Sustainability Director	OST Energy
Environmental Officer	Cytec
European Sustainability Manager	HAVI Global Solutions
Executive Director,	Haas School of Business
Fred R. Sullivan Professor	Wharton University of Pennsylvania
Green developer	Greendevelopments
Head of Energy and Environment:	Imperial College London
Lecturer	Pontificia Universidade Catolica
Lecturer	Senac
Lecturer	Universidade Federal de Minas Gerais
Lecturer in Operations Management	Durham University
Lecturer in Sustainable Enterprise	University of Surrey
Lecturer in Operations & Supply Chain Management	Coventry University
Lecturer in Operations Management	Aston University
Manager	AB INBEV
Manager	Nestle
Manager	Strategy & Sustainability
Manager Sustainability Services	PwC AG

Managing Consultant	Urbanag CIC
Managing Partner	Systemica
Operations Manager	University of Cambridge
Operations Sustainability Manager	Kingston University
Practitioner	Unipart Expert Practices
Professional Researcher	Haas School of Business
Professor	Heriot Watt University
Professor	Lancaster University
Professor	Universidad Autónoma de Aguascalientes
Professor	Universidade de Sao Paulo
Professor	Universidade Federal da Bahia
Professor	Universidade Federal de Minas Gerais
Professor	Universidade Federal de Santa Catarina
Professor	University of St Gallen
Professor	University of Surrey
Professor of Logistics	Huddersfield
Professor of Operations, Information, and Technology	Stanford University
Professor of Performance Management/Controlling	University of St Gallen
Professor of Supply Chain and Operations Management	Coventry University
Professor of Technology and Operations Management	Insead Business School
Professor, Department of Operations, Innovation and Data Sciences	ESADE Business & Law School
Reader in Supply Chain Management	University of Nottingham
Research Associate	MIT
Research Fellow	University of Oxford
Research Professor	Universidade Municipal de Sao Caetano do Sul
Researcher	Cranfield University

Researcher	Instituto de Pesquisas Energéticas e Nucleares - IPEN
Researcher	Universidade de Sao Paulo
Researcher	Universidade de Sao Paulo
Researcher	Universidade Paulista
Researcher	Volvo
Safety & Sustainability Improvement Specialist	Network Rail
Senior Associate	University of Cambridge
Senior Distribution Development Manager	Coca-Cola Enterprises
Senior Lecturer	MIT
Senior Lecturer	University of Bradford
Senior Lecturer	University of Brighton
Senior Lecturer in Operations Management and Business Excellence	Instituto Politécnico Nacional
Senior Lecturer in Operations Management	University of Northampton
Senior Project Manager	University of Cambridge
Service Process Design Consultant	Paraboloidal Management and Consultancy
Sr. Manager, Corporate Social Responsibility Strategy and Sustainability Operations	Raytheon
Sustainability Consultant	BASF
Sustainability Consultant	SAP
Sustainability VP	Corbetti Geothermal plc
Sustainability Manager	Waste Management
Sustainability Operations Manager	RobecoSAM
Vice President Sustainability, Strategic Operations Manager	Healthy Buildings
VISITING PROFESSOR OF BUSINESS ADMINISTRATION	Tuck school of business

Appendix B. Delphi study first round – Questionnaire

Sustainability Implementation

Sustainability implementation using Business Process Management

Delphi Study - Round 1

* Required

1. **1. Is Sustainability Implementation directly linked to Process Management?** *
   Mark only one oval.

   - Yes
   - No

2. **Please justify your answer**

Business Process Management & Sustainabiliity Implementation

3. **2. If Sustainability implementation is related to Process Management, is it justified to use the Business Process Management (BPM) approach? According to ABPMP (2009), Business Process Management is a disciplined approach to identify, execute, measure, monitor, and control both automated and non-automated business process to achieve consistent, targeted results, which are aligned with an organisation's strategic goals.** *
   Mark only one oval.

   - Yes
   - No

4. **Please justify your answer.**

Business Process Management & Sustainabiliity

The following figures represent the BPM framework.

Figure 1 - BPM implementation. Adapted from Scheer, (2006)

https://docs.google.com/forms/d/1y-nCipn_LbIW9PQWgIGBEHle3KoypH8qUrqMNkkywW0/edit 1/8

Figure 2 - BPM implementation. Netjes et al. (2006)

Figure 3 - BPM Lifecycle - ABPMP (2009)

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Figure 4: Conceptual Framework to Implement Sustainability Initiatives in Business Processes

content removed for copyright reasons

5. 3. Considering the BPM frameworks from Figure 1, Figure 2 and Figure 3, is it justified to represent the implementation of Sustainability initiatives using the BPM tool as the framework from Figure 4 suggests? *

Mark only one oval.

- Yes
- No

6. Please Justify.

Conceptual Framework

Figure 5: Conceptual Framework to Implement Sustainability Initiatives in Business Processes

7. **4. Which of the steps would be mandatory to an Analyse phase** *

Mark only one oval per row.

	Strongly Disagree	Somewhat Disagree	Neither agree or disagree	Somewhat Agree	Strongly Agree
Identify Business Scenario					
Determine and prioritize processes					
Define stakeholders					
Define project objectives					
Define Metrics					
Record enterprise map					
Record baseline values					
Perform Sustainability maturity assessment					

8. **If you have given a low rating for any of the statements, please justify. Please feel free to add any other comment.**

9. **5. Which of the steps would be mandatory to a Design phase** *
Mark only one oval per row.

	Strongly Disagree	Somewhat Disagree	Neither agree or disagree	Somewhat Agree	Strongly Agree
Define Scope					
Identify Improvement Opportunities					
Design to-be process					
Record predicted metrics values					
Define Implementation Strategy					

10. **If you have given a low rating for any of the statements, please justify. Please feel free to add any other comment.**

11. **6. Which of the steps would be mandatory to an Implement phase** *
Mark only one oval per row.

	Strongly Disagree	Somewhat Disagree	Neither agree or disagree	Somewhat Agree	Strongly Agree
Transform Business Processes					
Execute new processes					

12. **If you have given a low rating for any of the statements, please justify. Please feel free to add any other comment.**

13. **7. Which of the steps would be mandatory to a Monitor and Control phase** *

Mark only one oval per row.

	Strongly Disagree	Somewhat Disagree	Neither agree or disagree	Somewhat Agree	Strongly Agree
Monitor and analyse organisational performance					
Monitor and analyse process performance					
Monitor Metrics					
Realise value					
Identify optimisation opportunities					

14. **If you have given a low rating for any of the statements, please justify. Please feel free to add any other comment.**

15. **8. Which of these options can be viewed as enablers to the implementation of sustainability projects** *

Check all that apply.

- [ ] Corporate Governance
- [ ] Business Strategy
- [ ] Methods
- [ ] Information Technology
- [ ] Change Management
- [ ] Leadership
- [ ] Organisational Culture
- [ ] Other: _____

16. **Please feel free to add any other comment.**

Contact Information

Appendix C. Delphi study second round - Questionnaire

Sustainability Implementation

Sustainability implementation using Business Process Management

Delphi Study - Round 2

* Required

1. **1. In your opinion, what are the main challenges to implement sustainability initiatives in organisations?** *

Business Process Management & Sustainabiliity Implementation

2. **2. In your opinion, how is it possible to assess all the sustainability dimensions (social, environmental and economic) in terms of Business Processes?** *

Conceptual Framework

Please consider the following conceptual framework to answer the next questions.

Figure 1: Conceptual Framework to Implement Sustainability Initiatives in Business Processes

3. 3. Considering the framework from Figure 1, would you change the order of the steps or suit it in a different phase? *

Mark only one oval.

- No
- Yes

4. Please justify your answer. *

5. 4. How would you improve the framework? Feel free to add any other comment. *

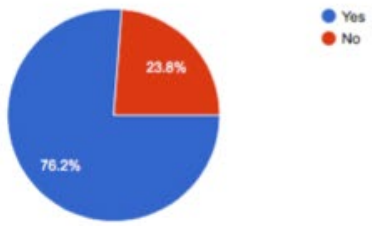
Appendix D. Delphi study first round - Results

Sustainability Implementation

21 responses

1. Is Sustainability Implementation directly linked to Process Management?

21 responses



Please justify your answer

14 responses

Não é algo que seja imprescindível, mas a visão por processos auxilia na implantação da sustentabilidade

Sustainability is a wider concept realated to the environment, social, and economic issues.

I want to answer both, I think the sustainability implementation takes several ways into the organisation. Sometimes the initiative of people is created before any intent of changing the process and procedures.

In my point of view, when we approach sustainability, we definetively have to rethink our process (inbound and outbound). That´s why sustainability is linked to process management

Sustainability is linked to business processes results in several ways. There are business processes that directly affect sustainability results, such as product development and manufacturing; and some business processes can influence business sustainability, for example, the strategic planning and human resource management processes.

The process should be sustainable in any stage (waste , energy and ultimately reworkable)

If you don't have sustainable processess, how can you talk about sustainability in a company?

There is a need to create changes, new approaches to sustainability, in the core processes of companies.

For any implementation, it is more efficient to link with process management, to reduce waste of materials and waste of time, for example.

I believe that sustainability must be part of the process as a whole. And not that it should be implemented as separate processes and actions that already exist in the business.

In my view, the implementation activity is a process in itself, which has to be adequately managed.

It can be linked. But you also can implement a Process Management without using the sustainability issues.

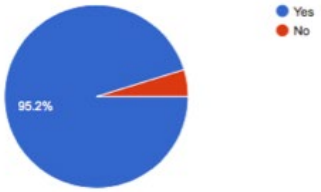
It is one part of sustainability implementation but it is the part that will realise many of the benefits operationally.

Life itself is made of processes. They are everywhere, not only on manufacturing places..thus, sustainability can be related to every scope of our lives

Business Process Management & Sustainability Implementation

2. If Sustainability implementation is related to Process Management, is it justified to use the Business Process Management (BPM) approach? According to ABPMP (2009), Business Process Management is a disciplined approach to identify, execute, measure, monitor, and control both automated and non-automated business process to achieve consistent, targeted results, which are aligned with an organisation's strategic goals.

21 responses



Please justify your answer.

11 responses

It could be a process level. Some processes may help to support key strategies.

I consider it important to integrate the sustainability into the management system yes, but that also depend on how and in which extent the BPM is applied. That could differ in organisations.

All company has business processes, but most of them do not explicitly adopt BPM. Furthermore, there are companies which adopt BPM and have problems in its implementation and execution. So, if all company has business processes and these business processes result in corporate sustainability, BPM can contribute to sustainability implementation.

BPM is about efficiency and cost not about sustainability

You can only verify the sucess of a sustainability implementation if you have data to measure, monitor, and control sustainability issues linked to the strategic goals of a organization

it provides a holistic view of the companies core processes

If with BPM you can manage the process, it is the way to have information and control of the system, so it is the way to manage sustainability implementation.

Yes, the inclusion of the sustainability issue should be part of the end to end process. It makes no sense to apply sustainability separately, because this complicates the understanding and also the application on a daily basis.

Yes, I think you can use a BPM approach to manage processes properly.

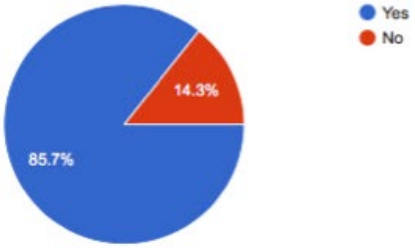
Although I say yes, this is because of the alignment with strategic goals. It may be that more flexibility is required for sustainability implementation including trial and error and so parts of it should be used.

You may use the BPM to make the process lean and improve the sustainability of a process by eliminating unnecessary things that may be indentified with the BPM

Business Process Management & Sustainabiliity

3. Considering the BPM frameworks from Figure 1, Figure 2 and Figure 3, is it justified to represent the implementation of Sustainability initiatives using the BPM tool as the framework from Figure 4 suggests?

21 responses



Please Justify.

12 responses

nem todos os itens da figura 4 foi possível ler... estão muito pequenos.

It looks a bit complex in Figure 4, but core activities in the middle looks fine.

I believe that you should be careful with 1) analysis and design steps need to be more refined in order to avoid overlaps. 2) not clear how to taken into consideration policies or strategies already implemented, such as environmental policy or code of ethics, or value map, like materiality, which have been hugely used by lead firms.

Yes it seems ok, but I think this is a leading question:-) And it doesnt consider the current state of the organisation, such as culture, other strategies etc. I think that would influence how well the process can be followed.

The inclusion of sustainability in BPM life cycle is crucial for sustainable business processes. Nowadays, when we talk about corporate sustainability it is essential mentioning the product life cycle perspective and its value chain. Some business processes determine the value chain and most of the environmental and social impacts ocurrs along the product life cycle. So, BPM have to promote the inclusion of life cycle thinking into business process. One suggestion is to include this concept in the middle of your conceptual framework as a discipline (e.g. life cycle management).

sustainability should be part of the design

Actually I would prefer something simpler than that.

it contains the specific actions to the desired implementation

Figure 4 is more complete related to sustainable process since the innitial part of the program (for example Analyse: Perform Sustainable Maturity Assessment), but Fig 4 is also a "mix" in most of other processes compared to Figs 1, 2 and 3.

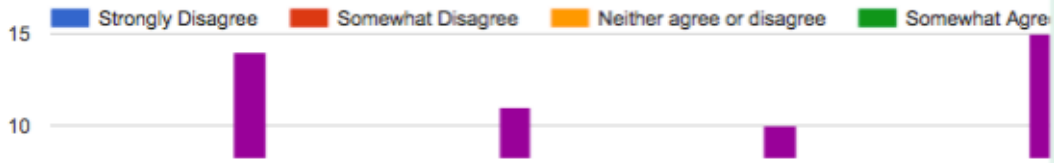
I believe it makes sense to apply this process in the implementation of sustainability. It seemed a complete process and tying the initiative.

I think Fig. 4 captures well aspects from Fig. 1 & 2. I am not very sure if it links well with Fig. 3.

The design covers many of the ideas from BPM.

Conceptual Framework

4. Which of the steps would be mandatory to an Analyse phase



If you have given a low rating for any of the statements, please justify. Please feel free to add any other comment.

6 responses

I think this stage could be a pre-diagnosis step - where is the firm?

One of the issues with Environmental and social metrics is that these seem harder and more complicated to be defined as metrics.

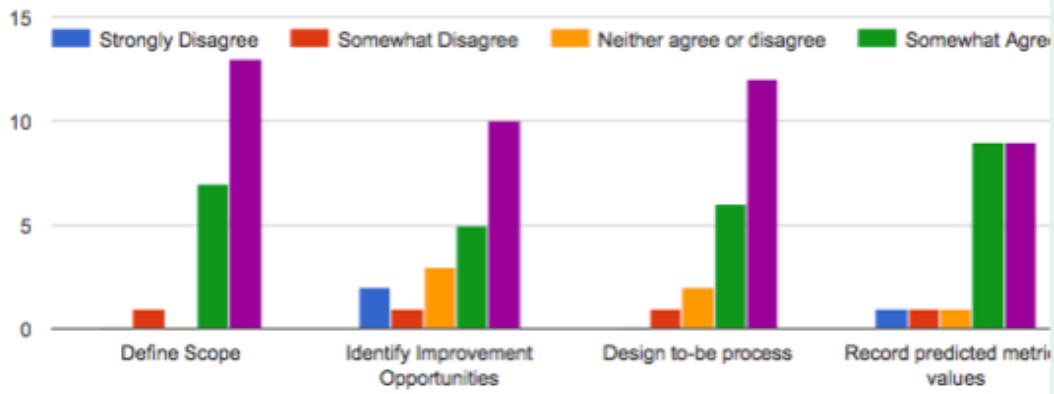
Does the step "define project objetives" makes reference to business processes improvements projects or the BPM project? If the response is about the business processes improvement projects maybe it may more sense to include this step in the beginning of Design phase.

I think the base of an analyze phase is to identify the business scenario. The other statements is not proper in this phase

Metrics depend on the objectives previously defined

All steps have to be in the process.

5. Which of the steps would be mandatory to a Design phase



If you have given a low rating for any of the statements, please justify. Please feel free to add any other comment.

4 responses

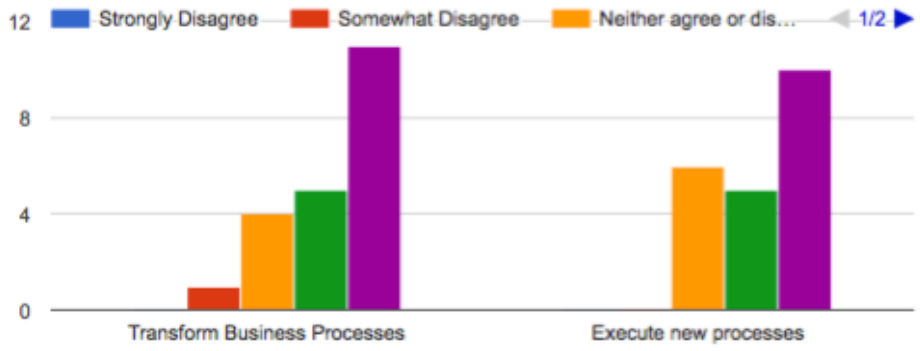
Element ticked as strongly disagree at the former item, I suggest to you to consider at the design phase. The topic 2 should be included at the phase 1.

Sometimes the process to innovation is unknown and not linear. And for a company that is perhaps the largest gains of sustainability.

identify improvement opportunities is in the analyze phase. I would put "define metrics values" in this fase

I think Identify Improvement Opportunities would fit better the Monitor & Control phase

6. Which of the steps would be mandatory to an Implement phase



If you have given a low rating for any of the statements, please justify. Please feel free to add any other comment.

1 response

capabilities?????

7. Which of the steps would be mandatory to a Monitor and Control phase

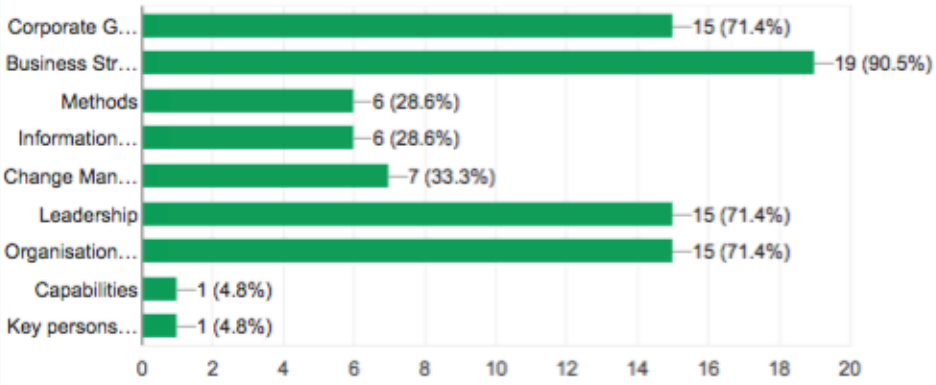
If you have given a low rating for any of the statements, please justify. Please feel free to add any other comment.

0 responses

No responses yet for this question.

8. Which of these options can be viewed as enablers to the implementation of sustainability projects

21 responses



Please feel free to add any other comment.

2 responses

my main concern is the diference between your model and management system standards, such as ISO 14001:2015, which has been updating process, including elements like leadership!, or 26000.

I'm not sure what you mean by methods - do you mean implementation methods and if so, what do these include?

Appendix E. Delphi study second round - Results

Sustainability Implementation

15 responses

1. In your opinion, what are the main challenges to implement sustainability initiatives in organisations?

15 responses

Dealing with resistence from individuals

the result and costs/resources involved.

I think that the main challenge is to create awereness of the importance of sustainability in terms of value added for the whole organization and its supply chain. Another point we have to stress is that organisations have to perceice that being sustainable means to be cost efficient.

The biggest challenges are the people, enable them to be ready; and resources: human, financial and time.

The multiple factors a company needs to consider parallell with sustainability, such as other factors coming from global competition (ex profitability, conditions compared to low cost countries) , meeting different customer demands, legislative and not, as well as just responding to other future trends such as digitilisation, flexibility etc

Cost, leadership buy-in, employee knowledge, unaware of benefits (or risk of not doing so)

Redesign processes, implement change, and manage related costs.

cost

Management of change

to expand understanding about sustainability benefits and roles in the company

Leadership compromised

Change the leadership team the mind set.

In my opinion, the main challenge to implement sustainable practices in organization is related to organizational culture. In general, many companies see sustainability as additional cost or legal requirements. There are a lot of sustainable business practices but most companies have not yet adopted them.

Most of the times the organisations are not willing to make changes towards a sustainable performance due to decreases in their monetary performnce. The short-term profit overcomes the long-term goal of sustainability.

The main challenge is to change the mindset of the leaders and bring sustainability for the main aspect, more important than sales.

Business Process Management & Sustainabiliity Implementation

2. In your opinion, how is it possible to assess all the sustainability dimensions (social, environmental and economic) in terms of Business Processes?

15 responses

quantifying the different aspect it IS business

It is very difficult to assess all three dimensions in one single scale.

I thonk that the main point is to link all these three dimensions form the triple botton line. An holistiv view of the triple botton line is crucial to achieve and assess sustainability in terms of Business Processes. Unfortunetly, it´s my perception that sustainability is something vague and mostly related to strategic level of organisations. So, one must creat a bridge between strategy and operations to assess sustainability.

the company needs to implement a policy that considers the TBL.

Hard question, I think business process management is one of the parts to reach sustainability, it is like the map how to drive and measures on the way, but it can not work without having the people (driver), the organisation (the vehicle) and the systems (surroundings) to work and understand where to go.

Clear KPIs/benchmarks so they must be addressed, even if the plan is to address in the future

You need to contextualize process outcomes within in the specific dimensions, and relate their potential impact on social, environmental and economic aspects.

leadership

Specific scorecard like balance scorecard

In my opinion, it is necessary a maturity of the field, more motivation of actors, and a serie of indicators to measure these three dimensiones, while balancing the achievement of competing interests.

It is necessary a global vision and indicators that complete all process in paralel.

Apply for training and consultancy in order to have the advantages for the 3BL (triple bottom line - social, environmental and economic)

In order to assess all the sustainability dimensions in terms of business processes it's important to identify how and what the business processes influence each dimensions, which activities and aspects are relevant, and which are the hotspots for each dimension in order to allow companies to prioritize the activities and aspects with highest potential for improvement in terms of sustainability. Thus, companies could develop and implement performance indicators on business process, but it is still a challenge to solve trade-offs between the three dimensions.

Using eMergy or Life Cycle Assessment approaches.

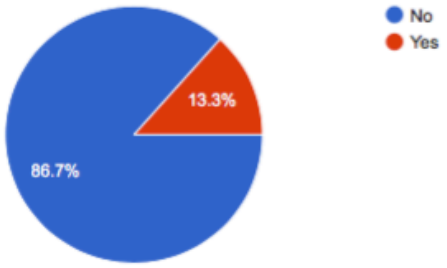
there is a tool called life cycle assessment that can calculate all the impacts for evaluation

Conceptual Framework

3. Considering the framework from Figure 1, would you change the order

of the steps or suit it in a different phase?

15 responses



Please justify your answer.

15 responses

Sustainability maturity should be part of monitor and control
depending on individual situation
In my opinion the framework is broad in terms os scope and adoption. So, I am satisfied with the way the framework is conceived.
The order is fine.
It makes sense to have them in that order, but I am considering the factors in the middle to also influence a lot if this wheel will work. And also what other dominant strategies and focuses the organisation have. Are they aligned?
Detailed enough at that level
The framework seems to follow a logical managerial sequence.
thats the way its Works
Its fine
it seems to integrare the necessary actions to create and act on improvement areas for sustainability
I think that it is ok
I think this is a reasonable correct order.
The steps are well structured and make sense in terms of logic.
I'd not change
I think its fine

4. How would you improve the framework? Feel free to add any other comment.

15 responses

see 3
hard to say, depending on the appropriateness according to the situation
No improvements
I believe it is OK.
The alignment to other objectives and goals would be the suggestion for improvement.
More detail - what do these steps mean to a layman?
It seems ok as it is.
no clue
Add delegation and identification of key deliverables
The center of the model looks a bit messy, no clear possition of elements.
No comments
No additional suggestion.
In my opinion, the framework could include a initial step or a pre-activity to define and clarify the concept of sustainability. This activity could also be included in first step "identify business scenario", but the important is to provide criteria or perspectives for assessing performance operation against the chosen definition. This definition can be included into bpm policy as mission and vision to be seen and diffused across the whole organisation.
I'd not
Monitor & Control: I suggest to include "indicators review / metrics review"