ISCTE Business School
Instituto Universitário de Lisboa

Impact of Lean Management at EDP Produção

Constança de Athayde de Antunes Varela Chaves

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Tutor:
Prof. Doutor Renato Pereira

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- Spine -

Acknowledgments

Certain people were decisive for the realization of this master's thesis and, therefore, I want to perpetuate my deep thanks to all of them.

First, I want to thank my fiancé João Boto who has always supported me and believed in my abilities, constantly challenging me to be a better version of myself.

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For all these people I wish them all the best.

Abstract

Nowadays, companies are in an environment of constant change and competitiveness, especially given the financial instability of some economies and the consumer´s awareness of their power and demanding in product and service specifications. Therefore, organizations are increasingly seeking recognition in the market not only for their quality but also for their efficiency and rapid response to changes. In this context, many methodologies have emerged to address the external factors that make markets extremely volatile.

Of these various methodologies, Lean stands out as a form of management, consisting of practices and concepts of continuous improvement and waste reduction throughout the value chain, aiming at consumer satisfaction. Lean is also a way of thinking, with the goal of developing people's skills by creating a culture where everyone is encouraged to use their thinking, knowledge and skills to solve problems and to improve constantly and continuously.

But even if Lean can be applied across all industries and services, it is not a simple change. To achieve this, there must be a strong sense of leadership from top management to the end of the hierarchical structure. It is also important to evaluate and monitor their performance in organizations.

In this context, the objective of this Case study is to understand how such a developed company as EDP (Energias de Portugal), more specifically EDPP (EDP Production), applies and monitors the Lean methodology.

It is intended to evaluate the balance between the results obtained from this methodology in a developed company and the investment required.

Key words: Lean management, Continuous improvement, Efficiency, EDPP

Resumo

Atualmente, as empresas encontram-se num ambiente de contante mudança e competitividade, dado sobretudo à instabilidade financeira de algumas economias e da consciência dos consumidores do seu poder nas especificações de serviços e produtos. Deste modo, são cada vez mais as organizações que procuram ser reconhecidas no mercado não só pela sua qualidade, mas também, pela eficiência e rápida resposta às mudanças. Neste contexto surgiram, muitas metodologias que têm como objetivo fazer face aos fatores externos.

Destas metodologias várias destaca-se o Lean, constituída por práticas e conceitos de melhoria contínua e redução de desperdícios em toda a cadeia de valor, visando a satisfação do consumidor. O Lean é também uma forma de pensar, com o objetivo de desenvolver as competências, através da criação de uma cultura onde todos são encorajados a usar o pensamento, conhecimento e capacidades adquiridas para resolver problemas e melhorar constantemente.

Mas apesar do Lean ser passível de se aplicar em todas as indústrias e serviços, não é uma mudança simples. Para tal, deve existir um sentido forte de liderança desde a gestão de topo até ao fim da estrutura hierárquica. É também de extrema importância a avaliação e monitorização de desempenho desta aplicação

Neste âmbito, o objetivo do presente Case Study é perceber a forma como uma Empresa tão desenvolvida, como a EDP (Energias de Portugal), mais concretamente EDPP (EDP Produção), aplica e monitoriza a metodologia Lean.

Pretende-se, desta forma, avaliar o balanço entre os resultados obtidos desta metodologia numa grande empresa e o investimento necessário.

Palavras Chave: Metodologia Lean, Melhoria Contínua, Eficiência, EDPP

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List of Abbreviations

5S – *Seiri, Seiten, Seison, Seiketsu, Shitsuke*
5W – Five Whys
5W1H – Five Whys and How
5W2H – Five Whys, How and How much
ACM – Área de Comunicação e Marca
ACP – Área de Contratação e Procurement
AEN – Área de Ensaios e Comissionamento
AGO – Operational Management Area
APS – Área de Prevenção e Segurança
CA – Board of Directors
CAE – Executive Board of Directos
CCCB – Combined Cycles of Castelo de Bode
CCLR – Combined Cycles of Lares
CCRJ – Combined Cycles of Ribatejo
CESE – Contribuição Extraordinária sobre o Sector Energético
CTG – China Three Gorges
DCB – Departamento Castelo de Bode
DCC – Combined Cycles Department
DCL – Cávado Lima Department
DDR – Douro Department
DEB – Departamento de Engenharia de Barragens
DEC – Department of Efficiency and Digitalization
DOC – Direção de Orçamento e Controlo
DOH – Departamento de Otimização Hídrica
DOT – Departamento de Otimização Térmica
DRH – Direção de Recursos Humanos
DRM – Direção de Regulação de Mercados
DSN – Sines Department
DST – Departamento de Setúbal
DTM – Tejo Mondego Department
EDP – Energia de Portugal
EDPD – Energias de Portugal Distribuição
EDPHC – Energias de Portugal Hídricas Cantábrico
EDPP – Energias de Portugal Produção
GQP – Quality and Processes Office
IRR – Internal Rate of Return
JIT – Just-In-Time
KPI – Key Performance Indicator
NPV – Net Present Value
OPEX – Operational Expenses
PDCA – Plan, Do, Check, Act

REN – National Electrical Network
RPA – Robotic Process Automation
SWOT – Strengths, Weaknesses, Opportunities and Threats
TPS – Toyota Production System
TQM – Total Quality Management
UNGE – Energy Management Business Unit
UO – Organizational Unit
VSM – Value Stream Mapping
WACC – Weighted Average Cost of Capital

1. Introduction

1.1. Objective and motivation

For the final master's degree project, I felt I had to choose a theme that not only I had enjoyed learning in classes but also that I could see some practical cases in companies.

One of the subjects I was most interested in was logistics. Among the themes addressed, one that drew me a lot of attention was Lean and continuous improvement.

Although we did not deepen the theme much, I was curious to know more and to perceive the practicality of the methodologies defended.

In this way, my goal with this case study is not only to perceive the practical reality of this management methodology as well as to understand and analyze benefits associated with its implementation.

To this end, I elaborated the case study on EDP Produção, one of the companies belonging to the group EDP Energias de Portugal S. A., which had the generosity of giving me the information throughout the thesis.

1.2. EDP and EDP Produção presentation

The Group EDP (Energias de Portugal) S. A is made up of a set of companies that are active in the energy sector (EDP Distribuição, EDP Renováveis, EDP Soluções Comerciais, EDP Valor, EDP Comercial, EDP Produção) and other companies that provide development and support services. The various companies operate in different geographies and segments of the value chain. The Group is also the holder of foundations in Portugal and Spain and an Institute in Brazil.

EDP is one of the largest wind energy operators in the world, the largest producer, distributor and marketer of electricity in Portugal and also in the Iberian Peninsula.

EDP's strategic agenda is defined to act directly in creating value for stakeholders and its customers. Thus, three strategic axes were defined:

- Higher efficiency;
- Focused and sustained growth;
- Controlled risk.

EDP Produção (EDPP) is the Competence Center of the EDP Group for the electricity generation business with approximately 1000 employees. EDPP wants to be valued internationally as a reference in all areas of its business and recognized as a model by

proactively assuming its responsibilities in the sustainable development of the Communities where it operates.

1.3. Structure of the document

In order to understand what is the state of the Lean Program implemented at EDPP it is necessary to explain what the concept of Lean is and what are its most common tools, besides the benefits it brings in general to companies. For that, in Chapter 2. Literature review, it is made an overview on this subject based on the works of the major authors about this them.

On Chapter 3. there is made an analysis of the state of the art of the Lean Programs on big companies that make business in Portugal, although not being competitors of EDPP.

After, on Chapter 4. Case Study – Lean at EDPP it is studided in more detail, starting with the issue that led to the pursue of this work. Then EDP and EDPP are briefly exposed in order to create a context and then it is explained how the Lean Program is implemented at EDPP. Finnaly, some examples where chosen to show real examples of real initiatives and the impact of it, as well as the global impact of the Lean Program at this company.

On the next Chapter it is made the analysis of the results of the Case Study, the methodology and tools used and the conclusions that should lead to the replecation of these iniatiatives within the company, as well as in other similar companies.

Finnaly Chaper 6. Consists on the Bibliography of the sources utilized in the development of this work, followed by the Appendixes with data relevant for the compreehension of the remaining chapters.

2. Literature review

The Lean Production concept has been given its name by John F. Krafcik in his research paper called Triumph of the Lean Production System (1988) in which he compares Fordism with this concept in car manufacturers' plants and concludes stating that the lean management policies lean to higher productivity and quality performance.

Two years later, a book published by Womack et al (1990) established the name Lean Production definitively worldwide and made the authors the most relevant in regard to this subject, nowadays being some of the most cited.

Although being named by Krafcik and Womack et al the Lean Production concept was not created nor developed by them. The Toyota Production System (TPS) developed by Eiji Toyoda and Taiichi Ohno is the basis of that concept and has been created to compete in cars' market with the mass production techniques developed by Henry Ford with Model T (Ohno, 1988). According to the author, the loss of the 2nd World War was a key moment for the company in order to implement new strategies which ended up by establishing the TPS.

Womack et al (1990) explained that Eiji Toyoda and Taiichi Ohno realized that the mass production systems, where a product is made over and over again in large quantities, wouldn't adapt to the Japanese market. They have realized that for political reasons and for the different needs of their consumers the Toyota Motor Company should adopt a Mass Customization strategy, in which the produced goods are more customized accordingly to the consumers' choice but are also produced in large quantities.

This new strategy lead to what is now known as the TPS. Stating Ohno (1988) "the basis of the Toyota Production System is the absolute elimination of waste" and "the two pillars needed to support the system are Just-In-Time (JIT) and Autonomation". JIT replaces the Just-In-Case philosophy of mass production focusing on reducing stock potentially to zero by delivering only what is needed, just when it is needed in the right amount that is needed. Of course, the more complex the manufacturing process the riskier it is to have zero stock, so the objective is to guarantee a good management and planning in order to have the minimum stock possible while still being prepared for unforeseen events. Autonomation on the other hand is best explained by the author as "automation with a human touch" and it means that machines should be upgraded in order to stop autonomously if even the slightest malfunction is detected. This would lead to machines that can work without human assistance can in fact work without human assistant while preventing fabrication of defective parts if the machine has some malfunction or even preventing that the machine itself gets more damaged.

In the work by Abdulmalek and Rajgopal (2007) it is explained that the lean "system is focused on pinpointing the major sources of waste, and then using tools…" that will be explained hereafter "to eliminate the waste". In fact, Wilson (2010) summarizes Ohno's work by saying that "the TPS is a production system which is a quantity control system, based on a foundation of quality, whose goal is cost reductions, and the means to reduce cost is the absolute elimination of waste". The word Lean is when applied to "Lean Production" refers to doing more with less and the author goes further by implying that the reductions are not only physical and financial (cost) but also emotional because the works job becomes simpler, more fluid and more proactive than reactive.

As the community started to apply the lean principles to enterprises whose main activity was not products' manufacturing the term "Lean Manufacturing" or "Lean Production" stopped being an appropriate name and shifted to "Lean Thinking" (Womack and Jones, 2003) that simply means applying the lean concepts in any kind of company, regardless of its main activity.

Ohno (1988) identifies the seven wastes, or *muda* in Japanese, that all companies should try to eliminate, because a company's capacity is the sum of the work and the waste and if the wastes are transformed into work the profits of the company should raise. The *mudas* are:

1. **Over-production** – This is characteristic of a Push strategy in which the quantities produced are based on forecast of demand and not on actual demand and it leads constantly to the Just-In-Case philosophy. Over-production creates larges batches that transform themselves into stock that stays in the warehouse instead of being sold;
2. **Waiting** – Stands for the interval of time in which the works have no added-value tasks, for example when a part isn't being worked on nor in transition from one station to another or the time of the replies between departments;
3. **Transportation** – The movement of raw materials or products from one place to another involves not only the cost of energy to transport but also the maintenance of the transportation machinery and any damage that occurs in this task;
4. **Waste of processing itself** – More easily explained by over-processing or rework in a product at it represents the work that it done and that doesn´t add value, like working a part more than is demanded by the client or doing the same work on a product twice;

5. **Inventory** – Maintaining raw materials, unfinished products (work in progress) or finished products involves cost, is space consuming and can oblige to too much transportation. In addition, the greater the stock the greater the probability of damage;
6. **Movement** – Any small unnecessary and excessive movements done by an operator or a machine over thousands of products can reflect a great waste of time (and money in consequence);
7. **Defects** – If any product has a significant defect there are actions that are required to tackle it, it is necessary to evaluate if the product can be reworked or if it must be thrown away. In addition, it is necessary to check other products form the same batch for defects and investigate what is the cause.

Later, Jeffrey Liker (2004) added an 8th waste that had already been identified by Taiichi Ohno and other Lean Thinking followers that is:

8. **Unused employee creativity –** The missed opportunities of time reduction, ideas, skills, improvements and learning by not taking into account the opinions and insights of the workers.

There are two other kinds of non-value-added activities present at companies that should be tackled and eliminated (Acharya, 2011). The first is the overburden of a person or a machine due to preparation, planning or unnecessary work – *muri*. The other is the unevenness of quality of the produced parts or the quantity – *mura*.

Having identified the wastes that can be present at any company, either of products or services the Lean Thinking can start to be implemented, but a good strategy is necessary if the companies' owners wish to succeed and not hurt even more the processes. Womack and Jones (2003) define the 5 principles that are considered essential for a company to become Lean (Lean Enterprise):

a. **Value** – A product or a service can be translated into money in three different ways and the three are correct: the cost, the price and the value. The cost is how much money was applied in a product or service to bring it to the consumer, the price is the money for which it is sold and the value is the money which the consumer is willing to give away in exchange for it. For a company to make profit is obvious that the price must be higher than the cost, yet the value of that product or service must be equal or higher than the price or the consumer won't be compelled to buy it. The value of each product or service is created by the manufacturer but is

defined by the consumer and shifts from person to person and also on time. So, "specifying value accurately is the critical first step in lean thinking. Providing the wrong good or service the right way is *muda*";

b. **Value Stream** – It is necessary to understand what are all the tasks utilized in order to offer the consumer a valued product or service. This is called Value Stream Mapping (VSM) and as stated in Rother *et al* (2009) is consisted by four stages and all activities, with or without added value, must be mapped. The first stage is the choice of what is the object or group or objects of the study. Next, the current state of the process is drawn to easily identify what are the tasks that can and cannot be improved. Thirdly, after identifying the wastes, a new process is drawn out eliminating or reducing these wastes. This step and the second are iterative and occur almost simultaneously. Finally, it is necessary to implement the ideas;
c. **Flow** – "Make those actions that create value flow without interruption, detours, backflows, waiting or scraps" (Hines *et al*, 2008). The more fluid a process is the more efficient it can be, so it is important to improve its flow;
d. **Pull** – Earlier it was stated that the Push strategy was an enemy of the Just-In-Time philosophy. Instead, as referred by Monden (2011), a Pull strategy is the best match fo this philosophy. It defends that it should be the costumer to "pull" the products from the company and not having the products being "pushed" by it. In a factory with a pull system it is the final assembly line who demands the preceding stations to deliver a certain number of parts, which then demand the preceding stations for the materials they need and so on. With this strategy the company can guarantee lower stocks and higher adaptability;
e. **Perfection** – As stated by Womack and Jones (2003) perfection means "the complete elimination of *muda*" and it is impossible to achieve. The important message of this principle is to continuously focus on reaching perfection even it being unachievable. Having the other four principles in motion the search for perfection becomes easier.

The perfection can be considered as the ultimate goal of any company or, as envisioned by Fujio Cho, the roof a house, in particular the roof of the Toyota Production System house (Liker, 2004). Cho was a disciple of Taiichi Ohno and was capable to visually describe what the complex TPS philosophy was in reality. For that he created the TPS house diagram, shown in Figure 2.1, in which the roof the goal of attaining perfection at all levels, as explained, the

two pillars are JIT and Autonomation, or *Jidoka*, referred in the beginning of this chapter, in the center of this house are the people and teamwork that when focused on waste reduction lead to the continuous improvement and provide stability to the whole house. Finally, on the bottom of the house are the foundations like Visual Management, which is interaction between workers and management, Stable and Standardized Processes and *Heijunka*, that represents the levelling of the production variety and quantity.

Figure 2.1 – TPS House Diagram. Retreived from Liker (2004).

This diagram also shows some of the many tools of Lean Thinking that should be applied in order to support the search for perfection and also the tools that will help the company to reach closer. The understanding and application of these tools is fundamental if the management wishes to obtain the best results from Lean Thinking. Hereafter will be explained the most important tools regarding this work.

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2.1. Kaizen

Kaizen is a synonym for Continuous Improvement and is the central tool of Lean Thinking, as shown in Figure 2.1. In truth, Kaizen isn't really a tool but more of a method, which incorporates (or is only possible due to) many other tools. According to Kiran (2017),

Kaizen "can be called the umbrella enveloping most of the Japanese practices involving creativity".

The translation of kaizen from Japanese is change for the good and in this context means continuously implement changes in the processes that lead to improvements, therefore the continuous improvement expression. This method is very different from innovation because innovation usually focuses on big modifications with large impact in specific moments in time, while kaizen is the reflection of small progressive improvements in a large period of time. Kiran (2017) exemplifies the difference of both methods and how impactful can be their interactions and his interpretation is shown in Figure 2.2.

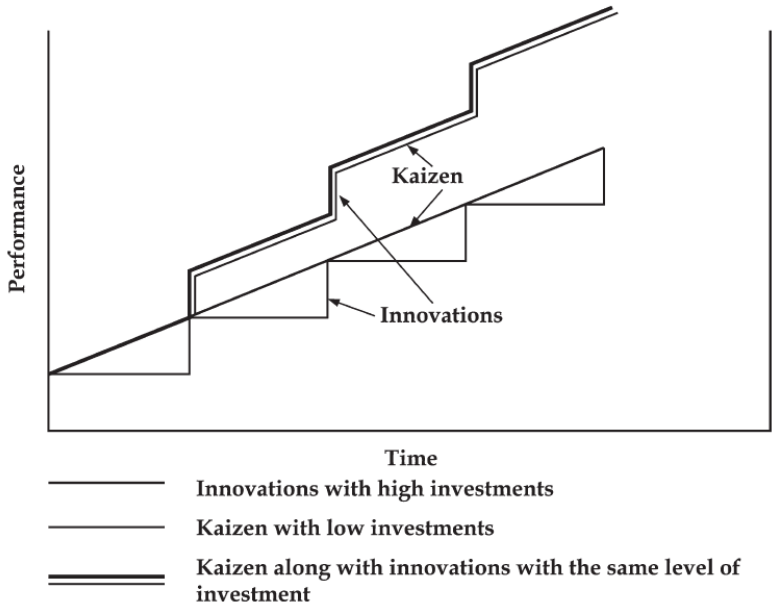


Figure 2.2 – Comparison and interaction between Kaizen and Innovations. Retrieved from Kiran (2017).

The development of the Continuous Improvement is mainly due to the need to deliver the costumer products with the highest possible quality. In order to achieve that the whole organization should make an effort to interact and improve its processes. This interaction is called Total Quality Management (TQM) and quoting The American Society for Quality "a core definition of TQM describes a management approach to long-term success through customer satisfaction. In a TQM effort, all members of an organization participate in improving processes, products, services, and the culture in which they work." (What is Total Quality Management (TQM)?, n.d.).

In short, the objective of the Kaizen method is to eliminate the wastes of a process while improving the interaction between the workers and management by involving everyone at the company. It also doesn't require large investment and brings excellence at the shop floor. For

it to be properly implemented there are ten requirements that are detailed in Kiran's work (2007):

1. Right attitude to solve the problem;
2. Accepting that the problem lies in the inadequacy of the present level in performance of the product or service;
3. Proper organization to solve the problem;
4. Adequate knowledge and practice in using problem-solving tools and techniques;
5. Structured method of problem-solving
6. Problem definition and analysis to be based in hard facts;
7. Solutions to the cause, more than for the symptoms of the problem;
8. Implementing and continuous monitoring until consistent result is obtained;
9. Overcoming resistance to change
10. Control system for reversible changes.

2.2. PDCA

The tool PDCA stands for Plan, Do, Check, Act, developed by Deming (Bicheno and Holweg, 2009), is a never-ending cycle of 4 stages that helps to improve the process and is represented in Figure 2.3. Plan is the first step in every cycle, although the author suggests that the first stage when initiating PDCA on a process is the Check and not the Plan, because the process must be observed before planning the improvements.

In detail the four stages are:

1. Plan – This stage's intention is to decide on how to improve a specific process. It is necessary to understand what the customer wants and try to what are the changes that will lead to that. The plan for this must also involve interaction between al the involved parties;
2. Do – Implementation of the plan designed in stage P. The better the plan is the easier it is to implement it;
3. Check – This is one of the most important but greatly overlooked steps. The objective of this stage is to observe if the process improved how it was expected and if all the planned changes where effectively implemented. It is also important to check for any other possible improvements;
4. Act – This stage can be divided in three parts: standardize the changes that had good results, correct the changes that didn't have the expected results and start the preparation for the next stage P.

Over the years many adaptations of the PDCA cycle have been created, like the IDEA, DMAIC and 8D (Bicheno and Holweg, 2009).

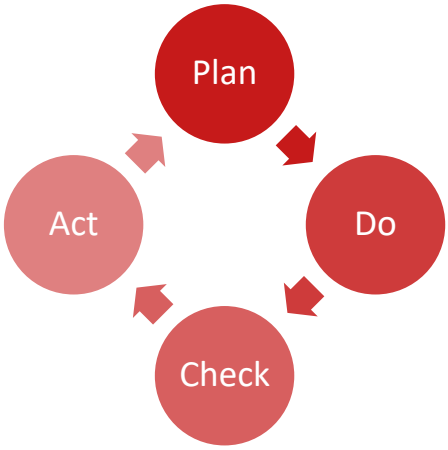


Figure 2.3 – PDCA cycle.

2.3. The Five Whys

One of Taiichi Ohno's focus was to eliminate a problem where they were originated and not superficially, since that way Toyota could prevent it to reappear or to resurface at another point in the process. Ohno (1988) calls it solving the root problem and the tool used for it is the Five Whys.

This technique consists, as the name suggest, to ask why five times when a problem is encountered. This means, when a problem occurs ask why it happened. When an answer is given ask why that cause for the problem happened. And so forth until the fifth why is reached. Ohno defends that by asking why five consecutive times the root of the problem is reached.

Bicheno and Holweg (2009) make notice that this tool can't be applied so linearly has it has been explained. The reason for that is that a problem can have more than one cause and those causes can have more than one cause themselves, as is shown in Figure 2.4, so when applying it is important to take into account every input possible and to decide which are the causes that should be resolved first.

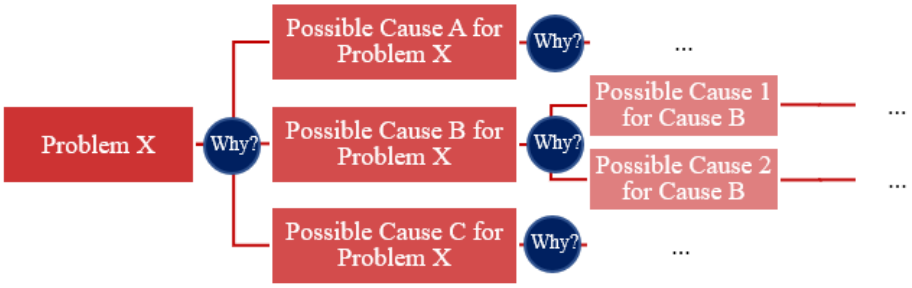


Figure 2.4 - Five Whys' scheme.

2.4. Genchi Genbutsu

Authors like Liker (2004), Bicheno and Holweg (2009), Wilson (2010), Koch *et al* (2012) and Dombrowski and Mielke (2013) consider essential for all levels of management to be involved and spend time in the production floor.

This idea exists since the time of Taiichi Ohno at Toyota and the purpose is for the managers to comprehend all the process involved on delivering a product or a service to the costumer. By comprehending the processes, it is easier for them to identify wastes, to understand what the best solutions for a problem can be and to improve the relationship with the workers. According to Liker (2004), one of Ohno's techniques was to draw a circle on the shop floor and stand there for up to eight hours just observing the flow.

The advantage of this visits is that the data that reaches the management at their offices are only indicators of what is really happening.

The names adopted for these visits is Genchi Genbutsu, which translates to "go and see for yourself, thoroughly understand the situation" (Wilson, 2010) and also Gemba Walks, in which Gemba means Real Place. Koch *et al* (2012) define Gemba Walk as "Going to production floor in order to directly watch the process, talk to employees, confirm data and understand the situation (instead of relying exclusively on computerized data and information from other people). This practice shall be applied by both top management and lower-level management.

One of the important reasons for doing Gemba Walks regularly is the connection with the workers, as has been stated. As referred by Wilson (2010), the most common practice is for managers to check the processes for themselves when there is a known problem. This causes tension and preoccupation between the works, who might feel that they are only called for criticism.

2.5. 5S

The 5S tool is mainly a methodology to help the company and the workers reach higher organizational levels and be more productive, as stated by Jaca *et al* (2014). This is one of the most important tools within Kaizen since there is a continuous waste reduction when this tool is applied correctly as well as it enables the workers and management to identify hidden problems.

The name was given because this tool consists in **5** stages each of them with a name started by **S**: *Seiri*, *Seiton*, *Seison*, *Seiketsu* and *Shitsuke*; that should be applied in sequence for attaining the best results. According to Monden (2011), the objective of this tool is to make the processes more efficient and to enable the company to use only the "necessary thing at the necessary time in the necessary quantity".

Kiran (2017) explains the 5 stages as follows:

1. ***Seiri*** – Structuring – The first stage of this tool consists in identifying what are the necessary and unnecessary items used on the workplace and store or discard the unwanted. The necessary items should be kept close and the unnecessary should be classified in "Wanted but not here", "Wanted but not in this quantity"; "Wanted but not now" and "Not wanted at all";
2. ***Seiton*** – Systemize – After identifying the necessary items it is important to dispose them in a way that the worker can be the most efficient. Every item should be in its place and the organization must include a separation of items that facilitates the workers job. To help in this it is common to utilize what is called Visual Seiton (Monden, 2011), that consist identifying the item and its storage with visual indicators to help the worker to find its right place. In this stage investments can be made in order to allow certain items to be easily picked up and stored, if these tasks take much time from the process;
3. ***Seiso*** – Sanitize – Making the worker responsible for cleaning and organizing his workspace before leaving. This should be done for respect to his coworkers and managers and also to make easier for the person who takes the next shift to find the needed items;
4. ***Seiketsu*** – Standardize – The managers of the workers must enforce them to adhere to the 5S and help implement it on all levels and to all the workers of the company. One of the techniques that help on this stage is the Visual Management that consists

on posters and signs with all the important information like the location of certain items;

5. ***Shitsuke*** – Sustain the discipline – The final stage of this tool is to be disciplined and utilize the 5S as a way of life, by focusing on eliminating all the bad habits. As shown in Figure 2.5 *Shitsuke* is the stage that holds the 5S together and without it, it would be impossible to implement this tool effectively.

Bicheno and Holweg (2009) state that the 5S is very popular among the lean community because it is not a hard tool to implement and its effects are immediate and easy to observe. One of the methods that Monden (2011) suggests is a great motivation to follow 5S is Point Photography which basically means taking a picture from the before and another after implementing 5S and posting the differences for everyone to see. This should provoke a reaction in the workers to achieve the same or better results.

This tool, and also mindset, will bring back to the company and to the workers, even on a personal level, reduction of waste, more consistency and higher productivity and efficiency, justifying the great results observed in industries like the Japanese (Jaca *et al*, 2014).

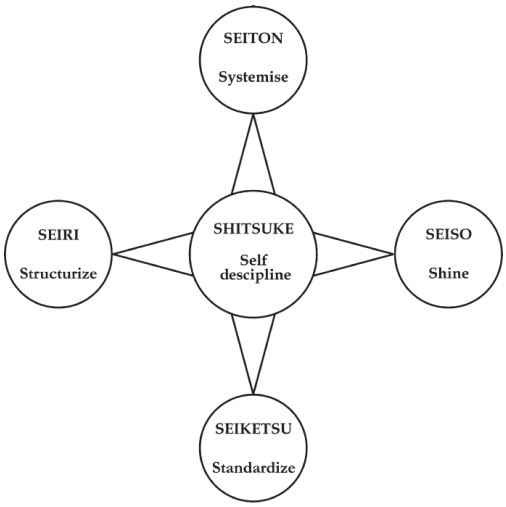


Figure 2.5 - Visual representation of 5S. Retreived from Kiran (2017).

2.6. A3 Report

The A3 report is the way Toyota's managers have found to simple expose a problem without and overload of information and still make it comprehensible, as described in Liker and Meier (2006). It consists in using just one face of one sheet of A3 paper (420 x 594 mm) to describe the most essential information and guarantee a great communication. As the author states, this is eliminating waste in presenting information.

There are many types of A3 reports, but the three more common and more relevant are the Proposal Story, that is made when a problem is identified and there is a need for approval

to solve it, the Status Story, that is constructed on the course of the implementation of the solution when key milestones are reached, and the Informational Story, that shows the effects of the solution and future steps to improve it. Although with different contents, the standard layout of the A3 reports is to have the page orientated as landscape and divide it into to columns, to be read from left to right and from top to bottom within each column. One thing that all types of reports must have in common is a section for the name of the author or authors and the date, for future reference.

The Proposal Story should include a brief introduction of the problem and of the background and a proposal on how to solve it on the left-side. On the right-side there should be an explanation on the plan to achieve the proposed results, a prediction on the obstacles that can appear and a timeline for the implementation (Figure 2.6).

For the Status Story, as shown in Figure 2.7, the report should start with the background of the problem, the objectives to be reach and the implementation plan. This information should be the same as in the Proposal Story report, unless something has changed. On the right column there should be presented the results of the implementation so far, the setbacks and the plan on how to solve them.

Finally the Information Story (Figure 2.8) is an overview of the problem solution process, so on the left-side there is a need to expose again the problem and to detail it and on the right side it is explained what was the implementation plan, the results achieved and what are the future steps to resolved pending problems or to further improve this matter.

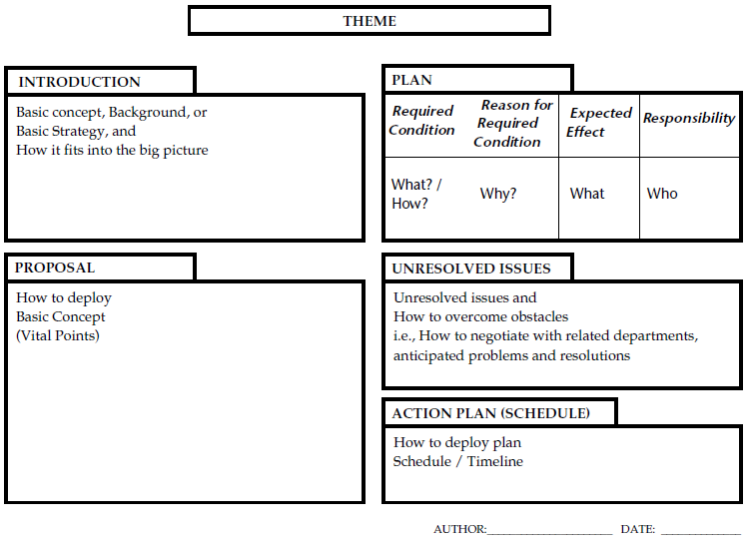


Figure 2.6 – A3 Proposal Story Report. Retrieved from Liker and Meier (2006).

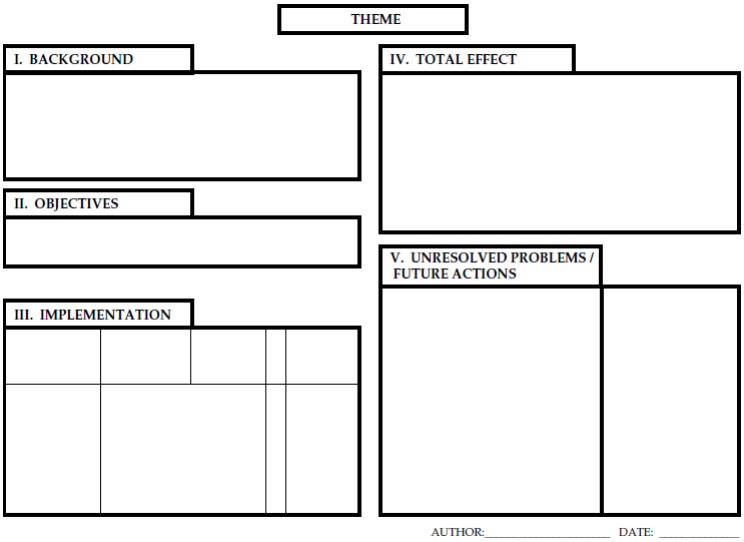


Figure 2.7 - A3 Status Story Report. Retrieved from Liker and Meier (2006).

Bassuk and Washington (2013) view the A3 report as a great example of the PDCA in motion, since all the stages of this cycle must be defined when creating any type of report. As explained before, the first cycle should begin with the Check instead of the Plan and indeed the exposure of the problem is that stage. Next there is elaborated a Plan for the implementation. The Do stage is the explanation of how the plan was implemented and the obtained results are the Check. To finalize, the Act stage is the future works section. Obviously in the Proposal Story it is impossible to show the Do, Check and Act stages, as in other types of reports, but there is a prediction for those too.

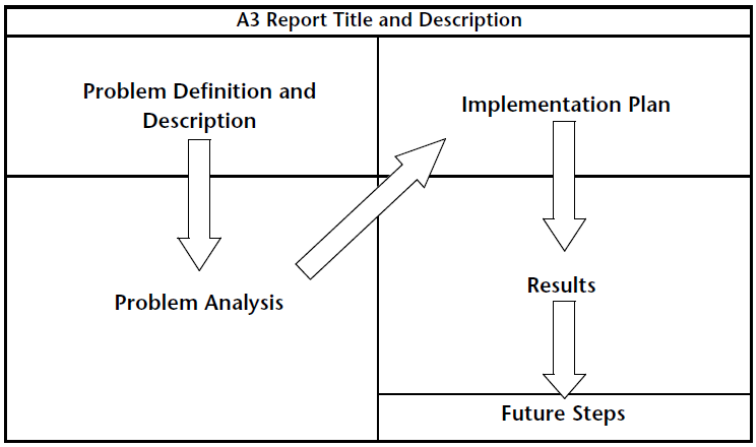


Figure 2.8 - A3 Information Story Report. Retrieved from Liker and Meier (2006).

2.7. Autonomation

As it was explained in the beginning of this chapter, Autonomation is the same as *Jidoka* and is one of the pillars of Lean Thinking. The focus of this tool is to guarantee quality products and make the problems visible. As can be read in work by Wilson (2010), Toyota

aimed for an inspection of 100 % of the products made at 100 % of the stages of production in order to make sure no consumer received a defective part while reducing costs.

In the 1930's the American companies started doing statistical quality control, by samples of the products, but this wasn't acceptable for Toyota since it didn't guarantee the inspection of all the products. As Monden (2011) refers, for parts that are produced at large quantities in short amounts of time it isn't feasible to verify all of them, but for every other process there is an 100 % verification.

The Autonomation is achieved by implementing on the machines, or even in manual processes, control devices that when is detected some deviation of the standard for that specific part the machine stops itself and visual and audible signals are activated so the operators can verify the origin of the problem (Liker and Morgan, 2006).

As stated in Monden (2011), this tool will allow that a single person can oversee a large number of machines because he only needs to attend to it if an error is detected and the machine is stopped, as opposed to the regular operation of one man per machine. When all machines are running as supposed the operator can be occupied with other added value tasks and not just monitoring the machines.

Another benefit is the machines' adaptability to changes in demand, since the autonomation is supposed to work in parallel to the JIT strategy, the machines are programed to stop when the desired quantity is reached, eliminating possible excessive inventory and also making the machines' ready to start the production of a different part if needed.

The final advantaged identified by the author is the respect for humanity, because it gives incentive to the workers to look for improvement opportunities. As referred, the machines stop if the slightest error is detected and thus the operator can start the identification of the root cause of the problem and, consequently, the elimination of a waste.

For Toyota, the robotization of processes is a natural step, since there is a clear reduction of operating costs, augmentation of productivity, repeatability of tasks with quality guarantee and flexibility of production. Yet this change can conflict with the respect for humanity if companies use machines to replace men when not for freeing the worker from repetitive tasks and allowing him to work in other more needed areas. As Monden (2011) puts it "robots, like any other kind of technology must remain the tool of men and not the other way around."

2.8. Standardization

When analyzing the workflow of workers of a mass production object it is easy to observe the standardization, which is performing the same tasks repeatedly without variation. This

occurs because one worker does the same task over and over again and implementing an uniformization of operations is easy.

Achieving Standardization in a Mass Customization strategy, like the one applied by Toyota Motor Company, is more complicated because there are tasks that are unique to some products, or the process can vary between these products. So, the standardization in this case is made by identifying common tasks and standardize them. Then, for the uncommon tasks it should be made an "isolation of the variation" (Liker and Morgan, 2006) and standardize the parts of each task that don't vary. Finally, for the varying, or abnormal, parts of the tasks there should be made an effort to standardize them too.

According to Oliveira, Sá and Fernandes (2017) the benefits of the implementation of this tool are:

a. Variability reduction and quality improvement – Since there are less margins for mistakes and the work becomes more measurable;
b. Cost reduction – Due to the elimination of wastes and smoothening flow;
c. Worker involvement – Since the tasks are defined by the company and not the worker, there are higher chances that a problem in production arises from a poor design of certain tasks, and so the worker becomes more enabled to suggest improvements.

Bicheno and Holweg (2009) state that for an effective Standardization it isn't sufficient to find a method for performing a task and implement it transversally. The great power of this tool is achieved if the implemented method is the best at the present time, but it mustn't be taken as guaranteed that it will be the best forever. The search for improvement cannot stop if one method is selected. This work must be done as an interaction between the engineers who design the process and the workers who perform the tasks regularly, because these are the persons who perform the tasks on a regularly basis and know which their difficulties are and where is there margin for improvements (Liker, 2004).

Although it has only been scrutinized the Standardization of processes, Jayaram, Das and Nicolae (2010) state that this tool should be applied to the materials and parts used for production and also for employee training.

Ultimately, the goal of this tool is not to have "the lowest possible unit cost" but really to reduce "the wastes within the system" (Liker and Morgan, 2006).

3. The Lean Methodology in Other Companies

3.1. IKEA

IKEA (Figure 3.1) is a private Swedish company founded in 1943. It is the world largest furniture retailer and international home products company that designs and sells ready-to-assemble furniture such as appliances and home accessories.

Figure 3.1 – Example of an Ikea store. Retrieved from https://www.brittonmdg.com/blog/the-ikea-story-from-flat-packaging-innovation-to-global-ambassador-of-sweden/.

Companies are constantly looking for ways to reduce costs and increase efficiency. IKEA is focusing on Lean methodology and processes to minimize the use of its resources, as well as providing better services.

According to Lechehab and Kamassi (2016) many activities during a visit to IKEA have aspects related with lean management, mainly:

1. The building and parking lot - Usually the stores have amazing designs. On the other hand, the IKEA stores that are not so surprising in terms of design, but, normally, organize all the space in order the maximum products in stock. The building does not cost much financially but is very efficient. As previously stated, the concept of Lean translates into using less resources to produce better products or services and could be observed by the building itself. They have a free parking space for customers who bought something in the store. The customer just pays for the product that bought and the parking ticket will be validated by the staff at the checkout counters;

2. Pencil and Tape Measure - Once the customer walks in, he will see the shelf where it can be found pencils and tape measure. To begin the visit, the clients can get one of each for their own use. The pencil is made of wood, with IKEA engraving and the ruler is made of paper that costs very little to the company. This idea is very useful when talking about Lean management, because it makes possible for all customers taking notes of all the items and measure the chair, table, bed and sofa etc, without having to bring their own tools;
3. The Catalogue - Almost every time that a person goes to a big store to buy something finds free catalogues that contain all the details about the products and the price. At IKEA, the catalogue is not given to the customers, but it can be borrowed. They decided to do in this way, since it cost a lot to give each customer a catalogue and secondly the customer will throw it away once he finished using it. Therefore, IKEA provides all the information of the products clearly on the product itself. A waste has been avoided;
4. The Arrangement and Placement - The incredible and the great thing in IKEA is the way how they arrange items inside for each room, Kitchen, living room, dining room, bathroom etc. In different spaces wide or small and different items sizes, so they can give an idea to customers how these items should be organized depending upon customer's houses space. This is also one of the unique strategies of IKEA to attract customer and by using the lean concept making the efficient use of resources available;
5. No Employee Around - The consumer, while passing through the various sections of the company, only sees some employees for assistance. This was a management tool that provided a reduction of costs. However, in order for customers to feel fully informed the products contain all the information clearly and visibly. There are also large posters, cards, about the details of the products and the corresponding price. This is another form of marketing to educate the customer about the product and the price. A customer can check the product, measure it, discuss it with friends and family before deciding about the purchase or not;
6. Reusable Bag - In order to commemorate the environmental day in 2009 and to save the planet, 0,70 € begun to be charged for each bag (retrieved from https://www.ikea.com/pt/pt/catalog/products/17228340/). A customer can put many items inside, and it is very solid. The bag can be used many times and it is

made by renewable materials to protect the environment. Reducing cost but at the same time, give something good and solid to the customer to use is a part of the lean mindset;

7. Disposable Rubbish - Everywhere throughout the store, we can see three different bins, one for paper, one for plastic and one for other waste. Whatever a customer wants to throw away, he can easily throw it into the respective bin. In that way, IKEA employee will easy classify the rubbish for the rubbish collector;
8. Information Check on PC - The clients see very few workers walking around to help them, but they can see a desktop computer in different places to check for information. In the developing computerize world, all Ikea shops must have these computers. Instead of asking an employee for help, the client can simply look for the information about the product on the different computers. This help IKEA reduce cost and provide all the available information at to all customers;
9. Space for Children - In the shops there is a space for children to play. In this way, parents can have a good and calm experience while buying at the same time that their children are having fun. This is another good strategy for IKEA, this space did not cost them much, which is lean and efficient for their business purpose;
10. The Store - There are many big items and products that are placed inside the big store that seems like a warehouse. However, it is very convenient for customers to buy from it because if they don't like a product they have picked, they can take another one right away, since the store has a lot of each product variety. The place can be seen as not nice or convenient but customers like it and the investments made by IKEA were just a. For the convenience of customers, IKEA even provide trolley for them to put the products heavier and harder to carry out;
11. Delivery Service - If a customer has bought a big that it is difficult to bring back home IKEA has the solution. The delivery service offered by IKEA is quick and easy. A product can be delivered to the client´s house on the same day, costing only 25 € (up to 500 € of purchases);
12. Assembly Service - When clients buy furniture at IKEA, they will get it in small parts and will have to assemble all the parts themselves. However, if customers don't know how to do it, IKEA can send their staffs to do the fixing for them. They just have to pay a reasonable price of about 5% of the retail price of the item that they have bought. This service can be considered very useful and effective since

the buyer may not have the necessary equipment or materials or even the knowledge to assembly. Thus, again, it can be said that IKEA has been able to develop a service which is considered lean.

To conclude, it is possible to assume that IKEA may be considered as an organization which has implemented lean in their daily business activities. There are very few people in the store, near the products, since all the information and details have been well placed on the products.

IKEA has been able to reduce cost, time and resources. The lean management system also focuses on customer satisfaction, so the company is getting, constantly, positive feedback from the customers.

3.2. GALP

At the 8th edition of the Kaizen Lean Awards (an event that annually distinguishes the national entities most distinguished by the use of the Lean methodology), GALP (Figure 3.2) was awarded an "Excellence" award due to its results obtained with its internal continuous improvement systems (GALP Energia, SGPS, S.A., 2019).

The Lean is, then, considered a methodology that changed the culture and behaviors of the teams and its development, as well as transformed the business processes and improved the specialized support/orientation of all GALP stakeholders (due involvement of top management).

Figure 3.2 - GALP Headquarters. Retrieved from https://shifter.sapo.pt/2015/12/ponte-ciclopedonal-em-lisboa-destacada-em-top-10-mundial-do-site-designboom/.

The operationalization of this program in the activities of GALP had its greater focus on the execution and agile implementation of the improvements. This involved more than 2,600 GALP employees and included: training of managers, coaching and mentoring by consultants, conducting audits and, finally, teams' certification.

The results were quite visible in the transformation of the business and allowed, for example: to reduce inventory cracking, automate inventory management processes, increase equipment availability, optimize staff size and ensure the availability of employees according to the demand to cement the GALP client-centric culture.

In order to guarantee the sustainability of this model implemented at the Iberian level, GALP intends to explore new areas and opportunities for applying the principles and methodology of this program now distinguished with a first prize of excellence Kaizen Lean.

3.3. Luís Simões

As stated by Almeida (2012), the improvement process at Luís Simões (Figure 3.3) was implemented in two transverse areas of integrated supply chain. Initially, the processes of the Administrative Area were analyzed, including the Customer Service Centre, and the area to support Internal Operations of warehouse. Regarding the first case, the objective was to measure the waste in terms of employees' free time. The second one, was based on the implementation of lean tools, particularly in terms of visual management, kaizen and standardization of processes in the area of Internal Operations on Warehouse: the reception, quality inspection, storage and picking.

Figure 3.3 - Luís Simões' truck. Adapted from https://revistacargo.pt/luis-simoes-desenvolve-projecto-para-cortar-emissoes-de-gases-com-efeito-estufa/.

With the application of lean methodology in the administrative sector, some issues were found, such as excess of free time on the elements of the area in support of Internal Operations and the existence of duplicated tasks. Therefore, it was suggested the reduction of time waste. Furthermore, to avoid duplication of tasks, it was suggested by the owners a task assignment plan and the respective back-ups.

On the warehouse, there were improvements due to the implementation of Kaizen daily meetings, visual management and standardization of processes, which caused a cultural restructuring and employee engagement in the process of continuous improvement that contributes significantly to further gains at the operational level.

4. Case Study – Lean at EDPP

4.1. Presentation of the issue

The authors mentioned in Chapter 2. as the majority of authors who have written about the Lean concept affirm that the methodologies and tools can be applied to all kinds of companies and not only the ones who deliver a physical object as their product.

EDP Produção (EDPP), the company chosen as the object of this study, is a company whose main product is the production of energy, through diverse process, which ultimately supplies homes and factories with electrical energy. Since it is still the manufacturing of a product it is included in the secondary sector of the economy alongside with the companies that manufacture physical objects.

This company is part of the multinational group known as EDP that is one the largest Portuguese based groups and it started as a government company. In 1998 the process of privatization started and it was concluded in 2011, which means that during the first 5 years of its Lean Program the company has been partially public.

On the other hand, EDP Produção doesn't have any relevant competitors in Portugal which could mean that for it to increase its profits the easiest option was to increase the prices of energy and they wouldn't lose any costumers, but due to policies on monopoly the energy market is very well regulated and the price raises are almost only limited to the inflation of the country. Other option is to increase production of energy, but it is limited to natural resources and mainly to the consumption of energy, but since energy is only consumed as it is needed the consumer dictates the production and there is no point is storing too much energy. As mentioned before, over-production and storage are wastes that could and should be eliminated. Another setback for the company is the European policies for energy consumption reduction that reflect on a decrease of energy production. One of the strategies to increase again this production is the internationalization of the company that has already begun.

Being limited on price increase, having already started internationalization and having a clear and imposed Pull Strategy, the company's search for higher profits passes through cost reductions that could be achieved in many ways. For this work, it is going to be studied the company's bet on the Lean Thinking methods that have been implemented and the consequent results will be analyzed.

In order to contextualize the subject of this work and for the readers to be able to replicate this methodology in similar companies, there will be made an introduction of the group EDP

and more particularly of EDP Produção. Then, there will be explained how the various departments of the company are defined and how their interaction is. After, it is important to show how Lean started at EDP Produção and how it has evolved until today. Finally, there have been chosen some examples of real initiatives implemented in order to show the process and results of particular activities that lead to the global savings that the Lean Program has proportionate this company.

4.2. EDP

EDP – Energias de Portugal is a Portuguese company that is a vertically integrated utility company. Throughout its 40 years of history, it has been building a relevant presence in the world energy scene, being present in 16 countries, in 4 continents.

With more than 11.500 employees, it is present throughout the electricity value chain and in the gas commercialization activity. EDP is the fourth largest wind energy production company in the world and almost 70% of its energy is produced from renewable resources. It provides electricity and gas to almost 11 million customers.

As shown in Figure 4.1, it is possible to divide the action of EDP in 4 areas: Production, Transport, Distribution and Commercialization.

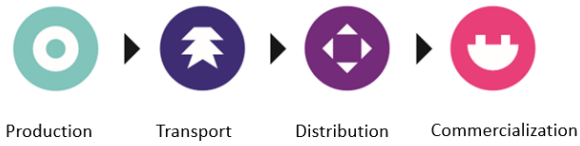


Figure 4.1 - The 4 areas of EDP. Retrieved from EDP (2019)

The Production is the first activity in the value chain of the electricity sector. Electricity is produced from renewable energy sources, essentially from water, wind or sun, or non-renewable energy sources, mostly from coal, natural gas, nuclear and cogeneration. In 2018, EDP produced 72 TWh of energy of which 73% came from wind or water energy (Figure 4.2).

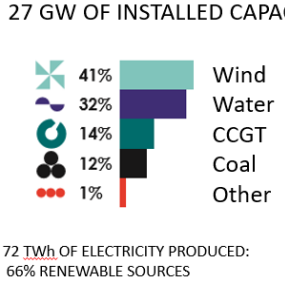


Figure 4.2 - Energy sources of EDP's 2018 Production. Retrieved from EDP (2019).

In transport activity, the energy produced is delivered to the transmission network, which consists of very high voltage lines and that subsequently channels the power to the distribution network. EDP has 1.184 km of transmission network, part of which is still under construction, and 113km of operation network.

In addition, in the distribution activity, the power channeled to the distribution network is then conducted to the supply points. Electricity distribution networks consist of high, medium and low voltage lines and cables. They are also an integral part of the distribution networks, substations, processing stations and public lighting facilities, as well as the necessary connections to consumer installations. It has 339.177 km of network (285.121 km of air distribution lines and 54.056 km of underground distribution lines) with 80 TWh of distributed energy.

To conclude, in the Commercialization activity, the distributed energy reaches the supply point and is then sold by the trader. Analyzing the electricity and gas value chain, commercialization is the closest activity to the customer, being responsible for the relationship with the final consumers. EDP has now more than with 9,8 M electricity clients and almost 1,6 M gas clients.

For what EBIDTA and financial results are concerned, the production and commercialization on Iberian Peninsula is responsible for 23% of Global EBITDA (all EDP company) regulated networks on Iberian Peninsula for 19% of Global EBITDA, renewable energy for 39% Global EBITDA and EDP Brasil for 19 % of Global EBITDA.

Strategy of EDP

EDP's strategy creates conditions for a context of low ecological footprint as well as behavioral and technological changes of its stakeholders. The strategy of EDP is based on five strategic pillars**:** Focused Growth, Financial deleverage, Controlled Risk, Superior Efficiency and Return to the shareholders.

EDP's Focused Growth Commitment is based on an expectation of an increase in EBITDA of approximately 3% per year until 2021 due to the creation of renewable energy growth, where wind technology predominates, but also hydro and solar. It’s projected that renewable energies rise 55% until 2020.

The financial deleverage effort seeks to reinforce the visibility of cash flow release in the medium term. The company establish as goal to be achieved in 2020 in terms of net debt and EBITDA ratio approximately of 3.0 X, through rigorous control over the level of investment

alongside the asset sales policy followed by EDP Renováveis and the implementation of the partnership with CTG (China Three Gorges).

Maintenance of the Low Risk Profile which characterizes EDP remains a priority pillar, notably as regards the distinction as the most integrated and regulated European utility, and is based on a commitment to maintaining the weight of its activities regulated around 75% of total EBITDA in 2020. To this end, EDP will endeavor to ensure, whenever possible, long-term energy sales contracts as well as diversify their business portfolio.

The Efficiency Commitment has been strengthened and is supported by the development of a culture of continuous improvement based on cross-group programmers. In 2015, the 4th edition of the OPEX programmed was launched, which presented a savings target of 130 million euros for 2018, which was exceeded in 2017, and amounted to 141 million euros of savings at the end of that year. Therefore, a new programmed (OPEX V) was launched in 2018 to reinforce the previous one, adding to the initially anticipated savings an additional value of 60 million Euros, totaling a savings target of 190 million euros and 260 million euros for 2019 and 2020, respectively.

Regarding the return to the shareholder, EDP assumed as a commitment the increase of 3% in the minimum dividend, to 0.19 €/share, from the dividend referring to 2016, based on the expectation of an increase in the net income from about 4% per year up to 20201 and a payout ratio set at a range between 65% and 75% of the recurring net income.

During the year 2018 operations were carried out with the aim of optimizing the group's portfolio, always with the goal to comply with the guidelines which was proposed during the implementation of the strategic Plan 2016-2020. In this context, it is to notice the sale of holdings held by the group in small water plants, both in Portugal as in Brazil, with a total fit of 287 million euros and a profit of 83 million euros.

In the view of the rapid changes in global technological context, EDP maintained its ambition to be in 2018 in the front of the digital transformation. It was in this sense that in 2017 it created a dedicated team (EDP X) to accelerate the transition, and in 2018 strengthened its resources.

The strategy of the Sustainability was organized around four strategic axes: creating economic value by investing in the Decarbonization, developing their people, improving environmental performance, reinforcing confidence; each of the Strategic axes is aligned with the Sustainable Development Goals defined by the United Nations.

Strategic Update 2019-22

Already in 2019, on 12 March, EDP presented an update of its strategic plan up to 2022, communicating the vision and strategic pillars as well as the repositioning of their business segments in conjunction with the initiatives targets for 2019-22.

EDP's vision is to take the lead in the energy transition to create superior value, based on 5 strategic pillars:

- Accelerated and targeted growth, with a clear bet on renewable energies;
- Continuous optimization of the portfolio through the rotation of renewable assets to accelerate organic growth and crystallization of value, and the sale of selected assets in order to balance the risk profile of EDP;
- Solid balance and low risk profile, based on the acceleration of financial deleverage by aiming at the consolidation of the investment grade rating and the reinforcement of the low risk profile;
- Efficient and digitally enabled, boosting efficiency across the organization with digital transformation to revolutionize EDP for the future;
- Attractive remuneration delivering superior value to shareholders through a distinctive history in renewable energies, strong profits growth and an attractive dividend policy.

4.3. EDP Produção and its structure

EDPP is a company focused on asset management and a reference in risk management, optimizing operations and maintaining production centres.

EDP Produção, with almost 1000 employees, promotes, dynamizes and manages more than 60 hydroelectric power plants and 4 thermoelectric power plants, which supply energy throughout the country.

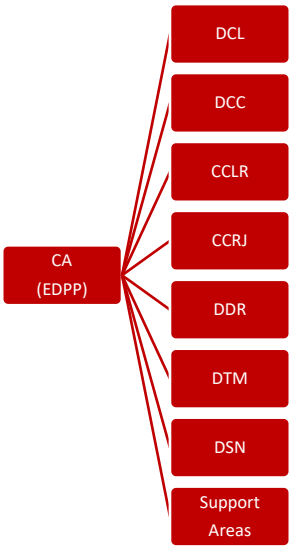
In accordance with EDP Group's environmental sustainability policy and values, EDP Produção's 68% of its installed capacity is based on renewable hydro power and the remaining 32% on conventional thermal power, subject to the latest technologies for CO_2 control and emission reduction pollutants

This company wants to be valued internationally in all domains of its business and recognized as a structural model, by the proactivity in the sustainable development of the communities where it operates. This vision meets the EDP group's vision, which aims to be a global energy company, a leader in value creation, innovation and sustainability.

EDP follows a management model that provides a corporate center, business units/shared services and management committees, in which the corporate Center operates in order to maintain the alignment of strategies and the diffusion of the EDP culture.

The Executive Board of Directors, or Conselho de Administração Executivo in Portuguese (CAE), is the body responsible for the management of the companies' activities and for establishing the strategy for each of the companies. The group's companies are managed functionally as business units/shared services, presupposing an articulation with the corporate center, in the context of the desired strategic alignment.

All companies of the group have its own Board of Directors, or Conselho de Administração (CA). In the case of EDPP the Board of Directors delegates and instructs a governing body, structured in Organizational Units (UO) or departments, as depicted in Figure 4.3. CA is responsible for the implementation of the company's strategy, business plan and development. Each department and respective director have autonomy to make their own decision when regarding operational and daily activities of the department action. However, when it comes to strategic decisions and activities that can change the routine of the company, these must pass through the approval of the CA of EDP Produção. Therefore, it can then be affirmed that EDPP currently follows a post-bureaucratic structure, i.e. horizontal.



CA	Board of Directors
DCL	Cávado Lima Department
DCC	Combined Cycles Department
CCLR	Combined Cycles of Lares
CCRJ	Combined Cycles of Ribatejo
DDR	Douro Department
DTM	Tejo Mondego Department
DSN	Sines Department
Support Areas	Departments that support the others responsible for the core activity. For example, DEC

Figure 4.3 - Structure Lean Program at EDPP.

The EDPP value chain, like most value chains, is divided into 2 large segments. One more operational that is composed by the core activities of the company. Without these activities the company could not carry out its main purpose and achieve the expected result – to produce energy.

And another area that contains the support activities that guarantee the support to the main activities in order to obtain the highest possible profit margin.

The operational segment is divided into three areas and its respective departments. The first area is called *Engenharia e Desenvolvimento de Negócio* (Engineering and Business Development, in English) and the main responsibilities of this area are related to: development of international projects, testing and commissioning, general studies and dam engineering. It is also constituted by the design and development team in Spain and by FOZ TUA department. The second area *Gestão de Ativos Hídricos* (Hydro Assets Management, in English) is constituted by: the hydro assets optimization department and by Cávado-Lima, Douro and Tejo-Mondego departments. Finally, the third area of this segments is *Gestão de Ativos Térmicos* (Thermic Assets Management) which is composed by: the thermic assets maintenance and optimization and by Sines and *Ciclos Combinados Biomassa e Cogeração* departments.

On the other hand, the support segment is divided into two areas. The first on is called *Controlo de Gestão e Contratação de Energia* (Control of Management and Contracting of Energy) and the main responsibilities of this area are related to: contracting and procurement activities, innovation and technology, risk continuous management, budgeting and market regulation. The second area is named *Sustentabilidade, Capital Humano e Eficiência* (Sustainability, Human Capital and Efficiency) and is made up of the Human Resources Department, the Department of Efficiency and Digitization (DEC), and the sustainability, prevention and safety department.

Regarding the main clients of EDDP , it can be considered: UNGE (Energy Management Business Unit), in charge of the purchase and sale management of electricity, coal, gas and carbon dioxide licenses, EDP Distribuição (EDPD), responsible for the distribution to final consumers and REN (National Electrical Network), which refers to power transport in very high voltage.

Strategy of EDPP

For 2019 EDP is planning to invest 94 M€, of which about 1/3 is intended for optimization projects that will improve the revenues of its assets and about 60 M€ are for investment in current maintenance.

An increase in international fuel and CO_2 markets is expected, which may reflect on the electricity prices. This will predictably lead to an increase in water energy margin, with some flattening of thermal energy margin due to lower production and unitary spreads. Thus, we

calculate that the gross margin reaches 880 million euros, with an EBITDA 652 M€ and a net income 176 M€.

For these results will also contribute a less negative view of regulatory costs, and with the CESE (*Contribuição Extraordinária sobre o Sector Energético*) redirection to reduce the tariff deficit. Operating costs will remain stable around 135 M€ because of the OBZ process (process for budgeting), with several specific initiatives being identified to be implemented throughout the year:

- Asset optimization – This initiative of improving the current assets include a project to increase operating range at Castelo de Bode (Figure 4.4 (a)), a study for floating photovoltaic solar panels with storage batteries at Alqueva (Figure 4.4 (b)), continued investment in Energy Ecological Flow at Alto Lindoso (Figure 4.4 (c)), Venda Nova (Figure 4.4 (d) and Castelo de Bode power plants, maintenance of the focus in the study of alternatives to maximize profitability of Sines taking into account adverse market context, increase efficiency in OPEX through OBZ and OPEX V initiatives, with accumulated savings of 12 million euros, continuation of the implementation of the monitoring and Diagnosis Center, which is predicted that Asset Performance Management extends to 7.5 GW of the water and thermal portfolio, renegotiation of CCGT maintenance contracts (LTMA) and maintenance of the scanning effort in field services: Examples such as Mobipro, Wi-Fi in hydropower plants and CCTG, and augmented reality with a pilot test in Castelo de Bode;
- Focus on regulatory management – Consisting in monitoring and participation in the response to processes relative to innovative costs, system services, note of illegality in progress in the competition authority, final adjustment, CESE and social tariff and evaluation of the conservation status and the rehabilitation costs of Cascata do Ave in order to be prepared for the contest that is to be launched for these assets;
- Generational renewal – Focused in Maintaining the knowledge management strategy and succession plan, adjusting the outsourcing strategy as a function of the effective versus predicted outputs, integration of new profiles to be contracted in the context of digitization (Digital People and Processes), evolution of headcount in line with the predicted in the base 0 sizing, which predicts it reach 2020 with 920 people and promotion of safety: continuous investment in safe

behaviors with the goal of training risk factor to all employees in 2019 and consolidation of the program Attention +, EDP defends that the attention is the best security.

(a) *(b)*

(c) *(d)*

Figure 4.4 – Four of EDPP's hydroelectric power plants. (a) Castelo de Bode power plant. Retrieved from http://bit.ly/2YpBhYS. (b) Alqueva power plant Retrieved from http://bit.ly/2xnqRNG. (c) Alto Lindoso power plant Retrieved from http://bit.ly/2XxbVLJ. (d) Venda Nova power plant Retrieved from http://bit.ly/2J0keHG.

4.4. Origin and structure of Lean at EDPP

Origin

The lean methodology is defined by a support structure and is spread to all power plants according to their needs (over the past 12/13 years, a large implementation of Lean methodology has been developed). The implementation of Lean at EDP emerges from the integration of the methodologies on the strategic projects and are transversal to all the company. At EDP Produção (from now on EDPP) this implementation was initiated at Sines power plant in June 2006. This was power plant chosen because it was the largest and presented a high potential in the dissemination of improvement initiatives to other power plants due to its already developed structured. (pilot's Sines project)

On the beginning of this Program, three main goals were defined:

1. Increase operation efficiency and maintenance in all functional areas;

2. Increase motivation and involvement of employees by stimulating changes on their daily activities and a mindset of continuous improvement;
3. To collect ideas of improvement from all levels of the organization improvement in a structured and way.

Therefore, to achieve the goals proposed at the start of the program, five teams were created and allocated to different areas, namely Energy Efficiency, Productivity in Operation and Maintenance, Availability (planned maintenance and unplanned stops), Energy Capacity and Management Infrastructure (indicators of performance and human resources and attitudes).

In July of the same year, in order to expand the project to more power plants, it was created and approved a roll out plan which its implementation only occurred between October 2006 and September 2007. This roll out was only possible due to the creation of a central of support named Lean Office that was integrated in the Quality and Processes Office of EDPP (GQP, with the aim of monitoring and developing of the program.

In this way, it was delegated to the Lean Office the following attributes: the facilitation, development and sustainability of the program across EDPP, as well as, the responsibility of ensuring the harmonization of the program.

Currently the structure responsible for the Lean program no longer has the designation of Lean Office, being now called of DEC (Department of Efficiency and Digitalization). How this department does the control of the Lean program throughout the organization, will be explained further.

The roll out was expanded from Sines (Figure 4.5 (a)) to Setúbal (Figure 4.5 (b)), (later decommissioned), passing through the hydroelectric power plants of the Tejo-Mondego. Simultaneously this program was launched to the support areas of EDPP. Furthermore, between May and July of 2007, the program was spread to the Spanish branch EDPHC Energías (Figure 4.5 (c)).

The criteria to choose which plans would be reached by the roll out was based on, the geographic proximity and the technological similarity.

Throughout the program the main challenge was to ensure the harmonization of the methodologies implemented without compromising the normal functionality of all departments involved (power plants and support areas).

The rollout was more successful than expected, since most departments, especially the power plants, managed to adhere to the Lean program and its methodologies with great enthusiasm and without great difficulties.

(a)

(b)

(c)

Figure 4.5 – Three examples of sites where Lean was implemented. (a) Sines power plant. Retrieved from http://bit.ly/2ZYsfm8. (b) Setúbal power plant Retrieved from http://bit.ly/325v4DZ. (c) EDP HC Energías. Retrieved from http://bit.ly/2Ytvz8E.

Lean program Structure

The Lean Program follows a structure of responsibilities according to hierarchical levels and support areas.

The general program's supervision is made by the administrators (CA) and by DEC (Department of Efficiency and Digitalization), as shown in The EDPP value chain, like most value chains, is divided into 2 large segments. One more operational that is composed by the core activities of the company. Without these activities the company could not carry out its main purpose and achieve the expected result – to produce energy.

And another area that contains the support activities that guarantee the support to the main activities in order to obtain the highest possible profit margin.

The operational segment is divided into three areas and its respective departments. The first area is called *Engenharia e Desenvolvimento de Negócio* (Engineering and Business

Development, in English) and the main responsibilities of this area are related to: development of international projects, testing and commissioning, general studies and dam engineering. It is also constituted by the design and development team in Spain and by FOZ TUA department. The second area *Gestão de Ativos Hídricos* (Hydro Assets Management, in English) is constituted by: the hydro assets optimization department and by Cávado-Lima, Douro and Tejo-Mondego departments. Finally, the third area of this segments is *Gestão de Ativos Térmicos* (Thermic Assets Management) which is composed by: the thermic assets maintenance and optimization and by Sines and *Ciclos Combinados Biomassa e Cogeração* departments.

On the other hand, the support segment is divided into two areas. The first on is called *Controlo de Gestão e Contratação de Energia* (Control of Management and Contracting of Energy) and the main responsibilities of this area are related to: contracting and procurement activities, innovation and technology, risk continuous management, budgeting and market regulation. The second area is named *Sustentabilidade, Capital Humano e Eficiência* (Sustainability, Human Capital and Efficiency) and is made up of the Human Resources Department, the Department of Efficiency and Digitization (DEC), and the sustainability, prevention and safety department.

The DEC department directly assumes the mission of supervising and approving basic guidelines. They act as the first promoter of continuous improvement at EDPP. However, the coordinator of local lean programs (program of each departments and power plants) has autonomy to develop and manage their own initiatives.

At a general level, there is a standard structure of Lean implementation at each department. However, in some cases, the coordinator of each department is allowed to make changes in his structured if justified.

The general standard is based on the following structure:

a. CA - The Board of Directors is responsible for approving and disclose the annual lean goals of EDPP
b. DEC- The Department responsible for: Elaborate the Lean Manual, Promote and plan the internal training of employees and for Monitor and follow up all the initiatives and respective benefits.
c. Coordinator of local lean program – Responsible for: Integrate the lean activities and programs into the projects pipeline of his department, Coordinate and support

the program development, managing the cycle of planning and monitor the department's initiatives and respective benefits.

d. Lean Team– Employees that actively participate in the diagnosis of development and improvement recommendations, as well as, in the process of implementation of new methodologies. These employees have specific training and area also responsible for the analysis of its own initiatives and the possibility of replicate initiatives from another department.

The Figure 4.6 exemplifies the interaction between the different areas.

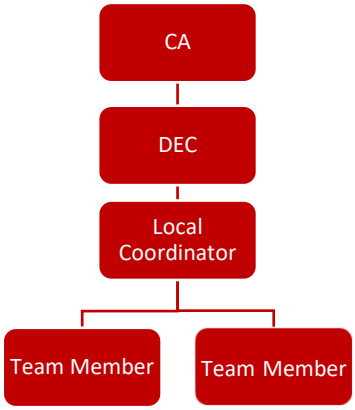


Figure 4.6 - Structure of each department's programs.

All employees can consult all initiatives (from their department or others) in a platform of knowledge sharing of EDPP - LINK.

Each local program coordination defines an action team of his department - lean team. In turn, each team not only evaluates improvement opportunities in its department but also analyzes the other initiatives of the other departments with the purpose of possible replication After this analyzes, the team sends its proposal the coordinator for approval. If the coordinator considers these initiatives feasible, the leant team draws up a plan to begin their implementation.

In order to be formalized the initiatives must be registered on the *GIL2WIN* platform. This is a platform created at EDPP to register initiatives and their benefits and on it, the department concerned, will only have access to information about their own initiatives. However, DEC, as the department responsible for coordinating and monitor the various local programs, has access to Lean information of all departments.

After a certain period of time, the lean teams verify the results of their initiatives. If the results aren't according to the plan, the lean team must introduce some changes in order to fulfill the goals. On the other hand, if all the results are according to what was planned, each

coordinator of the Lean program completes the initiative on the *GIL2WIN* platform and shares the respective A3 in *LINK*.

4.5. Development Phases of the Lean Program at EDPP

At EDPP, each Lean Program has three stages of development: Diagnosis, Implementation and Support/Sustainability

1. Diagnosis: this phase consists on, detection of problems, opportunities for improvement and definition of initiatives to be implemented;
2. Implementation: in this second phase development and implementation of initiatives are made;
3. Support/ Sustainability: Finally, the Coordinators of Lean Program guarantee the participation of all employees, in order to: better identify opportunities of improvement, promote sharing of information and knowledge to all areas involved.

The methodology of phases 1 and 2 area already consolidated through all the company. Therefore, Lean at EDPP is, now, at the support/sustainability phase. As Bicheno and Holweg (2009) say "… there is no self-sustainability; it requires ongoing efforts in the areas of processes and systems and people."

The sustainability of the program depends, mainly, on the attitudes and behaviors of all employees. In this sense, there are four axes, on which their mindset must be guided (with the purpose of integrating Lean as strategy and way of working):

1. Stimulation and Creation of Visibility Changes, that can be achieved by regular communication,
2. Management Visualization of the Problems, through continuous publication of the initiative's evolutions and some lean events.
3. Promotion of Formal Reinforcement Mechanisms, based on regular meeting routine and on the promotion of practices that ensure the integration of the program in the day-to-day organization
4. Developing talent and capabilities, because the support areas must maintain a continuous training plan and promote Rotation of Functions and sharing of experiences among all the teams of the organization.

The elaboration of the Lean Program Manual is part of the DEC´s (or Efficiency and Digitalization Department) activity plan. Until the preparation of the final Manual, some intermediate steps are carried out:

DEC elaborates a draft of this manual and sends it to the Coordinators of local programs. These, in turn, make their evaluation and return the draft with comments added. Then, DEC consolidates the draft version of the Manual with the comments received.

After this consolidation is done, DEC sends the document to the CA (Board of Directors) for approval. In case, they do not approve the preliminary version of the Manual, this document is return to Dec for rectification. Once rectified and approved by the CA, DEC shares the document in SGD (EDPP official document platform).

In the same way that the manual is found in DEC's activity plan, this department is also responsible for the training of EDP Produção employees in the Lean methodology and tools.

This training is prepared by DEC but is supported by the local program coordinators who usually define the participants, as well as the date and place of it.

After the training, the employees from the departments involved, will be able to identify improvement opportunities that should be optimized. In order to better understand how the initiatives are managed, the process of management and monitor by DEC will be explained later.

4.6. Monitor and follow up of Lean initiatives

Since 2013, DEC decided to finish the Audits to the lean program. Now, the existing process is called *Avaliação de Diagnóstico e Acompanhamento* (Diagnosis Evaluation and Follow-up, in English).

It was pretended, with this change, eliminate the formalisms and reduce the negative charge on the word Audit, that employees consider that usually causes discomfort and that the sharing of initiatives did not come so naturally.

The main objectives of the diagnosis and follow-up of the Lean program are:

a. Understand how the Lean program is developed and perceive its maturity status;
b. Power and promote the standardization of concepts;
c. Analyze some of the initiatives:
d. Promote the sharing of knowledge and experiences, as well as to facilitate the replication of initiatives among the departments.

DEC is responsible for the developing the *Programa Anual de Diagnóstico e Monitorização* (Annual Lean Diagnosis and Monitoring Program, in English). This program is made at the various local programs and consists on monitoring the execution of the program as well as on the consolidation of the information collected and on the following up.

Throughout all the program activities, DEC tries to help the departments with the problems that might arise.

Nowadays at EDP, the program is based on the follow-up of the initiatives of each department and the sharing of these between the various departments.

Both the Lean Program manual and DEC´s activity plan work as an input to the preparation of the Annual Diagnosis and Monitoring Program. This plan, after being drawn up, is sent to Coordination of Local Programs for evaluation. If it is in accordance with the defined parameters, the process of sharing initiatives continuous. Two teams are formed and participate in each process: The Visiting Team and the Visited Team. After the first round, there is another round in which these teams change position.

DEC starts the process of preparation of the Diagnosis and Follow-up sessions, sending the necessary information for the sessions (such as location and date). Then, the Coordinator of the Visiting Local Program chooses the team that will participate in the session and that will visit the other department. This team is called Visiting Team. In the same way the coordination of the local Program of the Visited Team constitutes the team that will receive the colleagues.

The Visiting Team chooses the initiatives (through the LINK platform) that can be replicated in its department and sent to the Visited Team. Throughout the session, the chosen initiatives are presented, and each team makes the questions that consider necessary and relevant.

After the sessions, the Visiting Team prepares the report and sends it to the other three areas involved: the Visited Team, the local coordinators of each team and to the DEC, which is responsible for inserting the report on the LINK platform, so that everyone can have access.

In a later phase of conclusion and reflection, the Visiting Team considers if it has aspects to improve, coming from some recommendation of improvement throughout the session. With the analysis made, if they come to the conclusion that they have aspects to improve, they will do an action plan. But if they don’t think that have anything more to improve, they give the action as completed.

Lean Tracking

Every year, DEC proposes the agenda for the presentation of the Lean Program to CA. This, after evaluating, sets the date for the follow-up.

With the inputs of the coordinator of the local programs, Dec prepares the presentation with the initiatives of the various departments their results and next steps.

This presentation is then sent to CA and shared on the Link portal. It works as the lean activity aggregation document for each year.

4.7. Lean Program Performance Indicators

Before explaining how this process is done, it is important to explain what Key Performance Indicator (KPI) is. A Key Performance Indicator is a measurable value that proves how effectively a company is on reaching key business objectives. Organizations use KPIs at multiple levels to measure their success at reaching targets.

Define and monitor program KPIs by DEC

The proposed definition of lean KPIs for each department is part of DEC's business plan.

The local program coordinator evaluates the proposal for your department and submits it with comments on your KPIs lean to DEC. This consolidates the lean objectives set for each department and sends it to CA.

If the CA does not approve, it identifies which corrections to make, otherwise approves and follows up.

Quarterly DEC requests departments to update the status of the benefits of the initiatives, then update this information in GIL2WIN

After updating the information, DEC prepares a program monitoring report which is then formally sent to the CA and other departments.

The communication of benefits between the departments and the DEC is made through Teams, a Skype-like communication platform that has the particularity of being able to draw graphs from the information sent.

Lean Performance Indicators

The Lean Program has changed the performance indicators according to the development phase they were in. Therefore, now at the sustainability phase, the established yearly Key Performance Indicators (KPI) for Lean Initiatives are defined by two main indicators:

a. Number of initiatives to be completed;
b. Financial benefits or savings.

Each year, every Local Program defines objectives to be fulfilled for the following year and these goals are often based on the history of each program and on the pipeline of improvement initiatives proposed by the collaborators. In addition, DEC must support the local programs to achieve the desired results. Each Lean KPI from each producing center reverts to the Performance KPI of each producing center.

At the beginning of each year, and before defining the KPI for that period, there is made an analysis if the results of the previous years to identify problems and difficulties but also methods to replicate in other departments.

On Table 4.1 it is possible to observe the comparison between the defined goals for the KPI and the real results after the end of the year. On the first column there are enumerated the various departments of EDPP. On the second and third columns there are quantified the goals for the number of initiatives to be implemented and the real number of implemented initiatives, respectively. On the fourth column there are defined the goals for the benefits of the initiatives, in k€, and on the fifth column the real benefits attained, also in k€. On the final two columns there is calculated the ratio between the real values and the goals of the number of initiatives and the benefits.

Analyzing the table there are some values that pop out, for example the completed initiatives of DCC-ACF/ACM, DCL, DST and especially DRM. These are great examples of EDPP's mentality of Lean Thinking, since these departments implemented more initiatives than what they have initially proposed to, in order to achieve greater savings. On the other hand, departments like DOC and DOT failed to implement all the initiatives they have aimed for. But the number of initiatives shouldn't be analyzed independently from the benefits that resulted from the implementation, since for example ACP implemented the exact number of initiatives that they have proposed to but achieved the highest ratio of real benefits to the goal of benefits, while APS also implemented the exact number of proposed initiatives, but had no benefits, since the initiative didn't have the planed results. Also, DRM that was just highlighted for the high difference between implemented initiatives and proposed initiatives, has obtained just 40% of the benefits it was aiming for. This shows that, although the greater the number of initiatives the lesser the wastes in its process, sometimes initiatives don't have the expected result, at least on the short-term. But this doesn't mean that initiatives with low prospective benefits should be overlooked instantly. There should always be made an analysis on the long run to evaluate this initiative and it should also be considered the workers conditions, as sometimes the concern for the workers should be more important than the financial benefits.

Overall, EDP Produção has implemented 9% more initiatives in 2018 than it was projected at the beginning of that year, but it achieved 2,70% less benefits or savings than what was expected. In absolute numbers, EDPP implemented 2100 initiatives in 2018 that resulted in

benefits of more than 2 M €, which shows that even after 12 years of Lean initiatives it is still possible to achieve great results.

Table 4.1 – Goals of the Lean Program (2018). Adapted from lean report EDPP.

Department	Completed initiatives		Benefits (k€)		Achievements	
	Annual goal	GIL2WIN 4T18	Annual goal	Dep. Info. 4T18	Completed Initiatives	Benefits
ACM	1	1	7,5	1,12	100%	14,90%
ACP	1	1	7,5	14,08	100%	187,70%
AEN	2	2	7,5	3,15	100%	42,00%
APS	1	1	7,5	0,00	100%	0,00%
DCC-ACF/ACM	7	9	145	200,26	128,60%	138,10%
DCC-LR	14	15	190	217,93	107,10%	114,70%
DCC-RJ	14	15	145	191,47	107,10%	132%
DCL	14	17	240	270,14	121,40%	112,60%
DDR	14	14	225	203,33	100%	90,40%
DEB	5	5	45	3,73	100%	8,30%
DEC	4	4	70	34,16	100%	48,80%
DOC	2	1	35	15,44	50%	44,10%
DOH	4	4	100	75,79	100%	75,80%
DOT	4	1	175	141,47	25%	80,80%
DRH	2	2	30	14,40	100%	48,00%
DRM	2	6	20	7,96	300%	39,80%
DSN	14	16	260	242,94	114,30%	93,40%
DST	3	4	125	139,33	133,30%	111,50%
DTM	14	15	265	267,49	107,10%	100,90%
EDP Produção	**122**	**133**	**2100**	**2044,19**	**109,00%**	**97,30%**

The initiatives may arise from different ways: employee proposals, recommendations for incident analysis reports, meetings between operations and maintenance, among others. These initiatives comply with certain selection criteria:

1. Focus on the scope of goals that are intended to be achieved;
2. Increase qualitative benefits such as changes in attitudes and behaviors, increases in productivity, rationalization of the use of time;
3. Quantitative benefits must be greater than the implementation effort;
4. Overhead costs (e.g., the cost of making equipment unavailable to implement the initiative), and costs with services and materials (implementation may imply the purchase of services and/or materials to external entities).

4.8. EDPP Lean Evolution

The year 2019 represents the 13th birthday of the Lean Program for EDPP but it also marks the 31st anniversary of the publication of Taichii Ohno's book on the matter which means, considering that EDP exists as a company longer than that, it took some time to be accepted as worthwhile methodology to be implemented

Regardless the timing, the most important factor to analyze is the company's commitment to this methodology since it has been implemented. Observing Figure 4.7 it is possible to verify that there has been a continuous bet on Lean Initiatives over the years. The chart has the accumulated values of the number of initiatives that where proposed and those that have been successfully implemented. Both columns have grown year to year, although it was never possible to implement all the proposed initiatives.

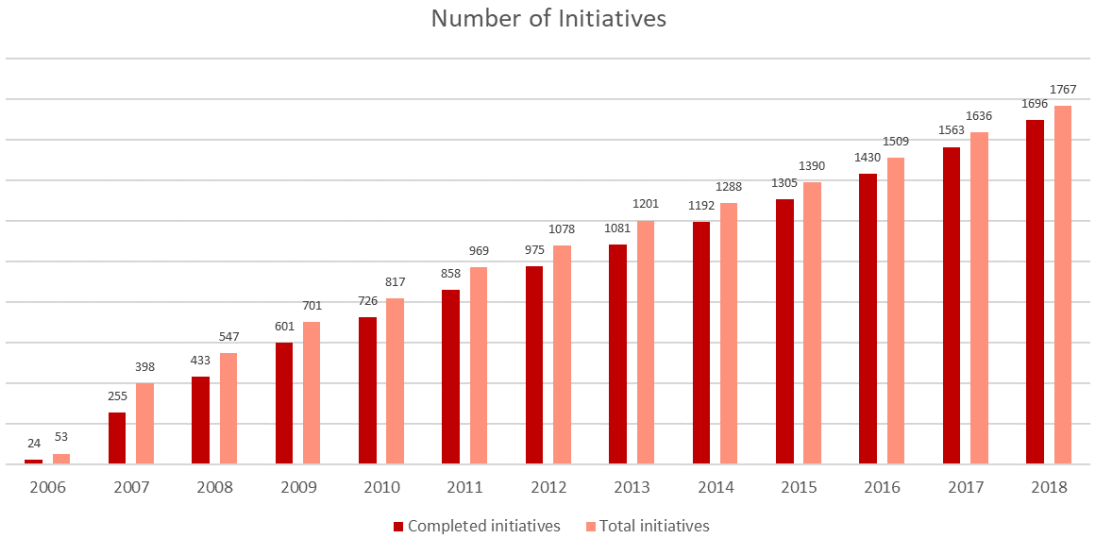


Figure 4.7 - Evolution of the number of initiatives since 2006 (accumulated values).

It is to be noted that the greater increment of initiatives was between 2006 and 2007, which is perfectly justified because it corresponds to the beginning of the implementation of the program. Since that the first phase of the program had to pass through problems' evaluation and its proposals of resolution. Innumerous initiatives have emerged in several producing centers related to the availability of equipment, which had to be improved in favor of efficiency. Other initiatives in security and energy efficiency area have also contributed greatly to this increase. This initial increment is in line with the beginning of the implementation of the methodology in organizations, because at the outset there are opportunities for visible and simple improvement to identify, which translates into an initial motivation to continue the implementation of the methodology.

On the Figure 4.8 and Figure 4.9 it was charted the increase of the number of initiatives each year and the percentage of growth of the number of initiatives regarding the year before, respectively. These Figures help comprehend how has EDPP been dedicated to the Lean Thinking methodology and it is possible to observe that in the first years there was a big slow down on the number of implemented initiatives. Inclusively on Figure 4.9 the data from the year 2007 was eliminated because there was such a great increase from 2006 that it made the chart unreadable.

It is also clear the effect of the 2008's Financial Crisis that affected Portugal and caused the investment to be cut and, with it, the number of initiatives also took a slum. From 2014 it can be noticed a slight recovery.

As mentioned before, the goals for the initiatives are set by CA according to the previous years and in recent years the goal for the number of initiatives has been slowly growing, but overall the growth is on a descending curve since 2007 which is opposed to the absolute values but is a natural reaction of the increasing, but almost steady, bet on Lean Initiatives.

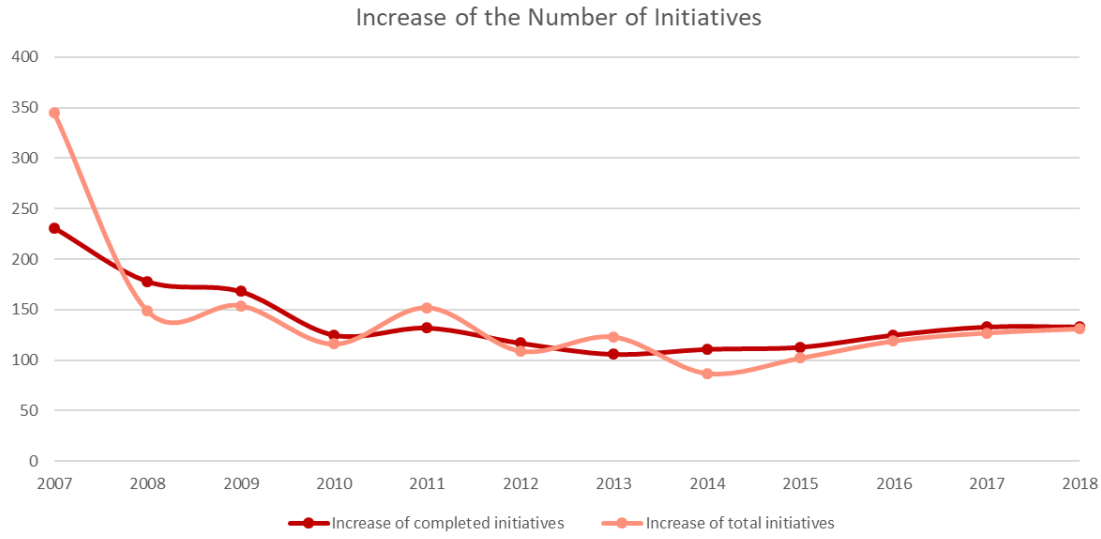


Figure 4.8 - Evolution of the increase in the number of initiatives since 2016.

As the identification and elimination of waste is increasing, this rise is becoming less visible, being harder to find and defining improvement proposals and solutions, thus the number of annual improvement proposals has diminished. Having said this, it is also necessary to realize that the methodology implemented in the producing centers is simpler to apply than in other areas of the organization, because it easier to identify the activities with major waste associated. However, the difficulty is not an impediment to implementing the Lean in other areas, and the organization is focused on defining solutions for other areas that are not only linked to critical energy production activities. As stated on Chapter 2., there is

perfect company with no opportunities to improve. It becomes harder and harder to find wastes that are worth eliminating (especially due to the investments required), but they are always present and it will always be possible to make EDPP more efficient.

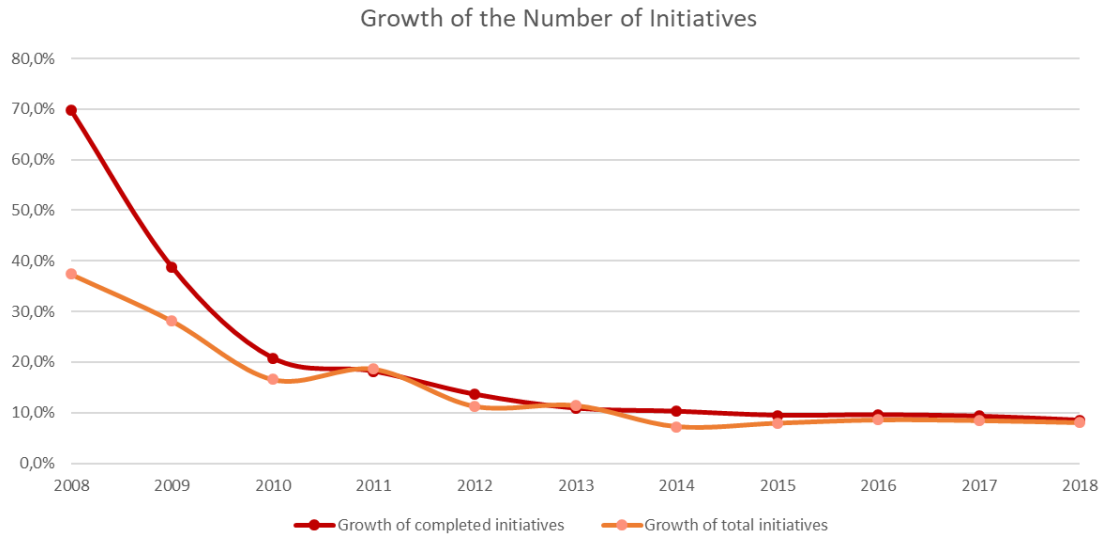


Figure 4.9 - Percentage of the growth in the number of initiatives since 2017.

"When you move from producing centers to more administrative areas, there is even greater concern about showing" quality "of the initiatives because in these areas it is much more difficult to quantify benefits such as people's time management, faster customer responses, and other difficult benefits to quantify."- EDP Employee

On the other hand, there is a significant increase of initiatives in the year of 2018, this increase was due to many activities that were robotized. The hours dedicated to these activities (called spared hours) are now allocated to other activities / processes that add more value to the company.

One of the tools that is increasingly emerging in the business world is Robotic Process Automation (RPA). With this tool, employees configure advanced software or robot (also known as bot) to perform routine processes. The biggest benefit for companies is that tasks are performed more efficiently and with a lower margin of error, reducing labor costs (Figure 4.10).

There are several reference technology solutions on the market. The tool selected by EDP in Iberia has the characteristics appropriate to EDP's ecosystem and architecture and the type of automation intended. The tools selected were the Blueprism and the Uipath software.

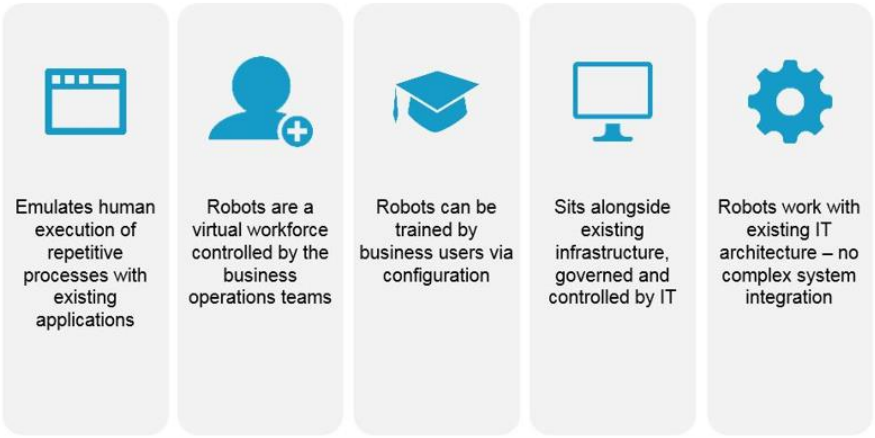


Figure 4.10 – Automation of Business Processes. Adapted from an institutional presentation.

The most appropriate processes for implementing an RPA solution are (https://www2.deloitte.com/pt/pt/pages/strategy-operations/articles/robotic-process-automation.html):

- Repetitive activities that add little value to the worker;
- Error-prone activities;
- Activities with rules implemented and with transport and data transfer;
- Activities with high administrative burden.

The benefits of RPA solutions are not just about cost savings. It also involves:

- Decreased cycle times and improved efficiency;
- Flexibility and scalability;
- Higher accuracy;
- Better customer and employee experience/satisfaction;
- 24/7 availability.

4.9. Example Cases

As shown in Figure 4.7Figure 4.7 - Evolution of the number of initiatives since 2006 (accumulated values)., as of 2018 there were over 1700 initiatives implemented at EDPP which means that it is not feasible analyze all in detail in this work. Nevertheless, it is important to show examples of real initiatives implemented at EDPP to understand how the results detailed on Chapter 5. Pedagogical Note were obtained.

There were chosen 7 initiatives from 2018 and 2019 because the accuracy and quantity of data are greater, and the A3 Reports of each case are presented on Annex A.

It is also transversal to all of the initiatives at EDPP that the benefits are divided in four groups: Costs Reduction (OPEX), Profits Increase, Avoided Costs and Labor Costs (considered 40 € per hour/worker).

Initiative *Validação de contagens de energia*

This initiative, which the A3 Report is shown at Annex A1, was developed in 2018 by the DOH (Departamento de Optimização Hídrica) and its objective was to reduce wastes on confirming and validating data.

EDPP utilizes two informatic tools to register the quantity of energy produced at hydroelectric power plants: GPinfo and Skipper. In general, the information transmitted by the two platforms matched, but sometimes the values differ for many reasons. This discrepancy should be corrected in order to evaluate the real results of the energy production at any given moment and this was a manual and time-consuming task.

Having identified the waste, the Operational Management Área – AGO (Área de Gestão Operacional) proceeded to apply the 5 Whys tool, explained before, to get to the root cause of this problem and a tool was idealized to automatically validate the entries from both platforms and to upload the data on Skipper's data base, due to the size of the date.

Three persons where involved in this project which lasted for 23 days and the costs involved where only labor and it was solved by created an Excel Macro that led, not only to labor costs reduction, but also to operational and reliability improvement. This tool still requires that a worker checks the data before a final validation, but the process is now more standardize and easy to follow through.

Due to the great results obtained, EDPP is considering implementing this tool to other data collection tasks that show the same problems.

Initiative *Otimização do processo de distribuição das ordens de manutenção preventiva*

The translation of the name of this initiative to English is Optimization of distribution process of the preventive maintenance orders and, as name indicates, it was focused on improving the method of sending the purchase orders of preventive maintenance to EDPP's suppliers in order to reduce the time wasted on processing them.

In Annex A2. it is possible to observe that the tool to identify the stages of the process that could be improved was VSM, which consisted in mapping all the actions that must be made to originate the maintenance orders with the SAP tool, measuring the time consumed at each action and identifying which of those could be improved.

In order to reduce the repetitive tasks, EDPP decided to implement RPA and automate some of the time-consuming tasks and for it it was utilized the PDCA tool. Although not well represented, the PDCA tool was applied according to what was described before and started with Check before the PDCA. The first Check was mistakenly incorporated in the Plan stage.

For this specific case, each Plan stage consisted in evaluating the time of each SAP action, followed by characterization and testing on the Do stage, then at the Check stage the benefits were evaluated and finally at the Act stage the replication of this method was also evaluated.

Like in the initiative presented before, EDPP's decided to investigate if this method could be applied to other similar cases.

Initiative *Monitorização das perdas de H_2 nos alternadores*

At Sines power plant there are installed alternators that require hydrogen (H_2) in order to function properly. This equipment has leakage of H_2 that must be constantly corrected by adjusting the flow of hydrogen. The system that was implemented before this initiative didn't allow for an efficient control of hydrogen intake.

As demonstrated in Annex A3., EDPP developed a page that received data from OSI/Skipper on how the pressure of the alternators fluctuated daily and chart a graph of the batteries' performance depending on this value. This tool also allowed to identify great H_2 leaks faster than before and thus act accordingly.

This initiative was successfully implemented in 2019 and there were no restraints, which proved to be a great success on waste reduction.

Initiative *Reestruturação dos ambientes de operação e engenharia na Central de Sines*

At the same power plant, EDPP also implemented an initiative for restructuring the operating and engineering environments in use on this site (Annex A4). This initiative was based on the 5S tool, more accurately *Seiri* and *Seiton*, ultimately leading to *Seiketsu* and *Shitsuke.*

This initiative was originated because there was a need to carry out the Continuity Plan of Sines Power plant and this required to create an additional command center, which should be constituted by 11 Control System Operating Stations.

Each of these stations, that are computers whose main function is to output the command and process information, has a considerable cost and require a large investment in configuration, so it revealed an opportunity for applying Lean Thinking before acting.

After a first analysis, it was verified that there are 57 stations at this power plant that are distributed among several rooms along this site, and some of them were not exploited to their

full capacity, so EDPP started with *Seiri*, which means Structuring and defined that there were 11 stations that were not needed for the normal operation of the power plant, so they followed that with *Seiton*, or Systemize, and rearranged the working stations on a more efficient disposition and achieved their target.

These changes created an impact on the workers of this power plant, by observing what the capabilities of Lean Thinking were and became more involved to try and cause an impact on the company (*Seiketsu*) and became more implicated on sustaining this kind of view at their site (*Shitsuke*).

This initiative of earlier this year, had some setbacks, mainly on reactivating of a network infrastructure disabled since 2013 and it requires a more closed monitoring for any possible problems originated with the changes, but the benefits of it overcome any possible difficulties.

Initiative *Melhoria do Template OBZ*

On the Annex A5. it is described an initiative developed by the Support Department that was achieved using the 5W2H tool, that is an upgrade on the 5 Why's described earlier. As stated by Bicheno and Holweg (2009), Rudyard Kipling created a tool that can be more powerful than the 5 Whys, because it is supported on it but is broader in trying to identify the real root cause of the problem. The name of this tool is Six Honest Working Men as it refers to the six following questions: What?, Why?(5 Whys), When?, Where?, How? and Who?; and it is also referred to as 5W1H by many authors due to the first letters of each question. Later, as described in Rumane, A. R. (2013), this tool evolved to 5W2H when the question How much (does it cost)? was added, that allowed to observe the real impact of the problem as it is being presented.

In this particular case, the department responsible for the Communication of the company, Área de Comunicação e Marca (ACM) had a template to analyze and report all the activities, including their budget, that could be improved. The tool was utilized as it follows:

- What (is the problem)? – Time consumed gathering information until OBZ closes;
- Why (does it occur)? – There are different means for the gathering of this information that result in information getting lost or being incorrect and also in waiting time;
- When (did it start)? – Since June 2017;
- Where (does it happen)? – ACM;
- Who (is involved)? – Every UO at EDPP;
- How (did the problem start)? – Overlapping means of gathering information;

- How much (does it cost)? – 1.120€ yearly.

To reduce this waste an Excel template was developed to make this the process faster and error proof that was to be filled by each UO. The only cost on developing it was the labor time, which only needed to be done once.

The major constraint that occurred after the implementation was the difficulty of each UO to understand the rules for filling the document, but after some training it was overcome and it is now the standard procedure.

Initiative *Melhoria do PRC Vender Energia*

Another example of EDPP's use of 5W2H is shown on Annex A6., which is an initiative of 2018 on which it was also used RPA as a solution.

In this situation, it was identified a waste on the Contracts Management Area (DRM--AGC) because there are several tasks that are repetitive and don't need constant human analysis, especially on emitting Purchase and Sale Orders.

The 5W2H tool was used as follows:

- What (is the problem)? – Time consumed performing repetitive tasks;
- Why (does it occur)? – These are essential tasks of the process Sell Energy;
- When (did it start)? – Since this process was created;
- Where (does it happen)? – DRM-AGC;
- Who (is involved)? – DRM-AGC and EDP Valor;
- How (did the problem start)? – With the increase of tasks associated to Sell Energy, there was an accumulation of activities;
- How much (does it cost)? – 18.240€ yearly.

Due to the high costs and, consequently, high possible returns EDPP decided to act and implement autonomation on this task and, in consequence, dispend more time in more attention needing activities.

This initiative only required to invest time of the company's workers in order to be achieved. It involved programing code in UIPatch that allowed for the monthly invoices to be aggregated in an Excel file, for the Purchase and Sale orders to be sent and for an e-mail with important information to be sent to EDP Valor all automatically.

This initiative, although working as it is supposed at the moment, had some difficulties in its implementation at the beginning.

Initiative *Otimização do controlo da drenagem da fossa do transformador principal do grupo 1*

The final initiative was chosen to show the involvement and commitment of the company's workers in applying Lean Thinking – the final stage of Standardization.

This initiative (Annex A7) doesn't represent any direct profit for the company, as there is no current waste solved, but it shows EDPP's concern for the environment and sustainability of the planet.

At Castelo de Bode power plant, that uses Hydric Energy, the main transformer has a cesspool that is drained by two pipelines. One of them goes directly for the river and the other for drainage well of the power plant. Both these pipelines have manual valves and as a principle, the pipeline that goes for the river is always closed and the other always open.

The workers and supervisors of this power plant, applying the *Genchi Genbutsu* technique, verified that is there was an oil leakage at the transformer, the oil goes to the drainage well and the to the river by the drainage pumps installed. If this happens there is a chance of a great environmental disaster that could affect the biodiversity at this region and would also signify a large fine for the company.

The first solution that was proposed was to close both valves and only opening them if there was a confirmation of no leakage, but soon this was discarded because this drainage well is higher than the greater part of the installations of this power plant and there was a risk of returning this residues to the site.

The approved solution was to install a motorized valve that would close if there was any alarm from the transformer. This prevented any leakage for the river while guaranteeing the correct operation of the power plant at normal conditions.

There is no immediate benefit for this initiative, only costs in installing the pump, but these costs are negligible when compared to any accident that could occur at the river. The next steps for this initiative are to replicate them at the remaining transformers of the power plant and at the transformers of similar power plants.

4.10. Resolution – analysis of the data

The objective of implementing Lean Thinking methodologies and tools in a company is not the reduction of wastes *per se*. The elimination of the wastes must be accompanied by an increase of profits, mainly by reduction of costs, or an improvement of the procedures that leads to a safer working environment.

Only these goals convince managers and shareholders to invest in Lean initiatives across all companies and EDPP is no exception. For this reason, it is important to show what the

financial impact of implementing the Lean Program has been at this company, detailing the initiatives mentioned at 4.9. Example Cases.

For the initiative *Validação de contagens de energia* the financial benefits identified in the A3 report are of 10.400 € per year, or 866,67 € per month, and it implies an investment of 3.040 € in December of 2018. This means that at the start of the month of December 2018 the company started to invest working hours in this initiative and by the end of that month there was a total of 3.040 € invested. At the beginning of January, the profits started to be collected. As it can be seen on Figure 4.11, for the first month there are no benefits only costs. Then, in January the benefits start to rise and cross the costs line during the month of April. This results that after 6 months of the beginning of this initiative the company hits the break-even point and starts benefiting from the investment.

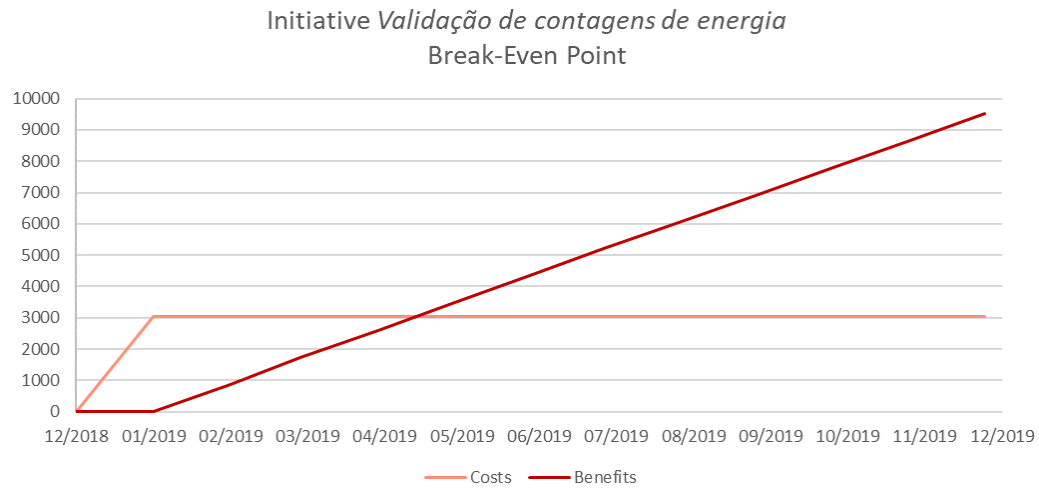


Figure 4.11 – Break-Even Point of the initiative Validação de contagens de energia.

Another important tool to utilize before making an investment is the Net Present Value (NPV) calculation, which helps to evaluate what will be the value of a certain investment after a certain period *t*. To be interesting the NPV must be higher than 0 and in a short period of time, in this case it will be made an evaluation of 3 and 5 years. The equation is as follows:

$$NPV = \sum_{t=0}^{n} \frac{C_t}{(1+r)^t} \tag{4.1}$$

In which *n* is the number over years considered for the analysis, C_t the cash flows of every year and *r* the discount rate, in this case it is equal to the Weighted Average Cost of Capital (WACC) that represents the rate that could be obtained from the money if it weren't invested in this initiative. ERSE (2017) defined de WACC for energy companies in Portugal at 5,75%, do that is the value to be used.

Computing equation 4.1 for 3 and 5 years it is obtained:

$$NPV_3 = \sum_{t=0}^{3} \frac{C_t}{(1+0{,}0575)^t} =$$

$$= \frac{-3040}{(1{,}0575)^0} + \frac{10400}{(1{,}0575)^1} + \frac{10400}{(1{,}0575)^2} + \frac{10400}{(1{,}0575)^3} \cong 24.888\ €$$

And

$$NPV_5 = \sum_{t=0}^{5} \frac{C_t}{(1+0{,}0575)^t} =$$

$$= \frac{-3040}{(1{,}0575)^0} + \frac{10400}{(1{,}0575)^1} + \frac{10400}{(1{,}0575)^2} + \frac{10400}{(1{,}0575)^3} + \frac{10400}{(1{,}0575)^4} + \frac{10400}{(1{,}0575)^5} \cong$$

$$\cong 41.068\ €$$

These results mean that an investment made in 2018 would have an accumulated return of 24.888 € in 2021 and 41.068 € in 2023, which are very attractive results.

The final important value to calculate is the Internal Rate of Return (IRR) which is the rate of profitability of the investment. This calculation is done by equaling the NPV equation to 0 and finding the rate *r*. This results that:

$$NPV_3 = 0 = \sum_{t=0}^{3} \frac{C_t}{(1+r)^t} \Leftrightarrow r \cong 338\ \%$$

And

$$NPV_5 = 0 = \sum_{t=0}^{5} \frac{C_t}{(1+r)^t} \Leftrightarrow r \cong 342\ \%$$

Which are obviously very interesting rates and explain why this imitative was implemented.

Opposed to this example is the initiative *Otimização do controlo da drenagem da fossa do transformador principal do grupo 1*, which has a cost of 4.000 € on the first year and doesn't have any defined benefits. The only benefit that EDPP can have with it is in the case there is a fine from the government because of leakage to the river. As commented before, the implementation of this initiative results from the company's commitment with sustainability and not to increase its profits. Nevertheless, it is possible to calculate what should be the fine if the accident occurred 3, 5 and 10 years after implementing the initiative in order for EDPP to obtain a benefit. This is done by setting NPV equal to 0 and defining all cash flows equal to 0 except the cash flow from the year considered for the accident. This results in:

$$NPV_3 = 0 = \sum_{t=0}^{3} \frac{C_t}{(1+0{,}0575)^t} \Leftrightarrow C_3 \cong 4.730\ €$$

Or

$$NPV_5 = 0 = \sum_{t=0}^{5} \frac{C_t}{(1+0{,}0575)^t} \Leftrightarrow C_5 \cong 5.290\ €$$

Or

$$NPV_{10} = 0 = \sum_{t=0}^{10} \frac{C_t}{(1+0{,}0575)^t} \Leftrightarrow C_{10} \cong 7.000\ €$$

This means that if the fine is higher than 7.000 € the company benefits financial for the first ten years after the initiative is implemented. As it is impossible to predict the value of the fine there it isn't easy to evaluate if this is a good investment, but considering the results calculated it is possible that this was a good decision, besides the sustainability benefits.

The next initiative to be analyzed is *Otimização do processo de distribuição das ordens de manutenção preventiva*. According to the A3 report of this initiative, there is an initial investment of 3.600 € at the end of January 2019 and then the company benefits 240 € every week plus 300 € every month, which translates to 16.080 € yearly. On Figure 4.12 it is possible to observe that the break-even is obtained during the month of April 2019, which means that after 3 months of having the initiative in motion, EDPP starts benefiting from it.

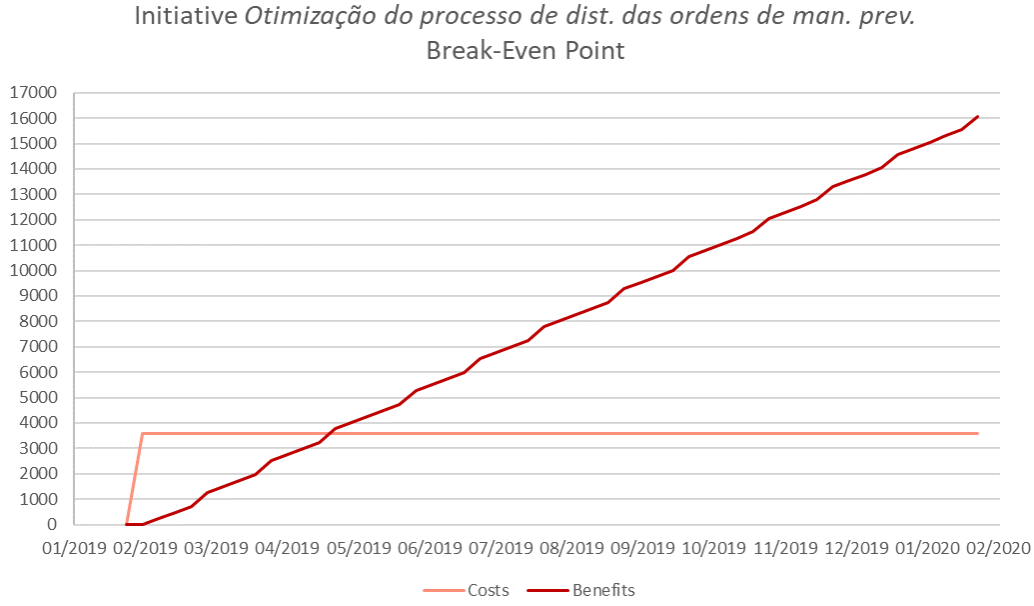


Figure 4.12- Break-Even Point of the initiative Otimização do processo de distribuição das ordens de manutenção preventiva.

Considering the periods of 3 and 5 years, it is interesting to compute the NPV of this investment also:

$$NPV_3 = \sum_{t=0}^{3} \frac{C_t}{(1+0{,}0575)^t} \cong 39.582\ €$$

And

$$NPV_5 = \sum_{t=0}^{5} \frac{C_t}{(1+0{,}0575)^t} \cong 64.598\ €$$

These values are very high and even more attractive than the initiative *Validação de contagens de energia*. In fact, computing IRR it results in:

$$NPV_3 = 0 = \sum_{t=0}^{3} \frac{C_t}{(1+r)^t} \Leftrightarrow r \cong 444\ \%$$

And

$$NPV_5 = 0 = \sum_{t=0}^{5} \frac{C_t}{(1+r)^t} \Leftrightarrow r \cong 447\ \%$$

These values of the Internal Rate of Return made for the initiative to be approved and successfully implemented.

For the initiative *Monitorização das perdas de H_2 nos alternadores* the investment costs haven't been calculated yet, but it's known through the A3 report that the costs that EDPP will have to support are labor hours in the development of the webpage. Having the benefits of 1.200 € per year it is possible to calculate what is the maximum amount of time that the company can invest in this project in order for it to be profitable. This is done by stating that NPV >0 for 3 and 5 years and calculating C_0, or the initial investment, considering that 1 hour of labor costs the company an average of 40 €. This results in:

$$NPV_3 > 0 \Leftrightarrow \sum_{t=0}^{3} \frac{C_t}{(1+0{,}0575)^t} > 0 \Leftrightarrow C_0 < 3.223\ €$$

And

$$NPV_5 > 0 \Leftrightarrow \sum_{t=0}^{5} \frac{C_t}{(1+0{,}0575)^t} > 0 \Leftrightarrow C_0 < 5.089\ €$$

This means that if EDPP expects a return on its investment after 3 years they can invest up to 80 hours on developing the program and if the goal is a return after 5 years this number rises to 127 hours.

Similarly, the for the initiative *Reestruturação dos ambientes de operação e engenharia na Central de Sines* EDPP also doesn't have calculated the investment, which is just labor hours too. But in this case the benefits are not cumulative over the years, they are what is called the Opportunity Costs, which consists in the difference between the best foregone option and the chosen option. In this case the option that was not adopted was an investment 192.500 € in new stations and 16.700 € in configuring them. This sums up to a total of 209.200 €. If the option chosen needed an investment of less than 209.200 € it should be chosen and considering that what was proposed involved only the labor of reconfiguration and rehabilitating equipment it only needed labor hours. Thus, if EDPP could achieve the needed results 5.230 hours, or what is 2 persons working every day for almost an entire year on this, it is the best option.

For the initiative *Melhoria do Template OBZ* the investment is also unknown and the benefits were estimated as 1.120 € yearly, so it is possible to compute the maximum investment in labor hours for this initiative to be profitable. Utilizing the same method as in the initiative *Monitorização das perdas de H_2 nos alternadores* the results are:

$$NPV_3 > 0 \Leftrightarrow \sum_{t=0}^{3} \frac{C_t}{(1+0{,}0575)^t} > 0 \Leftrightarrow C_0 < 3.008\ €$$

And

$$NPV_5 > 0 \Leftrightarrow \sum_{t=0}^{5} \frac{C_t}{(1+0{,}0575)^t} > 0 \Leftrightarrow C_0 < 4.750\ €$$

Which translates into 75 labor hours for the investment to be profitable within three years and 119 labor hours for a five years period.

Finally, for the *Melhoria do PRC Vender Energia* initiative the case is similar since there are no estimated costs and the benefits were calculated.as 18.240 € per year. The maximum investment in labor hours must be:

$$NPV_3 > 0 \Leftrightarrow \sum_{t=0}^{3} \frac{C_t}{(1+0{,}0575)^t} > 0 \Leftrightarrow C_0 < 48.982\ €$$

And

$$NPV_5 > 0 \Leftrightarrow \sum_{t=0}^{5} \frac{C_t}{(1+0{,}0575)^t} > 0 \Leftrightarrow C_0 < 77.359\ €$$

Or in hours, 1.225 hours for a three-year period and 1.934 hours for a five-year period.

As it was demonstrated, every initiative must be analyzed by itself independently (with the exception of two or more initiatives that might interact with each other and allow for higher profits when combined) in order to decide if it is a good investment.

Nevertheless, these analyses don't translate what is the real impact of the Lean Program at EDPP, for that it is necessary to look at the global performance of the program. Consulting the GIL2WIN report of January 2019 it is possible to observe that the investments made in each initiative are not accounted, like the majority of the examples analyzed before. This makes it impossible to conclude if the benefits of the initiatives are overcoming its costs, thus it is not possible to imply if the Lean Program has had a positive or negative impact in the company's financial performance.

As shown in Figure 4.7, there has been a bet on lean initiatives since 2006 at EDPP and the data from this figure is shown in Table 4.2 and Table 4.3. On Table 4.3 it is indicated that there are in development in 2019 73 initiatives. Besides the 2 that started this year, the other initiatives are from previous years and its implementation is still not complete[1]. As it is possible to observe, the number of initiatives raised from 2005 to 2007, then started to drop until 2014 and from then started to raise again. And the number of concluded initiatives accompanied these oscillations.

The profitability of an initiative is not dependent of its state, meaning that an initiative could have profit before being concluded, could only have profit the moment it was concluded or could have profit for perpetuity (or as long as that task is done), so EDPP can be benefiting from an initiative that has been completed or could have benefited one time, but not anymore. On Table 4.4 it is possible to observe that the number of initiatives developed each year has been mostly decreasing since 2007.

Through GIL2WIN it is also possible to verify that EDPP focus is to invest on initiatives of Efficiency and Management Practices, which translates to making processes dependent on less human resources and thus allowing the company to allocate better its resources (Table 4.5).

On Table 4.6 was made an evaluation of the number of initiatives by each Organizational Unit since 2005, being clear that DSN (*Direção de Sines*), with 238 initiatives implemented so far, and then DDR (*Direção do Douro*), with 208 initiatives implemented so far, are the departments where the number of initiatives is greater.

[1] It has been noted that some initiatives are not correctly updated and part of this value might be completed and no in development, but there is no correct way to assess it.

Table 4.2 - Initiatives started by year.

Initiatives started by year	
2005	1
2006	52
2007	345
2008	149
2009	154
2010	116
2011	152
2012	109
2013	123
2014	87
2015	102
2016	119
2017	127
2018	131
2019	2
Total	**1769**

Table 4.3 - Initiatives concluded by year.

Initiatives concluded by year	
2006	24
2007	231
2008	178
2009	168
2010	125
2011	132
2012	117
2013	106
2014	111
2015	113
2016	125
2017	133
2018	133
In Development	73
Total	**1769**

Table 4.4 - Initiatives developed by year.

Initiatives developed by year	
2005	1
2006	53
2007	374
2008	292
2009	268
2010	216
2011	243
2012	220
2013	226
2014	207
2015	198
2016	204
2017	206
2018	204
2019	73

Table 4.5 - Initiatives developed by category.

Initiatives developed by category	
Environment_Energy Efficiency	136
Environment_Atmosferic Emissions and Air Quality	6
Environment_Residues Management and Byproducts	32
Environment_Management of the Water Resource	33
Environment_Others	45
Availability	320
Efficiency and Management Practices	858
Others	25
External Costumers Relations	1
Supplier Relations	17
Health and Safety at Work	296
Total	**1769**

Table 4.6 - Initiatives developed by UO.

Initiatives developed by UO	
ACM	1
ACP	1
AEN	2
APS	1
Support Areas	61
CCCB	11
CCLR	143
CCRJ	151
DCB	41
DCL	173
DDR	208
DEB	12
DEC	25
DOC	4
DOH	15
DOT	9
DPI	37
DRH	6
DRM	11
DSN	238
DST	9
DTM	169
EPI	14
O&M BIO	45
O&M CO	186
O&M-BIO	1
PH TRANSV	14
PTCG	92
PTSB	89
Total	**1769**

GIL2WIN platform has been uploaded with the benefits obtained in 2017 and 2018 from many initiatives. This platform doesn't yet have all the information updated, so it is not possible to know if the reported benefits are the total sum or just part, but is possible to know what at least where the benefits. As explained before, these benefits can be resultant of the

implementation of initiatives prior to 2017 and divided into 4 categories: OPEX (or Operational Expenditures) costs reduction, profits increase, avoided costs and labor costs reduction.

As it can be seen in Table 4.7 in 2017 EDPP had a total benefit of 2,1 M€ from the implementation of lean initiatives, from which 1,25 M€ come from OPEX costs reduction whose major contributor is DDR with benefits of 432.180 €, 293.170 € come from profits increase where DTM (*Direção Tejo Mondego*) benefited 202.430 €, 254.900 € come from avoided costs where almost 50 % are achieved by DCB (*Direção de Castelo de Bode*) and 302.750 € come from labor costs reduction where there is no major contributor.

Table 4.7 – Benefits by UO (2017).

2017	OPEX Costs Reducion (k€)	Profits Increase (k€)	Avoided Costs (k€)	Labor Costs Reduction (k€)
ACM	0,00	0,00	0,00	0,00
ACP	0,00	0,00	0,00	0,00
AEN	0,00	0,00	0,00	0,00
APS	0,00	0,00	0,00	0,00
Support Areas	0,00	0,00	0,00	0,00
CCCB	0,00	0,00	0,00	0,00
CCLR	98,87	0,00	53,54	0,00
CCRJ	93,50	0,00	51,34	27,21
DCB	16,22	0,00	125,59	7,93
DCL	227,27	0,00	0,00	33,18
DDR	432,18	50,14	16,81	2,55
DEB	0,00	0,00	0,00	0,00
DEC	111,35	0,00	0,00	27,53
DOC	0,00	0,00	0,00	52,24
DOH	0,33	0,00	3,92	59,62
DOT	24,00	0,00	3,68	0,00
DPI	0,00	0,00	0,00	0,00
DRH	2,76	0,00	0,00	1,79
DRM	0,59	0,00	0,00	15,00
DSN	124,83	40,60	0,00	0,00
DST	47,78	0,00	0,00	0,00
DTM	69,95	202,43	0,00	29,38
EPI	0,00	0,00	0,00	46,00
O&M BIO	0,00	0,00	0,00	0,34
O&M CO	0,00	0,00	0,00	0,00
O&M-BIO	0,00	0,00	0,00	0,00
PH TRANSV	0,00	0,00	0,00	0,00
PTCG	0,00	0,00	0,00	0,00
PTSB	0,00	0,00	0,00	0,00
Total	**1249,62**	**293,17**	**254,90**	**302,75**

For the year 2018, as it is shown in Table 4.8, the total benefits of the initiatives amounted to 2,02 M€ which represents a 4 % decrease from the year before despite having been completed 133 initiatives. This shows that part of the benefits of 2017 were obtained by initiatives that didn't impact the company after that year. The OPEX costs reduction of 2018 was 546 k€, which is less than a half of the year 2017. The profits increase was of 450.000 €

and there isn't a department that clearly differentiates from the rest in this component, which is greater than the year before. For the avoided costs there was an increase of more than 500 k€ to 790 k€ from one year to the next, where CCLR (*Direção de Ciclos Combinados de Lares*) made the most difference. Finally, the labor costs reduction was of 232.850 € and DOH (*Direção de Optimização Hídrica*) was the department that benefited the most.

Table 4.8 – Benefits by UO (2018).

2018	OPEX Costs Reducion (k€)	Profits Increase (k€)	Avoided Costs (k€)	Labor Costs Reduction (k€)
ACM	0,00	0,00	0,00	1,12
ACP	0,00	0,00	0,00	14,08
AEN	0,00	0,00	2,67	0,48
APS	0,00	0,00	0,00	0,00
Support Areas	0,00	0,00	0,00	0,00
CCCB	0,00	98,00	0,00	0,00
CCLR	0,00	0,00	217,93	0,00
CCRJ	0,00	26,57	123,57	41,34
DCB	3,19	98,39	98,68	0,00
DCL	81,32	64,26	93,57	25,84
DDR	158,55	9,51	13,28	21,99
DEB	0,94	0,00	0,00	2,79
DEC	33,60	0,00	0,00	0,56
DOC	0,00	0,00	0,00	15,44
DOH	0,00	0,00	20,70	55,09
DOT	4,48	0,00	38,99	0,00
DPI	0,00	0,00	0,00	0,00
DRH	0,00	0,00	0,00	14,40
DRM	0,00	0,00	0,00	7,96
DSN	136,38	48,20	39,10	0,00
DST	127,33	0,00	12,00	0,00
DTM	0,30	105,41	130,02	31,77
EPI	0,00	0,00	0,00	0,00
O&M BIO	0,00	0,00	0,00	0,00
O&M CO	0,00	0,00	0,00	0,00
O&M-BIO	0,00	0,00	0,00	0,00
PH TRANSV	0,00	0,00	0,00	0,00
PTCG	0,00	0,00	0,00	0,00
PTSB	0,00	0,00	0,00	0,00
Total	**546,09**	**450,33**	**790,52**	**232,85**

Analyzing this data it is perceivable that EDPP has benefits of around 2 M€ each year from the implementation of lean initiatives. Considering the interest rate given by ERSE of r = 5,75 % it is possible to calculate what should be the invested money (C) if EDPP decided to loan to the bank and have profits of 2 M€ in 3, 5 and 10 years (n) considering simple interest rates (Equation 4.2) and compound interest rates (Equation 4.3).

$$Simple\ Interest = n * r * C \tag{4.2}$$

$$Compound\ Interest = C * (1 + r)^n - C \tag{4.3}$$

For 3, 5 and years the interests should be 6 M€, 10 M€ and 20 M€ respectively in order to have a 2 M€ benefit yearly. This means:

$$SI_3 = SI_5 = SI_{10} = 3 * 0{,}0575 * C \Rightarrow C \cong 34{,}8\ M€,$$

$$CI_3 = C * (1 + 0{,}0575)^3 - C \Rightarrow C \cong 32{,}9\ M€,$$

$$CI_5 = C * (1 + 0{,}0575)^5 - C \Rightarrow C \cong 31\ M€$$

And

$$CI_{10} = C * (1 + 0{,}0575)^{10} - C \Rightarrow C \cong 26{,}7\ M€$$

This means that for EDPP to have the same benefits with a loan to a bank that it has with lean initiatives there must be an investment of at least 26,7 M€ with compound interests if this profit could be obtained only after 10 years. If they were to be obtained the year after, there should be an investment of 34,8 M€ which is a very large sum of money.

4.11. Restatement of the issue

Has it has been shown, the Lean Methodology exists at EDP Produção since 2006 and in 2017 and 2018 it has produced around 2 M€ each year in benefits. The relationship between the benefits and the costs of the Lean Program can't be assessed because not every initiative has these costs calculated and so the real impact of the management's decision of implementing it is not possible to calculate.

This shows that even a decade of experience on Lean Tools doesn't make the company perfect and there is room for improvements on the company's processes.

In addition, after analyzing examples of initiatives that have the implementation costs calculated it was shown that some of the initiatives that are being implemented have great margin for being profitable. As commented before, no company is perfect and it is always possible to eliminate wastes. The fact that EDPP's initiatives are so profitable means that the decisions for the implementation aren't very difficult to make and the wastes that require larger investments or have lower returns are still to be tackle.

In short, the focus of this work is to analyze how the Lean Thinking and the tools that have been provided can positively affect a large company and, at the same time, what should be considered in order to improve the Lean Processes.

5. Pedagogical Note

5.1. The case's target audience

At 31st of May 2019 the Lisbon Stock Exchange closed with EDP shares' value at tenth place in PSI 20, according to Jornal de Negócios (https://www.jornaldenegocios.pt/cotacoes, accessed at 02/06/19), in which PSI20 is a group of the 20 most valued companies in the Lisbon stock exchange.

This shows how great this company is, but its consequence is that the shareholders demand certain financial growth goals that can be hard to achieve in companies so big whose tendency is to start to plateau.

As this market is so well regulated, one obvious way to continue growing is to reduce costs. This can be done, for example, as has been explained so far, by reducing operational costs (OPEX), by reducing the time spent on some activities and by improving the processes of each department and the interconnection among them, etc.

This case study is directed to managers and financial workers of medium and big companies who want to understand how implementing Lean Thinking can help improve the companies' results on the medium-long run.

However, this case study, also has the graduate and undergraduate students of business administration and related areas as indirect target audience.

5.2. Educational objectives

With this case study discussion, readers and participants should be able to:

- Comprehend how Lean emerged at EDPP and why;
- Learn about the evolution of Lean at EDPP;
- Understand how Lean Methodology is implemented and monitored throughout all departments;
- Understand the analysis of the results of this implementation and recognize how this kind of methodology can improve the performance of a big company.

5.3. Methodology

Exposed to the main ideas about this case study, it is important to explain the methodology used to explore this theme.

It was used Secondary data and Primary data, to collect information about the company and about Lean implementation. Firstly, about Lean, it was important to understand

everything about the methodology and its tools. And secondly, understand how EDP is structured, essentially EDPP, and how the company uses lean for their own benefit.

The **Secondary Data** is the data that has already been collected and published by other people. It was collected data from books, academic papers, EDP's website and annual reports, articles from magazines and newspapers, and all the information available on the internet that was useful for the research.

The **Primary Data** is the data that was collected to improving this research with different information. It where done informal interviews to EDPP employees in order to better understand the implementation of Lean at EDPP, its benefits and how it is managed

This case study is about Lean methodology at EDPP and how the company gets profits from using it. Therefore, the research paradigm is all about lean and its benefits to a big company.

The first phase consisted on gathering the fundamental information. In this way, the literature review served as guide to this case study, in order to better understand how lean methodology works, its tools and its benefits. This research was based on secondary data, studies, reports and articles.

Moreover, a market analysis was made, in order to find other examples of the application of Lean methodology. It was chosen three different companies: IKEA, GALP and Luís Simões. The analysis of the application of Lean at each company, allowed to compare the results, in a general way, between them and EDPP.

When it concerns qualitative data, several interviews were made, presently and by phone, to different employees of EDPP, more precisely to the ones of DEC department. In this way, it was possible to understand how Lean emerged at EDPP, how is implemented and monitored and what have been the benefits derived from this application. From these interviews it also resulted the documentation that it was possible or allowed to send, for example the continuous improvement area processes drawn, the A3 documents related to the lean initiatives and the annual benefits from each department.

5.4. Presentation of the set of analytical tools

Analysis between the companies

With a brief research on the application of Lean methodology in other companies, such as IKEA, Galp and Luís Simões, it is possible to compare, in a more macro level, the implementation of Lean in these companies against to the same application at EDPP.

It is easy to observe, that the success of this methodology in any company depends largely on the knowledge passed out to its employees. The better they are educated and familiarized with this methodology, the better they will apply it. Basically, lean as a methodology of continuous improvement, must be part of the company culture and be present in most activities performed by the workers. This is like a philosophy of work, a way of doing and being in different situations.

However, it seems, at least at Ikea, that the whole continuous improvement and lean mentality is rooted in every phase of the selling process. From the construction of the buildings and the arrangement of the items throughout the store to the delivery and assembly services.

With this, what transpires is that the methodology of continuous improvement, as well as Lean, are present in each phase of the sales cycle, and the mentality of doing more with less is one of the fundamental principles in the daily work of the employees.

At EDPP, although lean application is well structured and monitored, it is performed, practically, in an independent way from the other continuous improvement methodologies, such as the redesign of processes that aim to optimize tasks. That is, the adjacent mindset of continuous improvement and lean does not yet seem to be rooted in the daily life of the company.

The companies studied apply all continuous improvement methodologies in a more integrated way. Since the objective of all these methodologies is the same- the efficiency and effectiveness of the processes.

However, it is important to note that this conclusion may be hasty or even wrong. In fact, the information obtained about EDPP is much more detailed than the one obtained from other companies.

Financial Analysis

It has been stated throughout this work that main objective of the Lean Initiatives is to raise the companies' profit and so it is important to make a financial analysis on the global results of the Lean Program at EDPP and of some examples of initiatives to understand what can be the impact of a single initiative.

With the exception of some particular cases, all the initiatives proposed to management at EDPP have as the principal premise the reduction of costs or the raising of benefits from a particular activity. If these initiatives didn't need any investment, there would be no need to present them to the management for a decision to be made.

In case of EDPP, the investments could be in the form of money, through new equipment, new facilities, new software, etc. or in the form of labor, by dedicating company workers to the development of these initiatives. Consequently, it is important to consider the needed investments in order to correctly evaluate the impact of the initiative. Unfortunately, not all EDP Produção's departments keep a record of the costs involved in all initiatives, so it is not possible to evaluate the results of the Lean Program, besides stating that the benefits in the past two years were approximately 2M € per year. There is also no record of the benefits of the years before 2017 on all initiatives implemented, so it isn't also possible to observe the evolution of the benefits obtained.

On a more particular level, it was also analyzed 7 examples of initiatives implemented, of which only in 2 of them the investment is known. In order to understand if all 7 initiatives were or could be interesting to invest in there were used several tools, namely: break-even point, NPV calculation, IRR calculation and opportunity cost calculation.

On a corporate level, investments can't always be expected to produce results on the first year, but the period must also not be too large for the stakeholders to find them interesting. For the analysis of this particular case it was considering the periods of 3 years and 5 years, the first being the most attractive of the two. This is applicable to the initiatives that produce results continuously over the time.

The break-even analysis gives the period of time before the investments starts being profitable and the moment when the returns equal the costs is called the break-even point. It is only possible to calculate the break-even point for initiatives where the cost and the benefits are known, i. e. only for 2 of the chosen initiatives. After the calculation it is observed that for both of them after a few months the initiatives start to be profitable and, since it is much inferior to the 3 years defined, it is easy to approve them as long as the capital (or what is the equivalent labor hours) is available.

Then, it was analyzed the net present value of these initiatives considering the two periods. The NPV consists in the difference between the present value of the expected benefits and the present value of the expected investments, where present value means the equivalent in today's money. If the stakeholders decide that the investments should be profitable in 5 years, the NPV of the investment of a 5-year period must be positive and the higher it is the more attractive it is. The two initiatives that have the investments available have been calculated with a NPV of 25k € and 40k € and 41k € and 65k €, for 3 and 5 years periods respectively. For the initiatives that don't have information about the costs, it was calculated the maximum

investment for the initiatives to be profitable in those periods. That was made by leaving the initial investment as an unknown variable and equaling NPV to 0. If the investments made where inferior to the calculated values is was advantageous to proceed with the implementation.

The internal rate of return is the rate the company obtains by implanting these lean initiatives. This should be compared for example with the interest rate of the bank in order to evaluate if the company should invest in the initiative or apply it on another opportunity. To calculate IRR al the variables of the NPV formula must be known except the rate that should remain unknown. When NPV is equal to 0 the rate is equal to IRR and, in the two cases where the investment was known, the rates were more than 100 %, which is an inconceivable number for a bank.

Finally, the last tool utilized was the opportunity cost, which is the difference of investments between the chosen initiative and the best alternative. If the difference is positive, this value is considered benefit, if it is negative it is considered a loss. Sometimes the best alternative can be to maintain the current situation. In the case considered, some action was needed and EDPP had an option of investing in equipment or just in labor hours, opting for the second. The difference between both investments (although the second not being given) is the benefit the company has made.

SWOT Analysis of Lean Implementation at EDPP

SWOT is a tool that allows the process of making a strategic diagnosis of the company. The letters ***S***, ***W***, ***O*** and ***T*** refer, respectively, to a different group that should be analyzed: **S**trengths, **W**eaknesses, **O**pportunities and **T**hreats.

Regarding the Implementation of Lean Methodology at EDPP, it was identified several aspects to each group.

Strengths

- Lean management does not resume only about problem-solving, it is more about developing people´s problem-solving capability;
- Lean at EDPP emphasizes cutting wastes, while placing value on other actions. With the numerous unnecessary activities at the company, the impact of this methodology will be quite high;
- A proper Lean implementation, make one area more efficient and profitable, allowing the reallocation of resources to another area;

- Lean methodology is easier to implement compared to other continuous improvement initiatives. The tools of lean can be standardized, which helps its implementation. They can be applied to every situation;
- This methodology allows a good tracking of the results provided from the implementation of Lean tools.

Weaknesses

- Lean management is not quick fix, it requires consistent holistic involvement over a long team;
- Effective Lean implementation, requires deep organizational transformation in order to be sustainable;
- Lack of proper performance management at the company, makes difficult to measure the Lean advantage;
- EDPP is still very hierarchical with the board directors as the dominant decision makers. Conversely, Lean culture requires Teamwork
- Sustainability, though not a product of Lean itself, it is rather a common denominator essential for process of improvement initiatives;
- There is a general lack of Lean expertise inside the company, in order to teach the other employees.

Opportunities

- Losses have been evident throughout the company's history, therefore, initiatives directed at minimizing losses are most welcome;
- Most institutions are aware of the need for continuous improvement, labor efficiency, standardized work, smooth workflow, service times and cutting costs;
- EDPP is aware of clients (internal and external) pressure for improved service quality;
- The recent alarm to reduce operating costs has increased the awareness to go lean, cutting costs and service times.

Threats

- Short-term thinking from top management due to lack of knowledge and experience of long-term gains;
- Motivated and well-meaning but inexperienced employees set unrealistic expectations on what Lean methodology can do;

- Top management often has no exposure or knowledge of what lean can achieve for the company, so absorption can be inhibited;
- Job Losses - Lean is sometimes used as a method to reduce headcount, which reduces the efforts to apply Lean methodology;
- A Fast implementation of lean can become unsustainable and with numerous disadvantages;
- The improvement of the value stream involves most of the company departments, which may not be ready to change.

As can be seen, the application of Lean methodology brings innumerous advantages for the company. It allows the company to do its normal processes and activities better and with fewer resources. That is, in a more efficient way.

However, poor understanding and application of this methodology can cause some disadvantages that compromise the success of this application and, in extreme cases, the success of the company itself

5.5. Case study lecture plan

The Table 5.1 is a suggested teaching and work plan. It contemplates some preparation activities before the actual classroom discussion. The time allocated to each activity was estimated in order to define a challenging and interesting discussion, thus ensuring the pace of the analysis and the achievement of the objectives of the case.

Table 5.1 – Lecture Plan

Session-Work	Aims	Activities	Time
1st – Presentation (1 Class)	- Frame and ensure the students´ interest on the case	1. Provide the Company´s overview; 2. Provide the history of Lean at EDPP 3. Explain how Lean is implemented and managed at EDPP, nowadays. 4. Give some examples of initiatives and their benefits	1. 15 min 2. 15 min 3. 30 min 4. 30 min
2nd- Autonomous work (Students)	- Identify the most challenging and key themes in order to obtain as much information as possible for later discussion in class	1. Study the main goals and targets of Lean management at EDPP 2. Understand how lean is managed and monitored 3. Understand How the initiative may arise and what type of benefits they bring	1. 30 min 2. 30 min 3. 30 min
3rd – Discussion (Classroom)	- Set the main objectives and start the discussion	1. Each group of students should present the key points they think that are important 2. Debate between the groups 3. Conclusion (Wrap up)	1. 30 min 2. 30 min 3. 30 min

5.6. Lecture issues to be posed to the students

In order to better conduct the class and presentation, it is necessary to elaborate some basic questions that should be understood. These questions can be divided into two divisions / times: Presentation of the Case and Key Point analysis:

The following is non-exhaustive list of possible questions for the debate session on this case study:

Presentation:

- What is the case study about?;
- What is EDPP main business and why the need of continuous improvement tools?;
- The emergence of Lean at EDPP;
- Tre structure of Lean at EDPP.

Key point analysis:

- What are the most critical factors for a successful implementation of Lean Methodology?;

- How this methodology should be managed and monitored, in order to better achieve the goals;
- Is EDPP doing well? How can they improve?;
- Students may do their own SWOT analysis regarding the implementation of Lean;
- Students may think about the balance between the effort of implement Lean methodology and the benefits of its application.

5.7. Case resolution slides

The presentation of this case will be performed with resource to a set of slides, more specifically 21 slides.

The first slide will be the cover of the presentation, during which the introduction of this work will be stated. On the second slide it will be presented the structure of the presentation and an overview of the following topics will be made.

On slides 3 to 20 the focus will be on the subjects covered on this master's thesis, beginning with the explanation of the history of Lean Thinking on slide 3 and then a summary of some Lean tools on slide 4. The next slide it will be presented the state of the art of Lean in other big companies present in Portugal. Then, on slide 6 the issue that led to the writing of this case study is stated. The overview of company EDP will be done during slide 7 and the overview of EDPP will be done on the next slide.

For the presentation of the Lean at EDPP, including its history, strategy and structure, it was required to utilize the slides 9, 10 and 11. From then it is necessary to explain how the Lean Program as evolved at EDPP, which is done at the slide 12. In order to contextualize the lecturers on the type of Lean Initiatives developed by EDPP, some examples will be presented on slide 13, and its valorization will be done on slides 14 and 15. The next slide will be focused on the global results of the Lean Program.

On slide 17, the pedagogical note will be introduced and the analytical tools will be presented on slide 18. Then, at slide 19 the case study lecture plan and its issues will be stated, before concluding the work at slide 20.

The final slide, slide 21, will consist on the bibliography of the authors consulted of the presentation.

5.8. Management conclusions to be drawn from the case in question

The Lean Production concept has been given its name by John F. Krafcik in 1988, who (as previously said) compares Fordism with this concept in car manufacture's plants,

concluding that lean management policies lead to higher productivity and quality performance.

The Toyota Production System (TPS) is the true basis of the Lean Production concept that has been created to compete in cars' market, but in the years following the first papers on the subject, the Lean Production started to spread to other companies.

Furthermore, some companies started to apply the lean principles to their daily routine where the main activities were not based on products' manufacturing. Therefore, the term "Lean Manufacturing" or "Lean Production" no longer was the appropriated term and the name shifted to "Lean Thinking" that simply means applying the lean concepts in any company, regardless of its main activities.

As a result, several Lean Thinking tools have been continuously emerging. In order to achieve the best results, the understanding and correct application of each tool, has become critical.

Over the last dozen of years many countries, including Portugal, have been subject to an economic crisis that affected companies. One of the biggest challenges for companies within this framework is the rise in profits in a market where their growth is already stagnant or facing some difficulties. A good example is the case of EDP, more specifically EDPP, in the supply of energy throughout the country.

EDPP shortly anticipated this crisis by implementing its Lean Program in 2006 and, since then, is constantly trying to be more efficient, producing more with less resources. The number of initiatives implemented has been increasing, the profits have been growing and the company is continuously improving its actions.

Throughout this work it was possible to verify that EDP Produção is a big company with many independent power plants and, in consequence, many departments each of them with its own objectives and distinct processes and activities. This implies that it is not possible to implement common initiatives to all departments, but instead each department must identify what are the best opportunities for improvement, especially if the best results are to be obtained since, as it can be read on the major authors' works, the workers should always be involved in the development of the initiatives.

When talking about lean it is commonly said that there is always room for improvement and this does not only apply to the core processes of the companies' business but to all processes, and in the case of EDPP it is also applied to the Lean Program itself. It has been evolving and being improved since the first time it was implemented and more can be made.

As of the writing of this case study, the Lean Program at EDPP is dependent of a Support Department that assists each department in creating, analyzing, developing and monitoring their initiatives. It is essential that this department exists because it is the best way for the processes within the whole company are standardized and also because most initiatives require and investment that should be approved by the Board of Administrators and the Support Department is the bridge between them and all the other departments.

Regarding the financial results, in the past couple of years the benefits have been around 2 million euros per year. However, the cost benefit balance analysis can't be made since the cost of implementation of all initiatives has been assessed. This means that there is not possible to conclude if the impact of the Lean Program has been positive or negative. In addition, there is no record of benefits of the initiatives implemented before 2017 so the evolution of results of lean initiatives also isn't possible to map.

On the other hand, from the examples analyzed it was possible to verify that the benefits of the initiatives that had the required information available had great benefits when compared to implementation costs and if this is common to most initiatives that have been implement. According to many authors, processes have always room for lean initiatives to be implemented, but the more the company is developed in this way the higher the implementation costs will be, thus EDPP still has a lot of work to do in order to reach this stage and be a Lean Company.

Another important aspect to consider is the time and number of collaborators allocated to specific initiatives. In order for lean tools, when applied, have the expected results it takes time and manpower, which the company must reallocate from other tasks or hire externally. As the company's focus is not the lean initiatives but the production of energy, the development of the Lean Program is not as fast as it could be, but it on a steady and sustained growth.

Compared to other Portuguese companies, EDP, specifically EDPP, it is not leading in terms of the Lean Thinking, but it isn't also at the end of the table. Many big companies have found in Lean the resource for higher profits for plateauing sales. The difference between companies consists in the type of processes to improve and the decision to invest more or less in their development. Lean is clearly a trend in these companies and shows no sign of slowing down.

Although lean at EDPP is already in a sustainability phase, it still has much to grow and improve. Both management and monitoring of the Lean Program are done in a conscious and

detailed manner, however it is easy to see that the company still has some work to do. The lean culture should be embedded in the company routine and the tools used should be flexible in order to make possible its utilization, despite the activity.

As stated earlier, for a company to implement Lean effectively, it is necessary to give workers knowledge and training to work in tune.

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Annex A

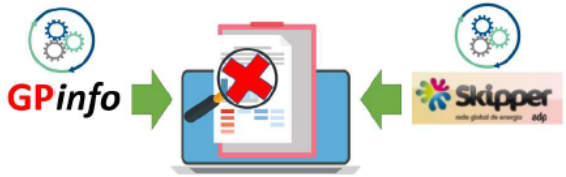
At the chapter 4. Case Study – Lean at EDPP there was made reference of 7 initiatives that were implemented at EDPP. The A3 Reports of those initiatives are exemplefied at the Annex A1 thorugh Annex A7

Annex A1 – A3 Report of the Initiative *Validação de contagens de energia*

lean Validação de contagens de energia – GPinfo - Skipper

Descrição

O GPinfo e o Skipper estão dotados de mecanismos independentes de carregamento de dados provenientes dos contadores de energia instalados nos aproveitamentos hidroelétricos.
Detetaram-se ao longo do tempo, por variadas razões, algumas discrepâncias entre a informação disponibilizada nas duas plataformas.



Análise

Devido ao facto de existirem dois carregamentos independentes identificou-se a necessidade de cruzar a informação das duas plataformas de forma a identificar precocemente discrepâncias nos valores apurados.

Aplicada a metodologia LEAN 5W, detetou-se a necessidade de implementar um processo que cruze, para cada aproveitamento, as energias de ambas as plataformas.

Constatado ainda que o carregamento de dados consolidados, devido ao volume elevado de registos envolvidos, deveria ser alvo de melhoria. Para tal, seria necessário disponibilizar uma forma expedita de efetuar o upload dos dados validados em Template Excel para a base de dados do Skipper que alimenta o BO (Business Objects).

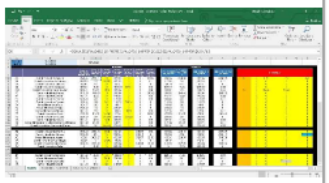
O processo a implementar deve ser baseado em procedimentos automáticos, já que manualmente ocupa cerca de 6 horas semanais de um colaborador.

Objetivo

Dotar a AGO de uma ferramenta que permita automaticamente realizar a validação das energias das duas plataformas e o upload dos dados para a base de dados Skipper.

Implementação

- ❑ Levantamento de Requisitos
  - I. **Armando Soares, Patrick Gonçalves, Nuno Oliveira** 08 a 12/01/2018
- ❑ Desenvolvimento aplicacional
  - I. **Nuno Oliveira** 15 a 26/01/2018
- ❑ Realização de ensaios e testes de validação
  - I. **Patrick Gonçalves** 29 a 31/01/2018



Benefícios

Custos de Implementação:
- Mão de obra exclusivamente interna com um custo estimado de 3.040,00€

Benefícios:
- ❑ Melhoria na eficiência operacional;
- ❑ Maior fiabilidade da informação disponibilizada no ecossistema GPinfo - Skipper;
- ❑ Redução de 5h semanais na validação e upload, o que equivale a uma poupança de cerca de 260h/ano avaliado num custo de **10.400€/ano**.

Constrangimentos

- ❑ Necessidade de uma análise/validação final por parte de um colaborador da AGO

Necessidade de seguimento e possibilidade de replicação

Avaliar a possibilidade de replicação da mesma metodologia para outro tipo de dados

Data de conclusão 20-Dez-2018

Programa Lean DOH / Equipa: Patrick Gonçalves; Nuno Oliveira

Annex A2 – A3 Report of the Initiative *Otimização do processo de distribuição das ordens de manutenção preventiva*

Annex A3 – A3 Report of the Initiative *Monitorização das perdas de H_2 nos alternadores*

lean 252-Monitorização de perdas de H2 nos alternadores

edp

Descrição

- As perdas de hidrogénio nos alternadores não eram monitorizadas.
- O atual sistema de monitorização de pureza tem perdas significativas devido ao modo de funcionamento.
- O ajuste do caudal nos analisadores é crítico para o controlo das perdas.

Análise

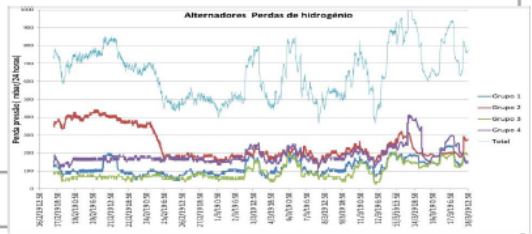
- A forma encontrada pra a monitorização das perdas foi a construção de uma. página utilizando dados do OSI/SKIPPER.
- O cálculo é baseado na perda de pressão dos alternadores em mbar/dia.
- Foram elaboradas curvas do tempo de duração de uma bateria em função da perda de pressão diária.

Objetivo

- Controlar o consumo de hidrogénio
- Detetar em tempo útil acréscimos de perdas.
- Disponibilizar indicador dos custos decorrentes das perdas de hidrogénio.

Implementação

- Criação da página (meios Internos)



Benefícios

- Disponibilidade Online das perdas de hidrogénio em cada alternador.
- Informação de custos.
- Otimização das metodologias de O&M
- Estima-se uma redução 5 % no consumo anual de hidrogénio.

80 Baterias H2 x 300 € x 5% = 1200 €/ano

	G1	G2	G3	G4
	Perdas mbar/dia			
18/03/2019 16:03	300	381	393	252
17/03/2019 16:03	296	272	265	277
16/03/2019 16:03	340	240	340	328
15/03/2019 16:03	294	246	294	271

Constrangimentos

Desenvolvimento sem constrangimentos

Equipa

L. Matos; J. Rocha; J. Ribeiro; A. Cortes

Direção Centro de Produção Sines DSN 2019

Annex A4 – A3 Report of the Initiative *Reestruturação dos ambientes de operação e engenharia na Central de Sines*

lean Reestruturação dos ambientes de operação e engenharia na Central de Sines

edp

Descrição

Para cumprir o PCCS (Plano de Continuidade da Central de Sines) existe a necessidade de dotar a Central de uma Sala de Comando "Extra" com Estações de Operação do Sistema de Controlo Industrial dos Grupos e Gerais do Tecnólogo ABB (800xA).

Análise

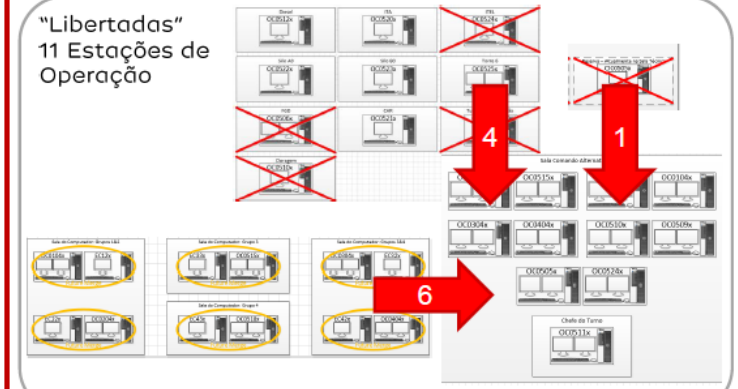
- A Central de Sines possui no seu sistema de comando principal 57 estações de operação e/ou engenharia, computadores que tem a função principal de disponibilizar o comando e informação do processo.
- Estas estações estão distribuídas entre as salas de comando e salas de instalações periféricas dentro do perímetro da Central.
- A necessidade de dotar a Sala de Comando "Extra" exige uma reorganização e reconfiguração das estações de operação, pelo que a DOT (AMN-ASA) e a DSN (AOP & AMN) em estreita colaboração, identificam uma solução passa por:
  - Abdicar de algumas estações dispersas pelos periféricos de Sines;
  - Reconfigurar algumas estações de engenharia para funcionarem também como estações de operação.
- O resultado traduziu-se na disponibilização de 11 estações de operação para a sala de comando "extra".

Objetivo

Dotar de Estações de Operação ABB 800xA a Sala de Comando PCCS

Implementação

"Libertadas"
11 Estações de Operação



Benefícios

Custo evitado:
- Na aquisição de novas Estações de Operação 800xA = 192,5 K€;
- Em trabalhos de configuração 800xA = 16,7K€.

Constrangimentos

A implementação careceu de configuração e reativação da infraestrutura de rede 800xA que estava desabilitada desde 2013.

Necessidade de seguimento e possibilidade de replicação

Necessidade de seguimento e ajuste caso ocorram alterações na gestão dos recursos de O&M.

Data de conclusão: 28-02-2019

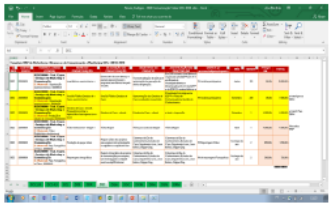
Programa Lean DOT Helder Fernandes  João Moura  Adalberto Pedras  Nabais Pacheco  Luís Matos 

Annex A5 – A3 Report of the Initiative *Melhoria do Template OBZ*

lean Melhoria do Template OBZ - Suporte de registo de atividades de Comunicação e Marca das UO`s

Descrição

Com a Implementação do Processo de OBZ nas UO`s, a Área de Comunicação e Marca (ACM) ficou responsável por analisar e reportar todas as atividades e respetivo orçamento no que diz respeito a Comunicação e Marca da EDP Produção.
Foi identificada a oportunidade de melhoria no template que a ACM usa na relação que tem com as UO`s.



Análise

Análise do problema	Análise do Problema
Qual é o problema	Consumo de tempo na recolha das informações necessárias até ao fecho do OBZ.
Porque ocorre	Porque o processo de recolha de informação dos dados necessários, é feito por diferentes meios com perdas de informação, ou informação errada e essencialmente tempo de espera.
Desde quando ocorre	Desde junho 2017 (desde o report do orçamento de 2018).
Onde ocorre	Área de Comunicação e Marca (ACM).
Quem está envolvido	Todas as UO da EDP Produção.
Como surgiu o problema	Com a sobreposição de meios na recolha da Informação junto das UO`s. (e-mails, telefonemas, reuniões presenciais).
Quanto custa	28 h.Homem por ano.

ANALISADO O PROCESSO:
Desperdícios identificados - Reprocessamento; tempo de espera; deslocações;
Solução - Criação de template em Excel que dê resposta ás necessidades de informação identificadas.

Objetivo

Aumentar a eficiência do processo de recolha da informação, para a definição das atividades e posterior registo monetário das mesmas em OBZ.

Implementação

Solução do problema	Ações
O que será feito?	- Construção de um template em Excel com a indicação para a recolha das informações necessárias. - Colocação de códigos e contas razão associadas à respectiva actividade. - Elaboração de instruções de preenchimento.
Porque será feito?	Para aumentar a agilidade durante todo o processo, reduzindo perdas de informação, ou informação errada, tempo de espera, evitar erro humano, aumentar produtividade.
Quando será feito?	Implementação no final do 2º trimestre de 2017. Verificação durante o 2º semestre 2017.
Onde será feito?	Na EDP Produção, envolvendo todas as UO`s.
Quem fará?	ACM e UO`s, em modo colaborativo.
Como será feito?	Recorrendo à construção do template de Excel, onde constam as necessidades de informação para correcto e ágil carregamento no cubo.
Quanto custará?	h.Homem dedicadas à construção do template.

Benefícios

- Processo mais eficiente.
- Melhoria em 28 h.Homem por ano, no valor de 1.12 k€.

Constrangimentos

- Dificuldade na interpretação das instruções de preenchimento por parte das UO`s.

Necessidade de seguimento e possibilidade de replicação

- Necessidade de seguimento após entrada em produtivo.
- Passível de replicação.

Conclusão: Janeiro de 2018

ACM / Equipa: Barbra Avelar; Ana Rita; Inês Varela; Carlos Alves.

Annex A6 – A3 Report of the Initiative *Melhoria do PRC Vender Energia*

lean

Melhoria do PRC Vender Energia-Emissões de Pedidos de Compra e Ordens de Venda

Descrição

Mensalmente a Área de Gestão Contratual depara-se com inúmeras tarefas que são repetitivas e que consomem recursos Humanos em detrimento de atividades que requerem tempo de análise.

Com o surgimento do *RPA - Robotic Process Automation*, foi identificada a oportunidade de robotizar atividades repetitivas, no PRC Vender Energia - Emissões de Pedidos de Compra e Ordens de Venda.

Análise

Análise do problema	Análise do Problema
Qual é o problema	Consumo de tempo em tarefas rotineiras em detrimento de atividades que necessitam de análise.
Porque ocorre	Porque são tarefas necessárias ao processo Vender Energia
Desde quando ocorre	Desde que se criou o processo Vender Energia
Onde ocorre	Direção de Regulação e Mercados - Área de Gestão Contratual (DRM-AGC)
Quem está envolvido	DRM-AGC; EDP Valor.
Como surgiu o problema	Com o acumular de atividades associadas ao processo Vender Energia
Quanto custa	456HxH por ano

Objetivo

Automatização da atividade de "Emissões de Pedidos de Compra e Ordens de Venda"

Implementação

Solução do problema	Ações
O que será feito?	-Programação em UIPath -Agregar num ficheiro Excel os dados mensais a faturar -Elaborar pedido de compra e ordem de venda em SAP - Envio por email para a EDP Valor da informação associada ao registo
Porque será feito?	Porque o RPA Robotic Process Automation possibilita a automatização desta tarefa
Quando será feito?	Programação no 2º trimestre de 2018 Implementação no 3º trimestre de 2018
Onde será feito?	Na plataforma UIPath
Quem fará?	DRM-AGC: Paes Faria; Rui Damião; Joaquim Veloso; José Silva
Como será feito?	Tarefas repetitivas efetuadas por colaboradores da Área de Gestão Contratual robotizadas – RPA Robotic Process Automation
Quanto custará?	Horasxhomem dedicadas à programação e implementação

Benefícios

- Melhoria PRC - 456 Horas.Homem por ano, com a robotização de tarefas repetitivas
- Mais tempo para dedicar a atividades que requerem análise

Constrangimentos

- Dificuldade da entrada em produtivo da aplicação

Necessidade de seguimento e possibilidade de replicação

- Necessidade de seguimento durante 3 meses após entrada em produtivo; Passível de replicação.

Data de conclusão: 27-09-2018

Programa Lean Áreas Suporte_DRM-AGC / Equipa: Paes Faria; Rui Damião; Joaquim Veloso ; José Silva

Annex A7 – A3 Report of the Initiative *Otimização do controlo da drenagem da fossa do transformador principal do grupo 1*

lean EDPP-DTM 186 - Castelo do Bode – Otimização do controlo da drenagem da fossa do transformador principal do grupo 1

edp

1 - Descrição

A drenagem da fossa do transformador principal faz-se a partir de duas derivações existentes. Uma derivação vai diretamente para o rio, a outra vai para o poço de drenagem da central. As derivações são compostas por válvulas manuais, a que vai para o rio está sempre fechada e a que vai para o poço está aberta, no sentido de drenar qualquer efluente para o poço.

2 - Análise

- Caso surja um derrame de óleo no transformador, o mesmo vai diretamente para o poço e por sua vez direto para o rio através das bombas de drenagem.
- Existe risco elevado de desastre ambiental caso exista uma rutura franca no transformador principal.
- As válvulas não podem estar fechadas devido ao risco do efluente da fossa do TR entrar para a central, uma vez que a fossa está mais alta que a cota da central.

3 - Objetivo

- Colocar controlo de descarga da fossa do transformador para mitigar o risco de acidente ambiental.

4 - Plano de Implementação

- Foi colocada uma válvula motorizada que fecha automaticamente com qualquer alarme do transformador, retendo o possível óleo/água que está na fossa até á chegada do disponível.
- Em caso de rutura franca existe possibilidade de esgotar a fossa controladamente.
- Não existe risco de inundar a central porque existem níveis altos que por proteção abrem a válvula controladamente.

5 – Benefícios/custos apurados

- Redução expressiva do risco ambiental na bacia Zêzere-Tejo.
- Controlo da drenagem com decantação liquido-liquido no inicio do processo.
- Custos materiais: 4 k€ para os 3 grupos (Ordem 610767038, 610767039, 610767040)

6 - Constrangimentos

Nada a assinalar

7 – Necessidade de seguimento e possibilidade de replicação

Replicação aos restantes grupos em 2019.

Equipa:




Samuel Antunes Marco Oliveira Leandro Coelho André Silva

Data de conclusão

15.Nov.2018