ANA CAROLINA MOISES DE SOUZA

SUSTAINABLE SOFTWARE ENGINEERING PRACTICES IN FINANCIAL SECTOR

Master's thesis presented to Graduate Program in Informatics of Pontifical Catholic University of Paraná to obtain the Masters of Science degree.

Curitiba
2017

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DEDICATION

To my family who always believed in my potential.

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To my loved dogs for all the moments of joy and unconditional love.

"Focusing on one thing that fascinates you can lead to world-changing results"

Radia Perlmann

ABSTRACT

Sustainable Software Engineering, also called "Green IN Software", focus on the production of software with Sustainable Software Engineering practices. Traditional Software Engineering development process cause negative impacts on the environment, economy and in the society. The negative impacts are classified in first, second and third order impacts. The energy consumption during software processing is an example considered as a first order impact because directly leads to high costs on energy bill and consequently on the environment. The optimization of a process implementation and software development, for instance, can lead to second order impacts, also called indirect impacts. Third order impacts consider the user's behaviors and consciousness regarding the environment, economy and society. In order to mitigate these impacts, the use of Sustainable Software Engineering practices reduces costs and sustainability impacts while developing software in the companies. As an opportunity of reducing costs during software development, the financial companies can take advantage of using Sustainable Software Engineering practices, since investments in Information Technology area has increased over the years. In this context, the goal of this research is to understand how Sustainable Software Engineering practices are applied during the software development in financial sector. To accomplish this goal, this research was conducted through qualitative data analysis methods, divided into two main phases: 1) Systematic Literature Review (SLR); and 2) multiple case studies in the financial sector. This research discovered 170 practices during the SLR organized into 7 categories emerged from the Grounded Theory. It was possible to categorize the practices into 13 SWEBOK knowledge areas, 7 Software Life Cycle phases and 3 Organizational Levels summarized in a mind map to represent this knowledge. During the case study 5 organizations of financial sector were analyzed. The case study analysis reported 28 new practices identified in industry along with 1 category and 52 existent practices found in the literature.

Keywords: Sustainable Software Engineering, Case Study, Software Engineering, Sustainability, Green In Software.

RESUMO

A Engenharia de Software Sustentável, também conhecida como "Green IN Software", tem o foco no processo de produção de software sustentável. O processo tradicional de desenvolvimento de software causa impactos negativos no meio-ambiente, na economia e na sociedade. Os impactos negativos são classificados em impactos de primeira, segunda e terceira ordem. O consumo de energia durante o processamento de um software é um exemplo a ser considerado como impacto de primeira ordem, o que resulta diretamente em elevados custos com energia e, consequentemente, degradação do meio ambiente. A otimização da implementação de processos e desenvolvimento de software, por exemplo, pode levar a impacto de segunda ordem, também chamado de impacto indireto. Por fim, impacto de terceira ordem considera comportamento e consciência do usuário em relação ao meio ambiente, economia e sociedade. Com o propósito de mitigar esses impactos, as práticas de engenharia de software sustentável podem reduzir custos e impactos ambientais na produção de software no setor financeiro. Como uma oportunidade de redução de custos durante o desenvolvimento de software, as empresas do setor financeiro podem se beneficiar da aplicação de práticas de engenharia de software sustentável, já que os investimentos na área de Tecnologia da Informação têm aumentado ao longo dos anos. Neste contexto, o objetivo desta pesquisa é entender como as práticas de engenharia de software sustentável são aplicadas durante o desenvolvimento de software no setor financeiro. Para atingir este objetivo, a pesquisa foi realizada por meio de métodos de análise de dados qualitativos, divididos em duas etapas: 1) Revisão Sistemática da Literatura (RSL) e 2) estudos de caso múltiplos aplicados no setor financeiro. O resultado da RSL foi de 170 práticas durante que foram organizadas em sete categorias que emergiram da *"Grounded Theory"*. Foi possível também categorizar as práticas em treze áreas de conhecimento do SWEBOK, sete fases do Ciclo de Vida do Software e três níveis de planejamento organizacional resumidos em um mapa mental para representar este conhecimento. Cinco organizações do setor financeiro participaram do estudo de caso, o qual resultou em vinte e oito novas práticas e uma categoria encontradas nas organizações e cinquenta e duas práticas existentes encontradas na literatura.

Palavras-chaves: Engenharia de Software Sustentável, TI Verde, Engenharia de Software, Sustentabilidade.

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LIST OF ACRONYMS

FEBRABRAN	Brazilian Federation of Banks
GREEN IT	Green Information Technology
ISO	International Organization for Standardization
IEC	International Electrotechnical Commission
IT	Information Technology
IUCN	International Union for Conservation of Nature
KA	Knowledge Areas
SWEBOK	Software Engineering Body of Knowledge
SLR	Systematic Literature Review
ICT	Information and Communication Technology
GT	Grounded Theory
SLC	Software Life Cycle
GeSI	Global e-Sustainability Initiative
GIS	Green IN Software
GBS	Green BY Software

CHAPTER 1 - INTRODUCTION

"Development that meets the needs of the present without compromising the ability of future generations to meet their own needs." Brundtland, 1987.

During the World Commission on Environment and Development organized by the United Nations in 1987, Brundland defined the term sustainability as a way of growing and developing society needs without exhausting the natural resources available today, allowing the next and future generations to make use of the same natural resources. In addition to the definition of sustainability, three dimensions were established: social, environmental and economic. The social covers the behavior, morals and ethics, placed into an egalitarian and respectful society. Environmental aspects concern the care of natural ecosystem through technological and educational initiatives. Finally, the economical, enabling the transformation of the goals achieved in the social and environmental dimensions in financial gains.

The three dimensions do not need to occur at the same time. However, one can affect another in terms of direct and indirect impact (NAUMANN et al., 2011). Regarding the direct or first order impact, the use of ICT (Information and Communication Technology), considering hardware manufacturing and infrastructure building and maintenance, contributed with 2% of CO_2 emissions globally (ERICSSON, 2013). Related to indirect or second order impact, the consumption of energy by network infrastructure and user equipment tends to increase, which demand more natural resources, increase the cost of energy and causes changes on the society life style, as represented in Figure 1 (MALMODIN, 2013). The third order impact is implicit, it means it is not trivial to assess, since it is related to long term impact results and people's attitude towards the three dimensions aforementioned (NAUMANN et al., 2011) and (FAUCHEUX; NICOLAÏ, 2011).

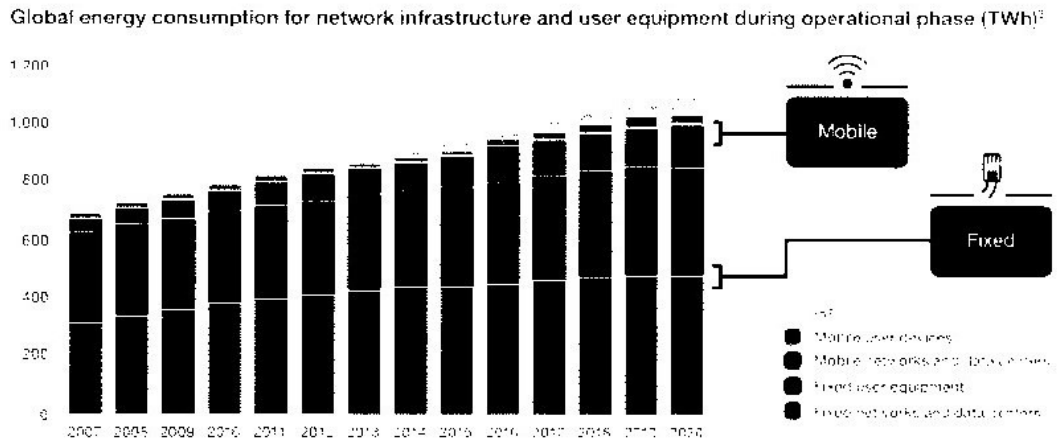

Figure 1 - The future carbon footprint of the ICT and E&M sectors. (MALMODIN, 2013)

It is important to understand where ICT acts regarding the three dimensions. When only environment awareness is raised by ICT, it is called Green Computing or Green ICT. When the three dimensions are covered by ICT it is called sustainable ICT. In our case, we aim to cover three dimensions from a perspective of Software Engineering, which we call Sustainable Software Engineering.

In this context, Sustainable Software Engineering aims to produce sustainable software development processes, i.e. processes during the software development lifecycle that reduce negative impacts on sustainability (NAUMANN et al., 2011). According to (CALERO; MORAGA; BERTOA, 2013) Sustainable Software Engineering is a way of developing software where the resource used meets the need of the software product while ensuring the sustainability of natural systems and the environment. The sustainability of a software product is the ability to develop a software product in a sustainable way.

To develop software in a sustainable way it is necessary to understand what practices are proposed in the literature and how these practices are applied in the industry. These practices once applied during the production of software contribute in the three dimensions of sustainability: social, economic and environmental. For instance, there are some researches concerning the reduction of software production costs as part of economic dimension as (NOUREDDINE et al., 2014), (MAHMOUD et al., 2013), (ATINKSON; SCHULZE, 2013), (ARDITO; MORISIO, 2013) (CHOWDHURY, 2012), (KOZIOLEK, 2011) and (ALBERTAO et al., 2010). Another example is regarding the social dimension, where it is possible to find research related to raising awareness about ICT usage (ATI, 2011). Related to the environmental

dimension, the examples are initiatives: as building energy efficiency algorithms (NOUREDDINE et. Al., 2012); choosing low energy consumption frameworks (PINTO; SOARES-NETO; CASTOR, 2015); and virtualized systems (PROCACCIANTI; LAGO; BEVINI, 2014).

One of the contexts where Sustainable Software Engineering practices can be explored, and is the context of this research, is the Information Technology (IT) area of the financial sector. The main reason for this choice is the new regulation of the Brazilian banks, called the Social and Environmental Responsibility Policy (Política de Responsabilidade Socioambiental - PRSA). This policy covers the three dimensions of sustainability and it is mandatory since 2014. In addition to this policy, the Brazilian banks investment on IT is really high, as it can be seen in the report of FEBRABRAN (Brazilian Federation of Banks), which showed an increase of 6% in investments and expenditure on IT where 16% of this correspond to software. As mentioned before, the economic dimension of sustainability suggests practices that can be applied to decrease the costs of software production. Thereby, the Brazilian financial sector could benefit from the use of Sustainable Software Engineering practices with the intention to reduce costs and complies with the policy.

1.1 Motivation

Currently, it has been observed a growing concern with global warming and unexpected weather conditions on our planet, as well as the maintenance and preservation of our entire ecosystem. Recently, in Paris at the Twenty-First Conference of the Parties (COP21) to the United Nations Framework Convention on Climate Change, it was reported that the use of ICT can reduce the impact of carbon dioxide (CO2) in 20% by 2030 in many sectors as showed in the Figure 2. Using ICT can eliminate 12.1 billion tons of CO2 emissions per sector each year. Being aware of that, scientists in the area of computing are proposing solutions and discoveries to mitigate the impacts on the environment by use of ICT.

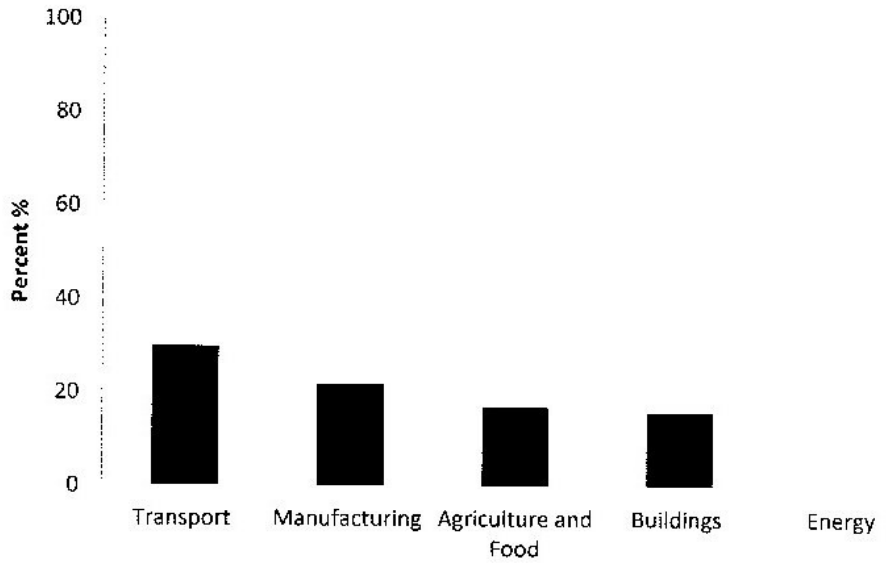

Figure 2 – ICT positive impacts, adapted from (WORLD BANK, 2015).

Mostly studies about ICT and its impact on the environment contemplate hardware or infrastructure. Studies related to hardware sustainability report new approaches during its manufacturing. As an example, hardware built with renewable raw materials, recycling of raw materials, energy-efficient hardware (CAPRA; FRANCALANCI; SLAUGHTER, 2012) and proper disposal respecting hardware life cycle assessment (JOUMAA; KADRY, 2012). Regarding infrastructure, the examples are: datacenters held by renewable energy called Green Datacenters; smart grids; cloud computing and virtualization; distributed Green Datacenters (PROCACCIANTIA; LAKE; BEVINI, 2014).

Another area that is emerging in the field of Green ICT is related to the production of software. There are two ways where it can contribute to sustainability as presented in Figure 3 (CALERO; PIATTINI, 2015):

- **Green IN Software or Green IN Software Engineering:** with respect to software development process where practical application of sustainability aspects takes place. For instance, a software that complies with customer software requirements causing less changes in its scope (AMRI; SAOUD; BEN 2014), (BETZ; CAPORALE, 2014).
- **Green BY Software:** with respect to software, system or application functionalities, which can be the means to obtain the sustainability of a process or business from any sector in the industry. For instance, a

software developed to measure the energy consumption of an equipment (AMSEL et al., 2011).

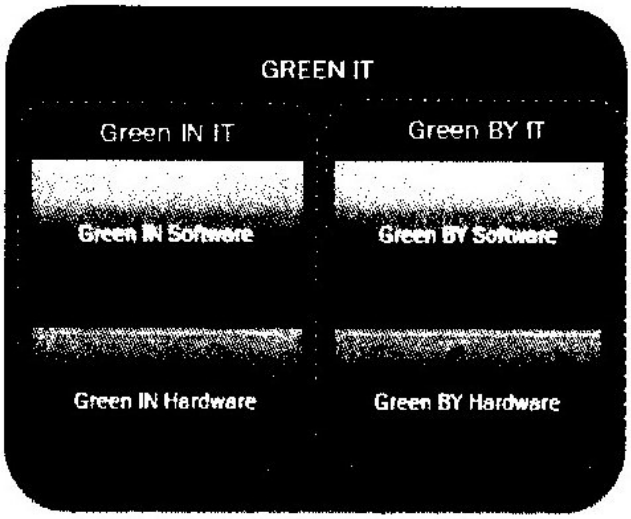

Figure 3 - Green IN IT, Green BY IT, adapted from (CALERO; PIATTINI, 2015).

While many studies related to hardware and infrastructure have been proven in the industry and academy, there are no evidence that Sustainable Software Engineering practices improves the software development and consequently reduce its costs. Therefore, this is a gap that can be explored, and this research will investigate it in the financial companies.

There are three main reasons to select the financial companies to identify these practices:

- High-energy costs with infrastructure: datacenters and technologies centers consume 45% of energy in these companies (ITAUTEC, 2011).
- They are the pioneers of new solutions to reduce the costs of IT as the demand for mobile banking and Internet banking are increasing (FEBRABAN, 2015).
- It must comply to the policy required by the Brazilian Central Bank (BANCO CENTRAL DO BRASIL, 2014): since April 25th of 2014 banks must comply with the Social and Environmental Responsibility Policy (Politica de Responsabilidade Socioambiental - PRSA) article 6º, resolution Nº 4.327, where one of the initiatives is to control the greenhouse emissions by improving business process, systems and controls.

The main motivator of this research is the possibility to identify Sustainable Software Engineering practices in financial company since none of the studies selected in SLR reported a similar study with the methods, the organizations studied and the results found in this research.

1.2 Research objectives

According to the scenario and the definitions of Sustainable Software Engineering in the previous section, the general objective of this work is: To **understand how Sustainable Software Engineering practices are applied in the area of Information Technology in the financial sector**.

The specific objectives are defined to meet the general objective:

i. To identify the Sustainable Software Engineering practices proposed in the literature.
ii. To investigate how Sustainable Software Engineering practices are applied in the area of Information Technology in the financial sector.

The accomplishment of these goals leads us to answer the main question of this research: **How the Information Technology area of financial sector companies addresses sustainability practices during the software development?**

1.3 Delimitation of scope

The scope of this work is to understand how Sustainable Software Engineering practices are applied in financial sector its does not aim to propose a system or tool for sustainable development.

In this research we will consider the Sustainable Software Engineering practices that would be applied during the software development life cycle. It does not necessary have to build a sustainable software product, but it can contribute to the construction of a software product using sustainable practices.

1.4 Research approach

In order to execute this research, we divided it into two steps represented in Figure 4.

- Step 1 – Systematic Literature Review: execution of Systematic Literature Review methods, elaboration of a theoretical framework based on the results of Grounded Theory analysis.
- Step 2 – Case Study: investigation itself, with field data collection through semi-structured interviews in selected financial sector companies. This step encompasses the individual's case description, in the light of the analysis, data analysis in aggregate form, outlining the panorama of the sector and extracting the generalizations and conclusions.

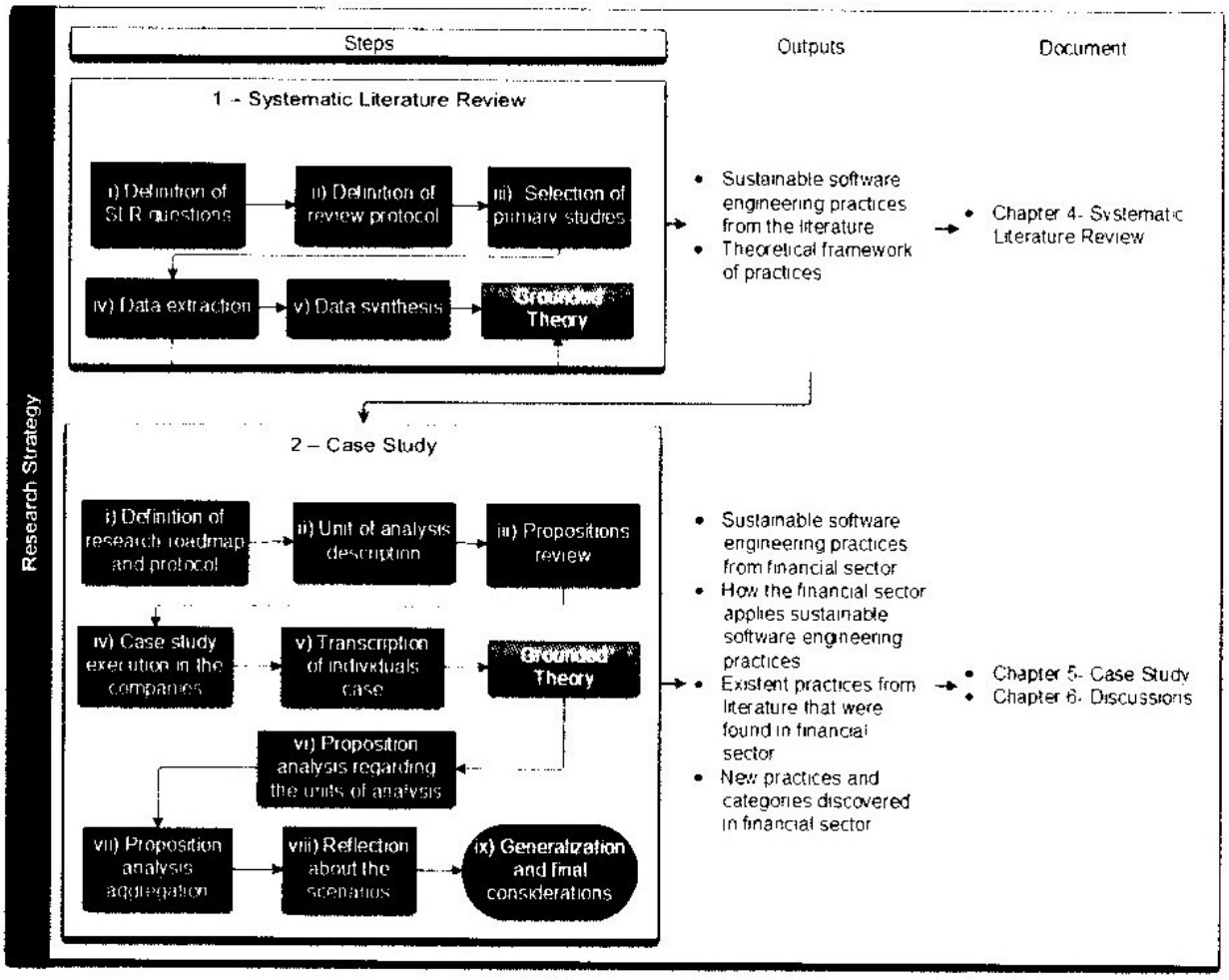

Figure 4 - Research strategy and document organization by the author.

1.5 Document structure

This document is structured as follows:

- Chapter 1 presented here, aims to provide the reader an overview about the objective and motivation of this research.

- Chapter 2 deepens the initial theoretical framework described in Chapter 1 and brings an overview of Sustainable Software Engineering, the main approaches used, and their main difficulties.
- Chapter 3 presents the research characterization, approach and strategy.
- Chapter 4 describes the results of the systematic literature review and grounded theory method.
- Chapter 5 describes the results of the case study and grounded theory method.
- Chapter 6 presents the discussions about the case studies results.
- Chapter 7 concludes this work with contributions and future work.

CHAPTER 2 - LITERATURE REVIEW

"The clear and present danger of climate change means we cannot burn our way to prosperity. We already rely too heavily on fossil fuels. We need to find a new, sustainable path to the future we want. We need a clean industrial revolution." Ban Ki-Moon

In general, sustainability is defined as the ability to regenerate and sustain the environment, economy and society making it available throughout all generations (BRUNDTLAND, 1987; BROWN et al., 1987; ADAMS, 2006; PENZENSTADLER et al., 2014). The International Union for Conservation of Nature (IUCN), a non-profit organization, who drives a global initiative of "valuing and conserving the nature, deploying nature-based solutions to global challenges in climate, food and development and tackling effective governance on global climate agenda" (IUCN, 2016), described sustainability by three interconnected dimensions represented by Figure 5.

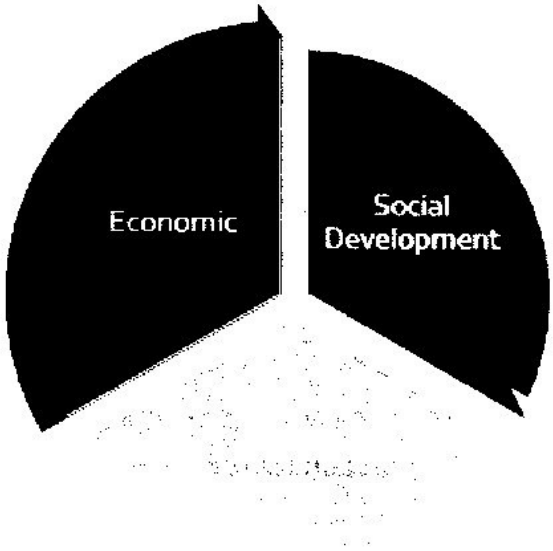

Figure 5 - Sustainability Dimensions, adapted from (IUCN, 2016).

The **environmental** dimension is about the fast recovering of natural resources in face of human degradation. Strongly related to social development and economic dimensions, since once exhausting natural resources the humanity can suffer the impacts of ecosystem imbalance, which can lead to natural disasters causing material and life damaging (IUCN, 2016).

Economic dimension directly impact the social development in an ambiguity way: it can be beneficial, as providing more job opportunities and can be harmful because of industry environment impacts (IUCN, 2016).

Social development dimension concerns people's well-being, quality of life and sustainable development, reducing the poverty, social justice and starvation. This dimension is directly affected by the economic and environmental dimensions, however, on the opposite way, to promote a prosperity society, where opportunities to grow are available it is important to battle against poverty and starvation (IUCN, 2016).

The presented sustainability dimensions are the basis to start to describe the sustainability in ICT. In this context, the sustainability in ICT covers the social, economic and environment issues from ICT perspective.

2.1 Sustainability in ICT

ICT has positive and negative impacts regarding carbon dioxide gigatonnes ($GtCO_2$) emissions on the sustainability as reported by SMARTer 2030 Projections. SMARTer is a strategic partnership event of ICT companies called Global e-Sustainability Initiative (GeSI), where the impacts of ICT on the three dimensions of sustainability and initiatives taken to mitigate these impacts worldwide are discussed. As represented in Figure 6, there is an increase in negative impact by 2030; in contrast, the reduction on global emission percentage is perceived - as the positive impact. The SMARTer justify this decrease in footprint - due to high investments on the sector as stated:

> "Our research shows that the decrease in the ICT sector's footprint is due to a range of investments companies in the sector have been making to reduce their emissions and to the expected improvements in the efficiency of ICT devices."

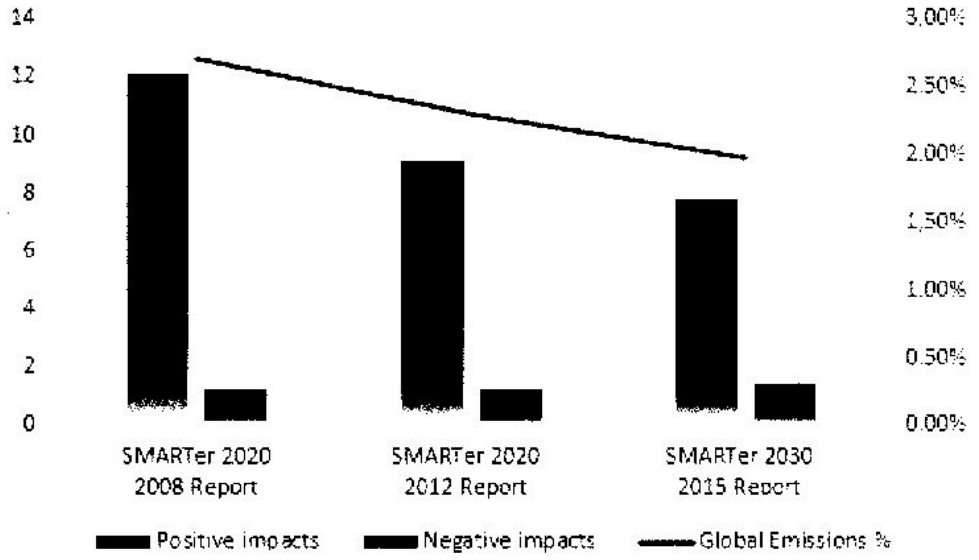

Figure 6 - Projection of ICT impacts per GtCO2, adapted from (SMARTer, 2015).

In the literature, researchers as (NAUMANN et al., 2011), describe examples of positive and negative impacts on ICT, represented in Figure 6 in relation with first, second and third order impacts. Regarding negative impacts ICT production process can cause harmful damage and degradation of energy resources, raw materials and carbon footprint. These examples can be classified per order of impacts. As an example of positive impact, the authors proposed a model called GREENSOFT to address software life cycle development regarding sustainability from the perspective of ICT as enabler of sustainability.

Recently, (HILTY; AEBISCHER, 2015) clearly describe and synthetize the dimensions of ICT impacts, order of impacts and technology activities that lead to ICT be part of solution, as enabler of sustainability, and part of the problem represented in Figure 7. As an example of ICT as a problem and enabler the authors mention "ICT applications for making freight transport more efficient increased the demand for transport (faster and cheaper transport stimulated demand), whereas utilizing the potential of ICT to dematerialize goods reduced the total demand for materials, which in turn reduced the demand for transport".

In the matrix proposed by (HILTY; AEBISCHER, 2015), represented in Figure 7, the first order impact considers the "direct environmental effects of the production and use of ICTs", as an example hardware or software life cycle assessment. The second order described as "indirect environmental impacts through the change of

production processes, products, and distribution systems". Four characteristics were described in second order impacts:

- Problem - Induction effect: ICT stimulates the consumption of another resource (e.g., a printer stimulates the consumption of paper as it uses it faster than a typewriter).
- Problem - Obsolescence effect: ICT can reduce the useful life of another resource due to incompatibility (a device that is no longer supported by software updates is rendered obsolete).
- Solution - Substitution effect: the use of ICT replaces the use of another resource (an e-book reader can replace printed books, which is positive if it avoids the printing of a sufficiently large number of books).
- Solution - Optimization effect: the use of ICT reduces the use of another resource (less energy is used for heating in a smart home that knows where the people who live in it are located, which windows are open, what weather is forecast, etc.).

The third order impact, as stated "indirect environmental impacts through impacts on life styles and value systems". In this case, the characteristics are:

- Problem - Rebound effects prevent the reduction of total material resource use despite decoupling by converting efficiency improvements into additional consumption, and new risks may emerge, for example due to the vulnerability of ICT networks.
- Solution - Transition towards sustainable patterns of production and consumption: ICT has the potential to support sustainable patterns of production and consumption.

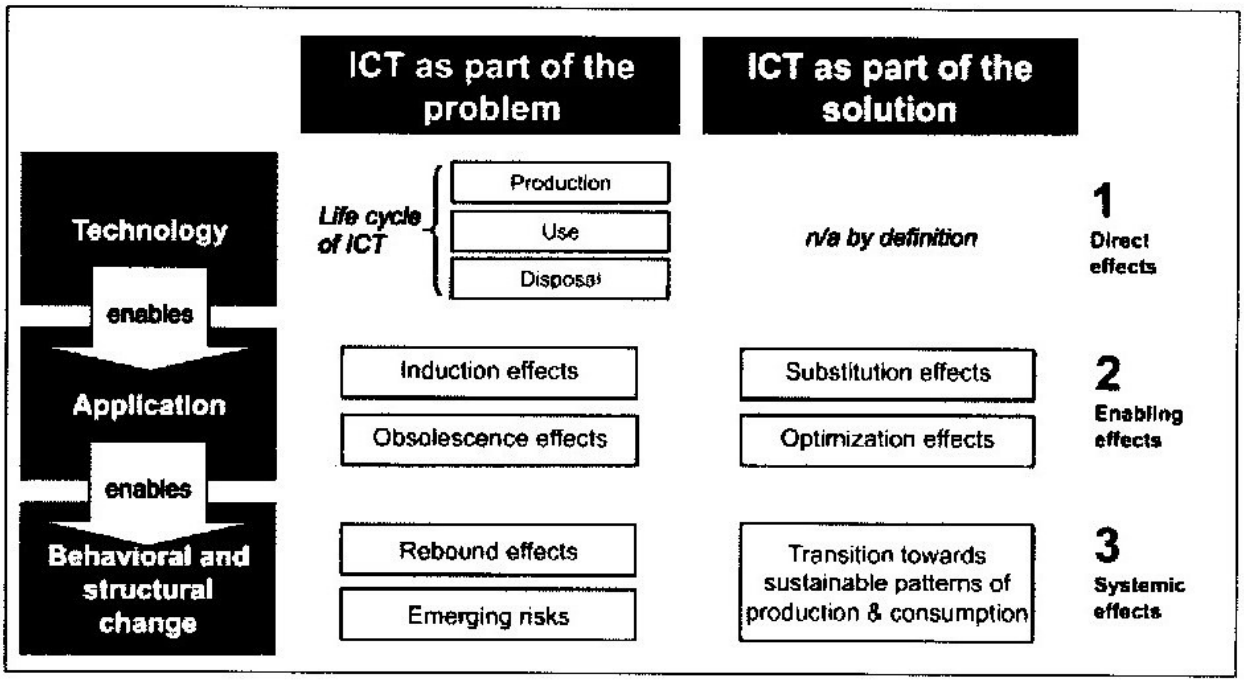

Figure 7 – Matrix of ICT order impacts from (HILTY; AEBISCHER, 2015).

Given the importance of considering and raising sustainability in ICT awareness to reduce the negative impacts mentioned before, the authors (CALERO; PIATTINI, 2015) define it as developing ICT solutions that offer benefits throughout processes and practices. This also covers, the three dimensions of sustainability reducing its negative impacts and increasing positive impacts innovating the use of ICT in business. Related to sustainability in ICT definition, it is important to mention that there are many other terms created to different areas of IT. Aiming to show the many existing terms we created the word cloud represented in Figure 8. The terms were extracted from the papers selected during this research and it has mostly cited terms related to Sustainability in ICT.

Figure 8 – Word cloud for Sustainability in ICT terminology.

In - (CALERO; PIATINNI, 2015) the terms presented in Figure 8 are explained showing the difference and intersection of these terms clearly, starting from the sustainability dimension perspective until the IT area related, which it can be noticed in Figure 9. All green related terms are situated on Environmental Sustainability dimension and related to Green by ICT, the areas of positive impacts produced by ICT in the environment. In this context, the Green by ICT and the Green in ICT terminology distinguish the characteristics aforementioned in Figure 7, respectively related to ICT as an enabler of sustainability and ICT as a problem (HILTY; AEBISCHER, 2015).

In the perspective of Green ICT and Green Computing, the terms are interchangeable and related to all areas of computer science considering hardware, telecommunication technologies, software, information systems, distributed systems, infrastructure, cloud, internet of things, internet of industry and mobile (MURUGESAN, 2008).

Figure 9 - Sustainability Dimensions and the relationship with Green ICT adapted from (CALERO; PIATINNI, 2015).

Whereas the studies and actions towards sustainability are well explored in the hardware manufacturing and infrastructures services (i.e.: datacenters), there is a gap in Software Engineering field. A refinement specification and consideration of Green in Software is taking into account when highlighting the importance of Sustainable Software Engineering that means adding the sustainability aspects into software development process.

2.2 Sustainable Software Engineering

The definition of Sustainable Software Engineering by (HILTY; LOHMANN; HUANG, 2011) is the software code being sustainable, agnostic of purpose. In (BROWN et al., 1987) the software purpose being to support sustainability goals, i.e. improving the sustainability of humankind on our planet. We can take this definition forward by defining Sustainable Software Engineering in a way of developing software with these approaches:

- **Minimizing the environment impacts on natural resources**:
  - green initiatives taken during the development phase, like measuring software application performance or the green metrics (GIUSEPPE; BUGLIONE, 2012), (WELTER et al., 2014), (ATKINSON; SCHULZE, 2013), (CALERO; BERTOA; MORAGA, 2013);
  - avoiding waste of time on rework, applying quality software attributes (MAHMOUD; AHMAD, 2013);
  - minimizing the unnecessary software changes (PINTO; SOARES-NETO; CASTOR, 2015), (JOHANN, 2011);
  - maximizing the software stability (DURDIK; KLATT; KOZIOLEK, 2012);
  - establishing software on a green infrastructure, using virtualization (DURDIK; KLATT; KOZIOLEK, 2012);
  - expanding home office hours and reducing the software development project cost on trips (ALBERTAO et al., 2010), (VENTERS et al., 2014).
- **Maximizing the social aspects in the local community** (KLEWITZ; HANSEN , 2014):
  - promoting a social work and volunteer programs by including the community during the software development phase. For instance, low-income students or disabled people learning and working with programming languages or helping during any phase of software development (JOHNSON et al., 2013), (PENZENSTADLER; MAHAUX; HEYMANS, 2013).

- **Changing software economics perspective from expenses to investment and return on it as valuable and tangible benefits regarding sustainability**:
    - a long-term return of Green Distributed Data Center (PROCACCIANTI; LAGO; BEVINI, 2014), when high investments occur in the beginning of the project but it returns and benefits to society is greater than the investment made during the next years.

All the approaches mentioned contribute during the software development and need to be applied as set of practices, with measurements and documents to determine the sustainability achievements of the software developed. The set of practices related to Software Engineering can be found in Software Engineering Body of Knowledge (SWEBOK v3), as well as in the standard of software development life cycle ISO/EIC 12207:2008 (MAHMOUD; AHMAD, 2013). Studies related to Sustainable Software Engineering suggests to adding or refactoring the best practices and standards proposed and commonly used nowadays to consider sustainability practices during software development, as presented in the systematic mapping of (PENZENSTADLER et al., 2014).

2.3 Related Work

This section is intended to give an overview of the related work regarding Sustainable Software Engineering linked with SWEBOK and ISO/EIC 12207:2008.

2.3.1 SWEBOK and Sustainability

Software Engineering is a set of fundamental activities to specify, develop, validate, maintain and evolve the software, covering the many abstract scenarios of real life (BOURQUE; FAIRLEY, 2014).

To promote the best practices of Software Engineering globally, the IEEE Computer Society approved and published the Guide to the Software Engineering Body of Knowledge (SWEBOK) in 2004. Currently, the version 3 is composed of 15 knowledge areas that cover the general and actual knowledge regarding best practices, foundations, methods, models and techniques of Software Engineering (BOURQUE; FAIRLEY, 2014). Briefly, a description of each SWEBOK knowledge area is presented in Table 1.

Chapter	Description
Chapter 1: Software Requirement	Aim to solve real-world problems and identify the business process of an organization, transforming this into automated process or software. A set of techniques is proposed to identify functional and non-functional software requirements from the stakeholders.
Chapter 2: Software Design	A composition of design principles and elements that establish a software. In general, it considers two-step process: Architectural, regarding how the software is organized into components and Detailed design, considering the components behavior.
Chapter 3: Software Construction	Technically software construction (coding, testing, and verification), where the goal here is working for minimizing complexity, anticipating change, constructing for verification, reuse and define standards in construction.
Chapter 4: Software Testing	Dynamically selection of finite test cases of expected behaviors from business domain. Software Testing should occurs during the entire software life cycle, starting at Software Requirements.
Chapter 5: Software Maintenance	The activities related to all areas of Software Engineering that happens during the warranty period or post implementation of the software product delivered. Two distinguished stages of software maintenance: Pre-delivery (planning and transition activities) and Post-delivery (training, software customization and application support).
Chapter 6: Software Configuration Management	Aim to manage and control, software, firmware and hardware collection from a specific versions.
Chapter 7: Software Engineering Management	Ensure that Software Engineering services are delivered as expected, on time and satisfy the stakeholder expectation. The main activities are: planning, coordinating, measuring, monitoring, controlling, and reporting
Chapter 8: Software Engineering Process	Concerned with work activities accomplished by software engineers to develop, maintain, and operate software, such as requirements, design, construction, testing, configuration management, and other Software Engineering processes.
Chapter 9: Software Engineering Models and Methods	Systematically and repeatable way to create software by using methods and models approaches.
Chapter 10: Software Quality,	Achievement of software quality provides measure of Software Engineering deliverables. It is a way to assess the software under development. It can be evaluated by software requirements and quality attributes, with respect to users' requirements adherence.
Chapter 11: Software Engineering Professional Practice	Software Engineer professional ethics and behavior towards the quality of software in different areas.
Chapter 12: Software Engineering Economics	Related to software costs, investment, and return on investment in a business context. It influences and supports technical and business decision-making helping engineers to decide on an action. Aim to show how economic analysis is used.
Chapter 13: Computing Foundations	The basics of computing foundations regarding: programming languages, data structures, debugging, algorithm, hardware, compilers, operating system, database, network, distributed system, human factors and software secure development.
Chapter 14: Mathematical Foundations	Basic techniques to identify a set of rules for reasoning in the context of the system helping to solve logic problems.
Chapter 15: Engineering Foundations	Common skills and techniques applied to Software Engineering and as well as other engineering disciplines. Topics of study: empirical methods and experimental techniques; statistical analysis; measurement; engineering design; modeling, prototyping, and simulation; standards; and root cause analysis.

Table 1 - SWEBOK Knowledge Areas (SWEBOK, 2013)

(PENZENSTADLER et al., 2014) describes the relationship between SWEBOK and sustainability in a systematic mapping. The results presented 83 papers classified in nine out of fifteen knowledge areas: Engineering Foundations, Software Construction, Software Design, Software Engineering Economics, Software Engineering Management, Software Engineering Models and Methods, Software Engineering Process, Software Quality and Software Requirements. The authors classified the studies by Research Types according to (WIERINGA et al., 2005):

- Evaluation: papers that investigate the problem of a practice or implementation proposed;
- Experience: papers that report author's experience of what they learned from his or her experience;
- Exploratory: papers that deal with problem space;
- Opinion: papers that reports author's wrong or right opinion about something;
- Philosophical: papers that sketch a new conceptual framework;
- Solution: papers that propose a solution technique without validation; and
- Validation: papers that investigate a solution proposal thorough methodologically research setup.

As it may be observed in Table 2, only five papers were classified as Evaluation and only four were classified as Experience. This means that only few authors can prove the proposed model in practice, in the industry or academy, leaving "the question of whether the topic is not really triggering a state of practice at all or whether it is simply not published much on yet" (PENZENSTADLER et al., 2014).

Knowledge Area	Related papers	Research Types	Reference
Software Engineering Economics	1	Experience	(JONES, 1994)
Software Engineering Management	1	Experience	(ATALLAH, 1993)
Software Quality	3	Evaluation	(CAPRA; FRANCALANCI; SLAUGHTER, 2012), (NOUREDDINE ET. AL., 2012), (GROSSKOP; VISSER, 2013)
	1	Experience	(JOHNSON et al., 2013).

Software Requirements	2	Evaluation	(AHMED; SHUAIB, 2012), (PENZENSTADLER; MAHAUX; HEYMANS, 2013)
	1	Experience	(MAHAUX; HEYMANS; SAVAL, 2011)

Table 2 - Systematic mapping results, adapted from (PENZENSTADLER et al., 2014)

In this systematic mapping (PENZENSTADLER et al., 2014) were presented 83 Sustainable Software Engineering studies that are related to nine knowledge areas of SWEBOK, however only five were applied in industry or academy. So, there is an important gap to investigate whether the proposed practices are applied and useful to IT industry.

Maintaining an argument in support of the Sustainable Software Engineering practices application, the authors (GIUSEPPE; MORUZZI; FUSANI, 2013) and (MAHMOUD; AHMAD, 2013) proposed the practices based on the International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC) ISO/EIC IS 12207, which are reported on section 2.3.2.

2.3.2 ISO 12207-2008 and Sustainability

International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC) form the specialized system for worldwide standardization in the field of Information Technology. A joint commission of IEEE Computer Society members elaborated the ISO/IEC 12207 version in 1995. Afterwards it was reviewed on 2008, adding new methods, Information Technology updates, actualization about life cycle processes and all process inherent to Software development new emerging technologies (ISO/IEC 12207, 2008).

The ISO/IEC 12207 purpose is to serve as guidance to an organization, a project, an acquirer or supplier and assessors. Moreover, it is "a strategy to achieve a fully integrated suite of system and software life cycle processes and guidance for their application" (ISO/IEC 12207, 2008).

Regarding sustainability and software life cycle processes, (MAHMOUD; AHMAD, 2013) suggested an empirical approach of sustainable software life cycle model divided in two levels. Level one is defined by "green Software Engineering process that is a hybrid process between sequential, iterative, and agile development

processes to produce an environmentally sustainable one", covering the traditional steps regarding life cycle and adding Green Analysis which determines the greenness of each increment of the system that is developed. Green Analysis step consist of four processes: Requirement Testing, Component Testing, Integration Testing, and Acceptance/System Testing. The goal of each activity is to collect data of energy monitoring tool to identify energy efficiency from CPU performance while running the software, for instance. The second level explains the green by software definition, when the software is a toll to aid green computing, monitoring resources and enhancing energy efficiency to the business process. To measure all the steps of green life cycle process, the Green Performance Indicators were created aiming to measure first order impacts of ICT and corresponds to IT Resource Usage GPIs, Application Life cycle KPIs, Energy Impact GPIs and, Organizational GPIs. There is no practical evidence that this model, applied to real software development process, can achieve any form of sustainability indicators.

A methodology to identify the sustainability indicator to be used during project management set up and to support the discovering of software sustainability goals is proposed by (GIUSEPPE; MORUZZI; FUSANI, 2013) . The authors suggest that these indicators can contribute on reduce carbon footprint during the software development activities. A measurement model is proposed using the Goal Question Metrics (GQM) method, a set of so-called Green Drivers and Direct-effect were derived.

Even though, the authors detail the studies very well, it was not mentioned the application of this model in industry and academy context as a proof of concept of these proposals.

2.4 Considerations about the chapter

This chapter described the literature review related to sustainability and its definitions. It described the definitions of Sustainable Software Engineering as well as the relationship between the SWEBOK and ISO/IEC 12207 proposed by different authors. In this literature review it is possible to identify the opportunity of research and importance of the presented study regarding the identification of Sustainable Software Engineering practices in Brazilian financial sector.

CHAPTER 3 - RESEARCH APPROACH

"We won't have a society if we destroy the environment."
Margaret Mead

This chapter describes the research structure conducted about Sustainable Software Engineering practices, as well as the concept of the methodologies adopted to conduct and evaluate this research.

3.1 Research Method

GIL, 2002 defines the processes of researching as:

> "rational and systematic procedure that has designed to provide answers to the problems that are proposed."

Furthermore, he explains that there are two scenarios when the need of a research is required:

a) There are not enough information to answer the problem;
b) When the available information is in such a state of disorder that cannot be properly related to the problem.

In our case, the problem to be explored is to understand how the information technology area of financial sector applies the Sustainable Software Engineering practices.

Considering the research objectives described in Chapter 1, we can characterize this as **Exploratory Research** since it aims to identify the Sustainable Software Engineering practices obtained from the systematic literature review and to describe how these Sustainable Software Engineering practices are applied in the financial companies during the software development.

3.2 Research Strategy

In order to answer the main research question: **How the Information Technology area of financial sector companies addresses sustainability practices during the software development** this research was organized in two main

steps: Systematic Literature Review (SLR) (KITCHENHAM, 2007) and Case Study (CS) (YIN, 2009). Each step has an output that is the input for the next step and comprehends the two specific objectives as represented in Figure 10.

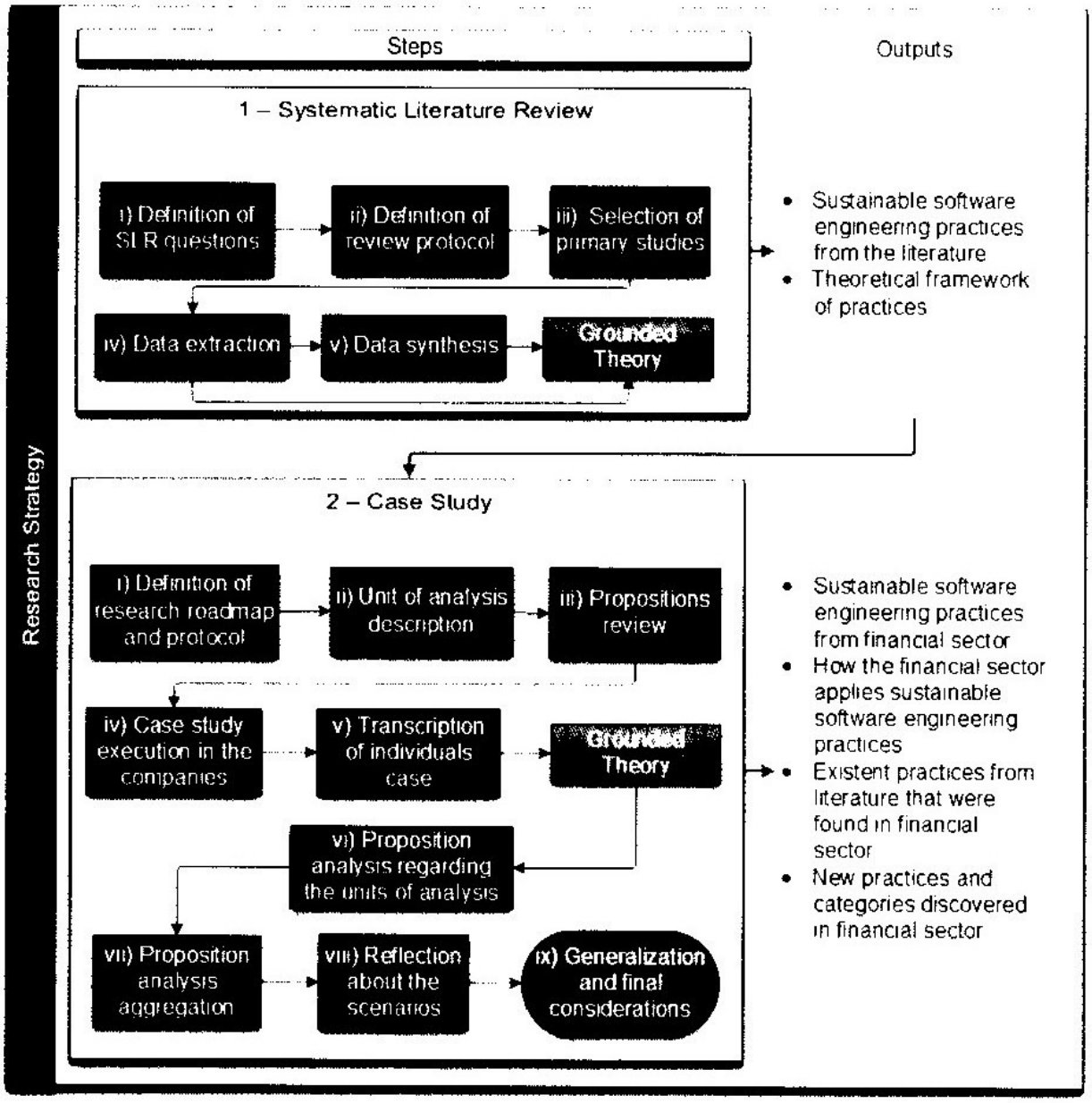

Figure 10 - Research Strategy by the author

3.2.1 Step 1 – Systematic Literature Review

According to (KITCHENHAM, 2007), the SLR is a form of secondary study with protocols and procedures. The main objective of performing SLR is to extrapolate the topic, in terms of giving a full picture about the recent studies available in the literature, finding an opportunity or gap to study, supporting the construction of an empirical study

and case studies propositions. As the author states, "systematic reviews must be undertaken in accordance with a predefined search strategy".

To specify and narrow our search attending to its objective, we adopt the SLR search strategy composed of three main stages based on (KITCHENHAM, 2007): Planning the Review, Conducting the Review and Reporting the Review as presented in Figure 11.

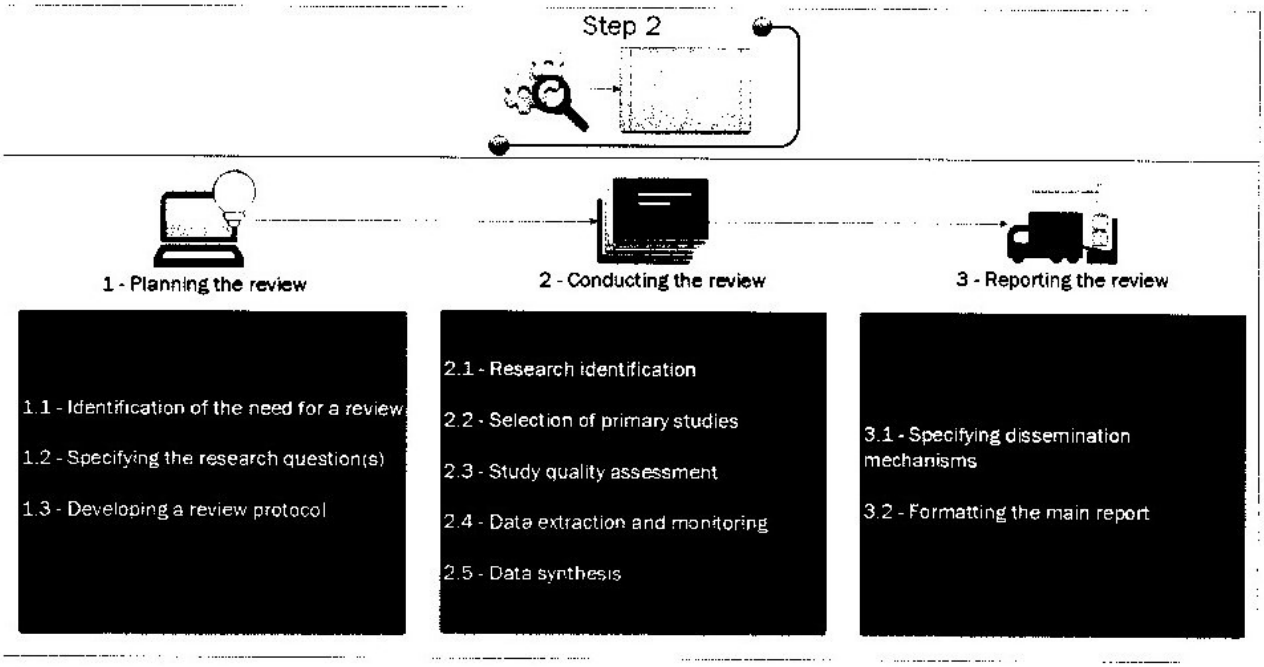

Figure 11 - Systematic Literature Review, adapted from (KITCHENHAM, 2007).

3.2.1.1 Planning the review

In this stage we defined the objective, the data sources to be searched, the inclusion and exclusion criteria, and the strategy for data extraction and analysis. Table 3 presents the planning questions and the answers formulated to organize the planning phase.

Planning questions	Planning answers
What are the review's objectives?	Identify the existent Sustainable Software Engineering practices applied in the industry and academy to support the theoretical framework for the case study.
What sources were searched to identify primary studies? Were there any restrictions?	Scopus, IEEEXplorer, Science Direct and ACM.
What were the inclusion/exclusion criteria and how were they applied?	**Inclusion Criteria:** I1 - Papers from Green IN Software, Sustainable Software Engineering, Green Software Engineering Conferences and Journals. I2 - Papers where practices of Sustainable Software Engineering are clearly defined in the results and discussion of primary studies

	I3 - Papers related to Sustainable Software Engineering with proof of concept in the context of industry and academy application. **Exclusion Criteria:** E1 - Discard duplicated papers. E2 – Results that are only conference, book chapter description, call for papers, special issue, and editorial. E3 – Papers from conferences and journals that are related to other areas of knowledge. E4 – Papers from conferences and journals that are not related to Software Engineering. E5 – Papers related to Software Engineering but not related to Green IN Software Engineering. E6 - Papers that has not proven the empirical purpose in the context of industry and academy application.
What criteria were used to assess the quality of primary studies?	All primary studies should be related to green Software Engineering, Sustainable Software Engineering, greener software and green in Software Engineering. In addition, it needs to report a case study, industry validity, academic validity, or proposed model evaluation in the industry in any stages of software development life cycle.
How were quality criteria applied?	Assess the risk of bias in included studies caused by inadequacies in study design, conduct or analysis that may have led to the effect being over or underestimated. The level of detail required in the assessment. The ability to distinguish between internal validity (risk of bias) and external validity (generalizability). Consider individual aspects of methodological quality in the quality assessment and synthesis. Consider the potential impact that methodological quality had on the findings.
How were the data extracted from the primary studies?	Papers were extracted by executing the string search in the scientific databases.
How were the data synthesized?	The data were synthesized based on the inclusion and exclusion criteria.
How were differences between studies investigated?	The selected papers were validated in industry or academy.
How were the data combined?	Grounded theory was used to combine the studies, create categories and define the practices to be identified in the case study.

Table 3 - Identification of the need to review.

The presented SLR aims to respond the specific objective 1: **To identify the Sustainable Software Engineering practices proposed in the literature**. To attend this specific objective, two research questions were created:

SLR Research Question 1: **What are the Sustainable Software Engineering practices applied in the industry and academy?**

SLR Research Question 2: **Which areas of Software Engineering are covered by Sustainable Software Engineering practices?**

3.2.1.2 Conducting the review

At this point, we elaborated the research string, which is the composition of carefully selected key words to cover the main words used to find as many as possible primary studies relating to the research question. Since the topic of this study is Sustainable Software Engineering and all the related terms, we defined the research string as:

(("Sustainable Software Engineering" OR "Sustainable software development life cycle" OR "software Sustainability" OR "Green Software Engineering" OR "green it' OR "green computing") AND ("Industry Application" OR "case study" OR "industry case" OR "evaluation" OR "validation"))

This string was executed in well-known and recommended scientific databases such as ACM, IEEEXplore, Science Direct and Scopus. These databases contains the published and reviewed papers from Journals and Conferences. The string was applied to get the title, full text and abstract of papers.

Once the papers were found through the query, the selection of primary studies started. This stage aims to identify the primary studies that provide direct evidence to the research question. Inclusion and exclusion criteria were applied to each study as described in Table 4.

Inclusion	Exclusion
I1 - Papers from Green IN Software, Sustainable Software Engineering, and Green Software Engineering published in conferences and journals.	E1 – Discard of duplicated papers.
I2 - Papers where practices of Sustainable Software Engineering are clearly defined in the results and discussion of primary studies.	E2 – Discard of book chapter, call for papers, special issue and editorial description.
I3 - Papers related to Sustainable Software Engineering with proof of concept in the context of industry and academy application.	E3 – Papers from conferences and journals that are related to other areas of knowledge.
	E4 – Papers from conferences and journals that are not related to Software Engineering.
	E5 – Papers not related to Green IN Software Engineering.
	E6 – Discard of secondary studies.
	E7 – Papers that have not proven the empirical purpose in the context of industry and academy application.

Table 4 - Inclusion and Exclusion criteria

The papers selected were classified by green type (CALERO; PIATTINI, 2015), study type (SHAW, 2003), context type (academy or industry) and location:

- Green Type: whether the papers selected was related to Green IN Software (GIS), Green BY Software (GBS) or Both.
- Type of Publication: whether the papers selected was published in Journal or Conference.
- Study Type: classified the papers selected as proposed by (SHAW, 2003). The description of each study type is in Table 5.
- Context: whether the papers selected were identified as an industry or academy application.
- Location: papers were identified by their countries.

Study	Description
Procedure or technique	New or better way to do some task, such as design, implementation, maintenance, measurement, evaluation, selection from alternatives; includes techniques for implementation, representation, management, and analysis; a technique should be operational—not advice or guidelines, but a procedure
Qualitative or descriptive model	Structure or taxonomy for a problem area; architectural style, framework, or design pattern; non-formal domain analysis, well-grounded checklists, well-argued informal generalizations, guidance for integrating other results, well-organized interesting observations
Empirical model	Empirical predictive model based on observed data
Analytic model	Structural model that permits formal analysis or automatic manipulation
Tool or notation	Implemented tool that embodies a technique; formal language to support a technique or model (should have a calculus, semantics, or other basis for computing or doing inference)
Specific solution, prototype, answer or judgment	Solution to application problem that shows application of SE principles – may be design, prototype, or full implementation; careful analysis of a system or its development, result of a specific analysis, evaluation, or comparison
Report	Interesting observations, rules of thumb, but not sufficiently general or systematic to rise to the level of a descriptive model.

Table 5 - Study type, adapted from (SHAW, 2003).

After classifying the papers, the Sustainable Software Engineering practices were identified supported by the Grounded Theory (STRAUSS; CORBIN, 1998) based on the process proposed by (MELLO; CUNHA, 2003).

Grounded Theory (GT) method is an inductive approach to research in which theories are proposed from an examination of data rather being derived deductively. GT is composed of three main steps: (i) open coding is the breakdown, analysis, comparison, conceptualization and the categorization of the data; (ii) the axial code examines the relations, casual conditions, new conditions and consequences as

actions and interactions of the categories; and (iii) selective coding is about the process of refinement to identify a central category related to others categories.

In this research open coding and axial coding were performed using the software to data analysis called ATLAS.ti[1]. The open coding was executed by selecting practices from the papers, named codes in ATLAS.ti. For each practice a memo was created describing the author conclusion, as presented in Figure 12. The axial code was executed interactively: first interaction helped to emerge categories from the relationship between the practices; second interaction helped to identify practices related to SWEBOK knowledge areas; third interaction helped to identify practices related to Software Life Cycle (SLC); and fourth interaction helped to identify practices related to Organizational Levels. These interactions resulted in several networks.

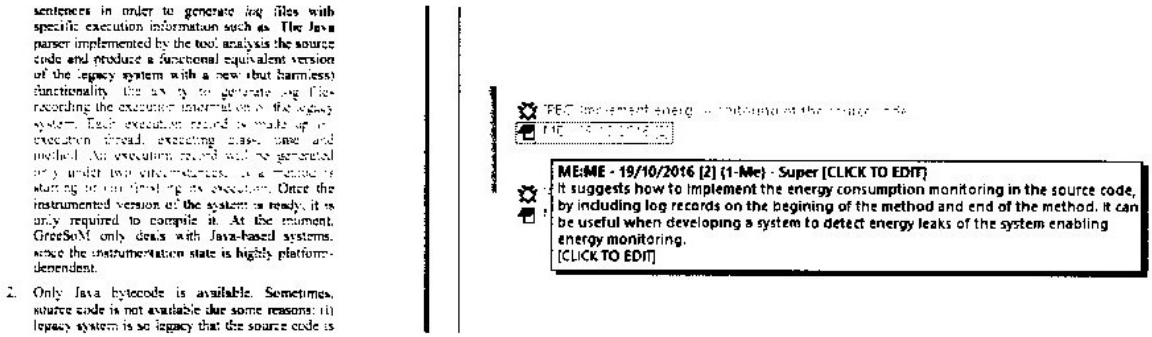

Figure 12 - ATLAS.ti Open Code and Microanalysis

The SLC phases where synthesized based ISO/EIC 12207 as presented below:

- Project Planning: the phase of planning basic project, conducting product feasibility, planning quality assurance, identifying risks and technical approaches.
- Requirements: the phase of discover software requirements, getting approval by customer, documenting requirements, define technical approaches.
- Design: the phase of designing the software architecture and modules, programing languages, infrastructure, the software structure and flow.
- Construction: the phase of building the software, coding based guidelines, using tools like compilers.
- Testing: identify defects, errors, mal functions or requirements that are not implemented.

[1] http://atlasti.com/

- Maintenance: occurs after the software be available for the customer. It is also the moment when software monitoring is implemented.
- Organizational Project-Enabling Process: are phases that support the software life cycle in terms of agreement, supply management, project management and human resources.

The Organizational Levels (BATEMAN, 2012) are defined as:

- Strategic: organizational strategy for long term.
  - Who: Executives, Seniors Managers, high-level consultors.
  - How: Definition of goals and strategy to grown the organization in a sustainable way.
  - Why: Decisions about the future of the organization is the base for tactic and operational planning.
- Tactic: translate high level goals from strategic level to specific goals.
  - Who: Supervisors, Managers, Coordinators, Managers, mid-level consultors.
  - How: Transform strategic goals on the goals for an area or department.
  - Why: Decentralization of the main goal to an area.
- Operational: procedures and process are executed daily to achieve the strategic and tactic goals.
  - Who: All employees of the organization that execute the activities.
  - How: Details of goals in activities controlled with schedules and other tools.
  - Why: Development and execution of strategic plan.

The output of SLR will be the base for elaborating the analysis points and propositions of the case study. The results of the SLR will be reported in detail in Chapter 4.

3.2.2 Step 2 – Case Study

The Step 2 refers to the multiple case studies applied in financial sector. It contains the activities presented in Figure 13: i) definition of research roadmap and protocol; ii) unit of analysis description; iii) propositions review; iv) case study execution in the companies; v) transcriptions of individuals case; grounded theory; vi) proposition

analysis; vii) propositions analysis aggregation; viii) reflection about the scenarios; and ix) generalization and final considerations.

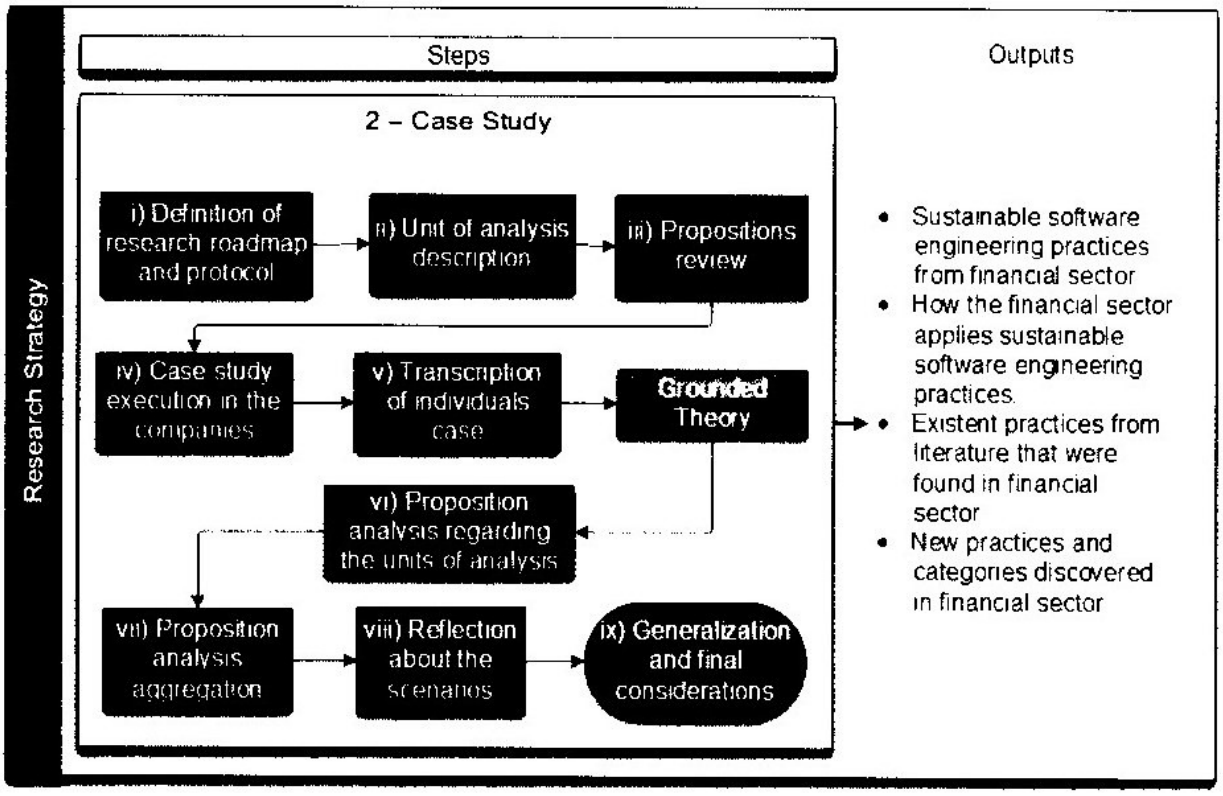

Figure 13 – Step 2 – Case Study.

The research roadmap and protocol is composed of research presentation, non-disclosure terms, operational procedures, propositions with the corresponding analysis points and interview analysis points as presented in Figure 14.

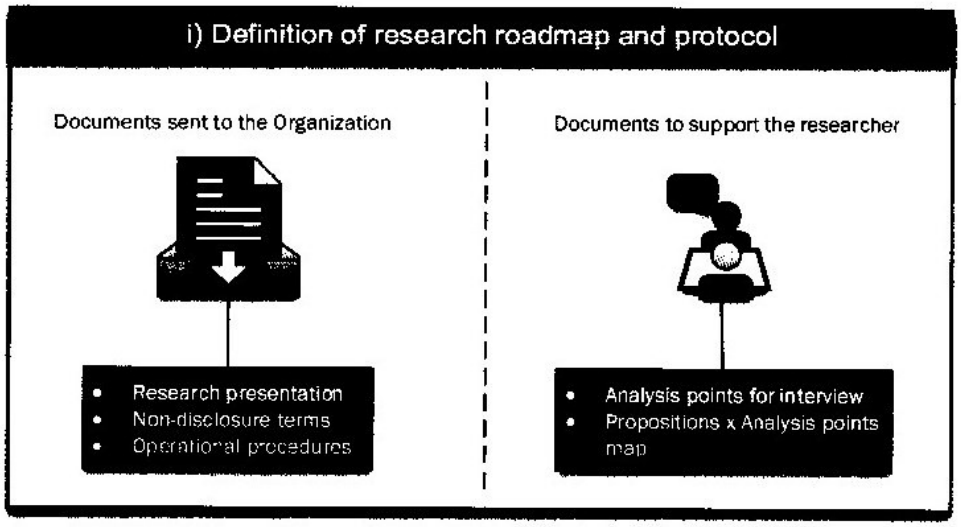

Figure 14 - Definition of research roadmap and protocol.

The research presentation (APPENDIX A) was sent to five organizations to present the research goals, the main research question, and brief description about

what is Sustainable Software Engineering in an infographic format and a formal researcher and supervisor's presentation.

Non-disclosure terms describes that no information about the organization name, data or people names will be shared. We compromise not to identify the organization and people involved in the case study. We did not receive any refuse or negative feedback about the non-disclosure terms. This document can be found in APPENDIX B.

The operational procedures were elaborated aiming to contact the largest number of participants. Different approaches were done to contact the organizations. First of them was personally in a congress called Smart City Business America[2]. The research presentation and non-disclosure terms were given to four directors and managers of sustainability department in Brazilian banks. The second approach was to go in the bank and give the documents in person to the directors of information technology from another Brazilian bank. In both cases we did not get any return from the directors, an email to remember them was sent after, but had no replies. The third approach was a more casual one, consisted in searching for people with friends in common in the LinkedIn[3] social media and send them a message. The benefit of selecting people from the social media is that we checked their background and confirmed that audience whether appropriated or not. Mostly of the interviewees accepted to participate with this approach.

The next stage is the unit of analysis description. Accordingly with (REINEHR, 2008), an unit of analysis is formed by an organization, a person, an event or any entity as decisions, programs and process to implement organizational change and it described the object to be study with the aiming of identify or describe a phenome.

In order to select a unit of analysis the following criteria were used:

- An organization from financial sector classified by Banco Central do Brasil[4] as: financial institution taking demand deposits, foreign exchanges banking and insurance companies (BANCO CENTRAL DO BRASIL, 2017).
- Have one more Information Technology area present in Brazil independently to be a national or international bank; and

[2] http://smartcitybusiness.com.br/home/scbeventos/smart-city-business-2017/
[3] https://www.linkedin.com/
[4] http://www.bcb.gov.br/en/#!/home

- In this area, have people working with software development directly or indirectly hired by the organization.

To guarantee that the unit of analysis were enough to execute the case study we adopted the criteria of selecting the companies with national representativeness, which means expressive results and earns, but also high investments in technology. We included organizations with insurance and foreign exchange business since they are also financial organizations as listed in Figure 15.

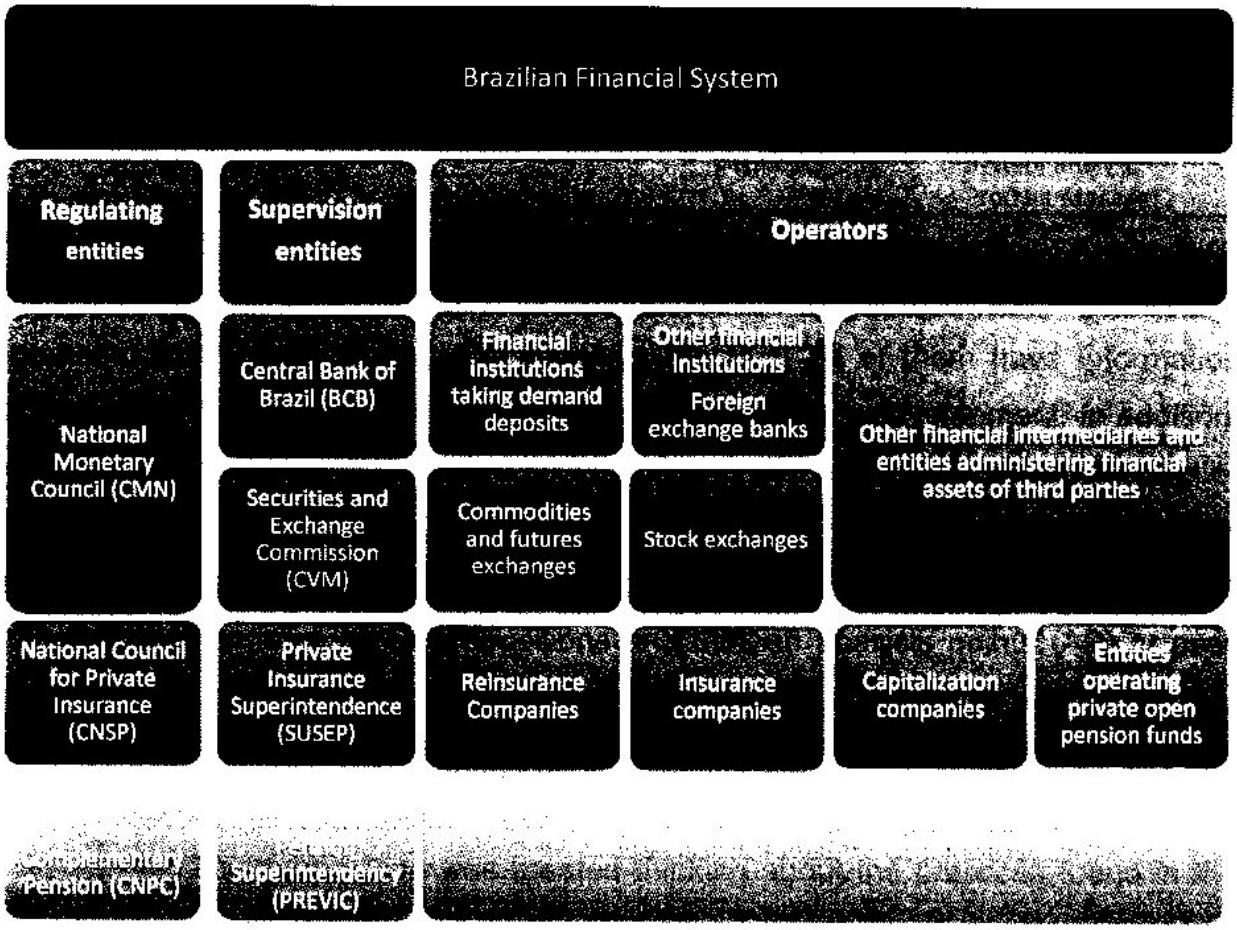

Figure 15 - Brazilian Financial System adapeted from (BANCO CENTRAL DO BRASIL, 2017)

For this study eleven organizations was contacted and five of them participated in this case study. They are classified by size, control type and operators as described in Table 6.

Organization	Size	Control type	Operators	Participants
Organization A	Large: Over 108K employees 1.2 billions of assets in 2016	Private owner	Financial institutions taking demand deposits	5 - Infrastructure Analyst, Software Development Manager, Project Leader, Senior Developer, Project Manager

Organization B	Large: Over 100K employees 162 billions of assets in 2015	Private owner	Insurance companies	3 - Systems Analyst, Senior Developer, Technical Lead
Organization C	Large: Over 94K employees 1.3 billion of assets in 2016	Private owner	Financial institutions taking demand deposits	3 - Specialist Developer, Senior Infrastructure Analyst, Senior System Analyst
Organization D	Large: Over 11K employees 18 million of assets in 2016	Private owner	Other financial institutions – global payments	4 - Software Engineer in Test, Senior Developer, Software Engineer in Test, Software Engineer in Test
Organization E	Medium: Over 150 employees Assets not informed.	Private owner	Foreign exchange banks – global payments	3 - Software Developer, Senior System Analyst, Product Manager

Table 6 - Unit of analysis selected.

Individually each of the organization are in accordance with the criteria presented and is part of Brazilian Financial System. All of them have information technology area in Brazil and is responsible for its software development. In addition, all of these organizations have to follow the Social and Environmental Responsibility Policy (Political de Responsabilidade Socioambiental - PRSA) resolution. To identify how the organizations follow the PRSA in the Information Technology area during the software development, three propositions and thirteen analysis points (AP) or case study questions, were defined and reviewed based on SLR results as below:

- Proposition P1 – Organizational policies driven to sustainability are systematically applied in software development in the financial sector.
    - This proposition was created thinking about the practices found in the literature that could be applied in the organization in a systematic way – following organizational policies or guidelines. All the analysis points related to this proposition are described in Table 7.

Proposition P1 and Analysis Points (AP)		
P1 **Organizational policies driven to sustainability are systematically applied in software development in the financial sector**		
AP-01	**Initiatives that promote awareness about organizational social responsibility within the IT sector** • Is there anyone responsible for disseminating sustainability information in IT projects? • Within the IT area is there a sustainability focal point?	(PENZENSTADLER; FEMMER; RICHARDSON, 2013), (PENZENSTADLER, 2014), (PENZENSTADLER; FEMMER, 2013), (ALBERTAO et al., 2010), (ZHONG; LIU, 2010)

	• Is there a reference model for achieving sustainability activities, dimensions, values, indicators and regulations? • What are the metrics for measuring sustainability goals? • Is there specification of sustainability actions? • Does the organization promote awareness raising about sustainability? • What are the awareness actions? • Is sustainability present in the organization's strategy? • Do sustainability aspects contribute to the organization's business process?	
AP-04	**Guidelines about sustainability requirements** • During the survey of software requirements do you see the use of guides describing Sustainable Software Engineering practices? • Is a benchmark model used to describe sustainability practices that should be considered when surveying software requirements? • Is there a guide that helps to identify the limitations of sustainability during software development? • Is there a guide to identify sustainability goals during software development? • Is there a guide to identifying sustainability interactions during software development?	(WEISS; REPETTO; KOZIOLEK, 2012), (PENZENSTADLER; FEMMER; RICHARDSON, 2013), (PENZENSTADLER, 2014)
AP-05	**Sustainable Software Engineering practices are identified at some levels of organization planning within the IT area.** • It is noticed that in the Strategic level the practices of Sustainable Software Engineering are defined, there is documented evidence of these practices? • At the Tactical level, practices defined in the literature are found in the organization? • At the Operational level, practices defined in the literature are found in the organization?	(PENZENSTADLER; FEMMER, 2013), (SCHIEN et al, 2013), (ZHONG; LIU, 2010), (PENZENSTADLER; FEMMER; RICHARDSON, 2013), (PENZENSTADLER, 2014), (CAPRA; FRANCALANCI; SLAUGHTER, 2012), (ALBERTAO et al., 2010), (CORDERO et al., 2015), (WEISS; REPETTO; KOZIOLEK, 2012)
AP-06	**Strategic alignment of the organization regarding the adoption of sustainability practices.** • Is it perceived that sustainability is part of the organization's strategy? • It is understood that senior management of the organization supports and encourages the tactical and operational levels to use Sustainable Software Engineering practices? • Is it possible to identify the meaning of sustainability for the organization?	(PENZENSTADLER; FEMMER, 2013), (ZHONG; LIU, 2010), (PENZENSTADLER; FEMMER; RICHARDSON, 2013)
AP-07	**A preference is given to hiring IT vendors who apply sustainability to their business.** • The organization prides itself for hiring suppliers who have sustainability seals, energy efficiency and clean energy. • Is it possible to identify that the organization uses software developed with Sustainable Software Engineering practices?	(ZHONG; LIU, 2010), (KIM; LEE; LEE, 2012), (NOUREDDINE et. al., 2012)

AP-08	**Concern to inform the customer that sustainability practices were adopted during the software development.** • Is it possible to identify that from the beginning of software development the customer is informed that the software is being developed with Sustainable Software Engineering practices? • Is it important for the organization to verify that the developed software is consuming a lot of power when the customer uses it? • Does the organization inform the customer of mechanisms that have been developed to avoid excessive consumption of energy by the software? • What are the customer-driven awareness actions that the organization establishes?	(PENZENSTADLER; FEMMER; RICHARDSON, 2013), (ALBERTAO et al., 2010), (CORDERO et al., 2015), (SCHIEN et al, 2013), (KIM; LEE; LEE, 2012), (MANOTAS et al, 2013)
AP-09	**It is possible to identify Sustainable Software Engineering practices at each phase of the software life cycle.** • Within the software requirements phase it is possible to find at least one of the practices: energy consumption (PEC), energy efficiency evaluation (PEEE) and sustainability (PSUD). • Within the project planning phase is it possible to find at least one of the practices: energy consumption (PEC), energy efficiency evaluation (PEEE), energy efficiency (PEF), business processes (PBP), life cycle assessment (PLCA) and sustainability (PSUD). • Within the software testing phase it is possible to find at least one of the practices: energy consumption (PEC), energy efficiency evaluation (PEEE), energy efficiency (PEF), end user energy consumption (PEUC) and sustainability. • Within the software design phase it is possible to find at least one of the practices: energy consumption (PEC), energy efficiency evaluation (PEEE), energy efficiency (PEF) and sustainability (PSUD). • Within the software maintenance phase it is possible to find at least one of the practices: energy consumption (PEC), energy efficiency evaluation (PEEE) and sustainability (PSUD).	(CORDERO et al., 2015), (PENZENSTADLER; FEMMER, 2013), (SCHIEN et al, 2013), (KALAITZOGLOU; BRUNTINK; VISSER, 2014), (ZHONG; LIU, 2010), (KIM; LEE; LEE, 2012) (PENZENSTADLER, 2014), (ALBERTAO et al., 2010), (WEISS; REPETTO; KOZIOLEK, 2012), (PENZENSTADLER; FEMMER; RICHARDSON, 2013), (KAMBADUR; KIM, 2014), (AGOSTA et al, 2012), (HINDLE, 2012), (MANOTAS et al, 2013), (NOUREDDINE et. al., 2012), (SAHIN et al, 2012), (CAPRA; FRANCALANCI; SLAUGHTER, 2012), (NOUREDDINE; ROUVOY; SEINTURIER, 2015), (SIEBRA et al, 2012), (MONTEIRO; AZEVEDO; SZTAJNBERG, 2013), (KOCAK; ALPTEKIN; BENER, 2014)
AP-12	**The criteria for evaluating software quality includes sustainability practices.** • Is it possible to confirm that software sustainability practices are related to software quality attributes? • What are the quality attributes adopted by the organization?	(KOCAK; ALPTEKIN; BENER, 2014), (PENZENSTADLER, 2014), (ALBERTAO et al., 2010)
AP-13	**Concern about the organization's reputation for adopting sustainability practices.** • Is it possible to find evidence on the dissemination of sustainability data to the customer? • Has the organization received recognition for developing sustainable software?	(PENZENSTADLER; FEMMER, 2013), (ZHONG; LIU, 2010), (PENZENSTADLER, 2014)

Table 7 – Analysis points to support P1.

- Proposition P2 - Sustainable Software Engineering practices are applied in a non-systematic way during software development
    - In this proposition, we analyze whether there are practices not related to any policies or guidelines defined or determined by the organization, it means a practice adopted because of individuals past experiences, seniority or observation. Table 8 describes the proposition P2 with the corresponding analysis points.

Proposition P2 and Analysis Points		
P2 **Sustainable Software Engineering practices are applied in a non-systematic way during software development.**		
AP-01	• Initiatives that promote awareness about organizational social responsibility within the IT sector • Is there anyone responsible for disseminating sustainability information in IT projects? • Within the IT area is there a sustainability focal point? • Is there a reference model for achieving sustainability activities, dimensions, values, indicators and regulations? • What are the metrics for measuring sustainability goals? • Is there specification of sustainability actions? • Does the organization promote awareness raising about sustainability? • What are the awareness actions? • Is sustainability present in the organization's strategy? • Do sustainability aspects contribute to the organization's business process?	(PENZENSTADLER; FEMMER; RICHARDSON, 2013), (PENZENSTADLER, 2014), (PENZENSTADLER; FEMMER, 2013), (ALBERTAO et al., 2010), (ZHONG; LIU, 2010)
AP-02	**Practices of Sustainability Dimensions are considered during the software development.** • In the project planning phase is it considered a model for sustainable software development where changes requests are not often, but the changes that are accepted, are easily implemented? • Is the non-functional requirements related to sustainability identified in the software requirements phase? • In the software design phase is there any guide to developing the sustainability-oriented software architecture? • In the software testing phase is it verified whether the software contemplates Sustainable Software Engineering practices? • In the maintenance phase of the software is there any sustainability practice applied? • Within each phase, has the person in charge knowledge about what is sustainability? • In the planning phase of the software is it considered a green data center that also considers sustainability important planning	(PENZENSTADLER; FEMMER, 2013), (ZHONG; LIU, 2010), (KIM; LEE; LEE, 2012) (SCHIEN et al, 2013), (KALAITZOGLOU; BRUNTINK; VISSER, 2014), (KAMBADUR; KIM, 2014),(HINDLE, 2012), (MANOTAS et al, 2013), (PENZENSTADLER, 2014), (ALBERTAO et al., 2010)

	phase of the software is it considered a green data center that also considers sustainability important? • In the software construction is it considered the use of practices related to modifiability, reusability, portability and supportability?	
AP-03	**Practices of Energy Consumption are considered during the software development.** • In the project planning phase is it possible to identify the use of practices related to the choice of hardware or devices, metrics and monitoring that can be added to software development to consume less energy? • In the phase of software requirements practices related to collection, measurement and configuration of power consumption are found? • In the design phase of the software you can find practices related to architecture, tools, frameworks, virtualization, standards and coding that reduce or monitor the software's power consumption. • In the deployment phase it is possible to find practices related to configuration, monitoring and automatic optimization of the server according to the power consumption of the software. • In the test phase it is possible to find practices related to test case definition, test framework, energy efficiency techniques, quality attributes and code performance that test the power consumption of the software. • In the construction phase is it possible to find practices related to programming without the use of frameworks, real-time code energy consumption monitoring and automation of memory allocation and CPU when the software is running?	(CORDERO et al., 2015), (SCHIEN et al, 2013),(KALAITZOGLOU; BRUNTINK; VISSER, 2014),(KIM; LEE; LEE, 2012), (WEISS; REPETTO; KOZIOLEK, 2012), (SCHIEN et al, 2013), (HINDLE, 2012), (MANOTAS et al, 2013), (PENZENSTADLER; FEMMER, 2013), (AGOSTA et al, 2012), (SAHIN et al, 2012), (CAPRA; FRANCALANCI; SLAUGHTER, 2012), (NOUREDDINE; ROUVOY; SEINTURIER, 2015), (SIEBRA et al, 2012), (NOUREDDINE et. al., 2012), (ZHONG; LIU, 2010), (KAMBADUR; KIM, 2014), (KIM; LEE; LEE, 2012), (KOCAK; ALPTEKIN; BENER, 2014), (MONTEIRO; AZEVEDO; SZTAJNBERG, 2013)
AP-04	**Guidelines about sustainability requirements.** • During the survey of software requirements do you see the use of guides describing Sustainable Software Engineering practices? • Is a benchmark model used to describe sustainability practices that should be considered when surveying software requirements? • Is there a guide that helps to identify the limitations of sustainability during software development? • Is there a guide to identify sustainability goals during software development? • Is there a guide to identifying sustainability interactions during software development?	(WEISS; REPETTO; KOZIOLEK, 2012), (PENZENSTADLER; FEMMER; RICHARDSON, 2013), (PENZENSTADLER, 2014)
AP-08	**Concern to inform the customer that sustainability practices were adopted during the software development.** • Is it possible to identify that from the beginning of software development the customer is informed that the software is being developed with Sustainable Software Engineering practices? • Is it important for the organization to verify that the developed software is consuming a lot of power when the customer uses it?	(PENZENSTADLER; FEMMER; RICHARDSON, 2013), (ALBERTAO et al., 2010), (CORDERO et al., 2015), (SCHIEN et al, 2013), (KIM; LEE; LEE, 2012), (MANOTAS et al, 2013)

	• Does the organization inform the customer of mechanisms that have been developed to avoid excessive consumption of energy by the software? • What are the customer-driven awareness actions that the organization establishes?	
AP-09	**It is possible to identify Sustainable Software Engineering practices at each phase of the software life cycle.** • Within the software requirements phase it is possible to find at least one of the practices: energy consumption (PEC), energy efficiency evaluation (PEEE) and sustainability (PSUD). • Within the project planning phase is it possible to find at least one of the practices: energy consumption (PEC), energy efficiency evaluation (PEEE), energy efficiency (PEF), business processes (PBP), life cycle assessment (PLCA) and sustainability (PSUD). • Within the software testing phase it is possible to find at least one of the practices: energy consumption (PEC), energy efficiency evaluation (PEEE), energy efficiency (PEF), end user energy consumption (PEUC) and sustainability. • Within the software design phase it is possible to find at least one of the practices: energy consumption (PEC), energy efficiency evaluation (PEEE), energy efficiency (PEF) and sustainability (PSUD). • Within the software implementation phase it is possible to find at least one of the practices: energy consumption (PEC), energy efficiency evaluation (PEEE) and sustainability (PSUD).	CORDERO et al., 2015), (PENZENSTADLER; FEMMER, 2013), (SCHIEN et al, 2013), (KALAITZOGLOU; BRUNTINK; VISSER, 2014), (ZHONG; LIU, 2010), (KIM; LEE; LEE, 2012) (PENZENSTADLER, 2014), (ALBERTAO et al., 2010), (WEISS; REPETTO; KOZIOLEK, 2012), (PENZENSTADLER; FEMMER; RICHARDSON, 2013), (KAMBADUR; KIM, 2014), (AGOSTA et al, 2012), (HINDLE, 2012), (MANOTAS et al, 2013), (NOUREDDINE et. al., 2012), (SAHIN et al, 2012), (CAPRA; FRANCALANCI; SLAUGHTER, 2012), (NOUREDDINE; ROUVOY; SEINTURIER, 2015), (SIEBRA et al, 2012), (MONTEIRO; AZEVEDO; SZTAJNBERG, 2013), (KOCAK; ALPTEKIN; BENER, 2014)
AP-12	**The criteria for evaluating software quality includes sustainability practices.** • Is it possible to confirm that software sustainability practices are related to software quality attributes? • What are the quality attributes adopted by the organization?	(KOCAK; ALPTEKIN; BENER, 2014), (PENZENSTADLER, 2014), (ALBERTAO et al., 2010)
AP-13	**Concern about the organization's reputation for adopting sustainability practices.** • Is it possible to find evidence on the dissemination of sustainability data to the customer? • Has the organization received recognition for developing sustainable software?	(PENZENSTADLER; FEMMER, 2013), (ZHONG; LIU, 2010), (PENZENSTADLER, 2014)

Table 8 – Analysis points to support P2.

- Proposition P3 - Tools that automatically measure or change the energy consumption of developed software are used.
    - This proposition was created thinking about the use of tools, techniques or implementation in the source code of an application that automatically changed its state when an energy consumption peak was identified as shown in Table 9.

Description of Applicable Points		
P3 **Tools that automatically measure or change the energy consumption of developed software are used**		
AP-02	**Practices of Sustainability Dimensions are considered during the software development.** • In the project planning phase is it considered a model for sustainable software development where changes requests are not often, but the changes that are accepted, are easily implemented? • Is the non-functional requirements related to sustainability identified in the software requirements phase? • In the software design phase is there any guide to developing the sustainability-oriented software architecture? • In the software testing phase is it verified whether the software contemplates Sustainable Software Engineering practices? • In the maintenance phase of the software is there any sustainability practice applied? • Within each phase, has the person in charge knowledge about what is sustainability? • In the planning phase of the software is it considered a green data center that also considers sustainability important? • In the software construction is it considered the use of practices related to modifiability, reusability, portability and supportability?	(PENZENSTADLER; FEMMER, 2013), (ZHONG; LIU, 2010), (KIM; LEE; LEE, 2012) (SCHIEN et al, 2013), (KALAITZOGLOU; BRUNTINK; VISSER, 2014), (KAMBADUR; KIM, 2014),(HINDLE, 2012), (MANOTAS et al, 2013), (PENZENSTADLER, 2014), (ALBERTAO et al., 2010)
AP-03	**Practices of Energy Consumption are considered during the software development.** • In the project planning phase is it possible to identify the use of practices related to the choice of hardware or devices, metrics and monitoring that can be added to software development to consume less energy? • In the phase of software requirements practices related to collection, measurement and configuration of power consumption are found? • In the design phase of the software you can find practices related to architecture, tools, frameworks, virtualization, standards and coding that reduce or monitor the software's power consumption. • In the deployment phase it is possible to find practices related to configuration, monitoring and automatic optimization of the server according to the power consumption of the software. • In the test phase it is possible to find practices related to test case definition, test framework, energy efficiency techniques, quality attributes and code performance that test the power consumption of the software. • In the construction phase is it possible to find practices related to programming without the use of frameworks, real-time code energy consumption monitoring and automation of memory allocation and cpu when the software is running?	(CORDERO et al., 2015), (SCHIEN et al, 2013),(KALAITZOGLOU; BRUNTINK; VISSER, 2014),(KIM; LEE; LEE, 2012), (WEISS; REPETTO; KOZIOLEK, 2012), (SCHIEN et al, 2013), (HINDLE, 2012), (MANOTAS et al, 2013), (PENZENSTADLER; FEMMER, 2013), (AGOSTA et al, 2012), (SAHIN et al, 2012), (CAPRA; FRANCALANCI; SLAUGHTER, 2012), (NOUREDDINE; ROUVOY; SEINTURIER, 2015), (SIEBRA et al, 2012), (NOUREDDINE et. al., 2012), (ZHONG; LIU, 2010), (KAMBADUR; KIM, 2014), (KIM; LEE; LEE, 2012), (KOCAK; ALPTEKIN; BENER, 2014), (MONTEIRO; AZEVEDO; SZTAJNBERG, 2013)

AP-08	**Concern to inform the customer that sustainability practices were adopted during the software development.** • Is it possible to identify that from the beginning of software development the customer is informed that the software is being developed with Sustainable Software Engineering practices? • Is it important for the organization to verify that the developed software is consuming a lot of power when the customer uses it? • Does the organization inform the customer of mechanisms that have been developed to avoid excessive consumption of energy by the software? • What are the customer-driven awareness actions that the organization establishes?	(PENZENSTADLER; FEMMER; RICHARDSON, 2013), (ALBERTAO et al., 2010), (CORDERO et al., 2015), (SCHIEN et al, 2013), (KIM; LEE; LEE, 2012), (MANOTAS et al, 2013)
AP-09	**It is possible to identify Sustainable Software Engineering practices at each phase of the software life cycle.** • Within the project planning phase is it possible to find at least one of the practices: energy consumption (PEC), energy efficiency evaluation (PEEE), energy efficiency (PEF), business processes (PBP), life cycle assessment (PLCA) and sustainability (PSUD). • Within the software requirements phase it is possible to find at least one of the practices: energy consumption (PEC), energy efficiency evaluation (PEEE) and sustainability (PSUD). • Within the software design phase it is possible to find at least one of the practices: energy consumption (PEC), energy efficiency evaluation (PEEE), energy efficiency (PEF) and sustainability (PSUD). • Within the software construction it is possible to find at least one of the practices: energy consumption (PEC), energy efficiency evaluation (PEEE), energy efficiency (PEF), end user energy consumption (PEUC) and sustainability (PSUD). • Within the software testing phase it is possible to find at least one of the practices: energy consumption (PEC), energy efficiency evaluation (PEEE), energy efficiency (PEF), end user energy consumption (PEUC) and sustainability (PSUD). • Within the software maintenance phase it is possible to find at least one of the practices: energy consumption (PEC), energy efficiency evaluation (PEEE) and sustainability (PSUD).	CORDERO et al., 2015), (PENZENSTADLER; FEMMER, 2013), (SCHIEN et al, 2013), (KALAITZOGLOU; BRUNTINK; VISSER, 2014), (ZHONG; LIU, 2010), (KIM; LEE; LEE, 2012) (PENZENSTADLER, 2014), (ALBERTAO et al., 2010), (WEISS; REPETTO; KOZIOLEK, 2012), (PENZENSTADLER; FEMMER; RICHARDSON, 2013), (KAMBADUR; KIM, 2014), (AGOSTA et al, 2012), (HINDLE, 2012), (MANOTAS et al, 2013), (NOUREDDINE et. al., 2012), (SAHIN et al, 2012), (CAPRA; FRANCALANCI; SLAUGHTER, 2012), (NOUREDDINE; ROUVOY; SEINTURIER, 2015), (SIEBRA et al, 2012), (MONTEIRO; AZEVEDO; SZTAJNBERG, 2013), (KOCAK; ALPTEKIN; BENER, 2014)
AP-10	**When abnormally energy consumption is detected, the software developed adjust itself to reduce its energy consumption** • Is any source code implementation used to reduce power consumption, such as memory allocation and CPU usage? • Is there any configuration on the server that allows you to change the performance of the software to use less power?	(AGOSTA et al, 2012), (KIM; LEE; LEE, 2012), (KOCAK; ALPTEKIN; BENER, 2014), (SIEBRA et al, 2012), (ZHONG; LIU, 2010), (MANOTAS et al, 2013), (MONTEIRO; AZEVEDO; SZTAJNBERG, 2013)

AP-11	**It is possible to measure the energy efficiency of the developed software.** • Is there any use of energy consumption measures? • Is there any use of energy efficiency measures or software performance that does not have an impact on energy consumption? • During the software development is the measurement of energy consumption? • What metrics are used to measure the software's energy efficiency? • Is there any other indicator linked to sustainability that is applied in the developed software?	(CORDERO et al., 2015), (AGOSTA et al, 2012), (SAHIN et al, 2012), (SCHIEN et al, 2013), KALAITZOGLOU; BRUNTINK; VISSER, 2014), (NOUREDDINE et. al., 2012) (KAMBADUR; KIM, 2014), (NOUREDDINE; ROUVOY; SEINTURIER, 2015), (SIEBRA et al, 2012), (MONTEIRO; AZEVEDO; SZTAJNBERG, 2013), (CAPRA; FRANCALANCI; SLAUGHTER, 2012), (KIM; LEE; LEE, 2012), (HINDLE, 2012), (MANOTAS et al, 2013), (PENZENSTADLER; FEMMER, 2013)

Table 9 – Analysis Points to support P3.

Once the propositions review has been done, the next stage from the step 2 is to execute the case study in the companies. In this stage individual cases were conducted cross cases analysis which is defined by (YIN, 2009) as multiple-case studies presented in Figure 16 were performed.

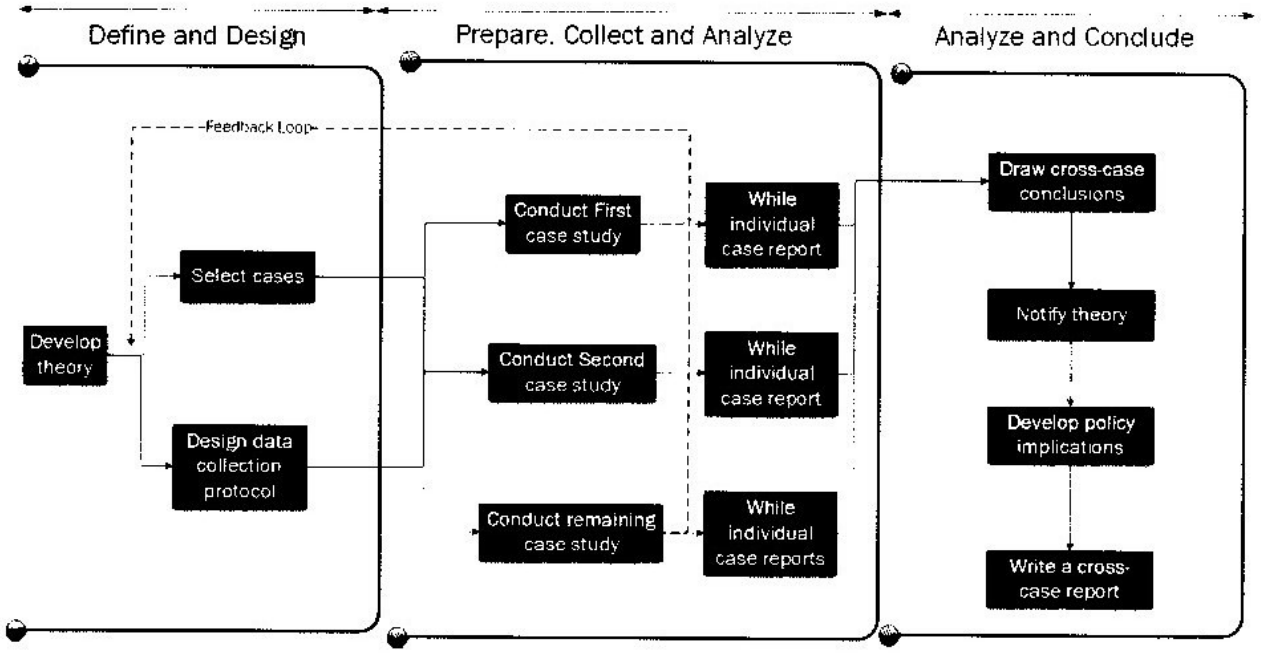

Figure 16 - Multiple-case studies process, adapted from (YIN, 2009).

During the multiple case studies the stages of: v) transcription of individual's case interviews; vi) propositions analysis regarding the unit of analysis; and vii) propositions analysis aggregation was performed in ATLAS.TI by supporting the application of Grounded Theory method explained in section 3.2.3 of this Chapter. In order to synthesize the results of propositions analysis regarding the unit of analysis with for each analysis point we used the format presented in Table 10. We choose the smile faces to interpret the findings as follow:

☹: The result is neither non-systematized nor systematized, meaning that nothing was found or referred to this question during the interview and grounded theory analysis.

😐: The result is non-systematized, meaning that the result found is applied or defined by the employee and is not something that is found in organization policy or guidelines.

☺: The result is systematized it means that the organization has policies or guidelines about sustainability in any level of organizational planning and software life cycle.

Qualitative study does not offer a logical manner to resume the results, however to note whether the AP was confirmed or not, we considered the high occurrences of green happy faces or blue neutral faces or orange said faces for each AP question. It does not matter the amount of practices that answering the AP questions.

AP-n (Sequence number of Analysis Point)	**Summarized description of Analysis Point**	**Results**	**Propositions**
AP-n.Q-n Sequence number of AP followed by Question number.	Detailed description of analysis point to support the interview with references.	Results of analysis point represented by: ☹ 😐 ☺	(P1, P2...)

Table 10 - Template of analysis points results presentation.

Regarding the propositions analysis aggregation and the individuals case report they are presented in Chapter 5 and the cross case conclusions and report, which are reflection about the scenarios, are presented in Chapter 6.

3.2.2.1 Grounded Theory Analysis

Figure 17 shows how the Grounded Theory method was applied during the individual's cases analysis and cross case analysis conducted in the organizations.

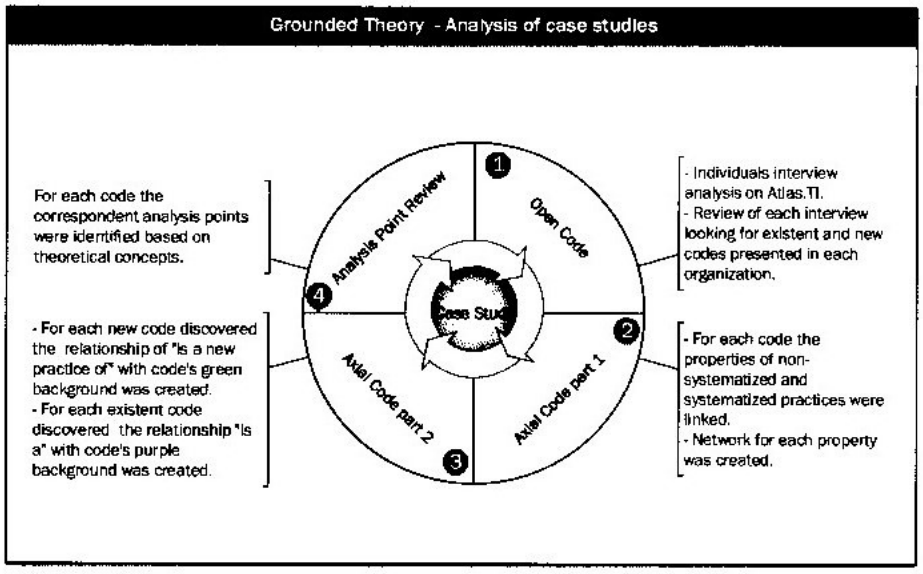

Figure 17 - Grounded Theory case study analysis

The first step to be conducted in GT analysis as reported by (STRAUSS; CORBIN, 1998) is the open code analysis. In this research we used Atlas.TI the same tool used for the SLR. We added all the interviews documents in this tool and started to find codes, what we also called practices, in each interview divided by the organization.

The second step is the axial code which aim to identify each code as systematized or non-systematized, helping to respond our propositions. One network for systematized and another for non-systematized was created for each organization. The networks help the research to identify the relationship and emerge the new categories or relate to existing ones.

The third step was the part two of axial code, to refine even more the findings, allowing the abstraction of the theoretical concept found. In this step, practices were classified as new practices, when new data not yet listed in the literature was found in the interviews, as well as existent practices, when we found practices from the literature. Moreover, for the networks be understandable to the reader we preferred to represent the codes with colors and relationship names “is new practices of” and “is a”.

The fourth step is the last part of the analysis and is about to find the connection between new practices and existent practices with analysis points and its concepts. This was done by looking on each network created and marked in a table the findings. This results is detailed on each Organizations sections about Analysis points descriptions. The networks are also shown on each Organization sections about Network analysis.

3.3 Considerations about the chapter

In this Chapter, we explained our research approach and how it was conducted to respond to the research objectives as showed in Figure 10. All the steps were related to each other as output and input connected the specific objectives, until responding to general research objectives. The purpose was only to show how we organized and performed this research and then the results of each step are described on the next Chapters.

CHAPTER 4 - SYSTEMATIC LITERATURE REVIEW

This Chapter presents the Systematic Literature Review (SLR) results identifying the existent Sustainable Software Engineering practices proposed in the literature to create a theoretical framework.

4.1 Systematic Literature Review

As presented on Chapter 3, in the planning review stage we defined the sources of scientific database and from them extracted the papers thought the string defined. It is important to mention that it was not necessary to specify data range in the search because first publication related to this topic started in 2008. Therefore, after running the string, an amount of 5837 papers were retrieved and organized by: author's name, paper title, publication year, publication type (Journal or Conference) and country. The results from each scientific database is listed in Table 11.

Source	Total Retrieved
ACM	1601
IEEEXplore	1069
ScienceDirect	1000
Scopus	2167
TOTAL	5837

Table 11 - Search string results per scientific database

All the papers found were imported into a spreadsheet to organize and perform inclusion and exclusion criteria as presented in Figure 18.

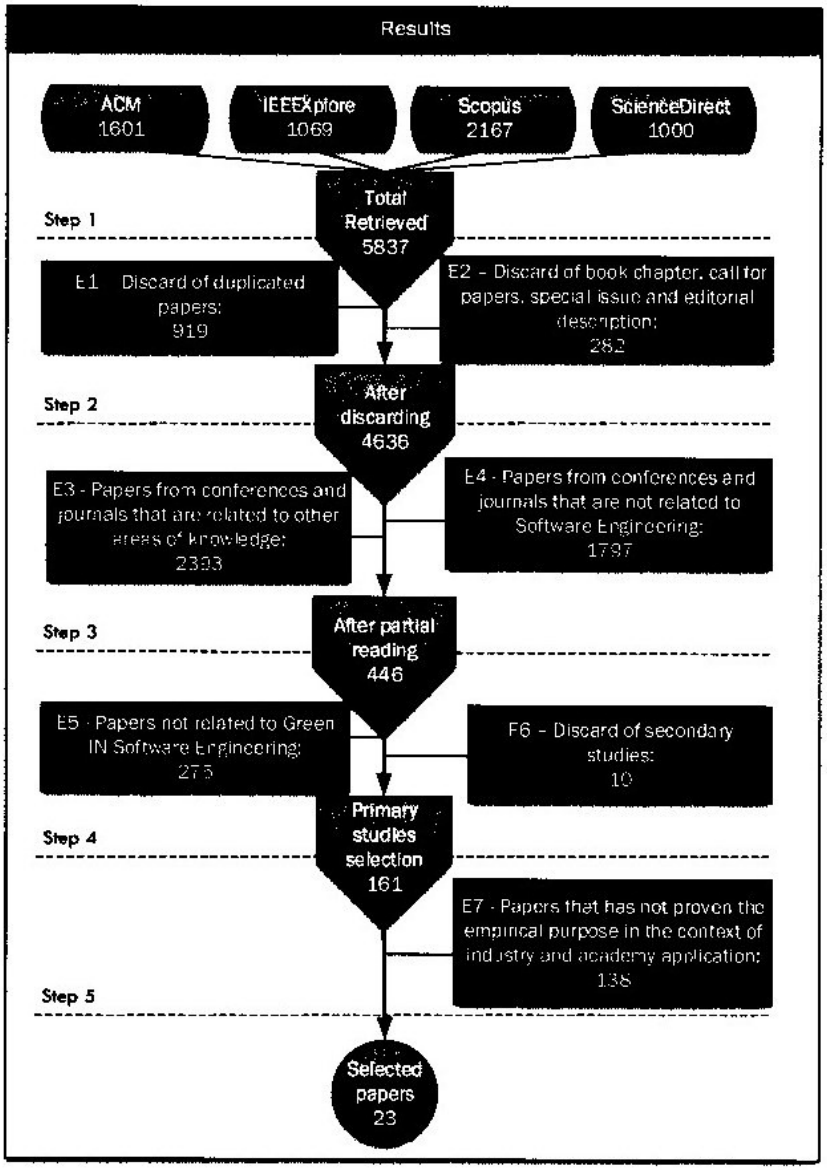

Figure 18 – Results of study selection stage by the author.

It is possible to observe a high amount (2393) of papers related to other areas of knowledge excluded on E3 criteria. This happened because of the terms **Sustainable, Sustainability and Green** are used in several others knowledge areas.

Another important point to mention is the amount (1797) of papers not related to Software Engineering in the E4 criteria. Most publication related to sustainability in ICT occurs in the areas of green computing, which are related to: infrastructure, distributed systems and hardware.

Regarding the papers not related to green IN Software Engineering (Sustainable Software Engineering) excluded in E5 criteria (275), we carefully selected the papers that proposed sustainability practices during the process and construction of a software, excluding green by software papers. At this point, it was possible to find

papers from secondary studies (systematic mapping or systematic literature review), which 10 of them were also removed from this SLR in E6.

The last exclusion criterion E7 is about papers that do not have real application in industry or academy. It means that the study proposed was not validated in a controlled environment, case study or experiment. In this case 138 papers were removed.

Finally, 23 papers were selected from primary studies. As part of the SLR method, these papers were classified as presented in Figure 19. The squares represent papers from Journal and cycle from Conference. Color blue means that we have more than one paper classified in that category.

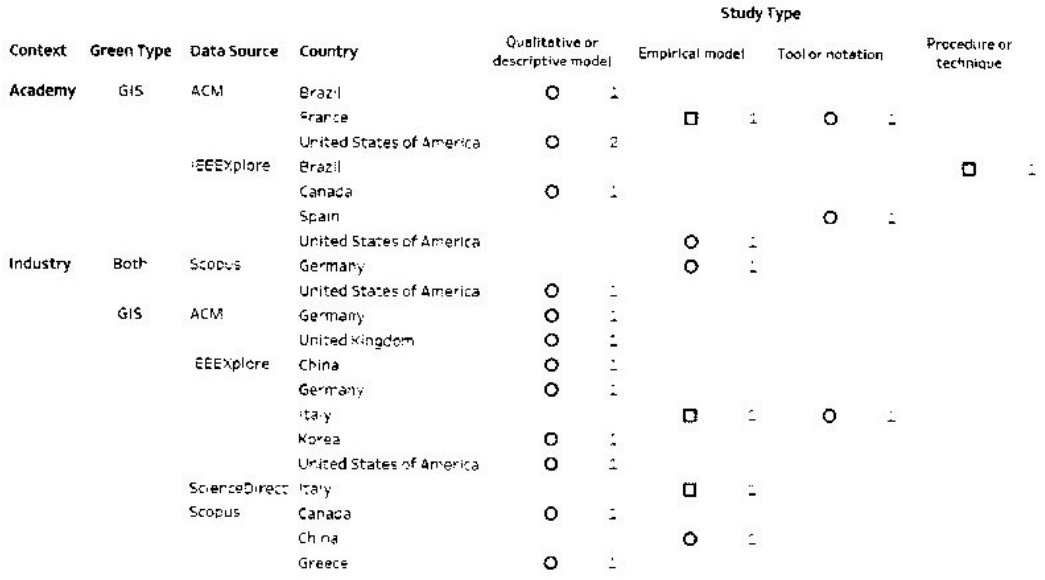

Figure 19 - Classification results from SLR.

It is possible to observe that United States is the country with 5 publications, being 4 of them qualitative models and only one empirical model. It is also interesting observe the different countries that are researching about this topic with academic and industrial applications.

4.1.1 RQ.01 - What are the Sustainable Software Engineering practices applied in industry?

To answer this question we applied the GT method as explained on Chapter 3. During the open coding it was possible to extract 170 practices from the 23 articles selected. Since there are many practices, one practice of each paper was selected to

describe in this section presented in Table 12. The remaining practices can be found in the APPENDIX D.

Practice	Reference	Practices Amount
Reduce the amount of complex code by using memorization/cache techniques.	(AGOSTA et al, 2012)	7
Identify practices of Development-Related Properties like modifiability, reusability, portability and supportability	(ALBERTAO et al., 2010)	17
Avoid the use of frameworks when developing small applications to improve energy efficiency.	(CAPRA; FRANCALANCI; SLAUGHTER, 2012)	4
Use of user interface components can impact the energy consumption.	(CORDERO et al., 2015)	11
Use of software power metrics like disk hits transaction per second.	(HINDLE, 2012)	3
Identify power consumption during peak workload.	(KALAITZOGLOU; BRUNTINK; VISSER, 2014)	7
Apply compilation optimization techniques such as performance.	(KAMBADUR; KIM, 2014)	9
Use of energy test case scenarios for web page energy consumption.	(KIM; LEE; LEE, 2012)	5
Use of quality attributes as Energy Efficiency considering the resource usage like, CPU, Memory and system performance.	(KOCAK; ALPTEKIN; BENER, 2014)	5
Configure web server setting to reduce the energy consumption.	(MANOTAS et al, 2013)	5
Improve energy efficiency by repartitioning databases across fewer disks.	(MEZA et al, 2009)	1
Set up reconfiguration actions when the application response time is outside a pre-defined configuration.	(MONTEIRO; AZEVEDO; SZTAJNBERG, 2013)	3
Test the energy efficiency performance of different programming languages.	(NOUREDDINE et. al., 2012)	5
Use of tool to estimate energy consumption at a code level of the application.	(NOUREDDINE; ROUVOY; SEINTURIER, 2015)	3
Identify quality requirements to measure sustainability dimensions.	(PENZENSTADLER, 2014)	12
Develop a software in economic sustainable way.	(PENZENSTADLER; FEMMER, 2013)	17
Have one or more stakeholders for each sustainability dimension.	(PENZENSTADLER; FEMMER; RICHARDSON, 2013)	5
Define stakeholders on software requirements.	(RODRIGUEZ; PENZENSTADLER, 2013)	1
Choose less energy consuming design patterns.	(SAHIN et al, 2012)	2
Use of web analytics to get energy consumption information.	(SCHIEN et al, 2013)	25
Enable software developers to continuously measure and monitor energy consumption of software under development	(SIEBRA et al, 2012)	4
Use of Software Sustainability Guidelines during software development.	(WEISS; REPETTO; KOZIOLEK, 2012)	2
Change the organizational culture to develop Green IT systems.	(ZHONG; LIU, 2010)	17
Total	**23 papers**	**170 practices**

Table 12 - Practices from the papers selected during SLR.

After identifying the open codes, here called as practices, we performed the axial coding, which was the stage of clustering and combining the practices into categories. In this direction, 7 categories emerged from the practices selected during the open coding and to identify the link between categories and practices an abbreviation of the category name was created as presented in Table 13.

References and Categories	Practices of Energy Consumption [PEC]	Practices of Sustainability Dimensions [PSUD]	Practices of Evaluating Energy Efficiency [PEEE]	Practices of Business Process [PBP]	Practices of Energy Efficiency [PEF]	Practices of End User Energy Consumption [PEUC]	Practices of Life Cycle Assessment [PLCA]
(AGOSTA et al, 2012)	7						3
(ALBERTAO et al., 2010)		17					
(CAPRA; FRANCALANCI; SLAUGHTER, 2012)	3		1				
(CORDERO et al., 2015)	10					1	
(HINDLE, 2012)	3						
(KALAITZOGLOU; BRUNTINK; VISSER, 2014)			7				
(KAMBADUR; KIM, 2014)	2		7				
(KIM; LEE; LEE, 2012)	4				1		
(KOCAK; ALPTEKIN; BENER, 2014)	1		4				
(MANOTAS et al, 2013)	5						
(MEZA et al, 2009)			1				
(MONTEIRO; AZEVEDO; SZTAJNBERG, 2013)	3						
(NOUREDDINE et. al., 2012)	1				4		
(NOUREDDINE; ROUVOY; SEINTURIER, 2015)	3						
(PENZENSTADLER, 2014)		12					
(PENZENSTADLER; FEMMER, 2013)	1	15		1			
(PENZENSTADLER; FEMMER; RICHARDSON, 2013)		5					
(RODRIGUEZ; PENZENSTADLER, 2013)		1					
(SAHIN et al, 2012)	2						
(SCHIEN et al, 2013)	19					3	
(SIEBRA et al, 2012)	2		2				
(WEISS; REPETTO; KOZIOLEK, 2012)	1	1					
(ZHONG; LIU, 2010)	3	8		6			
Total	**70**	**59**	**22**	**7**	**5**	**4**	**3**

Table 13 - Categories of practices.

The results presented in Table 13 shows that the category **Practices of Energy Consumption (PEC)** has 70 practices that can be applied during the software development. This category was created because the practices found were related to power, CPU, memory usage and code application performance. For instance, one practice reported in Table 12 is "**[PEC] Choose an energy efficient Design Patterns"**, which is selected from (CORDERO et al., 2015), where the aim is to propose a monitor tool called GreeSoM, to gather energy consumption of the application code and tested in on legacy system. In this paper, the results describe that facade design patterns was the most time consuming class in the software under development. The reason for this is related to the amount of times the class is called and also by its performance in the code. Therefore, we concluded that different approaches of software design and thus design patterns is possible to be made towards to write a code that consuming less energy.

Practices of Sustainability Dimensions (PSUD) is the second category with highest number of practices, 59. This category emerged from theory because many empirical studies covered the sustainability dimensions described in Chapter 2: social, economic and environmental. One practice inside this category and also reported in Table 12 is about "**[PSUD] Identify practices of Development-Related Properties like modifiability, reusability, portability and supportability**". This paper shows sustainability metrics related to quality attributes of software development (ALBERTAO et al., 2010). As stated by the author, the properties that impact the software development process are:

- Modifiability: The ability to introduce changes quickly and cost effectively.
- Reusability: Level in which system components can be reused in other systems.
- Portability: Ability of the system to run under different computing environments.
- Supportability: System's ability to be easily configured and maintained after deployment.

These properties improve the *Sustainability Performance* metrics related to the sustainability dimensions: economic, social and environment. We noticed that these properties are found in software quality knowledge area of SWEBOK and is defined as quality attribute for the software under development (SWEBOK, 2013).

Third category is **Practices of Evaluating Energy Efficiency (PEEE),** which has 22 practices. This category was emerged from the papers selected when evaluation methods and techniques were proposed and applied in real case scenario. One of these practices is **"[PEEE] Identify power consumption during peak workload"**. In (KALAITZOGLOU; BRUNTINK; VISSER, 2014), they propose and validate a model for software energy consumption and the practices found were related to how to measure energy consumption and how to apply this model, which is useful to measure software energy efficiency, during the software development.

Regarding the **Practice of Business Process (PBP)** category, with 7 practices identified, to develop a sustainable software or green software, business process need to be adaptable and flexible to adopt all the other practices, described until now, during software development. For instance, a **"[PBP] Change the organizational culture to develop Green IT systems"**. This practice was found in (ZHONG; LIU, 2010) with industry application, where a study case was conduct in China company. It was important to the company, who was concerned about the environment, that they employees were aware of practices to minimize the wastes of energy, recyclable materials, natural resources and water. The main target was to implement a Green system and for this organizational culture was one of the challenges to change.

Practices of Energy Efficiency (PEF) category with 5 practices, is technically the most complex, since it identifies the energy consumption or efficiency when a code is under execution and also development. To measure this a huge number of tests need to be done. One of the practice mentioned in Table 12 is **"[PEF] Test the energy efficiency performance of different programming languages."** This practice was selected from (NOUREDDINE et al., 2012) and is useful to decide which programming language will be used when developing a software.

It was possible to identify 4 practices related to **Practices of End User Energy Consumption (PEUC)** category and it appeared because end users of software are impacted by software development implementations chosen. One of them is **[PEUC] Use of web analytics to get energy consumption information"**. The purpose of (SCHIEN et al, 2013) was to investigate how use of digital media by end users can contribute on energy consumptions and how to get this information from web pages. In this case, to discover the energy consumption information, as well as the amount of energy consumed during data transferred over the network, a web analytics tool were implemented in the website of the newspaper. The contribution of this paper is relevant

because it was applied in the industry, performed behavior analysis and life cycle analysis. Practices of green in Software Engineering were found regarding the testing, developer's guidance, software usability and software design.

The last category identified as **Practices of Life Cycle Assessment (PLCA)**, with 3 practices only, is also related to end to end life cycle as proposed by (SCHIEN et al., 2013). As an example of practice related to this category we report **[PLCA] Calculate energy footprint end-to-end when developing a system** from APPENDIX D. This practice serves as a guidance to calculate energy footprint for each device, hardware or servers that the application is running on. We concluded that this practice can be executed during the software development life cycle and can be used as measure of life cycle assessment to achieve a requirement such as green software development.

Furthermore information about other practices and its categories are reported in APPENDIX D.

4.1.2 RQ.02 - Which areas of Software Engineering cover Sustainable Software Engineering practices?

To answer RQ.2 it was necessary to execute the axial coding rounds presented in Table 14. At this moment, the practices were reviewed and categorized in three types of categories: SWEBOK (SWEBOK, 2013); Software Life Cycle (ISO/IEC12207, 2008); and Organizational levels (BATEMAN, 2012).

Analysis steps	Type of Category	Example of Category	Amount
1. Open Code	Sustainable Software Engineering Practice.	[PSUD] Include Green IT in strategic management of enterprises	170
2. Axial Code 1º round	Sustainable Software Engineering category.	[PSUD] Practices of Sustainability	7
3. Axial Code 2º round	SWEBOK	Software Engineering Management	13
4. Axial Code 3º round	Software Life Cycle	Organizational Process	7
5. Axial Code 4º round	Organizational Levels	Strategic	3

Table 14 - Analysis of GT during SLR.

Based on the practice description, it was possible to categorize the practices into 13 SWEBOK knowledge areas: Computing Foundations (CF), Software Construction (SC), Software Configuration Management (SCM), Software Design

(SD), Software Engineering Economics (SEE), Software Engineering Management (SEM), Software Engineering Models and Methods (SEMM), Software Engineering Process (SEP), Software Engineering Professional Practice (SEPP), Software Maintenance (SM), Software Quality (SQ), Software Requirements (SR) and Software Testing (ST). As represented in Figure 20, the knowledge areas with more practices are SQ, SC, SR, SD and CF. This happened because the practices related to software test, construction, requirements, design and algorithms were proposed and identified by the papers selected in this SLR. It is important to report that one practice is categorized in one or more knowledge area of SWEBOK, the reason for this is because of the interconnected relationship between knowledge areas, which is also reported in SWEBOK. One example of this connection is the practice of **[PEC] Avoid the use of frameworks when developing small applications to improve energy efficiency** reported in Table 12 from (CAPRA; FRANCALANCI; SLAUGHTER, 2012), which was categorized in Software Construction and Software Design, since it can be applied in both knowledge areas.

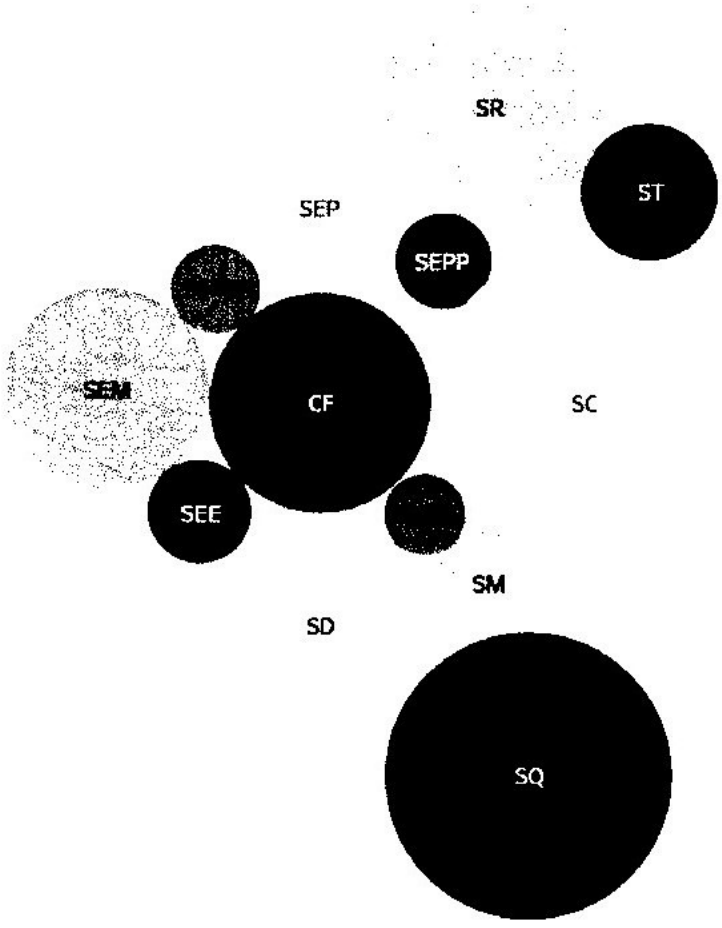

Figure 20 - SWEBOK KA's from SLR.

Summarizing and refining even more the practices, the SLC was created based in (ISO/IEC12207, 2008) to identify where at the development life cycle the practice is applied. Again, the testing, construction and requirements phase have more practices than the other phases as represented in Figure 21.

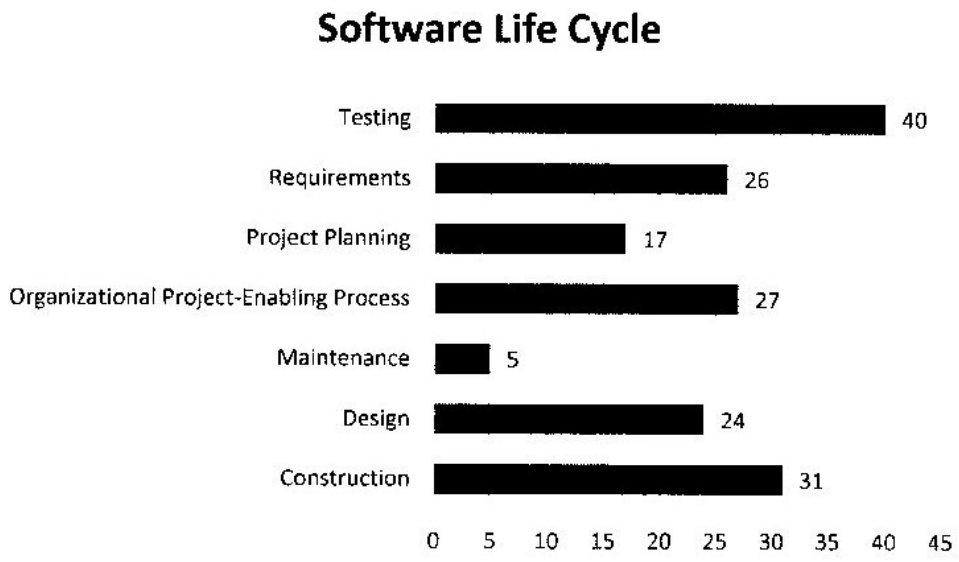

Figure 21 - Software life cycle and practices

Complementary to Figure 20, a network was created in Atlas.ti showing the connections of practices categories between the software life cycle phases as represented in Figure 22. The details of which practices are in each phase can be found at APPENDIX D.

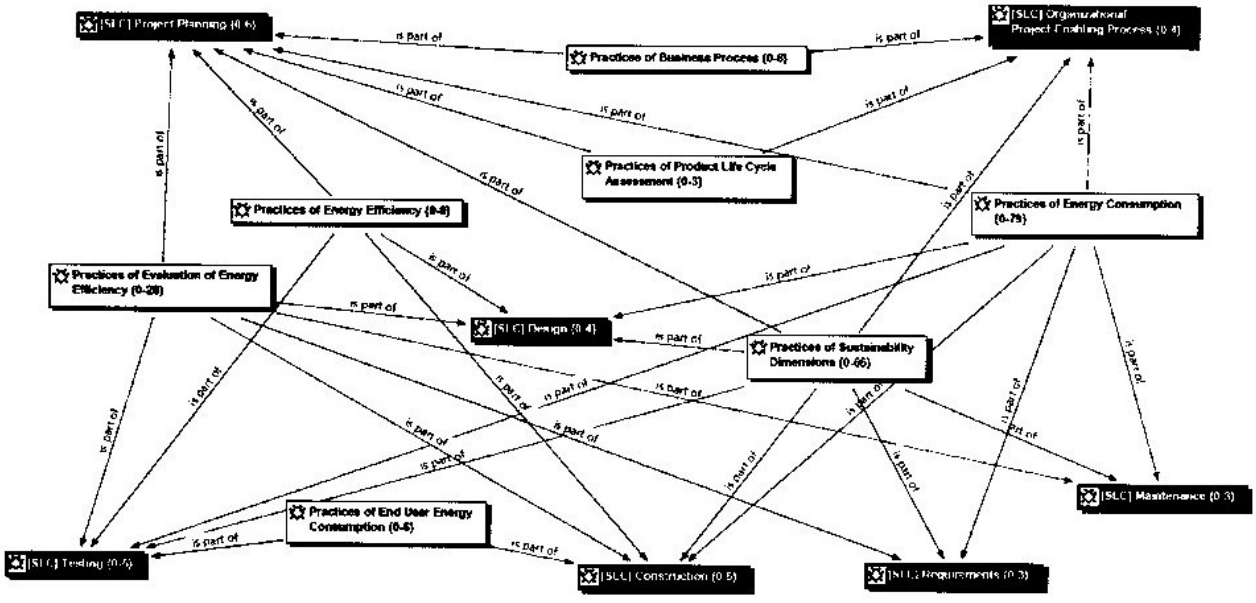

Figure 22 - Network of practices and SLC categories

Regarding the Organizational Levels category, it emerged by reading the practice and thinking whether that practice was used by Strategic, Operational or Tactic level in the organization. The results show 112 practices categorized as Operational, since there are many practice that will be used by developers and programmers during the software development. Regarding the Strategic levels we have 22 practices linked, most of them are practices related to organizational aspects, which will be applied by executives and people on strategic levels. About the Tactic level, we have 36 practices, which will be applied by the senior managers, coordinators e supervisors of the organization. One network, shown in Figure 23, can represent the practices related to Strategic Levels. The green practices are directly linked with strategic plans and is a generic description. The blue practices are specific practices that mean how the strategic level can be applied it in the organization. For instance, a practice categorized as Strategic level is one related to Practices of Sustainability Dimensions described as **[PSUD] Include Green IT in strategic management of enterprises** (PENZENSTADLER; FEMMER; RICHARDSON, 2013).

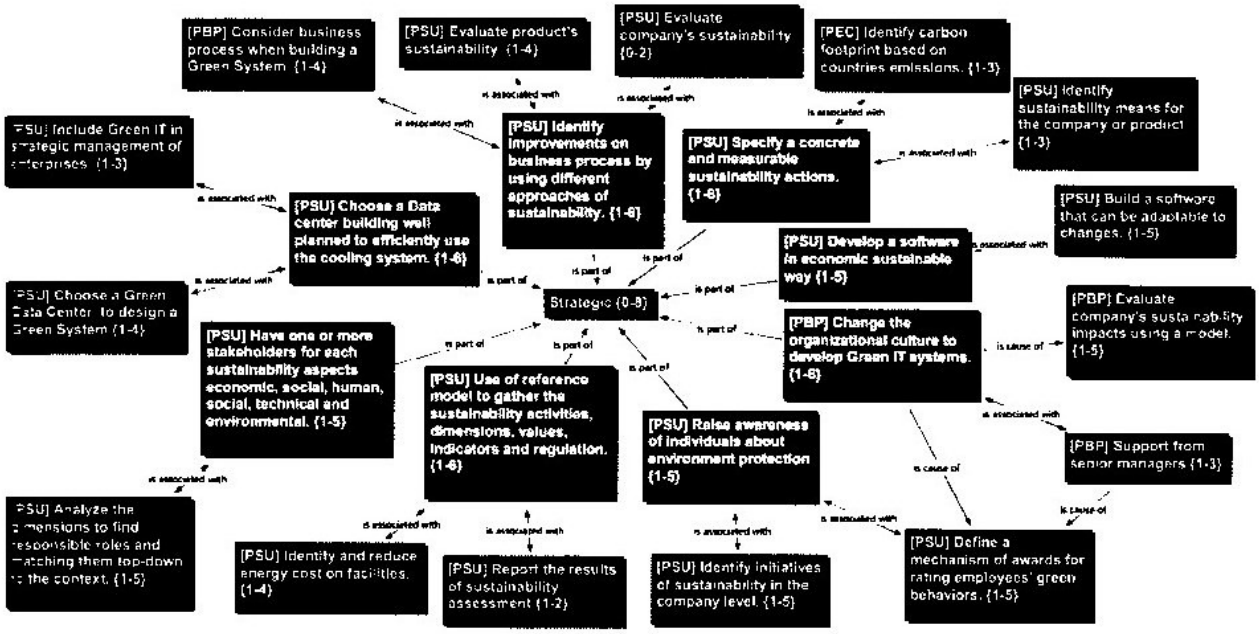

Figure 23 - Network practices samples categorized in strategic level.

To summarize the answer of RQ.2 from the analysis it was possible to conclude that all the Software Engineering main phases were covered among the 170 practices identified in the literature. Additionally, to support the identification of who will use the practice, the Organizational Levels were identified in each practice. Since there are

many practices and categories, it was necessary to group and explain the use of these practice throughout a mind map.

4.1.2.1 Mind Map

The intention of mind map is to connect the concepts by explaining its relationship and organize the knowledge discovered. We created this to help the researchers and software development industry to use the practices selected from 23 papers based on its empirical validation. Furthermore, this map helped to prepare and organize the analysis points and propositions for case study. To explain how the Sustainable Software Engineering practices were connected with the categories a mind map was created represented in Figure 24 and is composed of:

- Practices that explains **what** we have to do to apply Sustainable Software Engineering practice.
- Organizational Levels is about **who** is responsible and involved for a practice of Sustainable Software Engineering (BATEMAN, 2012).
- Software Life Cycle to identify **where** the practice will be described in software development life cycle (ISO/IEC12207,2008);
- SWEBOK knowledge areas, aim to respond **when** the practice will be used, in which moment of software development it will be used (SWEBOK, 2013);

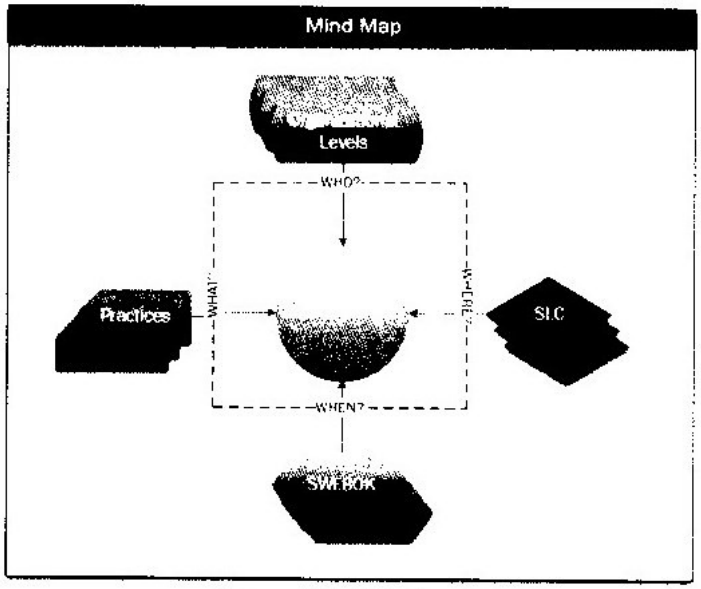

Figure 24 - Mind map

In order to explain the mind map emerged through the Grounded Theory, one of the practices found in the literature was used as an example and can be applied as shown in Figure 25.

- What? A practice of energy consumption which prescribes the creation of an environment for software energy measurements during the development.
- Who? This practice is used by developers and programmers from an IT department at the operational level of an organization.
- Where? This practice is described in the design phase of SLC, since it is where the architecture and procedures for the software development will be arranged.
- When? This practice can be executed at the moment of software construction, software maintenance and can be part of Software Engineering process as well.

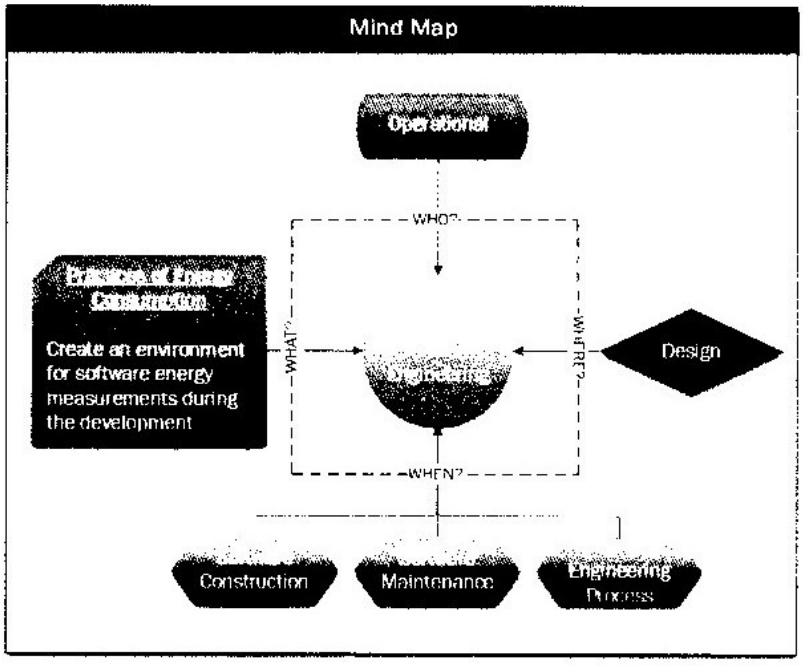

Figure 25 - The application of Mind map.

Even though the mind map was not applied in real case scenarios, the way of thinking about the categories and subcategories relationship helped the researcher to elaborate the propositions for the case study.

4.2 Considerations about the chapter

This Chapter presented how the systematic literature review was designed and executed. The results of the search string were considered high due to the fact of having many papers not related to IT nor Sustainable Software Engineering. The

results of this SLR generated the theoretical framework as expected, answering the RQ.1. For the RQ.2, besides categorizing and refine the practices into Software Engineering phases, we also categorized them into organizational levels. Finally, to understand how each practice is used and its categories relationship a mind map was created.

CHAPTER 5 - CASE STUDIES

The case study identification, propositions review, case study execution, transcription of individual's case and proposition analysis regarding the units of analysis are presented in this Chapter for each organization studied. Aiming to describe the analysis points found in the Organizations as well as their practices, we present first the network and then discuss each analysis point. The network was created in Atlas.Ti following the process of analysis described in Chapter 3 and is divided as systematized and non-systematized practices. **Systematized** means practices defined by the **organization process and guidelines**. **Non-systematized** is about practices defined by **employees' experience and knowledge** of software development. Another classification of the findings is about the **new practices not found in the SLR** but emerged from the case study, which are represented with green color in the network and with **"is a new practice of"** relationship notation. We also named the practices **from SLR** as **existent practices**, which was also found in the case study and is represented in the network with purple color and **"is a"** relationship.

5.1 Organization A

The organization A is the fourth largest national bank based on its assets income. It has a strong presence in Brazil since its foundation. Regarding the sustainability aspects, the organization has been conducting many programs, mostly of them in the organizational level not specifically for Information Technology. These programs are related to social-educational and environment. However, in its sustainability reports there is no detail about the actions they are doing and how they are measuring the carbon footprint of its operations and technology centers.

Even though the organization did not measure the sustainability gains, it is possible to see that investments in technology and initiatives that could generate positive third order impacts on sustainability are addressed. One of them was launch a digital bank where anyone can open a banking account from mobile application. The intention with this application was to reduce the number of agencies therefore the

operational costs. So far, the organization did not report whether or not this goal was possible to archive.

For this case study five professionals from IT area were interviewed and the details are presented in Table 15.

Organization A	Job description	Financial experience	IT experience	Interview duration
Employee A	Infrastructure Analyst	4 years	18 years	00:12:43
Employee B	Software Development Manager	9 years	17 years	00:10:38
Employee C	Project Leader	6 years	20 years	00:07:53
Employee D	Senior Developer	4 years	25 years	00:08:38
Employee E	Project Manager	7 years	9 years	00:11:24

Table 15 - Organization A - employee's profiles.

In order to show the results, the analysis points are described in the next session.

5.1.1 Organization A – Analysis Points description

In Figure 26 is possible to identify four practices discovered in the Organization A applied in systematized way. In this case, the Organization A has guidelines about these practices found in SLR, noted as purple, categorized into Practices of Sustainability Dimensions.

Regarding the new practices, which were not found in the SLR before, we discovered two practices. One practice was categorized into Practices of Business Process and another one into Practices of Energy Consumption.

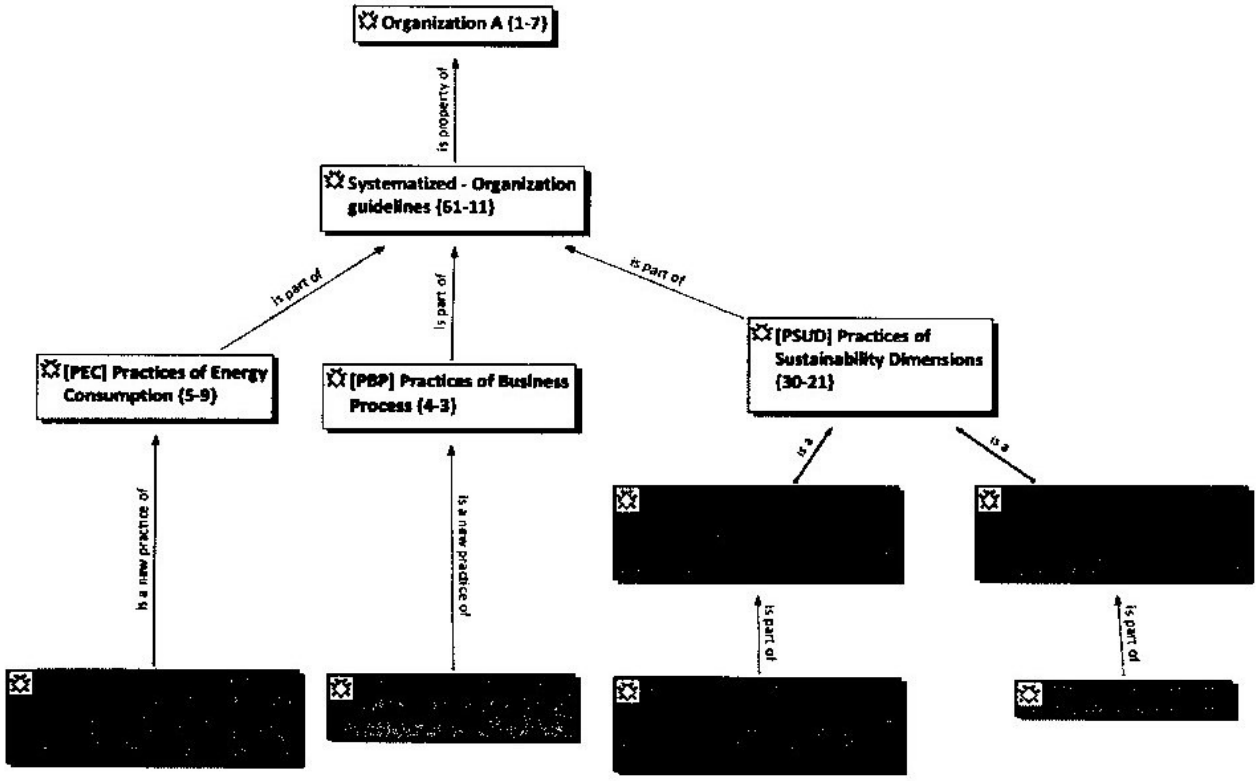

Figure 26 - Organization A - Network of systematized practices.

In Figure 27 we have Non-systematized practices, which are based from employees' experiences in software development and were not defined by the Organization A.

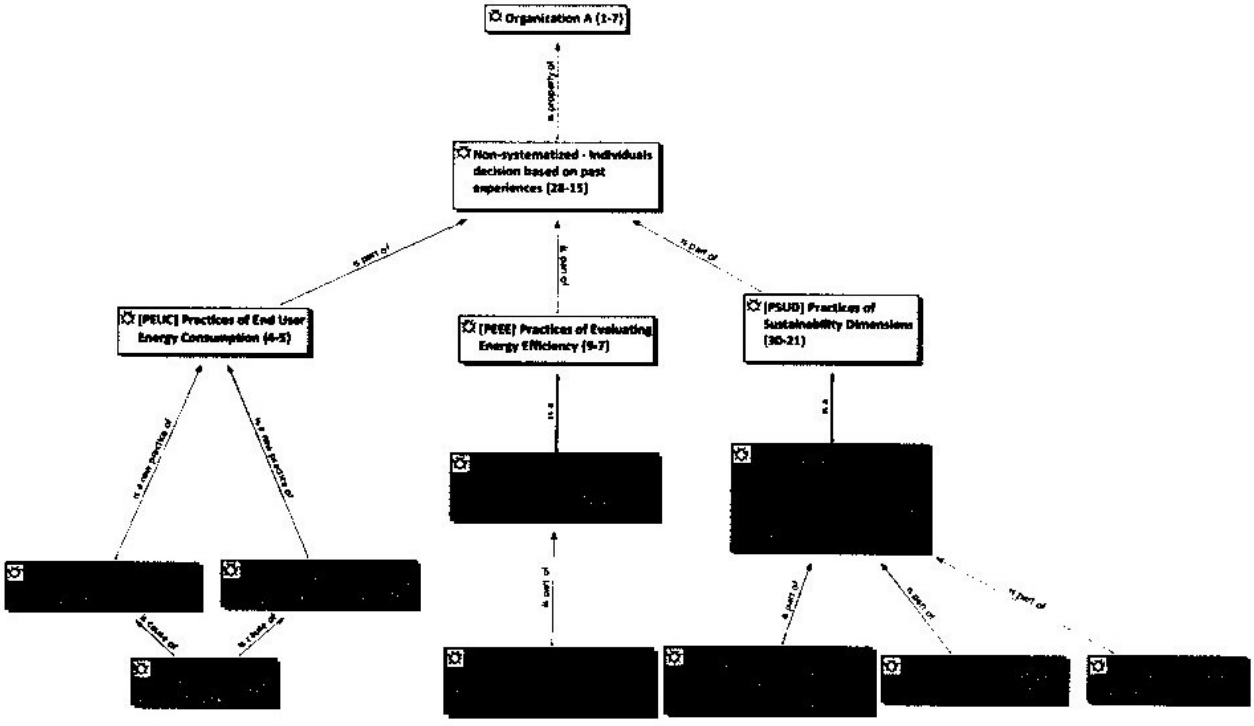

Figure 27 - Organization A - Network of non-systematized practices

In this case, we have six existent practices from SLR presented in Organization A distributed into Practices of Evaluating Energy Efficiency and Practices of

Sustainability Dimension categories. All these practices will be discussed in the corresponding analysis points.

Organization A - Analysis points results

With respect to AP-01 - Initiatives that promote awareness about organizational social responsibility within the IT sector described in Table 16, it was possible to identify existent practices from SLR and new practices from the case study. The existent practices from SLR found in Organization A is about **[PSUD] Raise awareness of individuals about environment protection** (ZHONG; LIU, 2010) and it was identified when asked to the employees what are the communications received. They answered they received internal communication about do not waste water and use less paper. This kind of communication is also part of an existent practice found in the literature **[PSUD] Identify initiatives of sustainability in the company level.** Internal communications is also used as a metric to measure sustainability goals and in this case was considered as systematized since the organization often communicates the employees (PENZENSTADLER; FEMMER, 2013). Since the organization communicates about sustainability, even though not specifically about Sustainable Software Engineering, it was possible to confirm that sustainability is in organization's strategy and is a concern. This confirmation is based on organization annual reports when they participate of United Nations Global Compact[5], Equator Principles [6] and have to show the sustainability indicators to meet 2030 sustainability goals.

Moreover, other confirmation about the organizational strategy towards sustainability is the new practice discovered **[PBP] Sustainability is a mean of marketing** categorized as Practice of Business Process, which enable the business gains throughout the sustainability. The case reported was about the use of mobile banking application without network access. Consequently this marketing increased the download and use of mobile banking reducing operational costs and also satisfying the user because it saves his money. Here again, we are talking about the third order effects as presented in Chapter 2 (NAUMANN et al., 2011) and (FAUCHEUX; NICOLAÏ, 2011).

The analysis points with sad face in Table 16 means they were not confirmed in the organization. The happy faces means the practices were not found in systematized

[5] https://www.unglobalcompact.org/
[6] http://www.equator-principles.com/index.php/about-ep/about-ep/38-about/about/352

way, since the Organization A determines the use of those practices. The neutral face means that practices were found in non-systematized way.

AP-01	Initiatives that promote awareness about organizational social responsibility within the IT sector	Exists? ORG A ☹ 😐 ☺	Propositions
AP-01.Q-01	Initiatives that promote awareness about organizational social responsibility within the IT sector. (PENZENSTADLER; FEMMER; RICHARDSON, 2013),(PENZENSTADLER, 2014)	☺	P1, P2
AP-01.Q-02	Is there anyone responsible for disseminating sustainability information in IT projects? (PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☹	
AP-01.Q-03	Within the IT area is there a sustainability focal point? (PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☹	
AP-01.Q-04	Is there a reference model for achieving sustainability activities, dimensions, values, indicators and regulations? (PENZENSTADLER; FEMMER, 2013) ,(ALBERTAO et al., 2010)	☹	
AP-01.Q-05	What are the metrics for measuring sustainability goals? (PENZENSTADLER; FEMMER, 2013)	☹	
AP-01.Q-06	Is there specification of sustainability actions? (ZHONG; LIU, 2010)	☺	
AP-01.Q-07	Does the organization promote awareness raising about sustainability? (PENZENSTADLER; FEMMER, 2013) (ZHONG; LIU, 2010)	☺	
AP-01.Q-08	What are the awareness actions? (ZHONG; LIU, 2010)	☺	
AP-01.Q-09	Is sustainability present in the organization's strategy? (PENZENSTADLER; FEMMER, 2013) ,(ZHONG; LIU, 2010)	☺	

Table 16 - Organization A - Results of AP-01.

To summarize the AP-01, only AP-01.Q-01, AP-01.Q-06, AP-01.Q-07, AP-01.Q-08 and AP-01.Q-09 were confirmed in Organization A by the practices described previously.

Regarding the AP-02 about Practices of Sustainability Dimensions during software development only one question (AP-02.Q-08), as presented in Table 17, was found and it was non-systematized, which means that the employee applied that because of his sense of experience and own decision. This practice is considered a new practice in this study because it was not found previously in the literature. The practices are **[PSUD] Use of clean code methodology to optimize the code maintenance** and **[PSUD] Build reusable components** all categorized into Practices of Sustainability Dimensions.

The **[PSUD] Use of clean code methodology to optimize the code maintenance** is adopted during the construction and maintenance phase, and the

developer use this to easily maintain the code, avoid spending many hours trying to understand what another developer did. This practice is not new in the traditional Software Engineering, there are many approaches and books talking about clean coding.

The **[PSUD] Build reusable components** practice is about build reusable components. This is described in SWEBOK as best practice of Software Engineering as well, however from SLR practices there were not mention about reusable components. The important point to notice here is that the interviewee was project leader, and said that this practice was adopted in project planning and also in design phase of software life cycle. This is because the cost of the project and time can change when using reusable components. From the interviewee understanding, this is a sustainable practice.

AP-02	Practices of Sustainability Dimensions are considered during the software development.	Exists? ORG A ☹😐☺	Propositions
AP-02.Q-01	In the project planning phase is it considered a plan for the software to be sustainable in order to suffer less changes during development? (PENZENSTADLER; FEMMER, 2013) ,(ZHONG; LIU, 2010) ,(KIM; LEE; LEE, 2012)	☹	P2, P3
AP-02.Q-02	Is the non-functional requirements related to sustainability identified in the software requirements phase? (PENZENSTADLER; FEMMER, 2013) ,(SCHIEN et al, 2013), (KALAITZOGLOU; BRUNTINK; VISSER, 2014), (KAMBADUR; KIM, 2014),(HINDLE, 2012) , (MANOTAS et al, 2013)	☹	
AP-02.Q-03	In the software design phase is there any guide to developing the sustainability-oriented software architecture? (PENZENSTADLER, 2014)	☹	
AP-02.Q-04	In the software testing phase is it verified whether the software contemplates Sustainable Software Engineering practices? (PENZENSTADLER; FEMMER, 2013) ,(ALBERTAO et al., 2010)	☹	
AP-02.Q-05	In the maintenance phase of the software is there any sustainability practice applied? (PENZENSTADLER, 2014)	☹	
AP-02.Q-06	Within each phase, has the person in charge knowledge about what is sustainability? (PENZENSTADLER; FEMMER, 2013) , (PENZENSTADLER, 2014) ,(PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☹	
AP-02.Q-07	In the project planning phase is it considered a green data center that also consider sustainability important? (ZHONG; LIU, 2010)	☹	
AP-02.Q-08	In the software construction is it considered the use of practices related to modifiability, reusability, portability and supportability? (ALBERTAO et al., 2010)	😐	

Table 17 - Organization A - Results of AP-02.

As represented in Table 17 only AP-02.Q-08 was confirmed in a non-systematized way.

The analysis point AP-03 is about considering practices of energy consumption during the software development. In this case only one question (AP-03.Q-05) was found and is about **[PEEE] Employ energy efficiency techniques as Source Code Tuning**. This practice was found in the literature and means that Source Code Tuning increases the energy savings of an application once it is refactored (KAMBADUR; KIM, 2014).

AP-03	Practices of Energy Consumption are considered during the software development.	Exists? ORG A ☹ 😐 ☺	Propositions
AP-03.Q-01	In the project planning phase is it possible to identify the use of practices related to the choice of hardware or devices, metrics and monitoring that can be added to software development to consume less energy? (CORDERO et al., 2015) , (SCHIEN et al, 2013), (KALAITZOGLOU; BRUNTINK; VISSER, 2014), (KIM; LEE; LEE, 2012) , (WEISS; REPETTO; KOZIOLEK, 2012)	☹	P2, P3
AP-03.Q-02	In the phase of software requirements practices related to collection, measurement and configuration of power consumption are found? (SCHIEN et al, 2013),(KALAITZOGLOU; BRUNTINK; VISSER, 2014), (KAMBADUR; KIM, 2014), (HINDLE, 2012) , (MANOTAS et al, 2013)	☹	
AP-03.Q-03	In the design phase of the software you can find practices related to architecture, tools, frameworks, virtualization, standards and coding that reduce or monitor the software's power consumption. (CORDERO et al., 2015) ,(PENZENSTADLER; FEMMER, 2013) , (SCHIEN et al, 2013), (AGOSTA et al, 2012) , (SAHIN et al, 2012) , (MANOTAS et al, 2013), (CAPRA; FRANCALANCI; SLAUGHTER, 2012) , (NOUREDDINE; ROUVOY; SEINTURIER, 2015), (SIEBRA et al, 2012)	☹	
AP-03.Q-04	In the construction phase is it possible to find practices related to programming without the use of frameworks, real-time code energy consumption monitoring and automation of memory allocation and CPU when the software is running? (CORDERO et al., 2015) ,(SCHIEN et al, 2013),(NOUREDDINE et. al., 2012),(ZHONG; LIU, 2010) , (KAMBADUR; KIM, 2014) ,(AGOSTA et al, 2012) ,(KIM; LEE; LEE, 2012) ,(KOCAK; ALPTEKIN; BENER, 2014) , (SIEBRA et al, 2012)	☹	
AP-03.Q-05	In the test phase it is possible to find practices related to test case definition, test framework, energy efficiency techniques, quality attributes and code performance that test the power consumption of the software. (CORDERO et al., 2015) , (SCHIEN et al, 2013), (KALAITZOGLOU; BRUNTINK; VISSER, 2014),(NOUREDDINE et. al., 2012),(KAMBADUR; KIM, 2014),(KIM; LEE; LEE, 2012) , (KOCAK; ALPTEKIN; BENER, 2014) ,(MANOTAS et al, 2013),(SIEBRA et al, 2012)	😐	
AP-03.Q-06	In the maintenance phase it is possible to find practices related to configuration, monitoring and automatic optimization of the server according to the power consumption of the software. (SCHIEN et al, 2013), (KALAITZOGLOU; BRUNTINK; VISSER, 2014), (SIEBRA et al, 2012), (MONTEIRO; AZEVEDO; SZTAJNBERG, 2013)	☹	

Table 18 - Organization A - Results of AP-03.

As represented in Table 18, only AP-03.Q-05 was confirmed and the interviewee reported that, when the code was refactored, the application performance was better and he said this was the sustainable practice adopted by him not imposed by the organization,.

Regarding AP-04, there are no practices found considering sustainability guidelines during software requirements phase we had no positive results for this analysis points. This happened because the organization do not have any guideline covering sustainability aspects to develop a software. The questions and results are presented in Table 19.

AP-04	Guidelines about sustainability requirements	Exists? ORG A ☹😐☺	Propositions
AP-04.Q-01	During the survey of software requirements do you see the use of guides describing Sustainable Software Engineering practices? (WEISS; REPETTO; KOZIOLEK, 2012)	☹	P1, P2
AP-04.Q-02	Is a benchmark model used to describe sustainability practices that should be considered when surveying software requirements? (PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☹	
AP-04.Q-03	Is there a guide that helps to identify the limitations of sustainability during software development? (PENZENSTADLER, 2014)	☹	
AP-04.Q-04	Is there a guide to identify sustainability goals during software development? (PENZENSTADLER, 2014)	☹	
AP-04.Q-05	Is there a guide to identifying sustainability interactions during software development? (PENZENSTADLER, 2014)	☹	

Table 19 - Organization A - Results of AP-04.

AP-05 presents the practices related to organizational levels found in the Organization A. For this AP, it was possible to confirm existent practices from SLR related to Strategic level applied in systematized way and Operational level applied in a non-systematized way as described in Table 20.

Classification	Organizational levels	Practices
Systematized	Strategic	[PSUD] Identify initiatives of sustainability in the company level.
Systematized	Strategic	[PSUD] Raise awareness of individuals about environment protection.
Non-systematized	Operational	[PEEE] Employ energy efficiency techniques as Source Code Tuning
Non-systematized	Operational	[PSU] Identify practices of Development-Related Proprieties like modifiability, reusability, portability and supportability.

Table 20 - Organization A - AP-05 Organizational Levels.

However in the Tactic level no existent practices from SLR were found as represented in Table 21.

AP-05	Sustainable Software Engineering practices are identified at some levels of organization planning within the IT area.	Exists? ORG A ☹ 😐 ☺	Propositions
AP-05.Q-01	It is noticed that in the Strategic level the practices of Sustainable Software Engineering are defined, there is documented evidence of these practices? (PENZENSTADLER; FEMMER, 2013) ,(SCHIEN et al, 2013),(ZHONG; LIU, 2010) ,(PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☺	P1
AP-05.Q-02	At the Tactical level, practices defined in the literature are found in the organization? (PENZENSTADLER; FEMMER, 2013) ,(SCHIEN et al, 2013),(ZHONG; LIU, 2010) ,(PENZENSTADLER, 2014) ,(CAPRA; FRANCALANCI; SLAUGHTER, 2012) ,(ALBERTAO et al., 2010) ,(PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☹	
AP-05.Q-03	At the Operational level, practices defined in the literature are found in the organization? (CORDERO et al., 2015) ,(PENZENSTADLER; FEMMER, 2013) ,(SCHIEN et al, 2013),(ZHONG; LIU, 2010) ,(PENZENSTADLER, 2014) ,(ALBERTAO et al., 2010) ,(WEISS; REPETTO; KOZIOLEK, 2012),(PENZENSTADLER; FEMMER; RICHARDSON, 2013)	😐	

Table 21 - Organization A - Results of AP-05.

Regarding AP-06, the strategic alignment is not perceived by the employees as presented in Table 22. No practices were found.

AP-06	Strategic alignment of the organization regarding the adoption of sustainability practices.	Exists? ORG A ☹ 😐 ☺	Propositions
AP-06.Q-01	Is it perceived that sustainability is part of the organization's strategy? (PENZENSTADLER; FEMMER, 2013) ,(ZHONG; LIU, 2010)	☹	P1
AP-06.Q-02	It is understood that senior management of the organization supports and encourages the tactical and operational levels to use Sustainable Software Engineering practices? (ZHONG; LIU, 2010) ,(PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☹	
AP-06.Q-03	Is it possible to identify the meaning of sustainability for the organization? (PENZENSTADLER; FEMMER, 2013) ,(ZHONG; LIU, 2010)	☹	

Table 22 - Organization A - Results of AP-06.

This AP-07, refers to hire vendors or suppliers in compliance with sustainability aspects. An example is Green Data Center using energy from renewable sources. In this case, as show in Table 23, none of them were found.

AP-07	A preference is given to hiring IT vendors who apply sustainability to their business.	Exists? ORG A ☹ 😐 ☺	Propositions
AP-07.Q-01	The organization prides itself for hiring suppliers who have sustainability seals, energy efficiency and clean energy. (ZHONG; LIU, 2010) , (KIM; LEE; LEE, 2012)	☹	P1
AP-07.Q-02	Is it possible to identify that the organization uses software developed with Sustainable Software Engineering practices? (NOUREDDINE et. al., 2012)	☹	

Table 23 - Organization A - Results of AP-07.

Regarding AP-08, where there is a concern to inform customer about the adoption of sustainability practices during the software development we have one non-systematized answer and one systematized.

About the non-systematized (AP-08.Q-02) a new practice was identified and classified as practices of energy consumption: **[PEC] Technical solution to use less smartphone battery.** The interviewee described this as something that they found important since the beginning of the project. They had to change technical solutions approaches, because it would spend too much battery from the user. He also mentioned that this was more an user experience approach, which it actually a Sustainable Software Engineering practice that can be applied on requirements phase as non-functional requirement and also in design phase, considering light solutions for mobile development.

Again one practice already found in AP-01 is **[PBP] Sustainability is a mean of marketing,** about the systematized approached AP-08.Q-04. All the other questions were not answered as presented in Table 24.

AP-08	**Concern to inform the customer that sustainability practices were adopted during the software development.**	**Exists? ORG A** ☹ 😐 ☺	**Propositions**
AP-08.Q-01	Is it possible to identify that from the beginning of software development the customer is informed that the software is being developed with Sustainable Software Engineering practices? (PENZENSTADLER; FEMMER; RICHARDSON, 2013), (ALBERTAO et al., 2010)	☹	**P1, P2, P3**
AP-08.Q-02	Is it important for the organization to verify that the developed software is consuming a lot of power when the customer uses it? (CORDERO et al., 2015) ,(SCHIEN et al, 2013)	😐	
AP-08.Q-03	Does the organization inform the customer of mechanisms that have been developed to avoid excessive consumption of energy by the software? (CORDERO et al., 2015) , (SCHIEN et al, 2013), (KIM; LEE; LEE, 2012) , (MANOTAS et al, 2013), (ALBERTAO et al., 2010)	☹	
AP-08.Q-04	What are the customer-driven awareness actions that the organization establishes? (SCHIEN et al., 2013)	☺	

Table 24 - Organization A - Results of AP-08.

With respect to AP-09, where it is possible to find Sustainable Software Engineering practices at each stage of the software life cycle, there are systematized and non-systematized findings presented in Table 25.

At the requirements phase it was found a new practice related to **[PEC] Build high performance mobile apps considering light solutions** confirming AP-09.Q-

02. As the interviewee said the Organization A "gives this recommendation when developing mobile applications". These light solutions are basically taking care of application size by considering image size or avoid the use of too much images or load the images as the user scrolling down in the application. Thinking about all these techniques we categorized this as Practices of Energy Consumption since its third order effects saves energy battery (KINDELSBERGER; WILLNECKER; KRCMAR, 2015).

Non-systematized practices were found at construction phase such as: **Build a software that is modularized**, **Build reusable components** and **Use of clean code methodology to optimize the code maintenance**. All of them is part of **[PSUD] Identify practices of Development-Related Proprieties like modifiability, reusability, portability and supportability**. Accordingly with (ALBERTAO et al., 2010), the properties of Reusability is "the level in which system components can be reused in other systems" and this why we have **Build a software that is modularized** and **build reusable components** extracted from the interviews linked to this practice responding the AP-09.Q-04.

Specifically to **Use of clean code methodology to optimize the code maintenance**, this is related with Supportability, which is defined by (ALBERTAO et al., 2010) as "the system's ability to be easily configured and maintained after deployment".

At the software test new practices related to Practices of End User Energy Consumption – practices that impact the energy consumption of any user devices was found responding to AP-09.Q-05. These practices are related to mobile development and were described by interviewee as "**Technical solution to use less smartphone 3G/4G**" and "**Technical solution to use less smartphone battery**". These practices were used by interviewee and it was not defined by the organization. When asked why these practices were important to be adopted the interviewee said "this was because a concern with user experience and from past experiences user complains when an application is using too much battery or internet". During the testing it was verified if the application was performing well, however they did not measure the energy consumption.

Existent practice related to non-systematized property informed by the user as **Code refactoring lead to reduce CPU resources thus energy consumption** was categorized as Practices of Evaluating Energy Efficiency and is part of **[PEEE] Employ**

energy efficiency techniques as Source Code Tuning. It is important to observe that the user inferred without deep knowledge of Sustainable Software Engineering practices that code refactoring lead to reduce CPU resources and consequently energy. It was clear for the developer the connection between CPU and energy consumption without further explanation. Perhaps, the understanding about Sustainable Software Engineering practices is easier for some people, and they already uses it during the software development, they only do not know the term for these approaches.

AP-09	**It is possible to identify Sustainable Software Engineering practices at each phase of the software life cycle.**	**Exists? ORG A** ☹😐☺	**Propositions**
AP-09.Q-01	Within the project planning phase is it possible to find at least one of the practices: energy consumption (PEC), energy efficiency evaluation (PEEE), energy efficiency (PEF), business processes (PBP), life cycle assessment (PLCA) and sustainability (PSUD). (CORDERO et al., 2015) ,(PENZENSTADLER; FEMMER, 2013) ,(SCHIEN et al, 2013),(KALAITZOGLOU; BRUNTINK; VISSER, 2014),(ZHONG; LIU, 2010) ,(KIM; LEE; LEE, 2012) ,(PENZENSTADLER, 2014) ,(ALBERTAO et al., 2010) ,(WEISS; REPETTO; KOZIOLEK, 2012),(PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☹	**P1, P2, P3**
AP-09.Q-02	Within the software requirements phase it is possible to find at least one of the practices: energy consumption (PEC), energy efficiency evaluation (PEEE) and sustainability (PSUD). (PENZENSTADLER; FEMMER, 2013) ,(SCHIEN et al, 2013),(KALAITZOGLOU; BRUNTINK; VISSER, 2014),(ZHONG; LIU, 2010) ,(KAMBADUR; KIM, 2014),(AGOSTA et al, 2012) ,(HINDLE, 2012) ,(PENZENSTADLER, 2014) ,(MANOTAS et al, 2013),(PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☺	
AP-09.Q-03	Within the software design phase it is possible to find at least one of the practices: energy consumption (PEC), energy efficiency evaluation (PEEE), energy efficiency (PEF) and sustainability (PSUD). (CORDERO et al., 2015) ,(PENZENSTADLER; FEMMER, 2013) ,(SCHIEN et al, 2013),(NOUREDDINE et. al., 2012),(ZHONG; LIU, 2010) ,(AGOSTA et al, 2012) ,(PENZENSTADLER, 2014) ,(SAHIN et al, 2012) ,(MANOTAS et al, 2013),(CAPRA; FRANCALANCI; SLAUGHTER, 2012) ,(NOUREDDINE; ROUVOY; SEINTURIER, 2015),(SIEBRA et al, 2012),(MONTEIRO; AZEVEDO; SZTAJNBERG, 2013)	☹	
AP-09.Q-04	Within the software construction it is possible to find at least one of the practices: energy consumption (PEC), energy efficiency evaluation (PEEE), energy efficiency (PEF), end user energy consumption (PEUC) and sustainability (PSUD). (CORDERO et al., 2015) ,(PENZENSTADLER; FEMMER, 2013) ,(SCHIEN et al, 2013),(NOUREDDINE et. al., 2012),(ZHONG; LIU, 2010) ,(KAMBADUR; KIM, 2014),(AGOSTA et al, 2012) ,(KIM; LEE; LEE, 2012) ,(KOCAK; ALPTEKIN; BENER, 2014) ,(SIEBRA et al, 2012)	😐	
AP-09.Q-05	Within the software testing phase it is possible to find at least one of the practices: energy consumption (PEC), energy efficiency evaluation (PEEE), energy efficiency (PEF), end	😐	

	user energy consumption (PEUC) and sustainability (PSUD). (CORDERO et al., 2015) , (PENZENSTADLER; FEMMER, 2013) , (SCHIEN et al, 2013), (KALAITZOGLOU; BRUNTINK; VISSER, 2014), (KAMBADUR; KIM, 2014), (KIM; LEE; LEE, 2012) , (KOCAK; ALPTEKIN; BENER, 2014) , (MANOTAS et al, 2013), (ALBERTAO et al., 2010) , (SIEBRA et al, 2012)		
AP-09.Q-06	Within the software maintenance phase it is possible to find at least one of the practices: energy consumption (PEC), energy efficiency evaluation (PEEE) and sustainability (PSUD). (SCHIEN et al, 2013),(KALAITZOGLOU; BRUNTINK; VISSER, 2014),(PENZENSTADLER, 2014) ,(SIEBRA et al, 2012),(MONTEIRO; AZEVEDO; SZTAJNBERG, 2013)	☹	

Table 25 - Organization A - Results of AP-09.

About AP-10 it was not possible to find any practice related to this analysis point as presented in Table 26. This is actually the most difficult question to answer since it requires a really good reason and high efforts to develop a software to adjust itself.

AP-10	**When abnormally energy consumption is detected, the software developed adjust itself to reduce its energy consumption**	**Exists? ORG A** ☹😐☺	**Propositions**
AP-10.Q-01	Is any source code implementation used to reduce power consumption, such as memory allocation and CPU usage? (AGOSTA et al, 2012), (KIM; LEE; LEE, 2012), (KOCAK; ALPTEKIN; BENER, 2014), (SIEBRA et al, 2012)	☹	P3
AP-10.Q-02	Is there any configuration on the server that allows you to change the performance of the software to use less power? (ZHONG; LIU, 2010), (MANOTAS et al, 2013), (MONTEIRO; AZEVEDO; SZTAJNBERG, 2013)	☹	

Table 26 - Organization A - Results of AP-10.

Regarding AP-11 there were not answers for these questions and somehow it is related to AP-10 presented in Table 27. There is no evidence that this organization measure energy efficiency, although the interviewees has concerns about software performance, but it is not related to energy efficiency.

AP-11	**It is possible to measure the energy efficiency of the developed software.**	**Exists? ORG A** ☹😐☺	**Propositions**
AP-11.Q-01	Is there any use of energy consumption measures? (CORDERO et al., 2015) ,(AGOSTA et al, 2012) ,(SAHIN et al, 2012)	☹	P3
AP-11.Q-02	Is there any use of energy efficiency measures or software performance that does not have an impact on energy consumption? (SCHIEN et al, 2013),(KALAITZOGLOU; BRUNTINK; VISSER, 2014), (NOUREDDINE et. al., 2012),(KAMBADUR; KIM, 2014),(NOUREDDINE; ROUVOY; SEINTURIER, 2015),(SIEBRA et al, 2012), (MONTEIRO; AZEVEDO; SZTAJNBERG, 2013)	☹	
AP-11.Q-03	During the software development is the measurement of energy consumption? (SCHIEN et al, 2013),(SIEBRA et al, 2012), (CAPRA; FRANCALANCI; SLAUGHTER, 2012)	☹	
AP-11.Q-04	What metrics are used to measure the software's energy efficiency? (SCHIEN et al, 2013), (NOUREDDINE et. al., 2012),	☹	

	(AGOSTA et al, 2012) , (KIM; LEE; LEE, 2012) , (HINDLE, 2012) , (SAHIN et al, 2012) , (MANOTAS et al, 2013)		
AP-11.Q-05	Is there any other indicator linked to sustainability that is applied in the developed software? (PENZENSTADLER; FEMMER, 2013) , (SCHIEN et al, 2013),(KALAITZOGLOU; BRUNTINK; VISSER, 2014), (NOUREDDINE; ROUVOY; SEINTURIER, 2015)	☹	

Table 27 - Organization A - Results of AP-11.

The practices to evaluate sustainability practices were not found on AP-12 as shown in Table 28.

AP-12	The criteria for evaluating software quality includes sustainability practices.	Exists? ORG A ☹ 😐 ☺	Propositions
AP-12.Q-01	Is it possible to confirm that software sustainability practices are related to software quality attributes? (KOCAK; ALPTEKIN; BENER, 2014) , (PENZENSTADLER, 2014)	☹	P1, P2
AP-12.Q-02	What are the quality attributes adopted by the organization? (ALBERTAO et al., 2010)	☹	

Table 28 - Organization A - Results of AP-12.

In AP-13, we found systematized practice related to evidence of informing the customer about the use of mobile banking without being connected to Internet. This was reported in AP-01 and AP-08 responding AP-13.Q-01. Therefore, we concluded that in this analysis point it is possible to identify evidence of customer information.

AP-13	Concern about the organization's reputation for adopting sustainability practices	Exists? ORG A ☹ 😐 ☺	Propositions
AP-13.Q-01	Is it possible to find evidence on the dissemination of sustainability data to the customer? (PENZENSTADLER; FEMMER, 2013) , (ZHONG; LIU, 2010) , (PENZENSTADLER, 2014)	☺	P1
AP-13.Q-02	Has the organization received recognition for developing sustainable software? (PENZENSTADLER; FEMMER, 2013) , (PENZENSTADLER, 2014)	☹	

Table 29 - Organization A - Results of AP-13.

The summary of all analysis points presented in detail until this moment and propositions results is explained in the next section.

5.1.2 Organization A – Propositions results

In this section we conclude the individual case study of Organization A. This section presents the propositions results and final results of each analysis point.

P1 - Systematized sustainability organizational policies in software development

Table 30 shows the results of the analysis point related to proposition P1.

☹	P1 - Organizational policies driven to sustainability are systematically applied in software development in the financial sector.	
AP-01	Initiatives that promote awareness about organizational social responsibility within the IT sector	☺
AP-04	Guidelines about sustainability requirements	☹
AP-05	Sustainable Software Engineering practices are identified at some levels of organization planning within the IT area.	☺
AP-06	Strategic alignment of the organization regarding the adoption of sustainability practices.	☹
AP-07	A preference is given to hiring IT vendors who apply sustainability to their business.	☹
AP-08	Concern to inform the customer that sustainability practices were adopted during the software development.	😐
AP-09	It is possible to identify Sustainable Software Engineering practices at each phase of the software life cycle.	😐
AP-12	The criteria for evaluating software quality includes sustainability practices.	☹
AP-13	Concern about the organization's reputation for adopting sustainability practices	☺

Table 30 - Organization A - Proposition 1 results

Even thought, the Organization A has a concern to raise awareness about sustainability to the employees and to the customer, confirmed in AP-01, it is not related to Information Technology area, this is related to organizational level and it does not means that the employee in the IT area check this communications frequently and are aware of this.

The AP-05 is confirmed because there are practices related to Strategic and Operational levels reported in AP-05 description.

The concern to inform the customer about the adoption of sustainability practices is confirmed in a non-systematized way by AP-08. It means that the employees care about its adoption, however there is no evidence or documents regarding the application, measurements or quality control by the organization. The same reason to be classified as non-systematized occurs for AP-09.

The AP-13 was confirmed by the new practices found in Organization A about Sustainability as a mean of marketing, in this case the Organization A promotes marketing campaigns regarding the possibility of using the mobile banking without internet connection.

Therefore, when we analyze the practices adopted in IT area that impacts the software development we conclude that the Proposition 1 has non-systematized practices invalidating our assumptions that organization policies are applied in systematized way in the software development area.

P2 - Non-systematized Sustainable Software Engineering practices

In Table 32 is possible to identify the analysis point that contributed to proposition final analyses. In this case we concluded that this proposition was valid, since non-systematized practices were found presented in Table 31 and are related to AP-02, AP-03, AP-08 and AP-09. It is important to observe that two new practices related to end user energy consumption was reported by the interviewee, they applied it without guidance from the Organization A and without know about Sustainable Software Engineering.

Since the propositions are complementary to each other, it is possible to observe the same results of AP-01 and AP-13 reported in proposition P1 previously.

😐 **P2 - Sustainable Software Engineering practices are applied in a non-systematic way during software development.**		
AP-01	Initiatives that promote awareness about organizational social responsibility within ıe IT sector	☺
AP-02	Practices of Sustainability Dimensions are considered during the software ɜvelopment.	☹
AP-03	Practices of Energy Consumption are considered during the software development.	☹
AP-04	Guidelines about sustainability requirements	☹
AP-08	Concern to inform the customer that sustainability practices were adopted during ıe software development.	😐
AP-09	It is possible to identify Sustainable Software Engineering practices at each phase of ıe software life cycle.	😐
AP-12	The criteria for evaluating software quality includes sustainability practices.	☹
AP-13	Concern about the organization's reputation for adopting sustainability practices	☺

Table 31 - Organization A - Proposition 2 results

P3 – Use of tools that automatically measure or change the energy consumption.

This proposition is about the use of algorithms, measures of power consumption and methods that automatically change the application state when there is high usage of energy.

We concluded that the organization has no measures or tools to identify this information in the application. Even though the practices of avoiding build solutions that uses too much mobile battery is considered it does not mean that these solutions are applied automatically without human intervention as represented in Table 32.

☹ P3 - Tools that automatically measure or change the energy consumption of developed software are used		
AP-02	Practices of Sustainability Dimensions are considered during the software development.	☹
AP-03	Practices of Energy Consumption are considered during the software development.	☹
AP-08	Concern to inform the customer that sustainability practices were adopted during the software development.	😐
AP-09	It is possible to identify Sustainable Software Engineering practices at each phase of the software life cycle.	😐
AP-10	When abnormally energy consumption is detected, the software developed adjust itself to reduce its energy consumption	☹
AP-11	It is possible to measure the energy efficiency of the developed software.	☹

Table 32 - Organization A - Proposition 3 results

Therefore, we concluded that it was not possible to validate this proposition in Organization A.

5.2 Organization B

The Organization B is part of Brazilian financial system regulated by Superintendence of Private Insurance (SUSEP) which "is an autarchy created by the Decree-law #73/66 directly linked to Ministry of Finance. It is the executive body of the politics delineated by the National Consul of Private Insurance (CNSP) and is also the insurance commissioner, responsible for the supervision and control of the insurance, open private pension funds and capitalization markets in Brazil." (SUSEP, 2017). Private insurance represented 3.16% of the Brazilian Gross Domestic Product (GDP) in 2014 (SUSEP, 2017). The Organization B market share is 24% from its report in 2015. It operates all type of insurance services.

Regarding sustainability aspects the Organization A compromised with United Nations Environment Program to voluntary commitment to the Principles for Sustainable Insurance of the United Nations Environment Program Finance Initiative (UNEP FI). The principles are a framework for the insurance market to address risks, create innovative solutions, improve business performance and contribute to environmental, social and economic sustainability and also in 2015 joined the International Council of PSI (Principles for Sustainable Insurance). None of these information was shared by the employees working in this organization it was extracted from public report headlines.

The Organization B, Information Technology area is mostly composed by contractors IT professionals, then by directly hired employee and it has over 10 employees. The employees profiles interviewed in this case study is reported in Table 33.

Organization B	Job description	Financial experience	IT experience	Interview duration
Employee A	Systems Analyst	2 years	8 years	00:13:34
Employee B	Senior Developer	7 years	23 years	00:23:04
Employee C	Technical Lead	8 years	12 years	00:27:58

Table 33 - Organization B- employee's profiles.

It is possible to observe that the technology area emphasizes the use of digital channels by customers and insurance brokers improving the compensation payment processes and generation of information for decision making.

5.2.1 Organization B – Analysis Points description

In Figure 28 is possible to identify five practices discovered in the Organization B applied in systematized way. In this case, we have five existent practices from SLR presented in Organization B categorized into Practices of Sustainability Dimension.

Two new practices identified in the interview was discovered in Organization B and are categorized into Practices of Sustainability Dimension.

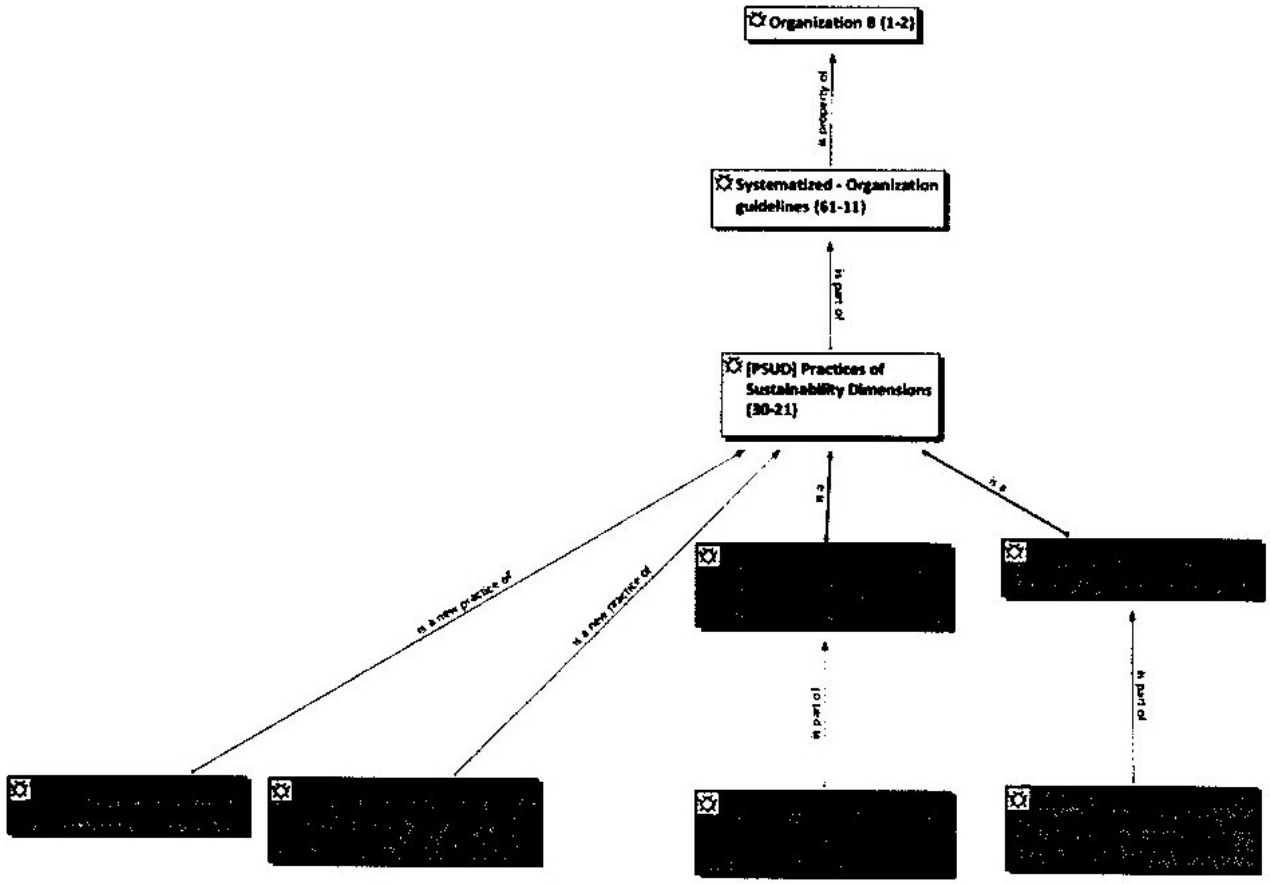

Figure 28 - Organization B - Network of systematized practices

In Figure 29we have Non-systematized practices, what are based from employees' experiences in software development and were not defined by the Organization B. In this case, the Organization B has guidelines about these practices found in SLR, noted as purple, categorized into Practices of Energy Consumption and Practices of Energy Efficiency.

Regarding the new practices, which were not found in the SLR before, we discovered eight practices. Four practices where categorized into Practices of End User Energy Consumption. One new practice was found and categorized into Practices of Energy Consumption.

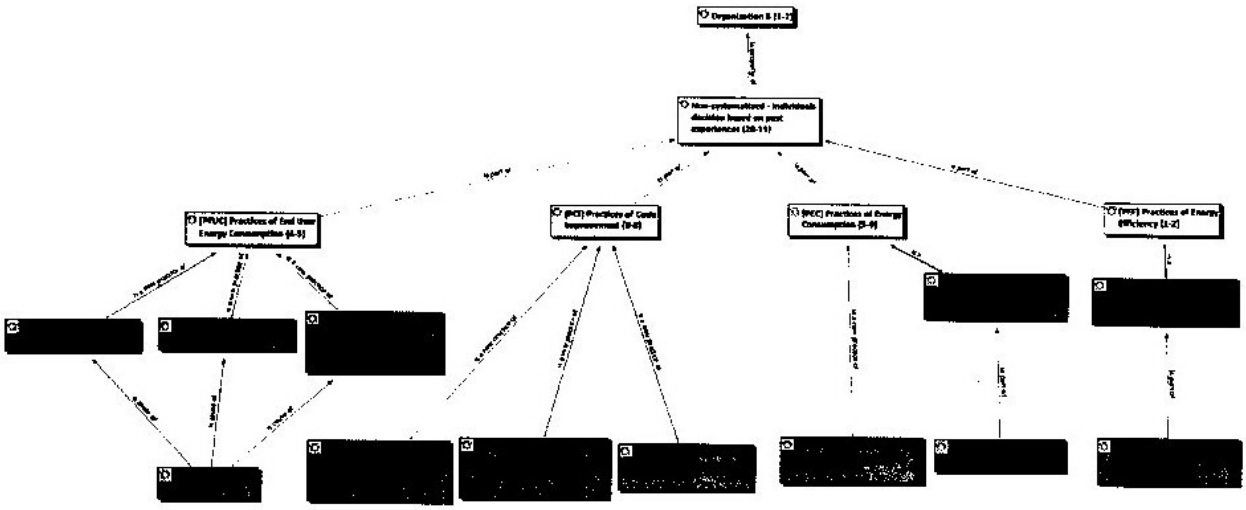

Figure 29 - Organization B - Network of non-systematized practices

A new category emerged from the interviews about Practices of Code Improvement and is composed of three new practices not found in SLR. All these practices will be discussed in the corresponding analysis points.

Organization B - Analysis points results

The AP-01 analysis point is about the organizational awareness regarding sustainability aspect in IT sector presented in Table 34. It was possible to identify practices related to AP-01.Q-07 and AP-01.Q-08, one of them is an existent practice found about **[PSUD] Raise awareness of individuals about environment protection** (ZHONG; LIU, 2010). In this case, the interviewee mentioned they receive emails the conscious use of water. This affirmation is also part of the practice **Internal communication about Organizational Sustainability** which does not impact on the software development itself, but contributes to the organizational sustainability aspects.

The second AP-01.Q-09 one is about the sustainability be part of organization strategy. In this case, the existent practice of **[PSUD] Develop a software in economic sustainable way**, is connected to strategic level because of the practice, discovered in interview, **Develop mobile apps with hybrid frameworks reduce cost and delivery it quickly** (PENZENSTADLER; FEMMER, 2013). From the interviewee it was mentioned an organizational change under IT sector regarding the mobile architecture definition. This change is about a model to support mobile hybrid

development. The definition of this model means developing an application that can run in multiple mobile operating systems avoiding the use of native programming languages for each operating systems. From the Organization B perspective there are positive impacts of using this new architecture for mobile application development: software project costs; duration of application development and resources with knowledge on specific programming language.

AP-01	Initiatives that promote awareness about organizational social responsibility within the IT sector	Exists? ORG B ☹ 😐 ☺	Propositions
AP-01.Q-01	Initiatives that promote awareness about organizational social responsibility within the IT sector. (PENZENSTADLER; FEMMER; RICHARDSON, 2013),(PENZENSTADLER, 2014)	☹	P1, P2
AP-01.Q-02	Is there anyone responsible for disseminating sustainability information in IT projects? (PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☹	
AP-01.Q-03	Within the IT area is there a sustainability focal point? (PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☹	
AP-01.Q-04	Is there a reference model for achieving sustainability activities, dimensions, values, indicators and regulations? (PENZENSTADLER; FEMMER, 2013) ,(ALBERTAO et al., 2010)	☹	
AP-01.Q-05	What are the metrics for measuring sustainability goals? (PENZENSTADLER; FEMMER, 2013)	☹	
AP-01.Q-06	Is there specification of sustainability actions? (ZHONG; LIU, 2010)	☹	
AP-01.Q-07	Does the organization promote awareness raising about sustainability? (PENZENSTADLER; FEMMER, 2013) (ZHONG; LIU, 2010)	☺	
AP-01.Q-08	What are the awareness actions? (ZHONG; LIU, 2010)	☺	
AP-01.Q-09	Is sustainability present in the organization's strategy? (PENZENSTADLER; FEMMER, 2013) ,(ZHONG; LIU, 2010)	☺	

Table 34 - Organization B - Results of AP-01.

The third analysis point is about Practices of Sustainability Dimensions considered during the software development. The analysis point presented in Table 35 describes each phase of software development. In this direction, the AP-02.Q-03 was answered by the new practice **Develop mobile apps with hybrid frameworks reduce cost and delivery it quickly,** this was marked as new because there are not existent practices from SLR related to this hybrid frameworks probably because from the papers selected in SLR none of them was about this subject. Additionally this practice was adopted because of markets trends, community usage and contractors preferences. As long as the project was progressing the Organization B accepted to

change their architecture standards. The hybrid framework or cross-platform mobile development technology used by Organization B is called IONIC v2[7].

A new practice was found in AP-02.Q-05 what is about **Use of tool to perform quality check during the build/deploy of code.** At Organization B a tool is used to check the code written in compliance with the best practices of software development, for instance commented lines of the code, amount of recursive loops and unused methods rules are set up. This tool is used for web projects in any language and is build based on Jenkins[8] an open source tool available on the market for application deploy and build.

Even though this is a common practice used on Software Engineering we noticed the interviewee relating this to Sustainable Software Engineering because of its third order impacts, meaning that by using this tool the code can be easy to maintain, avoid wasting server storage and performance issues on the application side. This tool also improves the software development efficiency since alerts and flags are raised and the developer can fix the issues quickly.

The last answered question is AP-02.Q-07, about consider green data center at the project planning phase. In this case the interview said that received information about sustainable data center but did not pay attention to the communication for further details. We considered this affirmation by associating this with the existent practice **[PSUD] Choose a well-planned data center to efficiently use the cooling system**

AP-02	Practices of Sustainability Dimensions are considered during the software development.	Exists? ORG B ☹ 😐 ☺	Propositions
AP-02.Q-01	In the project planning phase is it considered a plan for the software to be sustainable in order to suffer less changes during development? (PENZENSTADLER; FEMMER, 2013) ,(ZHONG; LIU, 2010) ,(KIM; LEE; LEE, 2012)	☹	P2, P3
AP-02.Q-02	Is the non-functional requirements related to sustainability identified in the software requirements phase? (PENZENSTADLER; FEMMER, 2013) ,(SCHIEN et al, 2013), (KALAITZOGLOU; BRUNTINK; VISSER, 2014), (KAMBADUR; KIM, 2014),(HINDLE, 2012) , (MANOTAS et al, 2013)	☹	
AP-02.Q-03	In the software design phase is there any guide to developing the sustainability-oriented software architecture? (PENZENSTADLER, 2014)	☺	
AP-02.Q-04	In the software testing phase is it verified whether the software contemplates Sustainable Software Engineering practices? (PENZENSTADLER; FEMMER, 2013) ,(ALBERTAO et al., 2010)	☹	

[7] https://ionicframework.com/
[8] https://jenkins.io/

AP-02.Q-05	In the maintenance phase of the software is there any sustainability practice applied? (PENZENSTADLER, 2014)	☺	
AP-02.Q-06	Within each phase, has the person in charge knowledge about what is sustainability? (PENZENSTADLER; FEMMER, 2013) , (PENZENSTADLER, 2014) ,(PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☹	
AP-02.Q-07	In the project planning phase is it considered a green data center that also consider sustainability important? (ZHONG; LIU, 2010)	☺	
AP-02.Q-08	In the software construction is it considered the use of practices related to modifiability, reusability, portability and supportability? (ALBERTAO et al., 2010)	☹	

Table 35 - Organization B - Results of AP-02.

Regarding analysis point AP-03 presented in Table 36 it was possible to find new practices and category related to AP-03.Q-04 what is about construction phase. The interesting part of this analysis point is the fact of a new category has emerged from the interviews what is about **Practices of Code Improvement**, since many interviewees of this organization reported that the code quality in terms of useful comments, methods with good implementation and best practices of programming been followed are perceived by them as practices of Sustainable Software Engineering, even when these practices are non-systematized.

The first new practice is about **[PCB] Develop a code that is easier for everyone understand and maintain**, this is too obvious that none of the practices selected from the literature covered this well known best practice. However it is necessary to give an attention to the basis of programming and how this practice facilitate the work day for the programmers, there are only benefits when best practices are adopted. The interviewee related this to Sustainable Software Engineering when asked which practices related to energy consumption was adopted by him or the organization. Aligned with this practice the interviewee also mentioned a more specific practice as **[PCB] Use of design patterns and java resources to improve the code understanding and maintenance.**

The second new practice is **[PCB] Avoid to leave commented lines in the code to not use too much space in source control repositories** was raised by interviewee since he noticed and has experienced a problem with disk space of source control repositories.

About non-systematized existent practices discovered we have **Reduce the cyclomatic complexity of the code** what is an existent practice part of **[PEC] Reduce the amount of complex code by using memoization techniques**. Cyclomatic

complexity was mentioned by the interview when asked about programming approaches that could impact on application performance. The use of memoization techniques proposed by (AGOSTA et al, 2012) reduces the energy consumption of an application as it caches the data in memory. The reason why the practices are connected is because the use of memoization techniques can reduce the cyclomatic complexity of the code.

Responding to AP-03.Q-05, the non-systematized existent practice was found **Use of new version of java to use functional programming as Streams** being part of **[PEF] Test the energy efficiency performance of different programming languages.** Accordingly with (NOUREDDINE et. al., 2012), the programming languages choice impacts on the application energy consumption. The interview noticed that when he compares the use of Streams from java version 8 and normal loops in java 7, he noticed an extremely difference in application performance. But, this practice is adopted by the organization B, but from his experience on other projects outside the organization B.

AP-03	**Practices of Energy Consumption are considered during the software development.**	**Exists? ORG B** ☹ 😐 ☺	**Propositions**
AP-03.Q-01	In the project planning phase is it possible to identify the use of practices related to the choice of hardware or devices, metrics and monitoring that can be added to software development to consume less energy? (CORDERO et al., 2015) , (SCHIEN et al, 2013), (KALAITZOGLOU; BRUNTINK; VISSER, 2014), (KIM; LEE; LEE, 2012) , (WEISS; REPETTO; KOZIOLEK, 2012)	☹	**P2, P3**
AP-03.Q-02	In the phase of software requirements practices related to collection, measurement and configuration of power consumption are found? (SCHIEN et al, 2013),(KALAITZOGLOU; BRUNTINK; VISSER, 2014), (KAMBADUR; KIM, 2014), (HINDLE, 2012) , (MANOTAS et al, 2013)	☹	
AP-03.Q-03	In the design phase of the software you can find practices related to architecture, tools, frameworks, virtualization, standards and coding that reduce or monitor the software's power consumption. (CORDERO et al., 2015) ,(PENZENSTADLER; FEMMER, 2013) , (SCHIEN et al, 2013), (AGOSTA et al, 2012) , (SAHIN et al, 2012) , (MANOTAS et al, 2013), (CAPRA; FRANCALANCI; SLAUGHTER, 2012) , (NOUREDDINE; ROUVOY; SEINTURIER, 2015), (SIEBRA et al, 2012)	☹	
AP-03.Q-04	In the construction phase is it possible to find practices related to programming without the use of frameworks, real-time code energy consumption monitoring and automation of memory allocation and CPU when the software is running? (CORDERO et al., 2015) ,(SCHIEN et al, 2013),(NOUREDDINE et. al., 2012),(ZHONG; LIU, 2010) , (KAMBADUR; KIM, 2014) ,(AGOSTA et al, 2012) ,(KIM; LEE; LEE, 2012) ,(KOCAK; ALPTEKIN; BENER, 2014) , (SIEBRA et al, 2012)	😐	

AP-03.Q-05	In the test phase it is possible to find practices related to test case definition, test framework, energy efficiency techniques, quality attributes and code performance that test the power consumption of the software. (CORDERO et al., 2015) , (SCHIEN et al, 2013), (KALAITZOGLOU; BRUNTINK; VISSER, 2014),(NOUREDDINE et. al., 2012),(KAMBADUR; KIM, 2014),(KIM; LEE; LEE, 2012) , (KOCAK; ALPTEKIN; BENER, 2014) ,(MANOTAS et al, 2013),(SIEBRA et al, 2012)	😐	
AP-03.Q-06	In the maintenance phase it is possible to find practices related to configuration, monitoring and automatic optimization of the server according to the power consumption of the software. (SCHIEN et al, 2013), (KALAITZOGLOU; BRUNTINK; VISSER, 2014), (SIEBRA et al, 2012), (MONTEIRO; AZEVEDO; SZTAJNBERG, 2013)	☹	

Table 36 - Organization B - Results of AP-03.

Regarding AP-04 considering sustainability guidelines during software requirements phase we had no positive results for this analysis points. This happened because the organization do not have any guideline covering sustainability aspects to develop a software. The questions and results are presented in Table 37.

AP-04	**Guidelines about sustainability requirements**	**Exists? ORG B** ☹😐☺	**Propositions**
AP-04.Q-01	During the survey of software requirements do you see the use of guides describing Sustainable Software Engineering practices? (WEISS; REPETTO; KOZIOLEK, 2012)	☹	**P1, P2**
AP-04.Q-02	Is a benchmark model used to describe sustainability practices that should be considered when surveying software requirements? (PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☹	
AP-04.Q-03	Is there a guide that helps to identify the limitations of sustainability during software development? (PENZENSTADLER, 2014)	☹	
AP-04.Q-04	Is there a guide to identify sustainability goals during software development? (PENZENSTADLER, 2014)	☹	
AP-04.Q-05	Is there a guide to identifying sustainability interactions during software development? (PENZENSTADLER, 2014)	☹	

Table 37 - Organization B - Results of AP-04.

The AP-05 is about the Sustainable Software Engineering practice identified at organization planning level inside the IT area described in Table 38.

AP-05	**Sustainable Software Engineering practices are identified at some levels of organization planning within the IT area.**	**Exists? ORG B** ☹😐☺	**Propositions**
AP-05.Q-01	It is noticed that in the Strategic level the practices of Sustainable Software Engineering are defined, there is documented evidence of these practices? (PENZENSTADLER; FEMMER, 2013) ,(SCHIEN et al, 2013),(ZHONG; LIU, 2010) ,(PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☺	**P1**

AP-05.Q-02	At the Tactical level, practices defined in the literature are found in the organization? (PENZENSTADLER; FEMMER, 2013) ,(SCHIEN et al, 2013),(ZHONG; LIU, 2010) ,(PENZENSTADLER, 2014) ,(CAPRA; FRANCALANCI; SLAUGHTER, 2012) ,(ALBERTAO et al., 2010) ,(PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☹	
AP-05.Q-03	At the Operational level, practices defined in the literature are found in the organization? (CORDERO et al., 2015) ,(PENZENSTADLER; FEMMER, 2013) ,(SCHIEN et al, 2013),(ZHONG; LIU, 2010) ,(PENZENSTADLER, 2014) ,(ALBERTAO et al., 2010) ,(WEISS; REPETTO; KOZIOLEK, 2012),(PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☺	

Table 38 - Organization B - Results of AP-05.

In this case, since we have systematized practices in the Strategic level such as **[PSUD] Raise awareness of individuals about environment protection.** Therefore, the answer to AP-05.Q-01 is confirmed because it is possible to find practices in Table 38. The reaming practices are listed in Table 39.

Classification	Organizational levels	Practices
Systematized	Strategic	[PSUD] Choose a well-planned data center to efficiently use the cooling system.
Systematized	Strategic	[PSUD] Develop a software in economic sustainable way.
Systematized	Strategic	[PSUD] Raise awareness of individuals about environment protection
Non-systematized	Operational	[PEC] Reduce the amount of complex code by using memoization techniques.
Non-systematized	Operational	[PEF] Test the energy efficiency performance of different programming languages.

Table 39 - Organization B - AP-05 Organizational Levels.

At the tactical level, we do not have any systematized practices from the literature that would confirm the question AP-05.Q-02. At the Operational level it was found systematized and non-systematized existent practices from the literature responding the AP-05.Q-03.

Regarding the AP-06 described in Table 40, the organization has sustainability in its strategy as presented on AP-01, practices informed by the interviewee like **Develop mobile apps with hybrid frameworks reduce cost and delivery it quickly** is driven the organizational change towards sustainability. It is important to notice the new changes are coming and incipient process regarding this practice is working in progress.

AP-06	Strategic alignment of the organization regarding the adoption of sustainability practices.	Exists? ORG B ☹ 😐 ☺	Propositions
AP-06.Q-01	Is it perceived that sustainability is part of the organization's strategy? (PENZENSTADLER; FEMMER, 2013) ,(ZHONG; LIU, 2010)	☺	P1
AP-06.Q-02	It is understood that senior management of the organization supports and encourages the tactical and operational levels to use Sustainable Software Engineering practices? (ZHONG; LIU, 2010) ,(PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☹	
AP-06.Q-03	Is it possible to identify the meaning of sustainability for the organization? (PENZENSTADLER; FEMMER, 2013) ,(ZHONG; LIU, 2010)	☹	

Table 40 - Organization B - Results of AP-06.

It is possible to perceive that the company uses green data center, responding to question AP-07.Q-01 listed in Table 41. This practice is described as **[PSUD] Choose a well-planned data center to efficiently use the cooling system** and is an existent practices categorized as systematized (ZHONG; LIU, 2010).

AP-07	A preference is given to hiring IT vendors who apply sustainability to their business.	Exists? ORG B ☹ 😐 ☺	Propositions
AP-07.Q-01	The organization prides itself for hiring suppliers who have sustainability seals, energy efficiency and clean energy. (ZHONG; LIU, 2010) , (KIM; LEE; LEE, 2012)	☺	P1
AP-07.Q-02	Is it possible to identify that the organization uses software developed with Sustainable Software Engineering practices? (NOUREDDINE et. al., 2012)	☹	

Table 41 - Organization B - Results of AP-07.

Regarding the AP-08 concern to inform the customer about the adoption of sustainable practices in software development as represented in Table 42, we have a non-systematized practice related to AP-08.Q-02.

About the non-systematized a new practice was identified and classified as practices of energy consumption: **[PEUC] Technical solution to use less smartphone 3G/4G.** The interviewee mentioned that he raised a concern about the use of high definitions images on http calls and how it impacted on the internet access of a user. The suggestion pointed after the code implementation was about to implement offline transaction using REST approach.

Another concern was about the user experience where the navigation in mobile application should be straightforward. The new practice discovered is non-systematized and is about **[PEUC] Develop an app that the navigation is optimized**

reducing the number of clicks it was classified as Practices of End User Energy Consumption.

AP-08	Concern to inform the customer that sustainability practices were adopted during the software development.	Exists? ORG B ☹ 😐 ☺	Propositions
AP-08.Q-01	Is it possible to identify that from the beginning of software development the customer is informed that the software is being developed with Sustainable Software Engineering practices? (PENZENSTADLER; FEMMER; RICHARDSON, 2013), (ALBERTAO et al., 2010)	☹	P1, P2, P3
AP-08.Q-02	Is it important for the organization to verify that the developed software is consuming a lot of power when the customer uses it? (CORDERO et al., 2015) ,(SCHIEN et al, 2013)	😐	
AP-08.Q-03	Does the organization inform the customer of mechanisms that have been developed to avoid excessive consumption of energy by the software? (CORDERO et al., 2015) , (SCHIEN et al, 2013), (KIM; LEE; LEE, 2012) , (MANOTAS et al, 2013), (ALBERTAO et al., 2010)	☹	
AP-08.Q-04	What are the customer-driven awareness actions that the organization establishes? (SCHIEN et al., 2013)	☹	

Table 42 - Organization B - Results of AP-08.

In Table 43 is possible to summarize the findings of practices by each phase of software development. Many of them are already discussed on the previous analysis points and thus they are listed as:

At the project planning phase (AP-09.Q-01) the existent practices were found and are applied in systematized way in the Organization B: **[PSUD] Choose a well-planned data center to efficiently use the cooling system**, **[PSUD] Develop a software in economic sustainable way** and **[PSUD] Raise awareness of individuals about environment protection.**

At the software design phase (AP-09.Q-03) the non-systematized new practices were found: **[PEUC] Develop an app that the navigation is optimized reducing the number of clicks** and **[PEC] Design webservices to use only the information that will be consumed.**

At the software construction phase (AP-09.Q-04) the non-systematized new practices were found: **[PEUC] Technical solution to use less smartphone 3G/4G**, **[PEUC] Technical solution to use less smartphone battery** and **[PEUC] Develop an app that the navigation is optimized reducing the number of clicks**. And non-systematized existent practices discovered we have **[PEC] Reduce the amount of complex code by using memoization techniques**.

At the software test phase (AP-09.Q-05) the non-systematized existent practice was found: **[PEF] Test the energy efficiency performance of different programming languages.**

AP-09	**It is possible to identify Sustainable Software Engineering practices at each phase of the software life cycle.**	**Exists? ORG B** ☹ 😐 ☺	**Propositions**
AP-09.Q-01	Within the project planning phase is it possible to find at least one of the practices: energy consumption (PEC), energy efficiency evaluation (PEEE), energy efficiency (PEF), business processes (PBP), life cycle assessment (PLCA) and sustainability (PSUD). (CORDERO et al., 2015) ,(PENZENSTADLER; FEMMER, 2013) ,(SCHIEN et al, 2013),(KALAITZOGLOU; BRUNTINK; VISSER, 2014),(ZHONG; LIU, 2010) ,(KIM; LEE; LEE, 2012) ,(PENZENSTADLER, 2014) ,(ALBERTAO et al., 2010) ,(WEISS; REPETTO; KOZIOLEK, 2012),(PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☺	**P1, P2, P3**
AP-09.Q-02	Within the software requirements phase it is possible to find at least one of the practices: energy consumption (PEC), energy efficiency evaluation (PEEE) and sustainability (PSUD). (PENZENSTADLER; FEMMER, 2013) ,(SCHIEN et al, 2013),(KALAITZOGLOU; BRUNTINK; VISSER, 2014),(ZHONG; LIU, 2010) ,(KAMBADUR; KIM, 2014),(AGOSTA et al, 2012) ,(HINDLE, 2012) ,(PENZENSTADLER, 2014) ,(MANOTAS et al, 2013),(PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☹	
AP-09.Q-03	Within the software design phase it is possible to find at least one of the practices: energy consumption (PEC), energy efficiency evaluation (PEEE), energy efficiency (PEF) and sustainability (PSUD). (CORDERO et al., 2015) ,(PENZENSTADLER; FEMMER, 2013) ,(SCHIEN et al, 2013),(NOUREDDINE et. al., 2012),(ZHONG; LIU, 2010) ,(AGOSTA et al, 2012) ,(PENZENSTADLER, 2014) ,(SAHIN et al, 2012) ,(MANOTAS et al, 2013),(CAPRA; FRANCALANCI; SLAUGHTER, 2012) ,(NOUREDDINE; ROUVOY; SEINTURIER, 2015),(SIEBRA et al, 2012),(MONTEIRO; AZEVEDO; SZTAJNBERG, 2013)	😐	
AP-09.Q-04	Within the software construction it is possible to find at least one of the practices: energy consumption (PEC), energy efficiency evaluation (PEEE), energy efficiency (PEF), end user energy consumption (PEUC) and sustainability (PSUD). (CORDERO et al., 2015) ,(PENZENSTADLER; FEMMER, 2013) ,(SCHIEN et al, 2013),(NOUREDDINE et. al., 2012),(ZHONG; LIU, 2010) ,(KAMBADUR; KIM, 2014),(AGOSTA et al, 2012) ,(KIM; LEE; LEE, 2012) ,(KOCAK; ALPTEKIN; BENER, 2014) ,(SIEBRA et al, 2012)	😐	
AP-09.Q-05	Within the software testing phase it is possible to find at least one of the practices: energy consumption (PEC), energy efficiency evaluation (PEEE), energy efficiency (PEF), end user energy consumption (PEUC) and sustainability (PSUD). (CORDERO et al., 2015) , (PENZENSTADLER; FEMMER, 2013) , (SCHIEN et al, 2013), (KALAITZOGLOU; BRUNTINK; VISSER, 2014), (KAMBADUR; KIM, 2014), (KIM; LEE; LEE, 2012) , (KOCAK; ALPTEKIN; BENER, 2014) , (MANOTAS et al, 2013), (ALBERTAO et al., 2010) , (SIEBRA et al, 2012)	😐	

AP-09.Q-06	Within the software maintenance phase it is possible to find at least one of the practices: energy consumption (PEC), energy efficiency evaluation (PEEE) and sustainability (PSUD). (SCHIEN et al, 2013),(KALAITZOGLOU; BRUNTINK; VISSER, 2014),(PENZENSTADLER, 2014) ,(SIEBRA et al, 2012),(MONTEIRO; AZEVEDO; SZTAJNBERG, 2013)	☹	

Table 43 - Organization B - Results of AP-09.

About AP-10 it was not possible to find any practice related to this analysis point as it presents in Table 44. This is actually the most difficult question to answer since it requires a really good reason and high efforts to develop a software to adjust itself.

AP-10	**When abnormally energy consumption is detected, the software developed adjust itself to reduce its energy consumption**	**Exists? ORG B** ☹😐☺	**Propositions**
AP-10.Q-01	Is any source code implementation used to reduce power consumption, such as memory allocation and CPU usage? (AGOSTA et al, 2012), (KIM; LEE; LEE, 2012), (KOCAK; ALPTEKIN; BENER, 2014), (SIEBRA et al, 2012)	☹	**P3**
AP-10.Q-02	Is there any configuration on the server that allows you to change the performance of the software to use less power? (ZHONG; LIU, 2010), (MANOTAS et al, 2013), (MONTEIRO; AZEVEDO; SZTAJNBERG, 2013)	☹	

Table 44 - Organization B - Results of AP-10.

Regarding AP-11 there were no answers for these questions represented in Table 45. There is no evidence that this organization measure energy efficiency.

AP-11	**It is possible to measure the energy efficiency of the developed software.**	**Exists? ORG B** ☹😐☺	**Proposition**
AP-11.Q-01	Is there any use of energy consumption measures? (CORDERO et al., 2015) ,(AGOSTA et al, 2012) ,(SAHIN et al, 2012)	☹	**P3**
AP-11.Q-02	Is there any use of energy efficiency measures or software performance that does not have an impact on energy consumption? (SCHIEN et al, 2013),(KALAITZOGLOU; BRUNTINK; VISSER, 2014), (NOUREDDINE et. al., 2012),(KAMBADUR; KIM, 2014),(NOUREDDINE; ROUVOY; SEINTURIER, 2015),(SIEBRA et al, 2012), (MONTEIRO; AZEVEDO; SZTAJNBERG, 2013)	☹	
AP-11.Q-03	During the software development is the measurement of energy consumption? (SCHIEN et al, 2013),(SIEBRA et al, 2012), (CAPRA; FRANCALANCI; SLAUGHTER, 2012)	☹	
AP-11.Q-04	What metrics are used to measure the software's energy efficiency? (SCHIEN et al, 2013), (NOUREDDINE et. al., 2012), (AGOSTA et al, 2012) , (KIM; LEE; LEE, 2012) , (HINDLE, 2012) , (SAHIN et al, 2012) , (MANOTAS et al, 2013)	☹	
AP-11.Q-05	Is there any other indicator linked to sustainability that is applied in the developed software? (PENZENSTADLER; FEMMER, 2013) , (SCHIEN et al, 2013),(KALAITZOGLOU; BRUNTINK; VISSER, 2014), (NOUREDDINE; ROUVOY; SEINTURIER, 2015)	☹	

Table 45 - Organization B - Results of AP-11.

The practices to evaluate sustainability practices were not found on AP-12 as shown in Table 46.

AP-12	The criteria for evaluating software quality includes sustainability practices.	Exists? ORG B ☹ 😐 ☺	Proposition
AP-12.Q-01	Is it possible to confirm that software sustainability practices are related to software quality attributes? (KOCAK; ALPTEKIN; BENER, 2014) , (PENZENSTADLER, 2014)	☹	P1, P2
AP-12.Q-02	What are the quality attributes adopted by the organization? (ALBERTAO et al., 2010)	☹	

Table 46 - Organization B - Results of AP-12

Regarding the AP-13 it was not possible to discovery practices related to concern about organization's reputation for adopting sustainability practices as represented in Table 47.

AP-13	Concern about the organization's reputation for adopting sustainability practices	Exists? ORG B ☹ 😐 ☺	Propositions
AP-13.Q-01	Is it possible to find evidence on the dissemination of sustainability data to the customer? (PENZENSTADLER; FEMMER, 2013) , (ZHONG; LIU, 2010) , (PENZENSTADLER, 2014)	☹	P1
AP-13.Q-02	Has the organization received recognition for developing sustainable software? (PENZENSTADLER; FEMMER, 2013) , (PENZENSTADLER, 2014)	☹	

Table 47 - Organization B - Results of AP-13

5.2.2 Organization B – Propositions results

In this section we conclude the individual case study of Organization B. This section presents the propositions results and final results of each analysis point.

P1 - Systematized sustainability organizational policies in software development

Table 48 shows the results for proposition P1. It was possible to confirm systematized practices in AP-01, AP-05, AP-06 and AP-07 as detailed in the previous section.

☺	P1 - Organizational policies driven to sustainability are systematically applied in software development in the financial sector.	
AP-01	Initiatives that promote awareness about organizational social responsibility within the IT sector	☺
AP-04	Guidelines about sustainability requirements	☹
AP-05	Sustainable Software Engineering practices are identified at some levels of organization planning within the IT area.	☺

AP-06	Strategic alignment of the organization regarding the adoption of sustainability practices.	☺
AP-07	A preference is given to hiring IT vendors who apply sustainability to their business.	☺
AP-08	Concern to inform the customer that sustainability practices were adopted during the software development.	😐
AP-09	It is possible to identify Sustainable Software Engineering practices at each phase of the software life cycle.	😐
AP-12	The criteria for evaluating software quality includes sustainability practices.	☹
AP-13	Concern about the organization's reputation for adopting sustainability practices	☹

Table 48 - Organization B - Proposition 1 results

The Organization B presents the sustainability aspects in organization strategy since they raise awareness of sustainability initiatives by emails to the employees and choose a green data center.

If we look at IT area, the sustainability aspects are adopted as the organization is changing they architecture model to use hybrid mobile development technologies. This decision was based on projects costs, shorts timelines and available resources that knows about the technology used.

Therefore, when we analyze the practices adopted in IT area that impacts the software development we conclude that the Proposition 1 has systematized practices validating our assumptions that organization policies are applied in systematized way during the software development.

P2 - Non-systematized Sustainable Software Engineering practices

This proposition is related to P1, but tries to find non-systematized practices during the software development. When we look at the AP's we find non-systematized practices in AP-03, AP-08 and AP-09 listed in Table 49.

😐 **P2 - Sustainable Software Engineering practices are applied in a non-systematic way during software development.**		
AP-01	Initiatives that promote awareness about organizational social responsibility within ıe IT sector	☺
AP-02	Practices of Sustainability Dimensions are considered during the software ɜvelopment.	☺
AP-03	Practices of Energy Consumption are considered during the software development.	😐
AP-04	Guidelines about sustainability requirements	☹
AP-08	Concern to inform the customer that sustainability practices were adopted during ıe software development.	😐

AP-09	It is possible to identify Sustainable Software Engineering practices at each phase of ıe software life cycle.	😐
AP-12	The criteria for evaluating software quality includes sustainability practices.	☹
AP-13	Concern about the organization's reputation for adopting sustainability practices	☹

Table 49 - Organization B - Proposition 2 results

The important finding of this P2 is about the new practices and new category emerged from the interviews. The new category is Practices of Code Improvement, means implementations to turn the software code more supportable and easy to understand. None of the selected papers from SLR and the literature review reference mentioned about those practices discovered in Organization B. It seems obvious for everyone working as a programmer that the code maintenance, refactoring and best practices should be applied. However, from the interviewee perspectives, even the more experienced one, the code improvements is considered a Sustainable Software Engineering practice and it is important for they daily work routine.

The result of this proposition is positive, since we could find many of new practices and existent practices in a non-systematized away and could identify new category as well as the understanding from the interviewee whom developer the software of Organization B.

P3 – Use of tools that automatically measure or change the energy consumption.

As presented in Table 50, this proposition is about the use of algorithms, measures of power consumption and methods that automatically change the application state when there is high energy usage.

☹ **P3 - Tools that automatically measure or change the energy consumption of developed software are used**		
AP-02	Practices of Sustainability Dimensions are considered during the software development.	☹
AP-03	Practices of Energy Consumption are considered during the software development.	😐
AP-08	Concern to inform the customer that sustainability practices were adopted during the software development.	😐
AP-09	It is possible to identify Sustainable Software Engineering practices at each phase of the software life cycle.	😐
AP-10	When abnormally energy consumption is detected, the software developed adjust itself to reduce its energy consumption	☹
AP-11	It is possible to measure the energy efficiency of the developed software.	☹

Table 50 - Organization B - Proposition 3 results

We concluded that the Organization B has no measures or tools to identify this information in the application. Even though the practices of avoiding building solutions that uses too much mobile battery is considered, it does not mean that these solutions are applied automatically without human intervention.

5.3 Organization C

The organization C is the second bank in Brazil in assets and it has noticeable concerns about social responsibility and sustainability. Since 2008 the bank has creating Digital channels like internet and mobile services it is used by 73% of the customers in contrast with Standard channels like ATMs or physical agency that is only 27%. Consequently the organization has invested billions of reals in technology and its infrastructure, a new data center was built with many green implementations which has saved tons of water representing an economy of 1.9 billion of reals.

Compared with other sustainability initiatives the initiatives regarding IT is where the mostly savings happens as presented in the Figure 30.

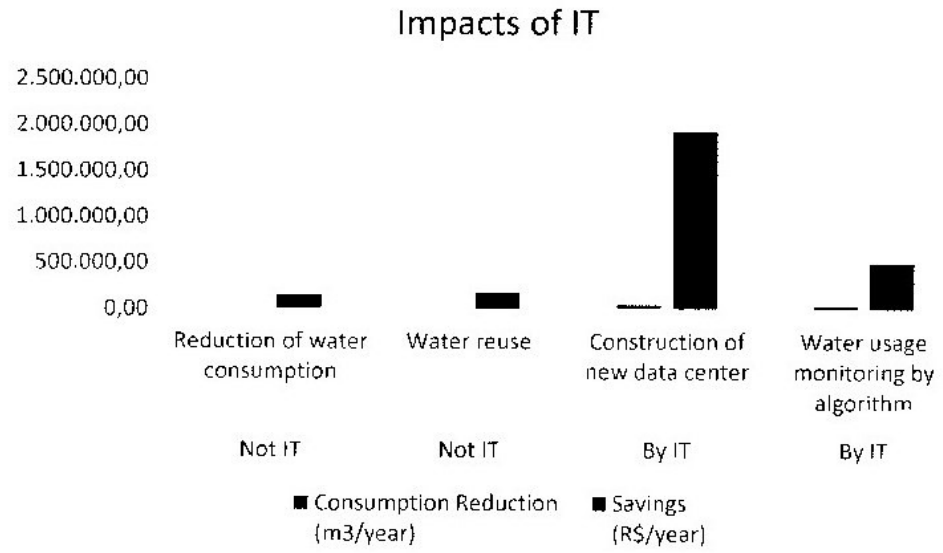

Figure 30 - IT impacts in Organization C

This data was extracted from the annual report of this organization. In this report, when they constructed a new data center, they deactivated the old one because the infrastructure costs was really expansive since old infrastructure were used causing impacts on water, energy and on the environment.

Moreover, the Organization C is investing on digital transformation of the bank creating new mobile applications accessible by any social class and with almost all the

services of a physical agency. In this case, the sustainability impacts is also measured by this organization and can be found on the same reported informed before.

For this case study, seven IT professionals working in Organization C was contacted, however only three accepted to be interviewed. Table 51 shows the employee profiles.

Organization C	Job description	Financial experience	IT experience	Interview duration
Employee A	Specialist Developer	14 years	30 years	41:45:00
Employee B	Senior Infrastructure Analyst	19 years	19 years	07:32:00
Employee C	Senior System Analyst	10 years	19 years	32:25:00

Table 51 - Organization C- employee's profiles.

5.3.1 Organization C – Analysis Points description

For the Organization C, because of the networks size, it were broken in three: systematized existent practices PSUD as shown in Figure 31; systematized new practices as shown in Figure 32; and non-systematized practices as shown in Figure 33.

There are twenty five existent practices from SLR discovered in the Organization C as per the network represented in Figure 31 and Figure 32. From this network, two practices are categorized into Practices of Energy Consumption. Sixteen practices are categorized into Practices of Sustainability Dimension. The last category is Practices of Evaluating Energy Efficiency with seven practices.

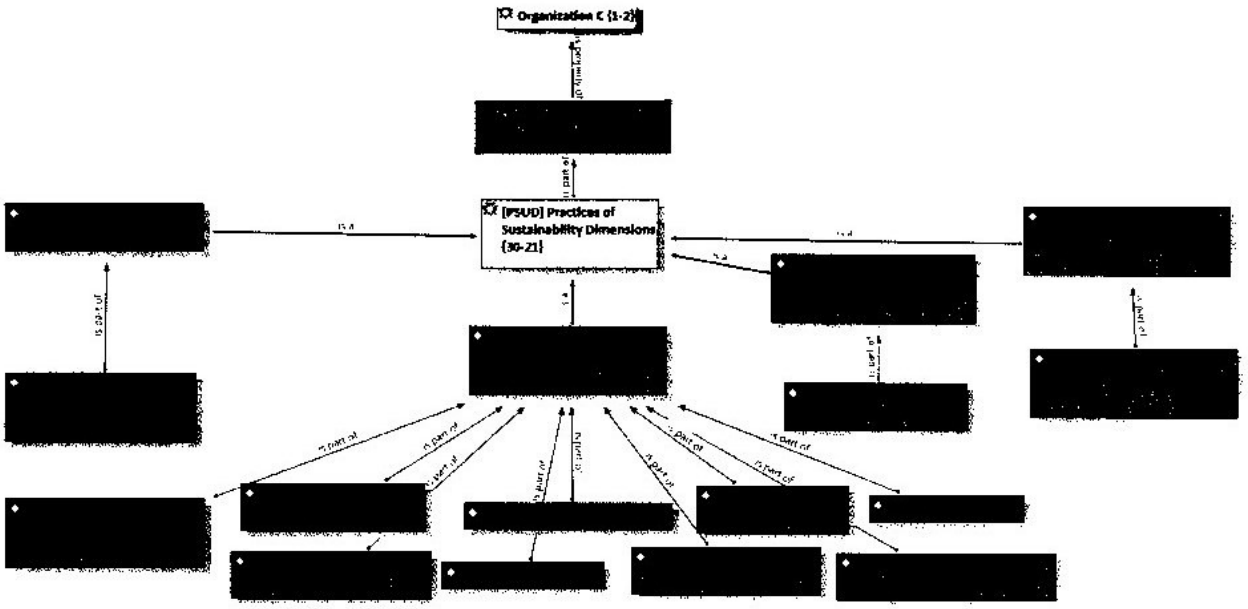

Figure 31 - Organization C - Network of systematized existent practices. PSUD

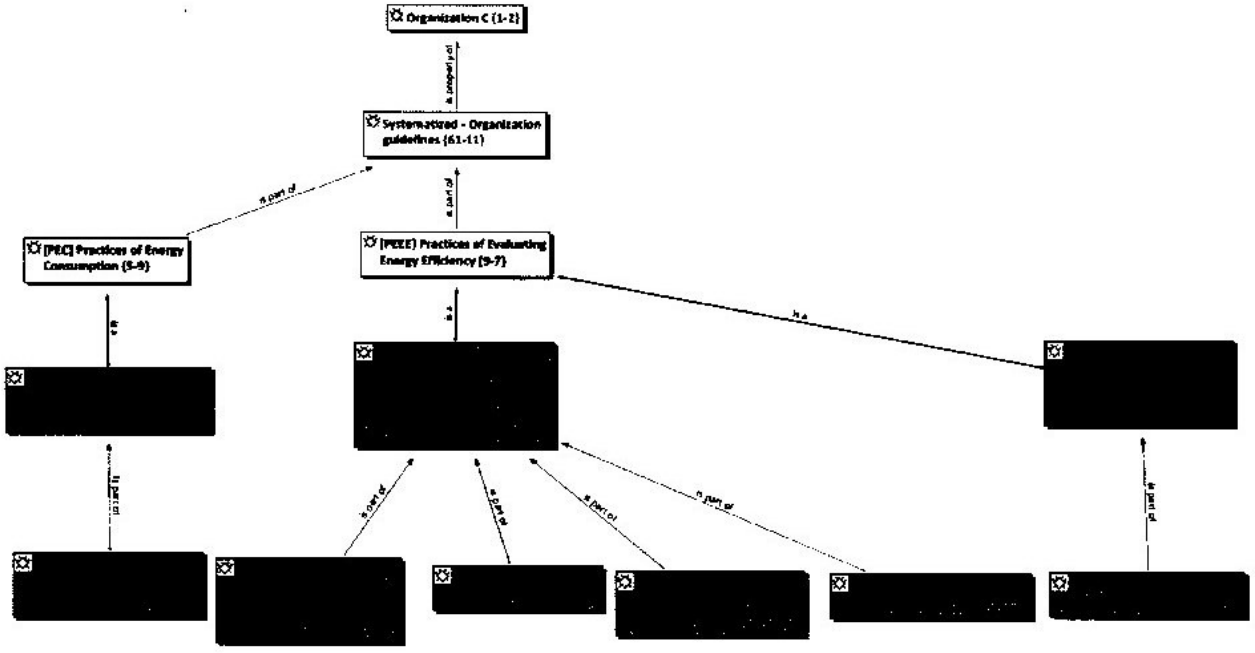

Figure 32 - Organization C - Network of systematized existent practices.

The network of systematized new practices represented in Figure 33 is composed of eight new practices not found in SLR. Two new practices were categorized into Practices of Sustainability Dimensions. One new practice was categorized into Practices of Code Improvement. One new practice was categorized into Practices of Energy Consumption. Two new practices were categorized into Practices of Business Process. The last category is Practices of Evaluating Energy Efficiency with two practices.

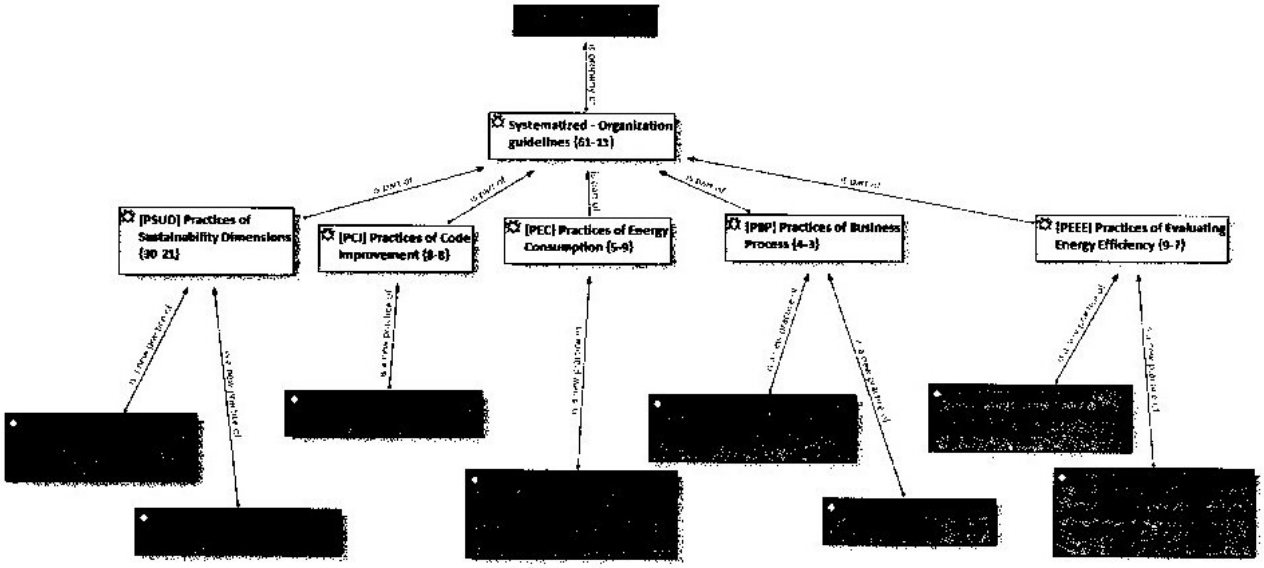

Figure 33 - Organization C - Network of systematized new practices.

Regarding the non-systematized new practice network, only one practice was found in the interviewee and categorized into Practices of Code Improvement represented in Figure 34.

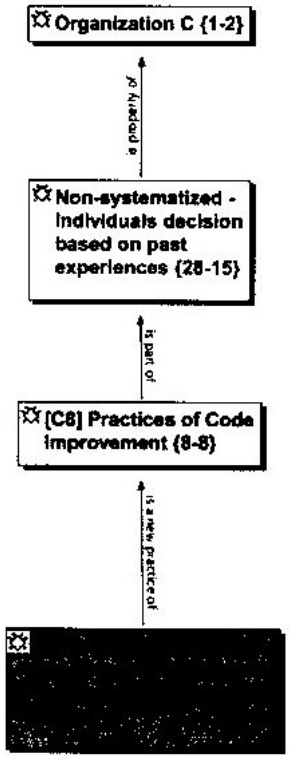

Figure 34 - Organization C - Network of non-systematized new practices.

Further information about all the practices presented in the networks will be will be discussed in the corresponding analysis points.

Organization C - Analysis points results

In this AP-01 regarding initiatives to promote awareness about organizational sustainability it is possible to find existent practices answering the question of AP-01.Q-03 as represented in Table 52. An existent practice found is about **Guidelines and checklist to contract a provider** that is part of **[PSUD] Identify initiatives of sustainability in the company level** a practice proposed by (PENZENSTADLER; FEMMER, 2013). The interviewee mentioned the criteria to contract a provider in accordance to ethical, social, environmental and work law compliance. In Organization C, no vendors, suppliers, contractor or provider is hired if they do not pass the checklist. Furthermore in this AP, the existent practice of **[PSUD] Raise awareness of individuals about environment protection,** extracted from (ZHONG; LIU, 2010) paper, was found and associated with a new practice summarizing and grouping all the **Internal communication about Organizational Sustainability** spread in Organization C. One of the evidence about the application of this practice is related to volunteer campaign motivated by the Organization what the interviewed expressed as:

> "...I think that the first time I understood what was sustainability it was here in this organization that I have been working for"

This comments from interviewee reinforce the importance of adopting and applying organizational internal communication about sustainability.

Regarding the AP-01.Q-05 new practices related to **Sustainability department** was discovered, which the interviewee refers to an area responsible for taking care of organization sustainability. Related to this question it was possible to find the new practices **Sustainability indicators are communicated to employees** and **Campaign to reduce energy consumption of mainframes**.

About the AP-01.Q-06 it is confirmed by the practice **Internal communication about Organizational Sustainability**, all the aspects about sustainability are communicated to the employees of Organization C. These communications includes changes in Data Center, awareness to use less paper, warnings about the time to automatically turn off the lights when people leaves the building and also social responsibility activists.

Regarding the AP-01.Q-07, the organization promotes the awareness of sustainability it is possible to find the existent practice related to this is about **[PSUD] Identify and reduce energy cost on facilities** (ZHONG; LIU, 2010) and new practices described as **Use less paper** and **Concerns about social responsibility**. Again the new practice of **Sustainability is a mean of marketing** was considered in this AP,

since the Organization C informed the customers about the digital credit card bill and also the new practice of **Sustainability indicators are communicated to employees**.

The question presented on AP-01.Q-08 have new practice related to **Practices of performance are not communicate openly due to market strategy**. It was identified as a **Practice of Business Process** since restricted information about performance of credit card time to process is one of the business strategy.

Finally, the AP-01.Q-09 regarding the sustainability considered as part of organization strategy we categorized the new practice **Sustainability is a mean of marketing** into Strategic level. In addition, all of the systematized practices described on AP-01.Q-01 are applied at the Strategic level of Organization C.

AP-01	Initiatives that promote awareness about organizational social responsibility within the IT sector	Exists? ORG C ☹ 😐 ☺	Propositions
AP-01.Q-01	Initiatives that promote awareness about organizational social responsibility within the IT sector. (PENZENSTADLER; FEMMER; RICHARDSON, 2013),(PENZENSTADLER, 2014)	☹	P1, P2
AP-01.Q-02	Is there anyone responsible for disseminating sustainability information in IT projects? (PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☹	
AP-01.Q-03	Within the IT area is there a sustainability focal point? (PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☺	
AP-01.Q-04	Is there a reference model for achieving sustainability activities, dimensions, values, indicators and regulations? (PENZENSTADLER; FEMMER, 2013) ,(ALBERTAO et al., 2010)	☹	
AP-01.Q-05	What are the metrics for measuring sustainability goals? (PENZENSTADLER; FEMMER, 2013)	☺	
AP-01.Q-06	Is there specification of sustainability actions? (ZHONG; LIU, 2010)	☺	
AP-01.Q-07	Does the organization promote awareness raising about sustainability? (PENZENSTADLER; FEMMER, 2013) (ZHONG; LIU, 2010)	☺	
AP-01.Q-08	What are the awareness actions? (ZHONG; LIU, 2010)	☺	
AP-01.Q-09	Is sustainability present in the organization's strategy? (PENZENSTADLER; FEMMER, 2013) ,(ZHONG; LIU, 2010)	☺	

Table 52 - Organization C - Results of AP-01.

Regarding the AP-02.Q-02 represented in Table 53, it is possible to find new practice described as **Develop a mobile app available for any social class** which is part of existent practice from the literature **[PSUD] Implement non-functional requirements** (PENZENSTADLER; FEMMER, 2013). The reason for this link been made between that new practice and non-functional requirements is from the

interviewee statement regarding the construction of a light mobile application which is installed in old version of mobile operating system, allowing people with less resources to use the mobile banking without have to buy a new high performance smartphone. This is an example of non-functional requirement related sustainability.

Organization C had built a new data center considering sustainability goals answering the AP-02.Q-07 with an existent practice **[PSUD] Choose a well-planned data center to efficiently use the cooling system (ZHONG; LIU, 2010)** and complementary to this practice a new practice was discovered **Construction of Green Data Center**.

AP-02	Practices of Sustainability Dimensions are considered during the software development.	Exists? ORG C ☹ 😐 ☺	Propositions
AP-02.Q-01	In the project planning phase is it considered a plan for the software to be sustainable in order to suffer less changes during development? (PENZENSTADLER; FEMMER, 2013) ,(ZHONG; LIU, 2010) ,(KIM; LEE; LEE, 2012)	☹	P2, P3
AP-02.Q-02	Is the non-functional requirements related to sustainability identified in the software requirements phase? (PENZENSTADLER; FEMMER, 2013) ,(SCHIEN et al, 2013), (KALAITZOGLOU; BRUNTINK; VISSER, 2014), (KAMBADUR; KIM, 2014),(HINDLE, 2012) , (MANOTAS et al, 2013)	☺	
AP-02.Q-03	In the software design phase is there any guide to developing the sustainability-oriented software architecture? (PENZENSTADLER, 2014)	☹	
AP-02.Q-04	In the software testing phase is it verified whether the software contemplates Sustainable Software Engineering practices? (PENZENSTADLER; FEMMER, 2013) ,(ALBERTAO et al., 2010)	☹	
AP-02.Q-05	In the maintenance phase of the software is there any sustainability practice applied? (PENZENSTADLER, 2014)	☹	
AP-02.Q-06	Within each phase, has the person in charge knowledge about what is sustainability? (PENZENSTADLER; FEMMER, 2013) , (PENZENSTADLER, 2014) ,(PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☹	
AP-02.Q-07	In the project planning phase is it considered a green data center that also consider sustainability important? (ZHONG; LIU, 2010)	☺	
AP-02.Q-08	In the software construction is it considered the use of practices related to modifiability, reusability, portability and supportability? (ALBERTAO et al., 2010)	☹	

Table 53 - Organization C - Results of AP-02.

Table 54 presents the practices of energy consumption applied in each phase of software development. The first question described on AP-03.Q-01 is about the project planning phase, which we can see the new practice about **Campaign to reduce energy consumption of mainframes**. The interviewee mentioned a project created to reduce the energy consumption of mainframes, many initiatives was taken

to accomplish its goal and the result was about 30% energy consumption savings. The interviewee did not offer any further details since this project was ran three years ago.

Regarding the software requirements phase on AP-03.Q-02, a new practice related to **Practices of Energy Efficiency Evaluation** was discovered **Develop a mobile app that do not require a lot memory our too much hardware processing**. This also consequence of the development of light mobile application as the interviewee explained.

The software design phase described on AP-03.Q-03 identify a new practice about **Use of development best practices to reduce the application size and perform better**. This was based on interviewee comments about the size of C++ code application and how it perform better when the development best practices are used.

In the construction phase defined in AP-03.Q-04 the new practices related to **Practices of Code Improvement** was found as **[PCI] Code refactoring to enhance application performance.** This is connected with the same comment of AP-03.Q-03

Regarding the test phase at AP-03.Q-05 we identified the existent practice of **[PEEE] Use of quality attributes as Energy Efficiency regarding time to response, amount of resources and software performance** (KOCAK; ALPTEKIN; BENER, 2014) and **[PEC] Adjust automatically servers CPU voltage** (ZHONG; LIU, 2010).

The last phase, as per our findings in Chapter 04 is the AP-03.Q-06 which a new practice related to code improvement was found **[PCI] Code refactoring to enhance application performance.**

AP-03	**Practices of Energy Consumption are considered during the software development.**	**Exists? ORG C** ☹ 😐 ☺	**Proposition**
AP-03.Q-01	In the project planning phase is it possible to identify the use of practices related to the choice of hardware or devices, metrics and monitoring that can be added to software development to consume less energy? (CORDERO et al., 2015) , (SCHIEN et al, 2013), (KALAITZOGLOU; BRUNTINK; VISSER, 2014), (KIM; LEE; LEE, 2012) , (WEISS; REPETTO; KOZIOLEK, 2012)	☺	**P2, P3**
AP-03.Q-02	In the phase of software requirements practices related to collection, measurement and configuration of power consumption are found? (SCHIEN et al, 2013),(KALAITZOGLOU; BRUNTINK; VISSER, 2014), (KAMBADUR; KIM, 2014), (HINDLE, 2012) , (MANOTAS et al, 2013)	☺	
AP-03.Q-03	In the design phase of the software you can find practices related to architecture, tools, frameworks, virtualization, standards and coding that reduce or monitor the software's power consumption. (CORDERO et al., 2015) ,(PENZENSTADLER; FEMMER, 2013) , (SCHIEN et al, 2013), (AGOSTA et al, 2012) , (SAHIN et al, 2012) , (MANOTAS et al, 2013), (CAPRA; FRANCALANCI;	☺	

	SLAUGHTER, 2012) , (NOUREDDINE; ROUVOY; SEINTURIER, 2015), (SIEBRA et al, 2012)		
AP-03.Q-04	In the construction phase is it possible to find practices related to programming without the use of frameworks, real-time code energy consumption monitoring and automation of memory allocation and CPU when the software is running? (CORDERO et al., 2015) ,(SCHIEN et al, 2013),(NOUREDDINE et. al., 2012),(ZHONG; LIU, 2010) , (KAMBADUR; KIM, 2014) ,(AGOSTA et al, 2012) ,(KIM; LEE; LEE, 2012) ,(KOCAK; ALPTEKIN; BENER, 2014) , (SIEBRA et al, 2012)	☺	
AP-03.Q-05	In the test phase it is possible to find practices related to test case definition, test framework, energy efficiency techniques, quality attributes and code performance that test the power consumption of the software. (CORDERO et al., 2015) , (SCHIEN et al, 2013), (KALAITZOGLOU; BRUNTINK; VISSER, 2014),(NOUREDDINE et. al., 2012),(KAMBADUR; KIM, 2014),(KIM; LEE; LEE, 2012) , (KOCAK; ALPTEKIN; BENER, 2014) ,(MANOTAS et al, 2013),(SIEBRA et al, 2012)	☺	
AP-03.Q-06	In the maintenance phase it is possible to find practices related to configuration, monitoring and automatic optimization of the server according to the power consumption of the software. (SCHIEN et al, 2013), (KALAITZOGLOU; BRUNTINK; VISSER, 2014), (SIEBRA et al, 2012), (MONTEIRO; AZEVEDO; SZTAJNBERG, 2013)	☺	

Table 54 - Organization C - Results of AP-03.

To answer the AP-04.Q-04 presented in Table 55, we asked the interviewee if the new practice identified as **Campaign to reduce energy consumption of mainframes** was part of guide and the interviewee said it was.

One of the sustainability interaction is about a new practice discovered in Organization C described as **Use less CPU processing when developing with c++**, answering the AP-04.Q-05

AP-04	**Guidelines about sustainability requirements**	**Exists? ORG C** ☹ 😐 ☺	**Propositions**
AP-04.Q-01	During the survey of software requirements do you see the use of guides describing Sustainable Software Engineering practices? (WEISS; REPETTO; KOZIOLEK, 2012)	☹	**P1, P2**
AP-04.Q-02	Is a benchmark model used to describe sustainability practices that should be considered when surveying software requirements? (PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☹	
AP-04.Q-03	Is there a guide that helps to identify the limitations of sustainability during software development? (PENZENSTADLER, 2014)	☹	
AP-04.Q-04	Is there a guide to identify sustainability goals during software development? (PENZENSTADLER, 2014)	☺	
AP-04.Q-05	Is there a guide to identifying sustainability interactions during software development? (PENZENSTADLER, 2014)	☺	

Table 55 - Organization C - Results of AP-04.

In Table 57 related to Sustainable Software Engineering practices identified at some levels it was possible to confirm the use of existent practices from SLR and it was possible to find evidence, so the answer for AP-05.Q-01 is confirmed.

Classification	Organizational levels	Practices
Systematized	Strategic	[PSUD] Choose a well-planned data center to efficiently use the cooling system.
Systematized	Strategic	[PSUD] Identify and reduce energy cost on facilities.
Systematized	Strategic	[PSUD] Identify initiatives of sustainability in the company level.
Systematized	Strategic	[PSUD] Raise awareness of individuals about environment protection.
Systematized	Operational	[PEC] Use of software power metrics like disk hits transaction per second.
Systematized	Operational	[PEEE] Employ energy efficiency techniques as Processor Frequency Tuning
Systematized	Operational	[PEEE] Use of quality attributes as Energy Efficiency regarding time to response.

Table 56 - Organization C - AP-05 Organizational Levels.

Regarding the AP-05.Q-02 and the AP-05.Q-03 it was possible to find practices from the SLR in Strategic and Operational level presented in Table 57.

AP-05	**Sustainable Software Engineering practices are identified at some levels of organization planning within the IT area.**	**Exists? ORG C** ☹ 😐 ☺	**Propositions**
AP-05.Q-01	It is noticed that in the Strategic level the practices of Sustainable Software Engineering are defined, there is documented evidence of these practices? (PENZENSTADLER; FEMMER, 2013) ,(SCHIEN et al, 2013),(ZHONG; LIU, 2010) ,(PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☺	**P1**
AP-05.Q-02	At the Tactical level, practices defined in the literature are found in the organization? (PENZENSTADLER; FEMMER, 2013) ,(SCHIEN et al, 2013),(ZHONG; LIU, 2010) ,(PENZENSTADLER, 2014) ,(CAPRA; FRANCALANCI; SLAUGHTER, 2012) ,(ALBERTAO et al., 2010) ,(PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☹	
AP-05.Q-03	At the Operational level, practices defined in the literature are found in the organization? (CORDERO et al., 2015) ,(PENZENSTADLER; FEMMER, 2013) ,(SCHIEN et al, 2013),(ZHONG; LIU, 2010) ,(PENZENSTADLER, 2014) ,(ALBERTAO et al., 2010) ,(WEISS; REPETTO; KOZIOLEK, 2012),(PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☺	

Table 57 - Organization C - Results of AP-05.

As presented on AP-01, the new practice of **Sustainability is a mean of marketing answer** the AP-06.Q-01 and AP-06.Q-03 described in Table 58.

AP-06	Strategic alignment of the organization regarding the adoption of sustainability practices.	Exists? ORG C ☹ 😐 ☺	Propositions
AP-06.Q-01	Is it perceived that sustainability is part of the organization's strategy? (PENZENSTADLER; FEMMER, 2013) ,(ZHONG; LIU, 2010)	☺	P1
AP-06.Q-02	It is understood that senior management of the organization supports and encourages the tactical and operational levels to use Sustainable Software Engineering practices? (ZHONG; LIU, 2010) ,(PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☹	
AP-06.Q-03	Is it possible to identify the meaning of sustainability for the organization? (PENZENSTADLER; FEMMER, 2013) ,(ZHONG; LIU, 2010)	☺	

Table 58 - Organization C - Results of AP-06.

The **Construction of Green Data Center** identified as new practice, allowed the Organization C to reinforce the preference to hire IT vender who applies sustainability aspect in the business responding to AP-07.Q-01 in Table 59. Another practices related to this is the **Guidelines and checklist to contract a provider** discussed on AP-01.

AP-07	A preference is given to hiring IT vendors who apply sustainability to their business.	Exists? ORG C ☹ 😐 ☺	Propositions
AP-07.Q-01	The organization prides itself for hiring suppliers who have sustainability seals, energy efficiency and clean energy. (ZHONG; LIU, 2010) , (KIM; LEE; LEE, 2012)	☺	P1
AP-07.Q-02	Is it possible to identify that the organization uses software developed with Sustainable Software Engineering practices? (NOUREDDINE et. al., 2012)	☹	

Table 59 - Organization C - Results of AP-07.

The AP-08.Q-02 is answered by the practice related to **Campaign to reduce energy consumption of mainframes** which the Organization C executed a project focusing on reducing the energy consumption and also enhance the performance of credit card transactions.

To confirm the AP-08.Q-04 described in Table 60 a new practice was identified **Communication to external client about digital services**. An example of this is the communication sent to customers about digital credit card bill.

AP-08	Concern to inform the customer that sustainability practices were adopted during the software development.	Exists? ORG C ☹ 😐 ☺	Propositions

AP-08.Q-01	Is it possible to identify that from the beginning of software development the customer is informed that the software is being developed with Sustainable Software Engineering practices? (PENZENSTADLER; FEMMER; RICHARDSON, 2013), (ALBERTAO et al., 2010)	☹	P1, P2, P3
AP-08.Q-02	Is it important for the organization to verify that the developed software is consuming a lot of power when the customer uses it? (CORDERO et al., 2015) ,(SCHIEN et al, 2013)	☺	
AP-08.Q-03	Does the organization inform the customer of mechanisms that have been developed to avoid excessive consumption of energy by the software? (CORDERO et al., 2015) , (SCHIEN et al, 2013), (KIM; LEE; LEE, 2012) , (MANOTAS et al, 2013), (ALBERTAO et al., 2010)	☹	
AP-08.Q-04	What are the customer-driven awareness actions that the organization establishes? (SCHIEN et al., 2013)	☺	

Table 60 - Organization C - Results of AP-08.

The AP-09 described in Table 61 is about the overall practices applied on each phase of software life cycle. In this case, the AP-09.Q-01 is **[PSUD] Choose a well-planned data center to efficiently use the cooling system** and all the other practices discussed on AP-01, including **[PSUD] Develop a software in economic sustainable way**.

The AP-09.Q-02 is about software requirements and it was found an existent practice described as **[PSUD] Implement non-functional requirements** (PENZENSTADLER; FEMMER, 2013) and **[PSUD] Derive sustainable system vision**.

Regarding software design the AP-09.Q-03 was answered with new practice related to **Develop a mobile app that do not require a lot memory our too much hardware processing**.

About software construction it was possible to find new practices considering **Use less CPU processing when developing with c++** on AP-09.Q-04.

The AP-09.Q-05 was answered by the existent practices **[PEEE] Use of quality attributes as Energy Efficiency regarding time to response, amount of resources and software performance**.

A new practice was informed by interviewee regarding **Use of MIPS indicator to identify transaction slowness** on the maintenance phase described on AP-09.Q-06.

AP-09	**It is possible to identify Sustainable Software Engineering practices at each phase of the software life cycle.**	**Exists? ORG C** ☹ 😐 ☺	**Propositions**

AP-09.Q-01	Within the project planning phase is it possible to find at least one of the practices: energy consumption (PEC), energy efficiency evaluation (PEEE), energy efficiency (PEF), business processes (PBP), life cycle assessment (PLCA) and sustainability (PSUD). (CORDERO et al., 2015) ,(PENZENSTADLER; FEMMER, 2013) ,(SCHIEN et al, 2013),(KALAITZOGLOU; BRUNTINK; VISSER, 2014),(ZHONG; LIU, 2010) ,(KIM; LEE; LEE, 2012) ,(PENZENSTADLER, 2014) ,(ALBERTAO et al., 2010) ,(WEISS; REPETTO; KOZIOLEK, 2012),(PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☺	**P1, P2, P3**
AP-09.Q-02	Within the software requirements phase it is possible to find at least one of the practices: energy consumption (PEC), energy efficiency evaluation (PEEE) and sustainability (PSUD). (PENZENSTADLER; FEMMER, 2013) ,(SCHIEN et al, 2013),(KALAITZOGLOU; BRUNTINK; VISSER, 2014),(ZHONG; LIU, 2010) ,(KAMBADUR; KIM, 2014),(AGOSTA et al, 2012) ,(HINDLE, 2012) ,(PENZENSTADLER, 2014) ,(MANOTAS et al, 2013),(PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☺	
AP-09.Q-03	Within the software design phase it is possible to find at least one of the practices: energy consumption (PEC), energy efficiency evaluation (PEEE), energy efficiency (PEF) and sustainability (PSUD). (CORDERO et al., 2015) ,(PENZENSTADLER; FEMMER, 2013) ,(SCHIEN et al, 2013),(NOUREDDINE et. al., 2012),(ZHONG; LIU, 2010) ,(AGOSTA et al, 2012) ,(PENZENSTADLER, 2014) ,(SAHIN et al, 2012) ,(MANOTAS et al, 2013),(CAPRA; FRANCALANCI; SLAUGHTER, 2012) ,(NOUREDDINE; ROUVOY; SEINTURIER, 2015),(SIEBRA et al, 2012),(MONTEIRO; AZEVEDO; SZTAJNBERG, 2013)	☺	
AP-09.Q-04	Within the software construction it is possible to find at least one of the practices: energy consumption (PEC), energy efficiency evaluation (PEEE), energy efficiency (PEF), end user energy consumption (PEUC) and sustainability (PSUD). (CORDERO et al., 2015) ,(PENZENSTADLER; FEMMER, 2013) ,(SCHIEN et al, 2013),(NOUREDDINE et. al., 2012),(ZHONG; LIU, 2010) ,(KAMBADUR; KIM, 2014),(AGOSTA et al, 2012) ,(KIM; LEE; LEE, 2012) ,(KOCAK; ALPTEKIN; BENER, 2014) ,(SIEBRA et al, 2012)	☺	
AP-09.Q-05	Within the software testing phase it is possible to find at least one of the practices: energy consumption (PEC), energy efficiency evaluation (PEEE), energy efficiency (PEF), end user energy consumption (PEUC) and sustainability (PSUD). (CORDERO et al., 2015) , (PENZENSTADLER; FEMMER, 2013) , (SCHIEN et al, 2013), (KALAITZOGLOU; BRUNTINK; VISSER, 2014), (KAMBADUR; KIM, 2014), (KIM; LEE; LEE, 2012) , (KOCAK; ALPTEKIN; BENER, 2014) , (MANOTAS et al, 2013), (ALBERTAO et al., 2010) , (SIEBRA et al, 2012)	😐	
AP-09.Q-06	Within the software maintenance phase it is possible to find at least one of the practices: energy consumption (PEC), energy efficiency evaluation (PEEE) and sustainability (PSUD). (SCHIEN et al, 2013),(KALAITZOGLOU; BRUNTINK; VISSER, 2014),(PENZENSTADLER, 2014) ,(SIEBRA et al, 2012),(MONTEIRO; AZEVEDO; SZTAJNBERG, 2013)	☺	

Table 61 - Organization C - Results of AP-09.

About AP-10 it was not possible to find any practice related to this analysis point as it presents in Table 62 . This is actually the most difficult question to answer since it requires a really good reason and high efforts to develop a software to adjust itself.

AP-10	When abnormally energy consumption is detected, the software developed adjust itself to reduce its energy consumption	Exists? ORG C ☹ 😐 ☺	Propositions
AP-10.Q-01	Is any source code implementation used to reduce power consumption, such as memory allocation and CPU usage? (AGOSTA et al, 2012), (KIM; LEE; LEE, 2012), (KOCAK; ALPTEKIN; BENER, 2014), (SIEBRA et al, 2012)	☹	P3
AP-10.Q-02	Is there any configuration on the server that allows you to change the performance of the software to use less power? (ZHONG; LIU, 2010), (MANOTAS et al, 2013), (MONTEIRO; AZEVEDO; SZTAJNBERG, 2013)	☹	

Table 62 - Organization C - Results of AP-10.

Table 63 is about the measure of energy efficiency of software under development and it is possible to find a new practice related to AP-11.Q-03 about **Application monitoring to identify lazy process**. The interviewee reported that all the application are monitored regarding the performance like CPU usage and memory performance, however when the application is too slow they report this to development who investigates the problem presented.

Regarding the indicator presented on AP-11.Q-05 used by Organization C is Use of **MIPS indicator to identify transaction slowness**, which is commonly used in mainframe servers provided by IBM.

AP-11	It is possible to measure the energy efficiency of the developed software.	Exists? ORG C ☹ 😐 ☺	Propositions
AP-11.Q-01	Is there any use of energy consumption measures? (CORDERO et al., 2015) ,(AGOSTA et al, 2012) ,(SAHIN et al, 2012)	☹	P3
AP-11.Q-02	Is there any use of energy efficiency measures or software performance that does not have an impact on energy consumption? (SCHIEN et al, 2013),(KALAITZOGLOU; BRUNTINK; VISSER, 2014), (NOUREDDINE et. al., 2012),(KAMBADUR; KIM, 2014),(NOUREDDINE; ROUVOY; SEINTURIER, 2015),(SIEBRA et al, 2012), (MONTEIRO; AZEVEDO; SZTAJNBERG, 2013)	☹	
AP-11.Q-03	During the software development is the measurement of energy consumption? (SCHIEN et al, 2013),(SIEBRA et al, 2012), (CAPRA; FRANCALANCI; SLAUGHTER, 2012)	☺	
AP-11.Q-04	What metrics are used to measure the software's energy efficiency? (SCHIEN et al, 2013), (NOUREDDINE et. al., 2012), (AGOSTA et al, 2012) , (KIM; LEE; LEE, 2012) , (HINDLE, 2012) , (SAHIN et al, 2012) , (MANOTAS et al, 2013)	☹	

AP-11.Q-05	Is there any other indicator linked to sustainability that is applied in the developed software? (PENZENSTADLER; FEMMER, 2013) , (SCHIEN et al, 2013),(KALAITZOGLOU; BRUNTINK; VISSER, 2014), (NOUREDDINE; ROUVOY; SEINTURIER, 2015)	☺	

Table 63 - Organization C - Results of AP-11.

The practices to evaluate sustainability software quality attributes as reported in Table 28Table 64 are found described through existents practices **Apply performance test prior to production deploy**, **[PEEE] Use of quality attributes as Energy Efficiency regarding time to response, amount of resources and software performance** and **Application monitoring to identify lazy process**, all related to AP-12.Q-01 confirming the question.

The AP-12.Q-01 the practices found are **Apply performance test prior to production deploy** and **[PEEE] Use of quality attributes as Energy Efficiency regarding time to response, amount of resources and software performance** proposed by (KOCAK; ALPTEKIN; BENER, 2014), which presents quality criteria to develop a green software. These quality criteria were identified by the use of Fussy AHP/Pairwise comparison and confirmed with expert interviews. The results of this study shows that Reliability, Functionality, Usability and Efficiency were qualified at Quality Criteria and Resource Usage and Energy impact were qualified as Environmental Criteria.

AP-12	**The criteria for evaluating software quality includes sustainability practices.**	**Exists? ORG C** ☹ 😐 ☺	**Propositions**
AP-12.Q-01	Is it possible to confirm that software sustainability practices are related to software quality attributes? (KOCAK; ALPTEKIN; BENER, 2014) , (PENZENSTADLER, 2014)	☺	**P1, P2**
AP-12.Q-02	What are the quality attributes adopted by the organization? (ALBERTAO et al., 2010)	☺	

Table 64 - Organization C - Results of AP-12.

About AP-13.Q-01 described in Table 65 it is possible to link the new practice **Sustainability is a mean of marketing** as discussed previously.

AP-13	**Concern about the organization's reputation for adopting sustainability practices**	**Exists? ORG C** ☹ 😐 ☺	**Propositions**
AP-13.Q-01	Is it possible to find evidence on the dissemination of sustainability data to the customer? (PENZENSTADLER; FEMMER, 2013) , (ZHONG; LIU, 2010) , (PENZENSTADLER, 2014)	☺	**P1**
AP-13.Q-02	Has the organization received recognition for developing sustainable software? (PENZENSTADLER; FEMMER, 2013) , (PENZENSTADLER, 2014)	☹	

Table 65 - Organization C - Results of AP-13.

5.3.2 Organization C – Propositions results

This section presents the propositions results and final results of each analysis point in following tables:

P1 - Systematized sustainability organizational policies in software development

Table 66 shows the results for proposition P1. Only AP-04 was not possible to find any practices related to systematized or non-systematized practices.

☺	**P1 - Organizational policies driven to sustainability are systematically applied in software development in the financial sector.**	
AP-01	Initiatives that promote awareness about organizational social responsibility within the IT sector	☺
AP-04	Guidelines about sustainability requirements	☹
AP-05	Sustainable Software Engineering practices are identified at some levels of organization planning within the IT area.	☺
AP-06	Strategic alignment of the organization regarding the adoption of sustainability practices.	☺
AP-07	A preference is given to hiring IT vendors who apply sustainability to their business.	☺
AP-08	Concern to inform the customer that sustainability practices were adopted during the software development.	☺
AP-09	It is possible to identify Sustainable Software Engineering practices at each phase of the software life cycle.	☺
AP-12	The criteria for evaluating software quality includes sustainability practices.	☺
AP-13	Concern about the organization's reputation for adopting sustainability practices	☺

Table 66 - Organization C - Proposition 1 results

For the proposition P1 we can noticed that the Organization C has adopted many practices from the literature and new practices were found as well, most of them in a systematized way.

Analyzing the Organization C profile, we noticed sustainability gains is recognized and is part of its business strategy. The evidence regarding these analysis points is found in Organization C annual reports available online to the public and also confirmed by its employees in a voluntary way.

The AP-04 was not possible to confirm in its totality. Probably because the organization does not know the term "Sustainable Software Engineering" and has

never used a model or guideline to apply this. However isolated evidences of systematized practices was found related to others software development phases.

Therefore our conclusion about Organization C is positive, regarding the fact of Proposition P1 been confirmed through the new and from the literature practices.

P2 - Non-systematized Sustainable Software Engineering practices

Since this proposition is related to P2 changing only to non-systematized, the AP-04 was neither non-systematized nor systematized. Therefore it was not possible to identify guidelines about sustainability requirements as explained on P1.

Regarding the remaining analysis points presented in Table 67 it was possible to find systematized practices mostly. This happens because there is only one new practice related to non-systematized what is about **Develop a code that is easier for everyone understand and maintain** as presented in Table 67

We concluded that Proposition P2 was not possible to confirm because the predominated findings are about systematized practices and the assumption of this proposition was to find non-systematized practices.

☺	**P2 - Sustainable Software Engineering practices are applied in a non-systematic way during software development.**	
AP-01	Initiatives that promote awareness about organizational social responsibility within the IT sector	☺
AP-02	Practices of Sustainability Dimensions are considered during the software development.	☺
AP-03	Practices of Energy Consumption are considered during the software development.	☺
AP-04	Guidelines about sustainability requirements	☹
AP-08	Concern to inform the customer that sustainability practices were adopted during the software development.	☺
AP-09	It is possible to identify Sustainable Software Engineering practices at each phase of the software life cycle.	☺
AP-12	The criteria for evaluating software quality includes sustainability practices.	☺
AP-13	Concern about the organization's reputation for adopting sustainability practices	☺

Table 67 - Organization C - Proposition 2 results

P3 – Use of tools that automatically measure or change the energy consumption.

As represented in Table 68, the AP-10 was not possible to confirm since there is no practices related to software automatically adjust itself. This happens because the Organization C does not know about the existence of this approach.

The practices found in Organization C supporting the P3 analysis are: **[PEEE] Use of quality attributes as Energy Efficiency regarding time to response, amount of resources and software performance** (KOCAK; ALPTEKIN; BENER, 2014), **[PEC] Adjust automatically servers CPU voltage** (ZHONG; LIU, 2010) and this new practice **Application monitoring to identify lazy process.**

Regarding this validation of this Proposition it is possible to identify systematized practices applied that are variables to support software energy consumption measurements responding to AP-11.

☺	**P3 - Tools that automatically measure or change the energy consumption of developed software are used**	
AP-02	Practices of Sustainability Dimensions are considered during the software development.	☺
AP-03	Practices of Energy Consumption are considered during the software development.	☺
AP-08	Concern to inform the customer that sustainability practices were adopted during the software development.	☺
AP-09	It is possible to identify Sustainable Software Engineering practices at each phase of the software life cycle.	☺
AP-10	When abnormally energy consumption is detected, the software developed adjust itself to reduce its energy consumption	☹
AP-11	It is possible to measure the energy efficiency of the developed software.	☺

Table 68 - Organization C - Proposition 3 results

5.4 Organization D

The Organization D is identified by the Central Bank of Brazil as global payments. The main business stream is credit card processing and service used by other banks and companies around the world.

In Brazil, the IT area has around 200 employees and has adopted and suggested process during the software development. All the employees working to Organization D are hired through an international company that provides IT services. Table 69 presents the employees profiles.

Organization D	Job description	Financial experience	IT experience	Interview duration
Employee A	Software Engineer in Test	7 months	7 years	13:05:00
Employee B	Senior Developer	7 months	18 years	19:57:00
Employee C	Software Engineer in Test	2 years and 8 months	7 years	17:40:00
Employee D	Software Engineer in Test	3 years	10 years	16:07:00

Table 69 - Organization D- employee's profiles.

5.4.1 Organization D – Analysis Points description

In Figure 35, it is possible to observe the new practices and existent practices applied in a systematized way. In the network there are two new practices not found in SLR categorized into Practices of Code Improvement. Regarding the existent practices from SLR there are six practices, two of them are categorized into Practices of Sustainability Dimensions. Three existent practices are categorized into Practices of Evaluating Energy Efficiency.

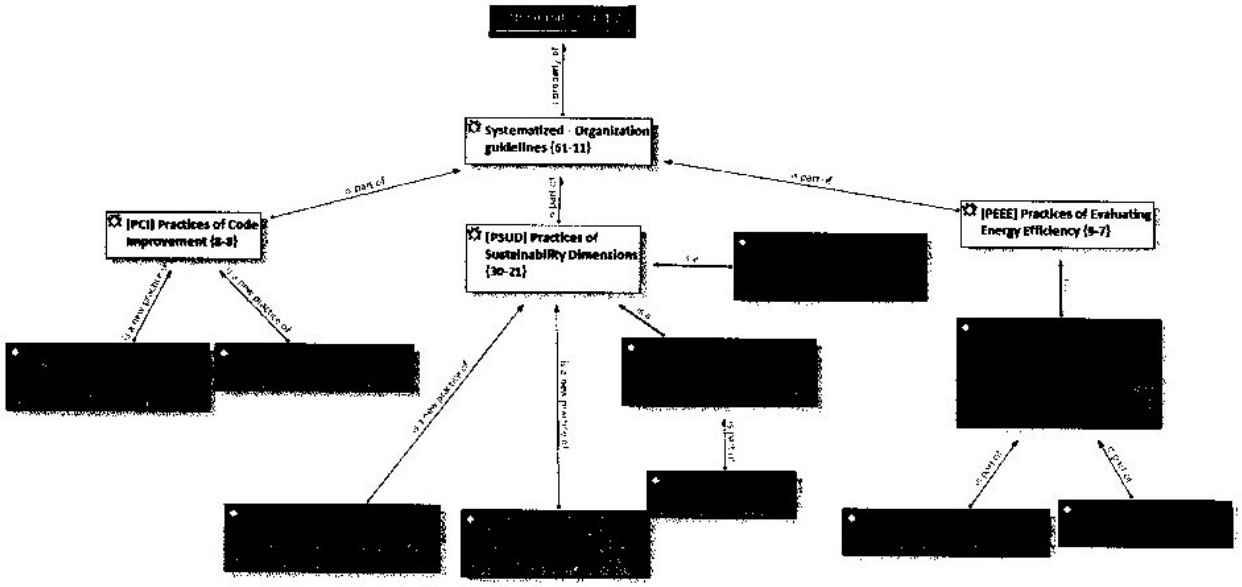

Figure 35 - Organization D - Network of systematized practices.

The network represented in Figure 36 is about non-systematized new practices and existent practices.

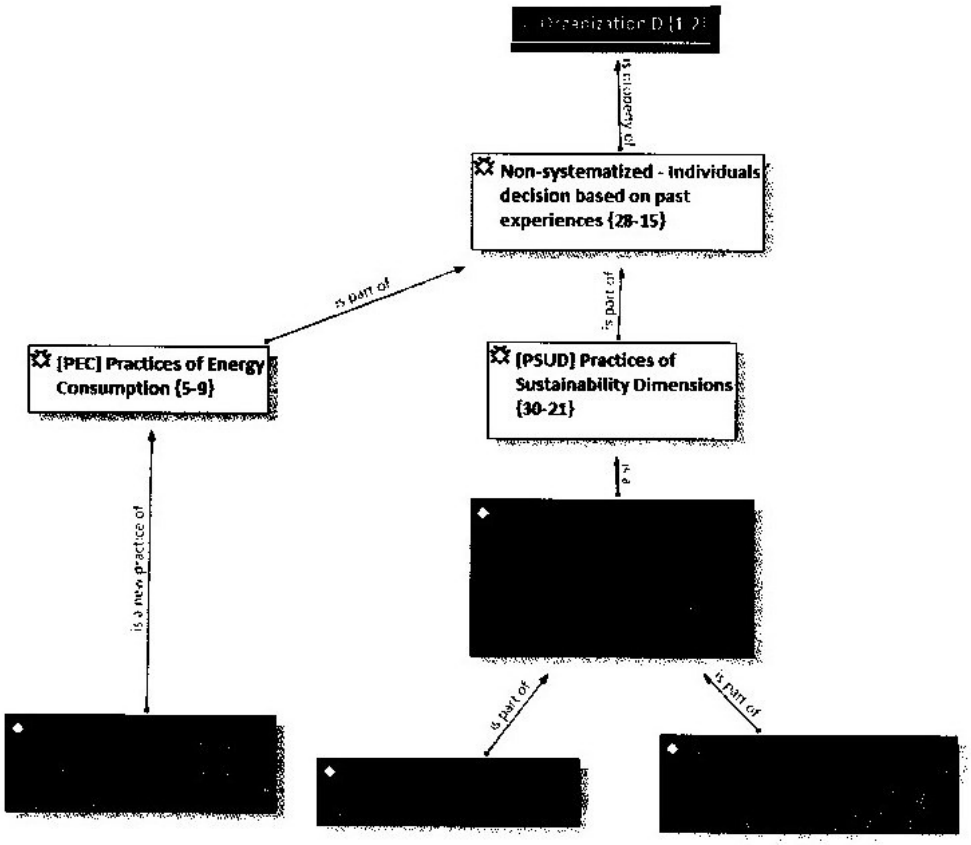

Figure 36 - Organization D - Network of non-systematized practices.

Regarding the new practices not found in SLR it was discovered one practice categorized into Practices of Energy Consumption. Three existent practices found in SLR was discovered and categorized into Practices of Sustainability Dimensions. All these practices will be detailed in the analysis point results.

Organization D - Analysis points results

Regarding the initiatives to promote awareness the AP-01 was analyzed as represented in Table 70. For this organization it was mentioned by the interviewee the concerns about sustainability associated with the systematized existent practice **[PSUD] Identify initiatives of sustainability in the company level** (PENZENSTADLER; FEMMER, 2013) and **Concerns about social responsibility.** The action includes voluntary work program on asylum houses which answers the AP-01.Q-06 and AP-01.Q-07.

AP-01	**Initiatives that promote awareness about organizational social responsibility within the IT sector**	**Exists? ORG D** ☹ 😐 ☺	**Propositions**
AP-01.Q-01	Initiatives that promote awareness about organizational social responsibility within the IT sector. (PENZENSTADLER; FEMMER; RICHARDSON, 2013),(PENZENSTADLER, 2014)	☹	**P1, P2**
AP-01.Q-02	Is there anyone responsible for disseminating sustainability information in IT projects? (PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☹	

AP-01.Q-03	Within the IT area is there a sustainability focal point? (PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☹
AP-01.Q-04	Is there a reference model for achieving sustainability activities, dimensions, values, indicators and regulations? (PENZENSTADLER; FEMMER, 2013) ,(ALBERTAO et al., 2010)	☹
AP-01.Q-05	What are the metrics for measuring sustainability goals? (PENZENSTADLER; FEMMER, 2013)	☹
AP-01.Q-06	Is there specification of sustainability actions? (ZHONG; LIU, 2010)	☺
AP-01.Q-07	Does the organization promote awareness raising about sustainability? (PENZENSTADLER; FEMMER, 2013) (ZHONG; LIU, 2010)	☺
AP-01.Q-08	What are the awareness actions? (ZHONG; LIU, 2010)	☹
AP-01.Q-09	Is sustainability present in the organization's strategy? (PENZENSTADLER; FEMMER, 2013) ,(ZHONG; LIU, 2010)	☹

Table 70 - Organization D - Results of AP-01.

Table 71 presents the results for AP-02, which is about Practices of Sustainability Dimensions applied during the software development. To answer the question AP-02.Q-01 the new practice was discovered **Use of agile methods allows good requirements specifications** and linked to **Practices of Sustainability Dimensions** category. As reported during the interviews the Organization uses agile methodology to support software development and it noticed that agile methods such as Scrum helps to team to identify and comply to the software requirements easily, as they do demos of small functionalities to the client. In the demos, after the functionality has been developed the senior analyst presents its working for the client, alright way the demo is approved or returned to change something.

They implements non-functional requirements related to performance of the system. This is related to existent practice **[PSUD] Implement non-functional requirements** (PENZENSTADLER; FEMMER, 2013). There is a team available exclusively execute performance test and fix performance issues. Even though the performance of the application is measured only by CPU processing and memory, there is no measures related to energy consumption. We considered this an answer to AP-02.Q-02 because since they measure CPU and memory, to measure the energy is just a matter of time.

New practices related to **Use of tool to perform quality check during the build/deploy of code was found in this organization** what is part of the new category **Practices of Code Improvement**. As reported before the code improvement category merged from the interviews since they related these kind of practices as sustainable practices since it improves the time, the performance of the team and the consistency of code. The use of Jenkins tool was defined by the organization D and is used in a systematized way, the same as Organization B answering AP-02.Q-05.

Regarding the AP-02.Q-08 a practice of **Build reusable components** was reported by the interviewee. During the tests automation they apply these practice to build reusable automatic test lead to this non-systematized practice **Choose some functionalities carefully to create reusable test automation.** Both practices related in this AP question were associated with the existent practice of **[PSUD] Identify practices of Development-Related Proprieties like modifiability, reusability, portability and supportability** since it is a form of reusability as informed by (ALBERTAO et al., 2010).

AP-02	Practices of Sustainability Dimensions are considered during the software development.	Exists? ORG D ☹ 😐 ☺	Propositions
AP-02.Q-01	In the project planning phase is it considered a plan for the software to be sustainable in order to suffer less changes during development? (PENZENSTADLER; FEMMER, 2013) ,(ZHONG; LIU, 2010) ,(KIM; LEE; LEE, 2012)	☺	P2, P3
AP-02.Q-02	Is the non-functional requirements related to sustainability identified in the software requirements phase? (PENZENSTADLER; FEMMER, 2013) ,(SCHIEN et al, 2013), (KALAITZOGLOU; BRUNTINK; VISSER, 2014), (KAMBADUR; KIM, 2014),(HINDLE, 2012) , (MANOTAS et al, 2013)	☺	
AP-02.Q-03	In the software design phase is there any guide to developing the sustainability-oriented software architecture? (PENZENSTADLER, 2014)	☹	
AP-02.Q-04	In the software testing phase is it verified whether the software contemplates Sustainable Software Engineering practices? (PENZENSTADLER; FEMMER, 2013) ,(ALBERTAO et al., 2010)	☹	
AP-02.Q-05	In the maintenance phase of the software is there any sustainability practice applied? (PENZENSTADLER, 2014)	☺	
AP-02.Q-06	Within each phase, has the person in charge knowledge about what is sustainability? (PENZENSTADLER; FEMMER, 2013) , (PENZENSTADLER, 2014) ,(PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☹	
AP-02.Q-07	In the project planning phase is it considered a green data center that also consider sustainability important? (ZHONG; LIU, 2010)	☺	
AP-02.Q-08	In the software construction is it considered the use of practices related to modifiability, reusability, portability and supportability? (ALBERTAO et al., 2010)	😐	

Table 71 - Organization D - Results of AP-02.

The AP-03 described in Table 72 is about practices of energy consumption considered during the software development. Regarding the software test phase as described on AP-03.Q-05, the systematized existents practices found were **Apply performance test prior to production deploy** and **Application monitoring to identify lazy process** which are part of **[PEEE] Use of quality attributes as Energy Efficiency regarding time to response, amount of resources and software performance** (KOCAK; ALPTEKIN; BENER, 2014).

Regarding AP-03.Q-06, about software maintenance, it was possible to identify a new practice related to **Use of a tool to discovery code inconsistent implementation** which is part of Practices of Code Improvement as well as **Code refactoring to enhance application performance**. Both practices are applied at test phase and they are applied with the a tool called Sonar[9] responsible to analyze the code healthiness and give hints of development best practices avoiding bad code implementation. Everyone in the Organization D has to use this tool.

AP-03	**Practices of Energy Consumption are considered during the software development.**	**Exists? ORG D** ☹ 😐 ☺	**Propositions**
AP-03.Q-01	In the project planning phase is it possible to identify the use of practices related to the choice of hardware or devices, metrics and monitoring that can be added to software development to consume less energy? (CORDERO et al., 2015) , (SCHIEN et al, 2013), (KALAITZOGLOU; BRUNTINK; VISSER, 2014), (KIM; LEE; LEE, 2012) , (WEISS; REPETTO; KOZIOLEK, 2012)	☹	P2, P3
AP-03.Q-02	In the phase of software requirements practices related to collection, measurement and configuration of power consumption are found? (SCHIEN et al, 2013),(KALAITZOGLOU; BRUNTINK; VISSER, 2014), (KAMBADUR; KIM, 2014), (HINDLE, 2012) , (MANOTAS et al, 2013)	☹	
AP-03.Q-03	In the design phase of the software you can find practices related to architecture, tools, frameworks, virtualization, standards and coding that reduce or monitor the software's power consumption. (CORDERO et al., 2015) ,(PENZENSTADLER; FEMMER, 2013) , (SCHIEN et al, 2013), (AGOSTA et al, 2012) , (SAHIN et al, 2012) , (MANOTAS et al, 2013), (CAPRA; FRANCALANCI; SLAUGHTER, 2012) , (NOUREDDINE; ROUVOY; SEINTURIER, 2015), (SIEBRA et al, 2012)	☹	
AP-03.Q-04	In the construction phase is it possible to find practices related to programming without the use of frameworks, real-time code energy consumption monitoring and automation of memory allocation and CPU when the software is running? (CORDERO et al., 2015) ,(SCHIEN et al, 2013),(NOUREDDINE et. al., 2012),(ZHONG; LIU, 2010) , (KAMBADUR; KIM, 2014) ,(AGOSTA et al, 2012)	☹	

[9] https://www.sonarqube.org/

	,(KIM; LEE; LEE, 2012) ,(KOCAK; ALPTEKIN; BENER, 2014) , (SIEBRA et al, 2012)		
AP-03.Q-05	In the test phase it is possible to find practices related to test case definition, test framework, energy efficiency techniques, quality attributes and code performance that test the power consumption of the software. (CORDERO et al., 2015) , (SCHIEN et al, 2013), (KALAITZOGLOU; BRUNTINK; VISSER, 2014),(NOUREDDINE et. al., 2012),(KAMBADUR; KIM, 2014),(KIM; LEE; LEE, 2012) , (KOCAK; ALPTEKIN; BENER, 2014) ,(MANOTAS et al, 2013),(SIEBRA et al, 2012)	☺	
AP-03.Q-06	In the maintenance phase it is possible to find practices related to configuration, monitoring and automatic optimization of the server according to the power consumption of the software. (SCHIEN et al, 2013), (KALAITZOGLOU; BRUNTINK; VISSER, 2014), (SIEBRA et al, 2012), (MONTEIRO; AZEVEDO; SZTAJNBERG, 2013)	☺	

Table 72 - Organization D - Results of AP-03.

Regarding AP-04 considering sustainability guidelines during software requirements phase we had no positive results for this analysis points. This happened because the organization do not have any guideline covering sustainability aspects to develop a software. The questions and results are presented in Table 73.

AP-04	Guidelines about sustainability requirements	Exists? D ☹ 😐 ☺	Propositions
AP-04.Q-01	During the survey of software requirements do you see the use of guides describing Sustainable Software Engineering practices? (WEISS; REPETTO; KOZIOLEK, 2012)	☹	P1, P2
AP-04.Q-02	Is a benchmark model used to describesustainability practices that should be considered when surveying software requirements? (PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☹	
AP-04.Q-03	Is there a guide that helps to identify the limitations of sustainability during software development? (PENZENSTADLER, 2014)	☹	
AP-04.Q-04	Is there a guide to identify sustainability goals during software development? (PENZENSTADLER, 2014)	☹	
AP-04.Q-05	Is there a guide to identifying sustainability interactions during software development? (PENZENSTADLER, 2014)	☹	

Table 73 - Organization D - Results of AP-04.

It is possible to identify practices from the literature in the Strategic and Operational level of Organization D as presented in Table 74.

Classification	Organizational levels	Practices
Systematized	Strategic	[PSUD] Implement non-functional requirements.
Systematized	Strategic	[PSUD] Identify initiatives of sustainability in the company level.

Systematized	Operational	[PEEE] Use of quality attributes as Energy Efficiency regarding time to response.
Non-Systematized	Operational	[PSUD] Identify practices of Development-Related Proprieties like modifiability, reusability, portability and supportability.

Table 74 - Organization D - AP-05 Organizational Levels.

It is possible to confirm practices related to organizational levels in AP-05.Q-01 and AP-05.Q-03 represented in Table 75. Regarding Tactical level there are no practices related to this in the Organization D.

AP-05	**Sustainable Software Engineering practices are identified at some levels of organization planning within the IT area.**	**Exists? ORG D** ☹😐☺	**Propositions**
AP-05.Q-01	It is noticed that in the Strategic level the practices of Sustainable Software Engineering are defined, there is documented evidence of these practices? (PENZENSTADLER; FEMMER, 2013) ,(SCHIEN et al, 2013),(ZHONG; LIU, 2010) ,(PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☺	P1
AP-05.Q-02	At the Tactical level, practices defined in the literature are found in the organization? (PENZENSTADLER; FEMMER, 2013) ,(SCHIEN et al, 2013),(ZHONG; LIU, 2010) ,(PENZENSTADLER, 2014) ,(CAPRA; FRANCALANCI; SLAUGHTER, 2012) ,(ALBERTAO et al., 2010) ,(PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☹	
AP-05.Q-03	At the Operational level, practices defined in the literature are found in the organization? (CORDERO et al., 2015) ,(PENZENSTADLER; FEMMER, 2013) ,(SCHIEN et al, 2013),(ZHONG; LIU, 2010) ,(PENZENSTADLER, 2014) ,(ALBERTAO et al., 2010) ,(WEISS; REPETTO; KOZIOLEK, 2012),(PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☺	

Table 75 - Organization D - Results of AP-05.

There were not enough evidence to confirm the AP-06 regarding the Organization D strategic alignment towards sustainability as represented in Table 76. We concluded this based on the fact of practices related to sustainability goals, measures, indicators, guidelines, supplier's checklist and concerns to inform this to the customer were not found.

AP-06	**Strategic alignment of the organization regarding the adoption of sustainability practices.**	**Exists? ORG D** ☹😐☺	**Propositions**
AP-06.Q-01	Is it perceived that sustainability is part of the organization's strategy? (PENZENSTADLER; FEMMER, 2013) ,(ZHONG; LIU, 2010)	☹	P1
AP-06.Q-02	It is understood that senior management of the organization supports and encourages the tactical and operational levels to use Sustainable Software Engineering practices? (ZHONG; LIU, 2010) ,(PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☹	

AP-06.Q-03	Is it possible to identify the meaning of sustainability for the organization? (PENZENSTADLER; FEMMER, 2013) ,(ZHONG; LIU, 2010)	☹	

Table 76 - Organization D - Results of AP-06.

Regarding AP-07, presented in Table 77, there were no evidences from the interviews that would be answering these analysis points.

AP-07	**A preference is given to hiring IT vendors who apply sustainability to their business.**	**Exists? ORG D** ☹😐☺	**Propositions**
AP-07.Q-01	The organization prides itself for hiring suppliers who have sustainability seals, energy efficiency and clean energy. (ZHONG; LIU, 2010) , (KIM; LEE; LEE, 2012)	☹	**P1**
AP-07.Q-02	Is it possible to identify that the organization uses software developed with Sustainable Software Engineering practices? (NOUREDDINE et. al., 2012)	☹	

Table 77 - Organization D - Results of AP-07.

Regarding AP-08, presented in Table 78, there were no evidences from the interviews that would be answering these analysis points.

AP-08	**Concern to inform the customer that sustainability practices were adopted during the software development.**	**Exists? D** ☹😐☺	**Propositions**
AP-08.Q-01	Is it possible to identify that from the beginning of software development the customer is informed that the software is being developed with Sustainable Software Engineering practices? (PENZENSTADLER; FEMMER; RICHARDSON, 2013), (ALBERTAO et al., 2010)	☹	**P1, P2, P3**
AP-08.Q-02	Is it important for the organization to verify that the developed software is consuming a lot of power when the customer uses it? (CORDERO et al., 2015) ,(SCHIEN et al, 2013)	☹	
AP-08.Q-03	Does the organization inform the customer of mechanisms that have been developed to avoid excessive consumption of energy by the software? (CORDERO et al., 2015) , (SCHIEN et al, 2013), (KIM; LEE; LEE, 2012) , (MANOTAS et al, 2013), (ALBERTAO et al., 2010)	☹	
AP-08.Q-04	What are the customer-driven awareness actions that the organization establishes? (SCHIEN et al., 2013)	☹	

Table 78 - Organization D - Results of AP-08.

The AP-09 is a double confirmation that Sustainable Software Engineering practices are applied on software life cycle presented in Table 79.

To answer AP-09.Q-02 regarding software requirements, the existent practice was found **[PSUD] Implement non-functional requirements** (PENZENSTADLER; FEMMER, 2013) in systematized way and is related to software performance in terms of CPU and memory performance.

The AP-09.Q-03 about software design, was answered by a new practice of **Use of pure java function to detect code inefficient performance** categorized as **Practice of Energy Consumption**. For this case, an interviewee mentioned the use of JUnit and java used functions to detect code inefficient performance not using any tool to detect this problem, therefore the practice is non-systematized.

Regarding AP-09.Q-05 software testing it was possible to identify the practices: **Choose some functionalities carefully to create reusable test automation, Application monitoring to identify lazy process** and **Apply performance test prior to production deploy** related to existing practice of **[PEEE] Use of quality attributes as Energy Efficiency regarding time to response, amount of resources and software performance** (KOCAK; ALPTEKIN; BENER, 2014).

AP-09	**It is possible to identify Sustainable Software Engineering practices at each phase of the software life cycle.**	**Exists? ORG D** ☹😐☺	**Propositions**
AP-09.Q-01	Within the project planning phase is it possible to find at least one of the practices: energy consumption (PEC), energy efficiency evaluation (PEEE), energy efficiency (PEF), business processes (PBP), life cycle assessment (PLCA) and sustainability (PSUD). (CORDERO et al., 2015) ,(PENZENSTADLER; FEMMER, 2013) ,(SCHIEN et al, 2013),(KALAITZOGLOU; BRUNTINK; VISSER, 2014),(ZHONG; LIU, 2010) ,(KIM; LEE; LEE, 2012) ,(PENZENSTADLER, 2014) ,(ALBERTAO et al., 2010) ,(WEISS; REPETTO; KOZIOLEK, 2012),(PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☹	**P1, P2, P3**
AP-09.Q-02	Within the software requirements phase it is possible to find at least one of the practices: energy consumption (PEC), energy efficiency evaluation (PEEE) and sustainability (PSUD). (PENZENSTADLER; FEMMER, 2013) ,(SCHIEN et al, 2013),(KALAITZOGLOU; BRUNTINK; VISSER, 2014),(ZHONG; LIU, 2010) ,(KAMBADUR; KIM, 2014),(AGOSTA et al, 2012) ,(HINDLE, 2012) ,(PENZENSTADLER, 2014) ,(MANOTAS et al, 2013),(PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☺	
AP-09.Q-03	Within the software design phase it is possible to find at least one of the practices: energy consumption (PEC), energy efficiency evaluation (PEEE), energy efficiency (PEF) and sustainability (PSUD). (CORDERO et al., 2015) ,(PENZENSTADLER; FEMMER, 2013) ,(SCHIEN et al, 2013),(NOUREDDINE et. al., 2012),(ZHONG; LIU, 2010) ,(AGOSTA et al, 2012) ,(PENZENSTADLER, 2014) ,(SAHIN et al, 2012) ,(MANOTAS et al, 2013),(CAPRA; FRANCALANCI; SLAUGHTER, 2012) ,(NOUREDDINE; ROUVOY; SEINTURIER, 2015),(SIEBRA et al, 2012),(MONTEIRO; AZEVEDO; SZTAJNBERG, 2013)	😐	
AP-09.Q-04	Within the software construction it is possible to find at least one of the practices: energy consumption (PEC), energy efficiency evaluation (PEEE), energy efficiency (PEF), end user energy consumption (PEUC) and sustainability (PSUD). (CORDERO et al., 2015) ,(PENZENSTADLER; FEMMER, 2013) ,(SCHIEN et al, 2013),(NOUREDDINE et. al., 2012),(ZHONG; LIU, 2010) ,(KAMBADUR; KIM,	☹	

	2014),(AGOSTA et al, 2012) ,(KIM; LEE; LEE, 2012) ,(KOCAK; ALPTEKIN; BENER, 2014) ,(SIEBRA et al, 2012)		
AP-09.Q-05	Within the software testing phase it is possible to find at least one of the practices: energy consumption (PEC), energy efficiency evaluation (PEEE), energy efficiency (PEF), end user energy consumption (PEUC) and sustainability (PSUD). (CORDERO et al., 2015) , (PENZENSTADLER; FEMMER, 2013) , (SCHIEN et al, 2013), (KALAITZOGLOU; BRUNTINK; VISSER, 2014), (KAMBADUR; KIM, 2014), (KIM; LEE; LEE, 2012) , (KOCAK; ALPTEKIN; BENER, 2014) , (MANOTAS et al, 2013), (ALBERTAO et al., 2010) , (SIEBRA et al, 2012)	☺	
AP-09.Q-06	Within the software maintenance phase it is possible to find at least one of the practices: energy consumption (PEC), energy efficiency evaluation (PEEE) and sustainability (PSUD). (SCHIEN et al, 2013),(KALAITZOGLOU; BRUNTINK; VISSER, 2014),(PENZENSTADLER, 2014) ,(SIEBRA et al, 2012),(MONTEIRO; AZEVEDO; SZTAJNBERG, 2013)	☹	

Table 79 - Organization D - Results of AP-09.

About AP-10 it was not possible to find any practice related to this analysis point as it presents in Table 80. This is actually the most difficult question to answer since it requires a really good reason and high efforts to develop a software to adjust itself.

AP-10	**When abnormally energy consumption is detected, the software developed adjust itself to reduce its energy consumption**	**Exists? ORG D** ☹ 😐 ☺	**Propositions**
AP-10.Q-01	Is any source code implementation used to reduce power consumption, such as memory allocation and CPU usage? (AGOSTA et al, 2012), (KIM; LEE; LEE, 2012), (KOCAK; ALPTEKIN; BENER, 2014), (SIEBRA et al, 2012)	☹	**P3**
AP-10.Q-02	Is there any configuration on the server that allows you to change the performance of the software to use less power? (ZHONG; LIU, 2010), (MANOTAS et al, 2013), (MONTEIRO; AZEVEDO; SZTAJNBERG, 2013)	☹	

Table 80 - Organization D - Results of AP-10.

Regarding AP-11 there were not answers for these question and somehow it is related to AP-10 presented in Table 81Table 45. There is no evidence that this organization measure energy efficiency.

AP-11	**It is possible to measure the energy efficiency of the developed software.**	**Exists? D** ☹ 😐 ☺	**Propositions**
AP-11.Q-01	Is there any use of energy consumption measures? (CORDERO et al., 2015) ,(AGOSTA et al, 2012) ,(SAHIN et al, 2012)	☹	**P3**
AP-11.Q-02	Is there any use of energy efficiency measures or software performance that does not have an impact on energy consumption? (SCHIEN et al, 2013),(KALAITZOGLOU; BRUNTINK; VISSER, 2014), (NOUREDDINE et. al.,	☹	

	2012),(KAMBADUR; KIM, 2014),(NOUREDDINE; ROUVOY; SEINTURIER, 2015),(SIEBRA et al, 2012), (MONTEIRO; AZEVEDO; SZTAJNBERG, 2013)		
AP-11.Q-03	During the software development is the measurement of energy consumption? (SCHIEN et al, 2013),(SIEBRA et al, 2012), (CAPRA; FRANCALANCI; SLAUGHTER, 2012)	☹	
AP-11.Q-04	What metrics are used to measure the software's energy efficiency? (SCHIEN et al, 2013), (NOUREDDINE et. al., 2012), (AGOSTA et al, 2012) , (KIM; LEE; LEE, 2012) , (HINDLE, 2012) , (SAHIN et al, 2012) , (MANOTAS et al, 2013)	☹	
AP-11.Q-05	Is there any other indicator linked to sustainability that is applied in the developed software? (PENZENSTADLER; FEMMER, 2013) , (SCHIEN et al, 2013),(KALAITZOGLOU; BRUNTINK; VISSER, 2014), (NOUREDDINE; ROUVOY; SEINTURIER, 2015)	☹	

Table 81 - Organization D - Results of AP-11.

To evaluate software quality attributes the Organization D applies the practices of **Apply performance test prior to production deploy** and **Apply performance test prior to production deploy** that are part of existent practice **[PEEE] Use of quality attributes as Energy Efficiency regarding time to response, amount of resources and software performance** (KOCAK; ALPTEKIN; BENER, 2014) answering the AP-12.Q-01 and AP-12.Q-02 in Table 82.

AP-12	**The criteria for evaluating software quality includes sustainability practices.**	**Exists? ORG D** ☹ 😐 ☺	**Propositions**
AP-12.Q-01	Is it possible to confirm that software sustainability practices are related to software quality attributes? (KOCAK; ALPTEKIN; BENER, 2014) , (PENZENSTADLER, 2014)	☺	**P1, P2**
AP-12.Q-02	What are the quality attributes adopted by the organization? (ALBERTAO et al., 2010)	☺	

Table 82 - Organization D - Results of AP-12.

Regarding AP-13 presented in Table 83, it was not possible to discovery practices related to concerns about organization's reputation related to sustainability from the interviews.

AP-13	**Concern about the organization's reputation for adopting sustainability practices**	**Exists? ORG D** ☹ 😐 ☺	**Propositions**
AP-13.Q-01	Is it possible to find evidence on the dissemination of sustainability data to the customer? (PENZENSTADLER; FEMMER, 2013) , (ZHONG; LIU, 2010) , (PENZENSTADLER, 2014)	☹	**P1**
AP-13.Q-02	Has the organization received recognition for developing sustainable software? (PENZENSTADLER; FEMMER, 2013) , (PENZENSTADLER, 2014)	☹	

Table 83 - Organization D - Results of AP-13.

5.4.2 Organization D – Propositions results

This section presents the propositions results and final results of each analysis point in following tables:

P1 - Systematized sustainability organizational policies in software development

Table 84 shows the results for proposition P1. Only three analysis points was confirmed in the Organization D for P1.

It is possible to find some systematized practices at Strategic and Operational levels. Specifically on strategic level, the practices found are not related to information technology area, only related to organizational aspects. However at operational level we have practices used during the software development.

Those practices were discovered at software testing and maintenance phases supporting the AP-09. About the software testing the practices discovered were related to quality criteria and software performance evaluation.

For Organization D the software performance is crucial for their business, since millions of credit card transactions are made by second, if one failed it means money and reputational loss. This justify why the testing area dedicate time and resources on performance testing, however it is important to notice that energy consumption is not monitored nor measured.

☹	**P1 - Organizational policies driven to sustainability are systematically applied in software development in the financial sector.**	
AP-01	Initiatives that promote awareness about organizational social responsibility within the IT sector	☹
AP-04	Guidelines about sustainability requirements	☹
AP-05	Sustainable Software Engineering practices are identified at some levels of organization planning within the IT area.	☺
AP-06	Strategic alignment of the organization regarding the adoption of sustainability practices.	☹
AP-07	A preference is given to hiring IT vendors who apply sustainability to their business.	☹
AP-08	Concern to inform the customer that sustainability practices were adopted during the software development.	☹
AP-09	It is possible to identify Sustainable Software Engineering practices at each phase of the software life cycle.	☺
AP-12	The criteria for evaluating software quality includes sustainability practices.	☺
AP-13	Concern about the organization's reputation for adopting sustainability practices	☹

Table 84 - Organization D - Proposition 1 results

Regarding software maintenance it is possible to see a list of tools used to improve code performance, understanding and supportability allowing the programmers to adjust the code immediately. From interviews is possible to find mention of best practices as sustainable software practices.

Although, there are some analysis points with systematized findings, it is not enough to conclude that P1 was confirmed.

P2 - Non-systematized Sustainable Software Engineering practices

In Table 85 it is possible to see that we have only systematized practices related to software development that AP-03 and AP-09.

The organization D have non-systematized practices and are described in Table 86. However it did not support this proposition since we had it only on maintenance phase of software development. The same analysis was made for AP-09, which has non-systematized only on software design.

In this case we concluded that P2 was not confirmed.

☹ **P2 - Sustainable Software Engineering practices are applied in a non-systematic way during software development..**		
AP-01	Initiatives that promote awareness about organizational social responsibility within the IT sector	☹
AP-02	Practices of Sustainability Dimensions are considered during the software development.	☹
AP-03	Practices of Energy Consumption are considered during the software development.	☺
AP-04	Guidelines about sustainability requirements	☹
AP-08	Concern to inform the customer that sustainability practices were adopted during the software development.	☹
AP-09	It is possible to identify Sustainable Software Engineering practices at each phase of the software life cycle.	☺
AP-12	The criteria for evaluating software quality includes sustainability practices.	☹
AP-13	Concern about the organization's reputation for adopting sustainability practices	☹

Table 85 - Organization D - Proposition 2 results

P3 – Use of tools that automatically measure or change the energy consumption.

In Table 86, we have practices that support software testing and software maintenance, however they do not perform is automatically. No evidences of energy consumption measure was done on developed software or during the software development. Therefore P3 was not confirmed in Organization D.

☹ P3 - Tools that automatically measure or change the energy consumption of developed software are used		
AP-02	Practices of Sustainability Dimensions are considered during the software development.	☹
AP-03	Practices of Energy Consumption are considered during the software development.	☺
AP-08	Concern to inform the customer that sustainability practices were adopted during the software development.	☹
AP-09	It is possible to identify Sustainable Software Engineering practices at each phase of the software life cycle.	☺
AP-10	When abnormally energy consumption is detected, the software developed adjust itself to reduce its energy consumption	☹
AP-11	It is possible to measure the energy efficiency of the developed software.	☹

Table 86 - Organization D - Proposition 3 results

5.5 Organization E

The Organization E is identified in Central Bank of Brazil as global payment operator and is also a Fintech offering payment methods in international companies. A Fintech is an organization that provides parts of bank services, in this case payment methods. Founded in 2012, with the intention to democratize the bank drafts (called "boleto bancario") for many international companies, this Fintech has been growing and providing digital services with impressive expansion. Table 87 shows the employee's profiles interviewed in this case study.

Organization D	Job description	Financial experience	IT experience	Interview duration
Employee A	Software Developer	4 months	8 years	16:33:00
Employee B	Senior System Analyst	8 months	23 years	18:00:00
Employee C	Product Manager	1 year and 6 months	10 years	17:35:00

Table 87 - Organization E- employee's profiles.

5.5.1 Organization E – Analysis Points description

In the Figure 37 the network of systematized new practices and existent practices is presented. In this network, it is possible to six new practices not found in SLR. Five of them are categorized into Practices of Sustainability Dimensions. One is categorized as Practices of Business Process and one is categorized as Practices of Code Improvement.

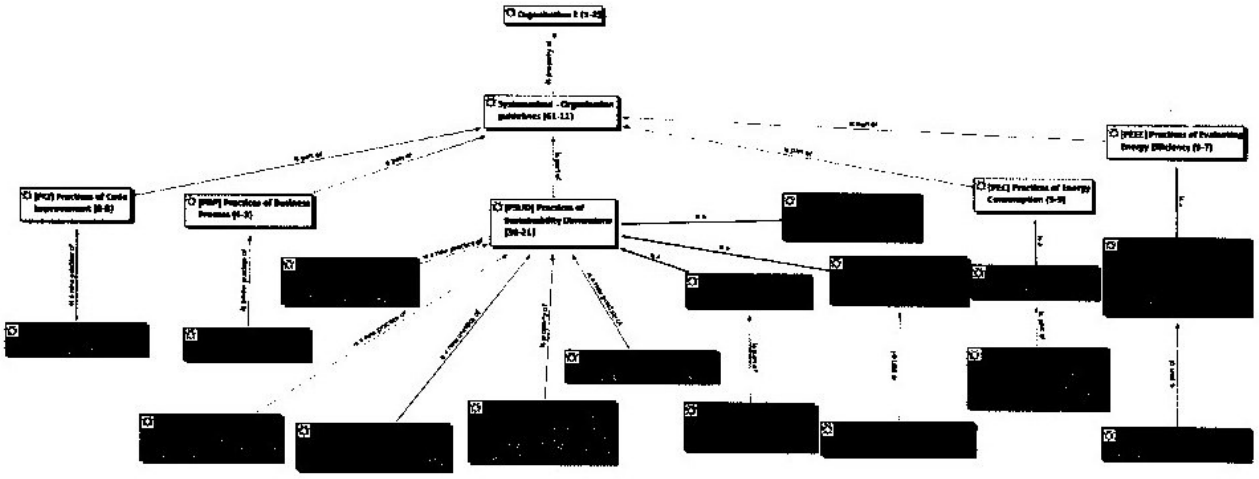

Figure 37 - Organization E - Network of systematized practices.

The Figure 38 presents the network of six non-systematized new practices not found in SLR. Four of them are categorized into Practices of Sustainability Dimensions and two of them are categorized into Practices of End User Energy Consumption.

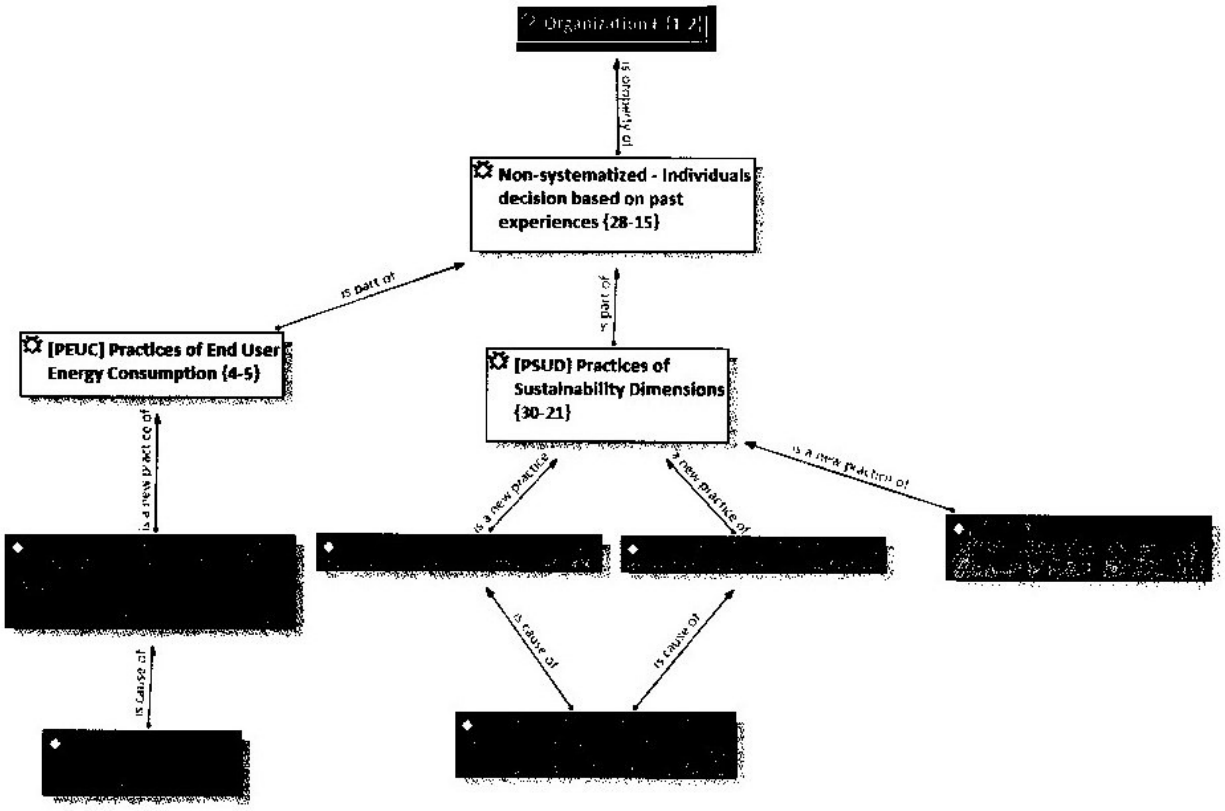

Figure 38 - Organization E - Network of non-systematized practices.

All the practices presented in the networks will be described in the analysis points results.

Organization E - Analysis points results

In Organization E it was possible to find an non-systematized practice related to **Concern about sustainability is exercised naturally** answering AP-01.Q-06, it

means that practices like use less papers, do not waste water, avoid use plastic cup, avoid print documents and all these practices we found systematized in traditional financial Organization, is applied naturally by the employees in Organization E. Regarding this fact an interviewee commented:

> "[..] in the last company I worked for, any little project people were printing 300 pages of requirements, here is really hard to find people with paper in the hands. I think that you feels a little shy to walk around with a paper in the hands. (P84)"

Regarding the AP-01.Q-07 a practice of **Communication to external client about digital services** was found and is part of an existent practice from the literature **[PSUD] Identify initiatives of sustainability in the company level as part of this practice** (PENZENSTADLER; FEMMER, 2013), which is also presented on AP-01.Q-09 presented in Table 88. This happens because the Organization E services are provided via digital platforms, there is no physical agency.

AP-01	Initiatives that promote awareness about organizational social responsibility within the IT sector	Exists? ORG E ☹😐☺	Propositions
AP-01.Q-01	Initiatives that promote awareness about organizational social responsibility within the IT sector. (PENZENSTADLER; FEMMER; RICHARDSON, 2013),(PENZENSTADLER, 2014)	☹	P1, P2
AP-01.Q-02	Is there anyone responsible for disseminating sustainability information in IT projects? (PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☹	
AP-01.Q-03	Within the IT area is there a sustainability focal point? (PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☹	
AP-01.Q-04	Is there a reference model for achieving sustainability activities, dimensions, values, indicators and regulations? (PENZENSTADLER; FEMMER, 2013) ,(ALBERTAO et al., 2010)	☹	
AP-01.Q-05	What are the metrics for measuring sustainability goals? (PENZENSTADLER; FEMMER, 2013)	☹	
AP-01.Q-06	Is there specification of sustainability actions? (ZHONG; LIU, 2010)	😐	
AP-01.Q-07	Does the organization promote awareness raising about sustainability? (PENZENSTADLER; FEMMER, 2013) (ZHONG; LIU, 2010)	☺	
AP-01.Q-08	What are the awareness actions? (ZHONG; LIU, 2010)	☹	
AP-01.Q-09	Is sustainability present in the organization's strategy? (PENZENSTADLER; FEMMER, 2013) ,(ZHONG; LIU, 2010)	☺	

Table 88 - Organization E - Results of AP-01.

Table 89 presents the AP-02 regarding Practices of Sustainability Dimensions applied during the software life cycle. The question AP-02.Q-01 regarding the project planning is answered by the new practice **Use of agile methods allows good requirements specifications** categorized as Practices of Sustainability Dimensions.

Regarding AP-02.Q-02 about non-functional requirements the existent practice of **[PSUD] Implement non-functional requirements** was found, however it is applied to guarantee the performance of high volume data.

The AP-02.Q-03 about software design has the new practice **Build a software that is configurable by any person and do not depends of developer** this practice was categorized as Practices of Sustainability Dimensions and it means build a software that do not suffers changes by developer that could be implemented. Another new practice is about to **Design a scalable application,** in this case the interviewee was referring to develop a code that can be executed and perform well in many scenarios of demand. From the perspective of Sustainable Software Engineering practices seems reasonable to consider this one practice of it.

Regarding the maintenance phase of AP-02.Q-05, it was possible to find a systematized new practice **Use of tool to perform quality check during the build/deploy of code.** The interviewee mentioned that tests automation are performed before go to production.

At software construction phase it was possible to answer AP-02.Q-08 by the new practice systematized **Personal code review to identify code inconsistence**. The organization E has the practice of code reviewing by a senior developer all codes before going to production to guarantee that there are no bugs in the code, the requirements were implemented and everything is tested.

AP-02	Practices of Sustainability Dimensions are considered during the software development.	Exists? ORG E ☹ 😐 ☺	Propositions
AP-02.Q-01	In the project planning phase is it considered a plan for the software to be sustainable in order to suffer less changes during development? (PENZENSTADLER; FEMMER, 2013) ,(ZHONG; LIU, 2010) ,(KIM; LEE; LEE, 2012)	☺	P2, P3
AP-02.Q-02	Is the non-functional requirements related to sustainability identified in the software requirements phase? (PENZENSTADLER; FEMMER, 2013) ,(SCHIEN et al, 2013), (KALAITZOGLOU; BRUNTINK; VISSER, 2014), (KAMBADUR; KIM, 2014),(HINDLE, 2012) , (MANOTAS et al, 2013)	☺	
AP-02.Q-03	In the software design phase is there any guide to developing the sustainability-oriented software architecture? (PENZENSTADLER, 2014)	☺	

AP-02.Q-04	In the software testing phase is it verified whether the software contemplates Sustainable Software Engineering practices? (PENZENSTADLER; FEMMER, 2013) ,(ALBERTAO et al., 2010)	☹
AP-02.Q-05	In the maintenance phase of the software is there any sustainability practice applied? (PENZENSTADLER, 2014)	☺
AP-02.Q-06	Within each phase, has the person in charge knowledge about what is sustainability? (PENZENSTADLER; FEMMER, 2013) , (PENZENSTADLER, 2014) ,(PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☹
AP-02.Q-07	In the project planning phase is it considered a green data center that also consider sustainability important? (ZHONG; LIU, 2010)	☹
AP-02.Q-08	In the software construction is it considered the use of practices related to modifiability, reusability, portability and supportability? (ALBERTAO et al., 2010)	☺

Table 89 - Organization E - Results of AP-02.

About the AP-03 presented in Table 90 the AP-03.Q-05 has existent practices related to **[PEEE] Use of quality attributes as Energy Efficiency regarding time to response, amount of resources and software performance** which can be explained by this practice **Apply performance test prior to production deploy.** The interviewee said:

> "[..] we had many automation tests and during these tests we had performance test, then a too was created in house to identify this type of problem. (85)"

Regarding the software construction phase on AP-03.Q-04 the **Use of server services to automatically adjust memory and cpu when the application requires** practice and is part of existent practice **[PEC] Adjust automatically servers CPU voltage** (ZHONG; LIU, 2010). When the application required more processing the services adjust its memory and CPU automatically. This is done on Amazon side, where the applications are hosted.

About software maintenance phase described on AP-03.Q-06 new practice related to **Code refactoring to enhance application performance** categorized as Practices of Code Improvement was identified.

AP-03	**Practices of Energy Consumption are considered during the software development.**	**Exists? ORG E** ☹ 😐 ☺	**Propositions**
AP-03.Q-01	In the project planning phase is it possible to identify the use of practices related to the choice of hardware or devices, metrics and monitoring that can be added to software development to consume less energy? (CORDERO et al., 2015) , (SCHIEN et al, 2013), (KALAITZOGLOU; BRUNTINK;	☺	P2, P3

	VISSER, 2014), (KIM; LEE; LEE, 2012) , (WEISS; REPETTO; KOZIOLEK, 2012)	
AP-03.Q-02	In the phase of software requirements practices related to collection, measurement and configuration of power consumption are found? (SCHIEN et al, 2013),(KALAITZOGLOU; BRUNTINK; VISSER, 2014), (KAMBADUR; KIM, 2014), (HINDLE, 2012) , (MANOTAS et al, 2013)	☹
AP-03.Q-03	In the design phase of the software you can find practices related to architecture, tools, frameworks, virtualization, standards and coding that reduce or monitor the software's power consumption. (CORDERO et al., 2015) ,(PENZENSTADLER; FEMMER, 2013) , (SCHIEN et al, 2013), (AGOSTA et al, 2012) , (SAHIN et al, 2012) , (MANOTAS et al, 2013), (CAPRA; FRANCALANCI; SLAUGHTER, 2012) , (NOUREDDINE; ROUVOY; SEINTURIER, 2015), (SIEBRA et al, 2012)	☹
AP-03.Q-04	In the construction phase is it possible to find practices related to programming without the use of frameworks, real-time code energy consumption monitoring and automation of memory allocation and CPU when the software is running? (CORDERO et al., 2015) ,(SCHIEN et al, 2013),(NOUREDDINE et. al., 2012),(ZHONG; LIU, 2010) , (KAMBADUR; KIM, 2014) ,(AGOSTA et al, 2012) ,(KIM; LEE; LEE, 2012) ,(KOCAK; ALPTEKIN; BENER, 2014) , (SIEBRA et al, 2012)	☺
AP-03.Q-05	In the test phase it is possible to find practices related to test case definition, test framework, energy efficiency techniques, quality attributes and code performance that test the power consumption of the software. (CORDERO et al., 2015) , (SCHIEN et al, 2013), (KALAITZOGLOU; BRUNTINK; VISSER, 2014),(NOUREDDINE et. al., 2012),(KAMBADUR; KIM, 2014),(KIM; LEE; LEE, 2012) , (KOCAK; ALPTEKIN; BENER, 2014) ,(MANOTAS et al, 2013),(SIEBRA et al, 2012)	☺
AP-03.Q-06	In the maintenance phase it is possible to find practices related to configuration, monitoring and automatic optimization of the server according to the power consumption of the software. (SCHIEN et al, 2013), (KALAITZOGLOU; BRUNTINK; VISSER, 2014), (SIEBRA et al, 2012), (MONTEIRO; AZEVEDO; SZTAJNBERG, 2013)	☺

Table 90 - Organization E - Results of AP-03.

Regarding AP-04 considering sustainability guidelines during software requirements phase we had no positive results for this analysis points. This happened because the organization do not have any guideline covering sustainability aspects to develop a software. The questions and results are present in Table 91.

AP-04	**Guidelines about sustainability requirements**	**Exists? ORG E** ☹ 😐 ☺	**Propositions**
AP-04.Q-01	During the survey of software requirements do you see the use of guides describing Sustainable Software Engineering practices? (WEISS; REPETTO; KOZIOLEK, 2012)	☹	**P1, P2**
AP-04.Q-02	Is a benchmark model used to describe sustainability practices that should be considered when surveying software requirements? (PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☹	
AP-04.Q-03	Is there a guide that helps to identify the limitations of sustainability during software development? (PENZENSTADLER, 2014)	☹	
AP-04.Q-04	Is there a guide to identify sustainability goals during software development? (PENZENSTADLER, 2014)	☹	
AP-04.Q-05	Is there a guide to identifying sustainability interactions during software development? (PENZENSTADLER, 2014)	☹	

Table 91 - Organization E - Results of AP-04.

With respect to AP-05 about the practices found in SLR related to Organizational Levels described in Table 92, it was possible to identified systematized practices of all organizational levels.

Classification	**Organizational levels**	**Practices**
Systematized	Operational	[PEC] Adjust automatically servers CPU voltage.
Systematized	Operational	[PEEE] Use of quality attributes as Energy Efficiency regarding time to response, amount of resources and software performance.
Systematized	Operational	[PSUD] Implement non-functional requirements.
Systematized	Tactic	[PSUD] Derive sustainable system vision.
Systematized	Strategic	[PSUD] Identify initiatives of sustainability in the company level.

Table 92 - Organization E - AP-05 Organizational Levels.

As presented in Table 93 all analysis points were confirmed. Therefore the AP-05 is confirmed in Organization E.

AP-05	**Sustainable Software Engineering practices are identified at some levels of organization planning within the IT area.**	**Exists? ORG E** ☹ 😐 ☺	**Propositions**

AP-05.Q-01	It is noticed that in the Strategic level the practices of Sustainable Software Engineering are defined, there is documented evidence of these practices? (PENZENSTADLER; FEMMER, 2013) ,(SCHIEN et al, 2013),(ZHONG; LIU, 2010) ,(PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☺	P1
AP-05.Q-02	At the Tactical level, practices defined in the literature are found in the organization? (PENZENSTADLER; FEMMER, 2013) ,(SCHIEN et al, 2013),(ZHONG; LIU, 2010) ,(PENZENSTADLER, 2014) ,(CAPRA; FRANCALANCI; SLAUGHTER, 2012) ,(ALBERTAO et al., 2010) ,(PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☺	
AP-05.Q-03	At the Operational level, practices defined in the literature are found in the organization? (CORDERO et al., 2015) ,(PENZENSTADLER; FEMMER, 2013) ,(SCHIEN et al, 2013),(ZHONG; LIU, 2010) ,(PENZENSTADLER, 2014) ,(ALBERTAO et al., 2010) ,(WEISS; REPETTO; KOZIOLEK, 2012),(PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☺	

Table 93 - Organization E - Results of AP-05.

The strategic alignment statement can be confirmed in Table 94, by the existent practice of **[PSUD] Implement non-functional requirements** answering the AP-06.Q-01.

Regarding the AP-06.Q-03 is possible to identify a new practice **Sustainability is a mean of marketing**, this practice was extracted because the interviewee informed that when launching a new product the Organization E consequently noticed an opportunity of informing the customers about the product impact on environment. They said the Organization E saw that as a form of marketing.

AP-06	**Strategic alignment of the organization regarding the adoption of sustainability practices.**	**Exists? E** ☹😐☺	**Propositions**
AP-06.Q-01	Is it perceived that sustainability is part of the organization's strategy? (PENZENSTADLER; FEMMER, 2013) ,(ZHONG; LIU, 2010)	☺	**P1**
AP-06.Q-02	It is understood that senior management of the organization supports and encourages the tactical and operational levels to use Sustainable Software Engineering practices? (ZHONG; LIU, 2010) ,(PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☹	
AP-06.Q-03	Is it possible to identify the meaning of sustainability for the organization? (PENZENSTADLER; FEMMER, 2013) ,(ZHONG; LIU, 2010)	☺	

Table 94 - Organization E - Results of AP-06.

The AP-07 in Table 95 is about hiring suppliers, contractors, vendors that also has sustainability in their strategy. In this case, the Organization E maintain all services in Amazon cloud. Amazon is one of the biggest company of Information Technology services to apply Green IT practices in the infrastructure installations and hardware

process. Even though it was not confirmed by any interviewee if this topic was discussed when the Organization E decided to contract Amazon.

AP-07	A preference is given to hiring IT vendors who apply sustainability to their business.	Exists? ORG E ☹ 😐 ☺	Propositions
AP-07.Q-01	The organization prides itself for hiring suppliers who have sustainability seals, energy efficiency and clean energy. (ZHONG; LIU, 2010) , (KIM; LEE; LEE, 2012)	☺	P1
AP-07.Q-02	Is it possible to identify that the organization uses software developed with Sustainable Software Engineering practices? (NOUREDDINE et. al., 2012)	☹	

Table 95 - Organization E - Results of AP-07.

Table 96 presents the analysis points for AP-08, which is related to concern to inform customer about sustainability aspects adopted. In this case the AP-08.Q-04 is answered by **Sustainability is a mean of marketing** and **Communication to external client about digital services**.

AP-08	Concern to inform the customer that sustainability practices were adopted during the software development.	Exists? E ☹ 😐 ☺	Propositions
AP-08.Q-01	Is it possible to identify that from the beginning of software development the customer is informed that the software is being developed with Sustainable Software Engineering practices? (PENZENSTADLER; FEMMER; RICHARDSON, 2013), (ALBERTAO et al., 2010)	☹	P1, P2, P3
AP-08.Q-02	Is it important for the organization to verify that the developed software is consuming a lot of power when the customer uses it? (CORDERO et al., 2015) ,(SCHIEN et al, 2013)	☹	
AP-08.Q-03	Does the organization inform the customer of mechanisms that have been developed to avoid excessive consumption of energy by the software? (CORDERO et al., 2015) , (SCHIEN et al, 2013), (KIM; LEE; LEE, 2012) , (MANOTAS et al, 2013), (ALBERTAO et al., 2010)	☹	
AP-08.Q-04	What are the customer-driven awareness actions that the organization establishes? (SCHIEN et al., 2013)	☺	

Table 96 - Organization E - Results of AP-08.

Regarding Table 97, AP-09 summarized all the practices found with respect to software life cycle. In the AP-09.Q-02, we can found these existent practices regarding software requirements **[PSUD] Implement non-functional requirements** and **Develop an application that includes sustainability requirements** that is part of the existent practices from the literature **[PSUD] Derive sustainable system vision**. About these last practices the interviewee commented:

> "[..] we have just implemented a new product thinking about sustainability. The client had to print the "boleto bancario"

> to pay the bill and after that the paper was throw in the trash [..] the solution was giving the possibility to the user scan the bar code in ATM when paying the bill [..] (P88)"

From this statement we also emerged this new practice **Consider digital sustainability requirements for application.**

Regarding the AP-09.Q-03, software design, we have this new practice **Design a scalable application**. From the perspective of the interviewee the implementation of the software need to consider scalable situation, therefore this practice is non-systematized.

The last one with findings is AP-09.Q-04 which has a new practice non-systematized **Build a software that is responsive and fit in any screen size categorized** as **Practices of End User Energy Consumption**. The responsive development of software has been turning into a mandatory requirement recently due to the constant use of smartphones and advances of different screen sizes. In any of the literature selected the use of responsive development was mentioned and this is a Sustainable Software Engineering practices applied in many companies. Besides the user benefits of responsive, there is financial return when developing one solutions for any size screens, since you do not need to invest on two or more software projects.

AP-09	**It is possible to identify Sustainable Software Engineering practices at each phase of the software life cycle.**	**Exists? ORG E** ☹😐☺	**Propositions**
AP-09.Q-01	Within the project planning phase is it possible to find at least one of the practices: energy consumption (PEC), energy efficiency evaluation (PEEE), energy efficiency (PEF), business processes (PBP), life cycle assessment (PLCA) and sustainability (PSUD). (CORDERO et al., 2015) ,(PENZENSTADLER; FEMMER, 2013) ,(SCHIEN et al, 2013),(KALAITZOGLOU; BRUNTINK; VISSER, 2014),(ZHONG; LIU, 2010) ,(KIM; LEE; LEE, 2012) ,(PENZENSTADLER, 2014) ,(ALBERTAO et al., 2010) ,(WEISS; REPETTO; KOZIOLEK, 2012),(PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☹	**P1, P2, P3**
AP-09.Q-02	Within the software requirements phase it is possible to find at least one of the practices: energy consumption (PEC), energy efficiency evaluation (PEEE) and sustainability (PSUD). (PENZENSTADLER; FEMMER, 2013) ,(SCHIEN et al, 2013),(KALAITZOGLOU; BRUNTINK; VISSER, 2014),(ZHONG; LIU, 2010) ,(KAMBADUR; KIM, 2014),(AGOSTA et al, 2012) ,(HINDLE, 2012) ,(PENZENSTADLER, 2014) ,(MANOTAS et al, 2013),(PENZENSTADLER; FEMMER; RICHARDSON, 2013)	☺	
AP-09.Q-03	Within the software design phase it is possible to find at least one of the practices: energy consumption (PEC), energy efficiency evaluation (PEEE), energy efficiency (PEF) and sustainability (PSUD). (CORDERO et al., 2015) ,(PENZENSTADLER; FEMMER, 2013) ,(SCHIEN et al, 2013),(NOUREDDINE et. al., 2012),(ZHONG; LIU, 2010) ,(AGOSTA et al, 2012) ,(PENZENSTADLER, 2014) ,(SAHIN et	😐	

	al, 2012) ,(MANOTAS et al, 2013),(CAPRA; FRANCALANCI; SLAUGHTER, 2012) ,(NOUREDDINE; ROUVOY; SEINTURIER, 2015),(SIEBRA et al, 2012),(MONTEIRO; AZEVEDO; SZTAJNBERG, 2013)		
AP-09.Q-04	Within the software construction it is possible to find at least one of the practices: energy consumption (PEC), energy efficiency evaluation (PEEE), energy efficiency (PEF), end user energy consumption (PEUC) and sustainability (PSUD). (CORDERO et al., 2015) ,(PENZENSTADLER; FEMMER, 2013) ,(SCHIEN et al, 2013),(NOUREDDINE et. al., 2012),(ZHONG; LIU, 2010) ,(KAMBADUR; KIM, 2014),(AGOSTA et al, 2012) ,(KIM; LEE; LEE, 2012) ,(KOCAK; ALPTEKIN; BENER, 2014) ,(SIEBRA et al, 2012)	😐	
AP-09.Q-05	Within the software testing phase it is possible to find at least one of the practices: energy consumption (PEC), energy efficiency evaluation (PEEE), energy efficiency (PEF), end user energy consumption (PEUC) and sustainability (PSUD). (CORDERO et al., 2015) , (PENZENSTADLER; FEMMER, 2013) , (SCHIEN et al, 2013), (KALAITZOGLOU; BRUNTINK; VISSER, 2014), (KAMBADUR; KIM, 2014), (KIM; LEE; LEE, 2012) , (KOCAK; ALPTEKIN; BENER, 2014) , (MANOTAS et al, 2013), (ALBERTAO et al., 2010) , (SIEBRA et al, 2012)	☺	
AP-09.Q-06	Within the software maintenance phase it is possible to find at least one of the practices: energy consumption (PEC), energy efficiency evaluation (PEEE) and sustainability (PSUD). (SCHIEN et al, 2013),(KALAITZOGLOU; BRUNTINK; VISSER, 2014),(PENZENSTADLER, 2014) ,(SIEBRA et al, 2012),(MONTEIRO; AZEVEDO; SZTAJNBERG, 2013)	☹	

Table 97 - Organization E - Results of AP-09.

About AP-10 it was not possible to find any practice related to this analysis point as it presents in Table 98. This is actually the most difficult question to answer since it requires a really good reason and high efforts to develop a software to adjust itself.

AP-10	**When abnormally energy consumption is detected, the software developed adjust itself to reduce its energy consumption**	**Exists? ORG E** ☹😐☺	**Propositions**
AP-10.Q-01	Is any source code implementation used to reduce power consumption, such as memory allocation and CPU usage? (AGOSTA et al, 2012), (KIM; LEE; LEE, 2012), (KOCAK; ALPTEKIN; BENER, 2014), (SIEBRA et al, 2012)	☹	P3
AP-10.Q-02	Is there any configuration on the server that allows you to change the performance of the software to use less power? (ZHONG; LIU, 2010), (MANOTAS et al, 2013), (MONTEIRO; AZEVEDO; SZTAJNBERG, 2013)	☹	

Table 98 - Organization E - Results of AP-10.

Regarding AP-11 there were not answers for these question and somehow it is related to AP-10 presented in Table 99. There is no evidence that this organization measure energy efficiency.

AP-11	**It is possible to measure the energy efficiency of the developed software.**	**Exists? ORG E** ☹😐☺	**Propositions**

AP-11.Q-01	Is there any use of energy consumption measures? (CORDERO et al., 2015) ,(AGOSTA et al, 2012) ,(SAHIN et al, 2012)	☹	P3
AP-11.Q-02	Is there any use of energy efficiency measures or software performance that does not have an impact on energy consumption? (SCHIEN et al, 2013),(KALAITZOGLOU; BRUNTINK; VISSER, 2014), (NOUREDDINE et. al., 2012),(KAMBADUR; KIM, 2014),(NOUREDDINE; ROUVOY; SEINTURIER, 2015),(SIEBRA et al, 2012), (MONTEIRO; AZEVEDO; SZTAJNBERG, 2013)	☹	
AP-11.Q-03	During the software development is the measurement of energy consumption? (SCHIEN et al, 2013),(SIEBRA et al, 2012), (CAPRA; FRANCALANCI; SLAUGHTER, 2012)	☹	
AP-11.Q-04	What metrics are used to measure the software's energy efficiency? (SCHIEN et al, 2013), (NOUREDDINE et. al., 2012), (AGOSTA et al, 2012) , (KIM; LEE; LEE, 2012) , (HINDLE, 2012) , (SAHIN et al, 2012) , (MANOTAS et al, 2013)	☹	
AP-11.Q-05	Is there any other indicator linked to sustainability that is applied in the developed software? (PENZENSTADLER; FEMMER, 2013) , (SCHIEN et al, 2013),(KALAITZOGLOU; BRUNTINK; VISSER, 2014), (NOUREDDINE; ROUVOY; SEINTURIER, 2015)	☹	

Table 99 - Organization E - Results of AP-11.

To evaluate software quality attributes the Organization E applies the practices of **Apply performance test prior to production deploy** and **Apply performance test prior to production deploy** that are part of existent practice **[PEEE] Use of quality attributes as Energy Efficiency regarding time to response, amount of resources and software performance** (KOCAK; ALPTEKIN; BENER, 2014) answering the AP-12.Q-01 and AP-12.Q-02 described in Table 100.

AP-12	**The criteria for evaluating software quality includes sustainability practices.**	**Exists? E** ☹😐☺	**Propositions**
AP-12.Q-01	Is it possible to confirm that software sustainability practices are related to software quality attributes? (KOCAK; ALPTEKIN; BENER, 2014) , (PENZENSTADLER, 2014)	☺	**P1, P2**
AP-12.Q-02	What are the quality attributes adopted by the organization? (ALBERTAO et al., 2010)	☺	

Table 100 - Organization E - Results of AP-12.

Regarding AP-13 presented in Table 101 is possible to confirm that the customer is in the center of Organization E solutions, and is informed about the sustainable approaches made to build that software, not technically but generally. The evidence of AP-13.Q-01 answered is the new practice **Sustainability is a mean of marketing.**

AP-13	**Concern about the organization's reputation for adopting sustainability practices**	**Exists? ORG E** ☹😐☺	**Propositions**

AP-13.Q-01	Is it possible to find evidence on the dissemination of sustainability data to the customer? (PENZENSTADLER; FEMMER, 2013) , (ZHONG; LIU, 2010) , (PENZENSTADLER, 2014)	☺	P1
AP-13.Q-02	Has the organization received recognition for developing sustainable software? (PENZENSTADLER; FEMMER, 2013) , (PENZENSTADLER, 2014)	☹	

Table 101 - Organization E - Results of AP-13.

5.5.2 Organization E – Propositions results

This section presents the propositions results and final results of each analysis point in following tables:

P1 - Systematized sustainability organizational policies in software development

Table 102 shows the results for P1 in Organization E. It is possible to confirm the presence of practices related to Sustainability applied in the Organization on systematized way in AP-05, AP-06, AP-07, AP-09, AP-12 and AP-13.

Some observations around the practices found in this Organization are about the way sustainability is conduced. They have knowledge of sustainability and the employees practice a good behavior about this without the organization determine. It something we called naturally.

A very strong practice related to Sustainability as mean of marketing emerged by the insight of an employee to send this information to customer about the new functionality of scanner the screen rather than print a paper. They said this was initially thinking as concern of user experience, but then consequently they notice the sustainability aspect was also presented.

Therefore it is possible to conclude that P1 is confirmed in the Organization E.

P1 - Organizational policies driven to sustainability are systematically applied in software development in the financial sector.		
AP-01	Initiatives that promote awareness about organizational social responsibility within the IT sector	☹
AP-04	Guidelines about sustainability requirements	☹
AP-05	Sustainable Software Engineering practices are identified at some levels of organization planning within the IT area.	☺
AP-06	Strategic alignment of the organization regarding the adoption of sustainability practices.	☺
AP-07	A preference is given to hiring IT vendors who apply sustainability to their business.	☺
AP-08	Concern to inform the customer that sustainability practices were adopted during the software development.	☹

AP-09	It is possible to identify Sustainable Software Engineering practices at each phase of the software life cycle.	☺
AP-12	The criteria for evaluating software quality includes sustainability practices.	☺
AP-13	Concern about the organization's reputation for adopting sustainability practices	☺

Table 102 - Organization E - Proposition 1 results

P2 - Non-systematized Sustainable Software Engineering practices

Regarding P2, presented in Table 103 it is possible to observe only systemized practices related to software development. This is good from the perspective of P1, however for P2 it means it did not reach the assumption of non-systematized practices been adopted. Therefore we concluded that P2 was not confirmed.

P2 - Sustainable Software Engineering practices are applied in a non-systematic way during software development...		
AP-01	Initiatives that promote awareness about organizational social responsibility within the IT sector	☹
AP-02	Practices of Sustainability Dimensions are considered during the software development.	☺
AP-03	Practices of Energy Consumption are considered during the software development.	☺
AP-04	Guidelines about sustainability requirements	☹
AP-08	Concern to inform the customer that sustainability practices were adopted during the software development.	☹
AP-09	It is possible to identify Sustainable Software Engineering practices at each phase of the software life cycle.	☺
AP-12	The criteria for evaluating software quality includes sustainability practices.	☺
AP-13	Concern about the organization's reputation for adopting sustainability practices	☺

Table 103 - Organization E - Proposition 2 results

P3 – Use of tools that automatically measure or change the energy consumption.

This propositions seems to be confirmed in Organization E, but it partially confirmed, since did not meet the primordial analysis points AP-10 an AP-11 as described in Table 104.

P3 - Tools that automatically measure or change the energy consumption of developed software are used		
AP-02	Practices of Sustainability Dimensions are considered during the software development.	☺
AP-03	Practices of Energy Consumption are considered during the software development.	☺
AP-08	Concern to inform the customer that sustainability practices were adopted during the software development.	☹

AP-09	It is possible to identify Sustainable Software Engineering practices at each phase of the software life cycle.	☺
AP-10	When abnormally energy consumption is detected, the software developed adjust itself to reduce its energy consumption	☹
AP-11	It is possible to measure the energy efficiency of the developed software.	☹

Table 104 - Organization E - Proposition 3 results

5.6 Considerations about the chapter

This chapter presented in details the unit of analysis characterization, the analysis points individual results, the network of practices and the propositions results for each organization following the research approach proposed in Chapter 3. Additionally it described the Organizations practices found in a systematized or non-systematized way, as well as new practices not found in SLR and existent practices found in SLR. In this case, it was possible to report the results and how the practices from SLR were found in the Organizations.

CHAPTER 6 - DISCUSSIONS

"I am a strong woman because of other strong women,"
former First Lady Michelle Obama

This Chapter presents the discussions about the cross case analysis of all the organizations studied. It starts presenting first analysis point's results and then the propositions analysis. We finish this Chapter with the description of research validation and reliability.

6.1 Propositions Analysis of Financial Sector

Firstly we start presenting the Analysis Points aggregation of Organizations as shown in Table 105 used as a basis to discuss about the propositions results in a cross case analysis manner.

	Analysis Points	Propositions	A	B	C	D	E
AP-01	Initiatives that promote awareness about organizational social responsibility within the IT sector	P1, P2	☺	☺	☺	☹	☹
AP-02	Practices of Sustainability Dimensions are considered during the software development.	P2, P3	😐	☺	☺	☹	☺
AP-03	Practices of Energy Consumption are considered during the software development.	P2, P3	😐	😑	☺	☺	☺
AP-04	Guidelines about sustainability requirements	P1, P2	☹	☹	☹	☹	☹
AP-05	Sustainable Software Engineering practices are identified at some levels of organization planning within the IT area.	P1	☺	☺	☺	☺	☺
AP-06	Strategic alignment of the organization regarding the adoption of sustainability practices.	P1	☹	☺	☺	☹	☺
AP-07	A preference is given to hiring IT vendors who apply sustainability to their business.	P1	☹	☺	☺	☹	☺
AP-08	Concern to inform the customer that sustainability practices were adopted during the software development.	P1, P2, P3	😑	😑	☺	☹	☹
AP-09	It is possible to identify Sustainable Software Engineering practices at each phase of the software life cycle.	P1, P2, P3	😑	😑	☺	☺	☺
AP-10	When abnormally energy consumption is detected, the software developed adjust itself to reduce its energy consumption	P3	☹	☹	☹	☹	☹

AP-11	It is possible to measure the energy efficiency of the developed software.	P3	☹	☹	☺	☹	☹
AP-12	The criteria for evaluating software quality includes sustainability practices.	P1, P2	☹	☹	☺	☺	☺
AP-13	Concern about the organization's reputation for adopting sustainability practices	P1	☺	☹	☺	☹	☺

Table 105 - Analysis Points aggregation by Organization

P1 - Systematized sustainability organizational policies in software development

Table 106 presents the Proposition P1 and all the concepts to support the application of systematized organizational policies driven to sustainability in software development. In this table besides the concepts, we have the analysis points of this propositions and each Organization result from the case study.

P1 - Organizational policies driven to sustainability are systematically applied in software development in the financial sector.

- Sustainability aspects are informed in IT area and has a focal point dedicated to this activity. (PENZENSTADLER; FEMMER, 2013), (PENZENSTADLER; FEMMER; RICHARDSON, 2013), (PENZENSTADLER, 2014)
- The organization use a reference model for achieving sustainability activities, dimensions, values, indicators and regulations and also measure the sustainability goals. (PENZENSTADLER; FEMMER, 2013), (ALBERTAO et al., 2010)
- Sustainability is part of organization strategy. (ZHONG; LIU, 2010)
- Use of guides to describe Sustainable Software Engineering practices during the software requirements helping to identify the limitations, goals and interactions of sustainability during software development. (WEISS; REPETTO; KOZIOLEK, 2012), (PENZENSTADLER; FEMMER; RICHARDSON, 2013), (PENZENSTADLER, 2014)
- Sustainable Software Engineering practices are identified at Strategic, Tactical and Operational levels of organization planning within the IT area. (PENZENSTADLER; FEMMER, 2013), (SCHIEN et al, 2013), (ZHONG; LIU, 2010), (PENZENSTADLER; FEMMER; RICHARDSON, 2013), (PENZENSTADLER, 2014), (CAPRA; FRANCALANCI; SLAUGHTER, 2012), (ALBERTAO et al., 2010), (CORDERO et al., 2015), (WEISS; REPETTO; KOZIOLEK, 2012)
- The organization prides itself for hiring suppliers who have sustainability seals, energy efficiency and clean energy. (ZHONG; LIU, 2010), (KIM; LEE; LEE, 2012), (NOUREDDINE et. al., 2012)
- The organization establishes customer-driven awareness actions regarding sustainability. (PENZENSTADLER; FEMMER; RICHARDSON, 2013), (ALBERTAO et al., 2010), (CORDERO et al., 2015), (SCHIEN et al, 2013), (KIM; LEE; LEE, 2012), (MANOTAS et al, 2013)
- Practices related to energy consumption (PEC), energy efficiency evaluation (PEEE), sustainability (PSUD), business processes (PBP), life cycle assessment (PLCA), end user energy consumption (PEUC), are applied in one or more software life cycle stages such as project planning, software requirements, software design, software construction, software testing, and software maintenance. (CORDERO et al., 2015), (PENZENSTADLER; FEMMER, 2013), (SCHIEN et al, 2013), (KALAITZOGLOU; BRUNTINK; VISSER, 2014), (ZHONG; LIU, 2010), (KIM; LEE; LEE, 2012), (PENZENSTADLER, 2014), (ALBERTAO et al., 2010), (WEISS; REPETTO; KOZIOLEK, 2012), (PENZENSTADLER; FEMMER; RICHARDSON, 2013), (KAMBADUR; KIM, 2014), (AGOSTA et al, 2012), (HINDLE, 2012), (MANOTAS et al, 2013), (NOUREDDINE et. al., 2012), (SAHIN et al, 2012), (CAPRA; FRANCALANCI; SLAUGHTER, 2012), (NOUREDDINE; ROUVOY; SEINTURIER, 2015), (SIEBRA et al, 2012), (MONTEIRO; AZEVEDO; SZTAJNBERG, 2013), (KOCAK; ALPTEKIN; BENER, 2014)
- The criteria for evaluating software quality includes sustainability practices. (KOCAK; ALPTEKIN; BENER, 2014), (PENZENSTADLER, 2014), (ALBERTAO et al., 2010)
- There is an evidence on the dissemination of sustainability data to the customer and the organization received recognition for developing sustainable software? (PENZENSTADLER; FEMMER, 2013), (ZHONG; LIU, 2010), (PENZENSTADLER, 2014)

AP	Description of Analysis Point	A	B	C	D	E

AP-01	Initiatives that promote awareness about organizational social responsibility within the IT sector	☺	☺	☺	☹	☹
AP-04	Guidelines about sustainability requirements	☹	☹	☹	☹	☹
AP-05	Sustainable Software Engineering practices are identified at some levels of organization planning within the IT area.	☺	☺	☺	☺	☺
AP-06	Strategic alignment of the organization regarding the adoption of sustainability practices.	☹	☺	☺	☹	☺
AP-07	A preference is given to hiring IT vendors who apply sustainability to their business.	☹	☺	☺	☹	☺
AP-08	Concern to inform the customer that sustainability practices were adopted during the software development.	😐	😐	☺	☹	☹
AP-09	It is possible to identify Sustainable Software Engineering practices at each phase of the software life cycle.	😐	😐	☺	☺	☺
AP-12	The criteria for evaluating software quality includes sustainability practices.	☹	☹	☺	☺	☺
AP-13	Concern about the organization's reputation for adopting sustainability practices	☺	☹	☺	☹	☺

Table 106 - Proposition P1 Syntheses

The first concept to support this proposition is about the sustainability aspects informed in IT area and whether the IT have a focal point dedicated to this activity extracted from the papers of (PENZENSTADLER; FEMMER, 2013), (PENZENSTADLER; FEMMER; RICHARDSON, 2013), (PENZENSTADLER, 2014). This concepts is the basis for AP-01 and it is possible to identify these aspects in three organizations out five studied:

- Organization A: initiatives to raise awareness of the employees about water wasting and use less paper in the organization. The initiatives like sustainability as means of marketing like inform the customer that no internet will be spent when using the mobile banking was the principal fact to Organization A have confirmed the P1.
- Organization B: also has initiatives of raising awareness of sustainability practices in the Organization, however the most important practices was about to develop a software in economic way by using hybrid frameworks for mobile developing.
- Organization C: has reached almost all AP questions in this case. Besides raise awareness practices, the organization C has indicators, goals and metrics about sustainability. They also operates a Green Data Center what contributes for the presence of systematized practices.

In these cases, all of them has two practices in common **[PSUD] Raise awareness of individuals about environment protection** an existent practices from

the literature and **[PBP] Sustainability is a mean of marketing a new practice** categorize as Practices of Business Process.

Two Organizations (D and E), in the case study, we did not identify many practices that would confirm the proposition.

The second aspects related to use of guides to describe Sustainable Software Engineering practices during the software requirements helping to identify the limitations, goals and interactions of sustainability during software development. (WEISS; REPETTO; KOZIOLEK, 2012), (PENZENSTADLER; FEMMER; RICHARDSON, 2013), (PENZENSTADLER, 2014) are not presented in any Organization.

This is because most of the Organization has systematized practices not aggregated or well defined in a container what as a guideline or policy. They have separated practices spreading around. From our perspective this is expected since Sustainable Software Engineering is an unknown and an innovative topic.

We have concluded from the SLR results presented in Chapter 4, that to support Sustainable Software Engineering all the organizational planning levels of the Organizations need to consider and apply accordingly to the authors (PENZENSTADLER; FEMMER, 2013), (SCHIEN et al, 2013), (ZHONG; LIU, 2010), (PENZENSTADLER; FEMMER; RICHARDSON, 2013), (PENZENSTADLER, 2014), (CAPRA; FRANCALANCI; SLAUGHTER, 2012), (ALBERTAO et al., 2010), (CORDERO et al., 2015), (WEISS; REPETTO; KOZIOLEK, 2012). In all Organization was possible to find on AP-05 at least one practice at one organizational level as classified the same way of the SLR practices.

Also, related to AP-05 concepts, the AP-06 was elaborated specifically for the Strategic level because at this level is who will sponsor all the sustainability programs and align with investors and all others hierarchies in the Organization the goal of sustainability. Therefore this AP was found in Organization B, C and E. An important fact about organization B is the reformulation of software architecture are to formalize the use do hybrid solutions. The Organization C developed a mobile banking that do not requires high performance smartphone, allowing people with less resource to use the mobile banking. This strategy has two gains, sustainability related to social aspects and environment once physical agencies will be less required and soon demised. About the Organization E, the main contribution is about Sustainability as means of

marketing that made people to avoid print documents, even though there are not statistics confirmed the success or failure of this implementation.

Regarding the AP-07, about the organization prides itself for hiring suppliers who have sustainability seals, energy efficiency and clean energy. (ZHONG; LIU, 2010), (KIM; LEE; LEE, 2012), (NOUREDDINE et. al., 2012). This was presented in three organizations B, C and E. Basically all the organization contracted or constructed a Green Data Center. In special the Organization C, that has built a new data center with Green IT practices and has shown significant savings regarding this initiative.

Regarding AP-08, the organization establishes customer-driven awareness actions regarding sustainability. (PENZENSTADLER; FEMMER; RICHARDSON, 2013), (ALBERTAO et al., 2010), (CORDERO et al., 2015), (SCHIEN et al, 2013), (KIM; LEE; LEE, 2012), (MANOTAS et al, 2013). We have two organizations with non-systematized results, what the employees basically decides to execute practices. Only the Organization C has systematized practices related to this analysis points since they inform the customer about digital services consequently they reduce the costs on paper and distribution of credit card bill.

AP-09 was a summary of all the AP previously discussed by looking for software development, in this it was possible to find non-systematized results for Organization A and B, and systematized for Organization C, D and E.

Regarding the AP-12, it is possible to identify software quality in Organization C, D and E. This is because the performance of the application is crucial for their business, and all the practices related is about Practices of Evaluating Energy Efficiency. Even when metrics are found they do not measure the use of energy. They only know the CPU and memory, but what we concluded here is that the new practices or existent practices related to this topic enable the measurement of energy consumption as proposed by (KOCAK; ALPTEKIN; BENER, 2014).

About AP-13 we can confirm that Organization A, C and E consider the reputation when talking about sustainability what are related to Sustainability as means of marketing.

In summary, what we concluded about P1, is that some Organizations are more ahead of this time than others Organization C for example is one that really keeps the IT area informed about all the change. From interviews everyone know about the same topics. Another positive points of Organization C is the sustainability report which details the actions, CO2 emissions in its operations and more on. The Organization B

is second place of this P1 list and is mostly because the architecture of the company are working with sustainability practices.

P2 - Non-systematized Sustainable Software Engineering practices

All the concepts are described in Table 107 and the analysis points AP-01, AP-04, AP-08, AP-09 was discussed on P1 as it is the same by non-systematized.

P2 - Sustainable Software Engineering practices are applied in a non-systematic way during software development.

The concepts are mostly the same as P1 (AP-01, AP-04, AP-08, AP-09) not considering organizational levels concepts and suppliers hiring since this proposition is not related to organizational processes.

- Practices of Sustainability Dimensions are considered during the software life cycle related to:
  - Implement a model for sustainable software development where changes requests are not often, but the changes requested are accepted. (PENZENSTADLER; FEMMER, 2013) ,(ZHONG; LIU, 2010) ,(KIM; LEE; LEE, 2012);
  - Non-functional requirements related to sustainability. (PENZENSTADLER; FEMMER, 2013) ,(SCHIEN et al, 2013), (KALAITZOGLOU; BRUNTINK; VISSER, 2014), (KAMBADUR; KIM, 2014),(HINDLE, 2012) , (MANOTAS et al, 2013);
  - Any guide to developing the sustainability-oriented software architecture. (PENZENSTADLER, 2014);
  - Verified software contemplates Sustainable Software Engineering practices. (PENZENSTADLER; FEMMER, 2013) ,(ALBERTAO et al., 2010);
  - Apply sustainability guidance like specific demands for software installation and launching such as use of green data center (PENZENSTADLER, 2014);
  - A sustainability stakeholder is present on each stage of software developing (PENZENSTADLER; FEMMER, 2013) , (PENZENSTADLER, 2014) ,(PENZENSTADLER; FEMMER; RICHARDSON, 2013);
  - A green data center that also consider sustainability (ZHONG; LIU, 2010);
  - Modifiability, reusability, portability and supportability (ALBERTAO et al., 2010);
- Practices of Energy Consumption are considered during the software life cycle related to:
  - The choice of hardware or devices, metrics and monitoring that can be added to software development to consume less energy;
  - Data collection, measurement and configuration of power consumption;
  - Architecture, tools, frameworks, virtualization, standards and coding that reduce or monitor the software's power consumption, configuration, monitoring and automatic optimization of the server according to the power consumption of the software
  - Test case definition, test framework, energy efficiency techniques, quality attributes and code performance that test the power consumption of the software
  - Programming without the use of frameworks, real-time code energy consumption monitoring and automation of memory allocation and CPU when the software is running

AP	Description of Analysis Point	A	B	C	D	E
AP-01	Initiatives that promote awareness about organizational social responsibility within the IT sector	☺	☺	☺	☹	☹
AP-02	Practices of Sustainability Dimensions are considered during the software development.	😐	☺	☺	☹	☺
AP-03	Practices of Energy Consumption are considered during the software development.	😐	😑	☺	☺	☺
AP-04	Guidelines about sustainability requirements	☹	☹	☹	☹	☹
AP-08	Concern to inform the customer that sustainability practices were adopted during the software development.	😑	😑	☺	☹	☹
AP-09	It is possible to identify Sustainable Software Engineering practices at each phase of the software life cycle.	😑	😑	☺	☺	☺
AP-12	The criteria for evaluating software quality includes sustainability practices.	☹	☹	☺	☺	☺

Table 107 - Proposition P2 Syntheses

Regarding AP-02 the concepts related to Practices of Sustainability Dimensions considered during software development applied in non-systematized way was only identified on Organization A, which has many practices not defined by the organization. An example is the Technical solutions for use less battery and less 3G/4G that was raised by an employee.

In the organizations B, C and E there are systematized practices, which is not the goal of this P1.

Regarding the AP-03 about the Practices of Energy Consumption, the second category with more than 70 practices found from the literature, returned with one organization as non-systematized and another as neither systematized nor non-systematized

For this Proposition we concluded that we have a good number regarding the amount of companies that apply practices. It is really difficult for people start to use this practice because they are not used with the term.

P3 – Use of tools that automatically measure or change the energy consumption.

Table 108 explains the concept of P3 and the only AP that is not common to P-01 and P-02 is about AP-10 and AP-11. In this case only AP-11 had findings in organization C, this is because the new practice related to AP-11.Q-03 about **Application monitoring to identify lazy process**. The interviewee reported that all the application are monitored regarding the performance like CPU usage and memory performance, however when the application is too slow they report this to development who investigates the problem presented.

Regarding the indicator presented on AP-11.Q-05 used by Organization C is Use of **MIPS indicator to identify transaction slowness**, which is commonly used in mainframe servers provided by IBM. At the end, it is only possible to confirm the use and application of this proposition by one Organization.

P3 - Tools that automatically measure or change the energy consumption of developed software are used

The use of tools is also related to some of concepts described on P1 and P2 (AP-02, AP-03, AP-08, AP-09), the only ones not related to are:

- Software developed adjust itself to reduce its energy consumption
  - Source code implementation used to reduce power consumption, such as memory allocation and CPU usage. (AGOSTA et al, 2012), (KIM; LEE; LEE, 2012), (KOCAK; ALPTEKIN; BENER, 2014), (SIEBRA et al, 2012);
  - Configuration on the server that change the performance of the software to use less power. (ZHONG; LIU, 2010), (MANOTAS et al, 2013), (MONTEIRO; AZEVEDO; SZTAJNBERG, 2013)
- Measure the energy efficiency of the developed software.

- Use of energy consumption measures. (CORDERO et al., 2015), (AGOSTA et al, 2012), (SAHIN et al, 2012);
- Use of energy efficiency measures or software performance that does not have an impact on energy consumption. (SCHIEN et al, 2013), KALAITZOGLOU; BRUNTINK; VISSER, 2014), (NOUREDDINE et. al., 2012)
(KAMBADUR; KIM, 2014), (NOUREDDINE; ROUVOY; SEINTURIER, 2015), (SIEBRA et al, 2012), (MONTEIRO; AZEVEDO; SZTAJNBERG, 2013);
- Indicators linked to sustainability that is applied in the developed software. (CAPRA; FRANCALANCI; SLAUGHTER, 2012), (KIM; LEE; LEE, 2012), (HINDLE, 2012), (MANOTAS et al, 2013), (PENZENSTADLER; FEMMER, 2013)

AP	Description of Analysis Point	A	B	C	D	E
AP-02	Practices of Sustainability Dimensions are considered during the software development.	😐	☺	☺	☹	☺
AP-03	Practices of Energy Consumption are considered during the software development.	😐	😑	☺	☺	☺
AP-08	Concern to inform the customer that sustainability practices were adopted during the software development.	😑	😑	☺	☹	☹
AP-09	It is possible to identify Sustainable Software Engineering practices at each phase of the software life cycle.	😑	😑	☺	☺	☺
AP-10	When abnormally energy consumption is detected, the software developed adjust itself to reduce its energy consumption	☹	☹	☹	☹	☹
AP-11	It is possible to measure the energy efficiency of the developed software.	☹	☹	☺	☹	☹

Table 108 - Proposition P3 Syntheses

6.1.1 Reflection about the results

At this moment we reflect about the results returning to the general objective of this work is: "**Understand how Sustainable Software Engineering practices are applied in the area of Information Technology in financial sector**" and also return to the bases research question "**How the application of Sustainable Software Engineering practices occurs in financial sector?**"

Observing the results presented on each analysis points and propositions we discovered new practices and existent practices applied in the sector. During the interviews it was asked what the interviewee knew about sustainability and after about sustainable software engineer. To our surprise all interviewees replied what they know about sustainability in general and all answers were correct, however about sustainable software engineer nobody answered, as expected. As we were evolving about the questions, the employee was understating what was Sustainable Software Engineering and they could make associations and remember of facts from the Organization they represented.

Moreover, the financial sector apply some of Software Engineering practices proposed by this study in a systematic way but also in a non-systematic way, which relies on employee experience in Information Technology area to apply the practices.

The systematized practices are in summary related to organizational process and just a few of these practices could be applied during the software development. We concluded that this observation is normal due to lack of knowledge about Sustainable Software Engineering.

6.1.2 Research validation and reliability

The research validation and reliability allows the validation of quality concepts presented in this study as proposed by (YIN, 2009). To guarantee that this study can be replicated we followed this strategy:

- The interviews were done in person, inside the organization, or via online chat when the person was not available to talk during the business hours or was from other city. To select the participants it was necessary to check them background and how much they know about the company.
- Annual reports available in the organizations web sites helped to confirm some information provided from the interviewees.
- Selection of demographic data from regulators and federations of financial sector like Central Bank of Brazil and Brazilian Federation of Banks.
- The accuracy of this research was presented in Chapter 3 with the research protocol and all steps to conduct this research, what can be used to replicate in other study.
- The use of Grounded Theory to analyze the data from SLR and case study helped to confirm the findings of each method reducing the biases since the steps of data collection and data syntheses were strictly followed.

With these steps taken we tried to guarantee the quality of this study.

6.2 Considerations about the chapter

This Chapter discussed about the overall scenario of the Organizations studied. It also compiled the results in a cross case analysis. This reflection gave as a summary of all the propositions and analysis points, it also gave as the answer to the research question of this study. In this case, the Organizations apply some Sustainable Software Engineering practices in a systematized and non-systematized way. Some of these

practices were defined as new practices that were not found in SLR, and others as existent practices found in SLR.

CHAPTER 7 - CONCLUSIONS

"Satisfaction lies in the effort, not in the attainment. Full effort is full victory." Indira Gandhi

After presenting the results and discussions about this research, this Chapter describes the research relevance, contributions, constraints and future works for the academy and industry in general.

7.1 Research relevance

In the last 10 years, Sustainable Software Engineering topic has been getting attention, especially when trying to determine the benefits of building a sustainable software product with sustainable software development process. From the systematic literature review presented in this research, just a few studies were covering the practices applied in the industry. Therefore, it was possible to observe that studies related to this topic have lack of application in the real world scenario of software development.

In 2008, when the first publication about Green IT was done by (MURUGESAN, S., 2008), it was considered only hardware and infrastructure aspects with no mention to software. Precisely, the first publication about software engineering related to sustainability aspects and energy consumption was reported by (MEZA et al, 2009), (MAHAUX; HEYMANS; SAVAL, 2011) and (NAUMANN et al., 2011). However, only (MEZA et al, 2009) model was applied in the industry. Regarding (MAHAUX; HEYMANS; SAVAL, 2011) and (NAUMANN et al., 2011) the models proposed were not validated in academy and industry. In this direction, it was not possible to confirm whether these models and practices from these models, could be useful in Software Engineering. Even discussions about the definitions of Green In IT, Green By IT, Sustainability ICT, Sustainable Software Engineering, were arising and being discussed many researchers of the area as reported by (CALERO; PIATTINI, 2015) which gave us the theoretical basis to conduct this research.

Finally, the gap regarding the confirmation that Sustainable Software Engineering practices exists and can be applied during the software development was

the main motivation of this research. As reported in this study, it is possible to find Sustainable Software Engineering practices that contributes to software development in the academy and also in the industry. Regarding the financial sector it is possible to identify existent and new practices in this industry, even when the definition of Sustainable Software Engineering were not clear, the employees of the studied Organizations knew what sustainability means and understood during the interview what and how it is applied in software development.

7.2 Research contributions

The main contribution of this research is related to its general objective about how the Information Technology area of financial sector address Sustainable Software Engineering practice. To achieve this objective the first step was to discover the Sustainable Software Engineering practices proposed in the literature thought out a SLR research method. The second step was to identify these practices in case study performed in the Information Technology area of financial sector where more practices and category were discovered using the GT data analysis process.

The second contribution is the theoretical framework composed of 170 practices and 7 categories of practices. These practices were categorized into 13 SWEBOK knowledge areas, 7 Software Life Cycle categories and 3 Organizational Levels during the GT analysis.

Third contribution of this research was the mind map helping to:

- identify the connections between categories;
- server as a guidance of how to apply a practice;
- elaborate the analysis points and propositions linking them with theory and;
- support the application of these practices by academy and industry.

The fourth contribution is about the 28 new practices and 52 existent practices identified in financial sector during the software development, what confirmed some practices found in SLR and also described how the financial sector addresses the sustainability during the software development. For instance it was possible to identify known Software Engineering best practices like as code improvement that was described by interviewee as a sustainable practice. Other practices related to

Organizational process were confirmed and was the starting point for the Organizations apply Sustainable Software Engineering practices. From the case study, was possible to identify Organizations that has process and guidelines about sustainability aspects in all organizational levels in a systematized way confirmed as positive finding of proposition P1. Non-systematized practices were also discovered. The concerns about sustainability in IT is remarkable by the employees who has more experience in the area they work for. Many practices not found in the SLR and found in case study were related to the employee perceptions and experience. So far none of the studies selected in SLR reported a similar study with the methods, the organization studied and the results found in this research.

Finally, the fifth contribution is about the reinforcement of best practices application during the software development as stated in SWEBOK. Some of these best practices were naturally linked with sustainability by the interviewees. For instance: code review and clean code, software performance regarding time to respond and hardware usage; clear and well defined software requirements; software quality regarding the quality attributes; use of modularized architecture and concerns about user experience and end user software performance.

7.3 Constraints

Regarding the SLR results, the data collection happened from July 2015 until March 2016, it is possible that some practices are missing from the time we did not update the references. In 2017, a new round of the SLR research string was performed and returned 40 papers to be analyzed and still on going. Financial word was not included in the string to search the papers, however the case study was applied in financial sector. Even though it was not added, from all the papers returned there were not reporting practices in financial sector.

Although this is not a quantitative research but qualitative, the number of Organizations selected for study can be a limitation. However, since the goal of grounded theory is to emerge the most available data until no more new data appears, we believe that five Organizations gave us good results and contribution for this research.

Probably another limitation is about the selection of Organization D, which is an international organization with employees in Brazil. This can be a limitation because they do not need to follow PRSA norm from Banco Central do Brasil (BANCO

CENTRAL DO BRASIL, 2014). However, none of the interviewees from other Organizations confirmed to know or be informed about this policy.

7.4 Future works

One future work is the application of non-systematized practices reported by the employees in the Organizations turning it into systematized practices inside the guides and process of them. This can be supported by the mind map following all the "W's" explained in Chapter 4.

The second possible future work is to apply these sustainable practices, both from SLR and case study, in real software development by performing energy measurements, applying continuous processes improvement and quantify in terms of costs, benefits, CO2 emissions how effective is to adopt Sustainable Software Engineering as a process improvement of software life cycle.

The third future work, can be related to perform a study with practices found in financial sector in other companies, like software development companies or other business domain to identify whether or not there is different sustainable software engineering practices or it can be generic for any company.

Finally, the last but not limited to future work is to create a repository to add these practices, which can be accessible and maintained by the community in general. We see that this is an opportunity to show the academic researches and trying to use the results according to the real world needs.

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APPENDIX A – RESEARCH PROTOCOL – RESEARCH PRESENTATION

Curitiba, <dia> de <mês> de 2017.
<Nome da Empresa>
<Nome do Responsável

<Prezado>,

Venho, por meio desta, solicitar a sua autorização para a condução de um estudo de campo da dissertação de mestrado da estudante Ana Carolina Moises de Souza, que está sendo desenvolvida sob nossa orientação e co-orientação no Programa de Pós-Graduação em Informática da PUC-PR.

O objetivo principal da pesquisa é entender como as práticas de engenharia de software sustentável são abordadas pelos departamentos de Tecnologia de Informação no setor financeiro brasileiro.

A pesquisa será realizada por meio de entrevista presencial, que visa coletar as informações necessárias para extrair resultados claros e concisos sobre como as práticas de engenharia de software sustentável são aplicadas no setor financeiro.

Gostaria, ainda, de afirmar o nosso compromisso em relação à confidencialidade das informações prestadas. Todos os dados serão tratados de forma a preservar a privacidade, tanto dos entrevistados, quanto da organização. Nenhuma informação personalizada será publicada, a menos que autorizado formalmente pela organização. Um Termo de Confidencialidade será assinado pelos pesquisadores, com termos a critério da organização.

Agradecemos a colaboração e permanecemos integralmente à disposição.

Atenciosamente,
Orientadora: Prof. Dra. Andreia Malucelli
Co-orientadora: Prof. Dra. Sheila Reinehr,
Programa de Pós-Graduação em Informática
Pontifícia Universidade Católica do Paraná - PUCPR

Tornando a Tecnologia da Informação Sustentável

Evidências das causas de mudanças climáticas são encontradas no desgelo e aumento do nível do mar (COP 21, 2015)

Estima-se que a produção de lixo mundial aumentará 2,3 bilhões até 2025 (PNUMA, 2015)

80% da energia global é gerada por combustíveis fosseis que impactam na emissão de gases de efeito estufa (IEA, 2016)

58% das emissões de gases de efeito estudo no Brasil é devido ao desmatamento (INPE, 2011)

Sustentabilidade

"Atender as necessidades do presente sem comprometer as habilidades das gerações futuras em satisfazer suas próprias necessidades."
(Brundtland, 1987)

Econômico

Integração de aspectos sociais e ambientais na área de negócios

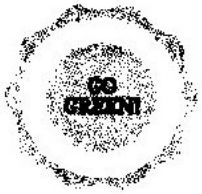
Ambiental

Rápida renovação após ações de degradação por parte dos humanos

Social

Ações que promovem qualdade social e consciência ética e moral

Como obter a Sustentabilidade



Descarte consciente de equipamentos eletrônico de acordo com ciclo de vida de uso de hadware.

Contratação e construção de data centers que implementam práticas de eficiência energética.

Adoção de Práticas de Engenharia de Software Sustentável durante o desenvolvimento de software.

Cumprimento da Resolução 4.327/14 sobre a Política de Responsabilidade Socioambiental (PRSA)

Este Infográfico é o resumo da dissertação de mestrado sobre:
Práticas de Engenharia de Software Sustentável no setor financeiro brasileiro.
Mestranda: Ana Carolina Moises de Souza
Programa de Pós-Graduação em Informática - PPGIa
Pontifícia Universidade Católica do Paraná - PUC-PR

ana.moises@ppgia.pucpr.br

APPENDIX B – RESEARCH PROTOCOL – NON-DISCLOSURE TERMS

Curitiba, <dia> de <mês> de 2017.
<Empresa>
<Responsável>

Prezado Senhor,
Este Termo de Confidencialidade visa estabelecer um acordo entre os pesquisadores ANA CAROLINA MOISES DE SOUZA, ANDREIA MALUCELLI E SHEILA REINEHR, doravante denominados Pesquisadores, e a Organização <EMPRESA>., doravante denominado Organização Participante, a respeito da confidencialidade das informações coletadas durante o processo de pesquisa da tese de doutorado do primeiro, sob orientação do segundo.
Por meio deste Termo de Confidencialidade, os Pesquisadores se comprometem a:

- Portar-se com discrição em todos os momentos da pesquisa acadêmica, não comentando ou divulgando qualquer tipo de informação que tenha sido repassada de forma oral ou escrita.
- Não divulgar o nome da Organização Participante, em qualquer meio, a menos que expressamente autorizado por esta.
- Não divulgar, em qualquer meio, os dados e informações individualizados coletados durante o processo de pesquisa na Organização Participante.
- Divulgar, em formato de tese, artigos e apresentações, apenas os dados agregados, dos quais não se possa retirar ou inferir a identificação da Organização Participante.
- Retornar para a Organização Participante, em formato agregado, todos os dados de todos os estudos de caso conduzidos.

As assinaturas abaixo expressam a concordância quanto ao cumprimento deste Termo de Confidencialidade, por prazo indeterminado.

Andreia Malucelli, Dra.
Programa de Pós-Graduação em Informática
Pontifícia Universidade Católica do Paraná

Sheila Reinehr, Dra.
Programa de Pós-Graduação em Informática
Pontifícia Universidade Católica do Paraná

Ana Carolina Moises de Souza
Programa de Pós-Graduação em Informática
Pontifícia Universidade Católica do Paraná

APPENDIX C – AUTHORS LIST SYSTEMATIC LITERATURE REVIEW

ID	Authors	ID	Authors
1	(AGOSTA et al, 2012)	14	(NOUREDDINE; ROUVOY; SEINTURIER, 2015)
2	(ALBERTAO et al., 2010)	15	(PENZENSTADLER, 2014)
3	(CAPRA; FRANCALANCI; SLAUGHTER, 2012)	16	(PENZENSTADLER; FEMMER, 2013)
4	(CORDERO et al., 2015)	17	(PENZENSTADLER; FEMMER; RICHARDSON, 2013)
5	(HINDLE, 2012)	18	(RODRIGUEZ; PENZENSTADLER, 2013)
6	(KALAITZOGLOU; BRUNTINK; VISSER, 2014)	19	(SAHIN et al, 2012)
7	(KAMBADUR; KIM, 2014)	20	(SCHIEN et al, 2013)
8	(KIM; LEE; LEE, 2012)	21	(SIEBRA et al, 2012)
9	(KOCAK; ALPTEKIN; BENER, 2014)	22	(WEISS; REPETTO; KOZIOLEK, 2012)
10	(MANOTAS et al, 2013)	23	(ZHONG; LIU, 2010)
11	(MEZA et al, 2009)		
12	(MONTEIRO; AZEVEDO; SZTAJNBERG, 2013)		
13	(NOUREDDINE ET. AL., 2012)		

APPENDIX D – PRACTICES LIST FROM SLR

Theoretical sample	Categories	References	Planning levels	ISO/IEC & SWEBOK
[PBP] Change the organizational culture to develop Green IT systems.	Practices of Business Process	(ZHONG; LIU, 2010)	Strategic	Organizational Project-Enabling Process
[PBP] Evaluate company's sustainability impacts using a model.	Practices of Business Process	(PENZENSTADLER; FEMMER, 2013)	Strategic	Organizational Project-Enabling Process
[PBP] Develop a Green IT systems with skillful employees.	Practices of Business Process	(ZHONG; LIU, 2010)	Tactic	Organizational Project-Enabling Process
[PBP] Develop a Green IT systems in collaboration (teamwork).	Practices of Business Process	(ZHONG; LIU, 2010)	Tactic	Organizational Project-Enabling Process
[PEC] Choose of consumption measurement analysis.	Practices of Energy Consumption	(CORDERO et al., 2015)	Tactic	Project Planning
[PEC] Use of a hardware to measure many types of energy measures	Practices of Energy Consumption	(CORDERO et al., 2015)	Tactic	Project Planning
[PBP] Support from senior managers.	Practices of Business Process	(ZHONG; LIU, 2010)	Strategic	Organizational Project-Enabling Process
[PEC] Identify consumption peak from the source code.	Practices of Energy Consumption	(CORDERO et al., 2015)	Operational	Construction
[PEC] Plan usage scenarios	Practices of Energy Consumption	(CORDERO et al., 2015)	Operational	Testing
[PEC] Identify consumption peak when launching an application.	Practices of Energy Consumption	(CORDERO et al., 2015)	Operational	Construction
[PEC] Choose an energy efficient Design Patterns	Practices of Energy Consumption	(CORDERO et al., 2015)	Operational	Design
[PEC] Use of user interface components can impact the energy consumption.	Practices of Energy Consumption	(CORDERO et al., 2015)	Operational	Design
[PEC] Implement energy monitoring of the source code.	Practices of Energy Consumption	(CORDERO et al., 2015)	Operational	Construction
[PEC] Perform tuning database instructions	Practices of Energy	(CORDERO et al., 2015)	Operational	Construction

	Consumption			
[PEC] Reduce the number of loops and database accesses by refactoring.	Practices of Energy Consumption	(CORDERO et al., 2015)	Operational	Construction
[PEUC] Identify high energy consuming user interface functionalities.	Practices of End User Energy Consumption	(CORDERO et al., 2015)	Operational	Construction
[PSUD] Build a software that can be adaptable to changes.	Practices of Sustainability Dimensions	(PENZENSTADLER; FEMMER, 2013)	Strategic	Project Planning
[PEC] Implement an architecture to automatically organize VM to use less energy not impacting the QoS.	Practices of Energy Consumption	(PENZENSTADLER; FEMMER, 2013)	Operational	Design
[PEC] Apply guidance to help on energy impact software design decisions	Practices of Energy Consumption	(SCHIEN et al, 2013)	Tactic	Design
[PEF] Use of modular architecture build for agile software programming (POWERAPI).	Practices of Energy Efficiency	(NOUREDDINE et. al., 2012)	Operational	Design
[PSUD] Develop a software in economic sustainable way	Practices of Sustainability Dimensions	(PENZENSTADLER; FEMMER, 2013)	Strategic	Project Planning
[PSUD] Define stakeholders on software requirements	Practices of Sustainability Dimensions	(RODRIGUEZ; PENZENSTADLER, 2013)	Operational	Requirements
[PEC] Reduce the amount of complex code by using memoization techniques.	Practices of Energy Consumption	(AGOSTA et al, 2012)	Operational	Construction
[PSUD] Implement non-functional requirements	Practices of Sustainability Dimensions	(PENZENSTADLER; FEMMER, 2013)	Operational	Requirements
[PSUD] Define sustainability indicators.	Practices of Sustainability Dimensions	(PENZENSTADLER; FEMMER, 2013)	Tactic	Requirements
[PEC] Choose an energy efficient storage technology.	Practices of Energy Consumption	(ZHONG; LIU, 2010)	Operational	Design
[PEC] Cache the pages can reduce the energy consumption of webpage.	Practices of Energy Consumption	(SCHIEN et al, 2013)	Operational	Construction
[PEC] Use of virtualized architectures can reduce the cost of dedicated hardware.	Practices of Energy Consumption	(ZHONG; LIU, 2010)	Tactic	Design

[PEC] Collect power utilization effectiveness (PEU) from cooling and power.	Practices of Energy Consumption	(SCHIEN et al, 2013)	Operational	Requirements
[PEC] Collect the energy consumption data.	Practices of Energy Consumption	(SCHIEN et al, 2013)	Operational	Construction
[PEC] Estimate energy consumption via data transferred over the network.	Practices of Energy Consumption	(SCHIEN et al, 2013)	Operational	Construction
[PEC] Estimate third-party server's energy consumption (CDNs) when the data from datacenter is not available.	Practices of Energy Consumption	(SCHIEN et al, 2013)	Operational	Project Planning
[PEC] Identify carbon footprint based on countries emissions.	Practices of Energy Consumption	(SCHIEN et al, 2013)	Strategic	Organizational Project-Enabling Process
[PEC] Identify user's monitor resolution	Practices of Energy Consumption	(SCHIEN et al, 2013)	Operational	Construction
[PEC] Reduce the amount of videos in the web page	Practices of Energy Consumption	(SCHIEN et al, 2013)	Operational	Construction
[PEC] Identify energy efficient applications based on ERPs, Image editors and games are less energy efficient than FTP clients and servers and calendar.	Practices of Energy Consumption	(CAPRA; FRANCALANCI; SLAUGHTER, 2012)	Tactic	Organizational Project-Enabling Process
[PEC] Reduce the size, resolution or number of images in the web page.	Practices of Energy Consumption	(SCHIEN et al, 2013)	Operational	Construction
[PEC] Use of a tool to stores energy consumption samples.	Practices of Energy Consumption	(AGOSTA et al, 2012)	Operational	Design
[PEC] Reduce the usage of JavaScript in the web page.	Practices of Energy Consumption	(SCHIEN et al, 2013)	Operational	Construction
[PSUD] Evaluate product's sustainability.	Practices of Sustainability Dimensions	(PENZENSTADLER; FEMMER, 2013)	Strategic	Testing
[PEC] Monitor servers activities when respond to users request.	Practices of Energy Consumption	(SCHIEN et al, 2013)	Operational	Maintenance
[PEC] Change the device for online newspapers use of e-readers devices instead of PC/laptops is advice.	Practices of Energy Consumption	(SCHIEN et al, 2013)	Tactic	Project Planning
[PEC] Reduce the use of third party servers.	Practices of Energy	(SCHIEN et al, 2013)	Tactic	Construction

	Consumption			
[PSUD] Monitor software impact in the environment	Practices of Sustainability Dimensions	(PENZENSTADLER; FEMMER, 2013)	Tactic	Testing
[PEC] Reduce the video resolution inside the web pages.	Practices of Energy Consumption	(SCHIEN et al, 2013)	Operational	Construction
[PEC] Reduce the web page rendering	Practices of Energy Consumption	(SCHIEN et al, 2013)	Operational	Construction
[PEC] Avoid write C++ interactive algorithms without a GNU Compile Collection (GCC).	Practices of Energy Consumption	(NOUREDDINE et. al., 2012)	Operational	Construction
[PEF] Use of a GNU Complier optimizations program reduce energy consumption of the code.	Practices of Energy Efficiency	(NOUREDDINE et. al., 2012)	Operational	Construction
[PEF] Use of Java using the default options is energy efficient.	Practices of Energy Efficiency	(NOUREDDINE et. al., 2012)	Operational	Construction
[PEC] Adjust automatically servers CPU voltage.	Practices of Energy Consumption	(ZHONG; LIU, 2010)	Operational	Construction
[PEC] Apply compilation optimization techniques such as performance.	Practices of Energy Consumption	(KAMBADUR; KIM, 2014)	Operational	Construction
[PEC] Avoid the use of Non-pure functions that have input parameters such as global variables and objects.	Practices of Energy Consumption	(AGOSTA et al, 2012)	Operational	Construction
[PEEE] Mitigate the idle consumption using Relative Idle Consumption metric	Practices of Evaluating Energy Efficiency	(KALAITZOGLOU; BRUNTINK; VISSER, 2014)	Operational	Maintenance
[PEC] Measure energy efficiency by collecting data transferred and user actions on the system.	Practices of Energy Consumption	(SCHIEN et al, 2013)	Tactic	Testing
[PEC] Monitor user devices when using the system.	Practices of Energy Consumption	(SCHIEN et al, 2013)	Operational	Project Planning
[PEC] Use of memoization programming technique	Practices of Energy Consumption	(AGOSTA et al, 2012)	Operational	Design
[PEC] Use of Memoization, pure functions and memory allocation can lead to reduce time execution and energy consumption.	Practices of Energy Consumption	(AGOSTA et al, 2012)	Operational	Design
[PSUD] Refine and deduce sustainability requirements	Practices of Sustainabili	(PENZENSTADLER, 2014)	Operational	Design

	ty Dimensions			
[PEUC] Identify the user device by web analytics.	Practices of End User Energy Consumption	(SCHIEN et al, 2013)	Operational	Testing
[PEC] Choose less energy consuming design patterns.	Practices of Energy Consumption	(SAHIN et al, 2012)	Operational	Design
[PEUC] Identify user's behaviors when using the software	Practices of End User Energy Consumption	(SCHIEN et al, 2013)	Operational	Testing
[PEC] Use of Power consumption measurement tool to identify design patterns' energy consumption.	Practices of Energy Consumption	(SAHIN et al, 2012)	Operational	Design
[PEC] Define design choices may impact on energy consumption when made to support high performance production.	Practices of Energy Consumption	(MANOTAS et al, 2013)	Tactic	Design
[PEC] Use of controlling methods to measure browser energy consumption	Practices of Energy Consumption	(MANOTAS et al, 2013)	Operational	Design
[PEC] Use of regulators and special agency data to be the base of energy consumption estimation.	Practices of Energy Consumption	(SCHIEN et al, 2013)	Tactic	Project Planning
[PEC] Avoid the use of frameworks when developing small applications to improve energy efficiency.	Practices of Energy Consumption	(CAPRA; FRANCALANCI ; SLAUGHTER, 2012)	Operational	Design
[PEC] Use of memoization techniques, optimized use of garbage collection and optimized use of memory increase energy efficiency.	Practices of Energy Consumption	(CAPRA; FRANCALANCI ; SLAUGHTER, 2012)	Operational	Design
[PEEE] Determine the energy consumption of the application by calculating the hardware consumption when a component has been executed.	Practices of Evaluating Energy Efficiency	(KALAITZOGLOU; BRUNTINK; VISSER, 2014)	Operational	Requirements
[PEC] Use of pure function to write code and allow memoization.	Practices of Energy Consumption	(AGOSTA et al, 2012)	Operational	Construction
[PLCA] Calculate energy footprint end-to-end when developing a system.	Practices of Life Cycle Assessment	(SCHIEN et al, 2013)	Operational	Project Planning
[PSUD] Use of devices that do not cause too much pollution.	Practices of Sustainability Dimensions	(ZHONG; LIU, 2010)	Operational	Requirements
[PEC] Use of Power Measurements during application execution.	Practices of Energy	(KAMBADUR; KIM, 2014)	Operational	Requirements

	Consumption			
[PEC] Define memory allocation policy	Practices of Energy Consumption	(AGOSTA et al, 2012)	Operational	Requirements
[PEEE] Use of pure SQL code in class rather than Frameworks like Hibernate improve energy efficiency.	Practices of Evaluating Energy Efficiency	(CAPRA; FRANCALANCI; SLAUGHTER, 2012)	Operational	Design
[PEC] Use of a tool to detect class and methods that mostly consumes energy.	Practices of Energy Consumption	(NOUREDDINE; ROUVOY; SEINTURIER, 2015)	Operational	Design
[PEC] Use of tool to estimate energy consumption at a code level of the application.	Practices of Energy Consumption	(NOUREDDINE; ROUVOY; SEINTURIER, 2015)	Operational	Design
[PEC] Use of tool to monitor at runtime the power consumption of software.	Practices of Energy Consumption	(NOUREDDINE; ROUVOY; SEINTURIER, 2015)	Operational	Design
[PEC] Use of software power metrics like disk hits transaction per second.	Practices of Energy Consumption	(HINDLE, 2012)	Operational	Requirements
[PEUC] Use of web analytics to get energy consumption information.	Practices of End User Energy Consumption	(SCHIEN et al, 2013)	Operational	Testing
[PEEE] Identify power consumption during peak workload.	Practices of Evaluating Energy Efficiency	(KALAITZOGLOU; BRUNTINK; VISSER, 2014)	Operational	Testing
[PEEE] Identify software sustainability.	Practices of Evaluating Energy Efficiency	(KALAITZOGLOU; BRUNTINK; VISSER, 2014)	Tactic	Testing
[PEEE] Identify the cost of non-energy efficient application per unit of work.	Practices of Evaluating Energy Efficiency	(KALAITZOGLOU; BRUNTINK; VISSER, 2014)	Tactic	Testing
[PEEE] Quantify the energy consumption scale with an increasing.	Practices of Evaluating Energy Efficiency	(KALAITZOGLOU; BRUNTINK; VISSER, 2014)	Operational	Testing
[PEF] Test the energy efficiency performance of different programming languages.	Practices of Energy Efficiency	(NOUREDDINE et. al., 2012)	Operational	Testing
[PEEE] Employ energy efficiency techniques as Compiler optimization Sets	Practices of Evaluating Energy Efficiency	(KAMBADUR; KIM, 2014)	Operational	Testing
[PEEE] Identify hardware provisioning over a period.	Practices of Evaluating Energy Efficiency	(KALAITZOGLOU; BRUNTINK; VISSER, 2014)	Tactic	Project Planning

[PEEE] Employ energy efficiency techniques as Interpreted versus Compiled	Practices of Evaluating Energy Efficiency	(KAMBADUR; KIM, 2014)	Operational	Testing
[PEEE] Employ energy efficiency techniques as Overclocking (Turbo boost)	Practices of Evaluating Energy Efficiency	(KAMBADUR; KIM, 2014)	Operational	Testing
[PEEE] Employ energy efficiency techniques as Parallelism	Practices of Evaluating Energy Efficiency	(KAMBADUR; KIM, 2014)	Operational	Testing
[PEC] Build a website with less flash contents.	Practices of Energy Consumption	(KIM; LEE; LEE, 2012)	Operational	Construction
[PSUD] Identify green deployment requirements for the system under development	Practices of Sustainability Dimensions	(PENZENSTADLER, 2014)	Operational	Maintenance
[PEEE] Improve energy efficiency by repartitioning databases across fewer disks.	Practices of Evaluating Energy Efficiency	(MEZA et al, 2009)	Operational	Maintenance
[PEEE] Employ energy efficiency techniques as Processor Frequency Tuning	Practices of Evaluating Energy Efficiency	(KAMBADUR; KIM, 2014)	Operational	Testing
[PEEE] Employ energy efficiency techniques as Processor Sleep States	Practices of Evaluating Energy Efficiency	(KAMBADUR; KIM, 2014)	Operational	Testing
[PEC] Create an environment for software energy measurements during the development.	Practices of Energy Consumption	(SIEBRA et al, 2012)	Operational	Design
[PEEE] Employ energy efficiency techniques as Source Code Tuning	Practices of Evaluating Energy Efficiency	(KAMBADUR; KIM, 2014)	Operational	Testing
[PEC] Analyze the impact of the web page size on power consumption.	Practices of Energy Consumption	(KIM; LEE; LEE, 2012)	Operational	Testing
[PEC] Use of a browser that consumes less energy when processing web pages.	Practices of Energy Consumption	(KIM; LEE; LEE, 2012)	Operational	Testing
[PEC] Use of energy test case scenarios for web page energy consumption.	Practices of Energy Consumption	(KIM; LEE; LEE, 2012)	Operational	Testing
[PBP] Develop a Green IT systems that is customer oriented.	Practices of Business Process	(ZHONG; LIU, 2010)	Operational	Construction
[PEEE] Use of quality attributes as Energy Efficiency considering the resource usage like, CPU, Memory and system performance.	Practices of Evaluating Energy Efficiency	(KOCAK; ALPTEKIN; BENER, 2014)	Operational	Testing

[PEC] Create mechanisms to reduce CPU energy consumption	Practices of Energy Consumption	(KOCAK; ALPTEKIN; BENER, 2014)	Operational	Construction
[PEC] Enable software developers to continuously measure and monitor energy consumption of software under development.	Practices of Energy Consumption	(SIEBRA et al, 2012)	Tactic	Construction
[PEC] Use of HVMM management to reduce energy consumption of an application on virtual or physical architecture	Practices of Energy Consumption	(MONTEIRO; AZEVEDO; SZTAJNBERG, 2013)	Operational	Design
[PLCA] Adopt a Life Cycle Assessment principles	Practices of Life Cycle Assessment	(SCHIEN et al, 2013)	Tactic	Organizational Project-Enabling Process
[PSUD] Avoid to develop noise systems.	Practices of Sustainability Dimensions	(ZHONG; LIU, 2010)	Operational	Construction
[PLCA] Estimate the energy impact from delivery of service until the end user.	Practices of Life Cycle Assessment	(SCHIEN et al, 2013)	Tactic	Organizational Project-Enabling Process
[PEC] Use of software power metrics like KB active (memory that was recently active)	Practices of Energy Consumption	(HINDLE, 2012)	Operational	Requirements
[PEC] Use of software power metrics like User-time per second (user space CPU usage).	Practices of Energy Consumption	(HINDLE, 2012)	Operational	Requirements
[PBP] Consider business process when building a Green System.	Practices of Business Process	(ZHONG; LIU, 2010)	Strategic	Organizational Project-Enabling Process
[PSUD] Choose a well-planned data center to efficiently use the cooling system.	Practices of Sustainability Dimensions	(ZHONG; LIU, 2010)	Strategic	Organizational Project-Enabling Process
[PEEE] Use of quality attributes as Energy Efficiency regarding time to response, amount of resources and software performance.	Practices of Evaluating Energy Efficiency	(KOCAK; ALPTEKIN; BENER, 2014)	Operational	Testing
[PSUD] Identify improvements on business process by using different approaches of sustainability.	Practices of Sustainability Dimensions	(PENZENSTADLER; FEMMER, 2013)	Strategic	Organizational Project-Enabling Process
[PSUD] Identify sustainability means for the company or product.	Practices of Sustainability Dimensions	(PENZENSTADLER; FEMMER, 2013)	Strategic	Organizational Project-Enabling Process
[PSUD] Identify initiatives of sustainability in the company level.	Practices of Sustainability Dimensions	(PENZENSTADLER; FEMMER, 2013)	Strategic	Organizational Project-Enabling Process
[PSUD] Elicit sustainability constraints	Practices of Sustainability Dimensions	(PENZENSTADLER, 2014)	Tactic	Requirements

[PSUD] Elicit sustainability objectives	Practices of Sustainability Dimensions	(PENZENSTADLER, 2014)	Tactic	Requirements
[PSUD] Choose a Green Data Center to design a Green System	Practices of Sustainability Dimensions	(ZHONG; LIU, 2010)	Strategic	Organizational Project-Enabling Process
[PSUD] Identify individuals satisfaction	Practices of Sustainability Dimensions	(PENZENSTADLER; FEMMER, 2013)	Tactic	Organizational Project-Enabling Process
[PSUD] Report the results of sustainability assessment	Practices of Sustainability Dimensions	(PENZENSTADLER; FEMMER, 2013)	Strategic	Organizational Project-Enabling Process
[PSUD] Identify sustainable actives that impact positively the indicators.	Practices of Sustainability Dimensions	(PENZENSTADLER; FEMMER, 2013)	Tactic	Project Planning
[PSUD] Monitor company and product performance on Requirements sustainability	Practices of Sustainability Dimensions	(PENZENSTADLER; FEMMER, 2013)	Tactic	Organizational Project-Enabling Process
[PEEE] Use of quality attributes as Functionalities regarding accuracy, suitability, security and interoperability.	Practices of Evaluating Energy Efficiency	(KOCAK; ALPTEKIN; BENER, 2014)	Operational	Testing
[PSUD] Raise awareness of individuals about environment protection	Practices of Sustainability Dimensions	(ZHONG; LIU, 2010)	Strategic	Project Planning
[PSUD] Specify a concrete and measurable sustainability actions.	Practices of Sustainability Dimensions	(PENZENSTADLER; FEMMER, 2013)	Strategic	Organizational Project-Enabling Process
[PSUD] Use of reference model to gather the sustainability activities, dimensions, values, indicators and regulation.	Practices of Sustainability Dimensions	(PENZENSTADLER; FEMMER, 2013)	Strategic	Organizational Project-Enabling Process
[PEF] Choose high-performance desktops and laptops that use efficiently hardware technologies.	Practices of Energy Efficiency	(KIM; LEE; LEE, 2012)	Tactic	Organizational Project-Enabling Process
[PSUD] Analyze sustainability of business or domain context	Practices of Sustainability Dimensions	(PENZENSTADLER, 2014)	Operational	Requirements
[PSUD] Derive sustainable system vision.	Practices of Sustainability Dimensions	(PENZENSTADLER, 2014)	Tactic	Requirements
[PSUD] Specify sustainable interaction	Practices of Sustainability Dimensions	(PENZENSTADLER, 2014)	Operational	Requirements
[PEC] Set up reconfiguration actions when the application response time is outside a pre-defined configuration.	Practices of Energy Consumption	(MONTEIRO; AZEVEDO; SZTAJNBERG, 2013)	Operational	Maintenance

[PEC] Configure web server setting to reduce the energy consumption.	Practices of Energy Consumption	(MANOTAS et al, 2013)	Operational	Requirements
[PSUD] Derive non-obsolescence requirements and quality characteristics of maintainability, supportability and reliability	Practices of Sustainability Dimensions	(PENZENSTADLER, 2014)	Operational	Requirements
[PSUD] Identify process requirement to build a green software.	Practices of Sustainability Dimensions	(PENZENSTADLER, 2014)	Operational	Requirements
[PSUD] Identify quality requirements to measure sustainability dimensions.	Practices of Sustainability Dimensions	(PENZENSTADLER, 2014)	Operational	Requirements
[PSUD] Identify sustainability stakeholders who issues objectives, constraints and consideration about the system under development.	Practices of Sustainability Dimensions	(PENZENSTADLER, 2014)	Operational	Requirements
[PEC] Use of neural networks to identify patterns of energy usage and automatically reconfigure the VM.	Practices of Energy Consumption	(MONTEIRO; AZEVEDO; SZTAJNBERG, 2013)	Operational	Design
[PSUD] Use of a model to identify sustainability stakeholders.	Practices of Sustainability Dimensions	(PENZENSTADLER, 2014)	Tactic	Requirements
[PSUD] Define a mechanism of awards for rating employees' green behaviors.	Practices of Sustainability Dimensions	(ZHONG; LIU, 2010)	Strategic	Organizational Project-Enabling Process
[PEC] Configure web servers to attend specifically the web application functionalities.	Practices of Energy Consumption	(MANOTAS et al, 2013)	Operational	Requirements
[PSUD] Identify and reduce energy cost on facilities.	Practices of Sustainability Dimensions	(ZHONG; LIU, 2010)	Strategic	Organizational Project-Enabling Process
[PSUD] Estimate efficiency by using the add value to the customer versus project- related effort to measure Project Efficiency.	Practices of Sustainability Dimensions	(ALBERTAO et al., 2010)	Tactic	Project Planning
[PSUD] Estimate the project footprint by considering the amount of hours working in house or in office.	Practices of Sustainability Dimensions	(ALBERTAO et al., 2010)	Tactic	Project Planning
[PSUD] Identify practices of Process- Related Properties like predictability, efficiency and project's footprint.	Practices of Sustainability Dimensions	(ALBERTAO et al., 2010)	Tactic	Project Planning
[PSUD] Use of metrics for sustainability improvement goals to achieve better results in sustainability.	Practices of Sustainability Dimensions	(ALBERTAO et al., 2010)	Tactic	Requirements
[PSUD] Include Green IT in strategic management of enterprises.	Practices of Sustainability Dimensions	(ZHONG; LIU, 2010)	Strategic	Organizational Project-Enabling Process

[PEEE] Use of quality attributes as Reliability to measure failure-free operation of the system	Practices of Evaluating Energy Efficiency	(KOCAK; ALPTEKIN; BENER, 2014)	Operational	Testing
[PEC] Use of modularization metrics to achieve sustainability quality system.	Practices of Energy Consumption	(WEISS; REPETTO; KOZIOLEK, 2012)	Tactic	Project Planning
[PSUD] Use of Software Sustainability Guidelines during software development.	Practices of Sustainability Dimensions	(WEISS; REPETTO; KOZIOLEK, 2012)	Operational	Project Planning
[PEC] Use of integration and acceptance testing framework to measure the energy consumption of web server	Practices of Energy Consumption	(MANOTAS et al, 2013)	Operational	Testing
[PSUD] Identify practices of Development-Related Proprieties like modifiability, reusability, portability and supportability.	Practices of Sustainability Dimensions	(ALBERTAO et al., 2010)	Operational	Construction
[PSUD] Identify practices related to Usage-related properties like performance, dependability, usability and accessibility.	Practices of Sustainability Dimensions	(ALBERTAO et al., 2010)	Operational	Testing
[PSUD] Use of metrics to assess Accessibility regarding social aspects of the system.	Practices of Sustainability Dimensions	(ALBERTAO et al., 2010)	Tactic	Testing
[PSUD] Use of Defect Density to measure Dependability.	Practices of Sustainability Dimensions	(ALBERTAO et al., 2010)	Operational	Testing
[PSUD] Use of Distance measurement for Modifiability and Reusability.	Practices of Sustainability Dimensions	(ALBERTAO et al., 2010)	Operational	Testing
[PSUD] Use of Effectiveness to measure usability.	Practices of Sustainability Dimensions	(ALBERTAO et al., 2010)	Operational	Testing
[PSUD] Use of error rate to measure usability	Practices of Sustainability Dimensions	(ALBERTAO et al., 2010)	Operational	Testing
[PSUD] Use of Estimated System Lifetime to measure Portability.	Practices of Sustainability Dimensions	(ALBERTAO et al., 2010)	Operational	Testing
[PSUD] Use of Estimation Quality Rate to measure the predictability.	Practices of Sustainability Dimensions	(ALBERTAO et al., 2010)	Operational	Testing
[PSUD] Inspect the context, understanding which concrete roles are involved, and match them bottom-up to the dimensions.	Practices of Sustainability Dimensions	(PENZENSTADLER; FEMMER; RICHARDSON, 2013)	Tactic	Organizational Project-Enabling Process
[PSUD] Analyze the dimensions to find responsible roles and matching them top-down to the context.	Practices of Sustainability Dimensions	(PENZENSTADLER; FEMMER; RICHARDSON, 2013)	Strategic	Organizational Project-Enabling Process

[PSUD] Have one or more stakeholders for each sustainability aspects economic, social, human, social, technical and environmental.	Practices of Sustainability Dimensions	(PENZENSTADLER; FEMMER; RICHARDSON, 2013)	Strategic	Organizational Project-Enabling Process
[PSUD] Use of Learnability to measure usability.	Practices of Sustainability Dimensions	(ALBERTAO et al., 2010)	Operational	Testing
[PSUD] Use of Relative Response Time to measure Performance	Practices of Sustainability Dimensions	(ALBERTAO et al., 2010)	Operational	Testing
[PSUD] Instantiate generic lists of sustainability stakeholders	Practices of Sustainability Dimensions	(PENZENSTADLER; FEMMER; RICHARDSON, 2013)	Tactic	Requirements
[PSUD] Analyze and refine a generic sustainability model	Practices of Sustainability Dimensions	(PENZENSTADLER; FEMMER; RICHARDSON, 2013)	Operational	Requirements
[PEEE] Implement multithreaded applications to use less time and turn the application energy efficient.	Practices of Evaluating Energy Efficiency	(SIEBRA et al, 2012)	Operational	Construction
[PSUD] Use of Support Rate to measure Supportability.	Practices of Sustainability Dimensions	(ALBERTAO et al., 2010)	Operational	Testing
[PSUD] Use of Sustainability Performance Metrics to improve sustainability aspects.	Practices of Sustainability Dimensions	(ALBERTAO et al., 2010)	Operational	Testing
[PEEE] Use of Dynamic Voltage and Frequency Scaling (DVFS) power management technique.	Practices of Evaluating Energy Efficiency	(SIEBRA et al, 2012)	Operational	Testing

APPENDIX E – PRACTICES LIST FROM CASE STUDY

Type of practices	Categories	Classification	Organization	Practices
Existent practices	[C2] Practices of Sustainability Dimensions	Systematized	Organization B	[ORG B] Develop mobile apps with hybrid frameworks reduce cost and delivery it quickly {1-2}
New Practices	[C2] Practices of Sustainability Dimensions	Systematized	Organization B	[ORG B] Development good practices are communicated {1-2}
New Practices	[C2] Practices of Sustainability Dimensions	Systematized	Organization B	[ORG B] Use of tool to perform quality check during the build/deploy of code. {6-2}
Existent practices	[C2] Practices of Sustainability Dimensions	Systematized	Organization B	[ORG C] Internal communication about Organizational Sustainability {4-3}
Existent practices	[C2] Practices of Sustainability Dimensions	Systematized	Organization B	[PSUD] Choose a Data center building well planned to efficiently use the cooling system. {1-2}
Existent practices	[C2] Practices of Sustainability Dimensions	Systematized	Organization B	[PSUD] Develop a software in economic sustainable way {1-3}
Existent practices	[C2] Practices of Sustainability Dimensions	Systematized	Organization B	[PSUD] Raise awareness of individuals about environment protection {4-3}
New Practices	[C1] Practices of Energy Consumption	Systematized	Organization A	[ORG A] Build high performance mobile apps considering light solutions {1-3}
Existent practices	[C2] Practices of Sustainability Dimensions	Systematized	Organization A	[ORG C] Internal communication about Organizational Sustainability {4-3}
New Practices	[C5] Practices of Business Process	Systematized	Organization A	[ORG C] Sustainability is a mean of marketing {3-2}
Existent practices	[C2] Practices of Sustainability Dimensions	Systematized	Organization A	[ORG C] Use less paper {2-2}
Existent practices	[C2] Practices of Sustainability Dimensions	Systematized	Organization A	[PSUD] Identify initiatives of sustainability in the company level. {13-11}
Existent practices	[C2] Practices of Sustainability Dimensions	Systematized	Organization A	[PSUD] Raise awareness of individuals about environment protection {4-3}
Existent practices	[C2] Practices of Sustainability Dimensions	Non-systematized	Organization A	[ORG A] Build a software that is modularized {1-2}
Existent practices	[C2] Practices of Sustainability Dimensions	Non-systematized	Organization A	[ORG A] Build reusable components {4-3}

Existent practices	[C3] Practices of Evaluating Energy Efficiency	Non-systematized	Organization A	[ORG A] Code refactoring lead to reduce CPU resources thus energy consumption {1-3}
New Practices	[C6] Practices of End User Energy Consumption	Non-systematized	Organization A	[ORG A] Concerns about user experience {5-6}
New Practices	[C6] Practices of End User Energy Consumption	Non-systematized	Organization A	[ORG A] Technical solution to use less smartphone 3G/4G {2-3}
New Practices	[C6] Practices of End User Energy Consumption	Non-systematized	Organization A	[ORG A] Technical solution to use less smartphone battery {2-2}
Existent practices	[C2] Practices of Sustainability Dimensions	Non-systematized	Organization A	[ORG A] Use of clean code methodology to optimize the code maintenance {1-3}
Existent practices	[C3] Practices of Evaluating Energy Efficiency	Non-systematized	Organization A	[PEEE] Employ energy efficiency techniques as Source Code Tuning {1-3}
Existent practices	[C2] Practices of Sustainability Dimensions	Non-systematized	Organization A	[PSUD] Identify practices of Development-Related Proprieties like modifiability
Existent practices	[C6] Practices of End User Energy Consumption	Non-systematized	Organization B	[ORG A] Concerns about user experience {5-6}
Existent practices	[C6] Practices of End User Energy Consumption	Non-systematized	Organization B	[ORG A] Technical solution to use less smartphone 3G/4G {2-3}
Existent practices	[C6] Practices of End User Energy Consumption	Non-systematized	Organization B	[ORG A] Technical solution to use less smartphone battery {2-2}
Existent practices	[C8] Practices of Code Improvement	Non-systematized	Organization B	[ORG B] Avoid to leave commented lines in the code to not use too much space in source control repositories {1-2}
Existent practices	[C1] Practices of Energy Consumption	Non-systematized	Organization B	[ORG B] Design web services to use only the information that will be consumed {1-2}
Existent practices	[C8] Practices of Code Improvement	Non-systematized	Organization B	[ORG B] Develop a code that is easier for everyone understand and maintain {4-2}
Existent practices	[C6] Practices of End User	Non-systematized	Organization B	[ORG B] Develop an app that the navigation is optimized reducing the number of clicks{1-2}

	Energy Consumption			
Existent practices	[C1] Practices of Energy Consumption	Non-systematized	Organization B	[ORG B] Reduce the cyclomatic complexity of the code {1-2}
New Practices	[C8] Practices of Code Improvement	Non-systematized	Organization B	[ORG B] Use of design patterns and java resources to improve the code understanding and maintenance {1-2}
Existent practices	[C4] Practices of Energy Efficiency	Non-systematized	Organization B	[ORG B] Use of new version of java to use functional programming as Streams {1-2}
Existent practices	[C1] Practices of Energy Consumption	Non-systematized	Organization B	[PEC] Reduce the amount of complex code by using memoization techniques. {1-3}
Existent practices	[C4] Practices of Energy Efficiency	Non-systematized	Organization B	[PEF] Test the energy efficiency performance of different programming languages. {1-3}
Existent practices	[C3] Practices of Evaluating Energy Efficiency	Systematized	Organization C	[ORG C] Application monitoring to identify lazy process {3-2}
Existent practices	[C3] Practices of Evaluating Energy Efficiency	Systematized	Organization C	[ORG C] Apply performance test prior to production deploy {4-2}
Existent practices	[C2] Practices of Sustainability Dimensions	Systematized	Organization C	[ORG C] Campaign to reduce energy consumption of mainframes {1-2}
Existent practices	[C2] Practices of Sustainability Dimensions	Systematized	Organization C	[ORG C] Communication to external client about digital services. {4-2}
Existent practices	[C2] Practices of Sustainability Dimensions	Systematized	Organization C	[ORG C] Communications about green data center and hardware energy efficiency {1-2}
Existent practices	[C2] Practices of Sustainability Dimensions	Systematized	Organization C	[ORG C] Concerns about social responsibility {3-2}
Existent practices	[C2] Practices of Sustainability Dimensions	Systematized	Organization C	[ORG C] Construction of Green Data Center. {1-2}
Existent practices	[C2] Practices of Sustainability Dimensions	Systematized	Organization C	[ORG C] Do not waste water {2-2}
Existent practices	[C3] Practices of Evaluating Energy Efficiency	Systematized	Organization C	[ORG C] Energy efficiency is a concern related to CPU
Existent practices	[C2] Practices of Sustainability Dimensions	Systematized	Organization C	[ORG C] Guidelines and checklist to contract a provider {1-2}

Existent practices	[C2] Practices of Sustainability Dimensions	Systematized	Organization C	[ORG C] Internal communication about Organizational Sustainability {4-3}
Existent practices	[C2] Practices of Sustainability Dimensions	Systematized	Organization C	[ORG C] Sustainability department {1-2}
Existent practices	[C2] Practices of Sustainability Dimensions	Systematized	Organization C	[ORG C] Turn off computer after while idle {2-2}
Existent practices	[C2] Practices of Sustainability Dimensions	Systematized	Organization C	[ORG C] Turn off lights automatically {1-2}
Existent practices	[C3] Practices of Evaluating Energy Efficiency	Systematized	Organization C	[ORG C] Use less CPU processing when developing with c++ {1-2}
Existent practices	[C2] Practices of Sustainability Dimensions	Systematized	Organization C	[ORG C] Use less paper {2-2}
Existent practices	[C3] Practices of Evaluating Energy Efficiency	Systematized	Organization C	[ORG C] Use of development best practices to reduce the application size and perform better {1-2}
Existent practices	[C1] Practices of Energy Consumption	Systematized	Organization C	[ORG C] Use of MIPS indicator to identify transaction slowness {1-2}
Existent practices	[C1] Practices of Energy Consumption	Systematized	Organization C	[PEC] Use of software power metrics like disk hits transaction per second. {1-2}
Existent practices	[C3] Practices of Evaluating Energy Efficiency	Systematized	Organization C	[PEEE] Employ energy efficiency techniques as Processor Frequency Tuning {1-3}
Existent practices	[C3] Practices of Evaluating Energy Efficiency	Systematized	Organization C	[PEEE] Use of quality attributes as Energy Efficiency regarding time to response
Existent practices	[C2] Practices of Sustainability Dimensions	Systematized	Organization C	[PSUD] Choose a Data center Construction well planned to efficiently use the cooling system. {1-3}
Existent practices	[C2] Practices of Sustainability Dimensions	Systematized	Organization C	[PSUD] Identify and reduce energy cost on facilities. {1-3}
Existent practices	[C2] Practices of Sustainability Dimensions	Systematized	Organization C	[PSUD] Identify initiatives of sustainability in the company level. {13-11}
Existent practices	[C2] Practices of Sustainability Dimensions	Systematized	Organization C	[PSUD] Raise awareness of individuals about environment protection {4-3}

New Practices	[C1] Practices of Energy Consumption	Systematized	Organization C	[ORG C] Applications automatically change its performance when high cpu process are being used. {1-2}
New Practices	[C8] Practices of Code Improvement	Systematized	Organization C	[ORG C] Code refactoring to enhance application performance {4-2}
New Practices	[C3] Practices of Evaluating Energy Efficiency	Systematized	Organization C	[ORG C] Develop a mobile app available for any social class {1-2}
New Practices	[C3] Practices of Evaluating Energy Efficiency	Systematized	Organization C	[ORG C] Develop a mobile app that do not require a lot memory our too much hardware processing {1-2}
New Practices	[C8] Practices of Code Improvement	Systematized	Organization C	[ORG C] Energy measurement of application occurs in the server side. {1-2}
New Practices	[C5] Practices of Business Process	Systematized	Organization C	[ORG C] Practices of performance are not communicate openly due to market strategy {1-2}
New Practices	[C2] Practices of Sustainability Dimensions	Systematized	Organization C	[ORG C] Sustainability indicators are communicated to employees {1-2}
New Practices	[C5] Practices of Business Process	Systematized	Organization C	[ORG C] Sustainability is a mean of marketing {3-2}
New Practices	[C8] Practices of Code Improvement	Non-systematized	Organization C	[ORG B] Develop a code that is easier for everyone understand and maintain {4-2}
New Practices	[C2] Practices of Sustainability Dimensions	Systematized	Organization D	[ORG B] Use of tool to perform quality check during the build/deploy of code. {6-2}
Existent practices	[C3] Practices of Evaluating Energy Efficiency	Systematized	Organization D	[ORG C] Application monitoring to identify lazy process {3-2}
Existent practices	[C3] Practices of Evaluating Energy Efficiency	Systematized	Organization D	[ORG C] Apply performance test prior to production deploy {4-2}
New Practices	[C8] Practices of Code Improvement	Systematized	Organization D	[ORG C] Code refactoring to enhance application performance {4-2}
Existent practices	[C2] Practices of Sustainability Dimensions	Systematized	Organization D	[ORG C] Concerns about social responsibility {3-2}
New Practices	[C8] Practices of Code Improvement	Systematized	Organization D	[ORG D] Use of a tool to discovery code inconsistent implementation {3-2}

New Practices	[C2] Practices of Sustainability Dimensions	Systematized	Organization D	[ORG D] Use of agile methods allows good requirements specifications {4-2}
Existent practices	[C3] Practices of Evaluating Energy Efficiency	Systematized	Organization D	[PEEE] Use of quality attributes as Energy Efficiency regarding time to response
Existent practices	[C2] Practices of Sustainability Dimensions	Systematized	Organization D	[PSUD] Identify initiatives of sustainability in the company level. {13-11}
Existent practices	[C2] Practices of Sustainability Dimensions	Systematized	Organization D	[PSUD] Implement non-functional requirements {5-2}
New Practices	[C1] Practices of Energy Consumption	Non-systematized	Organization D	[ORG A] Build reusable components {4-3}
Existent practices	[C2] Practices of Sustainability Dimensions	Non-systematized	Organization D	[ORG D] Choose some functionalities carefully to create reusable test automation {1-2}
Existent practices	[C2] Practices of Sustainability Dimensions	Non-systematized	Organization D	[ORG D] Use of pure java function to detect code inefficient performance {1-2}
Existent practices	[C2] Practices of Sustainability Dimensions	Non-systematized	Organization D	[PSUD] Identify practices of Development-Related Proprieties like modifiability
New Practices	[C2] Practices of Sustainability Dimensions	Systematized	Organization E	[ORG B] Use of tool to perform quality check during the build/deploy of code. {6-2}
Existent practices	[C3] Practices of Evaluating Energy Efficiency	Systematized	Organization E	[ORG C] Apply performance test prior to production deploy {4-2}
New Practices	[C8] Practices of Code Improvement	Systematized	Organization E	[ORG C] Code refactoring to enhance application performance {4-2}
New Practices	[C5] Practices of Business Process	Systematized	Organization E	[ORG C] Communication to external client about digital services. {4-2}
New Practices	[C2] Practices of Sustainability Dimensions	Systematized	Organization E	[ORG C] Sustainability is a mean of marketing {3-2}
New Practices	[C2] Practices of Sustainability Dimensions	Systematized	Organization E	[ORG D] Use of agile methods allows good requirements specifications {4-2}
New Practices	[C2] Practices of Sustainability Dimensions	Systematized	Organization E	[ORG E] Build a software that is configurable by any person and do not depends of developer {1-2}
New Practices	[C2] Practices of Sustainability Dimensions	Systematized	Organization E	[ORG E] Consider digital sustainability requirements for application {1-2}

Existent practices	[C2] Practices of Sustainability Dimensions	Systematized	Organization E	[ORG E] Develop an application that includes sustainability requirements {1-2}
New Practices	[C2] Practices of Sustainability Dimensions	Systematized	Organization E	[ORG E] Personal code review to identify code inconsistence {1-3}
Existent practices	[C1] Practices of Energy Consumption	Systematized	Organization E	[ORG E] Use of server services to automatically adjust memory and cpu when the application requires {1-2}
Existent practices	[C1] Practices of Energy Consumption	Systematized	Organization E	[PEC] Adjust automatically servers CPU voltage. {1-2}
Existent practices	[C3] Practices of Evaluating Energy Efficiency	Systematized	Organization E	[PEEE] Use of quality attributes as Energy Efficiency regarding time to response
Existent practices	[C2] Practices of Sustainability Dimensions	Systematized	Organization E	[PSUD] Derive sustainable system vision. {0-2}
Existent practices	[C2] Practices of Sustainability Dimensions	Systematized	Organization E	[PSUD] Identify initiatives of sustainability in the company level. {13-11}
Existent practices	[C2] Practices of Sustainability Dimensions	Systematized	Organization E	[PSUD] Implement non-functional requirements {5-2}
New Practices	[C6] Practices of End User Energy Consumption	Non-systematized	Organization E	[ORG A] Concerns about user experience {5-6}
New Practices	[C2] Practices of Sustainability Dimensions	Non-systematized	Organization E	[ORG E] Avoid printing documents {0-2}
New Practices	[C2] Practices of Sustainability Dimensions	Non-systematized	Organization E	[ORG E] Avoid using plastic cups {0-2}
New Practices	[C6] Practices of End User Energy Consumption	Non-systematized	Organization E	[ORG E] Build a software that is responsive and fit in any screen size {1-2}
New Practices	[C2] Practices of Sustainability Dimensions	Non-systematized	Organization E	[ORG E] Concern about sustainability is exercised naturally {1-3}
New Practices	[C2] Practices of Sustainability Dimensions	Non-systematized	Organization E	[ORG E] Design a scalable application {1-2}

APPENDIX F – SUMMARY OF PROPOSTIONS CONCEPTS

P1 - Organizational policies driven to sustainability are systematically applied in software development in the financial sector.

- Sustainability aspects are informed in IT area and has a focal point dedicated to this activity. (PENZENSTADLER; FEMMER, 2013), (PENZENSTADLER; FEMMER; RICHARDSON, 2013), (PENZENSTADLER, 2014)
- The organization use a reference model for achieving sustainability activities, dimensions, values, indicators and regulations and also measure the sustainability goals. (PENZENSTADLER; FEMMER, 2013), (ALBERTAO et al., 2010)
- Sustainability is part of organization strategy. (ZHONG; LIU, 2010)
- Use of guides to describe Sustainable Software Engineering practices during the software requirements helping to identify the limitations, goals and interactions of sustainability during software development. (WEISS; REPETTO; KOZIOLEK, 2012), (PENZENSTADLER; FEMMER; RICHARDSON, 2013), (PENZENSTADLER, 2014)
- Sustainable Software Engineering practices are identified at Strategic, Tactical and Operational levels of organization planning within the IT area. (PENZENSTADLER; FEMMER, 2013), (SCHIEN et al, 2013), (ZHONG; LIU, 2010), (PENZENSTADLER; FEMMER; RICHARDSON, 2013), (PENZENSTADLER, 2014), (CAPRA; FRANCALANCI; SLAUGHTER, 2012), (ALBERTAO et al., 2010), (CORDERO et al., 2015), (WEISS; REPETTO; KOZIOLEK, 2012)
- The organization prides itself for hiring suppliers who have sustainability seals, energy efficiency and clean energy. (ZHONG; LIU, 2010), (KIM; LEE; LEE, 2012), (NOUREDDINE et. al., 2012)
- The organization establishes customer-driven awareness actions regarding sustainability. (PENZENSTADLER; FEMMER; RICHARDSON, 2013), (ALBERTAO et al., 2010), (CORDERO et al., 2015), (SCHIEN et al, 2013), (KIM; LEE; LEE, 2012), (MANOTAS et al, 2013)
- Practices related to energy consumption (PEC), energy efficiency evaluation (PEEE), sustainability (PSUD), business processes (PBP), life cycle assessment (PLCA), end user energy consumption (PEUC), are applied in one or more software life cycle stages such as project planning, software requirements, software design, software construction, software testing, and software maintenance. (CORDERO et al., 2015), (PENZENSTADLER; FEMMER, 2013), (SCHIEN et al, 2013), (KALAITZOGLOU; BRUNTINK; VISSER, 2014), (ZHONG; LIU, 2010), (KIM; LEE; LEE, 2012), (PENZENSTADLER, 2014), (ALBERTAO et al., 2010), (WEISS; REPETTO; KOZIOLEK, 2012), (PENZENSTADLER; FEMMER; RICHARDSON, 2013), (KAMBADUR; KIM, 2014), (AGOSTA et al, 2012), (HINDLE, 2012), (MANOTAS et al, 2013), (NOUREDDINE et. al., 2012), (SAHIN et al, 2012), (CAPRA; FRANCALANCI; SLAUGHTER, 2012), (NOUREDDINE; ROUVOY; SEINTURIER, 2015), (SIEBRA et al, 2012), (MONTEIRO; AZEVEDO; SZTAJNBERG, 2013), (KOCAK; ALPTEKIN; BENER, 2014)
- The criteria for evaluating software quality includes sustainability practices. (KOCAK; ALPTEKIN; BENER, 2014), (PENZENSTADLER, 2014), (ALBERTAO et al., 2010)
- There is an evidence on the dissemination of sustainability data to the customer and the organization received recognition for developing sustainable software? (PENZENSTADLER; FEMMER, 2013), (ZHONG; LIU, 2010), (PENZENSTADLER, 2014)

P2 - Sustainable Software Engineering practices are applied in a non-systematic way during software development.

The concepts are mostly the same as P1 (AP-01, AP-04, AP-08, AP-09) not considering organizational levels concepts and suppliers hiring since this proposition is not related to organizational processes.

- Practices of Sustainability Dimensions are considered during the software life cycle related to:
  - Implement a model for sustainable software development where changes requests are not often, but the changes requested are accepted. (PENZENSTADLER; FEMMER, 2013) ,(ZHONG; LIU, 2010) ,(KIM; LEE; LEE, 2012);
  - Non-functional requirements related to sustainability. (PENZENSTADLER; FEMMER, 2013) ,(SCHIEN et al, 2013), (KALAITZOGLOU; BRUNTINK; VISSER, 2014), (KAMBADUR; KIM, 2014),(HINDLE, 2012) , (MANOTAS et al, 2013);
  - Any guide to developing the sustainability-oriented software architecture. (PENZENSTADLER, 2014);
  - Verified software contemplates Sustainable Software Engineering practices. (PENZENSTADLER; FEMMER, 2013) ,(ALBERTAO et al., 2010);
  - Apply sustainability guidance like specific demands for software installation and launching such as use of green data center (PENZENSTADLER, 2014);

- A sustainability stakeholder is present on each stage of software developing (PENZENSTADLER; FEMMER, 2013) , (PENZENSTADLER, 2014) ,(PENZENSTADLER; FEMMER; RICHARDSON, 2013);
- A green data center that also consider sustainability (ZHONG; LIU, 2010);
- Modifiability, reusability, portability and supportability (ALBERTAO et al., 2010);

- Practices of Energy Consumption are considered during the software life cycle related to:
  - The choice of hardware or devices, metrics and monitoring that can be added to software development to consume less energy;
  - Data collection, measurement and configuration of power consumption;
  - Architecture, tools, frameworks, virtualization, standards and coding that reduce or monitor the software's power consumption, configuration, monitoring and automatic optimization of the server according to the power consumption of the software
  - Test case definition, test framework, energy efficiency techniques, quality attributes and code performance that test the power consumption of the software
  - Programming without the use of frameworks, real-time code energy consumption monitoring and automation of memory allocation and CPU when the software is running

P3 - Tools that automatically measure or change the energy consumption of developed software are used

The use of tools is also related to some of concepts described on P1 and P2 (AP-02, AP-03, AP-08, AP-09), the only ones not related to are:

- Software developed adjust itself to reduce its energy consumption
  - Source code implementation used to reduce power consumption, such as memory allocation and CPU usage. (AGOSTA et al, 2012), (KIM; LEE; LEE, 2012), (KOCAK; ALPTEKIN; BENER, 2014), (SIEBRA et al, 2012);
  - Configuration on the server that change the performance of the software to use less power. (ZHONG; LIU, 2010), (MANOTAS et al, 2013), (MONTEIRO; AZEVEDO; SZTAJNBERG, 2013)
- Measure the energy efficiency of the developed software.
  - Use of energy consumption measures. (CORDERO et al., 2015), (AGOSTA et al, 2012), (SAHIN et al, 2012);
  - Use of energy efficiency measures or software performance that does not have an impact on energy consumption. (SCHIEN et al, 2013), KALAITZOGLOU; BRUNTINK; VISSER, 2014), (NOUREDDINE et. al., 2012)
    (KAMBADUR; KIM, 2014), (NOUREDDINE; ROUVOY; SEINTURIER, 2015), (SIEBRA et al, 2012), (MONTEIRO; AZEVEDO; SZTAJNBERG, 2013);
  - Indicators linked to sustainability that is applied in the developed software. (CAPRA; FRANCALANCI; SLAUGHTER, 2012), (KIM; LEE; LEE, 2012), (HINDLE, 2012), (MANOTAS et al, 2013), (PENZENSTADLER; FEMMER, 2013)

Table 109 - Summary of Propositions concepts.