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The Study of Measuring and Enhancing Project Performance Metrics and their application to construction management projects

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Abstract

The complexity of modern construction industry projects requires a developed and efficient management strategy to ensure project success. This thesis work explores the study of Key Performance Indicators (KPI) and their application to specifically construction projects, with the end goal to enhance the project performance and the ability for project managers on their decision making. This thesis work consists of an initial comprehensive literature review and an applied case study analysis for a fictional company which it is specialized in construction of data centers.

This study defines the different major parts of the project and identifies its goals, focusing on cost control, schedule adherence, quality, safety, environmental, legal and customer satisfaction. The utilized frameworks of study for the KPI selections are the Balanced Scorecard method, the Performance Pyramid method and the Performance Prism method, for each of the three defined project phases. This study also discusses some effective tracking and emphasis on the role of effective tracking tools, digital dashboards and company culture as contributing factors for project success.

The conclusions of this thesis work demonstrate how a well-defined KPI framework contributes significantly to a better visibility over the project goals, resource allocation, stakeholder control and overall improving the strategic and organizational success. This research also offers a practical view on how to apply these models for construction companies or projects, ensuring the correct project management review process by the use of the correct key performance indicators (KPIs).

Keywords/tags (subjects)

Key Performance Indicator, KPI, Management Systems, Quality, Policy, Risk Control, Dashboard, Metrics Performance, Balance Scorecard, Performance Prism, Performance Pyramid

1 Introduction

In today's world, where the global economy and markets are extremely competitive for all kinds of projects, companies and governments do not only have to deliver projects on time, but also project managers need to ensure the highest quality and safety standards. For project managers, Key Performance Indicators (KPIs) serve as an essential set of tools for monitoring these different project aspects and offering a valuable insight to the project performance. These tools and indicators allow project managers to take in-time decisions to steer the project and resources direction to meet the constantly increasing expectations.

This thesis work "The Study of Measuring and Enhancing Project Performance Metrics and their Application to Construction Management Projects", aims to study and analyze the need to have a robust pack of Key Performance Indicators to allow managers to effectively manage different type of projects and to obtain the most beneficial outcome with a set of given resources. This research aims to research and analyze which are the most beneficial strategies, objectives, classification and use of these key performance indicators for project managers and companies to take advantage and enhance their performance.

After a general literature review of all the different aspects of key performance indicators (Parmenter, 2015) and their usability, this study aims to analyze more in depth the construction industry. With the constant increased demand for Artificial Intelligence (AI), it is observed that the amount of construction projects for data centers is gaining a lot of attention. These projects involve a great number of stakeholders, market conditions, and require tight coordination between design, procurement, finance, engineering and construction departments for a successful execution of such a project. By integrating a robust strategy about the key performance indicator into the project planning, project managers and all the different projects stakeholders can achieve a level of great visibility into the different aspects of the project: timeline, budget, safety and quality control, among others. This systematic approach also aims to facilitate project managers with an effective way to maintain high standards and allow project managers to efficiently make the best decisions in time (Kerzner, 2011). Therefore, this study will aim to seek, identify and refine the most effective strategies for KPI selection and applications to achieve the most optimal outcome in the construction industry projects.

2 Research Methods and Objectives

2.1 Research Problems and Objectives

Nowadays the construction industry characterizes itself by the increased complex and operational challenges, deadlines, multistakeholder coordination and the high safety and quality standards. Even if key performance indicators are widely used in professional business and project management, there are specific sectors and projects which require a customized KPI framework to be able to deal effectively with all the challenges presented. Traditional project management tools and key performance indicators in some cases fail to meet their purpose, failing to understand a real time dynamic, which can lead to inefficiencies, non-efficient resources allocation and poor decision making.

This thesis research aims to analyze and investigate a comprehensive framework for the study, selection and implementation of Key Performance indicators and specifically for the construction projects industry. This study first establishes the theoretical understanding base of what are KPIs and how do they work, explaining the definitions, characteristics and classifications. Later on, it then evaluates the most important KPIs and the selection frameworks, including the Balanced Scorecard (Kaplan & Norton, 1992), the performance prism (Neely et al., 2002), and the performance pyramid methods, among others. The study also deepens to investigate which are the best practices in key performance indicators selection, understanding the industry needs and stakeholder requirements. The impact and consequences of not selecting the correct set of key performance indicators for a specific project or company, can often mark the difference between executing and completing successful project, or if the right indicators are not taken into consideration it can lead to a complete deviation of the initial objectives.

Additionally, to the theoretical analysis, this research is then applied to a specific case study approach to prove how an imaginary construction company can then develop their own KPI performance management system. This research also aims to reduce the gap between the academic theory and practical application, proving a structured and applicable model for KPI implementation in construction projects.

2.2 Research Questions and Intention of the Study

For the research carried out in this thesis work, it has been structured around the following key research questions that will guide the line of work:

1. Which are the most important Key Performance Indicators (KPIs) for construction projects and how these can impact the project success?
2. How can construction companies develop a structured approach to the effective selection of their KPI models to ensure their project is executed according to their objectives and goals?
3. Which are the most effective methods for implementing and following up with a KPI driven framework for construction projects and how these can also be adapted to other different projects?

This study follows indeed a qualitative research approach, combining a literature review with its corresponding theoretical analysis, followed also by a case study application. A comprehensive literature review then ensures that this piece of research is based on solid established academic and industry knowledge, providing an evaluation of the KPIs and best application practices.

By answering these research questions, the study aims to offer a structured roadmap and framework for the use and implementation of KPI, providing valuable insight to project managers which work with related construction projects and for the industry professionals, as well as to academic researchers. The findings aim to offer a guide for decision making, improving project efficiency and to improve the effective performance of these projects in the sector.

For this study, the main research method that will be utilized for the theoretical framework research and evaluation is the Case Study Analysis and its later application. The case study analysis is a method that allows an in-depth investigation into different research and examples, allowing the researcher to identify the patterns, challenges and outcomes which are directly relevant to the research objectives of this thesis work. In this chapter, there is a detailed overview of these methods and tools that will be utilized for the research process in this thesis work. These different case studies will draw the final insights, analysis and conclusion to support the theoretical framework, making these findings more relevant to the case study.

2.3 Qualitative Research – Case Study Analysis

The Case Study Analysis is an established and essential research methodology when it comes to qualitative research. This research method is widely used when the main goal is to investigate and review complex information from various fields of study (Lee & Saunders, 2020). This methodology allows researchers to have a deep exploration in different areas when other survey methods are insufficient (Yin, 2018). The Case Study is widely used across several disciplines such as business management, suitability, education and similar fields where the context plays an important role in the outcomes of the study.

One of the main advantages of the case study analysis is its ability to interconnect the different contextual variables with the studied case. For example, in one of the researched articles (Cerceau et al., 2014), the authors carry out an analysis of industrial ecology cities, using a different case analysis to identify sustainability practices in different regions with different backgrounds. In this research they reinforce the importance of having a general and common framework in which these studies can be conducted to ensure that the contextual differences do not affect the final comparison and outcomes. Another important aspect of the method which is worth sharing is the discussion between the single and multiple case design analysis. One case analysis allows the researcher to have a deeper check on the investigation, meanwhile on the other hand, having a multiple case study provides a broader analysis and perspective by checking different companies and scenarios which can improve the general findings (Yin, 2018).

One of the most important advantages that this methodology of research offers is the ability to be able to combine quantitative and qualitative elements for a better overview analysis. This method therefore allows a preliminary theoretical framework analysis review followed by a more in-depth analysis on a specific case scenario.

For this research work, it will follow a single case study approach to examine the different methods for selection and implementation of Key Performance Indicators (KPI). Instead of analyzing directly an existing company where the available data is restricted to the public, the study will work first on establishing the correct theoretical framework for the analysis, and then the study of an imaginary construction company for its application. The purpose is to also keep a realistic approach on how to apply the proposed KPI framework.

Once the theoretical framework and analysis is carried out, the first step is to identify and define the strategic objectives and the critical success factors (CSFs) of the specific company object of this study. Then the next step focuses on mapping these factors into the correct process selection for the adequate KPIs, which need to align with the best practices described earlier from the Balanced Scorecard analysis (Kaplan & Norton, 1992), the Performance Prism (Neely et al., 2002) and the other described frameworks. Afterwards a proposed personalized KPI portfolio is laid out to determine the necessary monitoring intervals, reporting mechanisms and implementation strategies.

This study aims to provide in-depth theoretical research with the adequate techniques to illustrate its applicability and replicability to a structured approach to KPI selection and implementation specified to construction management projects.

2.4 Data Collection and Analysis

After having described the intended qualitative research methodology to be used in this thesis, the next step is to define how the data collection and its after analysis will be performed, to fulfill the study goal which is the development of the framework for selecting and implementing KPIs in construction projects. In section 3 of this thesis, there is a comprehensive research analysis which has been performed from different books, articles and scientific papers to understand what are KPIs and why their use is vital to almost every single business model. The carried-out investigation provides valuable insights into how KPIs are defined, categorized and some of their characteristics which are important for the afterwards application. Next, in this thesis research, it will be presented the additional set of tools and guidance needed to understand which are the main characteristics and aspects of KPIs in construction projects.

2.5 Ethicality and reliability of the development research

As an important part within the master thesis, this section focuses on the ethical fundamentals of this academic research. This thesis works focuses on the research and analysis of key performance indicators applied to construction projects. This thesis works follows the Jamk University of Applied Sciences ethical guidelines (Liimatainen et al., n.d.), which puts special attention to transparency, accountability and responsible research practices. This research is conducted in a manner that respects integrity and avoids conduct such as plagiarism or falsification. It is also important to mention

that the Jamk thesis works also follows the Finnish National Board of Research Integrity (TENK) Guidelines.

This thesis work uses a systematic literature review and case study analysis to analyze peer-reviewed academic journals, reports and credible books on key performance indicators. During the writing process of the thesis work, it has been ensured to select high quality research that contributes to the study findings, as well as the rigorous selection of sources.

Additionally, it is important to mention that all references are cited according to the APA 7th edition style to ensure all materials are cited properly, preventing any intellectual property violations. This study maintains ethical compliance also in regards of data handling, ensuring that there is no personal or confidential data used. All the data used comes from either public available sources, available articles or academic papers. As a disclaimer, there are sections of this study which are subject to a personal interpretation of certain aspects, but it has been carried out avoiding as much as possible any potential biases, ensuring the most rigorous and professional approach view. Therefore, by following the above described, this research aims to be scientifically based, responsible and with academic purposes only, aligning with the Jamk's University of Applied Sciences ethical integrity (Liimatainen et al., n.d.).

3 Fundamentals of Key Performance Indicators

The main goal of this section is to contribute with the necessary theoretical framework and background information to understand what KPI are, and which is the role that they play in project management. The ability to measure and analyze the information in a project is key to ensure the success of a project, where a lot of parameters, information, resources and stakeholders are involved.

The definition of key performance indicator would be defined as a number or measurement of a specific parameter which are designed to summarize meaningful compared data. These are fundamental tools to measure, compare and evaluate different aspects and dimensions of a project against a goal or target (Peterson, 2006). KPIs need to be quantifiable measurements which are used to evaluate the progress and results against a business objective or goal. They provide the necessary guidance to allow organizations to make real time decisions to steer the direction based on data (Ishaq Bhatti & Awan, 2014).

The idea of measuring the performance started to emerge for early management and industrial efficiency practices where business wanted to quantify productivity and effectiveness in the production. Some of the first ideas emerged as structured frameworks such as the Balance Scorecard or other methodologies across the manufacturing industries(Kaplan & Norton, 1992).

After understanding what a Key Performance Indicator is, the next important task is to understand the different characteristics and classifications of these measurement tools, which will allow project managers to comprehensively understand them and make informed decisions on when to use each type.

3.1 Main Characteristics of KPIs

KPIs are used on our day-to-day work activities, however their effectiveness depends on how these KPIs are defined, measured and aligned with our business objectives. Among the most common KPI objectives, KPIs should reflect project performance, cost, schedule, quality or safety, among others. If KPIs are not well defined, these can lead to misinterpretation, ineffective decision making and even a waste of time and resources (Marr, 2012).

For a KPI to be meaningful and useful, it should have certain characteristics, such as providing valuable insights, they also should drive continuous improvement and contribute to achieving strategic goals. Below begins the evaluation and characteristics of a well-defined KPI:

3.1.1 Alignment with Busness Goals

One of the most important key characteristics of a KPI is its alignment with a specific need within a business goal or target (Kaplan & Norton, 1992). A KPI must be strictly related to what an organization aims to achieve or accomplish, and it should ensure a way to track the process towards what is relevant to the organization.

A KPI must strategically align with the company vision, mission and long-term strategy plans. Taking as an example construction projects, one of the key strategic targets could be reducing the impact on the environment, and the company could use a KPI such as the reduction on carbon emissions from their processes (Kerzner, 2011).

According to (Parmenter, 2015) study, KPI also represents and focus on Project Specific Objectives. Once these KPIs align with the overall company vision, they also must align to the project level goals such as completing tasks on schedule or staying within the approved budget. If these KPIs are not aligned and contribute towards the core goal, then the project team needs to evaluate the specific measurement tools that they want to use. KPIs do not only align with internal company values or team's objectives but also should align with stakeholder expectations.

3.1.2 Mesurability and Quantifiability

Based on the main purpose of a KPI which is to provide a measurement of a specific parameter, KPIs should be quantified and therefore measurable. The most common KPIs are either numerical or percentage-based metrics which represent ratios or quantifiable measurements against an established target. Another important characteristic is the defined measurement criteria. The calculation methods, frequency of measurement, data sources and units are important parameters to be defined in advance.

The measurability of a KPI is vital, otherwise it becomes subjective and loses the ability to be tracked over time effectively. As an example, one of the most important KPIs used in the field of finance is the 'Cost Performance Index (CPI)' and it is calculated with the following formula (Parmenter, 2015). It compares the planned budget against the actual project costs:

$$Cost\ Performance\ Index\ (CPI) = \frac{Earned\ Value\ (EV)}{Actual\ Cost\ (AC)}$$

3.1.3 Actionability

In the field of key performance indicators, their goal is not only to provide data, but they should also enable project managers to take efficient decisions, by offering clear information and insights of what the necessary actions should be (Kaplan & Norton, 1992). According to the authors Kaplan and Norton (1992), they also define KPIs as an indicator which has an actionable identified area. Once a KPI is defined and selected for a specific project, the next step for project managers and the leadership is to set some upper and lower limits to these values and the designated actions to be taken if during the life span on a project this value would surpass or decrease below the set limits. A KPI that does not lead to any action or improvement it is not useful for decision making.

An actionable KPI also means that it should allow project managers to have real time responsiveness, for example the number of incidents each 1000 hours should warn the project managers that an immediate action must be taken to avoid any future safety risks happening. Which also is linked to the topic that will be discussed in the section below, which is how frequent KPIs should be evaluated and looked at.

3.1.4 Frequency of Measurement

To be able to provide valuable information of the insights of a project performance, KPIs must be regularly measured and evaluated. The frequency of these measurements will vary depending on the kind of project and the nature of the selected KPIs.

When it comes to selecting the measurement frequency for each KPI, project managers need to take into account the following concepts:

There are types of KPIs, such as safety incidents or equipment downtime (in a construction project) which would require project managers to ensure a continues (real time) monitoring approach. There are other types, however, which require a daily or weekly analysis. In this category there are some important KPIs to be looked at, such as: inventory turnover, customer retention, error rates or operational efficiency. Also, some other key performance indicators would require a longer time frame for measurement. These are usually more global or financial KPIs about the overall project rather than individual aspects, sections or departments. Some examples of KPIs that are evaluated by project managers and companies on a monthly or quarterly basis are: gross profit margin, return of investment (ROI), total cost management, earnings before interests' taxes depreciation and amortization (EBITDA).

3.1.5 Simplicity and Clarity

The selected measurements and indicators should also remain simple and clear. When a KPI becomes complex and tedious, it can start to create confusion and mislead the team from the original project goals, and to misalign teams internally (Marr, 2012). KPIs should avoid overcomplicated formulas. For everyone to be in the same page, KPIs should ensure stakeholder accessibility and need to be clearly defined and communicated throughout all different project teams to ensure they all understand their role on performing against that specific goal or target. A well-defined key performance indicator aims to eliminate ambiguity and to enable effective teams making relevant and prompt decisions.

3.1.6 Relevance and Adaptability

One key aspect of the current projects and business models nowadays is adaptability and change. Projects face constant changes to which every stakeholder must adapt in order to succeed. This also happens when it comes to KPIs. These performance indicators must remain current to the business and to project priorities and flexible to adapt to the ever-evolving conditions. Outdated key performance indicators need to be updated or replaced if they don't align with the current business needs. KPIs should not only be aligned with internal but also to external industry trends. In this constantly changing working environment, the key performance indicators must remain flexible to adapt to these changes.

3.2 Different Classifications of KPIs

There are different frameworks and methodologies that can be used to differently classify different kinds of key performance indicators. Each methodology would provide an insight or perspective depending on each sector or industry; however, these classifications are very important to allow us to categorize and prioritize KPIs based on their relevance, impact and usability. An organization that has done the due diligence work to correctly classify and select their key performance indicator is an organization which can make better informed decisions, which improves accountability and has a more determined strategic alignment. These are some of the key reasons why this classification or different frameworks for KPI selection will be analyzed below:

3.2.1 The Balanced Scorecard method

As the first methodology that will be discussed in this section, developed by Kaplan and Norton in the early 1990s is the balanced scorecard strategy (Kaplan & Norton, 1992). It is based on a management plan system which enables companies to first analyze their vision and then translate it into actionable objectives. This methodology categorizes KPIs into these different categories:

1. Financial Perspective: Metrics and KPIs that focuses on growth, revenue and return of investments.
2. Customer Context: These metrics focus on customer satisfaction, retention and markets.
3. Internal Business Processes Objective: These evaluate the efficiency of internal processes.
4. Increase and Learning Viewpoint: These set of metrics aim to measure the ability to innovate, learn, develop their employees and improve as an organization.

This structure allows companies to clearly balance and target different sections and aspects within the same organization, to better facilitate and understand in which segments the company might be lagging or exceeding the expectations (Anbrasi Edward, 2011). As an example, for healthcare companies, the BSC method has been widely used to provide a structured approach to performance management (Harris, 2017), allowing leaders to make data-driven decisions and have the necessary tools and visibility to do that.

3.2.2 The performance Prism method

The methodology of the performance prism focuses on the different layers of all stakeholders. This framework would aim to obtain a holistic view in terms of performance from all different stakeholder points of view. It does not only stay within the processes and controls that a company can have from within but also aims to understand how these processes affect other external stakeholders such as customers (Neely et al., 1998). This valuable information allows companies to use this external data as feedback into their own production processes to fine tune according to the expected outcome. In regards of this categorization, we can find the following groups:

1. Strategies: Firstly, the organization focuses on the definition of the objectives and their plans to achieve and satisfy the different needs.
2. Processes: This area focuses on identifying the critical processes and parameters that will allow the organization to execute their strategies.
3. Capabilities: In this aspect of the analysis, the company will define the different capabilities and requirements for the company to execute the necessary processes defined above.
4. Stakeholder Satisfaction: The company identifies who are the stakeholders and their requirements.
5. Stakeholder Contribution: Lastly, in this area, the organization analyzes the different aspects which they require from the different stakeholders.

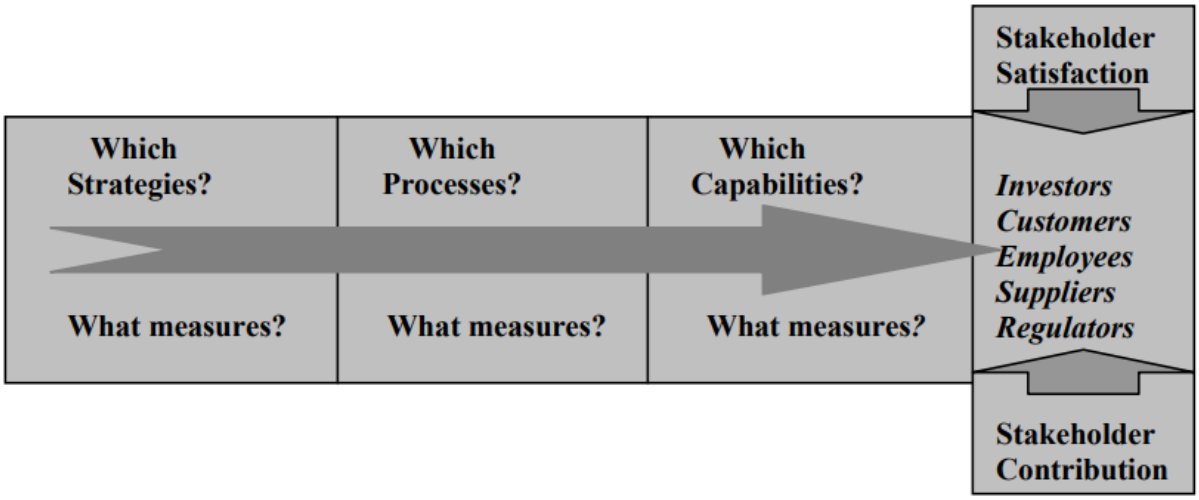


Figure 1: The Performance Prism (Neely et al., 1998)

In figure 1 it can be observed how these different aspects of the prism align strategically to give guidance and structure to the company to be able to meet the desired objectives. Additionally, according to (Neely et al., 2002), in figure 2, it can also be observed how these aspects of the prism are part of one as a whole organization, and each section will be supported by a set of specific KPIs.

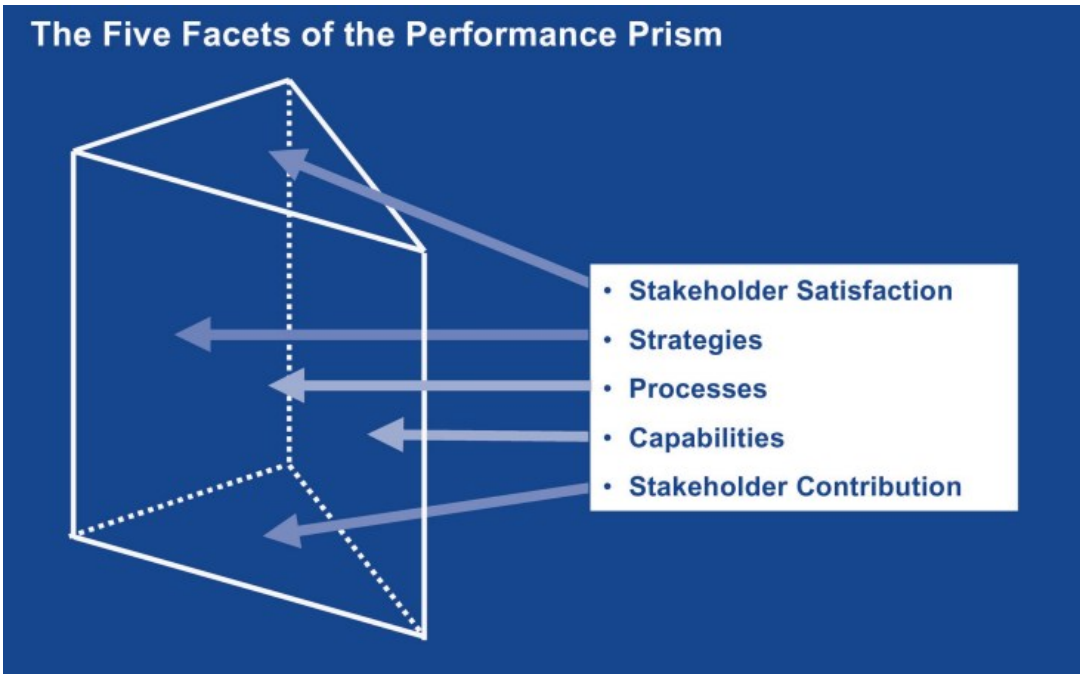


Figure 2: The five facets of the performance prism (A. D. . Neely et al., 2002)

3.2.3 The performance Pyramid method

The methodology of the performance pyramid aims to integrate the strategy of an organization with the operations departments through an integration of the company vision to different operational performance indicators (Striteska & Spickova, 2012). This pyramid performance method is structured in four different levels:

1. Corporate Vision: At the highest section of the pyramid stands the corporate vision. It represents the overall organization strategy and mission.
2. Market and Financial Measures: at the second level of the pyramid stand the financial measures which focus on market performance and overall success in terms of finance.
3. Operational Measures: There is a third level on the pyramid which aims to obtain the different KPIs which affect customer satisfaction and general company production.
4. Department Objectives: At the bottom of the pyramid, we can find the department objectives, these represent the base, in which all the upon is built, and aim to focus on quality and deliveries on the small blocks of the company.

This structure is quite representative and easy to understand, providing leadership and all different layers within the company with a clear visualization on how the company vision flows from top to bottom and how the operational goals set downstream need to align with the overall strategic company vision at all levels.

3.2.4 Sector Specific KPIs Classifications

There are different categorizations of KPIs that are cross functional and general for most companies. However, there are another set of KPIs and framework which are created for industry specific requirements. One of these sectors can be for example the healthcare section in which there are some sector specific KPIs such as patient satisfaction, quality of care and safety (Amer et al., 2022).

As another example of a sector specific KPI classification are the projects related to facility management. This has become a widely known sector and one of the most analyzed, creating with an extensive group of KPIs to provide a general view on the performance of the given facility, this set of KPIs focus on operational performance, efficiency, business effects and benefits or environmental factors (Sarel Lavy, 2010).

There are other sector-specific classifications which aim to provide a more accurate and specific set of KPIs to a unique operational context for different industries allowing project managers and leaders to have a more accurate insight into their organizations. Some of these sector specific classifications will be reviewed more in depth along this thesis work, specially focusing on construction projects.

3.2.5 Hierarchical Classification of KPIs

Even within all the above-mentioned different systems to classify KPIs, these can be also organized hierarchically to reflect different interdependencies with other KPIs or company departments. These KPIs interrelations can be categorized or classified as follows:

1. Basic Metrics: These KPIs are fundamental measurements. Straight forward values which do not really depend on any other, such as a failure rate, the number of absences per day or the volume of sales in a specific quarter.
2. Comprehensive Metrics: There are other KPIs which are aggregated measurements of different KPIs which contribute to a general one, for example an overall project completion rate.
3. Supporting Metrics: There are also indicators which can provide additional information on the context, such as maintenance schedules or employee qualifications.

This classification of KPIs can provide companies with a deep understanding on how to classify the metrics and KPIs to establish the different interrelations, which can allow companies to perform better and more accurate decisions (Ningxuan Kang, 2016).

3.3 Selection Process for KPIs Based on Project Types

The selection of Key Performance Indicators varies significantly depending on the type of project, their scale and which are the objectives of the given projects. For different projects, they operate under different situations, context, constraints, stakeholders, expectations, specifications, countries, regulatory environment, etc. This requires then a personalized and customized approach for the different KPI selection. There are some projects that prioritize more traditional and conservative aspects such as cost efficiency and schedule tracking, as well as some others focus more on sustainability practices or environmental impact. In any case, the selection for each case needs to be data driven, and aligned with the project goals, and these KPIS must be relevant measurable and actionable (Kaplan & Norton, 1992). This section analyzes the selection process for different project types as follows:

3.3.1 Different Project Types

The selection process of KPIs depends on the nature of the project. To better understand how these will influence when selecting the right KPIs, here is an overview analysis of the main type of projects as well as some customized KPI.

The first category of projects to mention is the **traditional construction projects**. These can be related to infrastructure, commercial or residential buildings or similar constructions. Normally these projects will follow a compliance-based approach and mostly will focus on cost, safety, schedule and quality. Some important KPIs which are usually taken into account when planning these types of projects is the Earn Value Management (EVM) methodology where the Cost Performance Index (CPI) and the Scheduled Performance Index (SPI) are key when evaluating and executing the project (Vargas, 2004). Other important aspects such as ISO 9001 quality guidelines also influence the KPI selection as per the materials, defects, compliance and safety regulations. Additionally, since the client of these projects, stakeholder known as end user, has also a very strong demand in terms of characteristics in the project, the selected KPIs need to align on customer expectations (Parmenter, 2015).

The second category of projects to mention is the group of **agile and fast track projects**. These are the methodologies normally used for software development projects or when modular construction

is used. These projects require adaptative KPI that can measure the efficiency through iteration and can adapt to fast responses and changes. The selection process for these projects is rather dynamic and focuses on the completion rates, time reductions and adaptability. A well-known methodology and type of indicators are the Scrum based KPIs which identify the backlogs and percentages of completions as well as sprint velocity, which monitor continues improvement. In definitive, these projects prioritize flexibility and real-time feedback which are essential for their success (Lakiza & Deschamps, 2018).

The third type of projects to be mentioned are the **public and government funded projects**. In this type of project, the focus is on the strict compliance rules, sustainability and financial transparency requirements, however cost efficiency goes to a lower level of priority. In this case, the KPIs focus on the regulatory adherence, budget accountability, and social return of investment (SROI). The criteria are more towards the long-term project impact, and environmental compliance (Parmenter, 2015).

On the fourth type of projects under analysis we can find the so-called **mega projects**. These types of projects are focused on the execution of large pieces of infrastructure such as airports, dams, highways or similar infrastructure. These mega projects have a different structure in terms of KPI frameworks, which are known as multi-layer or multi-tier, due to their scale, complexity, financial costs and stakeholder variety. For the selecting process for the KPIs for these projects are also established in regards of the guidance explained by (Parmenter, 2015), using the Balanced Scorecard (BSC) model, as well as a complex financial situation, processes, and extract construction requirements. The key performance indicators on these projects prioritize more risk management efficiency, supply chain effectiveness and contractors' performance, since given the project size, there is a complex integration of different suppliers, stakeholders and contractors.

The fifth type is the **technology integrated construction projects**, which are mainly smart buildings, data centers and BIM based projects. Within the construction projects classification there is a specific type which have a higher level of complexity since they included an increased number of technological and complex systems, such as data centers. In this type of projects, the more valuable KPIs aim to provide a real time monitoring to optimize efficiency. The construction process of these buildings cases focusses on using a software methodology called Building Information Modeling (BIM) to

efficiently implement and interconnect all these complex systems. In regards of the KPIs, these are more focused on the processes and efficiency, such as system uptime, automation efficiency, performance tracking or energy consumption per square meter (Lakiza & Deschamps, 2018).

Finally, the seventh type of project under analysis is the **sustainable and green building projects**. These construction projects prioritize above all KPI and conditions which align with the environmental objectives and industry standards. For example, a common set of KPIs for these projects could be the carbon footprint reduction, water efficiency and material sustainability(Parmenter, 2015). And they also incorporate a re-usable lifecycle of the project materials and an evaluation of the environmental impact.

3.3.2 Relevant Criteria for KPI selection

For any kind of project, the process to select the relevant and meaningful KPIs requires a structured process to achieve the desired alignment between strategic goals and operational performance. In this section it will be analyzed the most important criteria for KPI selection:

The first criteria are the KPI alignment with the strategic goals. A KPI should directly be related to the factors that represent the success on the project, ensuring it covers both short- and long-term business objectives. As mentioned in the section above, some projects like the mega projects would prioritize the risk mitigation, meanwhile other projects such as the agile would prioritize quick responsiveness, or other types of projects such public sector projects (Yuan et al., 2012) would focus on compliance KPIs to ensure accountability to all stakeholders.

The second relevant piece of criteria for KPI selection is KPI measurability and data availability. A KPI must be trackable, quantifiable, measurable and backed by a proven reliable data source. The risk of not ensuring the reliability of the sources can mislead the direction of the project. For technological driven projects the most valuable KPIs are the ones which provide real time data and tracking, however for traditional projects, project managers rely more on periodic reporting, such as EVM based KPIs.

The third criteria for selection of KPIs is that these need to be relevant and important for the targeted stakeholders. The KPIs need to be selected in function of the stakeholder expectations and

need to satisfy their needs. For example, for investors, the correct category of KPIs to be used will be the financial KPIs, for regulators the most adequate group of KPIs will be the compliance and safety KPIs, for project teams the most important KPIs will be the efficiency and process tracking, and for clients the most relevant KPIs will be the ones focusing on delivery performance and satisfaction.

The fourth set of criteria is based on the industry benchmark and its standardization. There are also industries and projects which have a global adoption and characteristics of compatibility and standardization, such as aerospace. These industries then have more generalized frameworks as could be the ISO 21500 or the Project Management Body of Knowledge Guidelines which provide the guidance for all industries to align on the same KPIs for standardization (Lakiza & Deschamps, 2018). This common benchmarking allows different competitors and industries to align on measuring the same parameters for better adaptability.

The fifth criteria aspect for KPI selection is the scalability and adaptability of the company or project. If a certain project requires scale and increases its complexity, the selected KPIs need to be in accordance to those expectations. For example, for mega projects, KPIs would require scalability across the different project phases.

Lastly, the sixth aspect to take into consideration for KPI selection is the KPI actionability and predictability. KPIs should allow project managers or the different stake holders to have the necessary proactive decision making and ability to take actions. In regards of this classification, KPIs are then classified as leading or lagging indicators (Sarel Lavy, 2010). The lagging indicators provide information on the performance confirmations of measured data, meanwhile the leading indicators utilized this measured data to provide predictive insights of upcoming expected results.

3.4 Main Criteria and KPIs in Construction Projects

The construction sector is characterized by the complexity and different stakeholders involved, which require a well-structured KPI framework to ensure these projects are delivered on time, according to the expected budget and with the highest safety and quality standards. Additionally, in these projects is also key the involvement of financial measurements, operational excellence and environmental compliance (Fang & Choudhry, 2008). Construction projects involve a vast number

of variables, stakeholders, regulatory compliance, resource management and the arranging of the workforce to execute accordingly. Therefore, this requires a detailed selection of KPI with project specific goals which align with the different stakeholders' objectives.

In the research article (Kunkcu et al., 2022), the authors perform an interesting analysis to 190 literature review articles and 55 research papers related to key performance indicators and construction projects. Among all the different groups and classifications, these are the most repeated and meaningful categories in which all KPIs in construction projects fall into: Cost, Time/Schedule, Satisfaction, Quality, Relationships, Management, Obstacles, Safety, Others.

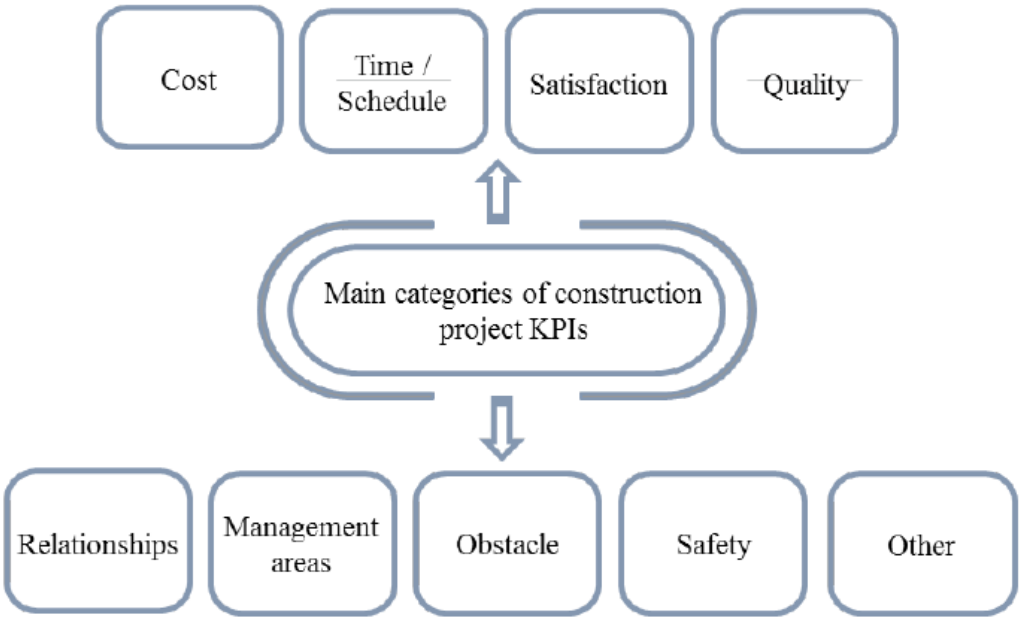


Figure 3: Most used KPI categories in construction projects (Kunkcu et al., 2022)

In figure 3 we can observe the illustration that shows how construction project performance is measured and assed across multiple dimensions. A good and complete selection of KPIs for any specific project requires a thorough analysis and this figure reinforces the argument of the need of a holistic approach to performance evaluation.

Following with the detailed research (Kunkcu et al., 2022), the study of the research literature reveals which are the most commonly and repeated used KPIs for construction projects for the given categories above. This offers a key insight into the importance of each group and the most widely used KPIs in each group. It highlights that the most dominant KPI categories in construction projects are the cost indicators KPIs such as cost performance, cost predictability or project cost growth. This indicates that budget and expenses control is critical and fundamental for project success to ensure that the project remains financially profitable and viable.

Table 1: Researched KPIs by relevance in construction projects (Kunkcu et al., 2022)

Category	KPI	Number of studies
Indicators related to cost	Cost performance	15
	Cost predictability	4
	Project cost growth	3
	Change cost factor	2
	Project budget factor	2
Indicators related to time/schedule	Schedule / time performance	15
	Time predictability	4
	Project schedule growth	1
Indicators related to quality	Quality / high-quality performance	12
	Rework	10
	Defects and quality errors	6
Indicators related to satisfaction	Client satisfaction	12
	User satisfaction	4
	Project team satisfaction	3
	Contractor satisfaction	1
Indicators related to safety	Safety performance / accident rate	11
	Lost time rate	1
Indicators related to management areas	Efficiency of quality-management system	2
	Effective risk management	1
	Effectiveness of material & resource management	1
	Management of internal & external stakeholders	1
Indicators related to relationships	Communication efficiency / effective information management	11
	Harmonious working relationships	2
	Long-term business relationships	2
Indicators related to obstacles	Claim occurrence	3
	Dispute occurrence	2
	Litigation occurrence	2
Other indicators	Productivity performance	9
	Innovation and improvement	5
	Profitability and financial objectives	4
	Effective planning	3
	Top management support	3
	Environmental performance	2
	Attitude of employees	2
	Professional image establishment	2
	Staff turnover	1

Equally, the scheduled performance KPIs such as time predictability and schedule growth are also highlighted as the second most important category of KPIs in construction projects. Normally any delay in a construction project leads to cost increases, contract penalties and a reduced profitability, making this section one of the most critical to the success of the project. As defined earlier in this thesis work, the Value Management (EVM) framework gains importance in these types of projects since it incorporates the relation of the Schedule Performance Index (SPI) as well as the Cost Performance Index (CPI), which gives an accurate idea of the progress of the project execution.

Beyond the main highlighted importance of the cost and schedule categories, it can be observed that the quality management and safety KPIs also play an important role for project managers when taking these into consideration. In regards of the quality management KPIs, the client satisfaction and reputational damage play an important role. Regarding safety, the accident rates and injury frequency rate (LTIFR) also play an important measurement benchmark in construction projects. Safety has always a high priority and importance in these projects for the own health of the employees and subcontractors but also for the relevant compliance regulations with the Occupational Safety and Health Administration (OSHA) which might have a legal impact in some of the companies and projects delaying projects or removing legal liabilities. In order of importance, it can be observed that the following categories in the raking are the stakeholder satisfaction as well as management effectiveness KPIs. Some of the indicators such as quality management, material effectiveness, supply chain coordination or stakeholder management reflect the operational health of the project. Additionally, contractors and end client satisfaction play also a very important role to the image of the company, which can affect the project or business in the medium or long term.

In conclusion, the selection process for construction management process has a multi-dimensional aspect in which several key areas must be taken into consideration before selecting the correct strategy. The main groups which are prioritized for KPI selection are: cost, schedule, quality and safety, according to several researchers (Kunkcu et al., 2022). However, the research also shows that management efficiency, stakeholder relationship and environmental performance are important factors for the project success. Depending on the project type, complexity and objectives each project manager, company or team should balance the use of these indicators to adopt the correct structure that aligns with their strategy and goals.

3.5 Additional Aspects for Successful KPI Implementation

During this thesis work, research and analysis has been presented on the effect of KPI indicators for evaluating and optimizing project performance. However, their effectiveness does not only depend on depend on their selection and ability to measure. They also depend on the strategic and organizational context of the company in which these are then applied to. Some other important factors to take into consideration besides the pure numerical data are how these strategies are communicated, how much commitment from the leadership team to the company vision, how these also align with the company strategic goals and if the company is able to cultivate a culture of continued improvements. According to the research article (Camilli et al., 2022), the authors present the paradigm of the integration of KPI strategic establishment as a cultural facture for an effective integration into the company's vision.

Another critical element is effective communication and employee engagement. A KPI cannot just be imposed from top to bottom without proactively engaging employees at all levels. The implementation of a KPI must be shared through robust communication strategies to aim for a high level of engagement between employees for the key performance indicators to be effective. In this category, it is also important to mention a factor for successful KPI implementation and it is the KPI strategic objective has a higher implementation success rate when it aligns with the organizational culture of the company(Camilli et al., 2022). The alignment of these strategic objectives and the overall global company culture is direct responsibility of the leadership and management teams, and the adoption rate depends on them.

Equally important is to have the necessary technological adoption to allow the relevant employees at different levels of the company to effectively monitor these key performance indicators. They should not just be relevant but also effectively monitored. If there are cases where KPIs are outdated or acquired through manual reporting processes, this could lead to inconsistences and affect the overall KPI tracking and usability (Peterson, 2006). The adoption of digital tools such as dashboard, collection systems has drastically improved tracking and accountability, leading to better project outcomes and more informed decisions.

Figure 4: The 7 key steps to develop a strategic vision (Ciancio, 2024)

The development of a comprehensive strategic vision and implementation for the key performance indicators in an organization plays a key role in their success. As can be observed in figure 4, the following research (Ciancio, 2024) lays out a sweeping analysis of additional aspects to what the company vision strategy should include: understanding the current reality, envision the future, gather insights and ideas, build consensus, draft the vision statement, communicate effectively, implement and monitor the progress.

4 Implementation

For this section, the thesis work will focus on the practical application of the before analyzed Key Performance Indicators in a construction project. Therefore, this focuses on creating the necessary structured framework to align with the before analyzed models and the real-world execution of a project. In previous sections of this thesis have been established some of the conceptual foundations of KPIs such as classification, selection and good practices. In this section however, the work focuses on applying a practical implementation of these concepts in a simulated company and project scenario. Using a case study approach, this thesis will apply the KPI methodologies to an imaginary construction company to allow a full analysis of KPI selection, performance measurement, to show the different mechanisms to track these KPIs according to the define strategy in a real case construction company.

The main goal in this section will be to demonstrate how the theoretical research of this study ca then be applied to a construction company applying a structured framework of Key Performance Indicators to ensure the before discussed terms: Safety controls, project execution efficiency, risk management, finance and budget control and quality expectations. Nowadays, the construction industry is characterized by a complex set of high standards in regards of regulations, coordination between several stakeholders, a complex supply chain market, and the fact that there is the need to manage multiple companies in a tight span of time (Kerzner, 2011). Even taking into account these tight timelines and restricted budget, the expectations are even higher to meet the never decreasing customer requirements. This makes it even more necessary to have a set of strong monitoring strategies through KPIs to ensure these requirements are met in the most efficient way possible. These Key Performance Indicators are supposed to provide the necessary data at the right time for project managers to make the necessary decisions on time to mitigate any possible risks and ensure successful completion of the projects.

In this introduction section is presented the created fictional company: **Ivan Gallego – Data Center Construction Solutions GmbH**, which is specialized in the design and construction of data centers. This company's main focus is to oversee and execute different data center design phase, as well as the construction of the data centers themselves to the final commissioning and handover sections. In this section of the thesis study the intention is then to outline the company structure, what is the

scope of the project, and which are the strategic goals which will then drive the selection and implementation of the specific KPIs for the practical case. Then a comprehensive selection of the necessary KPIs according to the business goals is carried out for the given project lifecycle, with the intention of didactically showing how to apply the different discussed KPI frameworks to ensure the correct resource utilization, performance tracking and project prosperity.

An important part of this section will be the selection and explanation of why the selected KPIs, and how these align with the strategic objectives of the fictional company. As previously mentioned, the methodology used for this section will be integrating the discussed Balance Scorecard (Kaplan & Norton, 1992), as well as the Performance Prism (Neely et al., 2002), and the Earned Value Management (EVM). By implementing these frameworks, a comprehensive analysis will be carried out to evaluate the project performance, addressing how these selected Key Performance Indicators can weigh not only efficiency and costs, but also quality control, risk mitigation and stakeholder satisfaction metrics. During this implementation, it will also be evaluated and analyzed the tracking suggested mechanisms, including periodicity intervals and different dashboards and tools to ensure that the selected Key Performance Indicators provide the necessary insights to the project managers and leadership.

Additionally, in this section will also be analyzed the different challenges which are involved on the implementation of these methods. It is known that KPIs can provide valuable insights, but these strictly depend on a certain set of conditions, such as: having the necessary accurate data, the necessary engagement from the different stakeholders, and the leadership support. As an additional part of the thesis research, it will also study the most up to date IT tools used in construction projects, such as: building information modeling (BIM), digital dashboards like Power BI, or project management software, which are used on the day to day real world for the effective tracking and reporting of Key Performance Indicators and project progress.

To wrap up the introduction section, this part of the study aims to bridge the gap between the theoretical knowledge and the real-world application, by constructing an applied framework for our specific company. This utilizes the KPI selecting methodologies to a construction company scenario, and it aims to provide a valuable insight of how project managers can utilize these tools to ensure project success, proper KPI selection and an effective decision making process.

4.1 Case Study Analysis: Application to a Construction Company

In this section it is introduced the case study company: **Ivan Gallego – Data Center Construction Solutions GmbH**, which is a fictional company, specialized in the design and construction of data centers. The company is responsible for overseeing different data center projects from the initial design phase, all the way to the construction, commissioning of equipment and final handover to the clients, ensuring the best data center project industry standards to meet client specifications within the expected timeframe and budget.

With the increased use of artificial intelligence, big data or the internet of things, companies now require a high performance and scalable infrastructure for computational power. Data Center projects are then emerging nowadays with an increased demand, due to an increased use of cloud services. According to the performed study by (Sujay Vialshery, 2024) and shown in Figure 5 below, it is estimated that in 2023 alone, a total of 270 billion US dollars were invested in the cloud infrastructure and data center business.

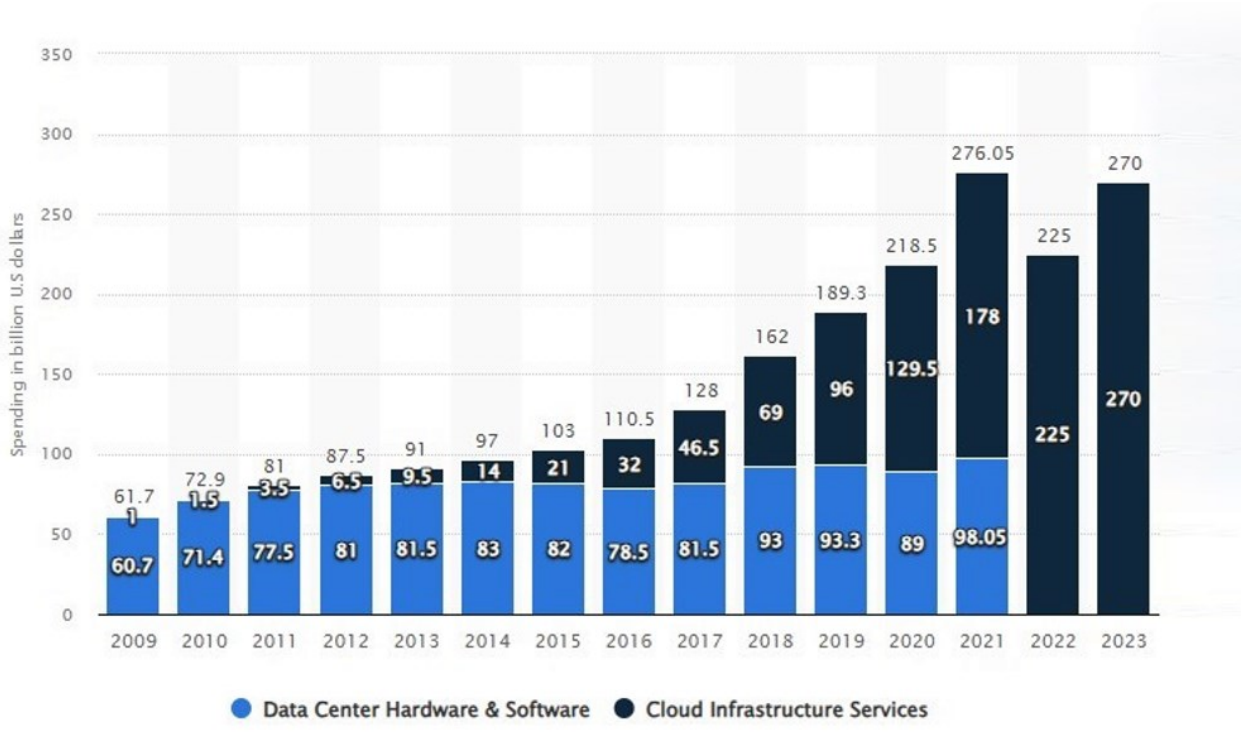


Figure 5: Enterprise spending on cloud and data centers by segment from 2009 to 2023 (in billion U.S. dollars) (Sujay Vialshery, 2024)

Equally, in a study carried out by Eurostat (Eurostat, 2023), it also shows the adoption of enterprises in terms of acquiring cloud computing services. It is estimated that in 2023 around 95.8% of companies at least bought one software as a service. As can be observed in figure 6, the distribution is much higher in lager enterprises, but the adoption follows a common pattern across all sizes of companies, increasing year after year their cloud services in at least 10%. This has shaped the data center industry, which demand continues to rise and therefore the applicability of this study to data center companies.

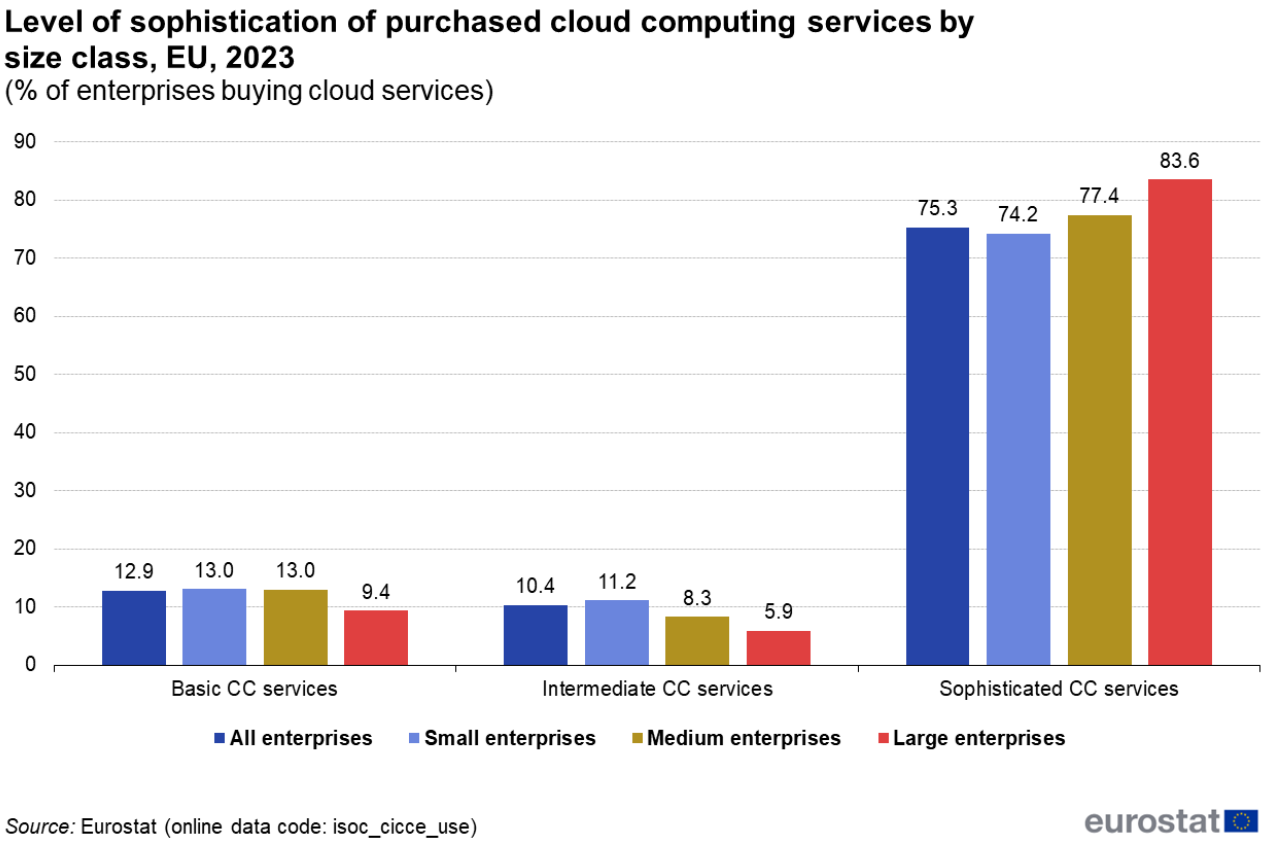


Figure 6: Cloud Computing Services Size, EU, 2023

Given the complexity of data center projects, in which the timeline is constrained by the high number of suppliers, stakeholders, complex processes and finance requirements (Cernisevs, 2024), this study aims to provide the necessary selection KPI for this specific company to operate within the technical environment ensuring performance measurement techniques which are crucial for a successful execution of the project. The following sub sections provide the details of the company, business model, requirements and operational challenges.

4.1.1 Company Information

Company Name: Ivan Gallego – Data Center Construction Solutions GmbH.

Industry: Data Center Design and Construction.

Headquarters: Frankfurt am Main, Germany.

Founded: 2025.

Company Size: Medium size company (approximately ~250 employees).

Intended Clients: Major cloud service providers which require data center constructions.

The core business and intention of this company is to specialize in the design and construction projects for data centers, managing the entire project cycle from the beginning design phase to the structural construction of the building, to the final commissioning phase and operational handover. The company works through a third party company, also known as a General Contractor or GC, which are the ones subcontracted for the physical construction and installation of the equipment but managed by our company. Our company then needs to ensure the necessary quality controls on the general construction throughout all project phases, to assure our final client that the necessary risks are mitigated, and the industry standards will be met within the expected time and budget.

Additionally, the key business objectives, and goals which will guide the KPI selection will be based on the following pillars:

1. One of the key pillars of the company is to deliver a exclusive quality solution and functional data center according to the client specifications and the industry standards, such as ISO 9001 (Quality Management Systems), the norm ISO 27001 (Information Security Management) or the TIA-942 (Telecommunications Industry Association (TIA), 2006).
2. Another important pillar from the company is to ensure that the projects are carried out within the expected budget allocated for each task. Deviating from these allocated funds and not maintaining correct cost management can have severe implications to the company and the business, therefore the need to control exhaustively the progression and consumption of the allocated funds.
3. To consider a project successful, the company will focus on the execution of the project within the expected timeline. A deviation in the timeline of the project has consequences on the delivery date, which can impact financially and the reputation of the company and our clients.
4. During the execution of the project the company must ensure to comply with the necessary safety guidelines and requirements frameworks to ensure no legal or human repercussions.
5. As another important pillar, to maintain the business and company reputation within the market, the company needs to ensure to be a reliable and trustworthy partner keeping the customer satisfaction metrics up to the standards to guarantee business continuity.

4.1.2 Project Data and Requirements

In the section above, it has already been defined the main characteristics and business goals of the imaginary company (Ivan Gallego – Data Center Construction Solutions GmbH). In order to also illustrate the application of the Key Performance Indicators to a real-world project scenario, it is also necessary to draw out the characteristics of a hypothetical data center construction project, for one of the large-scale cloud computing data centers, so the necessary concepts can be applied. These are the selected project characteristics:

Project Name: Data Center Development Project for Cloud-X Company.
Project Location: Frankfurt am Main, Germany.
Project Scope: Design, Construction and Commissioning of a Tier3 Data Center.
Project Duration: 24 months (2 years)
Project Budget: 260 million euros (€).
Total Space: 30 000 m².
Electrical Expected Consumption: 25 MW.
Cooling Systems: Air Cooled Chillers and CRAH units.
Security: Multi-layer biometrical access with outside surveillance.

To better illustrate the lifecycle of the selected project, Cloud-X Data Center construction has been structured in three main parts. On the first one, the design part, the project will focus on understanding the client requirements and translating these into all the project guidelines, focusing on the stakeholder and design teams' engagement, achieving the necessary approvals and starting to draft all the timelines for all project phases. During the second phase, the construction phase, the company will then focus on purely the execution of the engineering civil work of the building, where the Key Performance Indicators will highlight its importance on contractor performance, health and safety, cost control and quality. For the final phase, the commissioning and handover phase, it will be based on the final system verification, inspection and commissioning levels, to successfully deliver the expected project to our customer. In this last section of the project the Key Performance Indicators will be mainly based on commissioning success rates, client satisfaction and all necessary commissioning tags to ensure that the equipment is fully ready to serve its purpose.

Table 2: Data Center Project X Phases and Timeline

Phase	Duration	Key Milestones
Design Phase	6 months	Capture client requirements, architectural and engineering planning and infrastructure selection.
Construction Phase	12 months	Civil engineering works, structural development and equipment installation.
Commissioning & Handover	6 months	Commissioning L1 to L5 works, system verification, testing and final acceptance tests.

It is also important to highlight that during the different phases of the project (as shown in Table 2 above), the project needs will vary. Since the project needs, goals and objectives vary from phase to phase, in order to successfully track the different challenges and project evolution there needs to be a specific tailored approach to each project phase. Therefore, each project phase will count with their own set of specific KPIs to ensure the different priorities are addressed correctly throughout the project.

4.2 Application of the Conceptual Framework and KPI Selection Process

For the case study construction projects such as the Cloud X Data Center, the tracking mechanisms play a key role for the success of the project. As mentioned in earlier sections of this study, these performance indicators need to align with the overall company business strategy to succeed. This section will therefore try to utilize the previously outlined conceptual frameworks such as the Balanced Scorecard (Kaplan & Norton, 1992), and the Performance Prism (Neely et al., 2002) to the project and company Ivan Gallego – Data Center Construction Solutions GmbH project Cloud X Data Center.

To illustrate the need to use different strategies to be followed through the project, the project has been divided into three different phases which are required to meet the specific project goals for the different stages and situations of it. Despite these project phases different characteristics and requirements, the set of KPIs selected for each phase must align with the overall project business goals such as the correct tracking, the risk assessment, the time tracking, cost control and quality

assurance, as described in the best practices of the theoretical framework of this thesis work (Parmenter, 2015). The objective is to combine a mixed of leading indicators (Campbell, 2017) and lagging indicators (Schrage & Kiron, 2018) to allow project managers to have the necessary information to enable proactive decision making on time throughout the different project phases, providing a customized portfolio for each.

4.2.1 Key Performance Indicators Selection

As extensively discussed in section three of this thesis work, Key Performance Indicators serve as measurable tools which can benchmark a project health, status, progress, comparing these to a broader pre-stablished strategy and defined objectives. In situations where complex projects are analyzed, as can be the case of a construction project, it is common to apply several frameworks of different KPIs throughout the different stages of the project, which also aim to evaluate different dimensions of a project. These go from operational, to quality, to financial, stakeholders, productivity or similar areas. Utilizing different KPI frameworks for different project stages is necessary to ensure the correct perspective and variables are being monitored and analyzed in each correct stage.

For the selected project case study of this master thesis, it has been divided into a three-phase structure process: Design, Construction and Commissioning/Handover phases. During the design phase, the design team is in charge of collecting all different project requirements and combining all these into a final design proposal which ensures all regulatory and stakeholder requirements are captured and addressed correctly. In this phase it is particularly important to highlight the need to correctly define the scope clearly, as well as a comprehensive risk identification which could potentially impact the project in future stages. Secondly, this first phase is followed by the construction phase. In this construction phase is where the general contractor gets involved on the execution of the physical construction and architecture part of the project, procuring all different materials, directing the work on site with the different subcontractor companies, following and adhering to the created project schedules, ensuring all activities are executed safely without any incidents, and withing the expected budget forecasted. The third and final phase is the commissioning and handover phase. In this last phase the general contractor and different subcontractors are managed to commission all the different equipment according to the expected commissioning scripts, ensuring all building systems perform to their design expectations to meet the final customer needs. This last

phase involves a set of final acceptance and occupancy permits, which usually implies a set of last-minute challenges and decision-making priorities. Therefore, the KPIs to be selected for this category normally aim to ensure these last standards and how the changes can impact on the project requirements and cost.

For most projects, there is usually a set of pre-defined categories and aspects which are considered to be able to cover and track different project aspects. Some of the most used ones (Lavy et al., 2010) are named here which are also the ones which will be applied for our three defined different phases:

- Productivity
- Time Management
- Safety
- Quality
- Finance/budget
- Safety and Risk Management
- Stakeholder Satisfaction
- Resource Utilization and Efficiency
- Environmental
- Investigation and development improvements
- Communication
- Subcontractor Performance
- Human Resources Metrics
- Legal and Compliance
- Scope and Change Management

Following this introduction and discussion regarding the different project phases of our project and the different group of KPIs which are normally used for construction projects, the next step is to align each category set of Key performance Indicators for each project phase. As an example, for the first design phase, the scope of the KPI or metrics selected should comprehensively capture the scope, communication and regulatory compliance framework, among others. For the second phase which involves the construction part of the project, the set of selected KPIs should focus more on the productivity, schedule adherence, safety and budget control. And the last phase of the project tends to lean towards customer satisfaction, commissioning achievements and meeting all regulatory and legal frameworks.

To be able to effectively apply the different methodologies described in section three of this master thesis work, the following frameworks will be used for the KPI selection. For the first design phase,

the KPI selection will be carried out using the balanced score card methodology. For the second phase, the construction phase, the set of KPI categories selected will be evaluated by using the Performance Pyramid method. And finally, for the third project phase, the performance prism method framework will be used for the KPI selection. Each framework is intended to provide a different visibility on the strategies for effective KPI selection, from financial to performance, creating different hierarchical views of the strategy and cascading this to the selection process, taking into account how these methods add value to our customers and the overall execution of the project. By combining these methodologies, this work aims to illustrate how project managers can use these methods to engineer a set of Key Performance Indicators to each phase which require a set of unique characteristics to be tracked. This approach does not only ensure that the entire project objectives are taken into account, also ensures that each sub-objective and technical aspects are taken into consideration in a more detailed approach.

4.2.2 Phase 1: Design Phase KPI Selection. The Balanced Scorecard Method

For phase one, the design phase, the evaluation of the set of Key Performance Indicator categories, is selected using the balanced scorecard method, described in section 3.2.1. This method ensures an approach in which a strategy driven selection method for KPIs also aims to enhance organizational performance. This method, originally proposed by (Kaplan & Norton, 1992) is now used in both private and public projects due to its ability to transform high level organizational vision into manageable set of key performance indicators. One of its main advantages during the design stage is that it helps teams to evaluate and balance cost and schedule metrics with some other important aspects of a project such as innovation. It helps create a common understanding base between different project stakeholders like engineers, architects, project managers, procurement and finance teams to align on the strategy, which adds tremendous value to the project. This early alignment on the early phases helps the project manager to identify setbacks on an early stage which are far more preventable and have a less cost impact (Sharma & Gadenne, 2011).

In Phase 1 of our construction project, the balanced scorecard method has been particularly selected because it allows all the teams to align a specific, clear strategy and goal for every KPI category selection. This is also intended to improve and strengthen team collaboration and internal process alignments. Applying this methodology has the following intentions. In the first place, it intends to produce a detailed list of KPI which all teams can collectively monitor, establish the necessary

tracking mechanisms for a proper communication, efficiency on resource utilization, compliance with all different legal aspects, and in accordance to the project estimated budget. The correct tailored selection of these KPIs will not only aim to the common project goals but also will ensure less expected deviations in later stages on the project where changes have a higher impact in time, cost and resources. Also, to be able to classify better each KPI group, a balanced scorecard perspective has been assigned to each group, so each team can easily spot which is the strategic intention of that specific indicator: these represent internal processes, external stakeholders, finance/budgeting or innovation, such as lessons learned.

According to the article from the Harvard business school (Norton & Kaplan, 2021), here is shown the typical configuration of an initial balanced scorecard sheet for category and KPI selection. Here below in Figure 7, we can observe the pre-defined selected template for the Balanced Scorecard Sheet which will be used in the following KPI selection utilizing this BSC methodology. It has been divided into four main columns:

Category Group	**Key Performance Indicator**	**Definition and Selection Rationale**	**Scorecard Aspect**
Main Category KPI group. In this column, it will be defined as the category group of the Key Performance Indicator, as similar groups already defined in table 1 and section 4.2.1	This column will represent each one of the Key Performance Indicators within the general group.	In this section, it will be defined a short description of the key performance indicator and main purpose.	This section represents the scorecard aspect. Depending on the nature of the indicator can be divided into: Internal Process Customer/External Finance/Budget Company Growth

Figure 7: Balanced Scorecard Template

The four main categories selected for the balanced scorecard for the design phase are the following ones:

1. Design Scope & Change Management.
2. Resource Utilization & Efficiency.
3. Legal & Compliance.
4. Investigation & Development.
5. Communication.

Each one of these KPI categories selected have individual goals, which combined aim to capture, represent and contribute the project goals for this phase. In table 3 below, we can observe that for each KPI category of the balanced score card, four KPIs have been selected to cascade more specific aspects of each of the categories, with their definitions and the BSC aspect.

Table 3: Phase 1: Design. KPI definition and selection table. Balanced Scorecard

Category Group	Key Performance Indicator	Definition and Selection Rationale	Scorecard Aspect
1. Design Scope & Change Management	1. Design Change Frequency	Approved number of changes in design per 100 initial specifications.	Internal Process
	2. Average Design Change Turn Around	Number of days from a request for change until it is finally approved.	Internal Process Customer/External
	3. Early Phase Scope Stability Index	Percentage of change requests in Feasibility Design Phase.	Internal Process
	4. Cost Impact on Design Changes	Total costs from approvals on deviations on initial design conditions.	Finance/Budget
2. Resource Utilization & Efficiency	1. Planned vs Actual Design Hours	Actual design hours/Planned design hours (%).	Internal Process Finance/Budget
	2. BIM Utilization Rate	Number of deliverables BIM generated.	Internal Process
	3. Senior Designer Allocation	Hours of senior designer vs new designer.	Company Growth
	4. Ratio of Rework Hours	Rework hours/total labor hours.	Finance/Budget
3. Legal & Compliance	1. Regulatory Pass Rate	% of authority acceptance of deliverables.	Customer/External
	2. Permitting Pass Rate	Passed permits/Total permits (%).	Customer/External
	3. Design Violation Count	Number of non-conformities to law raised.	Internal Process
	4. Change Orders due to Compliance Deviations.	Total cost caused by change order deviations from initial design.	Finance/Budget
4. Investigation & Development	1. Innovation Proposal Ratio	Feasible project innovation/total submitted	Internal Process
	2. Lifecycle Cost Reduction from Innovations	Estimated savings per total of innovations.	Internal Process Finance/Budget
	3. Knowledge Lessons Learned Index	Amount of internal tasks documented with any attached lesson learned.	Internal Process Lessons Learned
	4. Digital Prototype Validations	Number of items validated via simulation prior implementation.	Internal Process Lessons Learned
5. Communication	1. Communication Hours	Amount of communication hours ratio in meetings (expected/total).	Internal Process
	2. Average RFI Response during Design Phase	Average of days to reply to RFIs.	Internal Process
	3. Stakeholder Review and Participation	Attendance of relevant stakeholders to design reviews (%).	Internal Process
	4. Collaboration Platform Adoption	Adoption % of engineers using the agreed platforms for documentation sharing.	Internal Process

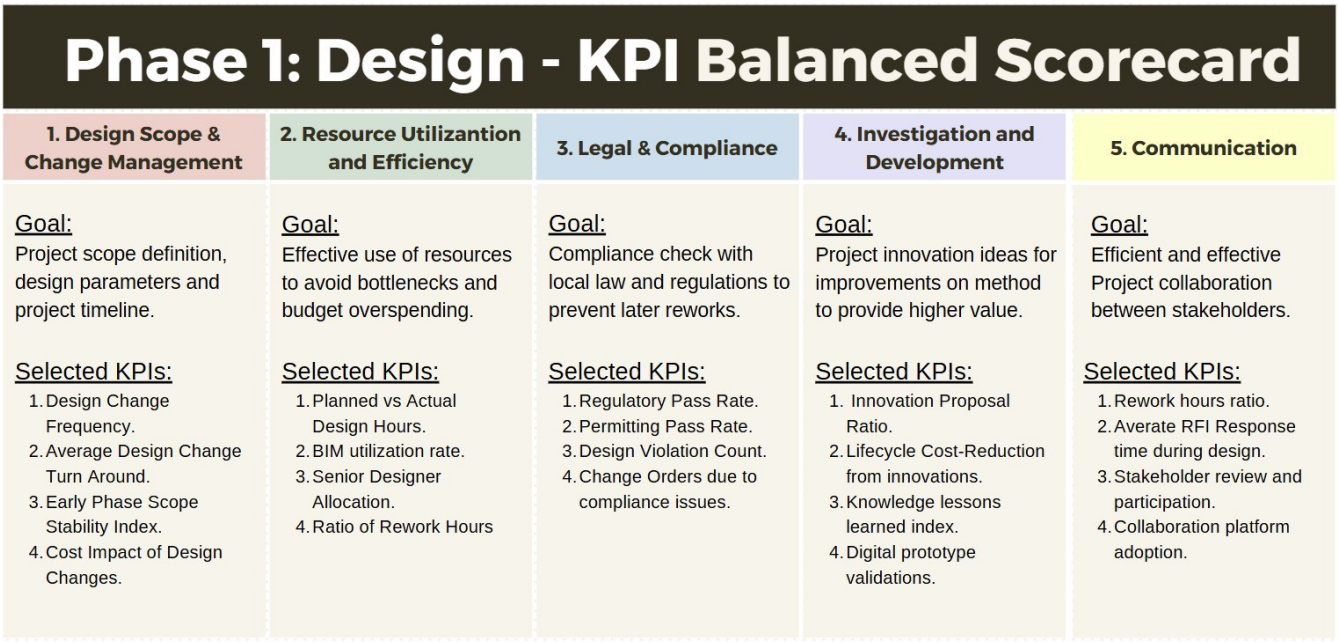


Figure 8: Phase 1: Design. KPI Selection Using the Balanced Scorecard Method

These selected goals have been chosen to address each one of the risks considered for the design phase. The goal for the design and scope management category aims to focus on early definition of the project requirements because of the known increased run-over costs which are caused by changes at a later stage of the project. For the resource utilization and efficiency section, the main objective is to address and avoid missing use of the project resources such as high-paid specialist hours into sections of the project which do not add value. Some indicators have been selected to ensure these do not occur, such as the senior designer hours allocation, or the check of BIM (Building Information Modeling) deliveries which usually also capture design early misalignment. In regards of the legal and compliance, it has been selected as one of the key categories to monitor since any deviation or non-acceptance of this type usually represents a complete stop of the project. The late identification of any legal non-compliance aspect has the potential of jeopardizing the project timeline and client acceptance, therefore it is a category that must be closely monitored. The investigation and development category goals aim to empower innovations and ideas that can make substantial improvements to the project and company internal processes. Even small processes improvement, compounded throughout the life of the project can have exponential benefits. Finally, the communication goal has as purpose to enhance the overall project communication between all different stakeholders to ensure an efficient cross team collaboration. By experience in other projects executed, the lack of enough replies, or the right professionals addressing the information requests on time can potentially impact the timelines and end quality of the project.

4.2.3 Phase 2: Construction Phase KPI Selection. The Performance Pyramid Method

For phase two, the project construction phase, the evaluation of the set of Key Performance Indicator categories, is carried out using the performance pyramid method, described in section 3.2.3. This method also known as the SMART KPI reporting technique (Cross & Lynch, 1989), was developed in Wang Laboratories and was due to a lack of satisfaction with the different KPI selection methods at that time. The main intention of this SMART pyramid system was to create four different levels in the organization (as shown in Figure 9). The main goal was to create clearly established levels to be able to allocate the right strategy and resources to each section. The first level represents the long-term company vision and strategy, which all the below segments aim to contribute to. On the second level, the objectives of the business are defined by observing the current market needs and the different financial characteristics of the current markets and the company as one. On the third level, the objectives of the company move to a more consolidated phase and more realistic measurement metrics for the specific company or department, defining more specific objectives for each department. Last but not least, as the fourth layer, as the base of the pyramid, it lays the key objectives to achieve on the lower level of all the different departments within an organization (Digalwar & Sangwan, 2011).

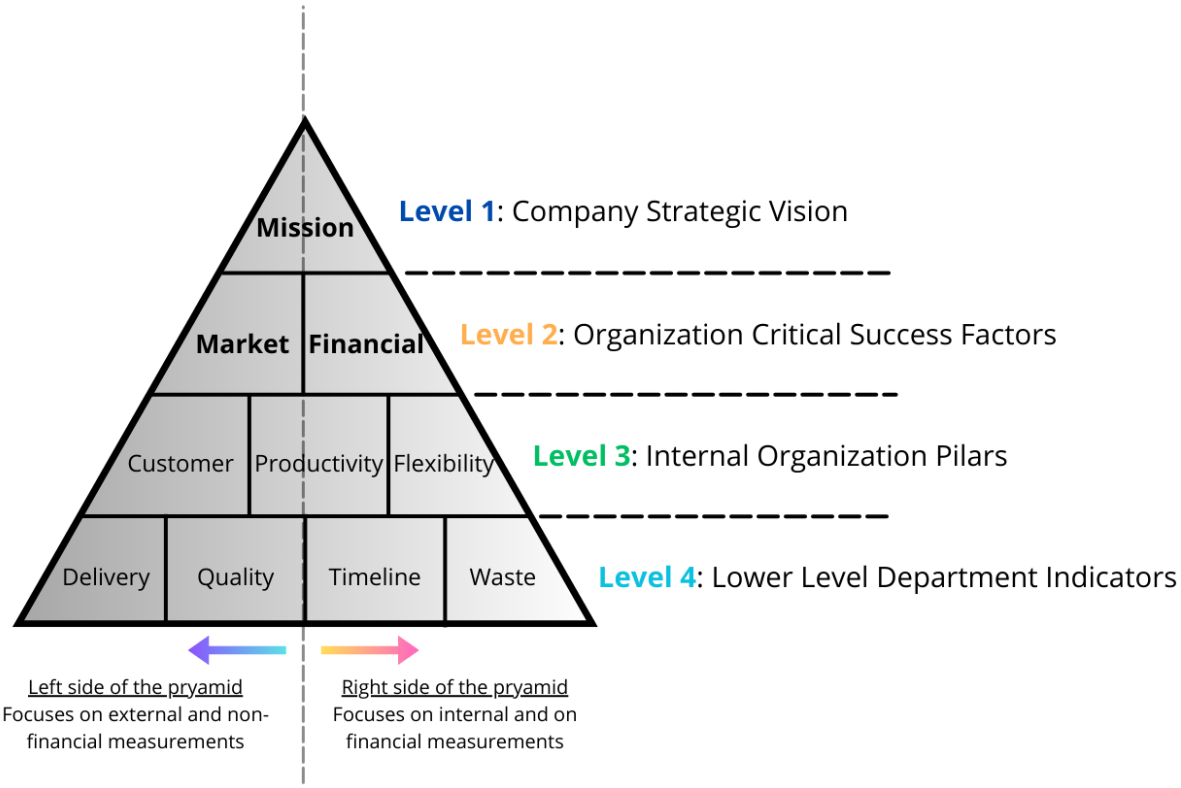


Figure 9: The Performance Pyramid Method Overview

The main advantage of this SMART performance pyramid method relies on the method ability to define the different priorities and areas of contribution at all the different levels of the organization, which give all departments the instruments and guidance to contribute and work towards the same goal. On the other hand, as one of the main disadvantages of this performance pyramid method, the lack of mechanisms in this method could be highlighted for an integration of a continuous improvement framework and the correct ability to effectively adapt to change, it is rather a more static and solid approach, when the bases are defined, they tend to remain static through time.

For the second phase of this project and as illustration of an application approach of the performance pyramid method, the following main categories of KPIs are selected for our specific case:

1. Productivity
2. Finance/Budget
3. Quality
4. Time Management
5. Safety
6. Subcontractor Performance
7. Human Resources Metrics
8. Environmental
9. Legal and Compliance

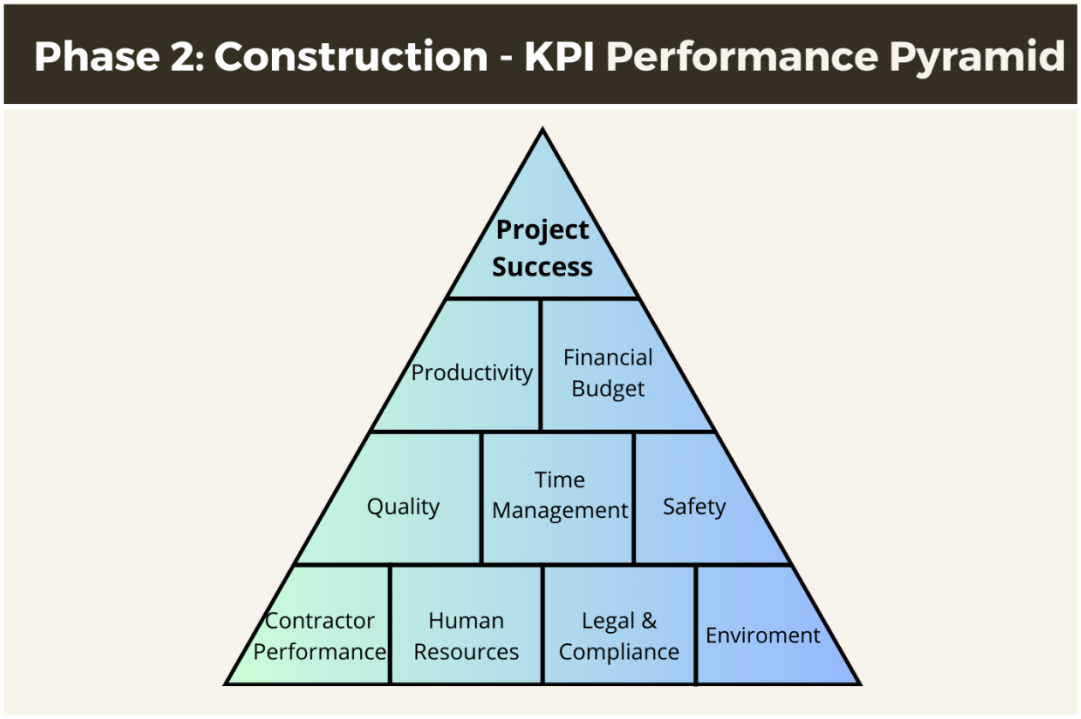


Figure 10: Phase 2: Construction. KPI Selection using the Performance Pyramid Method

All the KPI main categories would have a set of defined KPI for each category such as:

Table 4: Phase 2: Construction. KPI definition and selection table. Performance Pyramid

Category Group	Key Performance Indicator	Definition and Selection Rationale
1. Productivity	1. Percent Planned Complete (PPC) (%)	Actual percentage of completed work from last planner review
	2. Productivity Index (earned hours / actual hours)	Measurement of how effective labor hours are against the baseline. If higher than 1 means more hours than budgeted.
	3. Equipment Utilization Rate	It compares how many hours equipment such as trucks, excavators, cranes are working or standing by, which cause waste costs.
	4. Rework hours.	Wasted hours due to re-work required in any task.
2. Finance & Budget	1. Cost Performance Index (CPI)	Earned Value against Actual Cost (values lower than 1 expected).
	2. Variance Cost	Percentage of $ deviation of the budget from the initial forecast.
	3. Approved Change Order Cost (%)	Percentage deviation on change requests from initial project budgeted.
	4. Cash Flow Accuracy (CFA)	To control project liquidity, this KPI monitors the monthly planned vs actual spending.
3. Quality	1. First Pass Inspection Acceptance	Comparison of first task completed without rework needed.
	2. Identified Defects	The amount of punch list items to be corrected in a project area.
	3. Cost of Rework	The amount of $ spent, additionally to the initial budget, for a specific activity within a project (increase cost in %).
	4. Test Conformance Rate	Index, which represents the accuracy in achieving the desired quality on the first attempt.
4. Time Management	1. Scheduled Performance Index (SPI)	Earned value vs planned value.
	2. Number of Critical Path Delays	Number of critical tasks which will have an impact on the final project delivery date.
	3. Plan Compliance Tasks	Number of accomplished tasks in a given period which can estimate the expected completion rate for further weeks.
	4. Response time to RFI	Average time to reply to RFI from project designers.
5. Safety	1. Total Recordable Incident Rate (TRIR)	Standard Safety Metric to track the number of injuries or recordables per 200k hours benchmark.
	2. Injury Frequency Rate (IFR)	Track of severe incidents which stop the work and project.
	3. Near Miss Rate	Indicator of how safe works are being performed on site and the likely hood of a potential safety incident occurring.
	4. Safety Audit Completion Rate	% of safety audits completed, including housekeeping, PPE utilization, safety barriers, adequate training, etc.
6. Contractor Performance	1. Completed Tasks on time	Measure of contractor reliability by activities completed on time.
	2. Contractor Quality Defect Rate	Non-conformities found in subcontracted tasks.
	3. Contractor Safety Compliance	Measurement of deviations of subcontractors when it comes to having all permits, RAMS, PPE and performing activities safely.
	4. Chage Order Requests	Amount of request for change orders for project req changes.
7. Human Resources Metrics	1. Labor Turnover Rate	Number of employees renounce or leave the company.
	2. Number of Employee Sick leaves	Warning indicator of fatigue which can impact manpower.
	3. Training Hours per Week/Employee	Target to maintain employees trained and certified.
	4. Engagement Culture Score	Indicator of employee alignment to company and safety culture.
8. Environmental	1. Construction Waste Deviation	Comparison of waste recycled against all produced waste.
	2. CO2 Emissions Rate	Carbon footprint emissions per construction planned.
	3. Water Consumption per m2	The amount of water required for construction works per m2.
	4. Environmental Incidents	Spill, breach or incidents which can trigger a fine or a permit issue
9. Legal & Compliance	1. Regulatory Pass Inspections Rate	Local authorities' inspections rate compliance approval.
	2. Non-Compliant Activities	The amount of work stopped due to missing documentation or missing to address the current norms or regulations.
	3. Contract Claims	Number of complaints due to commercial conflict which require a change management order.
	4. Legal/Claim Costs (%)	Company legal cost to defend against claims (%).

These selected Key Performance Indicator main categories have been chosen to address and align with a set of different goals, to mitigate the considered risks and contribute to the successful completion of the second project phase, the construction phase.

The first group of KPIs selected, the productivity group, aims to maximize the work output per employee and individual per hour while also aiming to minimize the idle times in which people remain in standby which are not productive hours. The second category and set of selected KPIs belong to the group of finance and budgeting. During the construction phase of the project this is also considered to be one of the most important KPI categories to keep track of to stick to the initially planned budget and cost of the project and deviate as least as possible. It is known that during construction phases, there are unexpected costs due to modifications and this set of key performance indicators aims to flag early in case of any project costs increases, so a decision can be made on time. For the third selected category of KPI is the quality aspect of the project. One important principle to deliver a project effectively and done time is to deliver the right work first time according to the design specifications, and this set of key performance indicators aim to achieve that in line with the specs.

Another important set of metrics which are selected as the fourth category is time management. Time management KPIs aim to ensure that the project milestones are achieved within the expected time windows, avoiding any project delays and extra costs due to delivering the project on a later date as the agreed one. The fifth goal to be addressed with another set of KPIs is safety. It is essential that a project is not only delivered on time, but also safely, and with zero accidents. As the sixth set of KPIs has been targeted to measure the subcontractor performance. During the construction phase of the project a large number of subcontractors and companies will be participating in different areas of construction and an efficient strategy for managing all these different companies is a must to ensure the successful completion of the project on time. These set of KPIs ensure all subcontractors meet the right levels of commitment with schedule, quality and safety. The next category of KPI selected is to monitor the human resources of the project. One key element of the health of the project is the people working on it, these KPIs measure the training of all the different employees, their satisfaction and motivation, to avoid productivity decrease. Lastly, one of the most important categories is also the legal and compliance section. This set of key performance indicators ensures that the project adherence to the laws and regulations to avoid any disputes or permitting issues with the project which could impact its successful completion.

4.2.4 Phase 3: Commissioning Phase KPI Selection. The Performance Prism Method

For phase three, the commissioning and handover phase, the evaluation of the set of Key Performance Indicator categories is selected using the performance prism method. This method is described0 in section 3.2.2. of this thesis work, and this method aims to have a more comprehensive view of the different stakeholders than other studied frameworks. According to (A. D. Neely et al., 2002), it argues that a purely company decided strategy is not entirely correct, since the input and feedback from all different external partners, customers and stakeholders it is necessary to correctly address the performance indicator to define the company objective. This is the reason why this method is selected for the third phase of this project, which involves a more proactive approach to the customer's need for the final handover project phase. This method does not only consider the existing company strategy but has the advantage of having the necessary flexibility to also accommodate and incorporate the new stakeholder requirements and needs (Digalwar & Sangwan, 2011).

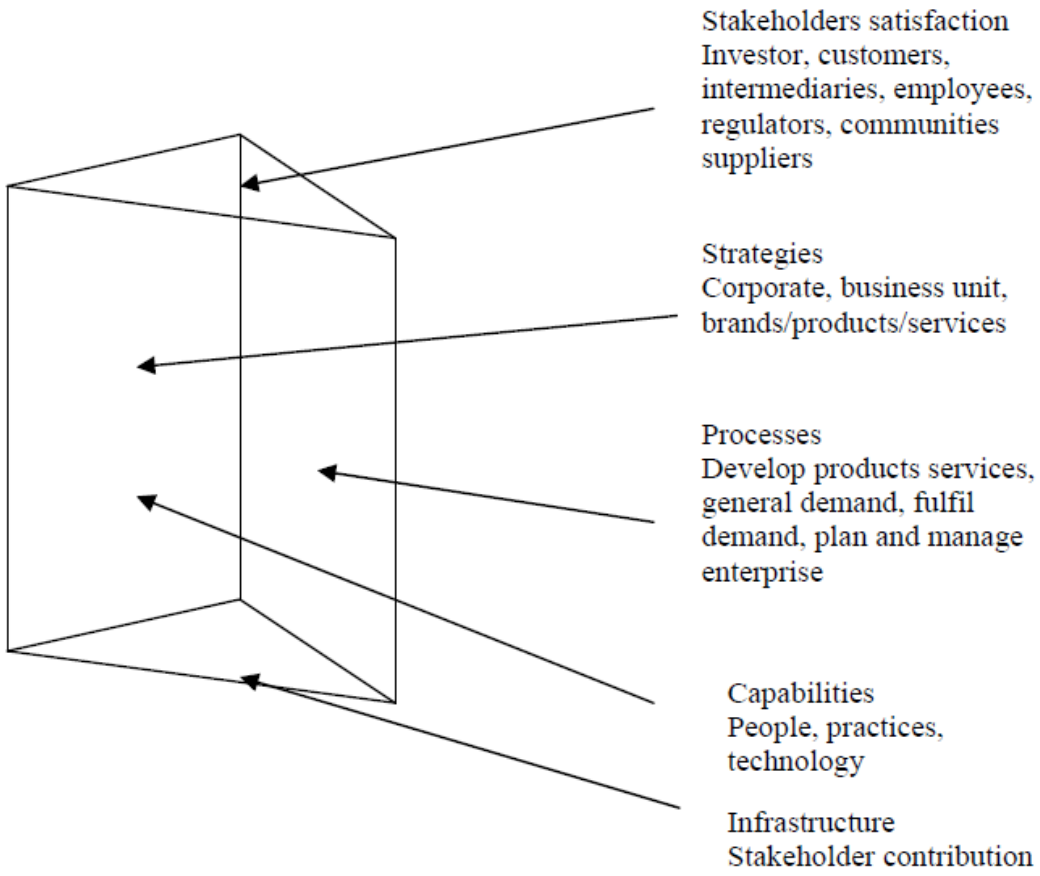


Figure 11: The Performance Prism Aspects Overview (Digalwar & Sangwan, 2011)

For our master thesis case study, and the final selection of the right categories of Key Performance Indicators for the commissioning and handover phase of this project, the following set of categories have been selected to align with the five aspects of the performance prism method:

1. Stakeholder Satisfaction.
2. Quality.
3. Finance/Budget.
4. Time Management.
5. Resource Utilization & Efficiency.
6. Communication.
7. Environmental.
8. Legal and Compliance.
9. Scope and Change Management.
10. Safety.

The Performance Prism method focuses on the classification of the category aspects into five different groups, these groups are: the stakeholder satisfaction, the strategies group, the processes group, the capabilities group and the stakeholder contribution aspect. For the case of this study therefore, these categories of KPIs have been distributed to address all the five groups as:

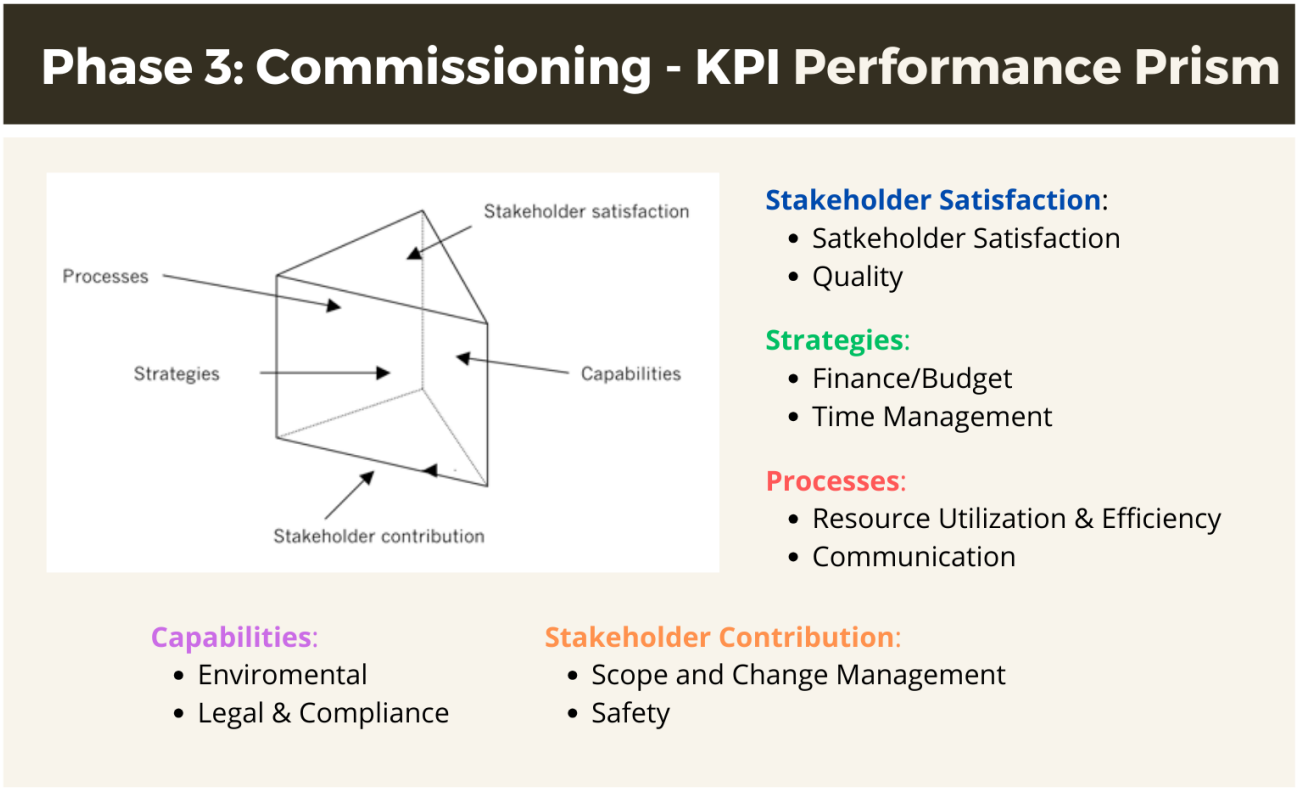


Figure 12: Phase 3: Commissioning. KPI Selection using the Performance Prism Method

All the KPI main categories would have a set of defined KPI for each category such as:

Table 5: Phase 3: Commissioning. KPI definition and selection table. Performance Prism

Category Group	Key Performance Indicator	Definition and Selection Rationale
1. Stakeholder Satisfaction	1. Satisfaction Index	Average of the scoring grade of different post-handover surveys.
	2. First Pass System Acceptance (%)	Systems acceptance rate without customer complaints.
	3. Customer Trainings	Knowledge check (grade) on effectiveness of customer trainings.
	4. Post-Handover Defect Rate	Defects identified withing first 60 days of post site delivery.
2. Quality	1. Integrated System Testing Rate	Final IST test completed successfully on the first run.
	2. Punch List Items	The number of raised reworks required after handover.
	3. Mean Time Between Failures	Hours in between critical site alarms.
	4. Commissioning Discrepancy Ratio	Identified items in commissioning/total commission script items.
3. Finance & Budget	1. Commissioning Cost Variance	Total Commissioning Cost / Forecasted Cost (%)
	2. Usage of Contingency Hours	Number of hours from buffer consumed / Total forecasted hours.
	3. Warranty Exposure	Number of unresolved defects covered by warranty.
	4. Energy Efficiency (PUE)	Amount of energy used for IT equipment vs Waste Energy.
4. Time Management	1. Commissioning Schedule Performance (SPI) Index	Number of days needed to commission all different systems vs the expected total days forecasted for commissioning activities.
	2. Ready for Service Date Variance	Real Building Ready Date – Date Expected by Contract.
	3. Punch List Lead Time for Closure	Average amount of days to close per issue identified. (Total days of punch list repairs / Number of punch list items).
	4. RFI questions return time	Number of hours for RFI responses during commissioning.
5. Resource Utilization & Efficiency	1. Commissioning Engineer Hours	Cost of Cx Eng hours / Forecasted Cx Eng hours.
	2. Equipment Tester Usage	Hours of equipment used vs all available equipment hours.
	3. Re-Testing Hours	Amount of hours of Cx Eng for repeating commissioning tests.
	4. Acceptance of Deliverables on time	Customer acceptance of documentation provided according to the agreed timelines. (Items on time / Items overdue)
6. Communication	1. Stakeholder Meeting Adherence	Number of stakeholders attended vs forecasted to attend.
	2. Average time for log issue resolve	Average of days on which a logged issue takes to be resolved.
	3. Cx Documentation Handover	Commissioning documentation Handover total accomplished (%)
	4. Score on Package delivery	Customer acceptance of Packages according to project schedule.
7. Environmental	1. Data Center PUE meassurement	Power Usage Effectiveness to be in accordance with regulation.
	2. Water Usage for Cooling	Data Center Water Requirement (m3 per MW IT load) to be in accordance with the local regulation.
	3. Waste Segregation Target	Amount of recycled and segregated trash vs total trash (%)
	4. Refrigerant Leaks Incident	Amount of refrigerant leaks during cooling cycle tests.
8. Legal & Compliance	1. Regulatory Inspections Pass Rate	% of accomplishments of passed inspections (fire, building, etc.).
	2. Permit Acomplished (%)	Amount of building permits achieved vs total number of permits.
	3. Compliance Violations Recorded	Number of work-stop due to project requirement violation.
	4. Data Center ISO/Tier Certification	Achieved items in ISO/TIER Data Center Certification. (%)
9. Scope & Change Management	1. Cx activities Change Order Cost	Amount of additional Change Order Request accepted.
	2. Late Customer Scope Chagne	Number of scope requests accepted after IST tests.
	3. Non-compliant to design items	Number of design or specification deviations items.
	4. Commissioning Scripts Changed	Number of commissioning scripts changed vs total number of scripts.
10. Safety	1. Injuries during Commissioning	Amount of recorded injuries during all commissioning activities per 100000 hours.
	2. Permit to Work (PTW) compliance	Audits performed on site and identification of number of permits not in accordance with the safety guidelines (%).
	3. Electrical Indicents	Number of electrical incidents (arc flash, electrical shocks) during commissioning activities.
	4. Emergency Response Drill Tests	Average response time for all employees to meet in the established assembly points vs the targeted expected time.

For this final section of the KPI selection process, the following categories have been selected to be able to track and align the following goals for each category. The first category of KPI group selected is the Stakeholder Satisfaction. In this last section of the project, it is very important to take into consideration the customer aspect, input and satisfaction when it comes to commissioning and handover, this is also why the performance prism method has been selected for this case. This first category ensures that the final building meets all the customer expectations, ensuring high satisfaction rates and a smooth handover. For the second category, the quality category, those set of key performance indicators ensure that all the commissioning tests leave a building to the end customer with no defects and with minimum rework required, to avoid extra costs or impact on our customer activities. As one aspect which repeats almost in all sections of the project is the finance and budget aspect, as third category, these key performance indicators ensure that all activities are performed in accordance with the forecasted budget with as minimum modification costs as possible.

The goal of the fourth selected category, the time management, is to keep a strict control of the timings of different activities to avoid schedule over runs and to ensure that all equipment are commissioned on time to also respect our customer SLA times. Which also aligns with the fifth next category which is resource utilization. This category also aims to combine the finance aspect with the time management, to ensure all of our resources are being correctly utilized and not wasted. The communication set of KPIs ensures that the project information is correctly traceable, on time, and the documentation is according to expectations and reaches all different stakeholders. As another important aspect of this project is the environmental and legal aspect, these two categories aim to achieve all regulatory sign offs and to ensure that the designed data center building is in accordance to all the local and country regulations and ready for operations. The scope and change management category of KPIs has the purpose to control how the project activities can change within the approved methods but without impacting the scope, budget, schedule or design intent. Finally, one of the most important tenets is the safety category. All activities on site must be carried out to ensure the highest standards of safety, with zero incidents and zero lost time due to incidents. The final goal is not only to deliver a fully functional building but also to do it safely. To wrap up, as has been applied in this section of the thesis work, the performance prism method aims to take more into consideration the different stakeholders and end customer aspects into the creation of the project goals and key performance indicator selection.

4.2.5 KPI Portfolio Overview

During this thesis work, a literally review has been carried out to understand all the different aspects of key performance indicators, including their main characteristics, classifications, measurability, relevance, selection methods and how these align with the overall project goals. It could then be described that a solid key performance indicators portfolio is a KPI portfolio which during the selection process has been considered its direct alignment with the overall company strategy, its measurability, controllability and comparability (Villazón et al., 2020). In order to provide an applicable example of the different KPI selection methodologies, a project has been selected which had different phases. This has also been selected for the purpose of proving the different methodologies advantages and disadvantages for different selection criteria. As a final combined outcome of these selection methods, here in figure 13, we can observe the final KPI portfolio selected for all the different phases throughout the project, using the key performance indicator selections method discussed in section 3 of this thesis work.

Design	
Phase 1	
1. Design Scope & Change Management	1. Design Change Frequency
	2. Average Design Change Turn Around
	3. Early Phase Scope Stability Index
	4. Cost Impact on Design Changes
2. Resource Utilization & Efficiency	1. Planned vs Actual Design Hours
	2. BIM Utilization Rate
	3. Senior Designer Allocation
	4. Ratio of Rework Hours
3. Legal & Compliance	1. Regulatory Pass Rate
	2. Permitting Pass Rate
	3. Design Violation Count
	4. Change Orders due to Compliance Deviations.
4. Investigation & Development	1. Innovation Proposal Ratio
	2. Lifecycle Cost Reduction from Innovations
	3. Knowledge Lessons Learned Index
	4. Digital Prototype Validations
5. Communication	1. Communication Hours
	2. Average RFI Response during Design Phase
	3. Stakeholder Review and Participation
	4. Collaboration Platform Adoption

Construction	
Phase 2	
1. Productivity	1. Percent Planned Complete (PPC) (%)
	2. Productivity Index (earned hours / actual hours)
	3. Equipment Utilization Rate
	4. Rework hours.
2. Finance & Budget	1. Cost Performance Index (CPI)
	2. Variance Cost
	3. Approved Change Order Cost (%)
	4. Cash Flow Accuracy (CFA)
3. Quality	1. First Pass Inspection Acceptance
	2. Identified Defects
	3. Cost of Rework
	4. Test Conformance Rate
4. Time Management	1. Scheduled Performance Index (SPI)
	2. Number of Critical Path Delays
	3. Plan Compliance Tasks
	4. Response time to RFI
5. Safety	1. Total Recordable Incident Rate (TRIR)
	2. Injury Frequency Rate (IFR)
	3. Near Miss Rate
	4. Safety Audit Completion Rate
6. Contractor Performance	1. Completed Tasks on time
	2. Contractor Quality Defect Rate
	3. Contractor Safety Compliance
	4. Chage Order Requests
7. Human Resources Metrics	1. Labor Turnover Rate
	2. Number of Employee Sick leaves
	3. Training Hours per Week/Employee
	4. Engagement Culture Score
8. Environmental	1. Construction Waste Deviation
	2. CO2 Emissions Rate
	3. Water Consumption per m2
	4. Environmental Incidents
9. Legal & Compliance	1. Regulatory Pass Inspections Rate
	2. Non-Compliant Activities
	3. Contract Claims
	4. Legal/Claim Costs (%)

Commissioning and Handover	
Phase 3	
1. Stakeholder Satisfaction	1. Satisfaction Index
	2. First Pass System Acceptance (%)
	3. Customer Trainings
	4. Post-Handover Defect Rate
2. Quality	1. Integrated System Testing Rate
	2. Punch List Items
	3. Mean Time Between Failures
	4. Commissioning Discrepancy Ratio
3. Finance & Budget	1. Commissioning Cost Variance
	2. Usage of Contingency Hours
	3. Warranty Exposure
	4. Energy Efficiency (PUE)
4. Time Management	1. Commissioning Schedule Performance (SPI) Index
	2. Ready for Service Date Variance
	3. Punch List Lead Time for Closure
	4. RFI questions return time
5. Resource Utilization & Efficiency	1. Commissioning Engineer Hours
	2. Equipment Tester Usage
	3. Re-Testing Hours
	4. Acceptance of Deliverables on time
6. Communication	1. Stakeholder Meeting Adherence
	2. Average time for log issue resolve
	3. Cx Documentation Handover
	4. Score on Package delivery
7. Enviromental	1. Data Center PUE meassurement
	2. Water Usage for Cooling
	3. Waste Segregation Target
	4. Refrigerant Leaks Incident
8. Legal & Compliance	1. Regulatory Inspections Pass Rate
	2. Permit Acomplished (%)
	3. Compliance Violations Recorded
	4. Data Center ISO/Tier Certification
9. Scope & Change Management	1. Cx activities Change Order Cost
	2. Late Customer Scope Chagne
	3. Non-compliant to design items
	4. Commissioning Scripts Changed
10. Safety	1. Injuries during Commissioning
	2. Permit to Work (PTW) compliance
	3. Electrical Indicents
	4. Emergency Response Drill Tests

Figure 13: Final KPI Selected Overview Portfolio

In general, a robust and solid portfolio aims to always align with the company strategy and the important aspects for the relevant stakeholders. These measuring factors need to be aligned with the critical success parameters defined for each specific company or project, which then need to drive all day-to-day decision based on this global company directrices (Kaplan & Norton, 1992). Then each of these key performance indicators need to be assigned to a specific team which they will be in charge of the monitoring and evaluating of its performance to be able to take the necessary decision on time (Villazón et al., 2020).

Secondly, a good, selected portfolio of key performance indicators needs to be balanced between all different important aspects and also needs to be multidimensional. A suitable approach needs to be found between the use of lagging or leading indicators to also seek detailed information on the current status of the company/project, but also to aim to provide the parameters for predictability of who the health status of the project is going (Neely et al., 1997). A mature KPI portfolio also addresses multi departmental and cross-functional teams to highlight the common objectives between departments and which aim to ultimately benefit the entire company, rather than independent teams working in silos.

Additionally, a professional KPI portfolio has to comprehend the company data integrity, tracking and comparability throughout time. For this reason, it is not only important that a team defines the company strategy and objectives, as well as the Key performance Indicator portfolio to be used, but also very importantly the definition of the benchmarks and baselines for these indicators to be able to be compared against a desired outcome.

This process tends to be tedious and usually adds an extra workload to all different teams in a company, in addition to the high workload that these teams usually have with their day-to-day activities. Nowadays, the tendency is to automate as much as possible the data collection and reportability of the information to the different teams, removing as far as possible all the work and burden of manual data collection. Therefore, once our main KPI portfolio has been selected, the next action for the project is to define the suitable methodologies and dashboards on which these Key Performance Indicators will be displayed, as well as the optimal periodicity for data collection and reporting.

4.2.6 Tracking Mechanisms, Periodicity and Dashboards

An important aspect to mention in regards of key performance indicators is how effectively track the evolution of these parameters, define how and when these parameters need to be measured. Equally important is to effectively represent these KPIs in the most visual way to streamline this important information into the different departments within the company. Missing to properly report a KPI on time or inconsistently or without enough context would jeopardize the ability of these key performance indicators to serve its purpose (Kerzner, 2011). Nowadays these tracking mechanisms continue to improve on a daily basis providing project managers with the necessary online and automatically captured tools to improve and enhance these tracking mechanisms for a more thorough analysis at the right times.

The periodicity on when these key performance indicators need to be captured, tracked, reviewed and evaluated might vary from project to project, depending on the timelines, priorities and overall business goals. There are, however, a set of standardized or required timing for each layer of key performance indicators which it is analyzed in this section of the thesis. The most optimal way in which key performance intervals are supposed to be analyzed would depend on the layer of importance for each set of KPIs (Li et al., 2023). Key performance indicators which are located on the overall company strategic level are normally intended to be evaluated on a quarterly basis. These are the KPIs which provide the insights on how the overall direction of the company aligns with the yearly or quarterly goals, these are reviewed during executive meetings. On a lower level of KPI review, there is the layer of organizational success, which is intended to be tracked in monthly steering meetings with the leadership of each of the independent company departments (operations, finance, safety, design, commissioning, construction, etc.). These inter-departmental performance indicators tracked on a monthly basis also need to align on a quarterly basis with the overall company strategy. And lastly on the lowest level or highest frequency tracking intervals, there are the daily operational tasks which are most effectively when tracked on a weekly basis project stand meetings (Villazón et al., 2020). A necessary characteristic of a successful tracking mechanisms, often forgotten, is accountability. Each set of key performance indicators should have a data owner, a reporting owner and a responsible accountable person. When these responsibilities are not clearly defined, it is vague and often leads to a failure on the purpose of the KPI, since the quality of the information is not fully up to date in the different dashboards, which leads to a miss on important trends and information being lost (Kerzner, 2011).

Once the previous section has been addressed and each set of key performance indicators have clearly established who are the necessary owners and accountable people, as well as the periodicity of recording these metrics, the next vital aspect of a successful tracking strategy is to have a solid and useful way to present the information. It would be of little use to have very meaningful sets of recorded information, without the correct ability to show this data. The most compelling way to showcase this set of information is through visually self-explanatory dashboards (Few, 2012).

A well designed and presented dashboard combines all the most relevant key performance indicators and information to show in an intuitive visual narrative. The main intention of a well design dashboard is to provide the information in a visual snapshot where early warnings can be observed, to be able to identify certain trends before they become real problems. Some of the main important characteristics that a dashboard would provide is not only the fact that graphs and trends can be easily visualized, but also, they provide the ability to showcase data using different colors, graphs, and other effects which enhance a better comparative analysis. These tools help project managers and company leaders to identify early trends and move from a passive report check to an active decision making strategy to be able to steer the direction of certain trends or metrics.

In order to illustrate how a practical approach of the creation of a dashboard for one of the specific phases of our project would look like, it as been applied to the construction phase (phase 2). The intention is the practical application of the learned and reviewed literature to a practical case for our project. In the following page we can observe in table 6 and figure 14 the Key Performance Indicator sheet for teams to fill up on a weekly basis for reporting the evolution of the metrics on the ground. As an example, it has been created to track eight calendar weeks, which is the equivalent of two months of the metrics to evaluate the progress of all the different key performance indicators selected for each one of the categories. Additionally, as discussed in this section, it has also been created a project dashboard tracker for a project manager executive report, in figure 15 and 16, which shows the project also for the construction phase 2, the tentative calendar, capturing all the different tasks, progress and expected completion times. These two tools combined have the intention to provide the project owners with the complete holistic overview in terms of all the different aspects how the project is going and to have the ability to evaluate if the quality, budget, safety, productivity, schedule and other targets are in line with the expectations, or actions are required.

Table 6: Construction Phase – Key Performance Metrics Sheet

Construction		January				February			
Phase 2		CW01	CW02	CW03	CW04	CW05	CW06	CW07	CW08
1	**Productivity**	**Productivity**							
1.1	Percent Planned Complete (PPC) (%)	0%	1%	4%	6%	9%	10%	12%	15%
1.2	Productivity Index (earned hours / actual hours)	1	0.92	0.95	0.89	0.83	0.9	0.92	0.96
1.3	Equipment Utilization Rate	60%	70%	75%	82%	88%	84%	76%	90%
1.4	Rework hours	0	0	0	0	4	10	20	30
2	**Finance/Budget**	**Finance/Budget**							
2.1	Cost Performance Index (CPI)	1	1.1	1.12	1	1.1	1.3	1.4	1.3
2.2	Variance Cost	-1000	-800	-500	0	500	1200	1500	1400
2.3	Approved Change Order Cost (%)	0	0.5	0.8	1	1.3	1.5	2	2.2
2.4	Cash Flow Accuracy (CFA)	90	92	93	88	95	97	94	96
3	**Quality**	**Quality**							
3.1	First Pass Inspection Acceptance	85	87	90	88	92	93	95	96
3.2	Identified Defects	10	12	9	8	6	5	4	3
3.3	Cost of Rework	0	0	0	0	2000	5000	8000	12000
3.4	Test Conformance Rate	98	97	97	96	95	96	97	98
4	**Time Management**	**Time Management**							
4.1	Scheduled Performance Index (SPI)	1.02	0.98	0.95	0.97	0.96	1.01	1.03	1.05
4.2	Number of Critical Path Delays	0	0	0	0	1	0	2	0
4.3	Plan Compliance Tasks (%)	0%	0%	1%	2%	4%	4%	6%	8%
4.4	Response time to RFI (h)	5	4.8	4.5	4.2	4	3.8	3.5	3.2
5	**Safety**	**Safety**							
5.1	Total Recordable Incident Rate (TRIR)	0	0	0	0	1.5	2	1.8	1.2
5.2	Injury Frequency Rate (IFR)	0	0	0	0	3	4	3	2
5.3	Near Miss Rate	5	6	4	4	3	3	2	2
5.4	Safety Audit Completion Rate	90%	92%	93%	95%	96%	97%	98%	99%
6	**Subcontractor Performance**	**Subcontractor Performance**							
6.1	Completed Tasks on time	75%	78%	80%	82%	85%	87%	88%	90%
6.2	Contractor Quality Defect Rate	6	5	4	4	3	3	2	2
6.3	Contractor Safety Compliance	88%	90%	91%	92%	94%	95%	96%	97%
6.4	Chage Order Requests	0	0	1	1	2	2	1	1
7	**Human Resources Metrics**	**Human Resources Metrics**							
7.1	Labor Turnover Rate	0	0.5	1	1.2	1.2	1	0.8	0.7
7.2	Number of Employee Sick leaves	2	3	4	3	4	5	3	2
7.3	Training Hours per Week/Em-ployee	1	1	1.2	1.5	1.5	1.8	2	2
7.4	Engagement Culture Score	70	72	73	74	75	76	78	80
8	**Environmental**	**Environmental**							
8.1	Construction Waste Deviation	5	4	3	4	3	2	2	1
8.2	CO2 Emissions Rate	50	52	55	60	58	56	54	52
8.3	Water Consumption per m2	4	4.2	4.1	4	3.9	3.8	3.7	3.6

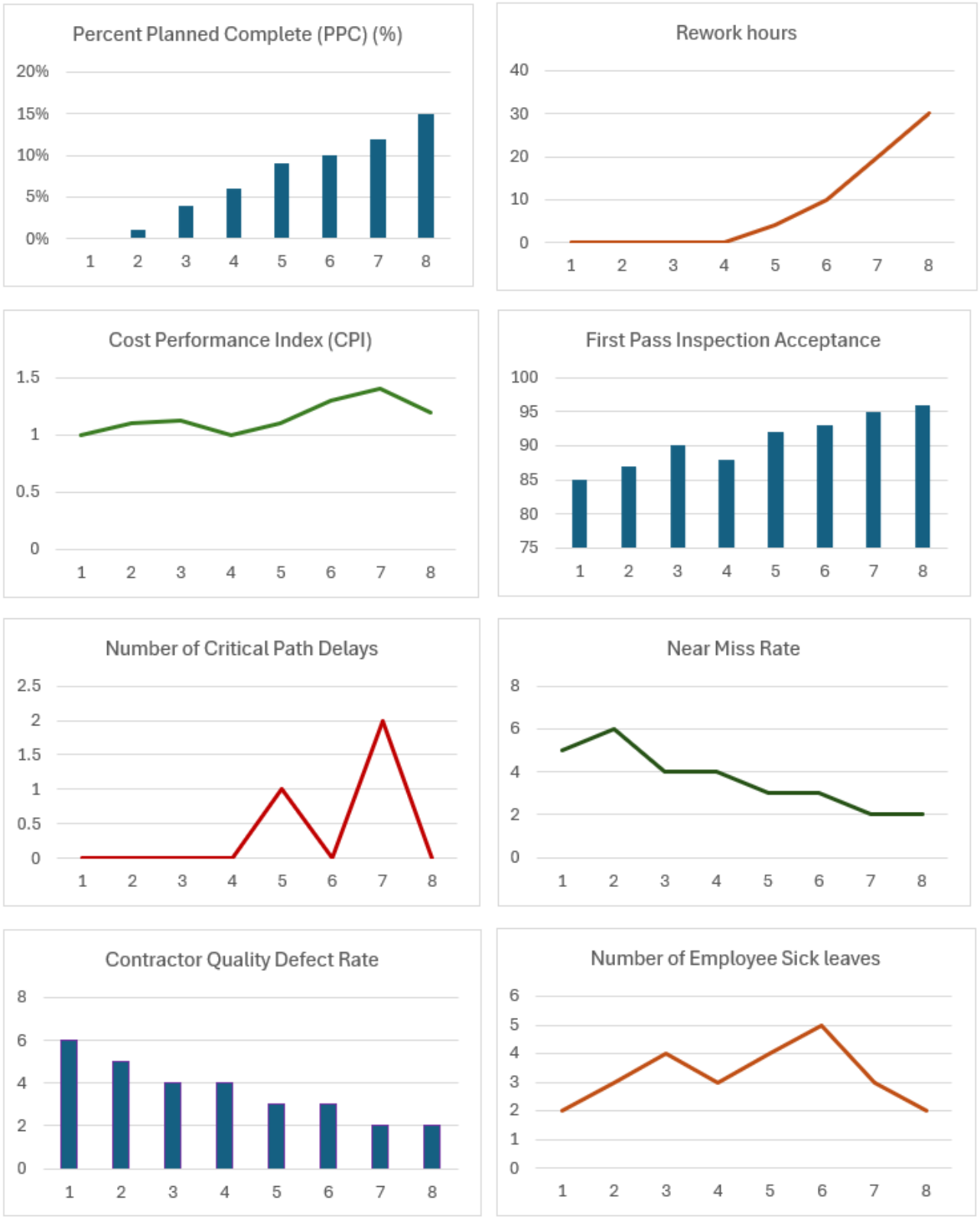
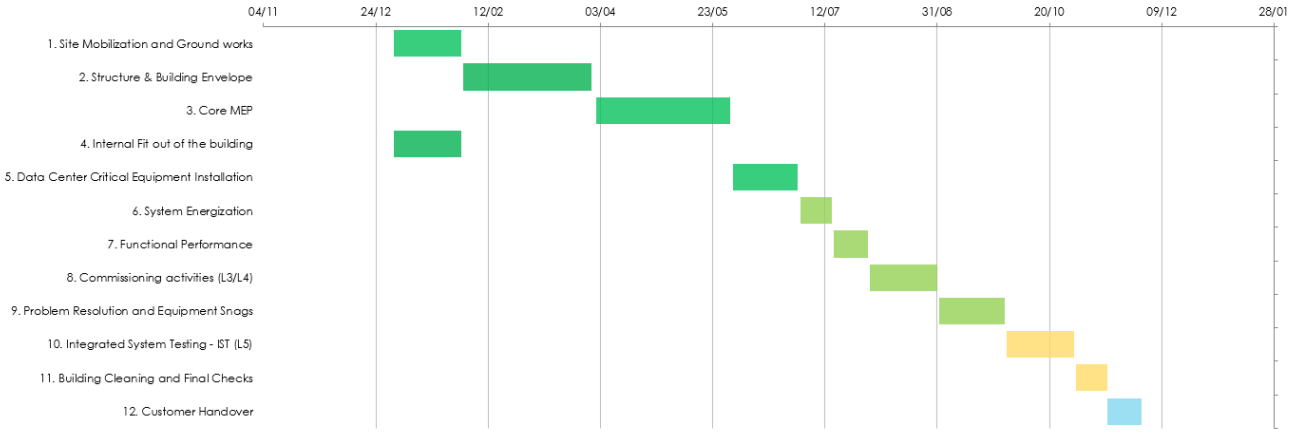


Figure 14: Representation of several Phase 2 Construction Key Performance Indicators with Data from Table 6

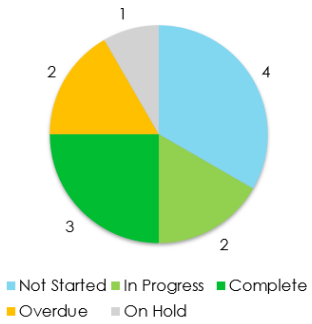
KPI Dashboard for Project Manager

Data Center Development Project for Cloud-X Company in Frankfurt am Main, Germany.	DATE	PROJECT STATUS	% COMPLETE
PROJECT - Phase 2 - Construction Phase KPI Dashboard	20/04/25	ON TRACK	72%

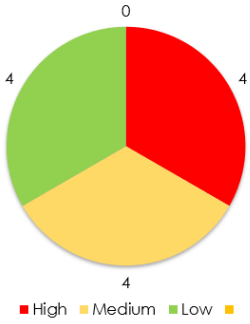
TASK TIMELINE



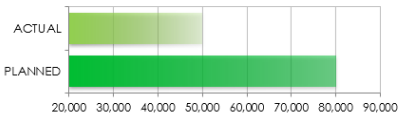
TASK STATUS %



TASK PRIORITY %



BUDGET



PENDING ITEMS

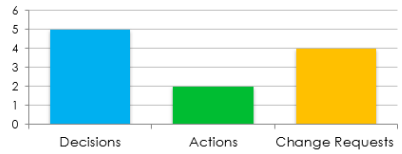


Figure 15: Dashboard for Phase 2 Project Management (1)

Phase 2 - Construction - Activities

TASK TABLE

TASK NAME	ASSIGNED TO	START DATE	END DATE	DURATION in days	STATUS	RISK	PRIORITY
1. Site Mobilization and Ground works	Construction Team	01/01	31/01	30	Complete	Low	Medium
2. Structure & Building Envelope	Construction Team	01/02	30/03	57	Complete	Medium	Low
3. Core MEP	Commissioning Team	01/04	31/05	60	Complete	High	High
4. Internal Fit out of the building	Construction Team	01/01	31/01	30	Overdue	Low	Medium
5. Data Center Critical Equipment Installation	Construction Team	01/06	30/06	29	In Progress	Medium	Medium
6. System Energization	Commissioning Team	01/07	15/07	14	In Progress	Low	Medium
7. Functional Performance	Commissioning Team	16/07	31/07	15	Not Started	Low	Low
8. Commissioning activities (L3/L4)	Commissioning Team	01/08	31/08	30	On Hold	Medium	High
9. Problem Resolution and Equipment Snags	Commissioning Team	01/09	30/09	29	Overdue	Medium	Low
10. Integrated System Testing - IST (L5)	Commissioning Team	01/10	31/10	30	Not Started	High	High
11. Building Cleaning and Final Checks	Construction Team	01/11	15/11	14	Not Started	High	High
12. Customer Handover	Project Manager	15/11	30/11	15	Not Started	High	High
Phase 2 - Construction	-	Total days		353			

TASK STATUS %

STATUS	COUNT	%
Not Started	4	33%
In Progress	2	17%
Complete	3	25%
Overdue	2	17%

TASK PRIORITY %

PRIORITY	COUNT	%
High	4	33%
Medium	4	33%
Low	4	33%

Figure 16: Dashboard for Phase 2 Project Management (2)

4.3 Other Factors to Consider for Successful Tracking

In the previous sections of this thesis work, a study analysis has been carried out regarding all the different aspects, types and characteristics of key performance indicators. The review focused on the characteristics and selection process to adequate a specific set of key performance indicators to meet project, stakeholders, departments and company needs. Still, the knowledge, use and adoption of key performance indicators goes beyond the previously analyzed sections. As an example, a company might have the most sophisticated tracking and reporting systems but still fail to adhere to their priorities or to effectively utilize this valuable provided information. This section of the thesis aims to dissect a topic which is often non discussed, and it is regarding all the other additional aspects which a company needs to embrace as culture or mentality to allow these tools to develop all their potential (Chaminda & Jayasinghe, 2021).

An additional aspect in which the paradigm of KPI implementation needs to be studied and discussed is thought to be the company adoption culture. The approach in which a company develops a complex KPI tracking system and dumps it into the employees has more of a negative impact rather than the expected one. The most suitable approach for a company to adopt a useful tracking methodology is by shaping the company culture to align with the overall strategic goals. This is also a broad aspect and rather subjective, but still, vital for the successful implementation of these methodologies described above. In order to dive deep into some of these constituting factors, in this section present some of the important considered ones which need to be transmitted from the higher layers of company leadership downwards to each individual. These are the most considered factors which influence the successful KPI adoption:

The first aspect to mention is the Company Strategic alignment and strong communication. Key performance indicators need to be adopted by all the different layers of an organization, and these need to equally align to the overall company strategic factors (Kaplan & Norton, 1992). When these concepts have a clearly explained and communicated logical connection on how they contribute towards the overall goals, they are much more likely to be correctly used and adopted by all employees. On the other hand, when these metrics are misunderstood on which are their strategy, this leads to confusion and misuse.

The second important aspect to mention in regards of a successful KPI adoption is the employee motivation. Despite this sounding like an obvious topic, this is often missed by different organizations. These metrics are in their majority reported and interpretated by the base employees in each company and department. If these individuals are empowered, highly motivated and aligned with the company values, they can utilize this data to take the right decision on the day to day activities. On the contrary, they will understand this extra task as burden which does not add any value to them and subsequently would be disregarded, harming the overall company objectives.

Third, a vital aspect to take into consideration for a successful KPI strategy implementation, which is the resource allocation. A company which has taken the proactive decision of implementing such complex methodologies for control and steering towards the company goals needs to equally invest in the correct resource allocation for this effort. A common mistake that companies make is to implement these strategies but the extra generated workload to allocate into the same amount of existing employees, which generates frustration, and the opposite intended effect. Equally important, as mentioned in the previous section, the selection of key performance indicators needs to be carefully selected together with the correct set of clear and accountable owners for each KPI. If key performance indicators have a clear and defined owner, with the necessary accountability and responsibilities it has a higher success adoption and usability rate. When this ownership rather loose usually appears problems with the tracking and reporting mechanisms due to a lack of accountability. So, in order to avoid this issue, project managers and company leadership need to select the correct accountable department responsible for each set of KPIs.

Lastly, as the last important factor to be analyzed and considered to have a great effect into key performance indicators adoption is the mentality of the company for empowering continuous improvement and innovation. After the implementation of a certain set of KPIs to a company strategy, there are different challenges and anomalies detected which were not identified during the design phase. At this point, the company mentality has to be the opposite from rigid. When these misalignments are encountered, a mature and successful organization would trust their hired employees to identify where the root causes of this analysis are and allow project managers to perform the correct adjustments on the go without having to fight with a tedious burden. A mature company which is able to also take into consideration these characteristics together with a solid KPI strategy implementation will have a substantial advantage and competitiveness in the market.

5 Results

In the process of this thesis work regarding the application of different key performance indicators framework case study to the company Ivan Gallego – Data Center Construction Solutions GmbH has been demonstrated the improvement and application of KPI selection process and project monitoring capabilities. Utilizing different key performance indicator selecting methodologies adjusted individually for each one of our three defined project phases. The balanced scorecard methodology has been used for the design phase, the performance pyramid has been used for the construction phase and the performance prism for the final commissioning phase. By using these three different methodologies for the different phases, the goal has been achieved of the application of a multidimensional view for project performance and KPI selection which aims to select a tailored selection of different indicators to address the specific requirements of each one of the phases.

During the first phase, the design phase, the balanced scorecard methodology has been utilized to provide a structured approach to prioritize which are the main categories of key performance indicators which are considered to provide more value to that specific project phase. It focuses on balancing the different processes, customer requirements, financial and organizational aspects. The selected groups of key performance indicators have the purpose of being able to define on an early stage of the project the different stakeholder design scope, the legal compliance of the project, and try to give early awareness of the different project risks or cost implication. The importance of the identification of these design risks early on is very important for the success of the project, since later these issues will have a greater cost impact.

During the construction phase of the project, the selection of the key performance indicators has been carried out utilizing the performance pyramid methodology, which emphasizes on the operational excellence and taking into consideration the company strategic objectives together with the construction execution on the ground. The group of key performance indicators selected for this phase aims to control the construction aspects, such as the subcontractor's performance, the safety aspects of the construction work, the budget variance metrics or the right indicators to allow the project manager to steer any operational adjustments and changes that might be required. Utilizing these defined key performance indicators, and the specific created dashboard for this phase, project managers have the ability to detect deviations of the current project plan and take the necessary corrective actions to minimize any potential impact to the project.

For the third a final phase, the commissioning phase, the performance prism methodology has been applied for the selection of the last set of key performance indicators. This methodology has been selected specifically for this last phase, since it has a more stakeholder centered approach which is a more adequate approach since the final phase aims to deliver the full commissioned building to a specific customer. The performance indicators group selected for this phase were focused on the correct commissioning of the building and engineering systems, ensuring the necessary satisfaction rates scores, the final correction of defect closures and the necessary final inspections and compliance aspects, such as legal and environmental. The correct monitoring and tracking of these aspects is key for ensuring a successful project completion and a smooth transition and handover to the final operation client. The advantage of utilizing the performance prism for this section of the project is that it provides a holistic overview which does not only take into consideration the internal company objectives but also the external customer requirements and needs.

Across all the three analyzed project phases, there is a common important point which has been discussed and analyzed, which is the strategic implementation of all necessary tracking mechanisms and KPI dashboards, to enhance the correct visibility and usability of the gathered KPI data. The intention of the integration of these monitoring systems is to provide the project manager with the correct set of tools to collect data in real time and be able to take the necessary decision at all times. These tracking methodologies which use a mix of leading and lagging indicators allow project managers to adapt to potential risks and opportunities, rather than just having to wait to issues to occur to correct them.

In summary, the obtained results after the application of a comprehensive set of key performance indicator methodology for selection is fundamental to have a well structured measurement system to achieve the desired project success. The main objectives of the methodologies used is to ultimately meet the company strategic objectives and project requirements, utilizing the assigned budget in the agreed timelines. The selection of the specific indicators for all different phases of the project ensures an improved efficiency, quality, stakeholder satisfaction and financial control. These outcome results from this analysis justify the importance of the correct selection and application of the right key performance indicators are indispensable tools for efficient project management in complex projects, especially for examples like the presented one in this case study for the construction of a data center.

6 Conclusions and Discussion

For the purpose of the study of this thesis work, a literature review and a further practical application has been applied to demonstrate the essential role of key performance indicators (KPI) framework for the enhancement of project management effectiveness applied to construction projects. Through a first theoretical analysis of the KPI selection techniques, followed but the application of a case study of fictional data center construction company, this thesis confirmed the importance of the correct selection, implementation and monitoring strategies for KPI, and how these contribute to a successful project achievement to meet all necessary customer needs and organizational excellence.

From this study there are different conclusions that can be obtained. Firstly, the discussed approach for key performance indicators selection using different framework for different project phases is a universal model which can be applied in different scenarios for different companies depending on their objectives and needs. Each one of the utilized methods: the balanced scorecard, the performance pyramid and the performance prism, offer different advantages for different project dimensions. This study offers some insights and knowledge on how to apply these techniques for project managers to ensure their KPI meet the defined project needs.

Secondly, as an important part of this study, it is highlighted that the selected key performance indicators need to align strategically with the organization objectives, as well as the project goals. In the case that the correct indicators are not selected or not in alignment with the project goals, these can mislead the decision making process, bad use of resources and a final failure of the project. A correct strategy for Key Performance Indicators selection will ensure the correct tracking of the main project pillars, ensuring the correct quality, budget to stay within control, stick to the designed project timelines, safety compliance and customer satisfaction, which are key important for the project success and company continuity.

Thirdly, as an often forgotten aspect of projects, this thesis work has also described and highlighted the importance of the correct data monitoring, tracking and its correct visualization tools (such as dashboards and digital tools) to ensure the correct tracking and success of the project. Nowadays, there are plenty of digital IT tools which enhance the correct KPI tracking, allowing project managers

to take better data driven decisions on shorter timeframes. This is a key aspect and characteristic, especially in today's construction projects, where time and speed matters.

Additionally, this thesis work also discusses other important cultural aspects of the KPI implementation. The general success of these methodologies and tracking mechanisms depends on the company leadership adoption and commitment to these. Without a general commitment and buy-in from all different layers on the organization, it doesn't matter how good these models might be, they will fail to effectively serve their purpose. A culture of continuous improvement, performance excellence and effective communication is required for these methodologies to work. The correct KPI company mindset and adoption has benefits that go beyond individual project success, and it aims to achieve construct better institutional knowledge to improve the organization, make the company more competitive to adapt to market trends, stakeholder requirements and improve its reputation.

However, there are also some limitation areas in this research study. Despite the ability of this case study approach to perform a literary review of these key concepts and their valuable application, this is in any case a fictional company and project. Therefore, the obtained results of this thesis work are just illustrating scenarios and for a real world case application it is necessary to analyze further real-world projects. Also, there are a set of construction building tools such as BIM modeling, Internet of things and new AI aspects which need to be considered into future studies research on this topic, since they will drastically re-shape the KPI selection process and tracking mechanisms.

In conclusion, this research thesis study addresses the initial research questions proposed at the beginning of this study, by identifying the most important key indicators applied to a construction project, controlling the project cost, schedule, quality, safety and stakeholder satisfaction as key metrics for project success. It has been demonstrated for the case of a selected construction company, the study of the following frameworks: the Balanced Scorecard, Performance Pyramid and Performance Prism, ensuring to align with the overall defined company objectives and project goals for the different phases. It has also been outlined some effective methods for tracking and monitoring these key performance indicators throughout time, allowing project managers to have access to these dashboards and tools to be able to take the necessary decisions on time, to ensure project success.

References

Amer, F., Hammoud, S., Khatatbeh, H., Lohner, S., Boncz, I., & Endrei, D. (2022). A systematic review: the dimensions to evaluate health care performance and an implication during the pandemic. *BMC Health Services Research*, *22*(1). https://doi.org/10.1186/s12913-022-07863-0

Anbrasi Edward, B. K. F. K. A. S. S. G. B. D. H. P. (2011). Configuring Balanced Scorecards for Measuring Health System Performance: Evidence from 5 Years' Evaluation in Afghanistan. *Plos.Medicine*.

Camilli, R., Hristov, I., & Chirico, A. (2022). The role of Key Performance Indicators as a performance management tool in implementing corporate strategies: A critical review of the literature. *ResearchGate*.

Campbell. (2017, May). Practical Guide to Leading Indicators: Metrics, Case Studies & Strategies. *Https://Www.Thecampbellinstitute.Org/Wp-Content/Uploads/2017/05/Campbell-Institute-Practical-Guide-Leading-Indicators-WP.Pdf*.

Cerceau, J., Mat, N., Juqua, G., Lin, L., & Laforest, V. (2014). Implementing industrial ecology in port cities: international overview of case studies and cross-case analysis. *Science Direct*.

Cernisevs, O. (2024). *KPI Selection for Fintech Companies: A Systematic Review of Literature*. www.arjhss.com

Ciancio, S. (2024). Strategic Vision: A Guide for Developing a Clear Roadmap for Your Organization. *The Strategy Institute*. https://www.thestrategyinstitute.org/insights/strategic-vision-a-guide-for-developing-a-clear-roadmap-for-your-organization

Cross, & Lynch. (1989). The SMART PMS, "The SMART way to define and sustain success." *National Productivity Review*.

Digalwar, A. K., & Sangwan, K. S. (2011). An overview of existing performance measurement frameworks in the context of world class manufacturing performance measurement.

International Journal of Services and Operations Management, *9*(1), 60–82. https://doi.org/10.1504/IJSOM.2011.040322

Eurostat. (2023). *Cloud computing - statistics on the use by enterprises - Eurostat*. Https://Ec.Europa.Eu/Eurostat/Statistics-Explained/Index.Php?Title=Cloud_computing_-_statistics_on_the_use_by_enterprises.

Fang, D., & Choudhry, R. M. (2008). Why operatives engage in unsafe work behavior: Investigating factors on construction sites. *ScienceDirect*, 566–584.

Few, S. (2012). *Show me the Numbers - Designing Tables and Graphs*.

Harris, E. (2017). *The Routledge Companion to Performance Management and Control*.

Ishaq Bhatti, M., & Awan, H. M. (2014). The key performance indicators (KPIs) and their impact on overall organizational performance. *Quality and Quantity*, *48*(6), 3127–3143. https://doi.org/10.1007/s11135-013-9945-y

Kaplan, R. S., & Norton, D. P. (1992). *The Balanced Scorecard-Measures that Drive Performance Harvard Business Review*.

Kerzner, H. (2011). Project Management Metrics, KPIs. *International Institute for Learning, Inc., New York*.

Kunkcu, H., Koc, K., Dagou, H. H., & Gurgun, A. P. (2022). Using key performance indicators in construction project literature. *Proceedings of International Structural Engineering and Construction*, *9*(2). https://doi.org/10.14455/ISEC.2022.9(2).CON-12

Lakiza, V., & Deschamps, I. (2018). How to Develop Innovation KPIs in an Execution-Oriented Company. In *Technology Innovation Management Review* (Vol. 8, Issue 7).

Lavy, S., Garcia, J. A., & Dixit, M. K. (2010). *Developing a categorization matrix of Key Performance Indicators (KPIs): A literature review*.

Lee, B., & Saunders, M. N. K. (2020). Conducting Case Study Research for Business and Management Students. In *Conducting Case Study Research for Business and Management Students*. SAGE Publications Ltd. https://doi.org/10.4135/9781529716702

Li, H., Johra, H., de Andrade Pereira, F., Hong, T., Le Dréau, J., Maturo, A., Wei, M., Liu, Y., Saberi-Derakhtenjani, A., Nagy, Z., Marszal-Pomianowska, A., Finn, D., Miyata, S., Kaspar, K., Nweye, K., O'Neill, Z., Pallonetto, F., & Dong, B. (2023). Data-driven key performance indicators and datasets for building energy flexibility: A review and perspectives. *Applied Energy*, *343*. https://doi.org/10.1016/j.apenergy.2023.121217

Liimatainen, L., Hautamäki, J., Kirjalainen, E., Kokko, M., Korhonen, K., Laitinen-Väänänen, S., Norvapalo, K., Törn-Laapio, A., & Hyvätti, S. (n.d.). *Jyväskylän ammattikorkeakoulun eettiset periaatteet*.

Marr, B. (2012). *Key Performance Indicators The 75 measures every manager needs to know*.

Neely, Adams, C., & Crowe, P. (1998). *THE PERFORMANCE PRISM IN PRACTICE*. http://www.emerald-library.com/ft

Neely, Adams, Chris., & Kennerley, Mike. (2002). *The performance prism : the scorecard for measuring and managing business success*. Financial Times/Prentice Hall.

Neely, Richards, H., Mills, J., Platts, K., & Bourne, M. (1997). Designing performance measures: A structured approach. In *International Journal of Operations and Production Management* (Vol. 17, Issue 11, pp. 1131–1152). https://doi.org/10.1108/01443579710177888

Ningxuan Kang, C. Z. J. L. &John A. H. (2016). A Hierarchical structure of key performance indicators for operation management and continuous improvement in production systems. *International Journal of Production Research* .

Parmenter. (2015). *Key Performance Indicators*.

Peterson, E. T. (2006). *The Big Book of Key Performance Indicators Book Two in the Web Analytics Demystified Series First Edition*. http://www.webanalyticsdemystified.com

Chaminda, P., & Jayasinghe, U. K. (2021). *Role of Peripheral Analysis Methods in Adoption of Successful KPIs for a Research Institute Working Towards Commercial Agriculture*.

Sarel Lavy, J. A. G. M. K. D. (2010). Establishment of KPIs for facility performance measurement: review of literature. *Emerald Insight*. https://www.sciencedirect.com/science/article/abs/pii/S0959652614002819

Schrage, M., & Kiron, D. (2018). Leading With Next-Generation Key Performance Indicators. *Massachusetts Institute of Technology*. https://doi.org/10.13140/RG.2.2.28573.05600

Sharma, B., & Gadenne, D. (2011). Balanced scorecard implementation in a local government authority: Issues and challenges. *Australian Journal of Public Administration*, *70*(2), 167–184. https://doi.org/10.1111/j.1467-8500.2011.00718.x

Striteska, M., & Spickova, M. (2012). Review and Comparison of Performance Measurement Systems. *The Journal of Organizational Management Studies*, 1–13. https://doi.org/10.5171/2012.114900

Sujay Vialshery, L. (2024). Enterprise spending on cloud and data centers by segment from 2009 to 2023. *Https://Www.Statista.Com/Statistics/1114926/Enterprise-Spending-Cloud-and-Data-Centers/*.

Telecommunications Industry Association (TIA). (2006). *TIA-942 - Data Center Standards Overview - ADC - 2006 - ADC Telecommunications*.

Vargas, R. (2004). *Earned Value Probabilistic Forecasting Using Monte Carlo Simulation*. Https://Ricardo-Vargas.Com/Articles/Earnedvaluemontecarlo/?Replytocom=15114.

Villazón, C. C., Pinilla, L. S., Olaso, J. R. O., Gandarias, N. T., & de Lacalle, N. L. (2020). Identification of key performance indicators in project-based organisations through the lean approach. *Sustainability (Switzerland)*, *12*(15). https://doi.org/10.3390/su12155977

Yin, R. K. (2018). *Case Study Research and Applications: Design and Methods* (6th ed.).

Yuan, J., Wang, C., Skibniewski, M. J., Asce, M., & Li, Q. (2012). *Developing Key Performance Indicators for Public-Private Partnership Projects: Questionnaire Survey and Analysis*. https://doi.org/10.1061/(ASCE)ME.1943-5479