Implementation of a KPI tree for shopfloor management and resource allocation

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Abstract

The present dissertation report documents the development of a Key Performance Indicator (KPIs) tree for an industrial unit, Portocork, a high-end natural cork stopper facility within the Amorim Cork group.

The tree development arose as a strategic decision from top management, as there was no tool to drill down performance and deviations down to the shop floor. Furthermore, the project aims to address issues regarding the lack of standardized performance indicators in certain factory sectors and standardize the monitoring of project indicators and their value within the industrial unit.

During the project's development, the Key Performance Result (KPR) of Operational Costs for the unit in question was broken down. The breakdown occurred in two ways: financial and operational. Firstly, the financial breakdown followed the established hierarchy already present and systematized in Amorim Cork, involving the breakdown between result, profit, and cost centers, where the result center is the Portocork unit, and the cost center is the various factory sectors.

Next, the operational breakdown was elaborated, which focused on the breakdown of the "Productivity" KPR by man-hours and by machine, using relevant KPIs such as the OEE. To support both breakdowns, the respective information was compiled in standardized formats to ensure reliability in updating routines.

The introduction of this tool in the continuous improvement cycle was found to be of great usefulness and potential, especially in formulating new projects in the identified sensitive areas. Furthermore, outside the project's perspective, it is considered an extremely useful tool in managing the monthly performance of the factory sectors. Regarding the tool's targeted objectives, the tool matched the expectations, meaning, the tool is capable of monitoring project indicators, tracking them monthly, and valuing them accordingly

Resumo

O presente relatório de dissertação documenta a elaboração de uma árvore de *Key Performance Indicators* (KPIs) para uma unidade industrial, a Portocork, uma unidade produtora de rolhas naturais de alto segmento da Amorim Cork.

A elaboração da árvore surgiu como decisão estratégica da direção de topo, por não existir uma ferramenta que desdobre tanto a performance como os desvios até ao chão de fábrica. Além disto, foi um objetivo do projeto colmatar problemas no que toca a alguns setores da fábrica, como não possuírem indicadores de performance padronizados, bem como uniformizar o acompanhamento dos indicadores dos projetos e a sua valorização na cadeia da unidade industrial.

Durante a elaboração do projeto foi desdobrado o *Key Performance Result* (KPR) de Custos Operacionais da unidade em questão. A desdobra sucedeu-se de dois modos, financeira e operacional. Primeiramente, a desdobra financeira seguiu a estipulação de hierarquia já presente e sistematizada na Amorim Cork, existindo então a desdobra entre centro de resultado, lucro e custo, sendo que o centro de resultado é a unidade da Portocork e o centro de custo são os vários setores da fábrica.

De seguida elaborou-se a desdobra operacional que se regeu na desdobra do KPR de "Produtividade" segundo homem e segundo máquina, usando indicadores relevantes como o OEE. Para suportar ambas as desdobras, as respetivas informações foram compiladas em formatos uniformes de modo a conferir fiabilidade nas rotinas de atualização.

A introdução desta ferramenta no ciclo de melhoria concluiu ser de grande utilidade e potencialidade, especialmente na formulação de novos projetos nas áreas identificadas como sensíveis. Além disso, fora da ótica do projeto, considera-se uma ferramenta de extrema utilidade na gestão da performance mensal dos setores da fábrica. Considerando os objetivos propostos, a ferramenta foi capaz de dar resposta aos mesmos, isto é, acompanhar os indicadores dos projetos, prever benefícios expectáveis e monitorizar o chão de fábrica por setor.

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Abbreviation List

AC – Amorim Cork

CEO – Chief Executive Officer

CI – Continuous Improvement

COO - Chief Operating Officer

CSF – Critical Success factor

JIT – Just-In-Time

KPI – Key Performance Indicator

KPR – Key Performance Result

KRI – Key Result Indicator

MES – Manufacturing Execution System

MTBF – Mean Time Before Failure

MTTR – Mean Time to Repair

OEE – Overall Equipment Effectiveness

PDCA – Plan Do Check Act

PI – Performance Indicator

PM – Project Management

PMS – Performance Measurement System

SAP – System Applications and Products in Data Processing

SOP – Standard Operating Procedure

TCA – Trichloroanisole

TPM – Total Productive Maintenance

TPS – Toyota Production System

TQM – Total Quality Management

TWI – Training within Industry

VSM – Value Stream Mapping

YTD – Year-to-Date

1 Introduction

The present dissertation arises from the strategic need to support the decision of resource allocation and critical points of action inside a particular business unit. This project was developed with Amorim Cork, in the department of Integrated Systems and Continuous Improvement. The project itself targets the implementation of a Key Performance Indicators (KPIs) Tree in Portocork's Industrial Unit.

The concepts of Performance Assessment and measurement were used as the basis for this thesis. Performance assessment is the act of collection analysis and information logging considering the organizations' previously defined operational goals and strategies. It is key considering this is the first step of the process, through which all the relevant information will derive, those being services or products.

Paired with assessment, Performance Measurement helps translate the previously measured, usually quantitative, values and compares them with the goals set by the organization. It is a ceaseless process, where these metrics are constantly being weighed up against both organization and industry standards. The nature of these matters can be both operational and strategical, the first one usually having a more profound impact in the short scope, whereas the strategical issues are aspects of much deeper analysis, subject to both quantitative and qualitative aspects and for that reason being the target of a medium to long term scope of action, due to its complexity.

These processes help managers navigate the everyday of their activity and the possible setbacks that may arise as the long-term objective is being reached. Only through the differences found between set parameters and measured performance can change and course of action be set, in turn leading to better more efficient activities.

In summary, it is of utmost importance for all purposes but especially for strategical ones, the implementation of a methodology that helps both navigate the course of long-term objectives and help define critical points in the operation where change is most relevant, these being the focal points of this thesis.

As previously mentioned, the project was conducted in Amorim Cork (AC), a market leader in the cork industry and one of the most relevant companies in Portugal's manufacturing sector. This is a century-old company, and the following sections will go more in-depth on both history and current overview of operations.

Most images referring to either internal processes, those being either cost structure, cost themselves and production levels, will be omitted. They are protected under a degree of security, meaning, only necessary information for development of the KPI tree will be presented. The indicators later measured and calculated will be, however, shown in order to give a general idea of the outputting product.

1.1 Grupo Amorim's history and the present

The use and extraction of cork dates back thousands of years since the Egyptian empire era. This is a material sourced from cork oak trees, that grow in the Mediterranean and Iberic regions. It is the outer bark of two cork oak species. First extractions can be made after 25 years of maturity and later 9 years following the first extraction. A tree of this species usually perishes after 200 years, implying that today's production is a factor of generational growth and investment. Cork is an extremely sustainable product with a seemingly infinite range of product utilities, from the well-known cork stoppers to other intricate applications such as footwear, wall insulation, and flooring. This is a light weighted product that is also very resistant and resilient to wear. Portugal is the biggest producer and exporter of cork and is where AC is based.

Grupo Amorim is the biggest cork transformation group in the world with a presence in more than 100 countries and a span of operation in more than 5 continents. The group was founded in 1870 by António Alves Amorim in Vila Nova de Gaia. The founded operation consisted in a factory that produced cork stoppers manually. It later expanded to Santa Maria de Lamas to expand production to the growing market's needs. The real growth of the group happened when this family-owned business reached the third generation, one that was ambitious enough to target internationalization. This move resulted in one of the biggest multinational Portuguese-based companies in the world, with yearly productions of more than 6 billion cork stoppers.

Being a financially profitable company was, however, not the only goal set by the group. The ongoing sustainability projects set this group apart on multiple levels. Across the whole value chain, and according to Amorim Cork's sustainability factsheet, the group manages to have a negative carbon footprint of up to -562gCO_2 eq. per cork (for the case of a sparkling wine cork), while having a near 100% utilization for this product, ranging from cork stoppers to insulation and flooring products. All residues from production are used as biomass fuel to power all the industry facilities, contributing for the total of 80% of energy used being renewable.

Grupo Amorim's thrive for continuous improvement lands them as a landmark case study in sustainable earth-connected industries. Their quality stands them apart, which is reflected in their market leadership. Their slogan, "Sustainable by nature," embodies their core values of sustainability alongside their reputation for quality and production standards.

1.1.1 Portocork's Industrial Unit

The project was objectively thought to be implemented in one of Amorim's business units, Portocork. This business unit drives value to the company by producing the highest quality natural cork stoppers possible. The production's quality is ensured by NDTECH, a patented technology that has proved to exclude from the value chain the corks with detectable levels of concentration of TCA, a condition that drives the value of each cork stopper substantially. The current flow of operations in Portocork can be described as a three-part process.

The unit can be divided in NDTech, where cork stoppers are tested on their TCA levels one by one, then Production, where stoppers are subject to washing and sorting, treatment, and branding processes. The last shopfloor flow in Portocork is Distribution, which may indicate the stoppers are shipped but it's the same flow as Production.

The output of these operations is mostly natural cork stoppers with the added value of having no TCA concentration. For the case of agglomerate stoppers, these are only subject to NDTech's certification, meaning they will also have the insurance of having no TCA.

Internally, although there is the financial separation of NDTech and Production, these two flows are exclusively named as one, being flow 1 or NDTech. The second flow, flow 2, is the equivalent to the Distribution flow.

This is a medium sized industrial unit located across the street from the company's headquarters. Although it does not possess the highest production level within the group, it produces the highest margin product within the natural cork family of products, ensured by NDTech.

The facility itself is not responsible for 100% of the cork's transformation, with its main input material being natural cork stoppers, provided by other Amorim Cork industrial units. This locates Portocork as a unit closer to the end of the value chain, responsible for NDTech certification, cork cleansing, sorting, branding, treatment and packaging of the cork according to client's requests.

1.2 Project Motivation and objectives

The current industry standard of competitiveness implies that companies need to incessantly strive for a competitive edge, that being efficiency, intellectual property, volume, or privileged relationships with customers. In terms of critical areas where you can directly impact the value of a company, efficiency is of utmost relevance, ensuring later sustainable growth and scalability with proper resource allocation.

The process of resource allocation is central for its performance. Allocating too many resources to a project with a small contribution to the general result may not correctly steer the company toward the targeted objectives. As such, companies with a large spanning value tree may find difficulties in efficiently attributing the resources across their project portfolio. To add to this, projects may have inter-departmental implications, meaning a project may impact multiple levels of the value chain. In this context, the introduction of a value tree through the correct use of KPIs is found applicable to aid both business unit-level management as well as C-level management.

The project arises because of the need for efficiency in resource allocation and ease of critical area identification. Because of this, it is vital to ensure a project's pertinence before its kickstart. If done properly, the priority list of projects is this way one of the first outputs of the KPI tree, resulting in faster and more optimal improvement opportunities.

The implementation of a correctly managed KPI tree aids management during all stages of a project's lifecycle, ensuring correct resource allocation before its beginning, the correct platform for performance measurement, and the project's final impact either on the value chain or just a particular sector.

The dissertation's main goal is to create a KPI tree that achieves these particularities inside the Portocork business unit. The scalability of this model to the whole group must be taken into account, meaning flexibility and effectiveness are key aspects to note.

The actual push for the development of such a project was due to the company's strategic directive. The company's vision of continuous improvement is to employ both VSM and the KPI Tree in their continuous improvement three-month cycles. In regard to this vision, the company is currently mapping the value chain of all its industrial units and is with this project developing a KPI Tree to integrate on its continuous improvement system.

KPI Tree is thought to be a tool easy to use and specially designed to easily visualize data. It also must portray the Kaizen culture of continuous improvement and embody constant process optimization.

As mentioned, the project aims to aid decision-making at its core, by driving information to the decision-makers. The scalability of the project is an aspect to consider. Part of the project is also the selection of correct indicators that translate and correctly measure the performance of the industrial unit in question. KPRs are already a central aspect of everyday management in most industrial units, but they are the result of an equation of multiple metrics of operation, which are mostly unlabeled and unmeasured. The project aims to solve this issue.

Apart from the selection and revision of KPRs, what indicators the KPR should unfold in is also a critical objective of the project. Proposing new KPIs to the already used ones and determining their assessment routes is a primary goal of the project.

KPIs serve little purpose but to aid department-level management. Real usability and scalability of these indicators is achieved when their relations are formed, either logical or mathematical. These relationships are of superlative importance since they represent the bridge between everyday manufacturing metrics and strategic-level decision-making. Evaluating how these KPIs relate to one another is key for the correct performance of the whole tree.

Although the project's main goal is to implement a KPI tree in Portocork, a secondary objective is to determine a way to standardize the implementation and utilization of KPI trees in other industrial units. These units may portray different indicators as pivotal for their value generation and so flexibility is required.

1.3 Methodology

To achieve the goals set for the project, during the 18 weeks of internship, a strict methodology was followed. This methodology respected the department's weekly meetings and was incrementally followed to solve the identified issues.

The methodology followed portrays the spirit of continuous improvement where the project was inserted. The method also allowed for constant feedback opportunities to detect possible inefficiencies. To effectively carry out the project, a good understanding of all the group's business units was mandatory. Transversal knowledge was acquired about all industrial units, specially Portocork since this project's main goal resides with it.

After the conceptual KPI tree was concluded, the format in which the tree should be represented was determined, in a way that information is accessible and digestible for all users, from the shopfloor level to business unit management.

1.4 Report Structure

As stated prior, the project's objective is to support decision-making and foment new improvement opportunities. For such, analysis of the processes at hand and both data collection and processing should be presented in a digestible way, resulting in the following structure:

Chapter 2 depicts the state of the art of the main topics elaborated in this project. These were Continuous Improvement, Continuous Improvement Project Management, Performance Measurement, and Performance Measurement systems.

Chapter 3 delineates an overview of Portocork's structure and operations. In addition, the current methodology for KPI tracking is at play.

Chapter 4 presents the proposed solution and strategy developed during the course of the internship. Main issues, shortcomings, and general problems that accrued from the introduction of the process and new data collection needs.

Chapter 5 concludes the project, where success metrics for the introduction of a tool like a KPI tree are discussed, and possible future work to follow the project.

2 Literature review

In this section of the report, the state of the art on all topics related to the introduction and implementation of a KPI tree are overviewed. The topics discussed are Kaizen, principles of continuous improvement, continuous improvement project management, performance metrics and performance measurement systems. On each topic, history and some previous use cases will be discussed.

2.1 Kaizen – Continuous Improvement

Kaizen is a Japanese word that fundamentally captures the core practices of continuous improvement. The Kaizen concept is now heavily diffused through western industries but its use as a continuous improvement methodology term can be traced back to post-World War II in Japan.

In need of fixing its economy, Americans helping the recovery of Japan's financial situation expanded the TWI program to a other war-torn countries and devastated industries. This was the first step towards the development of modern continuous improvement processes, which Toyota Motor Corporation later explored with the introduction of their management system and approach to continuous improvement, the TPS.

According to Taiichi Ohno (1988), known as the father of JITand TPS, the single most important objective of the Toyota system is to increase production efficiency by constant waste elimination, while maintaining a strong respect for humanity.

To aid this objective, two concepts are needed: JIT and autonomation (automation with a human touch). In short, JIT means that in a constant flow process, the right materials will reach the correct production live at the time they are needed and in the desired amount, in turn making the no-inventory concept possible.

2.1.1 Kaizen in management

The concept of Kaizen was then brought to the management sector with the help of Kaizen Institute Consulting Group's founder, Masaaki Imai. Imai (1997) affirms that to achieve a kaizen strategy, managers must apply certain basic concepts in their ranks, those being Kaizen and management, Process versus result, PDCA, emphasis on quality, data-driven changes, and customer focus.

In this light, management has two major functions: maintenance and improvement. Where maintenance refers not only to the physical well-being of a machine but also to the standards of technology, management, and operation. Under this philosophy, management should perform its tasks so that others can follow SOP. Improvement, on the other hand, is the act of elevating the past maintained standards. Improvement can then be classified as either innovation or Kaizen. Innovation refers to large-scale changes or dramatic evolution, manifested as new technology or equipment, while kaizen is small changes in ongoing tasks, a lot of them related to improvements in communication, training, teamwork, and self-discipline (Imai 1997).

As a method of achieving a kaizen strategy, PDCA is one of the most important concepts of this process. As mentioned previously, PDCA stands for Plan-Do-Check-Act. Each step is defined as the following (Durward et al. 2008):

- Plan is the step where the problem-solver extensively studies the problem at hand from as many point-of-views as possible. Following are analyses to find root causes, some ideas to correct in some way the lacking parts and engineering an implementation plan for the application of the measures considered.

- Do is the practical implementation of the plan designed previously.
- Check is the step where effects are properly measured and compared with both the target and the prediction.
- Act is the effective conclusion of the cycle, where all previously gathered conclusions and observations are summed in a standard way to execute the studied flow.

Regarding the quality aspect of the kaizen management application, the utmost priority on delivering the highest quality goods should always be the paramount concept to apply. Temptations to lower standards to meet certain delivery terms or attractive prices should be put aside to create a high-quality competitive product.

As far as improvements are concerned, understanding the problem is very important. This state can only be achieved if relevant data is collected. Trying to solve a problem without its correct understanding leads to an inefficient flow and a lack of clear focus.

Lastly, management under the kaizen ideology should consider every next process as a customer. Meaning the same focus given to the end customer should be made with internal customers, being an emphasis on quality, and the lack of defective parts. Ensuring every participant along the value chain receives a top-quality product ensures the end customer is left with a high-quality good or service.

2.2 Principles of continuous improvement

As the basis for CI, there are several principles that guide the way to achieve the results, which are waste reduction, the involvement of people, Gemba, visual management, and creating value for the client (Coetzee et al. 2016).

1. Waste reduction: it directly impacts the costs of an institution, therefore reducing them implies an increase in performance level, profits, and efficiency. Ohno (1988) identifies 7 types of wastes: transport, inventory, useless movement, waiting periods, overproduction, over-processing, and defects.
2. Involvement of people: people are the core of the workplace. In accordance with ISO 9000 (2000), organizations must encourage their workforce to use their abilities across all hierarchy levels, only through this can a company achieve the desired outcomes.
3. *Gemba*: in Japanese business terminology, *gemba* is “the place where things happen,” meaning that to understand the problem and collect data for it, there is no better place to do it than the *gemba.* Considering that decisions should be made on real data, going to the physical workplace helps to study the problem’s causes.
4. Visual Management: Process transparency as well as value and procedure transparency must be visible in both the whole organization as well as on the shop floor so that value, material, and information streams can be studied effectively (Suzaki 1993).
5. Value creation: Considering companies depend on clients for survival, creating value for them is the only way to achieve competitiveness in a tense market state. Competitive advantage is achieved by efficiently corresponding to clients’ expectations (Lucinda, 2010).

According to Maggie Millard, the continuous improvement model should reflect the core concept that organizations should seek for constant improvement of all their operations.

As part of this methodology for operation refinement, these improvements should be based on small changes, opposite to major developments or new inventions. This aids in its implementation speed, meaning that to execute changes the company doesn't need to wait for major strategy changes or new product releases. Added to the small nature of changes that are included in continuous improvement, is that these sets of improvements are usually inexpensive to implement.

Millard also states that ideas should mostly come from employees, not top management. This argument is supported by the simple fact that employees are the ones who perform the valuable tasks and are the ones in constant immersion in the *gemba*. Because employees usually have a smaller view of the organization, this aids them to suggest changes that usually remove waste and not add it, changes that empower their day-to-day tasks, which also helps them be inexpensive to implement.

Through this process of people involvement, the workforce is engaged and retains a sense of accountability and ownership to both their everyday operations as well as the direction of the organization. Autonomous motivation is empowered by participation in goal setting and task ownership but impaired by externally imposed goals and measures (Weibel et al. 2010).

2.2.1 Continuous improvement tools

Apart from the PDCA cycle, there are other tools and methodologies followed that guide the process of continuous improvement. Among them the 5S's methodology, Ishikawa diagram and the A3.

a) 5S's Methodology

Developed in the late 1960's in Japan by Takasi Osada, 5S's methodology was developed in order to achieve a quality environment within an organization. Osada (1989) developed this methodology based on 5 Japanese acronyms.

- Seiri (Organization) – consists in the segregation of needed and unneeded material from a said location.
- Seiton (Neatness) – this step entails placing all required goods in the best possible location for them to perform their functions in the workplace.
- Seiso (Cleaning) – encompasses regularly sweeping or cleaning and examining the workplace, tools, and machinery.
- Seiketsu (Standardization) – This stage involves standardizing the methods for sorting, organizing, and cleaning the workspace.
- Shitsuke (Discipline) – or maintain, refers to procedures built via worker self-discipline, in other words, to do without being instructed.

The effective deployment of 5S approaches in businesses has resulted in considerable improvements in manufacturing performance. The application of 5S leads to significant improvements in a variety of outcomes, including overall organizational performance. Manufacturing businesses' successes include production-related achievements, quality and continuous improvements, cost-cutting achievements, employee-related achievements, effective workplace achievements, and safety-related achievements (Randhawa & Ahuja, 2017).

b) Ishikawa diagram

The Ishikawa diagram, also known as the fishbone diagram, was developed by Kaoru Ishikawa, a Japanese organizational theorist in the 1960's, who developed this diagram in order to aid the analysis of causes for a given problem.

The goal of root-cause analysis is to uncover crucial correlations between variables, and the probable causes, giving more insight into process behavior. The causes arise via investigation, frequently during brainstorming sessions, and are classified along the main branches of the fishbone.

This visual way of representing the participating entities in a given problem requires extensive understanding about the issue, which in turn leads to very scoped view of the causes, this being the main objective of the tool.

c) the A3 tool

Developed by Toyota during their development of TPS, named after the size of the paper it was executed on, the A3 is a tool that aids the visualization of a project. The most important about this tool is not the template, but the reasoning behind it. Encompassed in the A3 mindset are 7 principles (Durward et al. 2008):

1. Logical thinking
2. Objectivity
3. Results and processes
4. Synthesis, distillation, and visualization
5. Alignment
6. Coherence
7. System viewpoint

Using these principles, the A3 should contemplate 6 steps:

- Problem definition: in this section of the A3, everything that concerns the issue at hand should be discussed, those being the current standard and current situation. Detailed description of what is currently happening in the location of action and what is currently happening wrong.
- Root-cause analysis: all principle causes for the problem should partake in this section. All information collected and data to be analyzed is subject of this study. The main objective is to determine the root-cause. To aid this analysis, Ishikawa diagram is often used to help conclude this section's objective.
- Objective or solution: following the identification of the root-cause, the A3 should contemplate the definition of the solution to be implemented and construction of an objective. Up to this step, all previous plans are considered part of the Plan phase in the Deming's PDCA cycle.
- Implementation: in this phase of the A3 an action plan should be designed in order to correctly fulfil all the stipulated objectives. Task assignment and execution are the key aspects of this step. This step is reminiscing of the Do phase in Deming's PDCA cycle.
- Verification or analysis of results: this next step is the logical sequence to the implementation. Results are analyzed and data is gathered once more to conclude if the implementation was successful and if the planned results align with the actual ones. A key aspect of this step is the monitoring and control of the action's efficiency. This step is equivalent to the Check phase in Deming's PDCA cycle.
- Standard: to conclude the A3, all information and conclusions on the process should be standardized in order to eliminate occurrences of the same problem. Following the previous analogies, this step is the final one of the PDCA cycle, the Act phase.

According to Durward (2008), the A3 doesn't plan to eradicate the problem. It offers a concise visual way to both analyze the issue and foment ideas on its solution.

The impact of facilitating tools in manufacturing organizations was object of Belekoukias's et al. (2014) work. They categorized the tools in categories such as JIT, TPM, Autonomation, Kaizen and more specifically the VSM. The methodology followed used correlations, regressions and structural equation modeling to determine the coefficients of all categories in accordance to quality, speed, dependability, flexibility and cost. The study concluded that the most impactful category was JIT followed by autonomation. The case of kaizen, TPM and VSM were concluded to be moderately impactful, non-correlated and negatively correlated, respectively. The authors explain these inadequacies with difficulties associated with the implementation of these ideology/concepts. For the case of the VSM, it is certainly understandable that the mapping of the value chain itself holds no value if not followed up with rigorous projects that target the solution opportunities identified.

2.3 Continuous improvement project management

Organizations are developing faster than at any other moment in recorded history. Organizations are in a perpetual state of flux because they are dynamic entities in an ever-changing environment. This highly competitive, ever-changing economy provides both possibilities and problems for managers. To properly address this predicament, many managers have adopted the kaizen, or continuous improvement, management concept (Reid, 2006).

One characteristic of benchmarking organizations is that they stress the importance of CI initiatives, and a project management system is implemented to do this (Gunnarsdóttir & Ingason, 2014).

One approach may be to guarantee that all CI is carried out in accordance with conventional PM principles. A project manager must identify the project's deliverables and assess and control how the project is developing against the project's objectives in order for it to be efficient and successful (Project Management Institute, 2009).

According to Kerzner (2017), each project must have at least one objective that is known to all project staff and supervisors. The aim is a goal, target, or quota that must be met within a specific time frame.

2.3.1 Critical Success Factors

According to John F. Rockart (1979), CSFs are the limited number of areas that result, if satisfactory, in the successful performance of an organization. They are the few areas where "things must go right" for the business to thrive. If this is not the case, the results for the defined period will be less than estimated.

A CSF can be a characteristic such as price or an advantage. It can also be a condition like the capital structure of a particular customer mix or an industry structural particularity such as vertical integration (Joel K. Leidecker et al., 1984).

In their CHAOS summary of 2009, The Standish Group International claims the success factor for projects can be boiled down to:

1. User Involvement
2. Executive Support
3. Clear Business Objectives
4. Emotional Maturity

5. Optimization
6. Agile Process
7. Project Management Expertise
8. Skilled Resources
9. Execution
10. Tools and infrastructure

In a very similar fashion, Kerzner (2017) presents a series of CSFs that are comparable to the previous ones shown. These are project understanding, top management support, communication, client involvement, team skills, project control, and problem-solving skills.

A project management methodology can identify primary and secondary success factors. This might help a project manager establish a risk management strategy and decide which risks are worthwhile to take and which are not.

2.4 Performance Metrics

Effective project management is both an art and a science that aims to govern company resources within schedule, cost, and performance restrictions. Most projects are one-of-a-kind activities for which there may not have been adequate planning of guidelines. As a result, the project manager may struggle to stay inside the time-cost-performance triangle.

According to Kerzner (2017), although most businesses utilize metrics for measurement, they appear to have poor knowledge of what a metric is, at least for project management. An individual cannot properly manage a project unless it has metrics and measurements that can provide him with integral or almost complete information. What you can't measure, you can't control. If the metrics are timely and informative, they lead to proactive project management rather than reactive project management.

Nowadays, a project manager's duty include determining which essential indicators must be developed and controlled in order for the project to be considered a success by all stakeholders. Project managers have realized that creating project-specific metrics and key performance indicators is a collaborative effort between the project manager, client, and stakeholders.

2.4.1 Metric categories and types

Under Kerzner's (2017) view of metrics, there are four main broad categories to be distinguished. These are:

- Business-based metrics
- Success-based metrics
- Project-based metrics
- Project management process metrics

Regardless of how metrics are chosen, each project constraint must have a tracking measure. Because the amount and criticality of constraints might vary from project to project, the project team is under pressure to develop increasingly complex metrics for tracking and reporting on each constraint (Kerzner, 2017).

Related to performance metrics, the work of Loch et al. (1996) depicts the use and definition of performance metrics for the electronic industry, more specifically the product development within this industry. In their work, they explore the definition of these metrics according to regression models. The use of statistical models to determine the correlation of an explored metric to an identified critical area is interesting, considering one can define the significance value and that way impact the number of metrics relevant for the definition of the performance. The methodology followed in their worked can then me summarized by a two-step framework. Firstly they define development output performance, measures and productivity and then the process performance, this way wrapping both business metrics such as marketing and sales capabilities as well as process level metrics measuring the quality of the process. The application of this methodology to 95 electronics companies worldwide resulted in an emphasis in development productivity as a detrimental success driver.

A similar work was done for the Australian water supply industry, by Coelli and Walding (2005). They use data envelopment analysis to provide different measures of efficiency, namely technical and scale efficiency. They explore data from 18 government owned water supply businesses. Performance metric definition was not at play in their work, considering only efficiency was targeted to be measured. Although this is the case, they identified critical areas needed to achieve excellence in this type of benchmark, which are the data differences between companies, that generate entropy on cross-comparisons. Apart from the data differences, they identified some companies just didn’t have the needed information deapth necessary to conduct some analysis on growth.

2.5 Key Performance Indicators

A metric is a broad term, but a KPI is more precise. KPIs act as early warning indications that, if an undesirable circumstance exists and is not handled, bad performance happens. Dashboards, scorecards, and reports may all display KPIs and metrics (Kerzner, 2017).

According to David Parmenter (2010), KPIs can be defined with seven characteristics. KPIs should be non-financial measures, meaning that once the unit becomes a money-based metric it has become a KRI.

KPIs are measured frequently, as in daily, weekly, monthly, constantly, etc. If a KPI is measured quarterly, or annually, its core information time period has effectively expired and the proper conclusion to take from it has greatly diminished.

Followed by frequency, follow-up must be ensured. KPIs need to be tracked by top management so that the collected information is acted on. This way chain of command can ensure the correct action is taken.

Apart from frequency and follow-up, indicators must be specific both in responsibility and what measures to take, meaning they should be tied both to a team/department and be comprehensible by the correct team so that the action is undistinguishable from the analysis of the KPI.

Logically, KPIs must have a significant impact on the organization or the process (impacting one or more critical success factors). Tracking and excelling in these indicators leads to the achievement of company-level goals.

Finally, before a measurement becomes a KPI, several testing is needed to ensure the desired behavioral outcome is ensured, which sometimes is not the case.

Kerzner’s (2017) view on KPI categories distinguishes them into three main categories differing in when the performance will be traduced. KPIs can then be:

- Leading: measuring future performance
- Lagging: measuring past performance
- Diagnostic: measuring current performance

The same author depicts KPIs as being SMART. The word is an acronym for Specific, Measurable, Attainable, Realistic, and Time-based. The correct application of this “rule” ensures that a KPI is clear and focused on performance, expressed quantitatively, is reasonable and achievable, is deeply connected to the work that is being done, and has a time period associated with its data.

Selection of a number of KPIs is a meticulous process that should ideally respond to a few questions such as: How are we now? Where are we going? Where should we go? How should we get there?

2.5.1 KPI interdependencies and relationships

Determining the status of a project is impossible if done with only one KPI or metric. KPIs are a collection of interconnected performance measurements that are required to satisfy the project's CSFs.

Several raw measurement components, such as machine busy time and production volume, are monitored and collected in production systems. KPIs of relevance to engineers and managers, such as efficiency and quality, may be derived and assessed using these factors. As a result, the directly monitored aspects serve as supporting measures for KPIs.

These KPIs are classified as basic since they generally show a single element of the system’s performance. More detailed KPIs, backed by numerous fundamental KPIs, may be derived to indicate total performance.

The OEE index, for example, which is based on individual equipment’s (or a whole set of equipment’s) working and failure time allocation, gives information on production efficiency and output loss. Similarly, the production line’s throughput is determined by all machines, buffers, locations, and interactions (Kang et al. 2016).

According to Cai et al. (2008), because the interactions between KPIs have gotten increasingly convoluted, it is difficult to measure their dependencies and conflicts using conventional approaches. After the KPIs and their objectives have been set, managers will be unable to update the KPIs in effective action-taking time.

As a result, the feedback loop is quite lengthy. For instance, most organizations have an annual formal planning process called the budget, which involves modeling financial targets and constraints, comparing actual results with previous plans, and refining KPIs and their objectives, in turn leading to an information flow that deteriorates the feedback flow.

A relevant study that correlates with the KPI theme is Zhu et al.’s (2017) work on identification of KPIs for manufacturing operations management in the process industry. Their work separates KPIs in two categories, process and equipment. Apart from creating some valuable equations that directly correlate KPIs within one another, it clearly depicts the relationship between process KPIs and equipment ones. Their work comprised in relating key measurement elements (time and quantity) with other manageable metrics such as “Quality” or “Scrap ratio” on the process side, and “Equipment load Ratio” or “Allocation ratio” for the equipment KPIs.

2.6 Performance Measurement Systems

Nelly’s et al (1995) vision of a PMS is that it is a collection of indicators used to assess the efficiency and effectiveness of actions.

Because performance measurement systems may be used for a variety of objectives, determining what is a good system must be based on its intended use. Some systems, for example, are designed primarily to provide strategic direction to staff (via targets based on measures of strategic performance), while others seek to improve staff and organizational capabilities (via "stretch targets" based on performance measures), others seek to support evidence-based management (via PIs for benchmarking exercises) and organizational learning (via measures of "what works") (Kempf-Leonard 2004).

Accounting or other quantitative figures have traditionally served as the foundation of performance measurement systems. One reason for this is that most accounting-based metrics are simple to use since they are readily available, as many accounting measures may be found in or created from a company's financial records. Although this information is readily available, using accounting figures as performance measurements is neither the best nor the only approach to assess performance. One difficulty is that some accounting data might be influenced by managerial activities, resulting in skewed performance outcomes (Franklin et al. 2019).

The performance measurement system can be used for top management control or to enhance shop-floor improvement. It can be compared to internal or external benchmarks. Whatever the system's goal or intended use of the performance data, a full manufacturing performance measurement system must be comprehensive and cover the organization's most significant performance aspects (Jonsson et al. 1999).

According to De Toni and Tonchia (2001), the PMS has three major phases or characteristics:

- Formalization: depicts the measures and measurements to collect. Must respond to “What will be measured” and “How will it be measured.”
- Integration: the system itself is not isolated, meaning many other inputs from other data systems are shared with the PMS. The PMS must coexist and facilitate both the digestion of information as well as its practicality of analysis.
- Utilization: planning, controlling, and coordinating activities, evaluation, and involvement of human resources, and benchmarking with other organizations.

These characteristics can be observed in Fig 1.

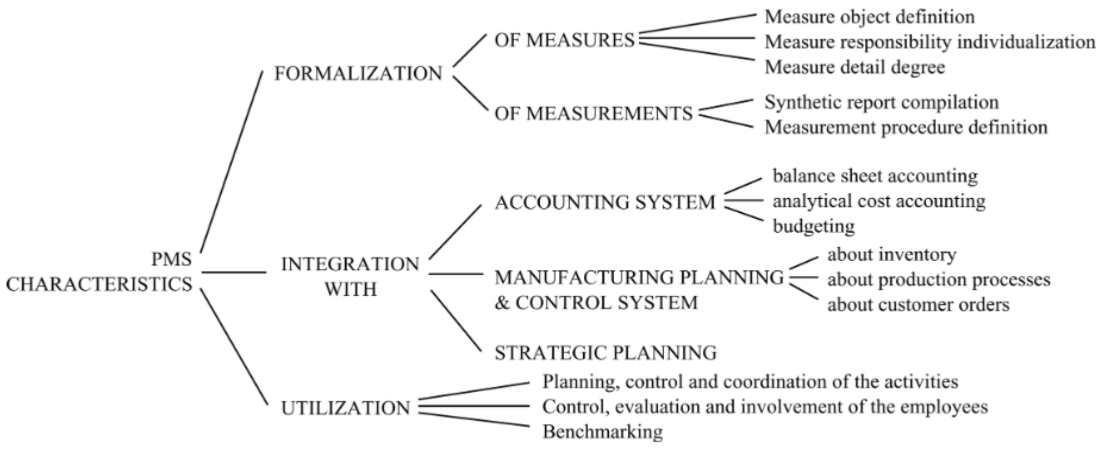


Figure 1 - PMS Characteristics (adapted from De Toni and Tonchia, 2001)

Figure 1 clearly illustrates the complexity of modern performance measurement systems. Divided in 3 branches, formalization, integration and the utilization. These are the identified dimensions of a traditional PMS according to the authors. The formalization process is the state of definition of the system, who is going to use it, what information is subject to analysis, what measurements are needed and in what visual layout. The integration depicts all dimensions of information that can be contemplated in these types of systematic models, meaning it must act according to other more stable systems, such as accounting systems, production systems or strategic systems. In terms of utilization, the PMS is used for three different scenarios. These range from planning and control of activities, the evaluation of employees and benchmarking between sectors or organizations (depending on the entity the PMS is associated with).

Because of the expanding of the spectrum of needed performances and the support of performance improvement programs (JIT and TQM), the rising interest in PMSs has resulted in, on one hand, an update of accounting systems and, on the other, an extension to non-cost performances.

The topic of PMS applied to manufacturing was a topic embraced by Ghalayiani et al. (1997) on the application of an integrated dynamic PMS with the goal of improving competitiveness. They targeted to develop a PMS that broke the traditional accounting-based nature of most PMS up to then. The system proposed to break-down several key areas of an organization, such as quality, delivery and customer satisfaction performances. The metrics were then drilled down to more specific impactful measures. In the case of the customer satisfaction, the metrics that were selected to justify that field's performance were quality, delivery, cost, and integration with customers, for example, meaning these areas are then interconnected with others, supporting the living and interconnected nature of organizations. Each key area has then identified a number of KPIs that subsequently justify the fields results. The authors of this PMS indicate that most companies are already customer focused yet the tracking of most non-value-added activities is not taken into consideration when viewing the customer in isolation, a matter strongly managed with the help of the PMS. In summary, their work targeted multi-level integration considering process improvement teams, management and shopfloor level performance were all aspects considered, aligning both managerial and operation level targets, then sustaining competitiveness growth.

Most notable for the study of the project itself, the KPI tree, was the standardization of KPI trees executed as a mater thesis project as well in Bosch's Braga facility, by Bumba (2020). Bumba's work depicts the use of KPI trees in continuous improvement projects before the author targeted to foment the use of this tool across the facility. Although the formulation of the KPI tree itself was not subject of his work, the standardization of a visual model and revision of the KPI relationships. The tree was then executed in excel, were several KPRs were drilled down according to several levels of KPIs defined as being improvement KPIs, monitoring KPIs, value stream KPRs and general facility KPRs. The relationship between these is hierarchical and visualized in a tree/pyramid structure, following the respective breakdown. The work concluded that most users of the tool found real benefits in utilizing a platform that easily compiles information and demonstrates deviations to stipulated targets, reducing the KPI analysis time and subsequently the project formulation time.

3 Description and analysis of the current situation

As described in the previous sections, the project started from the strategic directive to renew the model of continuous improvement currently used in Amorim Cork. The project was thought to be carried out in Portocork's factory as a pilot for exploration and then application of the model on other industrial units.

The site in question was chosen because of three main reasons. All workers at this site are very driven towards improvement and very understanding of changes if shown the end goal of said alternative. Added to this, the industrial director's curriculum was tailored for an approach using a value/KPI tree-like structure since he had worked in management control a few years back. Finally, paired with a medium size scale operation, Portocork solidified itself as a landmark for pilot tests such as the introduction of this system.

Because this project targets the implementation of a new system/tool, a preliminary description and analysis of the focus topics of the tool is displayed. These are the key areas of knowledge developed and documented in order to correctly achieve a successful outcome. Subject of this chapter are then the continuous improvement cycles and internal projects functioning, the current paradigm of information and the daily Kaizen of the facility. Finally, a roundup of identified problems concludes the chapter.

3.1 Current continuous improvement cycle in Portocork

Currently in its implementation phase, the current continuous improvement cycle follows a 3-month cycle. Part of the continuous improvement cycles are a number of projects that must be completed every three months. These projects are selected by the team according to the priority and projected benefits of their implementation. The cycle itself is ensured via meeting, were all ongoing continuous improvement projects are closed and new ones are formulated.

This selection of new projects is currently done based on both professional experience in the cork industry and some analytical support. These projects are tracked by a member of the Continuous Improvement department that ensures the milestones are reached in the planned time and that support is given throughout the project's life cycle.

A project's execution need is formulated according to the company's vision of the "True North", the name used to describe the company's direction of zero defects, 100% added value, and 100% delivery performance to clients. To achieve this vision, the strive for change is signaled from strategic KPRs and is properly connected to the shopfloor both via VSM and targeting the focus topics, with the KPI Tree. The vision for continuous improvement cycles in Amorim is subject in Fig 2.

The Kaizen is then supported with work standardization, qualification of the operator and especially the integration of everyone in the value chain, meaning, top management and shop floor level alignment.

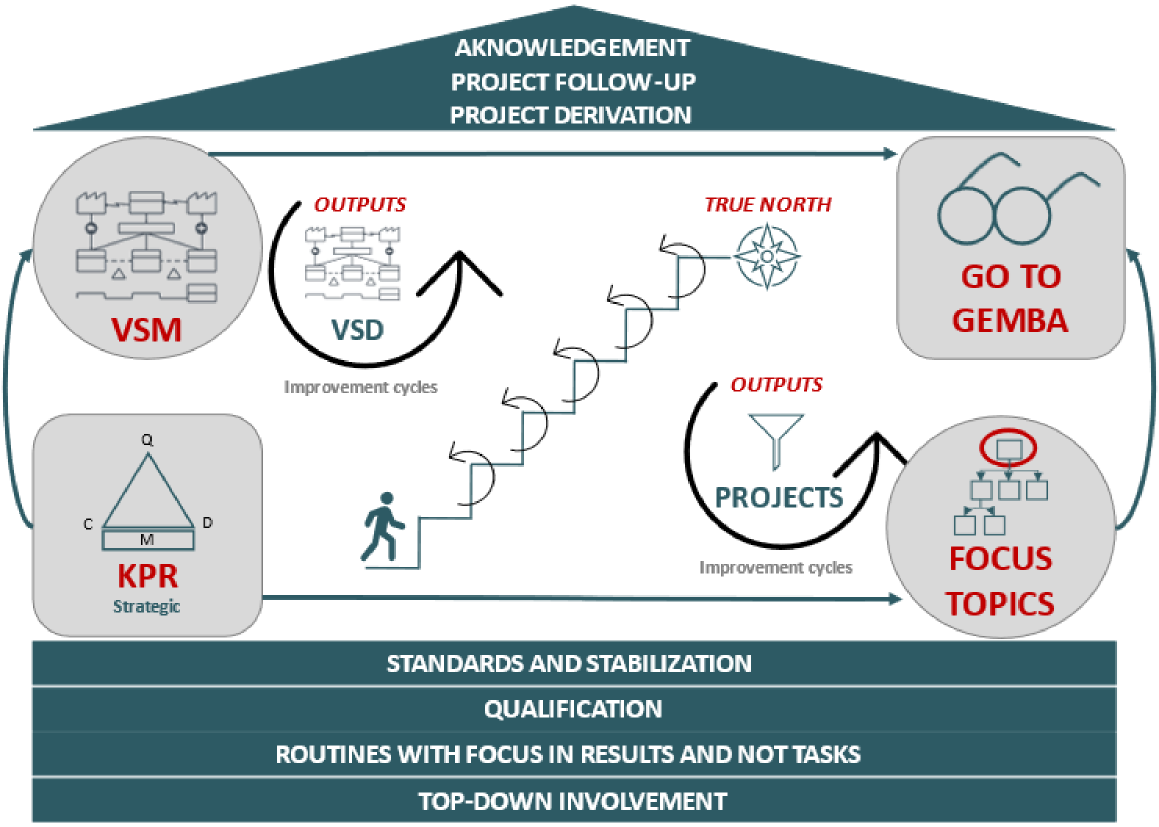


Figure 2 - Continuous improvement system in Amorim Cork

Figure 2 represents the continuous improvement methodology and cycle described earlier. The structure resembles a house that represents the pillars of company culture and continuous improvement. Underlying the main block is the kaizen principles developed and identified by the TPS. Those are that for kaizen to be achieved, everyone must be involved, routines must add value, constant learning is required, and standards and subsequent stabilization is of paramount importance to ensure the company moves forward. Regarding project derivation, projects are derived from strategic KPRs. The KPRs identify usually the main area needed to execute the project, while both the VSM and the KPI tree serve as the bridge between these KPRs and the shopfloor. The projects are then supported in the Gemba meaning the projects and the indicators must be associated with a real problem in the shopfloor, then ensuring the achievement of results. Apart from derivation, follow-up is the next needed step to ensure the cycle is achieved.

Currently, the VSM is being designed in most facilities, ensuring the upper route of project derivation. The problem here resides in the inability to identify the focus topics or areas with analytical data. The KPI tree is then the pilot project that targets to fill this gap and ensure the KPRs are actionable on the field and managed accordingly.

The tracking of the project is ensured with the support of either an A3 or an improvement sheet. These documents have both a template and a standard associated with them. The phases of the project go hand-in-hand with the PDCA cycle, as discussed prior in the literature review segment.

Apart from the tracking and development of ongoing projects, a spirit of continuous improvement is needed at the shop floor level. To ensure all employees carry these values, a Daily Kaizen is part of the factory's daily routine. Daily Kaizen is done in most sectors once per shift and must take around 5 minutes to conclude. Here employees discuss changes to the team, justify any deviation to improvement KPIs of the given sector, and suggest possible improvement opportunities in their routines.

3.1.1 Portocork's project definition and project tracking

One of the most important project assembling phases is the definition of the team. Every project has several roles tied to it that must be assigned first.

So, every project has a leader, a sponsor, and a team. The leader is the person in charge of taking the decisions around the project. The person assigned to this task must coordinate the project, make sure deadlines are met, and ensure the objectives or target conditions are fulfilled.

The sponsor is usually a top-level management individual (like the CEO or COO). All decisions must be approved by the individual assigned to this task. The team itself is composed by the individuals that will execute the actionable sequences that will translate into the objectives. Part of the team is usually department-level management personnel.

In some scenarios, a coach is also assigned. The coach is usually a person from the Continuous Improvement Department whose responsibility is to ensure the proper tools are used and that the team has the knowledge on how to use these tools. An example of a coach's task is to aid in the assembly of the A3.

Part of the project definition is the definition of what metrics to track. These indicators are the metrics responsible for classifying the project as a success of not. The team is then responsible to ensure all phases and indicators of the project are tracked.

In Amorim Cork, projects can be of mostly two natures. They can either be the change of stipulated systems or an actionable change in the shop floor. The first one is usually very hard to measure benefits in units but is usually very relevant strategy-wise. The second one, due to its result-driven nature, is usually easier to define both target conditions and tracking metrics.

As mentioned previously, most projects use the A3 as their tracking tool. The A3 utilized is a derivation of the template shown in Annex 1. In the initial phase of every project, as seen in Annex 2, a summary of the benefits must be made, among others. This field must be expressed in euros whenever possible so that projects can be selected based on the gain they protrude to the organization.

The definition of the project's success is done via KPIs. For each project, a set of KPIs is chosen to help predict if the changes translate into the intended behavior. These are then followed for a given number of weeks until the indicator is stabilized.

As far as changes in the company's results are concerned, there is not a clear metric that aids in the valorization of each project and its correct impact on the overall cost structure. Each of the projects is forwarded to the management control department, which is responsible for translating each of the project's objectives into a quantifiable sum.

3.1.2 The role of the Continuous improvement department

Currently, the continuous improvement department is responsible for the insurance of Kaizen, meaning the three-month cycles of improvement serve as the milestones to guarantee constant improvement is happening. Usually, part of the project's team is a member of this department. This ensures that all the tools and knowledge are present for the smooth execution of the project. As mentioned before, this member can instead be the coach, meaning its functions are exclusively to aid the execution of the project.

In this cycle, ongoing projects from the previous cycle are closed and new projects are chosen. The projects to be implemented result from either the company's strategic directives, the experience of the integrating party (that being the Industrial director, area managers, and other participants), or relevant data such as from the VSM and the KPI tree. Most projects have the analytical supported experience to justify their execution, while logically being aligned with strategic goals (growth, sustainability, etc).

3.2 The current state of information

3.2.1 Cost structure

Amorim Cork is currently undergoing a major digital transformation. The project to implement SAP began in 2019, which ended its implementation in 2022. This means that most of the information is currently part of this system. Some functions of this system are, however, not used to their full potential due to a lack of education in using this system and an inability to adequately create a routine that feeds the system's database.

This, however, is not the case with financial information. This field of information is currently very well documented in SAP and accessible directly through Cubes. These are updated every 12 hours and have all the information related to sales, operational costs, manufacturing goods, etc.

Inside Portocork's industrial unit, the current cost structure is made by centers. These centers follow a pyramid/tree hierarchy formation. At the top, there is a result center that decomposes in various profit centers that subsequently decompose in various cost centers. The result center represents the unit itself (Portocork or "AIPT-PTKN"). The profit centers are five and represent different profit fields. There is a profit center that represents all the costs and gains from general facility fields ("PTKN-Geral"), another one for distribution or flow 2 ("PTKN-Distribuição"), one for maintenance ("PTKN-Manutenção"), one specific to NDTech production (part of flow 1) ("PTKN-NDTECH") and finally one for the rest of the NDTech production flow or the rest of flow 1 ("PTKN-Produção").

The subsequent cost centers follow the same logic of categorization but are more specific. For example, inside "PTKN-Distribuição" the corks are marked, treated, and packaged. For each of these operations, there is a cost center. These cost centers and other ones related to other profit centers can be observed in Fig 3.

Centro cst	ÁCC	Empr	TpC.	Responsável	Usu.repons.	Texto breve
140620158	[redacted]					PTKN-PR-ESCOLHA
140620163	[redacted]					PTKN-PR-LAVAÇÃO
140620168	[redacted]					PTKN-PR-ROSA
140620427	[redacted]					PTKN-GE-LOG INTERNA
140620210	[redacted]					PTKN-ND-GERAIS
140620275	[redacted]					PTKN-ND-NDTECH
140620404	[redacted]					PTKN-GE-SIST INFORM
140620411	[redacted]					PTKN-GE-TERR EDIFIC
140620414	[redacted]					PTKN-GE-SERV SOC
140620415	[redacted]					PTKN-GE-DIR INDUSTRI
140620425	[redacted]					PTKN-GE-CQ PROCESSO
140620436	[redacted]					PTKN-GE-LOG SAÍDA
140620432	[redacted]					PTKN-GE-DESPOEIRAM
140620433	[redacted]					PTKN-GE-REDE INCEND
140620443	[redacted]					PTKN-GE-LOG ENTRADA
140620475	[redacted]					PTKN-GE-SUBCONTRATA
140620459	[redacted]					PTKN-GE-ESTRUTURA
140620462	[redacted]					PTKN-GE-GASTOS COMU
140620476	[redacted]					PTKN-GE-MES
140620477	[redacted]					PTKN-GE-SAP
140620478	[redacted]					PTKN-GE-IMOB INATIVO
140620479	[redacted]					PTKN-GE-TRANSF DIGIT
140620483	[redacted]					PTKN-GE-ENERGIA PTKN
140620421	[redacted]					PTKN-GE-AMB HIG&SEG
140620430	[redacted]					PTKN-GE-AR COMPRIM
140620466	[redacted]					PTKN-GE-REDE DE ÁGUA
140620523	[redacted]					PTKN-MN-MANUTENÇÃO
140620424	[redacted]					PTKN-GE-CQ PRODUTO
140620461	[redacted]					PTKN-GE-GÁS
140620358	[redacted]					PTKN-DI-ESC M.+PES
140620310	[redacted]					PTKN-DI-GERAIS
140620357	[redacted]					PTKN-DI-EMBALAGEM
140620364	[redacted]					PTKN-DI-MARCAÇÃO
140620371	[redacted]					PTKN-DI-TRATAMENTO
140620110	[redacted]					PTKN-PR-GERAIS
140620157	[redacted]					PTKN-PR-EMBALAGEM

Figure 3 - SAP cost centers of Portocork's business unit

The cost centers in question are in the last column and their names are a byproduct of the profit center they are inserted into and the center they represent (such as "PTKN-PR-Embalagem", "PTKN" meaning Portocork, "PR" referencing "Produção" and the name of the center itself, for example "Lavação").

The costs associated with each cost center are the responsibility of different individuals, but, overall, all costs associated with an industrial facility are vetoed by the industrial director.

3.2.2 Production system

Parallel to SAP, there is a production system in place with almost all operational information. This information includes both production volumes by machine and transition hours for logistical movements (when a cart is moved from one stage to another in the facility this operation is registered).

The tool used is MES and is used widely not just in Portocork but in other facilities as well. This tool is specially used for data gathering of multiple centers.

Although the system is currently running widely at the facility, much like SAP, the full functions and capacities of this tool are still being learned and developed in the group due to the same digital transformation directive that implemented SAP. This means full MES functionality is still in question, which leads to most production centers using MES much like a production record.

Because most machines are not directly connected to MES, via automaton, most information present in MES is still introduced manually, such as the logistical movements within the facility.

In terms of structure, this system is organized by centers as well. MES bridges with SAP in a field called "AreaSapWorkCenter." This field is very helpful in aiding the connection between production and costs.

SiteName	PTK
Group Type	Produções

Sum Quantity			Year	MonthId	Year	WeekYearId
			2023			
			202301			
			2023			
AreaSapWorkCenter	**SystemArea**	**SystemAltName**	**202301**	**202302**	**202303**	**202304**
LAV001	**Lavação**	Lavacao 01	[redacted]			
		Lavacao 02				
		Lavacao 03				
		Lavacao 04				
		Lavação Estornos				

Figure 4 - MES supplied pivot table, depicting production volumes of "PTKN-PR-Lavação"

In Fig 4 , an "Excel" PivotTable extracted from a MES cube is shown. This table is filtered to show the production of "PTKN-PR-Lavação" by month and week. The first column is the parallel field between both systems, all other columns are MES-specific. The third column, named "SystemAltName" shows the number of machines attributed to the center plus an additional one for wastes generated. This means in "PTKN-PR-Lavação" there are 4 machines, and their respective production is shown in all the following columns.

The machines themselves may be different and may operate different cycles, information that is not shown on the system. To correctly utilize the production data from MES, one must attend to the factory and clarify machine details and particularities, following the *Gemba* approach.

3.2.3 Difference between centers and workflow

The systems described cross all centers, but logically, due to the different types of operations carried out, different data and particular system use cases are in play. One example of this is the case of NDTech. This is a high-tech procedure, with major time allocation dedicated to it. NDTech is a very expensive patented technology that requires constant investment for both its maintenance and upkeep. In centers like this one, more information is gathered, and the depth of information is greater.

In this work center, all machine stoppages are registered, accounting for how much time a machine stopped and why it stopped. This leads to a greater depth of management and possible problem identification. This information originates maintenance KPIs such as the MTBF and MTTR, which are tracked and managed monthly by the operations director.

This span of information is not a common occurrence in other centers. No other center has traceability of stoppages, meaning, no indicators of this nature are tracked and managed.

The planning of operations and production is mostly done by hand and is often not deployed in either of the two systems. This is then a manual sheet with the production plan.

One characteristic that differs between work centers is the type of production carried out. While flow one, scoping "AIPT-PTKN-NDTech" and "AIPT-PTKN-Produção" (NDTech, washing, sorting, and packaging), produces under a make-to-stock strategy, flow two, scoping only "AIPT-PTKN-Distribuição" (branding, treatment, and packaging) produces under a make-to-order strategy.

3.3 Daily management

3.3.1 Daily Kaizen

Part of every team in the factory is a routine activity called daily Kaizen. This activity is a 5-minute meeting scoping the communication of everyday occurrences as well as future improvement opportunities. In this event, production deviations are discussed as well as misalignment of objectives. New objectives for the team are also defined.

The tracked KPIs on these meetings are monitoring KPIs, meaning it is not clear what problems the teams need to tackle. One example of an indicator with this profile is the production level. In all teams, the production level is the most important KPI, indicating the level of production the center achieved daily. The operators cannot improve production directly, they can only alter the problems that are negatively affecting production, meaning the KPI does not follow the clarity needed to imply action.

3.4 Problems identified

3.4.1 Project tracking and KPI monitoring

From the described processes regarding projects and their monitoring, there is not a clear understanding of how long the KPIs should be monitored and the exact way to measure them. Because all projects are supported by their respective A3, some of the defined monitoring metrics fail to classify as KPIs. Most of these have Euros as a unit of measurement, which makes them KRIs.

Parallel to this issue, most of the KPIs chosen are not defined generically, meaning they are one-time measurements of a new unit and pose no standardized way of being both managed and measured. This in turn may lead to different results when different people calculate/gather this data.

3.4.2 Information scarcity and cost center disparity

Apart from NDTech, all centers have no tracked indicator related to efficiency, meaning every day the teams are judged based on their production volumes, where they need to justify any possible deviation from the planned production. Most of these metrics are turned towards results but lack the actionability and clarity of problem resolution needed to be acted upon by operators. This is proven by the fact that only in NDTech is OEE measured and managed.

The overviewed information accentuates the lack of consistency in the information collected between different centers. An example of this is the maintenance indicators tracked in NDTech. This is the only center in the industrial unit where there is an MTBF and MTTR. This creates a much deeper action plan when an indicator is underperforming.

Currently in Portocork, there is a quality standard assumption for processes of 99,5%. This indicator means every process generates one defect per every 200 cork stoppers. The problem with this assumption resides with the defects only being tracked once in a process called sorting (“PTKN-PR-Escolha"). In this process defects (defects associated with the cork’s raw material and other physical defects of the product) are ruled out, having no later traceability to what process generated the defect. Quality is, in this case, a static metric that has no actionable solution if identified later in the selection process as a sensible KPI.

3.4.3 Daily managed objectives

As identified in section 3.3.1, the indicators managed daily by the teams are mostly related to production volume. This directly impacts the actionability of the team. If the defined success metric for a team doesn´t directly correlate to a possible solution, only indirectly can the team act upon a certain problem.

This is a known problem for the organization but because of the information scarcity and lack of more detailed KPIs, there is still the underlying issue of having this as a metric of success.

Ideally, all teams should have an improvement KPI, that is a KPI that is aligned with the desired main goal of the industrial facility yet translates into direct action, in turn resulting in a quicker problem turnaround and reducing the time to problem solve daily issues.

3.4.4 Project Valuation

Currently, the identified issues parallel a minor one concerning the valuation of projects. Across the wide span of the organization, all projects' main benefits must be calculated in euros, meaning projects must bring real value to the organization. The valuation of any initiative is a task assigned to the Management Control department, which has no standardized way to evaluate projects.

Because projects must bring value, their positioning in the pipeline depends on the forecasted benefits of the project. This results in a lack of prioritization of the pipeline, either because it is very hard to forecast a project’s financial gain or because the only decision supporting the order of project execution is the experience of what areas of the industrial facility should be acted upon, which can often lead to shortsighted decisions when compared with organizational alignment.

4 Proposed solution

The problems identified in section 3.4 are recognized by the company, resulting in efforts toward the mitigation of these inadequacies. The company's strategic directive envisions the execution of a value tree for the whole group, starting from the Operational Costs and drilling it down to shopfloor metrics. From this directive resulted the need to break down the operational costs of a pilot unit, Portocork.

The proposed solution is a KPI Tree elaborated with support of MS Excel, where financial and operational information was gathered and organized in such way that analysis and problem identification could be done in a consistent manner aiding both project formulation and overall facility management. The following section relates to how the project was developed as well as the rationale behind the decisions made. Underlying all this chapter's procedures is the parallel information structure displayed in the previous chapter.

An important general note transversal to all the tree-like structures shown is the base KPI card developed. In Fig 5, the common KPI card is shown. The card is a simple generalized visualization model that represents either a KPI or a KPR. Independent of the type of information selected, all cards have a unit, the current value (actual), the targeted value (target), 2021 and 2022's YTD values, and the comparison with the target. For the case of KPRs specifically, the absolute and relative percentage weights are displayed as well. The relative value represents the percentage the current KPR (PTKN-DI-Tratamento's cost in this case) occupies in the corresponding parent. Some later shown trees may have a different appearance, considering they are reminiscing of non-variable factors such as workdays in a given month. In these cases, the card is shorter and only have unit and actual value.

PTKN-DI-Tratamento	
Unit	€
Actual	
Target	
2021	
2022	
Actual vs Target	
Weight (Relative)	
Weight (Absolute)	

Table 1 - PTKN-DI-Tratamento's KPR cost card

4.1 Financial drill-down

The proposed KPR to drill down, operational costs, is a metric in euros associated to the industrial facility. It is organized in the centers described, where the result center represents the upper level of the structure.

Because financial information is deeply structured in SAP, the drill-down of the KPR followed the present center distribution resulting in the tree like structure represented in Fig 5 and in more detail in Annex D's objects.

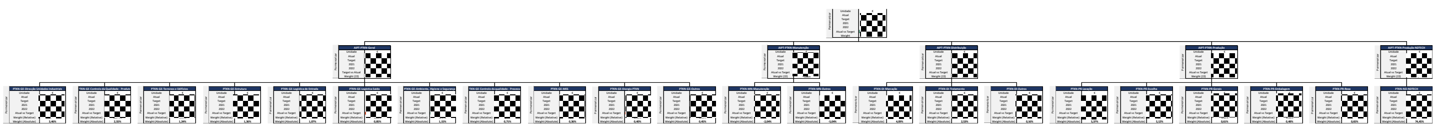


Figure 5 – Center tree structure, showing result, profit and cost centers by their respective level

The portrayed data aids visualization of costs associated to Portocork's facility. The picture clearly depicts the differences between the levels of costs in the facility. Three levels are then shown, result, profit and cost center level costs, respectively order from top to bottom

In these appendixes, every center is inserted into a standard KPI card. Every card has the unit of the value shown, the value itself, the targeted objective for the value, 2021 and 2022 results, the difference between the value and the target, and finally the absolute weight of the center (the center's weight comparing to the result center) and the relative weight of the center (the center's weight comparing to the previous hierarchy level). The hierarchy is ensured by the connections between cards.

The data is updated monthly, meaning the tree summarizes the financial cost structure of a given month. Parallel to the monthly view of information, a cumulative monthly view is possible in other to make possible the management of the information in a YTD basis.

With the current data, deviations between real costs and forecasted budgets can already be managed. Added to this, critical areas of the facility can be analyzed as well, corresponding to higher percentages of costs. For example, in Portocork's facility, the most critical area of the facility cost-wise is "PTKN-ND-NDTECH", representing around 70% of the industrial facility's costs.

This structure, however, lacks depth of information. To solve this issue, further drill-down of each center was executed, showing every center's cost by type of entry. The entry categories are costs with staff, maintenance, energy, depreciation and amortization process materials, impairments, and other costs. This categorization is possible for all centers, meaning cost centers, profit centers and the result center, which is represented in Fig 6.

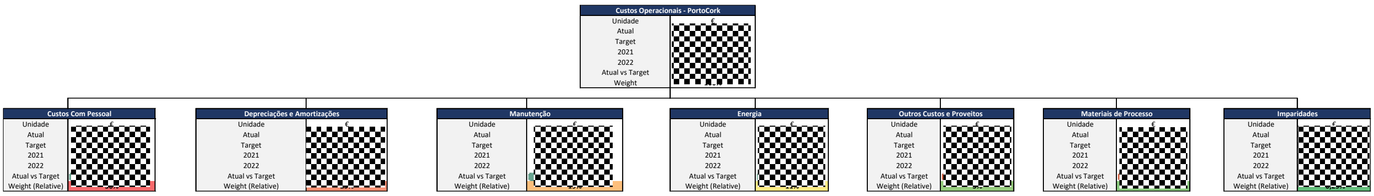


Figure 6 - Alternative view for center financial costs break-down

The view is very similar to the one shown in Fig 5, differs only in the previously discussed categorization of costs. The common KPI card was applied to each category as well.

The financial information aids in various aspects of management, such as budgeting, cost management, and problem identification, but lacks drill-down when it comes to operational performance, for example, the manager can identify a problem in a given center of the facility yet lack the depth of data needed to further pursue the issue, leaving it only identified.

The tree, as it was described, currently only aids in the realms of problem identification due to the data gathered and compiled in it. Also, although with less depth than now possible with the tool, cost management and budgeting are management dimensions currently practiced with great aptitude and extent in Amorim Cork.

In order to further develop the full capabilities of the tool, more and different information must be compiled. For this exact achievement, the development of operational indicators was executed.

4.2 Operational data and KPIs

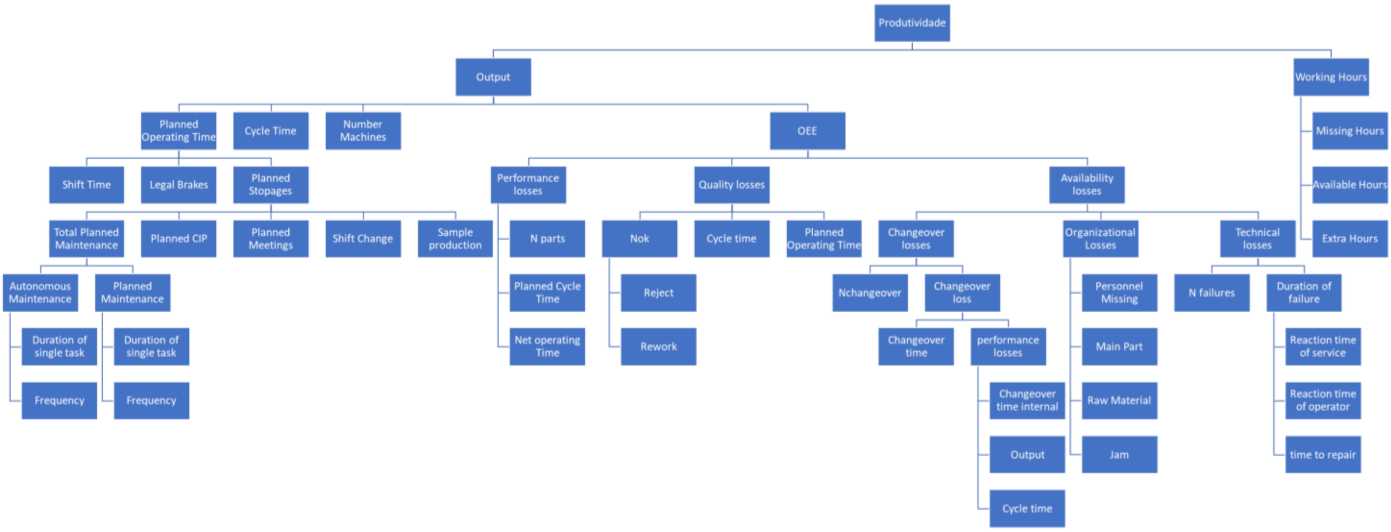
As a way to extensively search the root cause of identified problems, operational information was gathered. The rationale behind the further development of the KPI tree was to follow the productivity stream.

Firstly, an ideal state of productivity information was elaborated. This served as the guideline for the elaboration of the tree branches and as the ideal state to strive for.

The productivity was metric chosen as a KPR for operational level management. The drill-down of this indicator follows the standard defined in Fig 7.

Figure 7 - "Productivity" KPR drill-down rationale

The proposed drill-down shown in Fig 7 is very ambitious. The level of information detailed is of impressive magnitude and ensures proper root cause analysis of shopfloor indicators.



The detailed breakdown of productivity detailed in Fig 7 is formulated as such in table 2:

Table 2 – "Productivity" KPR drill-down and formulation

KPI	Unit	Formula	Description
Productivity	Th/hour	$= \dfrac{Output}{Working\ Hours \cdot 1000}$	Thousands of cork stoppers produced per working hour
Output	Number	$= \dfrac{Planned\ Operating\ time \cdot OEE \cdot Number\ Machines \cdot Days}{Cycle\ time}$	Production Volume for a given month
Working Hours	hour	$= Total\ Available\ Hours - Mis\sin g\ Hours + Overtime$	Planned working hours respecting human stoppages
Planned Operating Time	Hour	$= Shift\ time - Legal\ Brakes - Planned\ Stoppages$	Planned operating machine time
Planned Stoppages	hour	$= Total\ Planned\ Maintenance + Planned\ CIP + Meetings + Shift\ Changes + Sampling$	Machine planned stoppages
Total Planned Maintenance	Hour	$= Autonomous\ Maintenance + Planned\ Maintenance$	Total time regarding all planned maintenance activities

Autonomous Maintenance	Hour	$= Duration\ of\ \sin g\ le\ activity \cdot Frequency$	Total time for autonomous maintenance activities
Planned Maintenance	Hour	$= Duration\ of\ \sin g\ le\ activity \cdot Frequency$	Total time for non-autonomous maintenance
OEE	%	$= Availability \cdot Quality \cdot Performance$	Overall equipment efficiency
Performance	%	$= \frac{Real\ Pr o\ duction}{Planned\ Cycle\ Time \cdot Net\ Operating\ Time}$	Production losses on cycle time
Quality	%	$= 1 - \frac{Nok\ parts}{Total\ produced\ parts}$	Quality losses in production
Availability	%	$= 1 - \frac{Changeover\ Losses + Organizational\ Losses + Techical\ losses}{Planned\ Operating\ Time}$	Availability losses of the equipment
Nok	number	$= Reject + Rework$	Total number of defects
Changeover losses	hour	$= Number\ changeover \cdot Changeover\ loss$	Total time lost on changeover
Changeover loss	hour	$= Changeover\ time \cdot Performance\ losses$	Time lost on changeover per piece
Performance losses	hour	$= \frac{Internal\ Changeover\ time}{Cycle\ time} \cdot Output$	Total time lost on internal changeover times
Organizational Losses	hour	$= \sum All\ organization\ time\ losses$	Organizational losses such as Personnel Missing, Jams, lack of raw material, etc
Technical losses	hour	$= Number\ failures \cdot Duration\ of\ failure$	Total time lost due to technical reasons (maintenance)
Duration of failure	hour	$= Reaction\ time\ of\ service + Reaction\ time\ of\ operator + Time\ to\ repair$	Total time of single failure

Although the proposed drill-down of the Productivity KPR would offer an extensive root cause analysis possibility, the trade-off between the collection or not of information is an aspect that must be considered. The depth of information collected in this given tree is, then, only justified in centers with major investment/critical areas (firstly).

Having the KPR drilled down to the down most level of the shopfloor, the current situation for applicability purposes must be achieved. As such and following the as-is situation described in section 3, the drill-down depicted in Fig 7 must be adapted to each center according to how much information is available.

Regarding what centers are eligible for the elaboration of the productivity drill-down, every center that is productive, meaning, has a physical space in the facility with direct added value activities for the final product, the cork stopper, is subject to this drill-down. These are seven in total, separated between the 2 flows of the facility, and are some of the centers shown in Fig 3, specifically, "PTKN-ND-NDTECH", "PTKN-PR-Lavação", "PTKN-PR-Escolha", “PTKN-PR-Embalagem" for flow 1 and “PTKN-DI-Marcação", “PTKN-DI-Tratamento" and “PTKN-DI-Embalagem" for flow 2.

4.2.1 General adaptations to the rationale and customization

As mentioned previously, NDTech is the most prestigious center of Portocork’s facility, having privileged access to information. Although this is the case, many of the indicators and much of the drill-down rationale proposed are still unattainable.

The disparity between the information needed and the existing is notorious especially in the “Planned Operating Time” breakdown, as well as in the “Availability” drill-down.

The change made to the “Planned Operating Time” is transversal to all centers and should align the shift time with the legal brakes and planned maintenance. Simplifications to the drill-down of “Availability” were made as well due to the extensive descriptive nature the rationale was thought to portray. “Availability” was then formulated according to 3 manners, depending on the center the indicator was calculated.

Regarding the “Availability” indicator, it was pointed that in order to properly calculate this metric, a number of other times must be selected

For “PTKN-ND-NDTECH", because all machines' stoppages above 10 minutes are registered and updated on a SAP database, the “Availability” of these machines can be calculated with the maintenance indicators of MTBF and MTTR. All problems concerning organizational losses and technical losses are then visible in the production by comparison of the theoretical cycle time versus the actual cycle time. The current problem with the 10 minute registration is that, although stoppages are indeed tracked, there isn’t a standard for the type of registry associated with the stoppage, meaning, the same type of stoppage can in fact be associated with various connotations in system, making it very hard to categorize the types of stoppages for later drill-down. This limits the level of analysis possible from the “Availability” KPI.

In the case of the rest of the centers, except “PTKN-PR-Lavação”, the “Availability” cannot be calculated with maintenance indicators since they are not measured. Due to this reality, “Availability” is measured by the ratio between hours where a MES entry was given and total shift time. This is a trustworthy method if a couple of assumptions are made, those being that no overtime is done on the center and that MES entries are done at least hourly. The presented solution is considered a short-term fix to calculate the “Availability” KPI semi-automatically, considering that ideally all stoppages per center have a database associated with it, that can offer both down-time as well as type of stoppage, going then one step further than NDTech. The current methodology presented is very limited considered MES entries are not automatic in most centers, meaning, operators allocate the task of manually production registration according to their present needs. This results in much sparser registrations, that will impact the “Availability” KPR negatively, which sometimes isn´t the case.

For the case of “PTKN-PR-Lavação”, this method of measurement is not applicable considering every washing cycle takes more than one hour, resulting in scarce MES registries. Because of this very issue, for “PTKN-PR-Lavação”, the “Availability” is a result of the planned maintenance. sdfghdfgh

In the facility’s flow, non-conforming products are only selected in a process called sorting (“PTKN-PR-Escolha"), meaning only in one process defects are identified. The defects themselves are not subject to thorough identification, meaning no traceability is possible, resulting in the “Quality” in the choice center measuring the total flow defect. All other indicators of “Quality” are stipulated as 99,5%.

Products can either be rejected by being non-conforming (lack technical specifications) or by being considered a defect (physical damage to the cork). The facility was subject to serious strategic changes that altered the product and process flow, being in a stabilization process, which is why only defects are being considered for “Quality” purposes.

In addition to these customizations, information concerning available working hours to the factory was gathered with the human resources department in order to unlock the possibility to calculate the “Productivity” KPR.

All production levels were extracted using the real production registered in MES, either manual production or automatic.

4.2.2 Centers

4.2.2.1 NDTech (“PTKN-ND-NDTech”)

In this center, the development of the “Productivity” branch was the swiftest. Considering the management needed to make this process profitable, 3 different categorizations of OEE were made. The NDTech process was then separated into NDTech 1.0, NDTech 2.0 natural, and NDTech 2.0 champagne. This categorization follows the norm in this center, where the types of production are separated according to the 3 standard operational line types described.

This center works with two twelve-hour shifts, seven days a week. This means in terms of “Planned Operating Time”, 22 hours a day are considered minus the 30 minutes of planned cleaning/maintenance a day. The cycle times differ between the three lines, being 15 seconds per stopper in NDTech 1.0, 20 seconds per stopper in NDTech 2.0 natural and 16 seconds per stopper in NDTech 2.0 champagne.

The number of machines in each line is also an important factor that translates the production capacity of each line. For 1.0, 58 modules are operating, for the case of 2.0 natural, 4 modules are installed, and in the case of 2.0 champagne, 5 modules are operating.

The “Availability” is measured as discussed in section 4.3 using the MTBF and MTTR maintenance indicators.

The resulting data was compiled in the standard KPI tree proposed model, represented in annex B.1, with greater detail in annexes B.2, B.3, and B.4.

4.2.2.2 Washing (“PTKN-PR-Lavação”)

In the washing center, the application of the model had to suffer no differentiation of lines. Meaning only the customizations described in section 4.3 were applied.

This center works one 8-hour shift per day, 5 days a week. This center has 3 machines, each one capable of executing a different type of washing procedure. Machine one has the capability of executing 4 cycles in an 8-hour shift, while the other two machines can only manage to execute 2 cycles in the same period. The third machine needs to be cleansed every Friday due to the specifications of the procedure and the chemicals involved. This results in an “Availability” of 100% for machines 1 and 2 and only 90% for machine 3 since the cleansing process takes half a shift.

The procedure washes a maximum of 45000 cork stoppers per cycle, yet the realistic number of cycled stoppers is much lower because the procedures can be halved, according to production requirements, which happens frequently. This would result in a mismatched “Performance” indicator because, for the operating time, the output of the process would be much lower than the theoretical.

To solve this issue, instead of comparing the quantities produced versus the theoretically possible outcome, the comparison is made between the number of programs executed versus the theoretically possible. This generates a more stable "Performance" indicator but a more unexplainable volume outcome ("Output").

The resulting tree using the data explored in the current section is depicted in annex B.5 and with greater detail in annexes B.6 and B.7.

4.2.2.3 Sorting ("PTKN-PR-Escolha")

As it stands, the concept of single sorting procedures is common is industries were the main raw material is a natural product. All stoppers are subject to mechanical processes and defects are only "selected" apart in the process called sorting. Because of this, this is the only center in the facility defects are generated, leading to the assumption of "Quality" explored in section 4.3, meaning this center's "Quality" indicator will traduce the overall quality standard for the facility. The current indicator was expected to be around 5 to 10%, confirmed in March with 5.6% of all stoppers having been selected apart for the presence of defects.

Apart from this particularity, the center works on two 8-hour shifts as well, 5 days a week. Currently working, are 4 machines capable of outputting 191,5 cork stoppers a minute, or 3,2 corks a sec. "Availability" in this center was the first calculated using MES, in the process described in section 4.3 as well.

Although the quality indexed to a center's OEE should only consider defects generated in the highlighted process, because of this particularity concerning defect selection, the quality indicator is negatively affected while other centers appear to have a higher quality index.

Even though this is the current paradigm with quality across the group's facilities, in terms of operation line, the quality indicator in this center's OEE still explains the difference between input and output of this process, which is important data for the formulation of the "Productivity" KPR.

In order to empower the analysis from the "Quality" KPI, the defects would ideally be subject to a traceability identification process. This is possible considering each process usually generates a characteristic defect. The defects could then be traced back to the respective center. This would make possible the derivation of local projects in each center considering "Quality" increases or at least offer the level of defects generated in each center. This information is of paramount relevance considering that "Quality" overall is one of the most important aspects of every manufacturing business, but especially for Amorim Cork considering that defects are sold as waste at a much lower margin to supporting companies in Amorim's value chain, like Amorim Composites or Amorim Insulation.

The resulting indicators are illustrated in annexes B.8 and B.9.

4.2.2.4 Packaging ("PTKN-PR-Embalagem")

The final center of flow 1 is the packaging process, where the product is properly wrapped and boxed for later expedition. Flow 1 of manufacturing has its packaging center working the same two 8-hour shifts, 5 days a week.

This center only has one machine that packages up to 80000 cork stoppers per hour, or around 22 stoppers per second. These high cadences are a common practice on packaging machines, which usually makes another center other than packaging the bottleneck of the respective flow.

The usual problem with packaging units is that, although machines work very fast compared to the rest of the flow, supporting manual activities such as the physical moving of boxes and the assembly of boxes with the output bag (by the operator) are very time-consuming, meaning the machines themselves are stopped for long periods of time.

The resulting “Availability” is, because of this, very low in packaging operations within the group. This is no exception in this center, where the “Availability” indicator is valued at 58% in the month of March.

The final resulting “Productivity” branch is detailed in annexes B.10 and B.11

4.2.2.5 Branding (“PTKN-DI-Marcação”)

The first center of flow 2 is branding, which is the process where the cork is engraved with the desired design. There are three types of branding processes in Portocork. These are ink, fire, induction, and laser. Corks can also be marked either on the side of their body or their tops. This aspect is relevant considering the laser process needs two different machines to correctly perform both tasks.

Because of this differentiation, four different categorizations of output were considered, those being ink, fire, laser body, and laser top. This categorization was supported by the need for a different management of all these categories’ problems and improvement opportunities.

The center itself works two 8-hour shifts, 5 days a week. For the “Planned Operating Time”, however, 16 hours were considered per day instead of the normal 14 hours (1 break hour per shift), because there are no effective break hours in this center. This decision is supported by the current capacity problems at this center, where they are struggling to meet the forecasted output.

All categories have different specifications when it comes to cycle times, where ink marks 2000 corks per hour per machine, having five machines, totaling 10000 cork stoppers marked per hour or 2,78 corks per second. In the case of fire branding processes, 11000 units per hour per machine are marked, having three machines, totaling 33000 marks per hour or 9,17 corks per second. Laser branding machines, when it comes to cork tops, have a cadence of 5000 units per hour and are two machines, totaling 10000 corks marked per hour or 2,78 seconds per cork as well. Finally branding processes to a cork’s body using laser is only possible using one machine that has an output of 5500 corks per hour or 1,53 corks per second.

There is an inherent problem to a branding center, that has to do with setup times per order. Assuming the string of production orders waiting to be manufactured are from different clients, different branding stamps must be used, implying considerable setup times each time a new order is manufactured. This represents around 10 minutes for each setup and is a problem that will directly affect the “Performance” indicator.

All centers’ production lines are connected to MES, except the branding of tops using laser, this originates sparse manual entries in the system, which will very negatively impact the “Availability” indicator, which in March was 30%. Although, the deducted “Availability” is very low, “Performance” values exceed the theoretical one by a substantial margin, a fact supported by the machine operating, just not being registered its production value every hour. In March the “Performance” indicator was 172%.

The resulting tree is the largest of its peers and is depicted in annex B.12 and with greater detail in annexes B.13, B.14, B.15, and B.16.

4.2.2.6 Treatment (“PTKN-DI-Tratamento”)

The second stage of flow 2 is treatment, where corks are subject to a lubrification process using different chemical products. In this process, different types of treatments can be applied to the cork.

This center currently has 5 machines, each one capable of treating 16000 units per hour, totaling 80000 treated corks per hour or 22,22 corks per second. In terms of shifts, this center works two 8-hour shift schedules, five days a week as well.

The center's operation is direct and straightforward and most of its problems come from annex activities such as logistical movements and overall space, problems that have no direct traceability to the "Availability" but negatively impact it, translated by the March value of 47%.

The tree designed for this center is present in annexes B.17 and B.18.

4.2.2.7 Packaging ("PTKN-DI-Embalagem")

The final center of flow 2 is, again, packaging. The difference between flows makes it unpracticable the existence of only one packaging center, resulting in two stations that function very similarly yet package different final products.

The center in question has 2 machines, a manual packing machine, where bags full of cork must be sealed by an operator, and another machine that both bags the stoppers and seals the bag, leaving to the operator the task of boxing the bag.

The cadences of these two machines individually are not tracked, yet they collectively sum a total of 95000 packaged corks an hour or 26,4 corks per second. The shifts are similar to other centers, where two 8-hour shifts are worked per day, with 5 working days per week.

The "Availability" of this center suffers from the same problems the packaging in flow 1 does, where supporting tasks occupy most of the time spent by the operators, leaving the machines unattended and thus impacting the center's OEE.

The information, much like all other centers, was compiled in the standard KPI card tree and can be observed in annex B.19 and in greater detail in B.20.

4.3 Estimating Project Valuation

With both financial and operational information, one of the main uses of the tool can be tackled, which is the project valuation and focus topics. Projects must bring real value to the company, and from a selection of multiple projects the ones whose value generation is the highest should be prioritized.

As mentioned in section 3.15, project valuation is a dimension of a project calculated by the Management control department, following no standard procedure. This impacts both the speed and the reliability of how projects are valued.

To combat this issue, and using all the information previously gathered, a relativization of costs can be made. Associated with all production centers is a production and a monthly cost of operation, meaning that costs per thousand units can be monitored.

If, for a project, both an initial situation of the KPR and a final/desired stage is defined, both current and ideal costs per thousand cork stoppers are measurable. Knowing how many operations each center does in a year makes possible the extrapolation of costs saved with the project per year, retroactively if the project were to be implemented in January.

Logically, a project might have an investment associated with it, that must be considered when costs are relativized. For ease of use and more uniform project valuations, a tool capable of gathering the costs explored in this section was developed and is shown in table 3.

Table 3 - Project Valuation model for "PTKN-ND-NDTech"

NDTech Costs	Productivity	Working Hours	Costs per thousand	Anual Savings
A	B	C	D	L
E	F	G	H	

Projected anual production	J	Difference
Estimated extra cost	K	I

Table 3 is the table used to attribute a monetary gain (or loss) to a given project. The table shown is the template taken from “PTKN-ND-NDTech”. The table is composed by two major rows that present the pre and post change results. A, B and C represent the current values of costs, productivity and working hours, while E, F and G represent the same variables post change (calculated using the Productivity tree). Assuming a change has an investment opportunity tied to it, that monetary cost must be implemented in cell K, so that it is added to A, resulting in cell E. With these values, it is possible to calculate the average cost per thousand stoppers from that period, both current and projected costs (after the projects implementation). The difference between these 2 values results in cell I, that when multiplied by the projected annual production, cell J, gives a general range for the projects valuation, in L.

An example to illustrate the application of this model is the increase in the OEE by 10% in NDTech 2.0 champagne. The cost values to implement should be of stable nature, for example the cumulative costs of the center from January to March, as well as the productivity and the hours worked in the same time frame. The project itself resides with the increase in 10% on a particular line of NDTech, which, when upscaled, translates in an increase in productivity from 1,561 to 1,566 thousand per hour worked. Assuming this project won’t impact how many hours are worked in the center (*ceteris paribus*), the cost per thousand corks made in NDTech would go from a given value to an inferior one, resulting in the project valuation.

The value generated from the project is then the difference between these two values scaled by how many units this center produced, resulting in a given monetary gain saved for targeted annual production. The valuation of the project is calculated using a conservative approach of 85% of the direct calculation, due to variable costs associated with higher production levels, which are complex to incorporate in the desired simple approach of the tool.

This methodology for project valuation is present for all centers discussed in the prior section, meaning for all projects whose desired state alters in some way the “Productivity” KPR, its value can be calculated with this method.

4.4 Utilization of the tool

With the tool’s structure and the data inserted up to May, the next logical step onboarded was the execution of routines for analysis, data entry, and new KPI tree development.

4.4.1 Dashboard

After the information break-down according to the previously stated parameters, it was identified that the tool/document itself was very extensive and the filtering of important data is of complex nature. In order to solve this issue, an initial dashboard with the main takeaways was elaborated. This dashboard is separated into two parts, the financial and the operational, and the full view is present in annex C.1. In the financial part of the dashboard, the summaries of the years 2021, and 2022, and the YTD values of the year 2023. Part of these summaries is the real values present for all the profit centers (“PTKN-Geral”, “PTKN-Manutenção”, “PTKN-Produção”, “PTKN-NDTech” and “PTKN-Distribuição”) and their targets. The weight that each profit center occupies on the result center, Portocork (“AIPT-PTKN”), is also present, in order to aid the identification of deviations to previous years.

Adding to this information, comparisons between the total costs of the unit and the budgeted targets were included. This relationship is very important to justify deviations to the planned course of activities of the unit. These comparisons alongside all other information as compiled in the dashboard previously mentioned, yet the financial part of the dashboard is shown in Table 4.

Table 4 - Financial tracking dashboard for Portocork's profit centers

Costs		2021		2022		2023 (YTD)	
	Profit Center	€	%	€	%	€	%
	NDTech	[redacted]	79%	[redacted]	69%	[redacted]	58%
	Geral		11%		14%		20%
	Produção		10%		12%		9%
	Distribuição		3%		8%		11%
	Manutenção		-3%		-3%		1%
	Total		100%		100%		100%
	Target	-	-	[redacted]			

Paired with financial information, the operational information was compiled as well. Because the "Productivity" branches of the tree are very extensive as a collection of information, the correct management of this information is expected to be hard and tedious process.

The same logic was then applied to the indicators proposed, to make a small dashboard that compiles the pivotal information for the management of these centers.

Defining what indicators to represent in the tool followed the strategic rationale of the group, meaning, production volume is to be considered the paramount information to determine the performance of the center. Paired to the production volume, the OEE of the centers as well as the "Productivity" KPR of each center was included as well. To conclude the indicators to manage, the "Cost per thousand stoppers" was selected as well, being the bridge between the operational and the financial paradigms.

The operational information was compiled in a dashboard very similar to the previously shown and is present in table 5.

Table 5 - Operational tracking dashboard for Portocork's productive cost centers

Productivity			2023			
	Flow	**Cost Center**	**Output**	**OEE**	**Productivity (th/h)**	**Costs p/thousand**
	NDTech	NDTech	[redacted]	85,6%	[redacted]	[redacted]
		Washing		94,1%		
		Sorting		49,5%		
		Packaging		41,4%		
				Total		
	Distribution	Branding		45,2%		
		Treatment		26,87%		
		Packaging		34,22%		
				Total		

4.4.2 Analysis routine

With the implementation of the dashboard, a "standard" routine for data analysis was then made in order to normalize the way the results are taken out of the document.

The tool was thought to be part of the routines of mid to high level management, meaning utilization must be simple and conclusions concrete. For this the dashboard works as the overall check-up of the facility. Through this, the manager knows how the financial situation of the whole facility is undergoing as well as each particular profit center, meaning if one center is expending to much, the manager can then further pursue the issue in the detailed financial tree setting.

For example, is for the case of “PTKN-Distribuição”, if the center is outspending the budget, the manager is incentivized to further view the problem of this profit center by expanding it in the appropriate sheets, meaning, the deviation is the product of the cost centers’ deviations inside. The center then drills-down to the particular cost centers (“PTKN-DI-Marcação”, “PTKN-DI-Tratamento”, “PTKN-DI-Embalagem”, and “PTKN-DI-Geral”), where the problem can be further explored.

Parallel to this data analysis, the identification of malfunctions in the facility can also be observed in the operational part of the dashboard, following the drill-down explored previously. Associated with each cost center are the respective productions (if applicable) and the present indicators of OEE and “Productivity”. Through this, the manager can, in a monthly basis, evaluate the performance of each center and, if found justifiable, elaborate the performance with the more detailed tree-like view of the chosen center.

One example of this scenario would be if a manager identifies a drop in the OEE between two months. The manager would then be incentivized to explore the issue by pursuing the OEE components along the value chain and the fields they depend on, such as the “Availability” for example. The identified problematic sub-component would then be either source of improvement opportunities or just identified as a critical area for daily management activities.

4.4.3 Data updates

In order to keep the tool updated and correctly integrate it in the continuous improvement cycle, it must be ensured that the values are both easy to integrate as well as simple to extract.

For the financial drill-down of the operational costs, every year considered (the current year and up to two years prior, meaning, 2023, 2022, and 2021 were considered) has a sheet where the description of all relevant fields is displayed. Considered relevant for the correct break-down of the operational cost is the total cost of every center (result, profit, and cost centers) and the respective breakdown by the category of the cost entry (costs with staff, maintenance, energy, depreciations and amortizations, process materials, impairment, and other costs). The document was developed to incorporate future changes to data like new month costs and new cost registries. For the financial data to be properly updated, the assigned management control collaborator with all financial information permissions updates the table supplied by SAP cube data, and the tree is updated.

Although preferable, automation in the operational data is very limited, considering that some indicators like the MTBF and MTTR are still calculated manually in different local documents.

To correctly manage what information is integrated, accompanying each “Productivity” branch is the respective datasheet. Each datasheet works as the database for that center, in terms of operational data. The datasheet is tailored to each tree containing only the changing monthly information, such as production levels, “Availability” data, and working hours registered in the respective month.

The data contemplated in these datasheets clearly shows the intended metrics to update. For the correct functioning of the washing’s “Productivity” branch, it is needed, for example, that the update routines contemplate production levels (under the banners of “Lavações Maq 1”, “Lavações Maq 2”, and “Lavações Maq 3”) according to the number of cycles executed, as mentioned in section 4.3. Part of the datasheet is the number of working days of the respective month as well as the potential and effective working hours. Number of employees allocated to the center by the type of contract (temporary, effective, and term).

In order to facilitate this routine, some information is pre-automized in the sense that only routine updates and information requests are needed. One example of this is the production level, which is present in every datasheet, needing only to update the table and fill the respective space for the branch to be updated successfully. Other information, such as working hours (from the Human Resources department), must be manually requested, and updated on the database by the responsible party.

4.5 Integration in the continuous improvement cycle

The final requisite to determine whether the tool generates improvement opportunities is the correct integration tool in the continuous improvement cycle. Given the internal cycles of continuous improvement are of three months, three different updates to the tree are then possible to analyze.

The case of project tracking is then ensured, meaning, if a project is implemented in March and its due date is in June, the objective that the project envisions to improve is possibly monitored monthly. This ensures the project is followed up and that the project's actions are translating into the desired outcome. The projects are then concluded with the according indicator tracked and monitored in a clear manner and with a standard visualization model.

Regarding the formulation of new projects and identification of improvement opportunities, the integration of the KPI tree in the facility, supported by the experience of the industrial director or other collaborators in the shopfloor, provides numbers and metrics to the observed problems, meaning most problems are currently identified but hardly quantified. Provided the problem is in the tool's scope, identification of critical areas and indicators may incentivize the formulation of projects whose objective is to target changes in these areas. An ongoing example of this scenario is the packaging center in flow 2 ("PTKN-DI-Embalagem" in the distribution flow). It was identified both visually and numerically that the center was underperforming. From the visualization of the respective "Productivity" branch, the OEE was very low, around 50% for the month of May with high variability in the previous months. This indicates the machine itself is stopped or not packaging, meaning either maintenance was the issue or supporting activities of the machine were occupying the operator's time, impacting the process cycle time. It was verified the second case was happening, which triggered a project of task balancing for packaging operators in this sector.

The final objective of the tree was to rapidly and clearly indicate what projects should be prioritized. As mentioned previously, because projects need to bring value to the group, project valuation is of utmost importance. Projected monetary benefits are now possible to calculate using expected production volumes as well as the total costs of the center for a given time frame (as displayed in section 4.6). This was especially relevant considering the company has pipelined an extensive number of projects per facility, mostly without projected benefit, meaning projects are poorly ranked, a characteristic that can be revised with the formulation of other KPI trees customized for each facility, following the described method.

5 Conclusions and future work

5.1.1 Conclusions

The tool's development was, as mentioned, a strategic initiative by the top-level management of the group, and the resulting product was well accepted by both top-level management as well as Portocork's industrial direction team.

The tool was integrated into the ongoing continuous improvement cycles, pairing with the VSM in order to both elaborate the pipeline as well as rank it according to both sensible areas as well as valuation. With the tool's functions in place, new projects and better parametrization of projects was possible, with more value and better changes occurring faster.

One of the immediately identified problems was the overall lack of information, especially considering the machine's stopping times. The rationale proposed was designed as an ideal state for the drill-down of information, especially the operational, which was instated as the norm for the breakdown of the "Productivity" KPR and design of new KPI trees.

The company's direction indicates that the next logical step is to implement a large-scale digital transformation, connecting all machines' productions and operating times to MES system, a scenario that would greatly smooth out the measurement of some of the indicators proposed.

Overall, the proposed objectives to fulfill with the design of the KPI tree were to enable project ranking, ease the process of critical area identification and both facilitate and standardize the process of project valuation.

In this aspect, the developed tool currently holds the capabilities to succeed in these scenarios, with the added benefit of providing a standardized way to view the overall performance of the facility, outside of the project's mindset, meaning, it compiles useful data for other tasks other than project tracking and continuous improvement, being relevant for planning and industrial management.

The desired state of the continuous improvement model for Amorim Cork, shown in Fig 2, requires as the basis for improvement, the almost symbiotic relationship between the VSM and the KPI tree. This integration is easily achieved with the current model since multiple information overlaps both tools, such as cycle times, number of machines, and collaborators. The model's integrity is supported by field activity, or visits to the Gemba, in order to correctly attribute the values and mapping to direct problems in the facility.

5.1.2 Future Work

The project itself was developed between the months of February and June, and although the output was well accepted among Portocork's industrial direction a lot of improvements could impact the overall functioning of the tool.

Firstly, the software chosen, MS Excel, presents some limitations specially while viewing large data structures, in this case, the KPI tree and its branches. Ideally, another application would be used in order to better compile the information and represent the data with possible opening and closing of branches. Logically, some options other than MS Excel were discussed, yet, because of the respective tool's limitations and the ongoing use of MS Office applications within the group, it ended up being the desired tool to first develop the project.

The next problem identified with the methodology followed has to do with information accessibility. The main problem regarding this topic with how information is distributed, because although most information is contemplated within either SAP or MES, there is still key information distributed locally among some collaborators. This limits both the tool's update autonomy as well as the maximum update frequency. Frequency is particularly relevant for operational KPIs whose actionable time frame is much shorter than financial KPRs.

Regarding information as well, the discrepancy in information depth between sectors of the facility is still very considerable. Although understandable due to the overall Portocork cost structure, NDTech is still the center with the most tracked information. The next steps are to improve the depth of information on other centers other than NDTech, either by increasing automation in MES introduced information or by instating registry sheets in the operators' routines for stopping-time information on machines (for better "Availability" calculation).

Still considering the information structure contemplated in the KPI tree, the information is currently compiled in Excel format but it is in the company's interest as well to pursue a more integrated approach, that meaning a more structured database implementation with automatization always in mind.

Finally, with the conclusion of this KPI tree, it is in the company's strategic interest to pursue the development of this tool for other facilities so that the continuous improvement model is ensured across the group in the same manner, in a standardized way.

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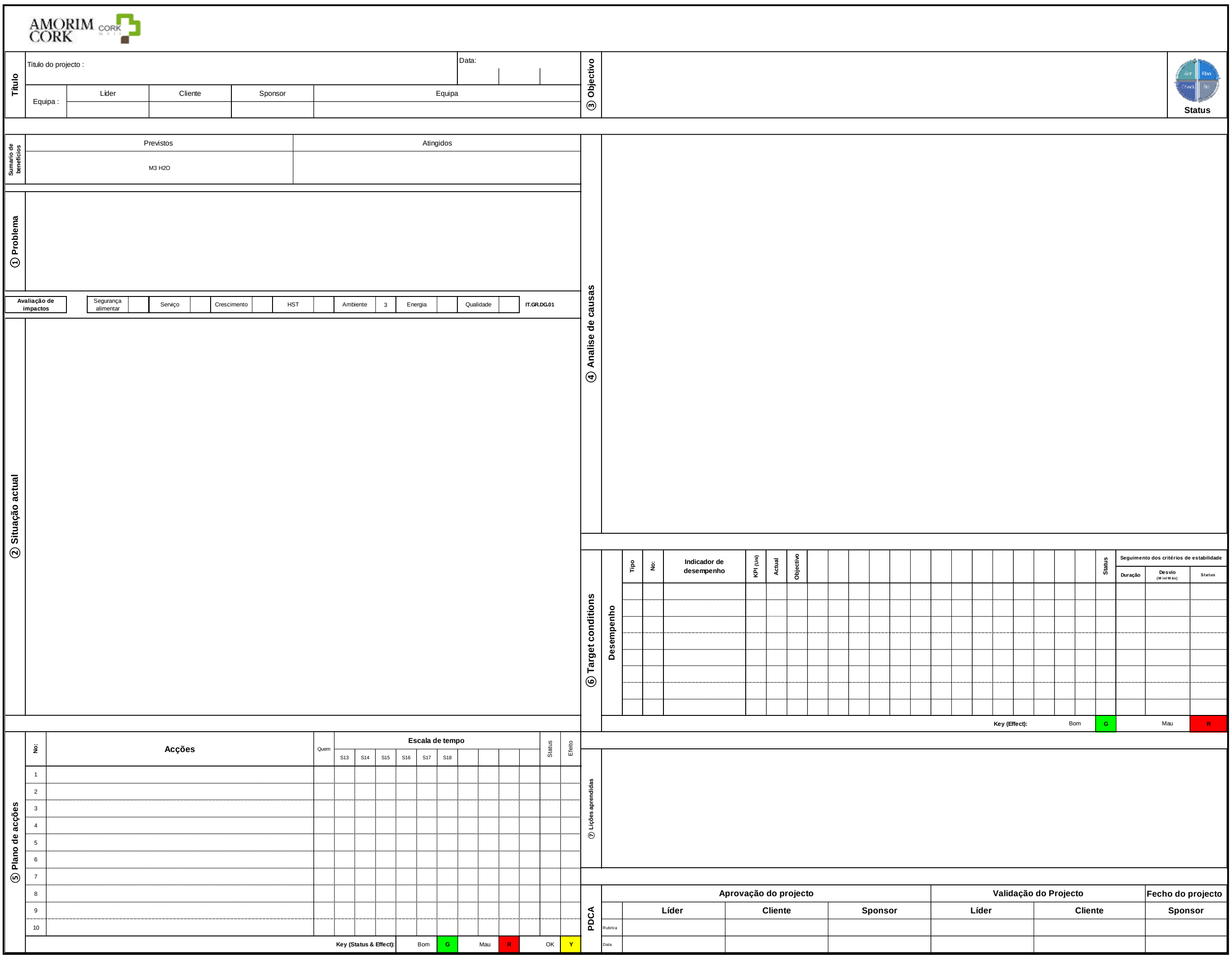
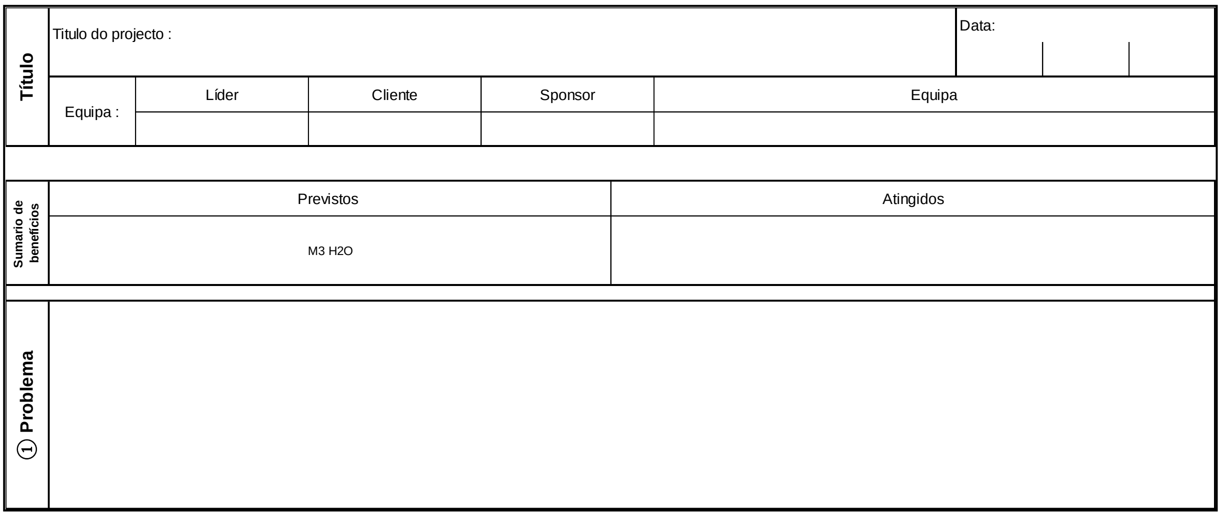
ANNEX A: The A3 document


AMORIM CORK
Título
Titulo do projecto :
Data:
Equipa :
Lider
Cliente
Sponsor
Equipa
③ Objectivo
Status
Sumario de beneficios
Previstos
Atingidos
M3 H2O
① Problema
Avaliação de impactos
Segurança alimentar
Serviço
Crescimento
HST
Ambiente
3
Energia
Qualidade
IT.GR.DG.01
② Situação actual
④ Analise de causas
⑥ Target conditions
Desempenho
Tipo
Nº
Indicador de desempenho
KPI (Un)
Actual
Objectivo
Status
Seguimento dos critérios de estabilidade
Duração
Desvio
Status
Key (Effect):
Bom
G
Mau
R
⑤ Plano de acções
Nº
Acções
Quem
Escala de tempo
S13
S14
S15
S16
S17
S18
Status
Efeito
1
2
3
4
5
6
7
8
9
10
Key (Status & Effect):
Bom
G
Mau
R
OK
Y
⑦ Lições aprendidas
PDCA
Aprovação do projecto
Validação do Projecto
Fecho do projecto
Líder
Cliente
Sponsor
Líder
Cliente
Sponsor
Rubrica
Data

Annex A.1 - A3 template used in AC.


Título
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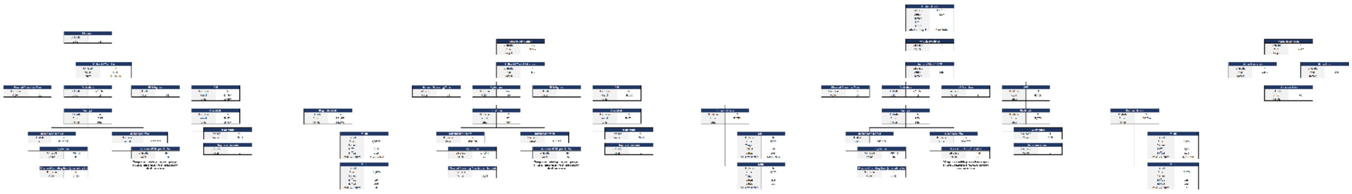
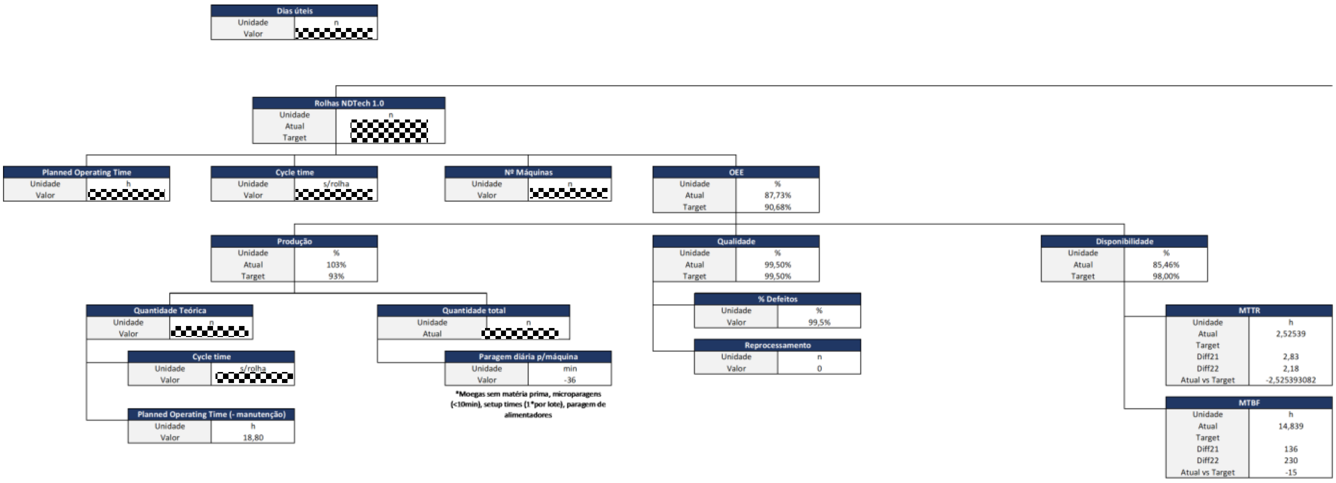
Data:
Equipa :
Líder
Cliente
Sponsor
Equipa
Sumario de beneficios
Previstos
Atingidos
M3 H2O
① Problema

Annex A.2 - Initial Phase of the A3

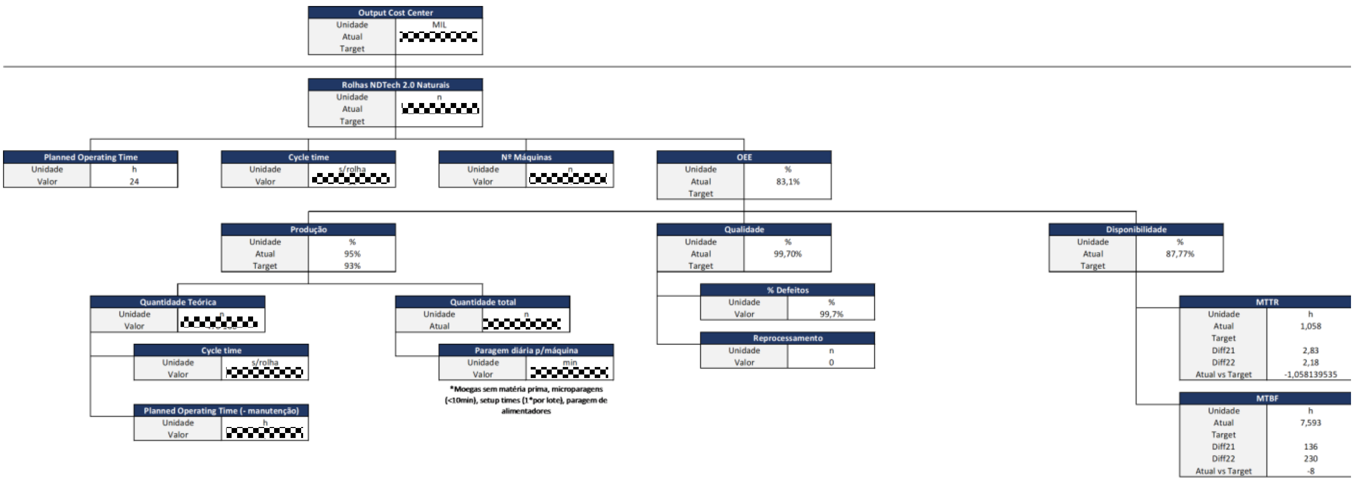
ANNEX B: Productivity branches



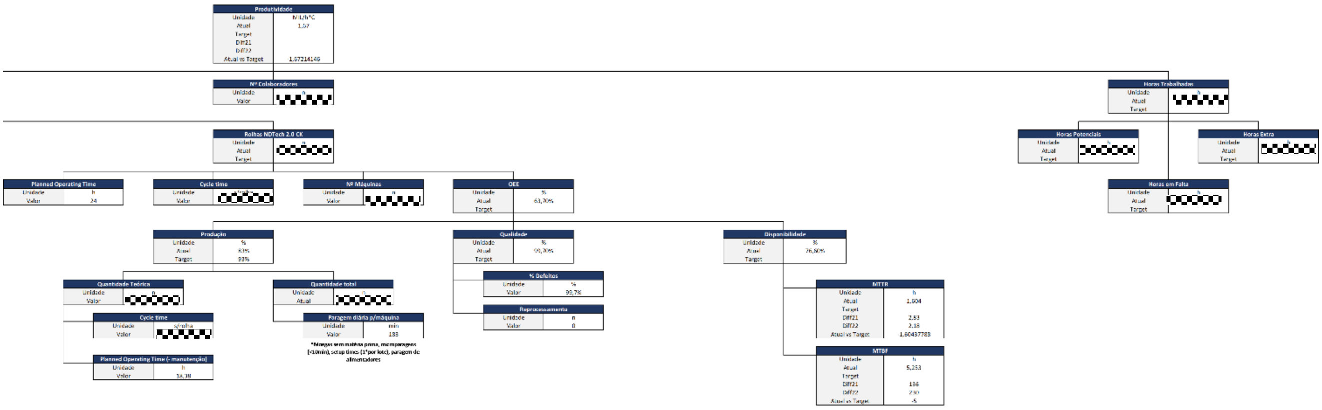
Annex B.1 – Productivity branch of “PTKN-ND-NDTech”, with march values



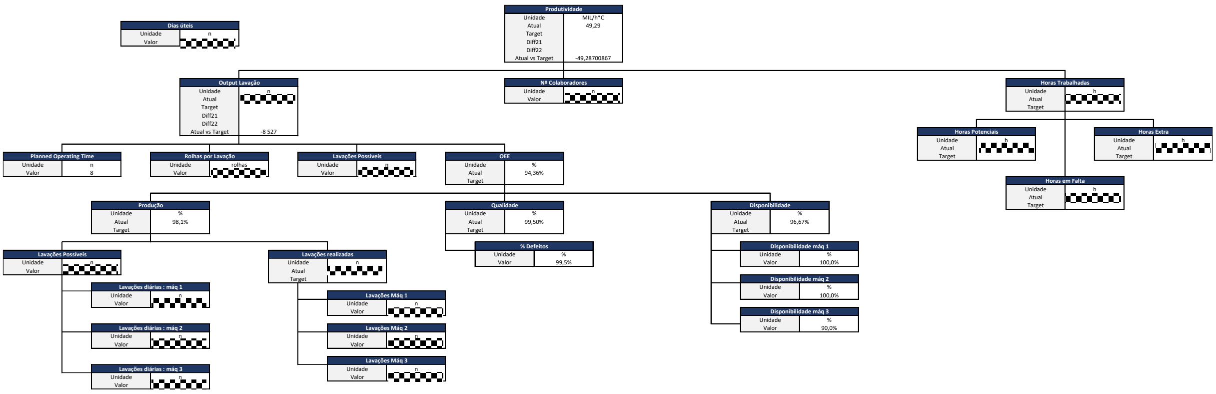
Annex B.2 – Productivity branch of “PTKN-ND-NDTech”, NDTech 1.0 drilled down, with march values.



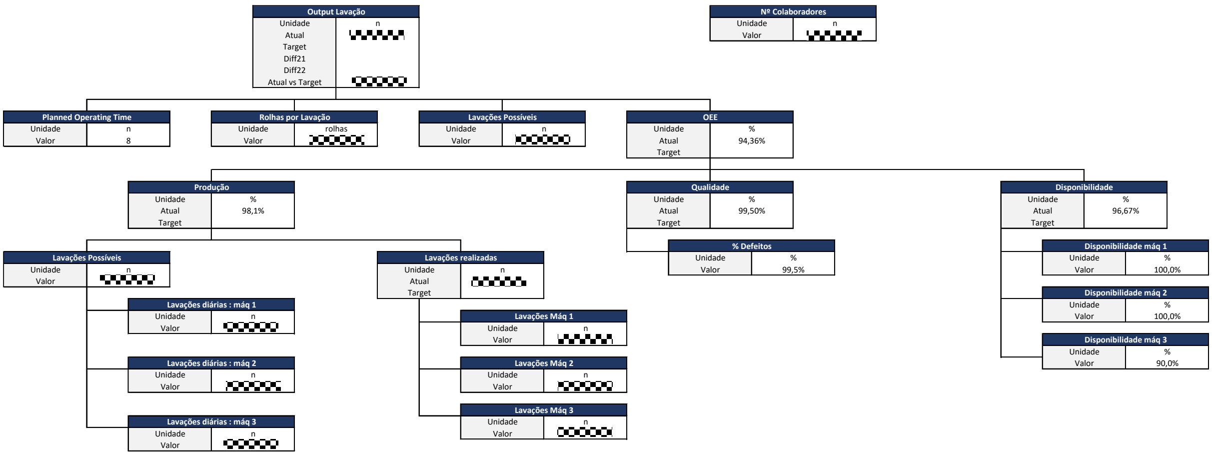
Annex B.3 - Productivity branch of “PTKN-ND-NDTech”, NDTech 2.0 natural drilled down, with march values.



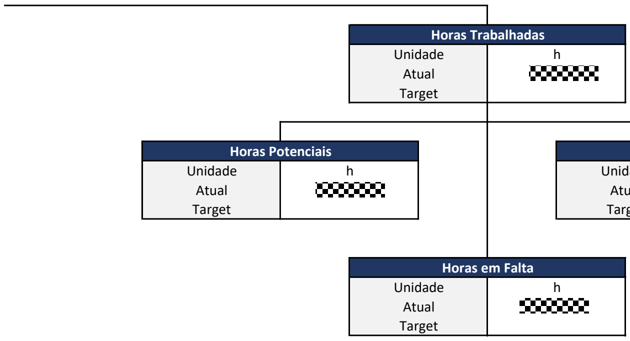
Annex B.4 - Productivity branch of “PTKN-ND-NDTech”, NDTech 2.0 champagne drilled down, with march values.



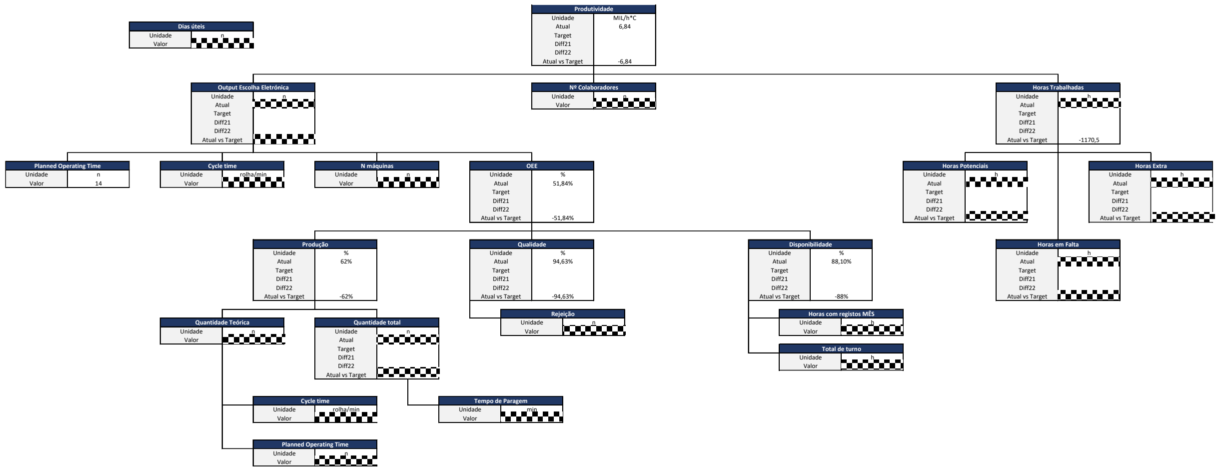
Annex B.5 – Productivity branch of “PTKN-PR-Lavação”, with march values.



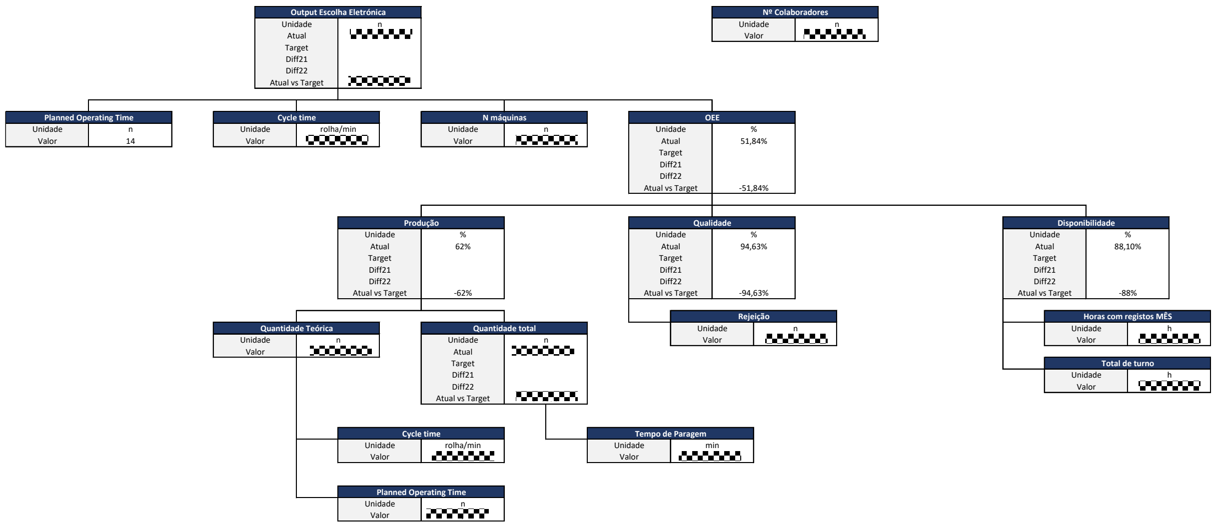
Annex B.6 - Productivity branch of “PTKN-PR-Lavação”, detailed on “Output”, with march values.



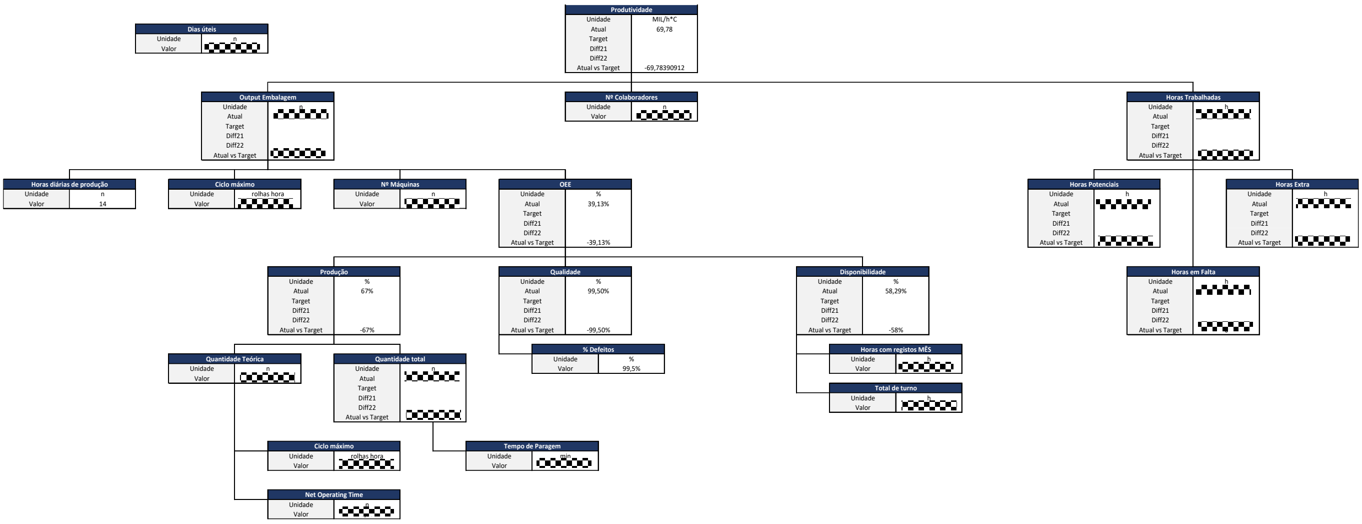
Annex B.7 - Productivity branch of “PTKN-PR-Lavação”, zoomed on “Working Hours”, with march values.



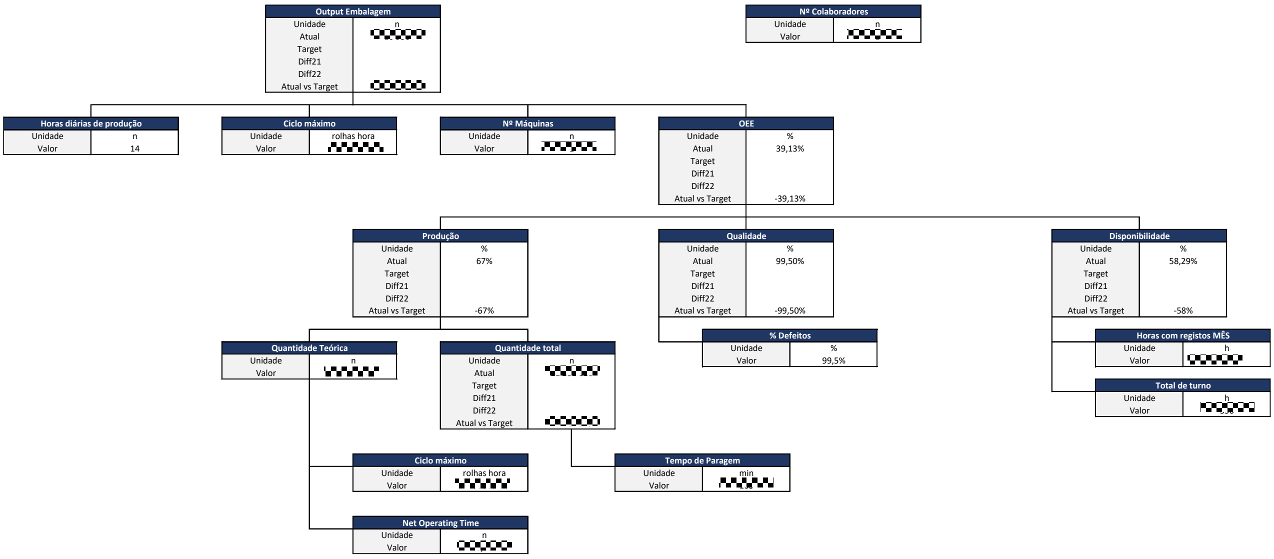
Annex B.8 - Productivity branch of “PTKN-PR-Escolha”, with march values.



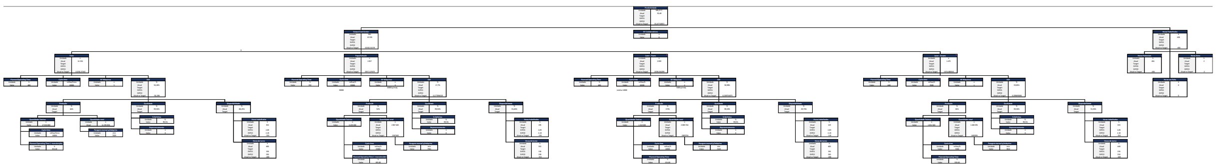
Annex B.9 - Productivity branch of “PTKN-PR-Escolha”, detailed on “Output”, with march values.



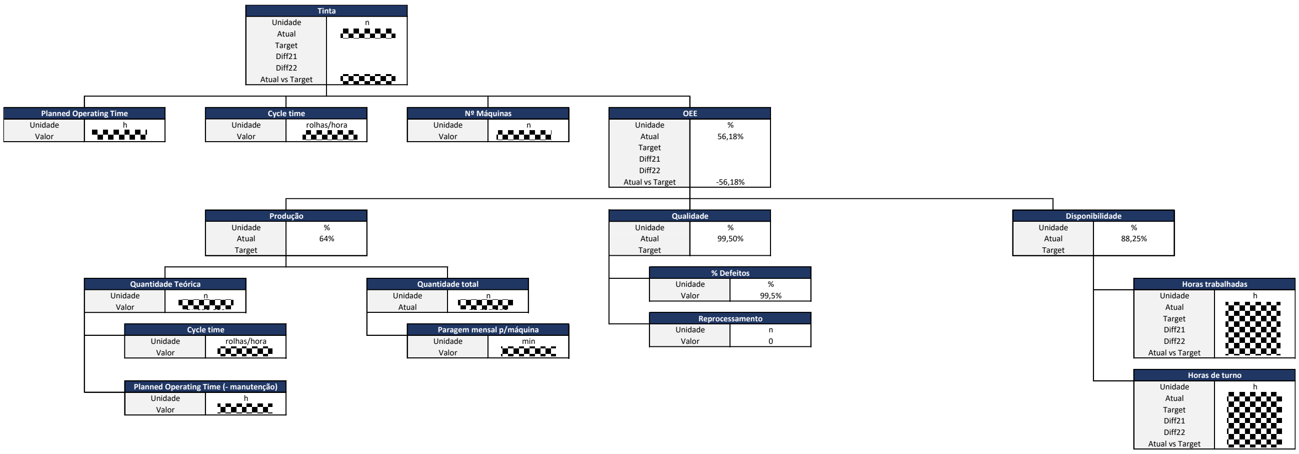
Annex B.10 - Productivity branch of “PTKN-PR-Embalagem”, with march values.



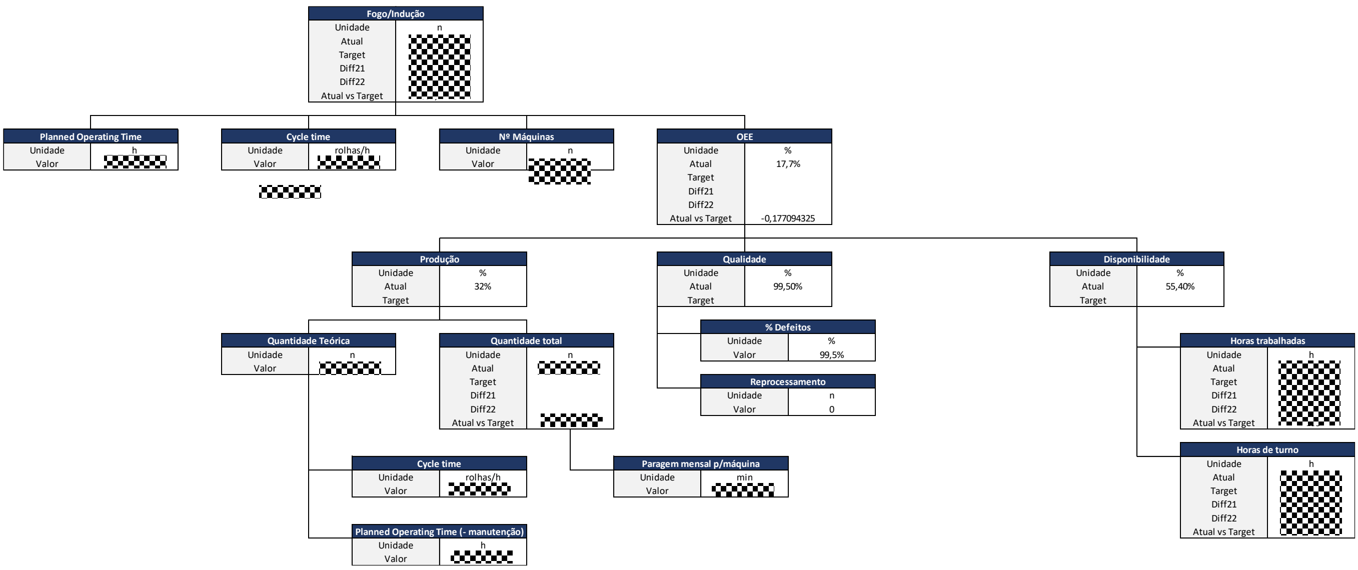
Annex B.11 - Productivity branch of “PTKN-PR-Embalagem”, detailed on “Output”, with march values.



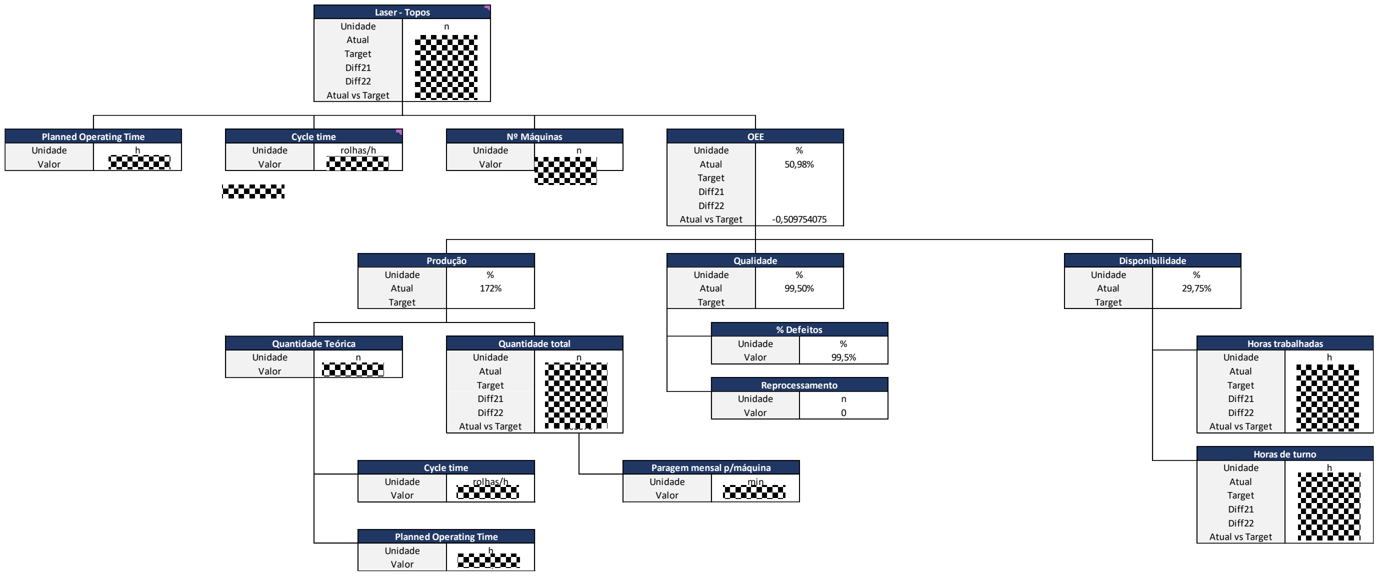
Annex B.12 - Productivity branch of “PTKN-DI-Marcação”, with march values.



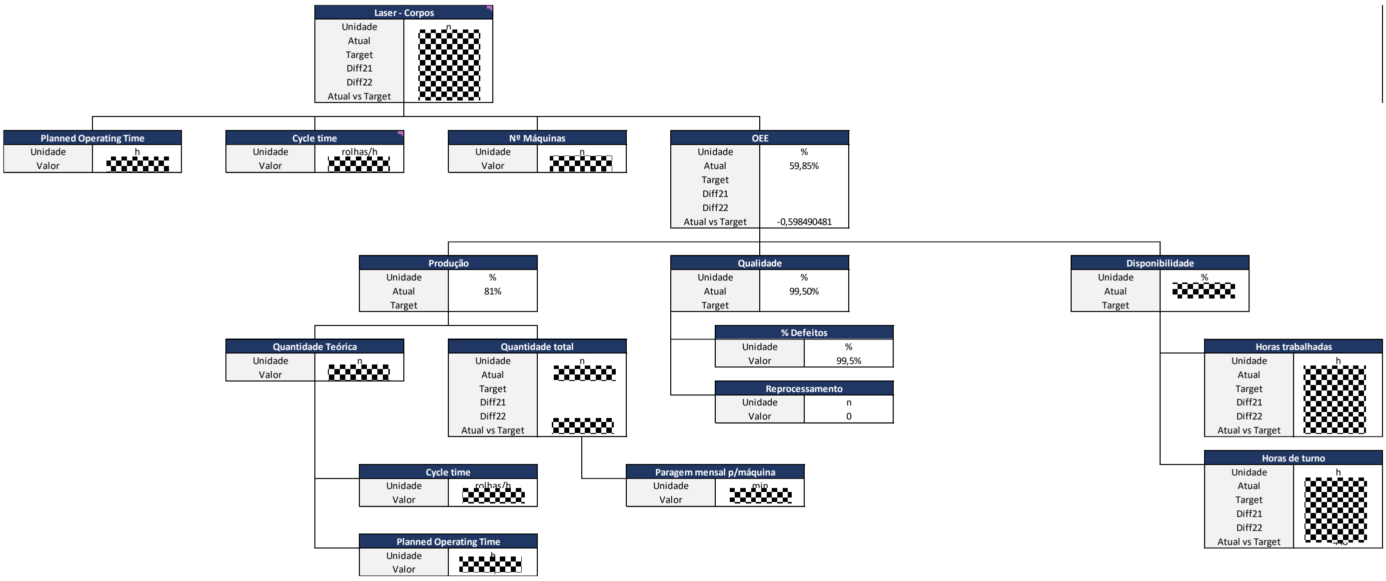
Annex B.13 - Productivity branch of “PTKN-DI-Marcação”, detailed on “Output” from ink category, with march values.



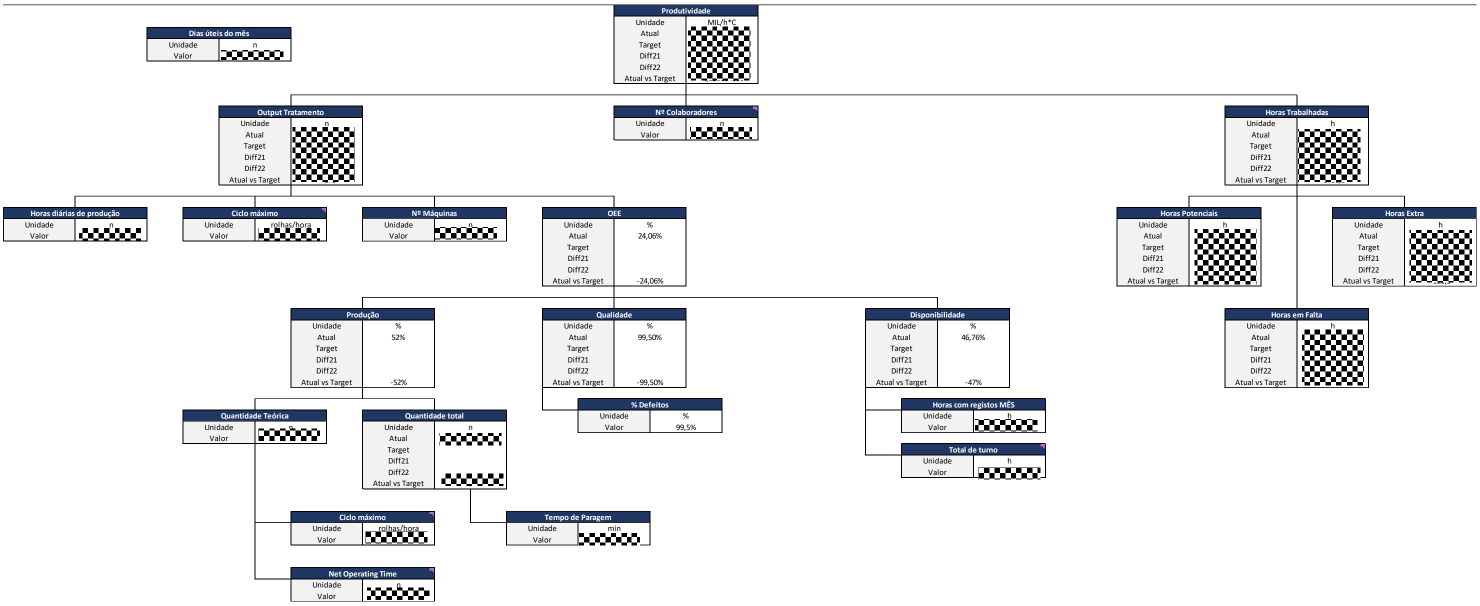
Annex B.14 - Productivity branch of “PTKN-DI-Marcação”, detailed on “Output” from fire/induction category, with march values.



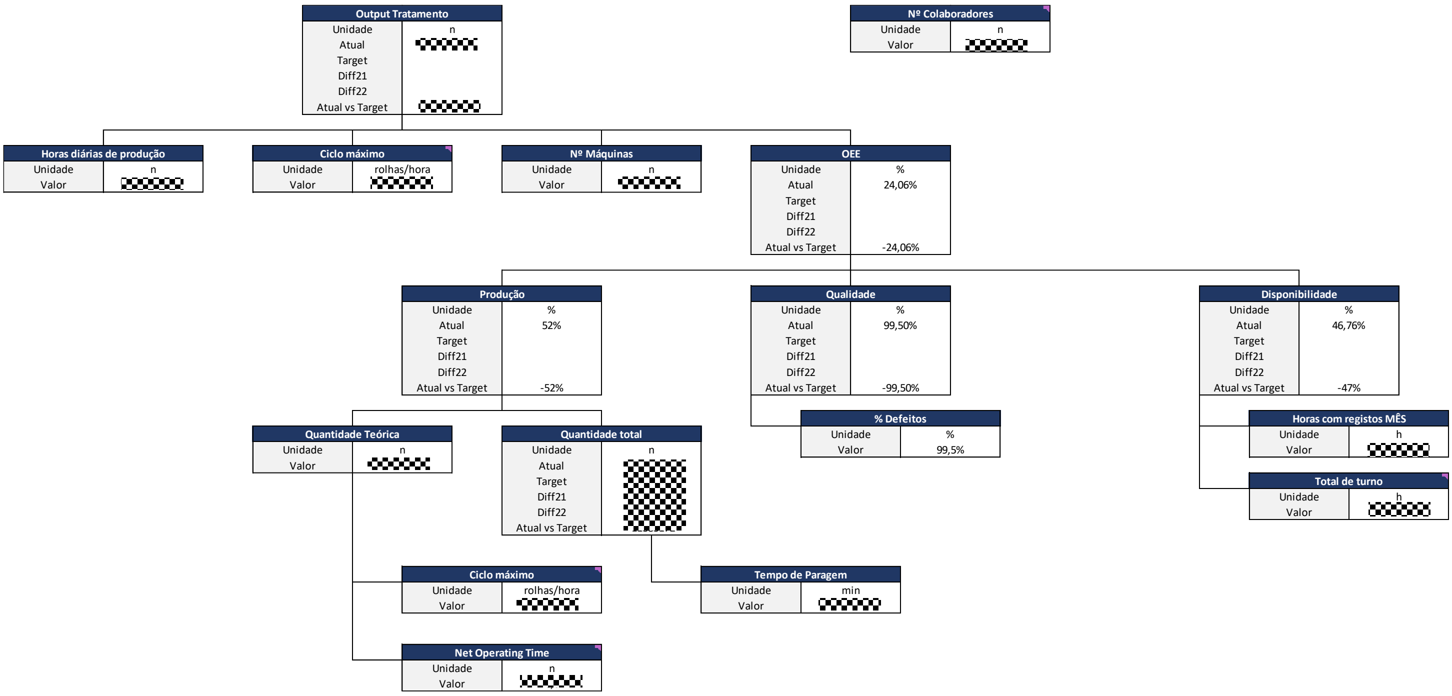
Annex B.15 - Productivity branch of “PTKN-DI-Marcação”, detailed on “Output” from laser tops category, with march values.



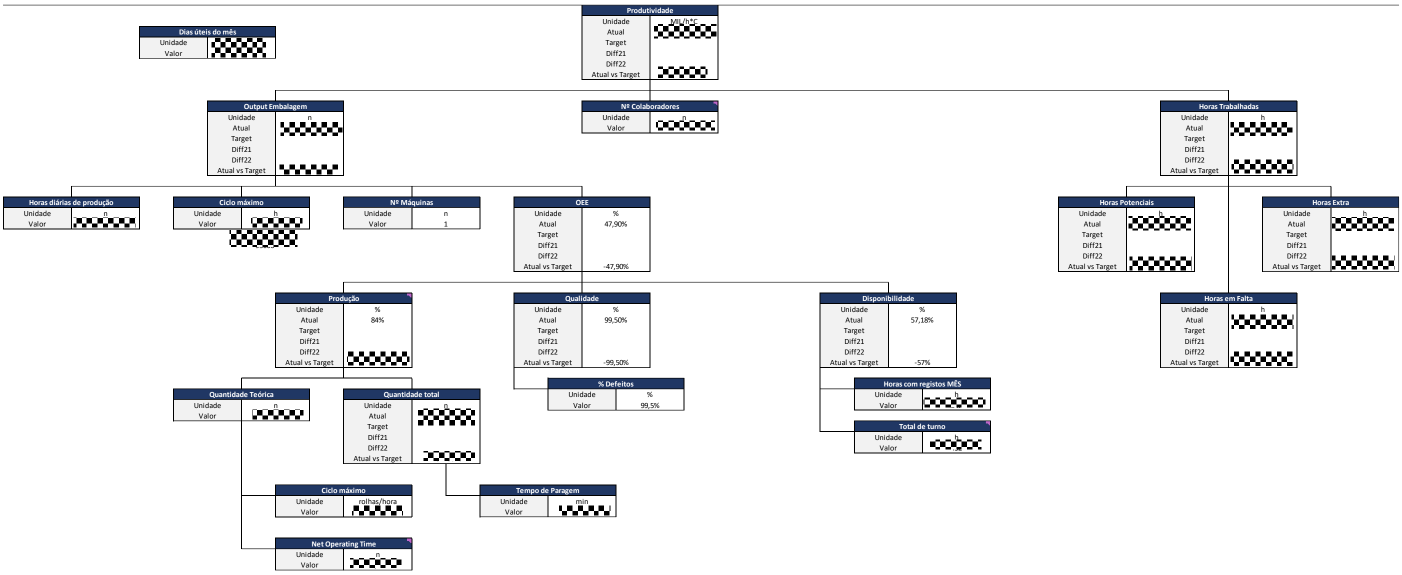
Annex B.16 - Productivity branch of “PTKN-DI-Marcação”, detailed on “Output” from laser body category, with march values.



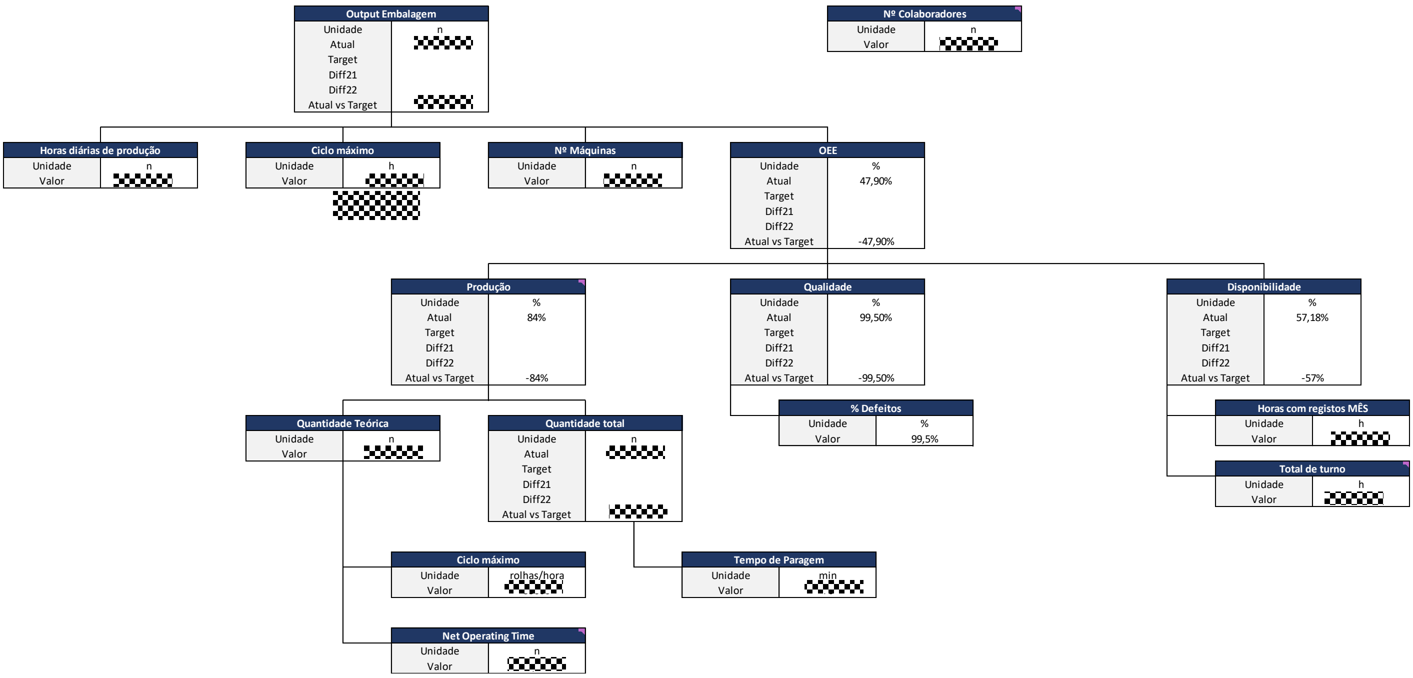
Annex B.17 - Productivity branch of “PTKN-DI-Treatment”, with march values.



Annex B.18 - Productivity branch of “PTKN-DI-Tratamento”, detailed on “Output”, with march values.

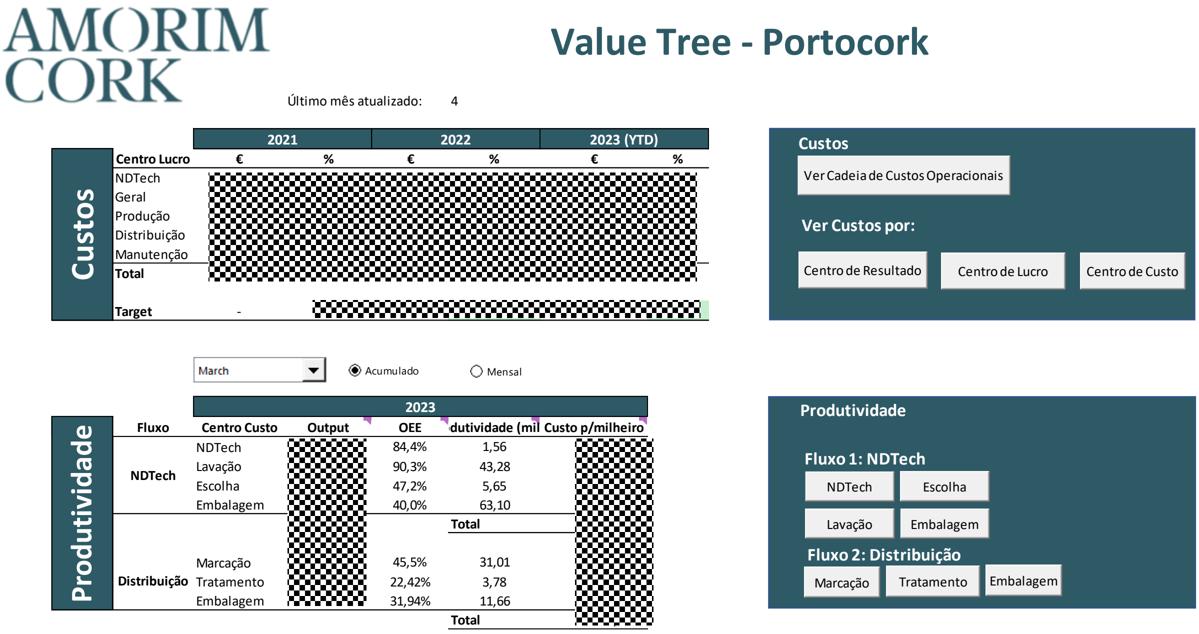


Annex B.19 - Productivity branch of “PTKN-DI-Embalagem”, with march values.



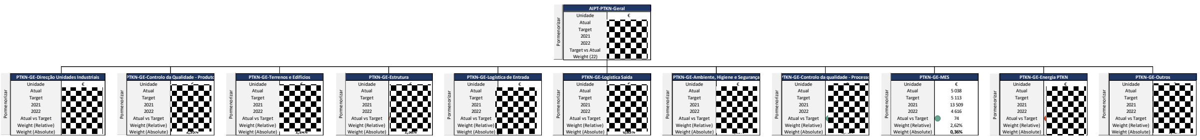
Annex B.20 - Productivity branch of “PTKN-DI-Embalagem”, detailed on “Output”, with march values.

ANNEX C: Initial Dashboard

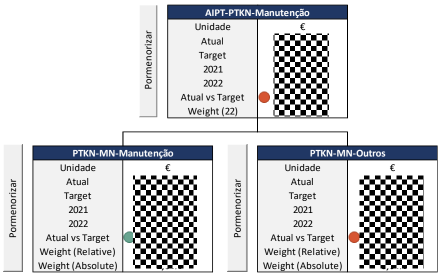


Annex C.1 – Portocork’s Value/KPI tree initial dashboard

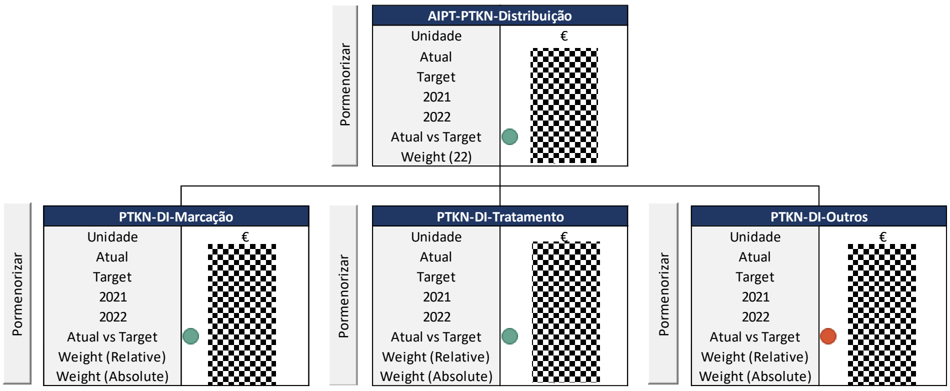
ANNEX D: Financial information structuring



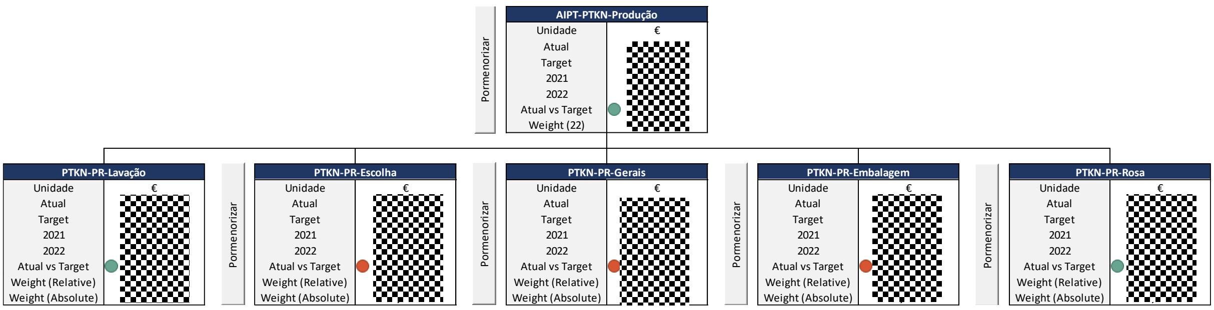
Annex D.1 – Portocork's "Geral" profit center and all cost centers inside



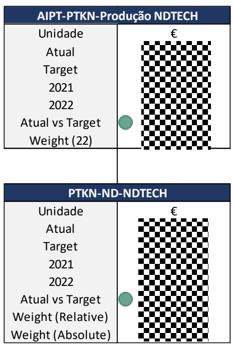
Annex D.2 – Portocork's "Manutenção" profit center and all cost centers inside



Annex D.3 – Portocork's "Distribuição" profit center and all cost centers inside



Annex D.4 – Portocork's "Produção" profit center and all cost centers inside



Annex D.5 – Portocork's "NDTech" profit center and NDTech single cost center