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IM-Lab – Master's Thesis

Department of Management Engineering

CONTINUOUS IMPROVEMENT PROJECT FOR SALES MANAGEMENT: DEVELOPMENT OF AN ADAPTIVE CONFIGURATOR

Case Study: Electro Adda S.p.A

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ELECTRO ADDA
il motore che fa la differenza

Abstract

This master's thesis pertains to the increased capabilities of the online sales configurator and independency of the sales department at Electro Adda S.p.A – an Italian motor manufacturer located in Brivio, Lecco. This report follows the A3 problem-solving method, a common lean manufacturing procedure that revolves around problem-solving and continuous improvement. This allowed for a structured approach to a new problem, which outlines the chapters for this report.

The A3 methodology begins with understanding and defining the actual problem statement, answering the question as to why this is a problem and to whom it matters. The problem breakdown then better quantitatively and qualitatively characterises the problem more definitively. The data collection process was the longest step, as several weeks were required to understand and map the process, as well as cleaning and analysing the data coherently. This allowed for the targets to be set, being specific, measurable and achievable, whilst the root cause analysis was used to identify the causes behind the problem and to develop countermeasures. These countermeasures were decided by our team with close cooperation with the management of Electro Adda S.p.A, and were executed by the end of June 2022, with close monitoring of results.

The problem (defined as new product orders that are lost or delayed owing to long waiting and internal lead times within the sales department) was addressed by the implementing countermeasures relating to the Electro Adda digital database and online sales configurator. These countermeasures correspond to new features and capabilities on the digital sales configurator, namely a broader selection of motor series, price calculations, lead time estimates, data accessibility and manipulation, as well as better confidence in using the tool. The quantitative results from this report showed that the proposal lead time had decreased significantly, whilst qualitative survey analysis also indicated that the sales department were very satisfied with the updated configurator. The project goals were thereby achieved, adequately reducing the lead time of order proposals and instilling confidence in the configurator, whilst providing recommendations for continuous improvement.

Key words: Sales department, configurator, A3 methodology

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Abstract in lingua italiana

Questa tesi magistrale riguarda il lavoro volto all'aumento delle funzionalità del configuratore online e dell'indipendenza del dipartimento commerciale, presso Electro Adda S.p.A, un'azienda produttrice di motori elettrici, con sede in Brivio, Lecco. Questo report segue la metodologia di risoluzione di problemi A3, una procedura molto utilizzata nella cultura "Lean" che si sviluppa intorno al concetto di miglioramento continuo. Questo metodo ha permesso un approccio strutturato alla risoluzione dei problemi che saranno descritti nei capitoli di questo report.

La metodologia A3 prescrive di iniziare con il capire il problema e darne una definizione precisa, che dichiari gli effetti e chi è realmente impattato. Questa prima sezione viene poi analizzata più nel dettaglio dalla "Scomposizione del problema", attraverso metodi sia quantitativi che qualitativi. Il lavoro di raccolta dei dati necessari è stato molto impegnativo, sono state necessarie diverse settimane per mappare il flusso del processo e per analizzare i dati raccolti. Questo ha portato a definire degli obiettivi specifici, misurabili e raggiungibili, come da disposizioni del A3. Metodi di "Analisi delle cause principali" sono stati usati per scomporre il problema nelle sue cause di origine. Abbiamo quindi pianificato delle contromisure in stretta collaborazione con la dirigenza di Electro Adda S.p.A, e sono state implementate per la fine di Giugno 2022, seguite da un periodo di rigoroso controllo dei risultati.

Il problema è stato definite come: esagerato numero di ordini persi o ritardati a causa di lunghi tempi di processo interni al dipartimento delle vendite. Questo è stato affrontato implementando contromisure relative alla base dati digitale e al configuratore dei prodotti online di Electro Adda. Queste azioni hanno portato a nuove funzionalità, nello specifico: una selezione più vasta di serie di motori, il calcolo del prezzo automatico, la stima del tempo di consegna, una più semplice accessibilità ai dati e alla loro manipolazione. I risultati quantitativi mostrati in questo report evidenziano una diminuzione significativa del tempo necessario per evadere una proposta d'ordine, mentre un'indagine qualitativa ha indicato che il dipartimento commerciale si è trovato soddisfatto degli aggiornamenti. Gli obiettivi di progetto sono stati raggiunti, riducendo il tempo di processo e aumentando la confidenza nell'utilizzo del configuratore e allo stesso tempo fornendo raccomandazioni per il miglioramento continuo del software.

Parole chiave: Dipartimento commerciale, configuratore, metodologia A3

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Executive Summary

Company Overview: Electro Adda S.p.A. is an Italian family-owned business in Brivio, Lombardy that specialises in the design and manufacturing of AC electric motors for local and global markets. The company was founded in Lecco, 1948, as an artisan workshop and has been transformed into a highly customised and certified international electric motor manufacturer.

Background: This thesis is a continuation of previous work carried out by prior Politecnico di Milano students of the Industrial Management stream. Their work created the foundation for this project whereby they assisted in updating the printed catalogues, containing all relevant technical motor data and storing them in a digital database utilised by the company. Their team also created a test version of the digital configurator – a sales tool utilised by potential customers and the sales force. This provided the platform for our project, whereby we used their preliminary work to build new and improved functionality to the sales configurator and sales force. Therefore, the work completed in this thesis, beginning on 10 March 2022, takes the original idea and allowed the roll-out of the new digital configurator for the sales force to use. The report follows the A3 problem-solving methodology.

Market Analysis: The company operates in the Italian market with a smaller foothold in the global market. Since the company aims to grow organically, both the Italian and international markets were analysed, considering several growth factors such as the electric motor market, electricity consumption, as well as price and availability of critical raw materials used in the manufacturing process. The analysis showed a positive expected growth rate in terms of the electric motor demand in Italy and internationally, whilst only the global electricity demand is expected to rise. The increase in metal prices, namely aluminium, copper and steel alloys, are a major limitation to growth, alongside the potential shortage of basic components. These factors and risks need to be carefully evaluated to ensure organic growth within local and foreign markets.

Since the sales process was identified as major point of contact for customers, and to promote organic growth within the company for new orders, it was important to expand upon prior knowledge of the sales process and how it could be adapted to fit the focal company. Two key sales process models were identified that depict the basic process at Electro Adda, whereby many customer enquiries are obtained by the company and are funnelled through the sales process to a lower number of successful and confirmed orders. Prior case studies, similar to the work at Electro Adda, showed that the sales pipeline is important for work prioritisation and defining criteria, the importance of receiving buy-in from the sales department to follow a strict sales processes well as clearly defining the sales process before implementing sales tools. These digital sales and marketing tools (DSMTs) improve the relationship with customers and allow mass customisation, especially within a company such as Electro Adda with many product varieties and local or international customers. This analysis was considered for the final design of the sales configurator available to both customers and the internal departments at Electro Adda.

Introduction: To better understand the problem, several external and internal factors were considered with respect to the sales department. Many external factors (economic pressure, competition, external environment etc.) were excluded from the analysis, whilst factors within the control of the sales department were considered i.e. waiting period for customers and internal lead time for creating order proposals. Following the A3 methodology, it was discovered that the problem statement refers to *new product orders that are lost or delayed, owing to long waiting and internal lead times within the sales department***.** It was determined that in 2021, only 21% of all customer proposals were accepted with a sales team of six employees throughout Italy. Each sales representative is expected to handle approximately 1000 new orders annually, therefore improving the sales process and independency was key.

Problem Background: This problem was broken down further, mapping the process flow and determining the major bottlenecks for the order proposal process. This process is defined from when a customer initially enquires to the sales department until the order has been prepared with the necessary documents and sent to the customer for their approval. The critical bottlenecks were identified, such as creating feedback loops when a customer does not have a clear or complete technical sheet, when the sales department create an customer order backlog by unnecessarily requesting assistance from the technical department, as well as the long waiting time for the engineering department to create preliminary drawings for new product orders. These three pain points were then expanded upon using the A3 methodology to determine the extent of the problem.

To better understand the product families, a Pareto analysis of all motor series was conducted. The results showed that the top three motor series (TA-EG Series, C Series and FE series) correspond to 97% of the total number of orders and 90% of the total value. The remaining series and spare parts were thus excluded from further analysis. It was then identified that the minority of confirmed orders (6.1%) require technical assistance, however this corresponds to a significant portion of the recorded value (19.4%). This process was split between standard and special orders, whereby many of the standard orders were unnecessarily sent to the sales department. The lead times were carefully analysed, whereby standard and special orders required 3.0 days and 12.7 days on average, respectively, to be sent to the customer for approval. With regards to special motors, there were several extreme observed values, whereby some customers waited between 20 and 45 days to receive an order proposal. In order to reduce these lead times, realistic targets were set and formed the goal of this work.

Goal Setting: The aim of this project is to thereby decrease the lead time of customer proposals, with targets that are a must-have (MH) and nice-to-have (NTH). With respect to standard orders, achievable and realistic MH and NTH targets were set as 2 days and 1 day, respectively. Similarly with special orders, MH and NTH targets were set to 6 days and 4 days, respectively. Although the standard deviation of these average lead times is important, it was not considered as part of the key performance indicators (KPIs) since specific goals were difficult to set and the data pool of reliable information was not large enough. The frequency of weekly customer enquiries was also analysed, however no patterns or trends were identified throughout 2021. Therefore, it was assumed that the frequency of customer enquiries should not have a significant effect on the reduction of proposal lead times throughout this project.

Root Cause Analysis: Two common methods for determining the root cause of a problem (following the A3 lean methodology) included the Ishikawa, or fishbone diagram, to determine the overall causes, as well as the *5 Why* methodology to determine the true root causes. The problem, defined as the long lead time for new customer proposals, formed the head of the Ishikawa diagram. After spending sufficient time with the company and various departments, the Ishikawa diagram was split between three areas, namely *Methods*, *Materials* and *Man* (people). Many of the root causes related to the methods used by the sales team, especially the long lead time trying to match customer needs to available motors. This further expanded to finding motors with the correct specifications, estimating the expected delivery time, calculating the price of the motor, as well as wasting time manually looking through digital or printed catalogues to find the appropriate information. The *5 Why* analysis broke these problems down further to their root causes, described as a partially incomplete database, inaccessibility to editing the database, unavailability of 3D drawings, time wasted on siloed Excel spreadsheets, unwillingness to attach incorrect quotations and incorrect estimated delivery times.

The *Material* section related to the unavailability of technical drawings and time wasted waiting for the preliminary drawings to be completed. This issue was again broken down into the root cause, namely the lack of specialised skills and information to quickly and efficiently create these 3D drawings. Lastly, with

regards to the actual employees (*Man*), a main cause of the problem was identified as the sales department unnecessarily sending non-technical orders to the technical department, creating a backlog within the technical department and reducing time available for high-value special orders. One root cause was then determined to be the unwillingness of the sales departments to send incorrect information to customers, which would in turn reduce their own performance and KPIs. Additionally, the sales department is not utilising the dedicated sales configurator to aid their work. This is because the current configurator has inconsistent or inaccurate values, so their confidence in the tool is very low.

Countermeasures: These root causes listed above therefore formed the basis of the countermeasure development and implementation process. The countermeasures were developed according to their impact on the lead times and the ease of implementation. The first countermeasures relate to expanding the configurator to other series and including automatic price calculations, which have the biggest and most direct impact on the proposal lead time with the highest benefit to the company. These measures should thus aid in centralising the information, simplifying the process and providing the most up to date information possible. These countermeasures can be considered as *Major Investments*, since they have the highest benefit and difficulty for implementation.

The next countermeasures, relating to medium-direct impact on lead time, correspond to creating the configurator link to allow 3D drawing downloads and displaying estimations of the delivery lead time. These countermeasures were perceived to be important to achieving high levels of success, although not as significant as the countermeasures listed above. The difficulty in implementation is also relatively high.

Finally, the last three countermeasures relate to low-indirect impact on the proposal lead time, namely updating the database, creating an option to edit the database through the configurator and correcting existing bugs. These countermeasures are still deemed essential to improving the configurator, although they were ranked lower in terms of benefit to the company as the effect on lead time has a more indirect relationship. These were therefore considered as *Quick Wins* as they can be implemented much more easily and still hold importance to the functioning of the configurator.

The initial barrier for completing these countermeasures was the lack of coding knowledge, whereby our team spent the majority of the first month learning the different coding languages i.e. php, SQL and HTML. The majority of these tasks were also completed in parallel with one another, as planned on the project Gantt chart. Many of the *quick wins* were tackled first, whilst the *major investments* were carefully planned and implemented throughout the project lifecycle. Both of these categories were completed by 20 May, whereby the relevant code and updated database were sent to the Head of IT at Electro Adda. The previous configurator was then replaced to include all of the necessary changes into an improved configurator (version 1). The countermeasure relating to the technical drawings was suspended until further notice as the external team responsible for the project faced several challenges. The code to link future drawings was however still included. The countermeasure relating to the delivery time estimation took the longest of all tasks since the planning department was very hesitant to adopt the idea. The idea was changed many times, whilst the final concept was made available on the configurator on 24 June 2022 (version 2). This also included the addition of the TA-EG Series on the configurator, which was only decided much later into the project cycle.

Monitoring of Results: The lead times for creating customer proposals from 30 May to 14 June were collected, cleaned and analysed to determine the change after implementing version 1 of the new configurator. The results showed that the average time for creating customer proposals reduced from 3.04 to 2.14 days for standard orders and 12.74 to 6.33 days for special orders. This is a significant improvement in lead time, almost reaching the must-have targets for each order type. Another important observation is that the extreme lead times for special orders also decreased, shifting the values to a lower and narrower

range. A qualitative survey was completed for all sales personnel, resulting in overall positive reviews for the new configurator. The tool was described as intuitive, clear and helpful to their work, therefore also making the adoption of the tool more likely. Much of the critical feedback however referred to many specific technical issues that are not available on a standard configurator, as well as the lack of 3D drawings.

Successes and Recommendations: The result of our work was largely successful in reducing the lead time of generating order proposals, as well as increasing the confidence of the sales department in using the configurator as a sales tool. The management at Electro Adda also decided to use the updated tool as standard practice, thereby encouraging and monitoring use to generate customer proposals and streamline the process. Our team also carefully documented all procedures and instructions on how to use the configurator, including detailed change logs of the code for any future development of the configurator.

As the A3 methodology follows the lean approach, continuous improvement is a key aspect. This project can be improved upon by contracting a dedicated team to the parameterisation of each motor to include detailed 3D drawings. This would significantly reduce the waiting time for the sales department to complete order proposals sent to the customer, thereby reducing time lost and improving customer satisfaction. Another suggestion is that the company adopts other tools such as customer relationship management (CRM) and enterprise resource planning (ERP) software to better understand customers and link the work between all departments, respectively. Although the configurator is used to help customers as well, the use of CRM software can improve the knowledge base of both old and new customers, allowing better targeting of projects. The CRM could also replace the Excel sales tracking sheets, since many of the values are inconsistent or missing. The use of an ERP system would also help the planning department to better understand their current and future workload, thus creating more efficient operations. The company currently relies on a basic ERP system (AS400), although this system is outdated and should be replaced with a system with more features.

The time spent working on this project at the company was a largely beneficial experience with many key takeaways. It was crucial to first understand the project before attempting any solutions, which is also a core aspect of the A3 framework. It was also important to investigate, instead of taking information at face value. Several delays were as a result of failing to address the true issue at hand, therefore this experience was valuable to learn from these mistakes. Finally, having the support of the company and dedicated tutors was fundamental in the success of this project, with clear and specific guidelines to help achieve the desired goals.

1. Literature Review

Electro Adda S.p.A is an Italian company founded in 1948 that specialises in designing and manufacturing AC electric motors. They thereby operate in the Italian market, branching out to the global market. Currently the company is also investigating ways to streamline its sales process to work more efficiently. It is therefore important to analyse both global and Italian motor markets in detail to assess possible growth factors and strategies for Electro Adda to grow organically. Additionally, the sales process will be explored further to determine important factors that determine the effectiveness of the sales process within the company and possible tools or strategies to aid the sales department.

1.1. Market Analysis

Since the company operates in the global and Italian AC electric motor markets, these domains will be examined with regards to current and future valuation, annual growth and related factors towards its growth.

1.1.1. Global Demand

The global market for electric motors was valued between $107 billion (Fortune Business Insights, 2021) and $113 billion (Markets and Markets, 2020) in 2020, with respective compounded annual growth rates (CAGR) of 7% between 2026 to 2028. This growth however was stunted during the Covid-19 pandemic, causing a negative growth rate of -9.6% during 2020 (Fortune Business Insights, 2021). This decline in sales and market growth was caused by government imposed shutdowns and restrictions, disrupted global supply chains and workers' availability and health (Pawar & Sumant, 2022). Many industries and countries came to a standstill during this period as the pandemic situation was at its peak. Fortunately, the need for electric motors is still high, allowing the market to rebound after the pandemic-related disruptions had settled.

There are several factors owing to the growth in the electric motor industry, such as the global electrical consumption, increased use of electrical equipment and machines in different industries, as well as improved standards and regulations. The increase in electricity consumption was driven by strong economic growth and higher fluctuations in global temperatures, which thus increased global electricity consumption by 6% in 2021 (IEA, 2022). The IEA also expect electricity consumption to grow moderately by 2.7% between 2022 and 2024, with approximately 42% of all electricity being consumed within the industrial sector in 2019. The figure below illustrates the overall growth of the global electricity consumption from 1974 to 2019 across various sectors, which shows its massive expansion within this period. As of 2019, the most significant sectors therefore correspond to industry (9566 TWh), residential (6072 TWh) and commercial and public services (4849 TWh).

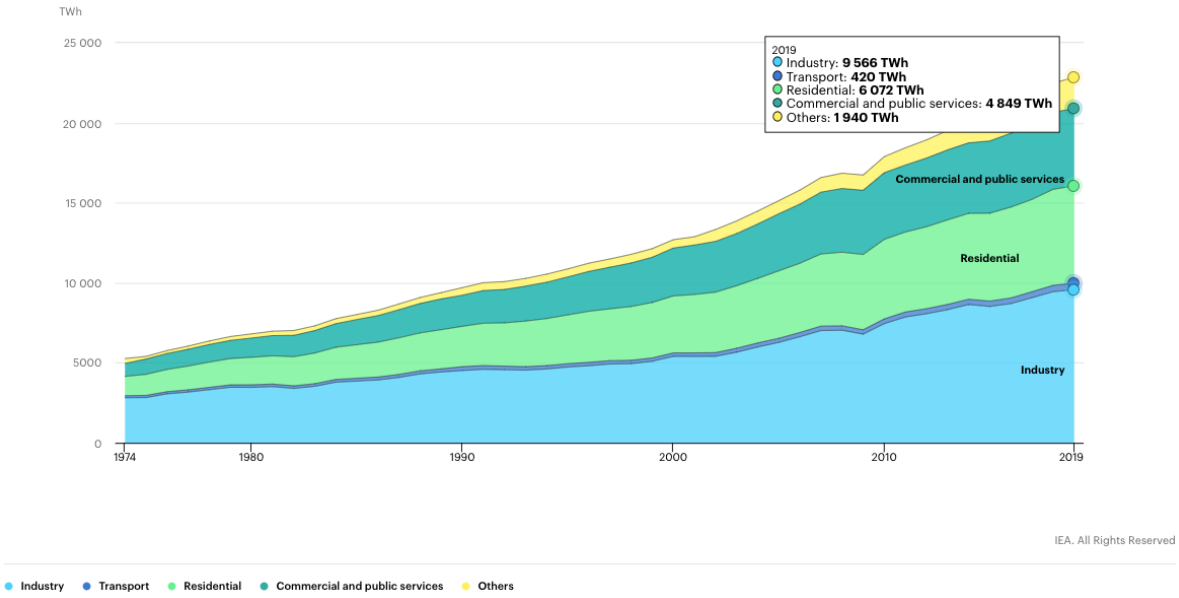


Figure 1: Figure to show the increased global energy consumption from 1974 to 2019 across various sectors (IEA, 2022)

Another contributing factor is the growing need for electric motors in other industries. One major component of this growth is related to heating, ventilation, and air conditioning (HVAC) systems which are utilised in residential, commercial, and industrial sectors. The global construction sector is expected to invest $1.08 trillion over the next 5 years (Markets and Markets, 2020), which all largely contain HVAC systems. This is especially prevalent in developing economies as commercial spaces and standard of living are increasing steadily (Fortune Business Insights, 2021). Finally, another significant factor consists of better global standards and regulations for managing energy efficiency in motors, such as the Minimum Energy Performance Standards (MEPS) (WEG, 2021). This system incorporates a minimum level of performance for electric motors to enter a local market (Eichhammer & Fleiter, 2012), allowing more transparency, lower transaction costs and better long-term performance of motors in industrial roles. All of these conditions have allowed the electric motor market to continue growing throughout the world, allowing further opportunities in developing markets.

1.1.2. Italian Demand

As of 2022, the Italian market for electric motors, generators and transformers is valued at €6.9 billion with an average annual growth rate of 5.5% between 2017-2022 (IBISWorld, 2022). Italy was also hit hard economically by the Covid-19 pandemic, which caused a short-lived recession (-8.9% in GDP, 2020) and stagnated economic growth (Istat, 2021). However, according to Istat, various economic support programmes and the loosening of pandemic restrictions allowed Italy to rebound to pre-pandemic levels in 2021 – with the highest growth attributed to manufacturing, construction and other services. The annual change in industry revenue for Italy and Europe (IBISWorld, 2022) from 2009 to 2021 can be seen on the figure below, with future predictions for 2022 to 2028.

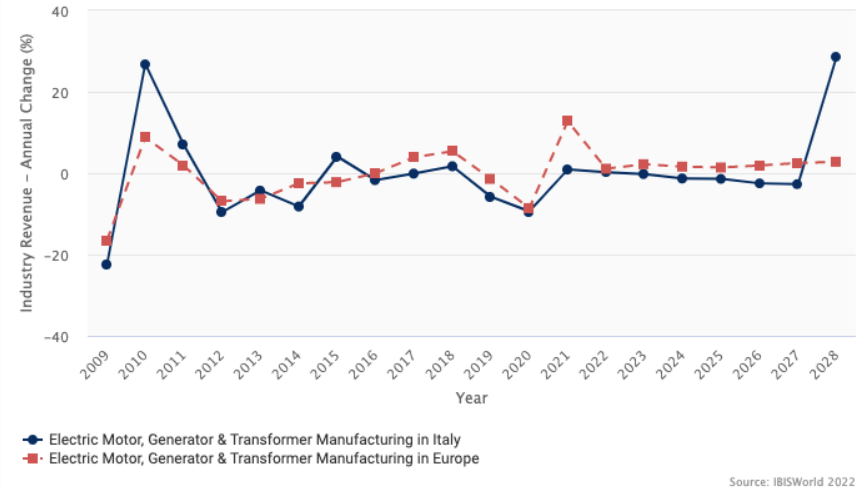


Figure 2: Figure to show the annual change (%) in industry revenue for the AC electric motor market for both Italy and Europe (IBISWorld, 2022)

The figure above shows that Italy closely follows the overall trends in annual revenue change (%) with Europe, especially before the Covid-19 pandemic in 2020. The electric motor market in Italy is thus predicted to remain relatively constant from 2022 onwards, with a lower growth rate than the European average. According to ANIE Energia (2014), new regulations (Reg. 640/2009) have allowed the Italian electric motor market to shift away from lower efficiency motors (IE1) and gradually replace them with higher efficiency motors (IE2 and IE3, respectively). This trend is expected to continue as the MEPS guidelines gradually improve within Europe (ANIE ENERGIA , 2014).

Behind Germany, Italy is characterised as one of the largest importers of electric motors, especially since China can produce price-competitive AC motors (CBI: Ministry of Foreign Affairs, 2017). According to the CBI (2017), Italy was the largest importer of AC motors from developing countries (€205 million) in 2015, with an annual growth rate of 0-3%. It is estimated that 48% of the total imports of AC electric motors to Europe are manufactured in Germany, Italy and China, whereby China has shown high annual market growth (8%) since it has invested heavily in specialisation at a competitive level (CBI: Ministry of Foreign Affairs, 2017). In terms of exports, the CBI states that Italy has the second highest exports in Europe (13% share), which is considerably lower than their German competitors (41% share). The CBI also identified several trends for the European AC motor markets, such as increased energy efficiency, strong domestic and international price competition, stock availability, consolidation of established companies and the presence of premium products especially from technologically advanced brands like Siemens or ABB.

Another factor concerns Italy's energy consumption and growth, since it is also a relative proxy for the electric motor market. Therefore, it is important to analyse these overall trends and future predictions. The figures below show that between 1985 and 2005 there was a steady increase in electricity consumption, however after 2005 the rate of consumption remained relatively stable (Ritchie, et al., 2020).

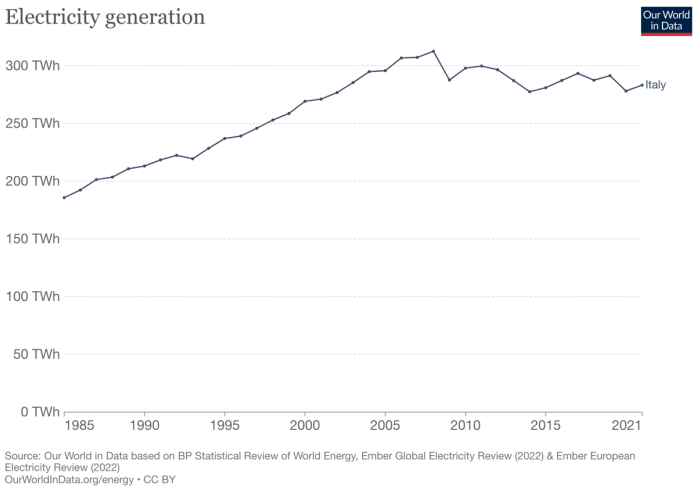


Figure 3: Figure to show the electricity consumption in Italy from 1985 to 2021 (Ritchie, et al., 2020)

Some of the factors influencing the low growth rate of electricity generation in Italy stem from the high dependence on energy imports, seeing as over 70% of the generated electricity is produced by fossil fuels (CMS, 2015). This high reliance on natural gas and oil severely restricts Italy's growth, as it is dependent on many global macroeconomic factors that directly affect the production and distribution of these fossil fuels.

1.1.3. Raw Materials Cost

According to the catalogues available at Electro Adda, many of the main components of an electric motor (stator, rotor, bearings and windings) are composed of materials such as iron, steel alloys, copper and aluminium (Electro Adda, 2021). The abovementioned materials are thereby crucial for the manufacturing of different components of an electrical motor and cannot be assembled without them. However, the prices and availability of these metal commodities are dependent on complex global factors viz. energy shortages, supply chain disruptions, shipping bottlenecks and high demand (Marioli & Baffes, 2021). Steel availability was exceptionally disrupted during the Covid-10 pandemic as many of the production facilities were not operating, which caused a major supply deficit within 2020 and early 2021 (Terzian & Bandmann, 2021). In 2022, this has been further exacerbated by the lockdowns in China and conflicts in Russia, which are both high-volume steel producing regions (Eurofer, 2022).

The trends seen below relate to other base metals required for the production of electric motors, namely copper and aluminium. These commodities have also significantly risen in price owing to similar global production and supply shortages. According to information available from the London Metal Exchange, the price ($US/tonne) of each commodity has more than doubled since the beginning of 2020 (LME, 2022). These price increases significantly affect other industries downstream in the supply chain, as increased raw material prices can considerably decrease profitability of related industries i.e. electric motor manufacturers.

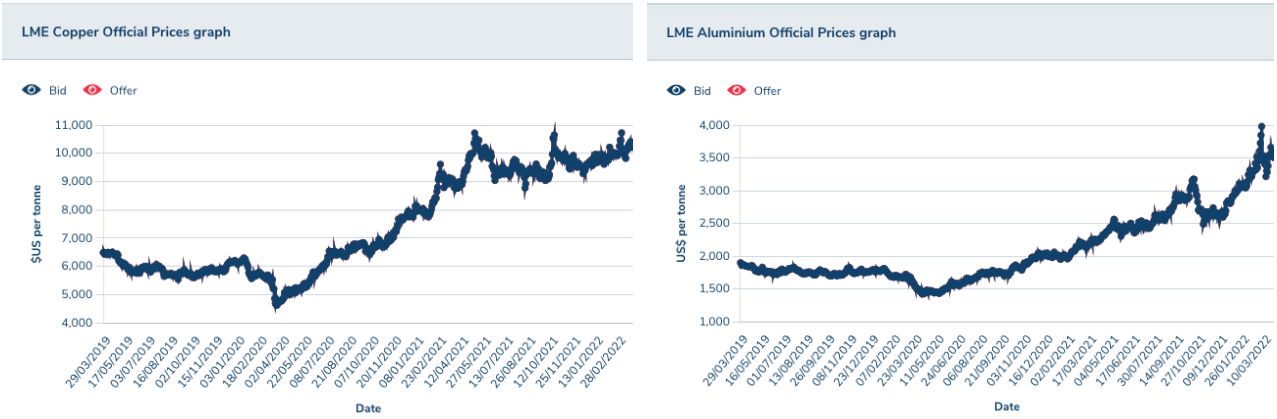


Figure 4: Figure to show the price increases ($US/tonne) of copper (left) and aluminium (right) between 2019 and 2022 (LME, 2022)

Another critical component for motor windings is electric steel, otherwise known as silicon steel since its main additive element is silicon (Hayakawa, 2022). Electric steel can be defined as a type of steel that possesses the ferromagnetic properties of iron, which is the most used (over 90% of the total volume) soft magnetic material (Fortunati, et al., 2016). This material is an important component within electromagnetic devices such as motors, generators and transformers because of its ferromagnetic ability to magnify the effects on current-carrying coils (Beckley & Sujan, 2016). Since this is a critical component for electric motors, the current market analysis for non-grain oriented electric steel will be explored further.

The electric steel market was valued at $15 billion in 2019 with a CAGR of 5.8% from 2020 to 2027 (Narune & Prasad, 2020). Specifically for non-grained electric steel, a CAGR of 4.5% in the same time period is expected, owing to the surge in demand for electric vehicles. This surge in electric vehicles is caused by the maturity of certain technologies (especially batteries), promoted support for low greenhouse gas emitting transportation and reduced environmental impact – whilst global automakers are committing more than $140 billion to the electrification of transportation (Muratori, et al., 2021). Motors for electric vehicles may also contain approximately 80 kg of electric steel per motor (Fortunati, et al., 2018), therefore the increased demand for electric vehicles has a significant impact on the demand for electric steel. Currently the global market is not able to satisfy this growing demand since most of the mills that manufacture electric steel are located in China and are affected by the Covid-19 lockdowns and restricted manufacturing, overwhelmed ports and increasing freight rates (Wolf, 2022). Therefore, Wolf (2022) expects that the supply for this material will be severely restricted for several years, similar to semiconductor shortage during the global pandemic. This increased demand and limited supply will thereby handicap many manufacturing industries, including the electric motor market.

1.1.4. Expected Growth for Electro Adda

Electro Adda therefore has the potential to grow the business organically as the international market for AC electric motors is growing (Markets and Markets, 2020), especially within developing countries with emerging economies (Fortune Business Insights, 2021). The increase in electricity consumption is also an indicator of market growth and industrialisation, especially as electric motors are also required in various sectors of the economy (IEA, 2022). Within the Italian market, the market is expected to pick up after the Covid-19 pandemic (Istat, 2021), especially with economic support systems available. There is however expected to be limited growth in the Italian electric market until 2027 (IBISWorld, 2022), which is also implied

by the stagnant growth in electricity consumption (Ritchie, et al., 2020). This period is also characterised by shifting away from lower efficiency motors because of new regulations (ANIE ENERGIA , 2014).

One major limitation to growth is the price and availability of materials and components used to manufacture electric motors. There have been many global disruptions that have affected the production and distribution of these materials (Marioli & Baffes, 2021), whereby the prices of base metals (LME, 2022) and steel (Terzian & Bandmann, 2021) have increased considerably. Similarly, another important material such as electric steel is in short supply (Wolf, 2022) whilst demand is increasing significantly because of the electrification of transportation (Muratori, et al., 2021).

Therefore, the expected growth for the company should be moderately stable with regards to the local and global demand for electric motors. However, the external factors that may hinder this growth relate to the shortage and increased prices of materials required to manufacture their products. Whilst considering these external economic factors, it is also critically important to assess the internal factors within the company. The company thereby identified the sales department as the key driver for organic growth and global expansion as this department is responsible for contacting and onboarding new potential customers.

1.2. Sales Process

The sales department is a major point of contact for customers, therefore it is important to expand upon prior knowledge of the sales process and how it can be adapted to fit the focal company. The sales process will therefore be discussed with regards to several established models, case studies from similar experiences and industries, and finally considering sales tools that are often implemented to improve the efficiency and effectiveness of a company's sales department.

1.2.1. Sales Process Definitions and Models

The sales process can be defined as the activities designed to promote customer purchase of a product or service either in person, through phone calls, email communications or other communication media (American Marketing Organization, 2007). Additionally, personal selling can be described as "face-to-face interaction with one or more prospective purchasers for the purpose of making presentations, answering questions, and procuring orders" (Kotler, et al., 2007). Both definitions thereby stress the importance of interaction between sales representatives and prospective customers for a successful transaction to take place.

The sales process has been mapped and modelled to better represent how it operates in reality. One of the most accepted models corresponds to the sales funnel, which is the visual representation of the customer journey from awareness to action (Singh, et al., 2011). Alternatively, the sales funnel may also be broken down into generic categories such as awareness, interest, desire and action (Hayton, 2019).

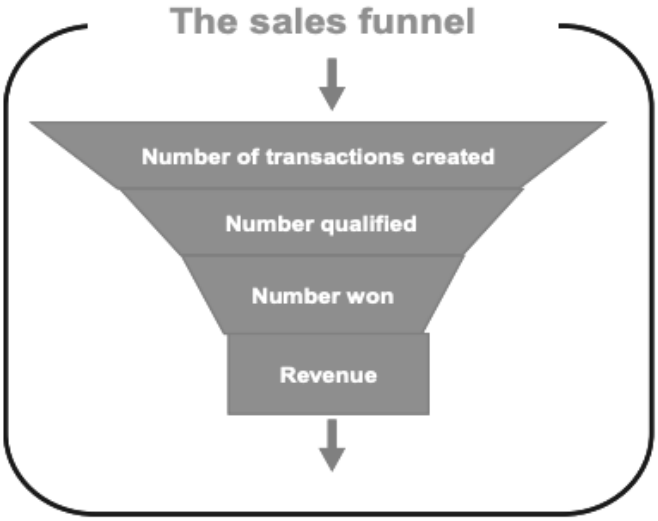


Figure 5: Figure to visually depict the sales funnel to better understand the sales process (Singh, et al., 2011)

The figure above illustrates that interested customers aware of the product or service begin the sales process by interacting with the sales department to express their interest and find out more information. Once contact has been made with the sales team, the opportunity can be considered qualified if the customer expresses interest and implies a budget has been specified. The next step is when the customer decides to purchase the product or service, resulting in revenue to the company. As described by Singh, et al., 2011, potential sales are lost through each stage of the process, whereby the number of sales won are generally significantly lower than the amount of initial customer interest. This funneling scenario, otherwise also characterised as a sales pipeline, helps companies to identify and evaluate their sales process critically through each stage.

Another similar model was developed by Kotler and Armstrong, 2012, whereby the sales process was expanded into seven disctint stages. This model focuses finding and obtaining new customers, whereas sales departments tend to focus on existing customers and build relationships (Kotler & Armstrong, 2012). The model, as seen below, will be explored further to assess it practicality for the sales team.

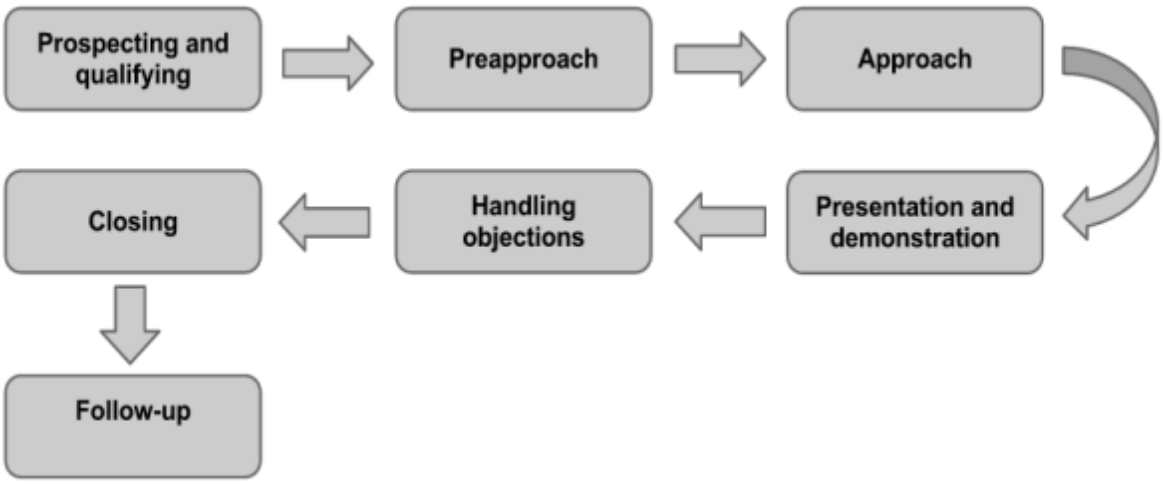


Figure 6: Figure to show the sales process according to the model proposed by Kotler and Armstrong, 2012

The first step of the process is related to prosecting and qualifying, whereby the sales team are expected to proactively search for potential new customers. This corresponds to reaching out through existing networks of business contacts or searching through other forms of media to identify possible clientelle. The preapproach phase relates to presreening and learning more about the possible clients before actually contacting them. This is important to identify objectives and gather information to make the sales pitch easier. The approach phase is then important to introduce yourself warmly and politely to the prospective customer to get the relationship to a good start.

The following step is the presentation phase whereby the sales representative introduces the product or service for sale, explaining the story behind the product, how it works and how it can benefit the customer i.e. helping them to earn more money. It is important to identify the buyer's attitudes, needs and buying style to effectively handle this stage in the process. Once presented the product, customers often tend to have doubts or objections. The next step focuses on handling these objections, either logical or psychological, to better clarify the product or minimise their doubts. This requires a skilled salesperson to understand the customers' doubts and thereby reduce the risk of losing the sale.

The closing phase is next, which has been identified as a difficult stage for inexperienced salespeople. Some sales people may feel unconfident or guilty when proposing products to customers, or simply miss the right opportunity to close. Another tactic used is to offer reduced prices or extra quantities to persuade the customer. The final step, which is one of the most important for ensuring repeat business, relates to the customer follow-up whereby the salesperson should disclose all information about delivery time, urchase terms or other useful information. A follow-up call is also sugested at a later point to ensure that the customers' needs have been met and that there are no issues upon delivery or installation.

Both models above depict the sales process in similar ways, representing and explaining the key roles of the sales team through this process. These serve as a reference point when identfying and mapping actual sales processes in reality.

1.2.2. Case Studies for Sales Process Improvement

The endeavour to improve the sales process throughout an organisation has been explored many times in most companies, therefore the results relating closest to Electro Adda will be explored further.

The work completed by Torehov and Hällöv, 2015, relates to the strategic measurement of the sales process to further improve it. Their empirical study was done in association with Saab, a military defence company operating in Sweden that sells military equipment. Their team investigated the sales pipeline discussed previously to identify its strengths and weaknesses within a company and to test the theoretical information. The results concluded that the sales pipeline analysis can aid the company by better identifying bottlenecks in the sales process, support decision making when evaluating business opportunities and visualisation of the tool for ease of use (Torehov & Hällöv, 2015). However, the issues with the pipeline relate to difficulty in task prioritisation and the amount of time taken to assess an opportunity's viability. Throughout their study, it is recommended to use to the sales pipeline as a tool to better filter opportunities by certain criteria that will aid the business, however too many criteria can cause some opportunities to be neglected or lost. A fine balance is therefore required to ensure the best business opportunities filter through the sales process.

The next case considers the work by Parsalis, 2019, whereby interviews and observations from sales companies were analysed over several years. The aim of the work was to close the knowledge gap between literature and actual sales processes. One of the major observations relates to companies that may already have organised sales departments, however the actual sales processes have not been strictly defined or well-structured. The report highlights that after sample companies have developed clear definitions and standard operating procedures for the sales process, the businesses increased their revenue between 20-28%, irrespective of industry or product (Parsalis, 2019). The takeaways from this study indicate that a balance must be established between having a strictly followed sales process that is simultaneously appealing to the actual salespeople following the process and the upper-management that wish to remain in control. Often the sales teams feel that they are neglected and expected to follow a strict procedure, therefore it is important to receive the buy-in of the idea from the sales personnel.

Another case that was investigated pertains to the Master's thesis by Lindgren, 2015, that also focused on the improvement in performance of the sales team in an actual company. The original aim of his work was to suggest and implement a sales enhancing tool and improve communication with customers. Through further investigation, it was identified that the sales process was not actually well defined enough to implement an effective sales tool. The goal of the thesis was then changed to defining and structuring the sales process (Lindgren, 2015). This was successfully completed and created the foundation for the use of sales tools in the future. The importance of this study highlights that a sales tool cannot be successfully implemented into a company with an undefined or unorganised sales process.

1.2.3. Sales Tools

The use of sales tools in small and medium sized companies allows the sales representatives to achieve their business objectives more easily and to compete with larger scale companies (Myhr & Taawo, 2021). Digital sales and marketing tools (DSMTs) are a powerful new resource to better improve the relationship between customer and sales team, especially through the use of sales configurators (Myhr & Taawo, 2021). These sales configurators help support companies through mass customisation, often becoming the entry point for customers to interact with the related company (Abbasi, et al., 2013). This notion is also supported by Gustafsson and Lindholm, 2010, whereby they state mass customisation in Europe is driven by the following trends: Increasing complexity and variants of products, diminishing lifetimes of products, requirement for short sales delivery process lead-times, increasing pressure from competitors and customers, as well as accounting for specific customer requirements. Therefore, the use of configurators can significantly help a sales department when handling a larger portfolio of products with high levels of customisation.

A sales configurator can also be explained as a tool that allows users to interact with a graphical user interface (GUI) that guides the user, handles and verifies constraints amongst options, propagates user decisions and handles conflicting decisions (Abbasi, et al., 2013). Configurators on belonging to 111 different companies were studied by Abbasi et al., 2013, regarding three specific dimensions: configurator options, constraint handling and process support. The quantitative results from their work indicated that more than half of the configurators studied have cross-cutting constraints, meaning that many of the options are logically dependent on one another. Regarding the process, approximately half of the configurators had multi-tier configuration and more than two-thirds have the ability for backwards navigation. Qualitatively, the major challenges relate to the constraints imposed on the configurators and the lack of checking and consistency.

Although the basic functionality and constraints are checked, some errors manage to propagate through the decision-making process and remain unfixed. The final issues are that the visual representation and lack of guidance pose a problem for users when not handled correctly.

Another issue with mass customisation is the risk of losing sales by offering too much variety to customers (Trentin, et al., 2013). This paradox is the result of having too many options, often deterring the customer. The research by Trentin et al., 2013, explored five major capabilities based on previous research to avoid the product variety paradox. These capabilities, as summarised and developed by their team, have been adapted and can be seen below:

Table 1: Table to show the five major capabilities of a sales configurator, adapted from Trentin et al., 2013

No.	Capability	Definition
C-1	Benefit-cost communication	Communicating the consequences of a user's choice in terms of what they get (benefit) against what they give (cost)
C-2	User-friendly product-space description	Explaining and adapting different product offers and descriptions to potential customers, based on various contexts
C-3	Easy comparison	Minimising the effort required for customers to compare multiple options and configurations
C-4	Flexible navigation	Allowing better navigation to customers to minimise the effort in changing current or previous configurations/options
C-5	Focused navigation	Allowing better navigation to customers to quickly and efficiently search their desired product/option that matches their requirements

Their hypothesis (H_0) was that the value for the user, both hedonic and creative, was affected by each of these capabilities. The statistical results from their study showed that each of these capabilities do in fact influence the user, and that each capability is statistically significant. Therefore, when creating a configurator with high levels of customisation, it is important to carefully consider the configurator's capabilities. These capabilities should be thoughtfully designed in accordance with the capabilities listed above to allow more value perceived by the user.

Another consideration for sales configurators is the adoption and use by the sales department, whereby the willingness to use the tool varies across the sales team. The adoption of the tool is first decided at an organisational level and followed by the actual sales team, making the process dependent on both parties (Sanakulov, et al., 2018). Although the sales configurator tool is intended to improve the efficiency of each individual sales person, Sanakulov et al. (2018) mention that the implementation plan may fail for as it can be seen as a micromanagement tool, changes to the sales process and disrupting the status quo, different viewpoints between management and the sales team and commitment from the organisational level (Barker, et al., 2009).

Sanakulov et al. (2018) therefore investigated the main factors for the adoption of a sales configurator through detailed interviews with the sales department at an international machining company in Europe. The results from their work, as seen in the figure below, identifies the main themes of performance expectancy (PE), effort expectancy (EE), facilitating conditions (FC), personal innovativeness and risks

associated with the tool. Each of these categories were split into higher and lower-order themes that contribute towards the attitude and perception of the sales team.

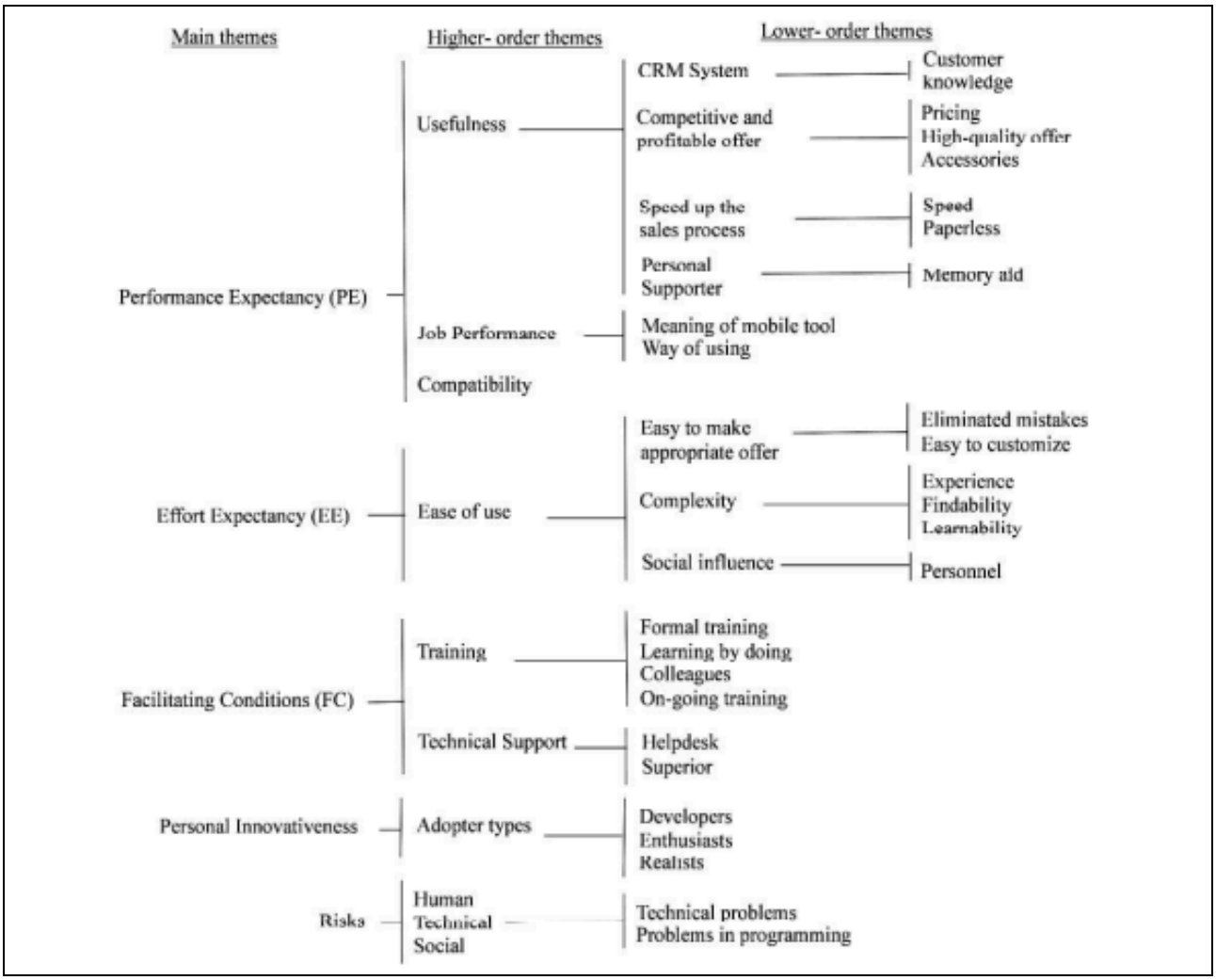


Figure 7: Figure to show the main factors for the adoption of a sales configurator tool by the sales team (Sanakulov, et al., 2018)

The information displayed above indicates that it is important for a sales individual to feel that the tool is actually aiding their work (PE) with relatively low effort (EE), whilst being in a supportive and cooperative environment (FC). When implementing a sales configurator, it is thus very important to consider the attitudes of the sales team and potential impact that would have on the adoption and implementation of the sales tool.

1.2.4. Key Findings for Electro Adda

Two key sales process models were identified, namely the sales funnel (Singh, et al., 2011) and the sales process mapped by Kotler and Armstrong (2012). These models depict the basic process at Electro Adda, whereby many customer enquiries are obtained by the company and are funnelled through the sales process to a lower number of successful and confirmed orders. Prior case studies, similar to the work at Electro Adda, showed that the sales pipeline is important for work prioritisation and defining criteria (Torehov & Hällöv, 2015), the importance of receiving buy-in from the sales department to follow a strict sales process (Parsalis, 2019), as well as clearly defining the sales process before implementing sales tools (Lindgren, 2015).

These digital sales and marketing tools (DSMTs) improve the relationship with customers (Myhr & Taawo, 2021) and allow mass customisation (Abbasi, et al., 2013), especially within a company such as Electro Adda with many product varieties and local or international customers. A sales configurator, which had already been explored at Electro Adda, is a useful tool if designed correctly (Abbasi, et al., 2013). It is important to consider five major capabilities of a configurator (Trentin, et al., 2013) to avoid the mass customisation paradox and losing orders because there are too many available options. Lastly, it is important to receive buy-in from the sales department to actually use the sales configurator. The configurator at the company should therefore consider performance expectancy, effort expectancy, facilitating conditions, personal innovativeness and other risks when designing the configurator (Sanakulov, et al., 2018).

Finally, once the sales process at Electro Adda has been defined and established, it is possible to improve the rudimentary version of the existing sales configurator based on prior case studies, mass customisation paradox, user design and the buy-in from the sales department. These factors will therefore be integrated into the final design of the sales configurator available to both customers and the internal departments at Electro Adda.

2. Problem Background

Electro Adda S.p.A (EA) operates in the AC electric motor market, where it designs and manufactures motors largely for the local Italian market and has steadily expanded into the global market – owing to its high degree of customisation and international certification. EA aims to grow organically, further increasing its turnover and the geographical reach of the company. The company relies on repeating orders and new product orders as the main sources of revenue, with repeating orders playing the significant role in terms of both number of orders and value generated. However, the company has set its sight on new product orders to facilitate organic growth and expand the business. The upper level of management therefore want to improve the number and generated value of motors sold for new orders.

The company's operational performance is affected by several factors that can either be internal or external with respect to the overall company or sales department. Many external factors are uncontrollable and unpredictable, such as the global pandemic and conflicts that negatively affect the supply chain and resource availability. Other external factors that had a large negative effect on the company include economic pressure through the increased prices of commodities, as well as emergent technology in the automotive industry. The unit price of metal commodities such as aluminium, copper and steel have significantly increased from 2020 until early 2022. These increased material prices therefore reduces the profit margins of the business, and has caused them to adopt several price increases on major product lines. Additionally, the automotive and electrical car industry has grown rapidly in the past several years, but shares a common resource with electric motors – such as electric steel. Therefore, the demand of electric steel has also increased significantly, affecting the availability for Electro Adda.

Other external factors, with respect to the sales department, can include the selling price, technical specifications and availability, delivery time of products and competition. As mentioned above, the selling price is affected by several other factors and cannot be controlled within the sales department, but is major contributor towards customers not willing to make the purchase. The availability of technical specifications required by the customer is also a key factor, since many of the clients request specific customised motors applicable to their particular industry. The production capacity of the company and delivery time of products can also cause orders to be lost, especially for the case of future orders from current customers. These factors thus deter both current and prospective customers from ordering new motor products.

Therefore, the internal factors that relate to the sales department include the waiting period and internal lead time. These factors can thus be controlled and managed accordingly by the sales team. The overall problem identified during the first month on site was that the internal process between a customer enquiry and an accepted order was very tedious – involving many feedback loops between multiple departments, lack of digital information flow and missing information. Such issues have collectively hindered the processing of new product orders internally, which is the focus of this report.

The table below indicates which factors are included and excluded from the analyses.

Table 2: Table to show all external and internal factors for Electro Adda and how each factor affects the company.

Factors	Lost Orders	Delayed Orders
External (Company)	- External Environment - Economic Pressure - Laws & Regulations - Emergent Technology - Competition	- Laws & Regulations - Third-party Logistics
External (Sales Department)	- Technical (Specifications) - Selling Price - Delivery Time of Products - Production Capacity	- Delivery Time of Products - Production Capacity - Availability of Technical Documents (Drawings) - Frequency and complexity of incoming customer enquiries
Internal (Sales Department)	- Waiting Period	- Internal Lead Time - Communication between other departments

The problem statement, following the A3 methodology, is therefore defined as follows:

New product orders are lost or delayed, owing to long waiting and internal lead times within the sales department.

In the past few years, Electro Adda had noted that they receive approximately 5000 and 6000 new order enquiries from prospective customers in 2020 and 2021, respectively, however only 25% and 21% of these enquiries were accepted and converted into confirmed customer orders. The figures below illustrate the proportion of new customer enquiries that are accepted, either with or without requiring the help of the technical department, as well as the orders that remained unconfirmed throughout the year.

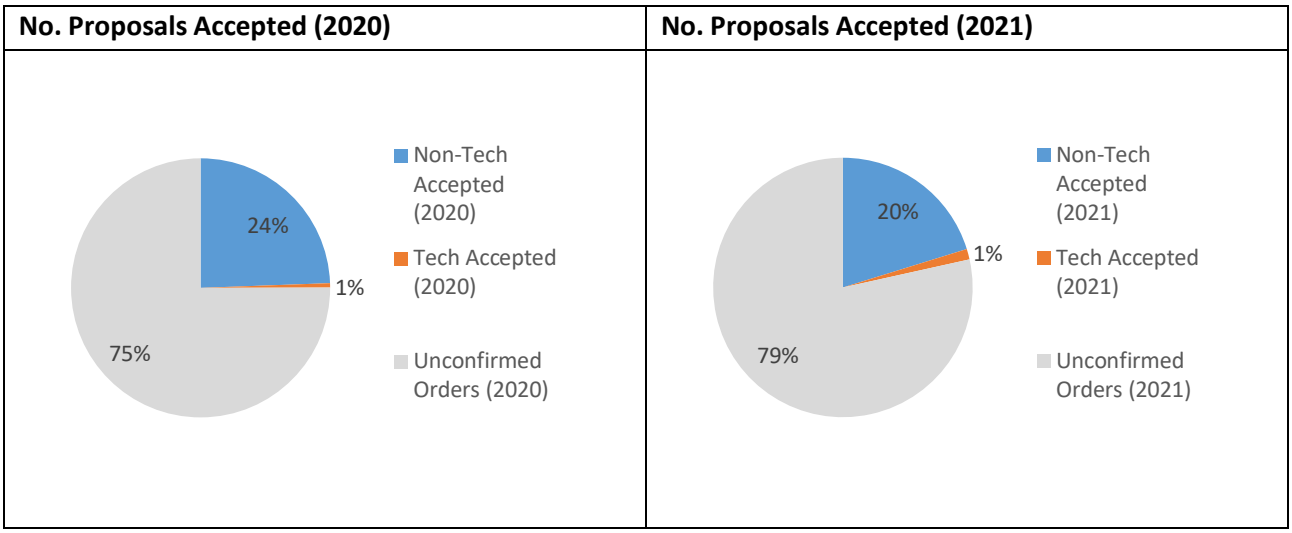


Figure 8: Figure to show the number of new proposals accepted by customers in 2020 (left) and 2021 (right)

The current sales force is limited to six employees, meaning that each sales representative can expect to process approximately 1000 new order proposals annually. Processing each order requires sufficient time to process, which also depends on the order complexity, therefore a digital sales configurator was identified and implemented by the company to aid the sales process in configuring orders to match the clients' requirements.

This sales tool, known as the configurator, allows either the customer or the sales representative to enter information into the Electro Adda configurator website and choose the ideal motor with two layers of customisation available. The initial premise is that the customer can freely and independently choose their own motor based on their desired specifications and the sales team can use the tool to cross-check customers' technical sheets with motors available in the Electro Adda catalogues. The current configurator however is rudimentary, containing a very basic and minimal layout with limited options. This tool was expanded upon by another Politecnico di Milano team in 2021 that created a test-configurator for the company based on updated catalogues. Although this new configurator was not made live for potential customers, it can now be used cautiously by the Electro Adda sales force to cross-check client demands with better accuracy.

3. Problem Breakdown

As discussed above, the problem is related to the long lead time for the sales department to generate a customer proposal after receiving an enquiry. The problem was therefore investigated further with respect to the process flow as-is, the process bottlenecks and in-depth data analysis – consisting of motor unit prices, order quantities and value, as well as proposal lead times through the process.

3.1. Order Proposal Flow Diagram

After identifying the problem, the process flow diagram was mapped to determine and identify specific problems within the proposal process. The simplified flow diagram can be seen below, with reference to the full flow diagram available in the appendix *(Full Process Flow Diagram).*

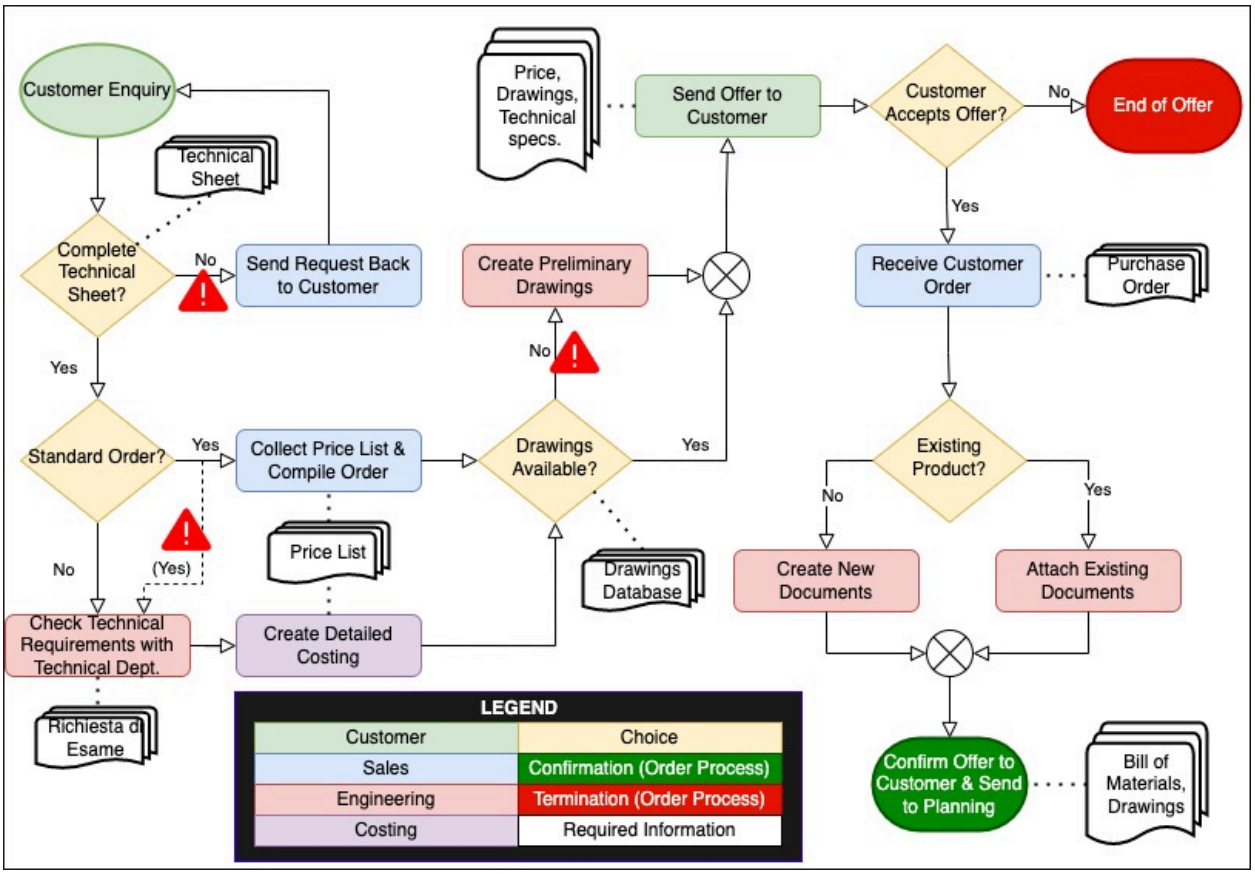


Figure 9: Process flow diagram for an order proposal process at Electro Adda S.p.A

The full order proposal process begins from a customer enquiry for a new product, since repeating orders have not been included in the scope of this project. The end points are defined as either offer confirmation to the customer and distributing the relevant information to the planning department, or if a customer rejects the offer. Since customers' decisions remain outside the scope of the sales department, the lead time from customer enquiry until the sales team has sent the prepared proposal to the customer was considered for this analysis. This simplified flow diagram is used to illustrate the pain points in the process, and not to give a full representation of the process. The Full Process Flow Diagram displays the overall process and better represents the complexities of the proposal process.

3.2. Order Proposal Process Description

The process begins when a customer wishes to enquire about purchasing a new electric motor, whereby they contact the sales/commercial department. This is either in the form of self-configurating their own technical requirement sheet (TS) based on a company template, or assisted-configuration with the sales department using the Electro Adda Configurator. This configurator, which is an option not currently readily available to customers, allows the customisation of motors on basic and advanced levels with three tiers of options available. Currently the sales department use information from the customer TS or direct customer instructions to fill out of the configurator for the requested motor, although this is only possible if the motor series is available on the configurator.

The first pain point (Bottleneck 1) in the process is when a customer is not clear or does not have a complete TS for the sales department, creating a loop between sales and the customer until all the required information is collected.

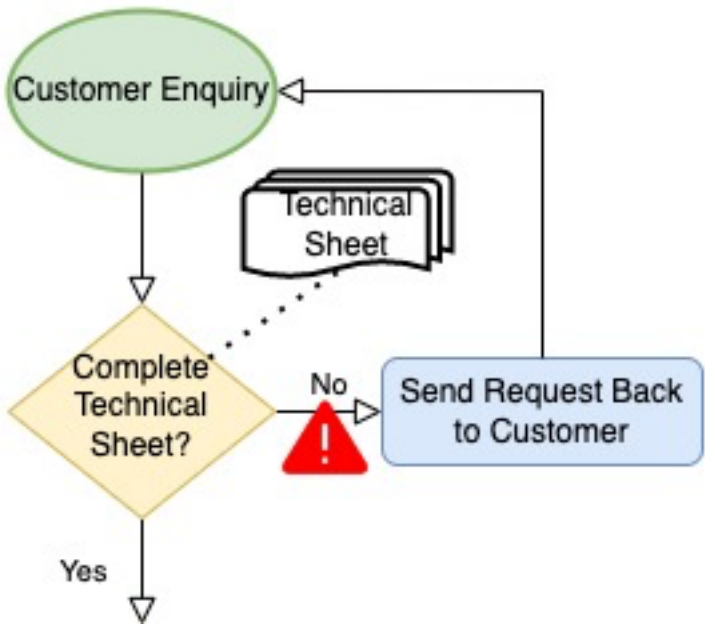


Figure 10: Diagram to show Bottleneck 1 - relating to an incomplete or incoherent technical sheet

Problem Description: *The lack of information sent to the sales department can significantly increase the lead time of the proposal process. Considering a completely new customer, the procedure and required information may vary across different industries and applications. Therefore, if a customer sends their own technical sheet to the sales team, it may exclude important details for the sales team to adequately identify and cost the motor, or it may include additional data that may not make sense to anyone without technical knowledge and experience. This means that the sales team may either send the technical sheet back to customers for clarification, hold the TS in their inbox until they are ready to focus more in-depth, or wait for the technical team to be available for any questions relating to the customer request. Each option therefore significantly increases the time for a technical sheet to be deemed acceptable for the next stage of the process. Repeating customers with new orders may reduce the likelihood of increasing the lead time as many have adapted their technical sheets to the Electro Adda sales force or existing technical sheets from previous orders should be available.*

The next step for the sales department is to assess whether the order is standard, consisting of make-to-order (MTO) motors, or a special order such as design-to-order (DTO) and engineer-to-order (ETO). If the motor is a standard MTO product, then the sales department retrieve the pricing list with all available options and compile the quotation ready for the next step. If the order is DTO or ETO, then generally the technical department is required to check the customer's technical requirements to see if they can be met. This information is then sent to the costing department for a detailed quotation.

The next pain point refers to the sales department that send the information to the technical department even when the order is standard. This therefore accumulates for the technical department where they have to spend extra time on low-value orders, taking time away for more ETO products, and delaying all potential orders.

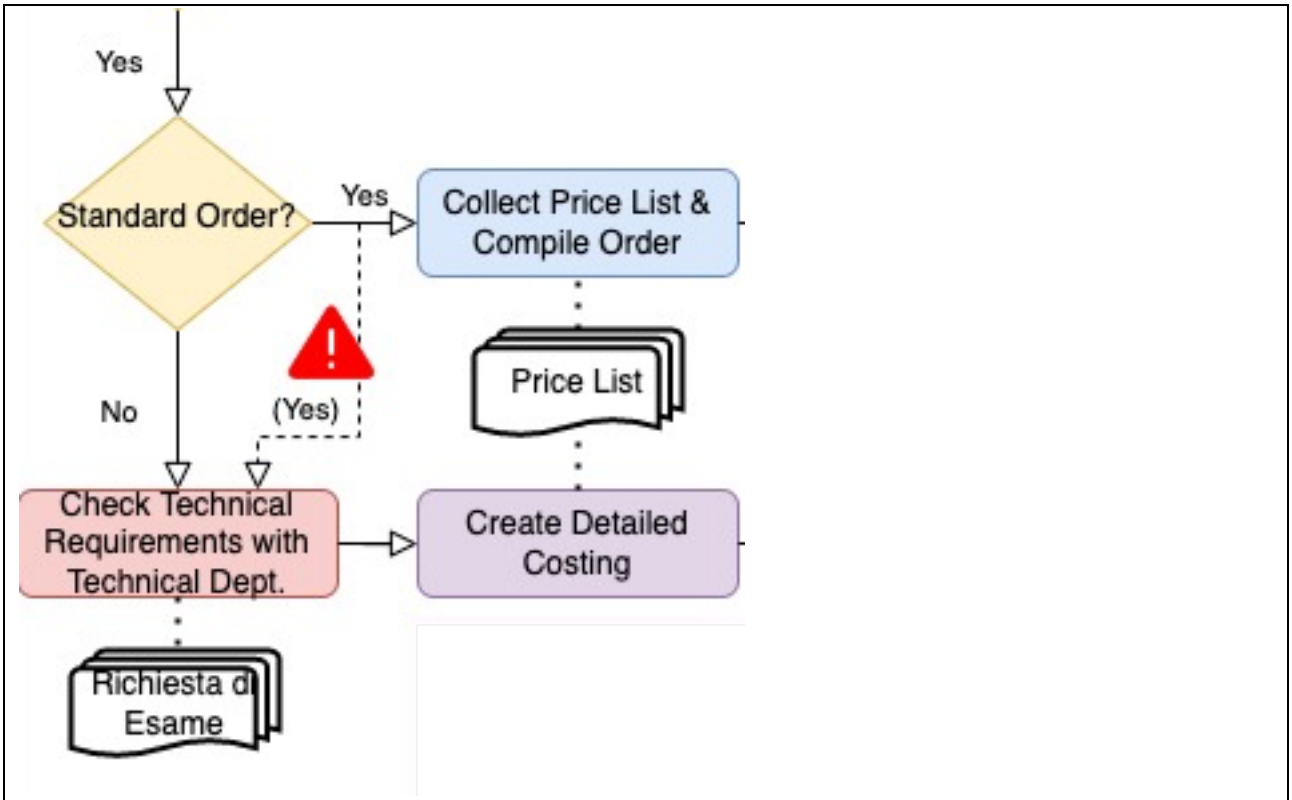


Figure 11: Diagram to show Bottleneck 2 - relating to the sales department that send standard orders to the technical department

Problem Description: *Whenever the sales team sends a standard order to the technical department to assess, the orders fill into their mailboxes with no indication of priority. This means that both high value and low value orders may accumulate for each member of the technical team, meaning that they may waste unnecessary time checking low value orders and passing the orders through the system to the costing department. The pricelists for the standard orders are available only in catalogue format and also require time to compile each order. It has been noted that the sales team still send the orders to the technical team even if the prices are available in the standard pricelists.*

Once the motor has been costed, the technical drawings must be attached for the full customer proposal. However there is only a limited database of drawings for existing motors, whilst new technical drawings must be created by the engineering team. This pain point thus delays the order process as the customer proposal cannot be complete until the preliminary technical drawings are completed.

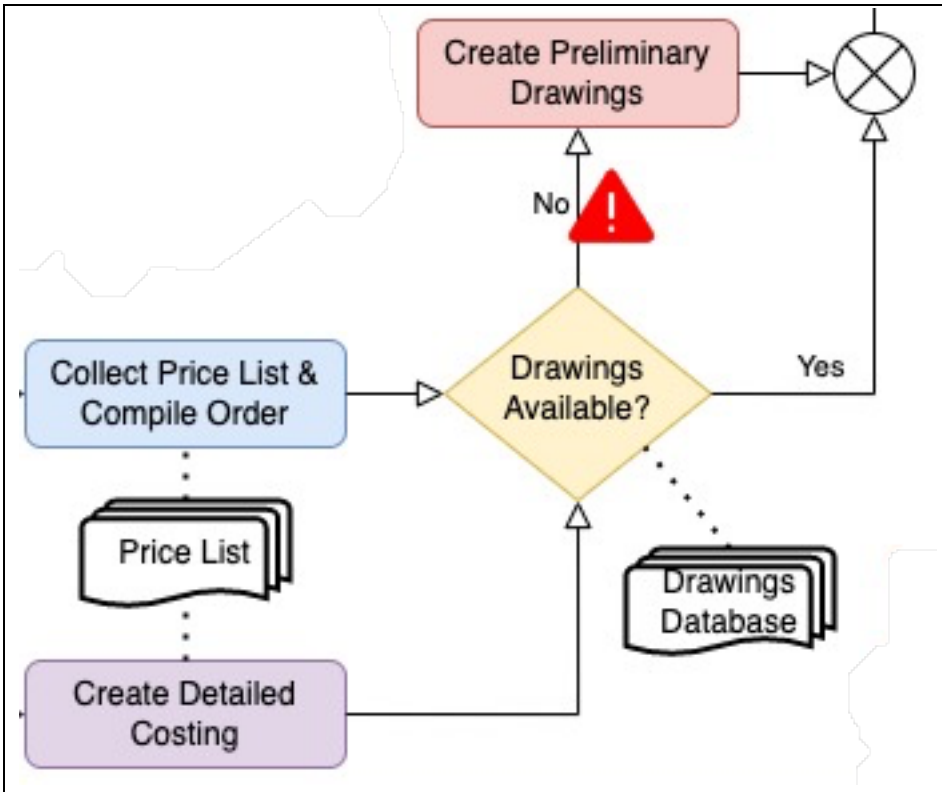


Figure 12: Diagram to show Bottleneck 3 - relating to unavailability of technical drawings for the customer

Problem Description: *Technical drawings are a requirement for all electric motor applications and related industries, therefore these must be attached to customer proposals. The engineering department is responsible for attaching these drawings to existing motor configurations, however a lot of time is spent for high-value customised orders. Creating these preliminary drawings is very time consuming and can heavily delay the order proposal process if they are overloaded with existing jobs. Existing drawings can be manually linked by the engineering department to previously configured motors, although this may also increase the lead time if lower valued orders are not prioritised since there is no automatic pairing of motors to drawings.*

Only once the technical documents, technical drawings and quotations are available, they are sent to the customer and wait for their response.

Now that the proposal is with the customer, the sales team has to await feedback whether the customer intends on proceeding with the order. If the customer does not accept the offer for any reason, the order process ends, although negotiation is possible. As soon as the customer order is confirmed, a purchase order (PO) is created within Electro Adda and loaded onto the internal platform (AS400) for all other departments to append their own information such as technical details, costing and bill of materials for the planning department. The next step is to attach all relevant documents to the order, whether it is an existing product

with available information or if it is a new product and requires new documents – such as a final technical drawing. The order is then confirmed to the customer and the information is forwarded to the planning department to place the order into production.

3.3. Data Analysis of Order Proposal Process

Data was collected and analysed from Electro Adda to produce insights to better describe the problem quantitatively. All customer proposals were thus analysed in terms of the total number of orders and the value that it represents to the company. This included comparisons between different motor series, confirmed and unconfirmed orders, as well as orders requiring the technical department or not.

3.3.1. Data Sources & Considerations

The data is captured in two formats, namely through Excel spreadsheets or through an internal platform (AS400) for tracking orders between departments. The former method relates to the sales department that manually input customer information onto an Excel spreadsheet that is saved onto the local K-drive of Electro Adda. This information includes the different dates (customer enquiry, date sent to other departments and date of offer), customer details, technical details, offer value and final order status (confirmed or not). Since this data was inputted manually, it included systematic errors from different sales personnel that inputted the data differently from their colleagues e.g. different definitions of “date of offer” meant that not all the data was consistent, as well as human errors e.g. the date exceeded the current date. Therefore, extensive time was spent cleaning the 2020 and 2021 datasets so that all values were consistent and followed the same logic. Many data points were cross-checked with the sales department to understand and explain the information displayed and updated accordingly.

The next tool, AS400, was developed in the 1980s by IBM and is currently used by Electro Adda for enterprise resource planning (ERP). Although not a modern ERP system, it allows the company to track and record orders between all department, with the information being stored on a server. This information is thereby more accurate than the Excel spreadsheet since the information is critical for each department to make important decisions regarding the customer order. This information was retrieved from January 2018 until March 2022, although it does not include all comprehensive data that is displayed on the Excel spreadsheets. Instead this information was useful for internal product analysis, such as order date, product code and description, type of motor, order quantity and order value.

3.3.2. Pareto Analysis of Motor Volumes and Value

Electro Adda has a wide range of motor selections for various industries or applications. Many of these options are displayed on the company website as follows:

Table 3: Table to show the main electric motors available from the online Electro Adda catalogues

Motor Series	Motor Description
C SERIES	three-phase asynchronous motors
S SERIES	Squirrel cage three-phase asynchronous motors. For smoke extraction systems
PE - SERIES	explosion-proof three-phase asynchronous motors
W SERIES	water cooled three-phase asynchronous motors
MR SERIES	three-phase asynchronous motors for roller tables
TH-MAR SERIES	three-phase asynchronous motors for marine applications
FE SERIES	three-phase asynchronous brake motors
CR SERIES	wound rotor three-phase asynchronous motors
VE-A SERIES	asynchronous motors for electric and hybrid vehicles
G SERIES	three-phase asynchronous generators for hydropower plants and windmills

Some items are also not shown on the company website, such as the TA-EG Series which is imported instead of manufactured. Since there are many options available, the analysis was simplified by considering the motor series that are significant in terms of order volume and value. The Pareto analysis of the various motors is thus shown below:

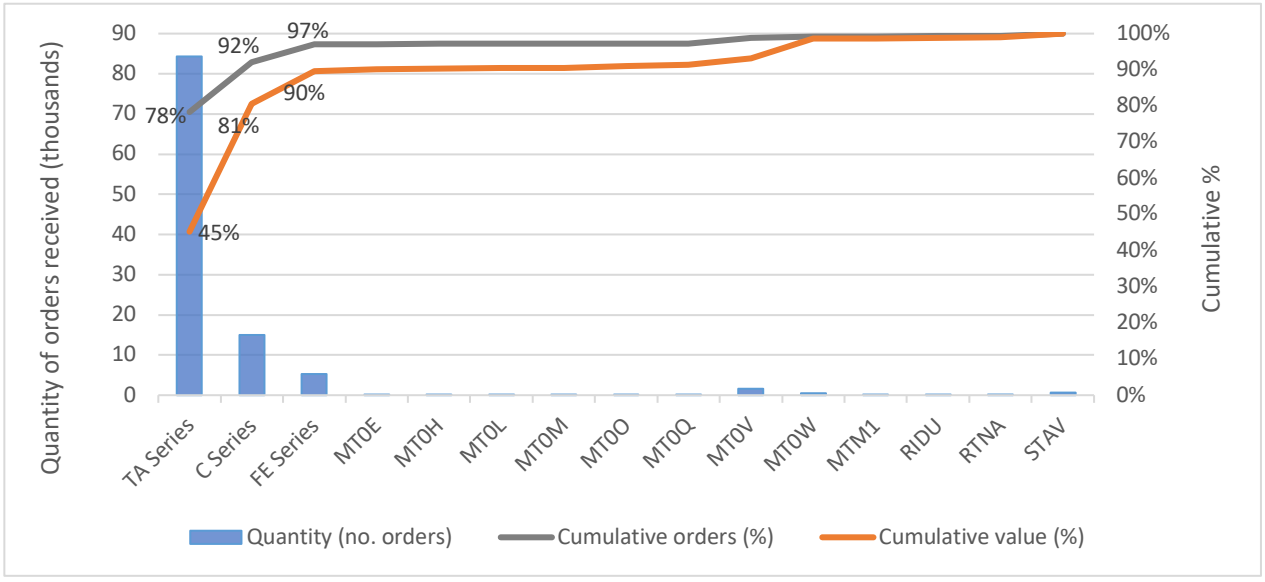


Figure 13: Pareto analysis of the most significant motors in terms of volume and value. The first three motor series codes (MT01, MT0C, MT0D) were replaced with their series names, respectively, for clarification.

The Pareto chart therefore shows that the first three motor series (TA Series, C Series and FE series) correspond to 97% of the total number of orders and 90% of the total value. The remaining series and spare parts were thus excluded from further analysis considering the unit prices and proposal lead times.

3.3.3. Unit Prices of Electric Motors

The next step was to compare the proportions of unit prices (€/unit) and relative changes from 2018 to 2021. This information is useful to understand how the nature of each motor series affects the business and relative importance of each motor series in terms of value. The figure below therefore indicates that the share of motor value between each series is very similar from 2018 until 2021.

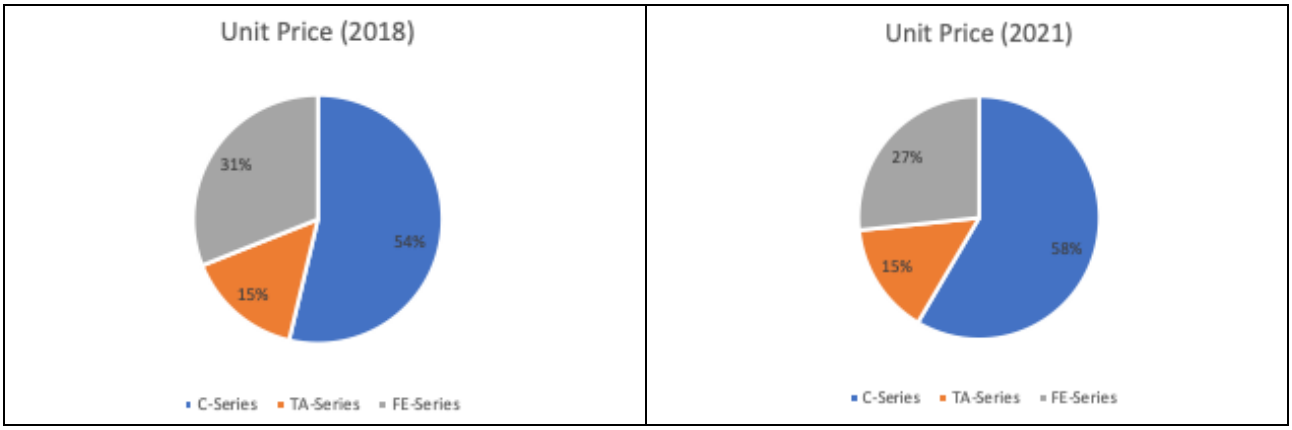


Figure 14: Figure to show the unit price of each motor series (C, FE and TA-EG) as a relative proportion (%) to one another

Although the relative unit price proportions stayed constant between the different motor series during this time period, the price increase of each series varied considerably. The figure below shows the increase of unit price in terms of value and relative increase (%) from 2018 to 2021. The values however were excluded as the information is confidential, however the graphical representation shows that the C Series dominates in terms of unit price, followed by FE Series and TA-EG Series, respectively. In terms of increases, the C Series has seen the highest increase of 28.3% from 2018 to 2021, followed by TA Series (15.2%) and limited increases from the FE Series (1.1%).

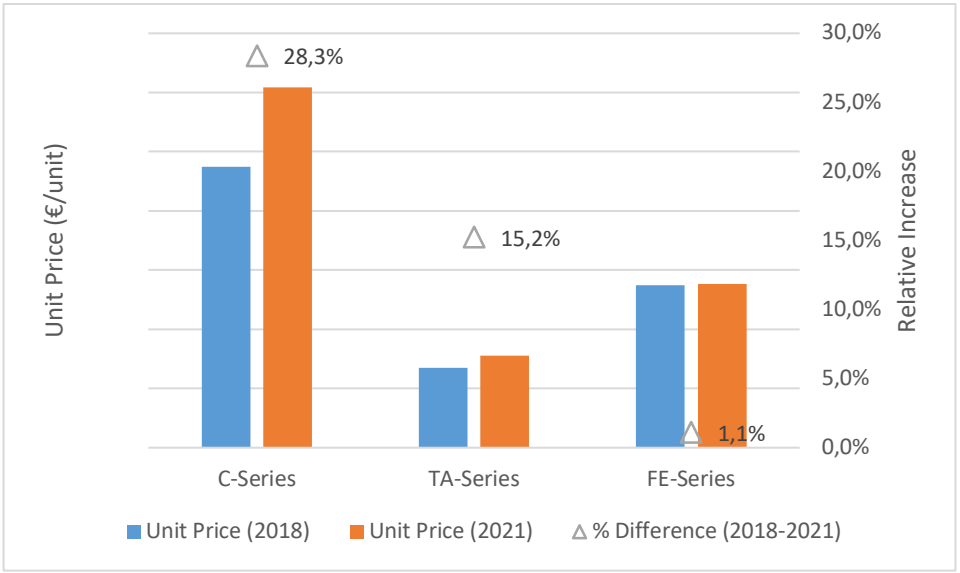


Figure 15: Figure to show the relative motor unit prices (values not displayed) and price increases from 2018 to 2021

Although sales factors such as motor selling price were external to the sales department, this analysis is helpful to illustrate the relative importance of each motor to the company, especially since the changes in unit prices have been significant for the C and TA-EG Series since 2018.

3.3.4. Order Quantities & Value

The company receives many customer enquiries, although not all are converted into confirmed customer orders. Many of these orders are lost owing to the external sales forces described in the problem description. Therefore, the following diagram indicates the extent of the customer proposals in terms of the number and value of orders, the split between the technical and non-technical departments (i.e. sales department) and the number of accepted proposals for 2021.

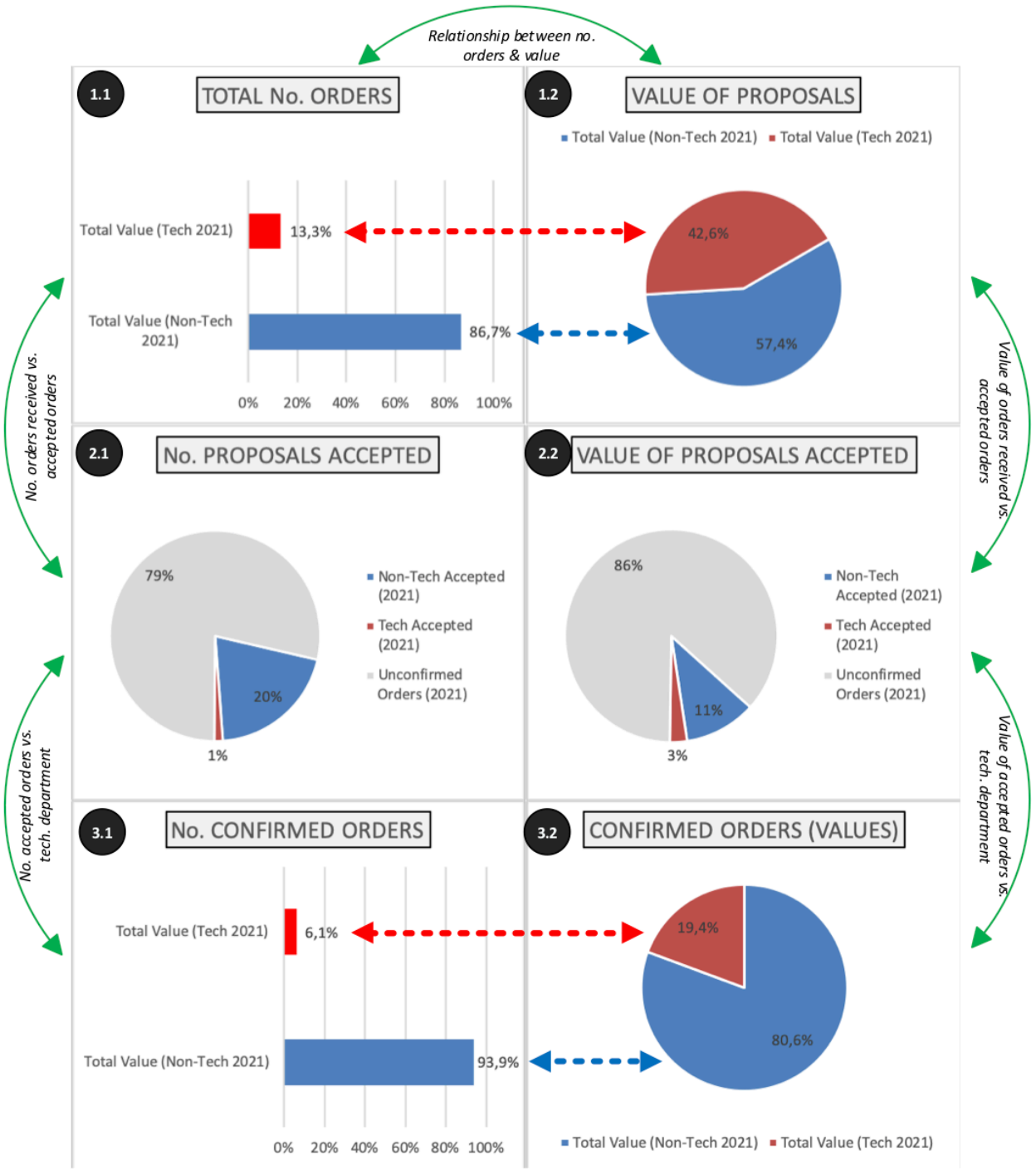


Figure 16: Figure to show the value flow for new orders for 2021, both in terms of no. orders and generated monetary value

Table 4: Table to describe the value flow for new orders in 2021 with relative descriptions and insights

No.	Description	No.	Description
1.1	The total number (quantity) of customer enquiries received by the sales department were sent to the technical department 13.3% of the times, while the remaining 86.7% was carried out within the sales team.	**1.2**	Although only 13.3% of the enquires were sent to the technical department, this corresponded to 42.6% of the total value received by the sales department in 2021.
2.1	From the total enquiries, only 21% of all orders were confirmed within 2021. The majority of orders (20%) were handled by the sales department, whilst only 1% of total orders were accepted and thus sent to the technical department.	**2.2**	Similarly, only 14% of the total value was retained by the sales team, with 11% corresponding to the sales department and 3% to the technical department.
3.1	From all the accepted and confirmed orders, 6.1% of these orders were sent to the technical department for processing, while the majority (93.9%) was processed by the sales team.	**3.2**	The confirmed orders thus show that 19.4% of all value created from new orders goes through the technical department, while 80.6% is handled by the sales department.

The information above contains critical insights from the data analysis, which can be summarised below:

- A significant proportion of company value (19.4%) is retained through a much smaller number of technical orders (6.1%).
- Only 21% of the orders were accepted by customers (14% of the value was retained).
- The insights shown were compared between the technical and non-technical (sales) departments to illustrate the value flow through the company. Additionally, standard and special orders were not included into the diagram above since not all requests to the technical department were special orders, but also included standard orders.

3.3.5. Order Proposal Lead Times

The company has previously categorised the orders according to their difficulty and complexity, which allows for the prioritisation and process flow of customer orders. This includes orders such as make-to-order (MTO), design-to-order (DTO) and engineer-to-order (ETO), in order of increasing difficulty. However, the process of characterising and capturing this data was halted during the covid-19 pandemic as the disruption did not allow the staff to spend more time on data capturing, with a clear focus on client and financial information. This means that limited information is available regarding lead times of each process order, especially for the various categories.

The company therefore provided their recommendations based on sales information before the pandemic, which can be summarised in the table below:

Table 5: Table to show the difficulty characterisation for the manufacturing of motors and their expected lead times (days)

Category	MTO	DTO	ETO
Process	Make-to-order	Design-to-order	Engineer-to-order
Lead Time (Days)	1-2	3-4	5+

Since this specific information was not available from 2020 onwards, the orders were characterised as either standard or special orders for this analysis – whereby MTO can be considered as standard products, while DTO and ETO are specialised products. The analysis was carried out using the most recent data from 2021 and 2022, after the adverse effects of the global pandemic had begun to settle. However, it was difficult to separate standard and special orders from the available dataset since this information was often neglected or entered incorrectly from the sales team. It was then required to spend time with the sales team responsible for inputting the values and cleaning the data to better represent the proposal lead time more accurately. The team identified and corrected 49 data points for the standard motors, while only 11 points were available for special orders. Although this is very few points and may not be representative of the data, the 11 data points were sampled from a specific customer characterised by high customisation and detail, as recommend by the technical team with regards to the analysis. Therefore, the special motor analysis was conducted using a carefully selected sample as per the technical team's suggestion. The figure below shows the boxplot diagram for standard and special orders in 2021 and 2022, alongside the descriptive statistics determined using Minitab.

Figure 17: Boxplot to show the lead time distribution between standard and special motors in 2021 and 2022

Table 6: Table to show the descriptive statistics between standard and special motors in 2021 and 2022

Variable	N	N*	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Standard Orders	49	0	3,041	0,299	2,091	1,000	1,000	3,000	5,000	9,000
Special Orders	11	0	12,73	3,77	12,49	4,00	6,00	8,00	14,00	45,00

The data therefore shows that the mean lead times (days) for standard and special motors were 3 and 12.7 days, respectively. There is however a very high standard deviation for both categories, considering that the number of data points were restricted and there is high variability in lead times – especially for special items. Two data points were originally flagged as outliers (27 and 45 days), however after investigating further with the sales team, these values were in fact accurate with a very long delay. This also affects the distribution of data, since the mean (12.7 days) for the special motors is much higher than the median (8 days). Conversely, the standard order lead times are more controlled, with equal mean and median values, although with a high standard deviation relative to the mean.

4. Target Setting

The next step of the A3 framework refers to the target setting of desired results. The targets discussed below were thereby discussed and agreed upon by the company's management team.

4.1. Setting the Targets

After analysing the process lead time above, it was then possible to define targets that are specific, measurable, attainable, relevant and time-based. The lead times were split between standard and special motor orders with mean values of 3 and 12.7 days respectively. The aim of this project is to thereby decrease the lead time of customer proposals, with targets that are a must-have (MH) and nice-to-have (NTH). These targets are summarised in the table below:

Table 7: Table to show the current and target lead times (days) for standard and special motors

Mean Value of Lead Times (Days)	Standard Order	Special Order
Current Value ($\bar{X}$)	3.0	12.7
Must-Have Target ($\bar{X}_*$)	2.0	6.0
Nice-to-Have Target ($\bar{X}_{**}$)	1.0	4.0

These MH values were chosen to reduce the lead times to acceptable level, set by our team in consultation with the Electro Adda management. These goals are also attainable since the MH values are possible to achieve, however orders with much longer delays can significantly increase the mean values. Therefore, this target will indirectly target and potentially eliminate extreme values. These targets have been represented visually as follows:

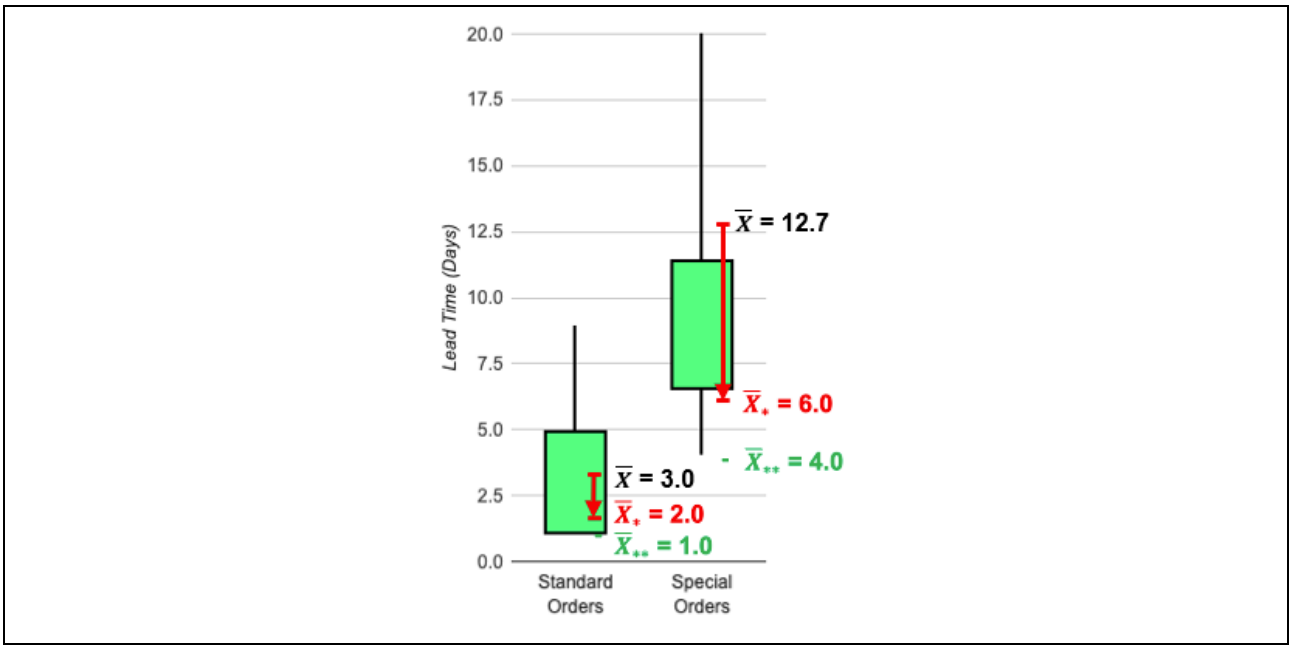


Figure 18: Boxplot to summarise the current mean lead times (days), must-have and nice-to-have targets

4.2. Standard Deviation

The standard deviation for this project was not selected as a major key performance indicator (KPI) for two main reasons. The first reason being that the scope of our work may have a positive impact on the mean lead time reduction, however the standard deviation and dispersion within the data is unknown – creating doubts that a reduction in standard deviation might not be attainable within the time frame of the project. Secondly, defining a specific target for the standard deviation might be arbitrary since there is not baseline for comparison. The best indication of data dispersion can be reflected using a histogram displaying both standard and special orders. The figure below indicates that the lead time for special motors is significantly spread out and with much higher values than standard orders. Although no targets will be set specifically for standard deviation, the histogram can be used to qualitatively describe the improvement of lead time after the implementation of countermeasures, as well as visually display the distribution around the mean lead time values.

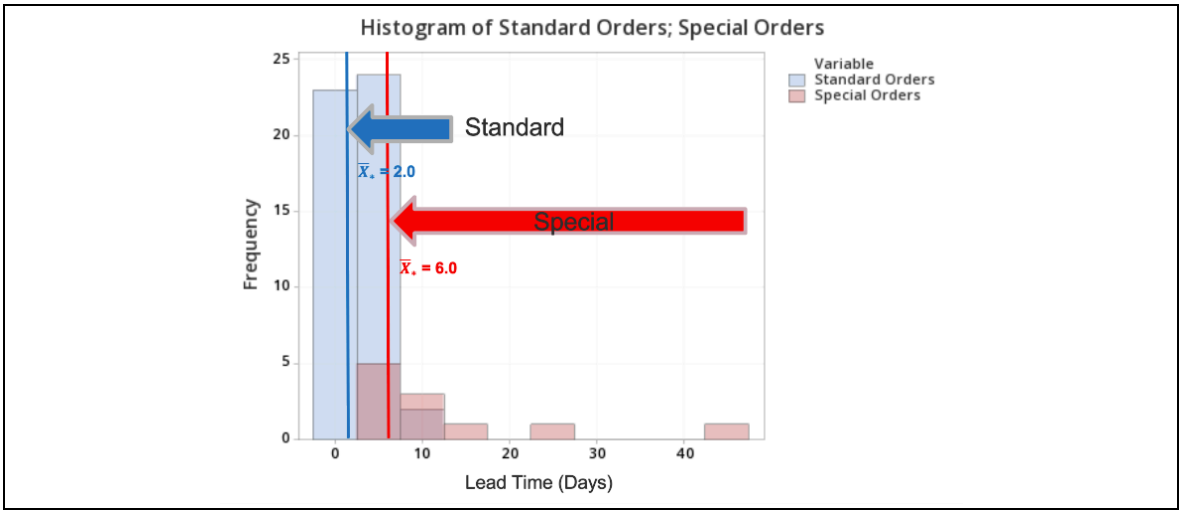


Figure 19: Histogram to show the lead time dispersion between standard and special motors in 2021 and 2022

4.3. Customer Enquiry Frequency

Another factor that must be considered is the frequency and complexity of customer enquiries, which can be split into orders that require technical assistance and non-technical orders that only need intervention from the sales department. If the frequency of enquiries increases over a certain period, these enquiries may accumulate within the sales team's inbox, thus causing order delays or even lost orders. Similarly, if the complexity of orders increases, the accumulation of enquiries may occur either within the sales department or even in the technical department. For this reason, it was important to evaluate the past trends of customer enquiries to determine whether the sales department or technical department may be overloaded.

Therefore, information was collected from the sales department regarding the number of customer enquiries received in 2021. These orders were split into technical and non-technical orders accordingly where they were tracked weekly. The figure below thus displays the number of customer enquiries (technical and non-technical) per week for the year 2021.

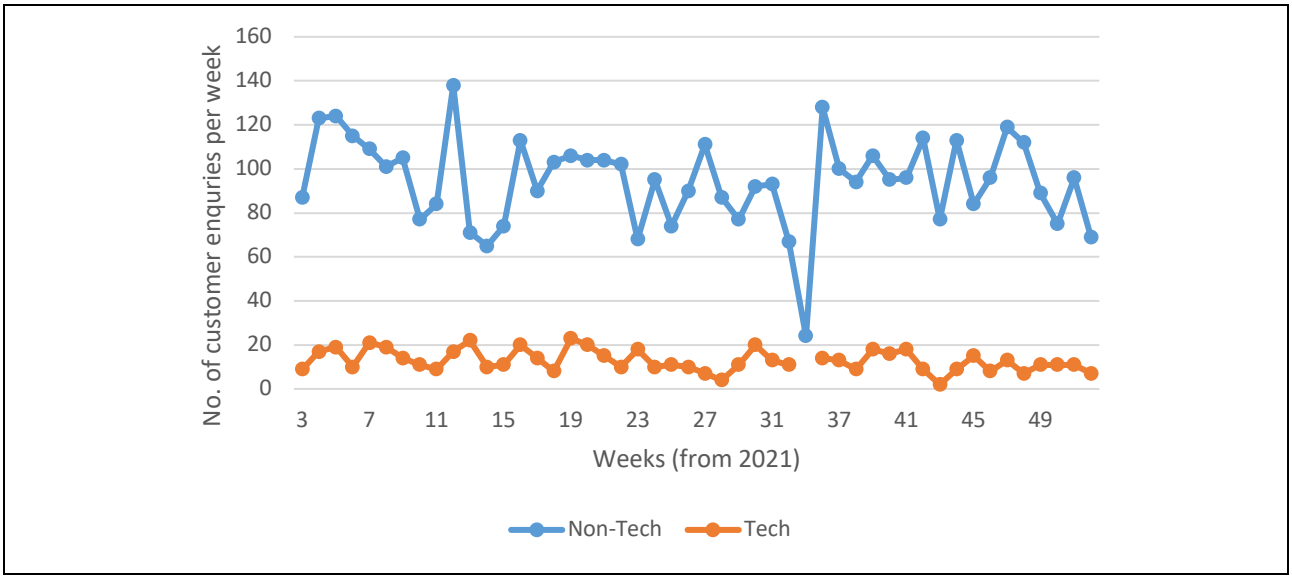


Figure 20: figure to show the number of customer enquiries (technical and non-technical) per week for the year 2021

The figure above therefore shows that the number of customer enquiries requiring the technical department ranges from 0-20 orders per week with low variability. For non-technical orders, the number of enquiries tends to range between 60-140 with a higher degree of variability.

Although this variability for non-technical orders is not ideal for the sales department, the more complex technical orders are stable and remain below 20 orders per week. This shows that there is no increasing trend in enquiries received, therefore allowing the assumption that the number of enquiries received throughout the year does not significantly increase – which would then affect the proposal lead times and influence the outcome of the results. If however there was a significant increase in the number of weekly enquiries received, then this could increase the proposal lead times if not matched with more staff.

5. Root Cause Analysis

Now that the targets have been set, it is important to determine the true root causes of the problem. Two methods following the A3 lean methodology included the Ishikawa, or fishbone diagram, to determine the overall causes, as well as the 5 Why methodology to further elaborate the overall causes and determine the root causes.

5.1. Ishikawa Diagram

The Ishikawa (fishbone) diagram first identifies a problem statement at the head of the body, to which all causes are related. This report is therefore focusing on the problem defined as: "Long lead time for new customer proposals". Using this problem statement, the causes of the problem are separated according to several categories i.e. Methods, Machinery (Equipment), Management, Materials and Man (People). However, for this report, only factors relating to methods, materials and man were identified. The diagram below is therefore the result of the Ishikawa root cause analysis, which will be discussed further:

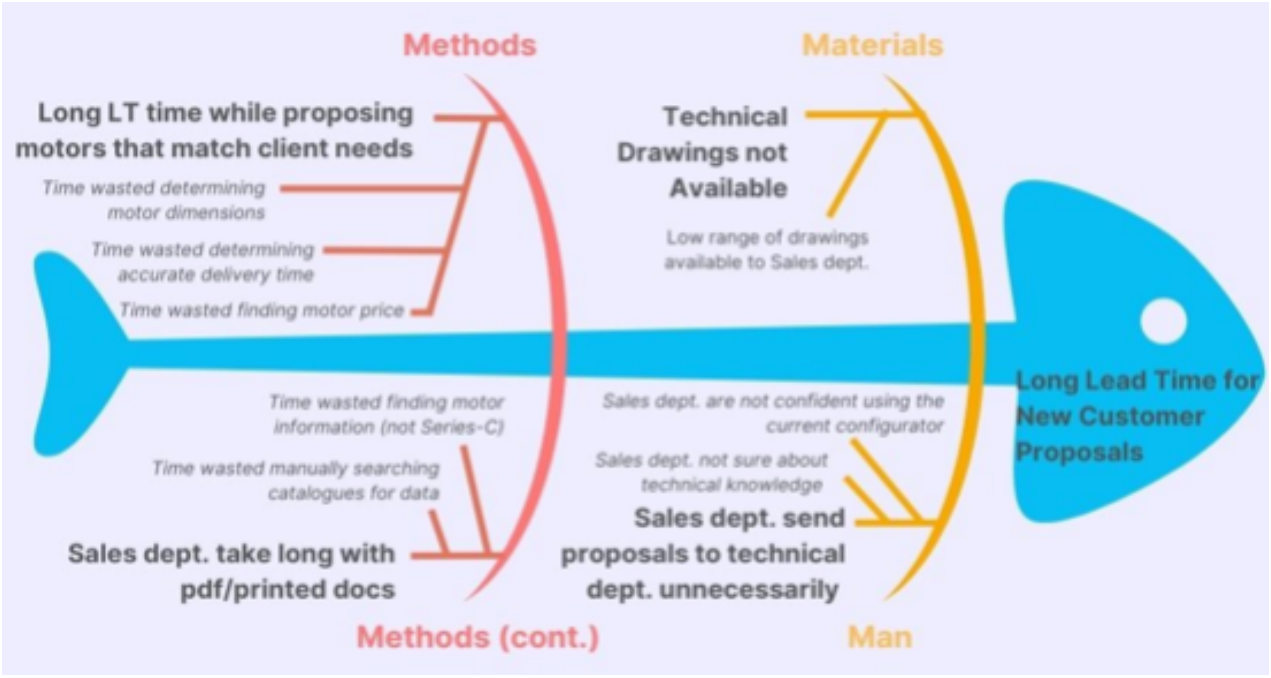


Figure 21: Ishikawa diagram displaying the causes of the problem defined as the "long lead time for new customer proposals"

5.1.1. Methods

When identifying the causes of the stated problem, many of the issues discovered relate to the methods carried out by the different departments within Electro Adda and the way they work together. These methods consist of the steps to produce a customer order, such as determining the motor specifications, delivery time and price. Therefore, the first main cause related to method is that it takes much longer time than required to propose a motor to a client that matches all of their technical needs.

The sales team begins by checking the technical sheets from the customer against the Electro Adda catalogues, whether printed or available on the shared network. Manually checking each catalogue between each customer technical sheet takes much time to ensure that the motor can be manufactured by Electro Adda. Sometimes the sales team can access the already existing test version of the online sales configurator,

however this is only applicable to the C-Series motors – which corresponds to approximately only 36% of the total value from new customer orders as established in the Pareto analysis. This means that the process to access other motor series is not streamlined or efficient. Similarly with the costs, the sales team has access to internal costing and price lists to give the customer quotations for their enquiry. The sales team are responsible for costing standard orders, while the special orders should be sent to the technical team and costing team for providing detailed technical pricing feasibility. The pricelists are not centralised and multiple versions exist, therefore making it difficult to find and use the most updated price information. Often the sales team will send the order to either, or both, technical and costing departments to avoid making errors regarding the order proposal. Another step relates to giving the customer an estimated time for order completion and delivery, depending upon the expectations of the customer. Currently the sales and planning departments hold a weekly meeting to discuss the next availability of motors. This list is based on current and already planned motors scheduled into production, which does not consider high levels of forecasting. Instead the motors are planned according to motor size families (small and large) and the estimated time to be completed. The sales team use this limited information to tell customers an expected release date, although they are not always confident in the feasibility of producing the motors by the set date, and often tell customers to expect a slight delay depending on the order type and customer.

Therefore, much time is wasted whereby the sales department have to manually find, collect and gather data regarding the desired customer motor to make an order proposal, usually from decentralised printed or online catalogues. This includes many steps, including asking each of the other departments for their inputs, which thereby creates many unnecessary loops that add to the proposal lead time delays.

5.1.2. Materials

The materials for our report relate to the collection of specialised technical drawing, usually referring specifically to the 3D drawings. These 3D drawings are required by all customers across all industries, especially within heavy industrial applications. The drawings contain important information to engineers that use the motors for installation, use and maintenance purposes. The current issue is that the collection of drawings is not large or diverse enough to cover all the standard motor configurations, especially not including customised motors that require much more time and effort to generate.

Once a customer enquiries about an order, the sales department then send all the related technical information to the engineering team to create a preliminary drawing. If the motor is standard and in the collection, the engineering team can simply modify some details to fit the customer requirements. However, this is often not the case, and many times the engineering team needs to spend much more time creating the preliminary drawings before the customer can even consider the order proposal. This also delays the sales team regarding both standard and special orders, although the latter are significantly more detailed and require more time. Therefore, the low range of technical drawings for existing motors is a limiting factor for producing more rapid customer proposals.

5.1.3. Man

The last branch of the Ishikawa diagram relates to Man, otherwise known as the employees of Electro Adda for this report. The main cause corresponds to the sales department that unnecessarily send standard motor orders to the technical department instead of compiling the order themselves. Although this issue also

relates to the method section through the process of sending proposals to other departments, it is strictly related to the sales personnel and their reasoning behind sending the information instead.

When a sales representative receives a customer enquiry, it is their job to assess the technical sheet and compile the customer order if possible. Since the sales team does not have much technical knowledge of the motors themselves, they are expected to send the orders to the technical team if the customer requirements are very specific or require expertise. The issue however is that if a sales representative is unsure of the technical feasibility, they simply forward the information to the technical team instead of manually checking through the catalogues or previous orders. This creates a bottleneck within the technical department, especially with many orders that are much lower value. The technical team should only focus on high-value orders, therefore this bottleneck restricts their ability to complete more complex orders. This delays both standard and special orders sent back to the sales team after the feasibility checks have been completed. The sales team also has access to the test version of the configurator, however it is very limited (only one working series), has several bugs and does not display their relevant information clearly.

These issues cause the customer proposal process to have longer expected lead times since many orders are delayed in the inboxes of the technical team when they could have been executed by the sales team. The root causes of each issue will be elaborated upon in the following analysis.

5.2. 5 Why Analysis

The 5 Why analysis is a useful tool to identify the true root causes by questioning each point of reasoning repetitively to determine the underlying causes. This method was used in conjunction with the Ishikawa diagram to reveal the true root causes step-by-step, since the Ishikawa diagram and related explanations have already given context to the problems. The table below shows how each cause in the Ishikawa diagram has been expanded to reveal the actual root cause of the long lead time for new customer proposals:

Table 8: Table to show the 5 Why analysis and determine the root causes for the long lead time for new customer proposals

Category	No.	*Why?*	*Why?*	*Why?*	*Why?*	*Why?* (Root Cause)
Method	1.1	Sales dept. takes too much time with pdf/printed docs	Requires manually searching catalogues for data	Info is available only on paper/pdf catalogues/internal documents	Database is inconsistent with updated information (Excel files)	**Database is partially incomplete**
	1.2	Sales dept. takes too much time with pdf/printed docs	Requires manually searching catalogues for data	Info is available only on paper/pdf catalogues/internal documents	Database is inconsistent with updated information (Excel files)	**Editing database not user-friendly & IT skills required**
	1.3	Time wasted proposing motors that match client needs	Client must contact sales dept. for info on required motors	Long time to inform client on dimensions of the motor	Clients have to ask sales for the technical drawing	**Drawings are not readily available for the client**

	1.4	Time wasted proposing motors that match client needs	Client must contact sales dept. for info on required motors	Finding the right motor is time consuming	Sales has to find required specifications manually on the excel	**Excel spreadsheets are time consuming since are not user-friendly**
	1.5	Time wasted getting the price of the motor	Unnecessary loops between departments	Sales discuss prices with costing department for accurate costing	Sales ask costing the price even if it is on the price list	**Sales avoids mistakes when matching specifications with costs on the price list**
	1.6	Time wasted for precise estimate of the delivery time	Unnecessary loops between departments	Sales discuss est. delivery date with planning department	sales requires precise estimate of the delivery time	**The estimated delivery time is imprecise**
Material	2.1	Technical Drawings not readily available	Low range of drawings available to Sales dept.	3D drawings not present in the database (External Project)	3D drawings designed by dedicated external team	**Specialised skills & information required**
Man	3.1	Sales dept. Send proposals unnecessarily to technical dept.	Sales do not have the technical knowledge	Sales are focused on orders, not tech. knowhow	Sales team's performance based on no. orders accepted	**Sales team aim to improve own KPIs, sending to tech. to avoid mistakes**
	3.2	Sales dept. are not confident using the current configurator	The configurator may have incorrect values	Configurator does not display all required or updated information	Existing configurator not checked for all customer conditions	**Information showed has inconsistencies and inaccurate values**

Now that the root causes have been identified in the final column of the table, it is possible to understand the extent of the problem and develop countermeasures to mitigate or eliminate these issues.

6. Development of Countermeasures

The development of countermeasures is the step of the A3 methodology, whereby the root causes are targeted and addressed to mitigate the problem. Therefore for this report, the focus will be on developing and implementing countermeasures to reduce the lead time of new customer proposals within the sales department to ensure that customer proposals can be processed in the required timeframe. This step of the process involved brainstorming within our team and in conjunction with the Electro Adda team – engaging with each department individually and with the management. This was an important step since the lean thinking approach often uses “Gemba walks”, focused on physically going to the affected area or department and witnessing first-hand how the process is carried out with the responsible team. This approach will be included in the countermeasure discussion, since all countermeasures should always consider the people that will eventually use them going forward.

Through careful consideration, concerning feasibility, cost, time required and continuity, the countermeasures were developed and summarised in the table below:

Table 9: Table to show the proposed countermeasures considering each root cause

No.	Root Causes	Countermeasure
1.1	Database is partially incomplete	**Update the database with FE series data**
1.2	Editing database not user-friendly & IT skills required	**Editing and manipulation of database from configurator**
1.3	Drawings are not readily available for the client	**Create configurator link & downloading of 3D drawings**
2.1	Specialised skills & information required	
1.4	Excel spreadsheets are time consuming since are not user-friendly	**Expand existing configurator to the other series**
3.1	Sales team aim to improve own KPIs, sending to tech. to avoid mistakes	
1.5	Sales avoids mistakes when matching specifications with costs on the price list	**Calculate the price automatically on the configurator**
1.6	The estimated delivery time is imprecise	**Display precise estimate of the delivery time directly on the configurator**
3.1	Information showed has inconsistencies and inaccurate values	**Correct bugs in the existing configurator**

6.1. Countermeasure Descriptions

Each countermeasure will thus be expanded upon and discussed below to show how they were considered. This will thereby define the starting points of each task, which can then be compared to the final implemented countermeasures.

6.1.1. Updating the database

In the past few years, Electro Adda underwent the task of adding all of the product catalogues onto a digital platform. This project was also carried out with a team from the Politecnico di Milano that focused on creating an electronic database for easier data management. The outcomes of this project were the new catalogues that can be easily edited or appended, as well as the baseline for the electronic sales configurator. Additionally, the team preceding ours also worked on updating the database with the most recent values since some international standards and regulations had changed with respect to energy efficiency.

However, upon closer inspection it was visible that not all of the tables in the catalogues had been included in the database. The previous team was concerned predominantly with the C Series motors, therefore the remaining series may have been overlooked. When we were adding the FE Series motors to the configurator options, we noticed that the information was not available on the database, but only on the catalogues. An example can be seen below for the FE Series motors that are missing information for the IE3 efficiency class:

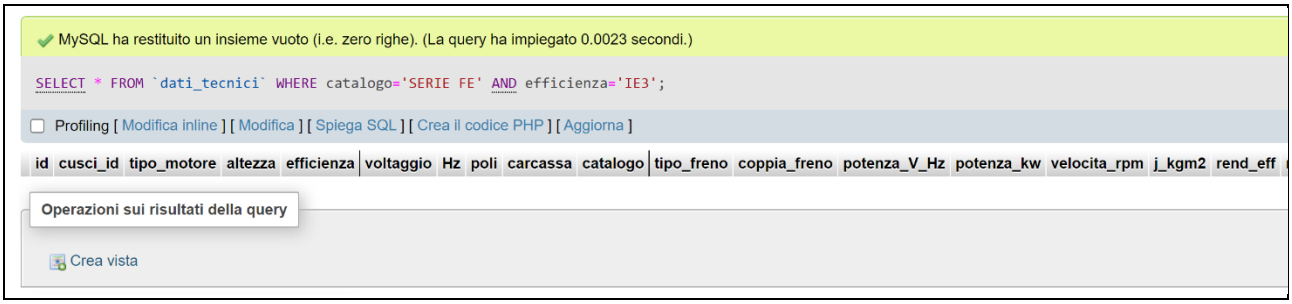


Figure 22: Figure to show an example of missing information, whereby the FE Series motors are missing information related to IE3 efficiency rating on the database whilst it is available in the catalogues

Therefore, it was necessary to crosscheck all catalogues with the database values to check if there was any incorrect or missing values that are essential to a working configurator.

6.1.2. Allow direct database editing from the configurator

The database mentioned above currently has very restricted access to ensure that the data integrity has been protected. Although this is standard protocol, changing or updating values on the database is very difficult since it requires login credentials, IT knowledge and a good understanding of how the database is configured. This means that the sales team do not have access to the database, yet the configurator uses those values. The image below indicates where and how the database can be manipulated through the server page *phpMyAdmin*. Once a user is logged in, they need to navigate to the desired table, click on the function they wish to use ("Insert" in this scenario) and edit the information. This is a very time consuming and tedious method to change values within the database, with more time wasted editing multiple data entries. It is also very important that the information added is correct and does not contain errors, as this would undermine the integrity of the database and create complications within the company using incorrect values.

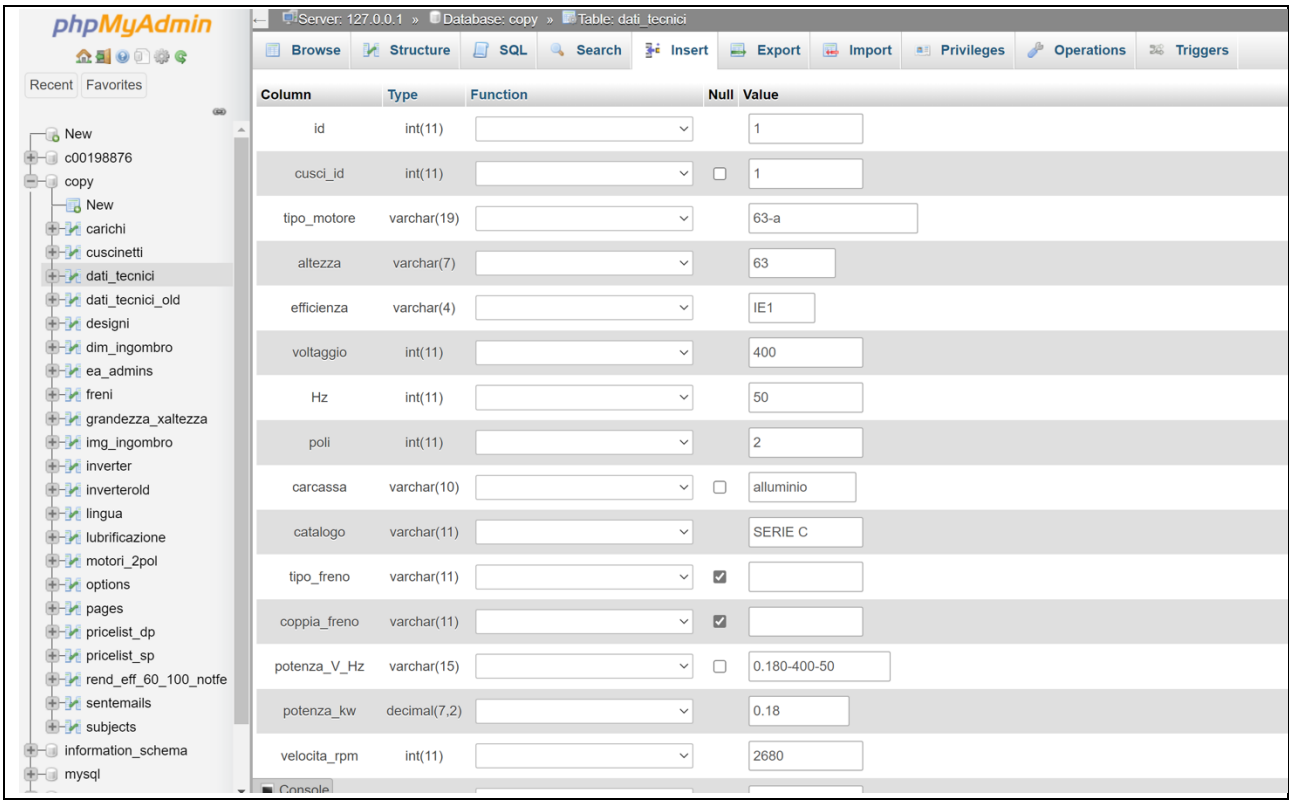


Figure 23: Figure to show an example of editing the database through the phpMyAdmin server, which is currently the only way to change, add or remove values in the protected database

Although the previously mentioned countermeasure will update the database with the most current and updated information, it is likely that motor information will need to be edited, added or removed in the future. Therefore a better method and interface to change the database will be created.

6.1.3. Allow download of 3D drawings from the configurator

Since the 3D drawings are a critical component of the sales process and part of the customer requirements, having greater accessibility to a wider range of drawings for different configurations would greatly reduce

the time taken for the engineering team to develop more preliminary drawings. Currently, when a customer's technical requirements have been verified by the sales or technical department, the information is sent to the engineering department to create preliminary drawings before the customer accepts the proposal. This step also takes considerable time depending on the complexity of the technical requirements.

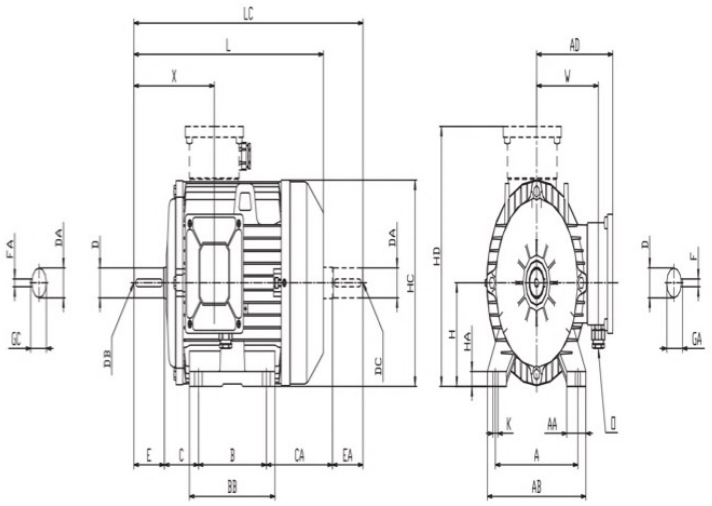
Alternatively, the current version of the configurator displays a basic 2D drawing of the standard motor accompanied with its physical dimensions. This was created so that customers have a better idea and understanding of the standard motor dimensions to aid their purchase decision. This idea was to give a preliminary version of the drawing to alleviate the workload on the engineering team and to decrease the backlog of motor drawings. These drawings, as seen in the figure below, are completely based on the standard motors for that specific size and do not actually represent the actual customisation options chosen by the customer on the configurator.

Standard Motor

Motor data sheet

Motor type: 100L-b Supply: GRID Efficiency: IE3

IEC 60034-1, IEC 60034-30



Overall dimensions

A	160.0	AA	37.0
AB	198.0	AC	
AD	155.0	B	140.0
BB	173.0	C	63.0
CA	107.0	H	100.0
HA	14.0	HC	205.0
HD	255.0	K	12.0
L	361.0	LC	430.0
X	160.0	W	123.0
E	60.0	LA	
D	28 j6	F	8.0
DB	M10x1.5	GA	31.0
DA	28 j6	EA	60.0
FA	8.0	GC	31.0
DC	M10x1.5	M	
N		T	
S		P	
O	M25x1.5		

Figure 24: Figure to show an example of a 2D drawing from the downloadable configurator technical sheet and its overall dimensions

As seen in the figure, the drawings are not a visually accurate representation, seeing as the motor shape is elliptical instead of circular. The dimensions are also used to indicate the approximate size of the motor, however these dimensions shown in the drawing do not represent the scale of the drawing or actual dimensions available at Electro Adda that are subject to change, especially if different motor options are requested. For example, if you desire a size-90 motor, the "S" and "L" models display the exact same drawings and labels, however the values in the dimensions table are different.

Therefore, it is important to generate better 3D drawings that are parameterised to a larger selection of motors and selected options. Another team from the Politecnico di Milano, Lecco, are currently working on a project to parameterise the Electro Adda catalogue and provide these drawings to the company. It is

therefore important to allow the download of these 3D drawings on the configurator once they are available to decrease the lead time waiting for drawings and improve customer satisfaction.

6.1.4. Expand configurator to other series

One of the biggest reasons that the current configurator is not yet marketed towards customers is because the configurator only has one working product line, namely the C Series. Likewise, the sales team do not regularly use the configurator when assessing orders for the same reason. This corresponds to 36% of the total value for new motor orders, as per the Pareto analysis described in the problem background, whereas the remaining 64% of value pertaining to other motor series have been omitted. This means that both customers and the sales team only have access to the online catalogues that are downloadable in pdf format. Searching through the catalogues can be very tedious whilst looking for very specific motor information, especially for new customers that are not familiar with the Electro Adda product catalogue. This potentially discourages customers from evaluating the motors for themselves, and definitely requires them to contact the sales team to move forward with an enquiry. The sales team also spend much of their time answering simple customer enquiries as the information is not readily available to the customer, as well as spending time themselves looking through the catalogues. The image below shows the current configurator product lines, whereby only the C Series is actively live.

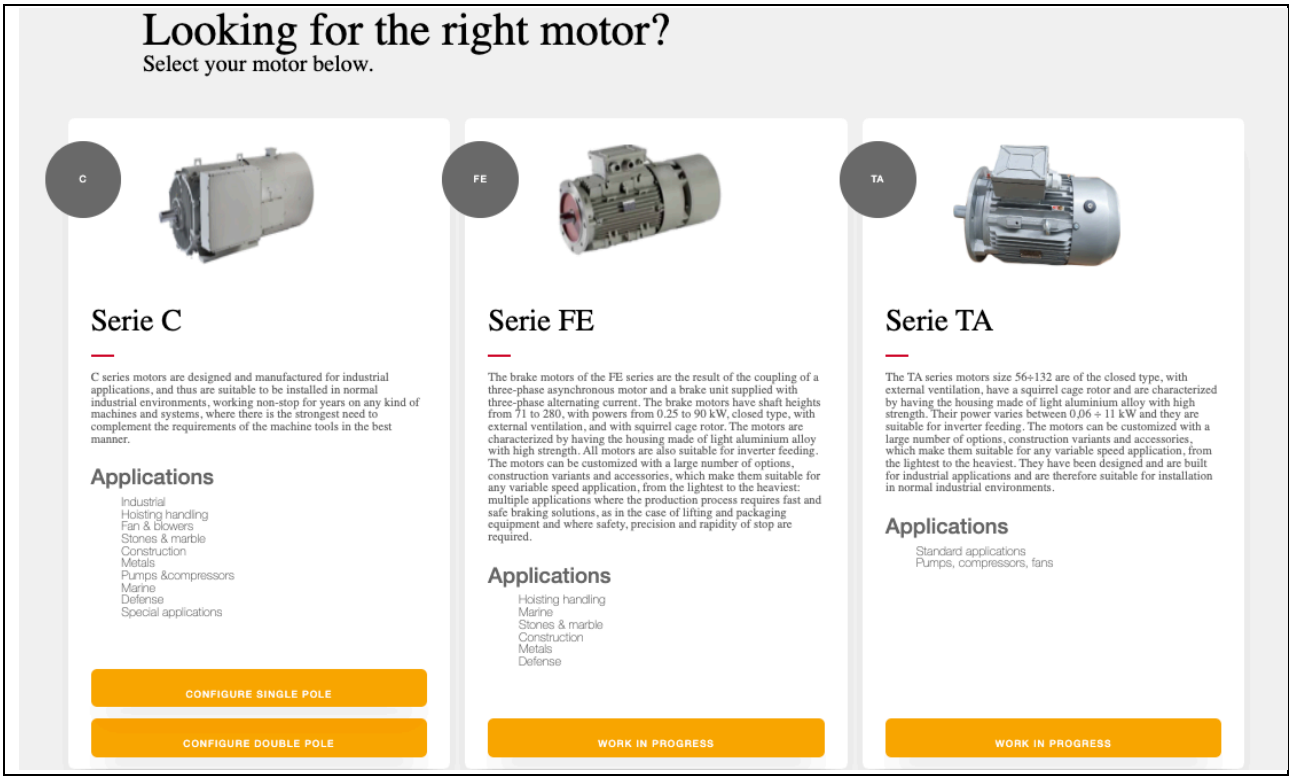


Figure 25: Figure to show the current configurator's product lines, whereby only the C Series is operational

Adding the additional motor lines (FE, FECC, FECCL, TA and EG) will allow customers to see options and customise accordingly, corresponding to 90% of the total value of new orders (Pareto analysis). The aim is to reduce the difficulty and time wasted for customers enquiring about the other major product lines whilst simultaneously improving the efficiency of the sales team to find the right motor specifications and options to match a customer's enquiry.

6.1.5. Automatically calculate the motor price from the configurator

Similar to finding the correct motor specifications from a catalogue, finding the price options for motors can only be found in internal Electro Adda catalogues, although only available to the sales, technical, costing and planning departments within Electro Adda. The company prefers not to disclose motor prices publicly, as they wish to protect their pricing options from competitors. This sensitive information is therefore kept internally, with no intention to add pricing options for customers on the configurator. An example of the pricing list with different customised options and shaft height has been included below, although the values have been omitted owing to confidentiality of sensitive information.

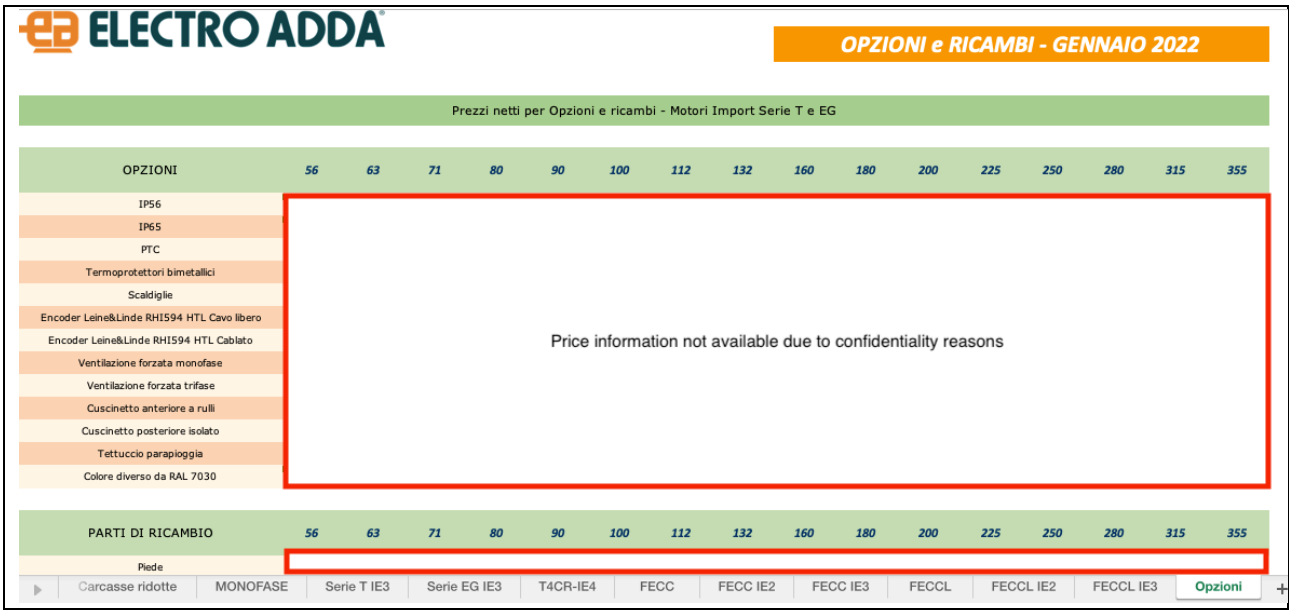


Figure 26: Figure to show the outline of the pricing list available internally to Electro Adda, whilst the values have been omitted for confidentiality reasons

The aim of this countermeasure is therefore related to reducing the time taken by the sales team to find correct and updated pricing options from the internal catalogues. Instead, the pricing options can be compiled into the existing database and displayed on the configurator depending on the options selected, thereby reducing the time taken for evaluating each individual option. It is therefore important to hide this information from the customers for the time being, so these values will only be accessible to Electro Adda users logged in to the configurator through the administration area. The employees that have access to this sensitive information should also be carefully selected by the Electro Adda management team.

6.1.6. Display lead time estimates from the configurator

The lead time of customer orders is important as each customer wishes to know the expected date of arrival for the motors, especially if the order is time-sensitive. Currently the only estimate of production and delivery dates is available from the planning department, whereby a weekly scheduled meeting provides the sales team with the available production scheduling. An example of the information shared can be seen below, which is a typical planning sheet for one specific week.

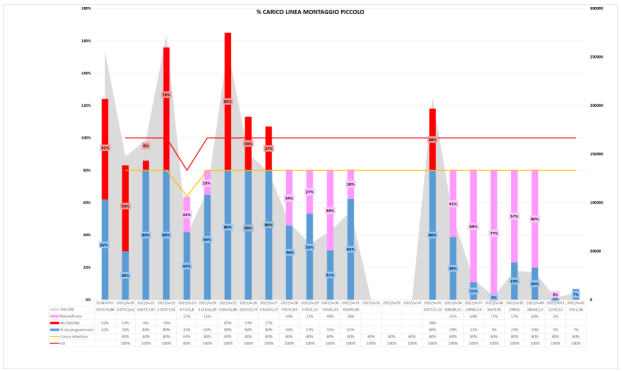
RIUNIONE PRODUZIONE - COMMERCIALE	n. 20	DATA:	16/05/2022

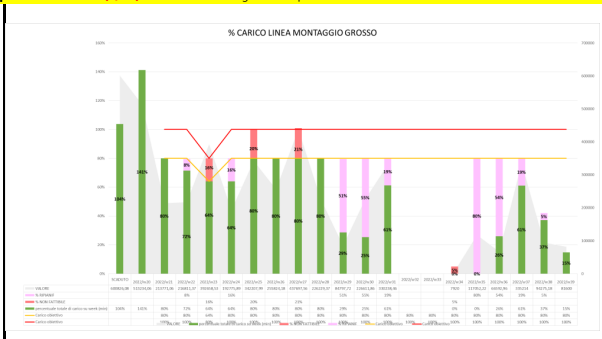
SITUAZIONE ATTUALE

Assenze:

MONTAGGIO PICCOLO	MONTAGGIO GRANDE
Linea piccola satura fino a week 40 di consegna considerando il ripianificato per recuperare scaduti:	Linea grande satura fino a week 37 di consegna considerando il ripianificato per recuperare scaduti:
PROSSIMI ORDINI da inserire: week 29 (22/07) per motori alluminio e standard !	PROSSIMI ORDINI da inserire: week 29 (22/07) per motori alluminio e standard 160 - 280T
per autofrenanti: week 30 (29/07)	per autofrenanti: week 30 (29/07)
per motori ATEX: week 31 (05/08)	per motori ATEX: week 31 (05/08)

Data di consegna per motori autofrenanti con voltaggio speciale: WEEK 36 (9/09) - lead time di consegna di Temporiti





ORDINI fino al 27/05:

	Fattibile	Non fattibile	Carcasse	Rotori	Flange/Scudi	Freno	Altro
già scaduti: 688	50%	50%	77	392	84	42	14
in scadenza al 20/05: 403	36%	64%	37	23	5	5	0
in scadenza al 27/05: 448	41%	59%	202	366	59	48	0

ORDINI fino al 27/05:

	Fattibile	Non fattibile	Carcasse	Rotori	Flange/Scudi	Freno	Altro
già scaduti: 175	28%	72%	60	81	41	3	4
in scadenza al 20/05: 147	29%	71%	78	86	59	1	4
in scadenza al 27/05: 53	9%	91%	33	31	11	4	2

Figure 27: Figure to show an example of the weekly production planning sheet given to the sales department every Monday, split between different motor sizes and characteristics

The planning sheet is split between small motors (“Montaggio Piccolo”, below a shaft height of 132 cm) and large motors (“Montaggio Grande”, above and including a shaft height of 132 cm), showcasing the next available dates for different motor types i.e. standard motors, motors with brakes and ATEX motors (special cast-iron motors). The production plan has also been included and displays if the production has exceed the line capacity. The bottom of the page also summarises how many motors and which percentage are delayed based on their characteristics.

The sales team therefore take this information and relay it to the customers when asked, although the feedback our team received is that these estimates are not accurate and usually have additional delays. The sales team also have to contact and wait for responses from the planning department for customer enquiries with specific technical requirements not included in the planning sheet above. The planning team can also not be certain on delivery dates since there is no stock management system in the warehouse, and motor parts are counted manually and updated on an Excel spreadsheet. Therefore extra delays are observed when certain parts with high procurement times have limited stock, requiring the company to place orders before the stock runs out. A countermeasure is thereby required to indicate a more accurate lead time to the customers without having to constantly interact and wait for responses from the planning department. This

is however limited by the lack of a stock management tool and lack of information regarding internal production times for motors based on different configurations.

6.1.7. Correct bugs in the current test configurator

The final countermeasure to be developed is based on the bugs existing in the current test configurator. During the initial stages of the project, we were alerted to several issues with the configurator such as missing information, incorrect values, formatting issues and incorrect outcomes. The feedback received by the sales team is that they were reluctant to use the configurator to assess customer inquiries because of several bugs, which thus led to a lack of confidence in the online sales tool. An example of several bugs can be seen below, whereby the "cusci_id" column has missing values and "coppia_freno" has formatting issues.

id	cusci_id	tipo_motore	altezza	efficienza	voltaggio	Hz	poli	carcassa	catalogo	tipo_freno	coppia_freno
1343	*NULL*	CA 71-2 FE-a	71	n.a.	400	50	2	alluminio	SERIE FE	70 MD/MS	3.75â"œÃ€9
1344	*NULL*	CA 71-2 FE-b	71	n.a.	400	50	2	alluminio	SERIE FE	70 MD/MS	3.75â"œÃ€9
1345	*NULL*	CA 80-2 FE-a	80	n.a.	400	50	2	alluminio	SERIE FE	MEC71 MD/MS	6.8â"œÃ€17
1346	*NULL*	CA 80-2 FE-b	80	n.a.	400	50	2	alluminio	SERIE FE	MEC71 MD/MS	6.8â"œÃ€17
1347	*NULL*	CA 90S-2 FE	90S	n.a.	400	50	2	alluminio	SERIE FE	90 MD/MS	26.9â"œÃ€35
1348	*NULL*	CA 90L-2 FE	90L	n.a.	400	50	2	alluminio	SERIE FE	90 MD/MS	26.9â"œÃ€35
1349	*NULL*	CA 100L-2 FE	100L	n.a.	400	50	2	alluminio	SERIE FE	100 MD/MS	30â"œÃ€48
1350	*NULL*	CA 100L-2 FE	100L	n.a.	400	50	2	alluminio	SERIE FE	100 DD/MS	60â"œÃ€96
1351	*NULL*	CA 112MT-2 FE-a	112MT	n.a.	400	50	2	alluminio	SERIE FE	100 MD/MS	30â"œÃ€48
1352	*NULL*	CA 112MT-2 FE-a	112MT	n.a.	400	50	2	alluminio	SERIE FE	100 DD/MS	60â"œÃ€96

Figure 28: Figure to show examples of bugs in the current database, such as missing values and incorrect formatting, which is linked to the configurator

Although the bugs are fairly noticeable and can be corrected, the bigger impact is the lack of confidence in the configurator, which deters the sales team from using it more frequently. Together with the other countermeasures, the aim of to instil confidence into the sales department to work more independently through the configurator.

6.2. Countermeasure Summary

After exploring each potential countermeasure in detail, it was important to assess each of them with respect to the impact on lead time, benefit to the company and difficulty in executing. These values were chosen based on our understanding of the process and consultations with the management team of Electro Adda. The impact on lead time was thus characterised as either a large-direct impact, medium-direct impact or even a low-indirect impact. The benefit of each countermeasure for Electro Adda was also chosen and measured as a ranking from 1 to 7, with 1 being the most significant impact. Additionally, the difficulty was rated from level 1 to 5, with level 1 being the most difficult to implement. The table below summarises the countermeasures and assigned values:

Table 10: Table to show each countermeasure and its impact on the lead time, benefit to the company and difficulty for implementation

Root Causes	Countermeasure	Impact on Lead Time	Benefit Ranking (1 = highest)	Difficulty (1-5) (1 = Most Difficult)
1.4 & 3.1	1) Expand existing configurator to the other series	Large-Direct Impact	1	1
1.5	2) Calculate the price automatically on the configurator	Large-Direct Impact	2	2
1.3 & 2.1	3) Create configurator link & downloading of 3D drawings	Medium-Direct Impact	3	3
1.6	4) Display precise estimate of the delivery time directly on the configurator	Medium-Direct Impact	4	2
1.1	5) Update the database with FE series data	Low-Indirect Impact	5	3
1.2	6) Editing and manipulation of database from configurator	Low-Indirect Impact	6	4
3.1	7) Correct bugs in the existing configurator	Low-Indirect Impact	7	5

The table above therefore indicates that the countermeasures relating to expanding the configurator to other series and including automatic price calculations has the biggest and most direct impact on the proposal lead time with the highest benefit to the company. This is because the sales team spend the most time trying to find relevant information to match the customer's technical needs through their printed or digital catalogues unnecessarily. These measures should thus aid in centralising the information, simplifying the process and providing the most up to date information possible. However, these countermeasures also have high degrees of difficulty, with values of 1 and 2, respectively. This is because the database needs to be updated with information that is only available on the catalogues and requires a high degree of IT skills to create the code and associated logic. These countermeasures can be considered as "Major Investments", since they have the highest benefit and difficulty for implementation.

The next countermeasures, relating to medium-direct impact on lead time, correspond to creating the configurator link to allow 3D drawing downloads and displaying estimations of the delivery lead time. These countermeasures were perceived to be important to achieving high levels of success, although not as significant as the countermeasures listed above. This is because the sales team spend time unnecessarily either waiting for the technical drawings or estimating a realistic delivery date, however these issues correspond more with the engineering and planning departments, respectively, thus having a higher importance to linking the departments to the sales team compared to the sales department working independently. The difficulty rating is also relatively high, with values of 3 and 2, respectively.

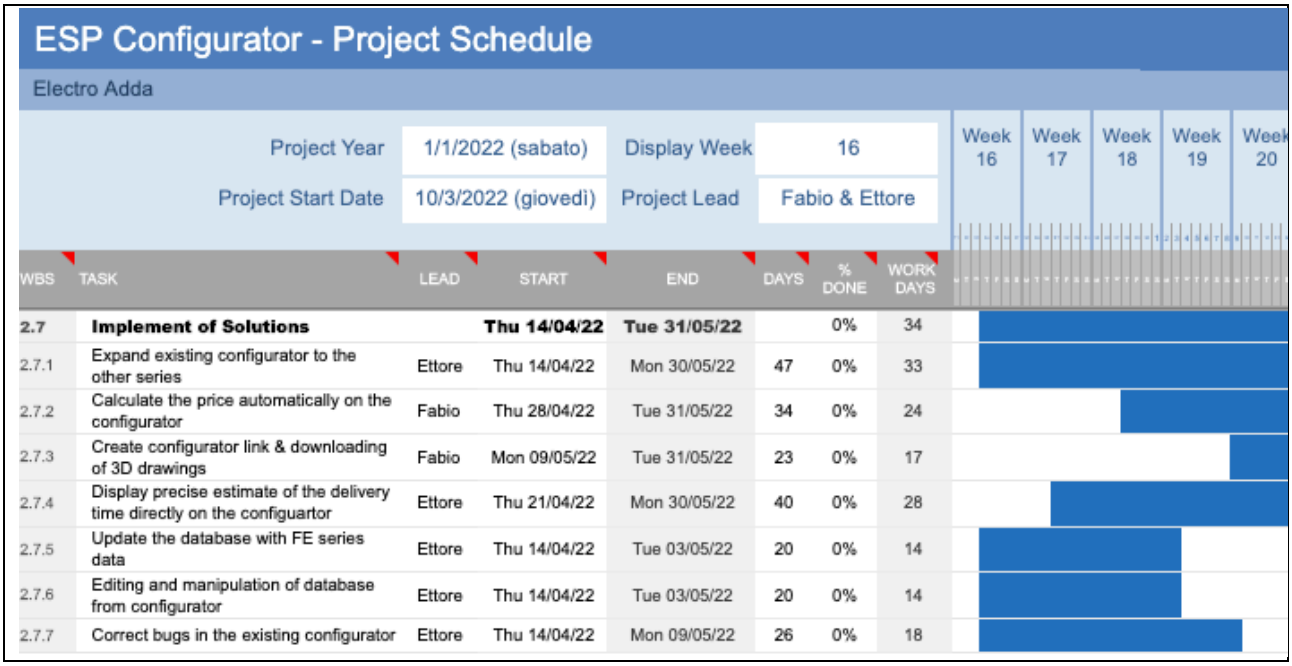
Finally, the last three countermeasures relate to low-indirect impact on the proposal lead time, namely updating the database, creating an option to edit the database through the configurator and correcting existing bugs. These countermeasures are still deemed essential to improving the configurator, although they were ranked lower in terms of benefit to the company as the effect on lead time has a more indirect relationship. These were therefore considered as "Quick Wins" as they can be implemented much more easily and still hold importance to the functioning of the configurator.

7. Countermeasure Implementation

Now that the countermeasures have been identified, it is important to carefully plan their implementation, considering the workload required and available dates, as well as tracking their development step-by-step.

7.1. Countermeasure Plan

To better plan and track the development of the countermeasures, a Gantt chart was utilised as a suitable tool. The image below displays the Gantt chart that was created after identifying all necessary countermeasures, which is useful to understand how the project was planned. The full Gantt chart can be viewed in the appendix *(Gantt Chart)* in relation to the full project and actionable items.



WBS	TASK	LEAD	START	END	DAYS	% DONE	WORK DAYS
2.7	**Implement of Solutions**		**Thu 14/04/22**	**Tue 31/05/22**		0%	34
2.7.1	Expand existing configurator to the other series	Ettore	Thu 14/04/22	Mon 30/05/22	47	0%	33
2.7.2	Calculate the price automatically on the configurator	Fabio	Thu 28/04/22	Tue 31/05/22	34	0%	24
2.7.3	Create configurator link & downloading of 3D drawings	Fabio	Mon 09/05/22	Tue 31/05/22	23	0%	17
2.7.4	Display precise estimate of the delivery time directly on the configuartor	Ettore	Thu 21/04/22	Mon 30/05/22	40	0%	28
2.7.5	Update the database with FE series data	Ettore	Thu 14/04/22	Tue 03/05/22	20	0%	14
2.7.6	Editing and manipulation of database from configurator	Ettore	Thu 14/04/22	Tue 03/05/22	20	0%	14
2.7.7	Correct bugs in the existing configurator	Ettore	Thu 14/04/22	Mon 09/05/22	26	0%	18

Figure 29: Figure to show the Gantt chart used to plan and measure progress of all identified and actionable countermeasures.

The Gantt chart was established using 10 March 2022 as the start date, since this was the first time our team went to visit the company in presence. Much of the time was spent on understanding the company and learning the associated processes, especially in connection with the sales department. Within the work breakdown structure (WBS), the previous levels relate to all the work discussed previously in our project report. The countermeasures, as depicted above, were split between our team to actively ensure that someone was accountable for the work planned. These were split according to each of our competencies and specialities.

The first date for the implementation of countermeasures began on 14 April 2022 after discussing the proposed solutions with our project supervisor. Another key date (27 April 2022) not indicated on the Gantt chart was the adaptive configurator board meeting, whereby we presented our detailed analysis and action plan to the board of directors and stakeholders. This meeting proved successful, obtaining the approval from the board of directors for each of the proposed actions, as well as receiving useful feedback from the sales representatives that attended. This allowed for the continuation of the project without any major roadblocks or limitations regarding approval.

The number of days required to complete the actions were also loosely based on the difficulty rating displayed in Table 10. Therefore countermeasures with higher difficulty ratings had a much higher required workload. Another factor considered was the availability of information and reliance on external parties. One major reason that the countermeasure related to the 3D drawings could not be started sooner was that an external team from the Lecco campus of the Politecnico di Milano had not yet made significant progress in their own project, thus delaying the start time for this countermeasure. Similarly, the approval for using pricelists and adding them to the internal database required the approval from the board of directors. Once approval was granted, the work was scheduled from the next day (28 April 2022). All other work was completed in parallel, since none of the tasks were directly dependent on each other.

Considering that most of the work related to data analysis, coding and manipulating databases, it was only required to be on site once per week – depending on the availability of the company supervisors. The work was split between the team, where we regularly discussed the work via MS Teams if there were any concerns or important decisions. If these decisions were not resolved internally, we scheduled brief online meetings with the company supervisor and related staff depending on the nature of our queries. Once on site, the work completed thus far was shown to the supervisors and fresh queries were resolved that day. Meeting on site was also important to understand each department and obtain useful insights as to how each of these departments interacted with the sales department. Much of the work was completed remotely, but the in presence meetings were essential to achieving a better understanding between the work completed and the goals of the company. The progress of the work completed will therefore be discussed below in detail to better explain the development of each countermeasure, the challenges faced and methods used to overcome them.

7.2. Progress of Countermeasure Implementation

Although the required work had been identified and defined, there were still some limitations to the implementation plan. The main constraint at the beginning of the project was that a good understanding of several coding languages (namely php and HTML) were required to access and make changes to the test version of the configurator. It was unknown at the beginning of the project the extent of coding knowledge required, therefore considerable time was spent trying to understand the languages, and thereby understand the code that relates to the configurator's functionalities. There was also no record of the code description from the team that established the online configurator, therefore there was no clear indication of how it works and what can be changed. Fortunately, with the guidance of the head of IT at Electro Adda, we were instructed to download and install certain software (XAMPP and FileZilla) to access the code and create a local host. The previous code was copied and moved to a local host server, visible and accessible only to our team. This allowed us to test the code and make changes without disrupting or damaging the actual configurator. Similarly, the database was copied and saved onto a local drive. Therefore we were able to work on the previously discussed countermeasures on a local host, and once the code and database was deemed complete for each task, the code and database could be transferred back to its original position and replace the old files.

The descriptions of the countermeasures below therefore describe in detail the progress of each countermeasure, the challenges faced and the methods used to overcome these disruptions. Many of the

obstacles pertained to a combination of lack of process information, lack of data, coding knowledge and technical requirements, as well as coordination within and between departments. The order of the countermeasures listed below does not correspond to the order of completion since many of the tasks were completed in parallel and included several delays.

7.2.1. Updating the database

The most fundamental task when working with any digital tool is to ensure that the data and information used is correct and structured. Seeing as the database contained several bugs or data omissions, it was important to correct this first as a "Quick Win". The first step taken was to correct the incorrect formatting of special symbols, as seen in Figure 22, such as the column "coppia_freno". This was completed by editing the database on the local host server manually for each value, replacing the incorrect symbols with a "÷" separator. It was important that the data is also visually appealing since this is what will be displayed to customers and sales team through the digital configurator. In terms of the functionality, the missing values for the "cusci_id" columns were required. These values were available by the Electro Adda technical department only on a Excel spreadsheet saved to the company's local drive. After receiving this file, the values in the database were carefully populated with the correct information. Both examples can be seen in the image below, specifically for the Series FE motors and IE3 efficiency rating.

Showing rows 0 - 24 (114 total, Query took 0.0368 seconds.)

```
SELECT * FROM `dati_tecnici` where catalogo='SERIE FE' AND efficienza='IE3';
```

Profiling [Edit inline] [Edit] [Explain SQL] [Create PHP code] [Refresh]

1 > >> | Show all | Number of rows: 25 Filter rows: Search this table Sort by key: None

+ Options

	id	cusci_id	tipo_motore	altezza	efficienza	voltaggio	Hz	poli	carcassa	catalogo	tipo_freno	coppia_freno	potenza_V_H
Edit Copy Delete	1773	519	C3A 80-2 FE-a	80	IE3	400	50	2	alluminio	SERIE FE	MEC71 MD/MS	6.8÷17	0.750-400-50
Edit Copy Delete	1774	519	C3A 80-2 FE-b	80	IE3	400	50	2	alluminio	SERIE FE	MEC71 MD/MS	6.8÷17	1.100-400-50
Edit Copy Delete	1775	520	C3A 90S-2 FE	90S	IE3	400	50	2	alluminio	SERIE FE	90 MD/MS	26.9÷35	1.500-400-50
Edit Copy Delete	1776	521	C3A 90L-2 FE	90L	IE3	400	50	2	alluminio	SERIE FE	90 MD/MS	26.9÷35	2.200-400-50
Edit Copy Delete	1777	522	C3A 100L-2 FE	100L	IE3	400	50	2	alluminio	SERIE FE	100 MD/MS	30÷48	3.000-400-50
Edit Copy Delete	1778	522	C3A 100L-2 FE	100L	IE3	400	50	2	alluminio	SERIE FE	100 DD/MS	60÷96	3.000-400-50

Figure 30: Image to show the corrected database columns for Series FE motors with IE3 efficiency

The process of correcting or inserting values in the database was carried out continuously as new errors would arise throughout the development of countermeasures, especially for adding new motor series. Many of the motor series were neglected since they had not been used on the database yet, and therefore were not checked thoroughly. Throughout the early stages of the project development, the database was updated when needed. Once it was considered sufficiently complete, the database was sent back to the head of IT to replace the old database with the corrected version. This had to be checked carefully as the data was sensitive and could become corrupted if not managed effectively. The new database was therefore uploaded onto the company's server with a new server address (IP Address), and was available for use in the new test version of the configurator. This database could still be edited remotely by logging in to the company's portal through the phpMyAdmin administration tool. This was important since the live and active database was not anymore

on our local server, which was accessible only to our team. Therefore it was necessary to have access to the database if needed.

7.2.2. Allow direct database editing from the configurator

The ability to edit the database in a user-friendly manner is an important feature since it allows the company to have a centralised source of data instead of relying upon siloed Excel spreadsheets. The issue however is that the data integrity needs to be protected, avoiding changes that may be incorrect or damage the database. After discussing this issue with the management level of Electro Adda, multiple levels of access were required with corresponding permissions and accessibility. A private section for administrators was already existent on the configurator, but the only thing an admin could do was add other admins onto the system. Instead, we wanted our project to include three-layer access: *View*, *Edit* or *Administrator*. The image below shows the creation of a new user with the options to allow the user to view or edit the content on the configurator, as well as the option to add another administrator.

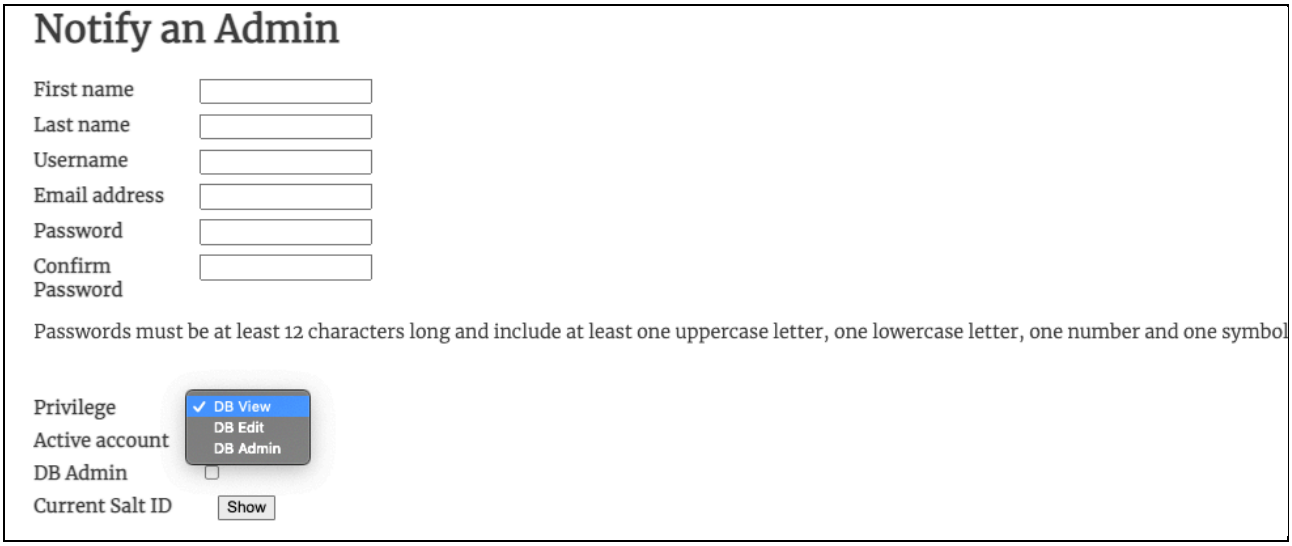


Figure 31: Image to show the three-layered access to the configurator, namely view, edit or administrator levels

The option to view simply allows a logged-in user to see the company information that will be explained later in the other countermeasures, specifically the price of motors and lead time. This is important for employees to have visibility on information that would otherwise be only available on their catalogues. The edit functionality allows the user to actually change or manipulate values located on the database. This is much more restricted to avoid any unwanted changes to the database, however it is very important when a user receives permission from management to update a value. For example, if the price of a motor option changes, this can be edited easily through the configurator. The last level of access is the administrator, which is only available to the company management and head of IT. This level controls who has access to the configurator and whether a user should be allowed to either view or edit data. Strict control of users with the capability to edit the database is necessary, with instructions to edit only after receiving approval from the relevant manager. This standard operating procedure (SOP) has not been included in this scope of work, but has been acknowledged by the management team and will be further developed internally.

The next thing we did was create the database download section in the admin area and the window to select the database sheet. From there you would be redirected to a script that collects all the data in the database

and organizes it in columns and rows. The output was formatted as an Excel file. This is useful when employees need to export the data or share it with other departments more freely.

The following step was to show the extended options based on the status of the user: if logged-in, a user would see the buttons for inserting a new motor, deleting one or modifying the data of the selected motor. Each one of these buttons redirects to a SQL query on the database, and the change is live after submitting.

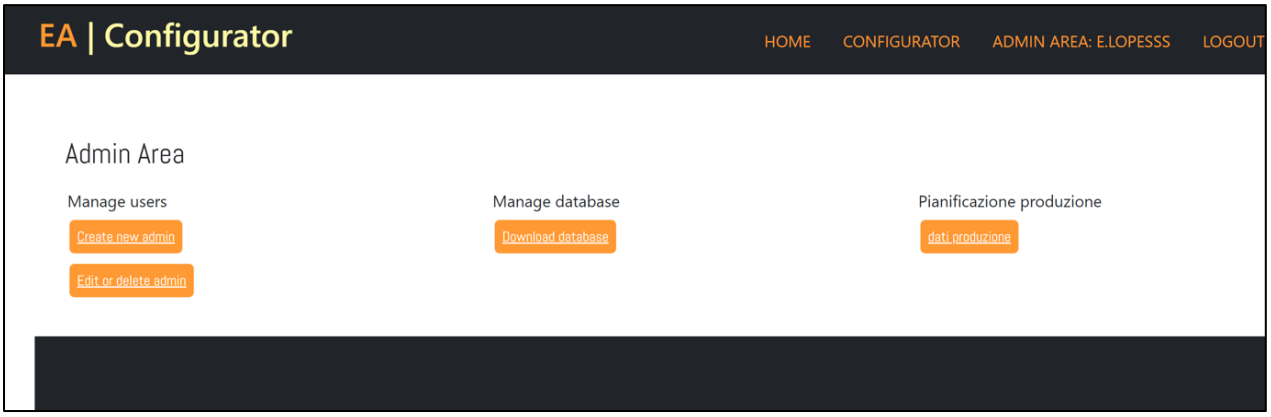


Figure 32: Image to show the administration area with regards to user management and database management

After creating the improved administration area, the Electro Adda management thereafter identified all the necessary users and shared their email addresses with us. Most of these users corresponded to the sales team of the company throughout Europe. A profile was therefore created for each user, considering their names, email address and accessibility levels. Secure passwords were also created and shared discretely to ensure maximum security. Additional functionality was also developed to monitor and record the usage of the updated configurator, whereby administrators had access to a live Excel file that displays the amount of time a logged-in user spends online. If the user is inactive for 15 minutes on the same page of the configurator, they will automatically be logged-out by the system and the time recorded. This was an important initiative identified much later in the project cycle to ensure the tool is being utilized and standard practices adopted.

Once a user has successfully logged in, they then have access to more functionality compared with non-logged in users. The example below shows the extra functions when selecting a motor, specifically the *Show*, *Edit* or *Delete* functions, where the last two options are only available to users with permissions to edit. The *Show* function will also be explained later in the report in conjunction with other countermeasures.

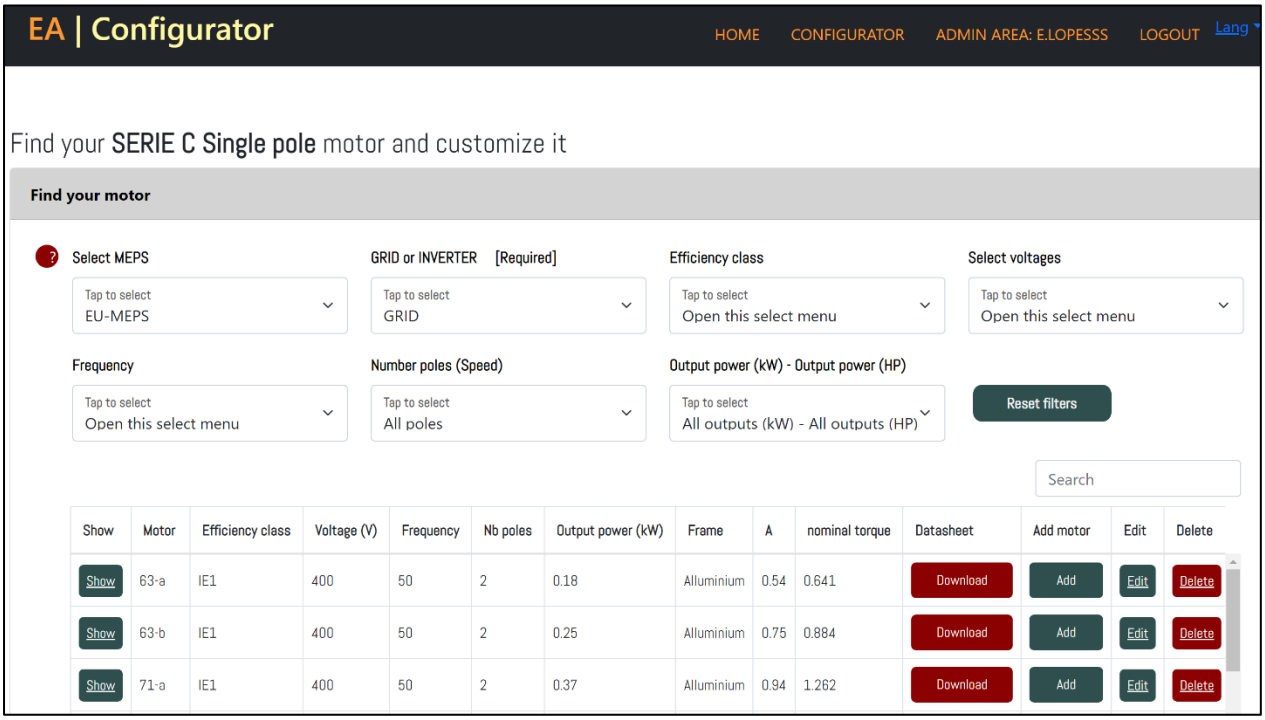


Figure 33: Image to show the updated configurator catalogue with additional features for logged-in users: Show, Edit, Delete

For users with the permission to edit the database, the image below displays this functionality. Each value corresponds to a column and row in the database, therefore editing here will change the value on the actual dataset. The user selects the value they wish to edit, makes the necessary changes and clicks the submit button to permanently change the value.

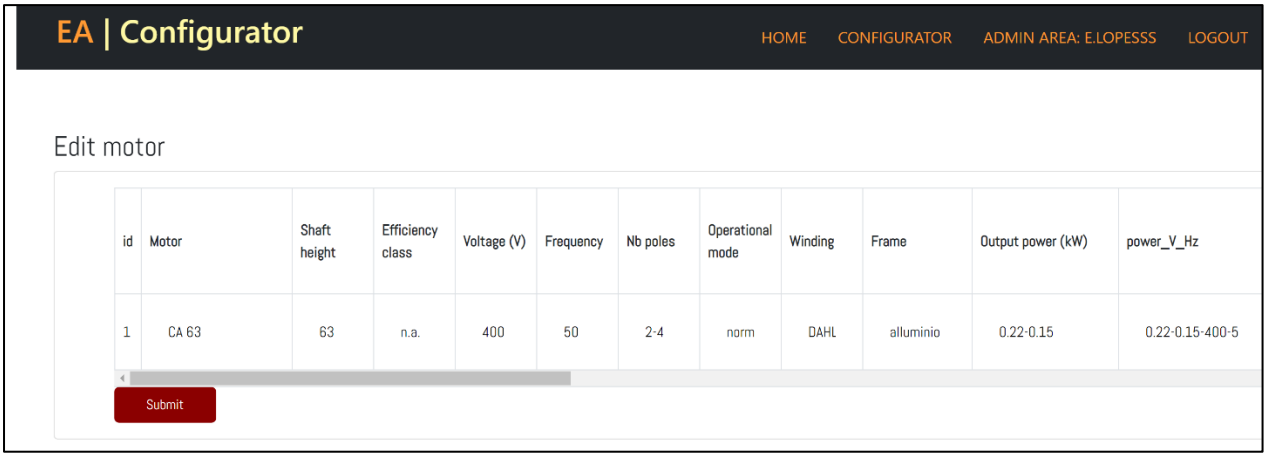


Figure 34: Image to show the "Edit" function whereby a logged-in user with the appropriate access level can permanently change a value on the database

The option to allow selected users to edit the values on the configurator, and database, significantly improves the accuracy and confidence in the configurator as a sales tool. The sales team should thereby have more confidence in using the configurator and reduce the time to find updated values in other catalogues because of the centralisation of information. Finally, this countermeasure should reduce inconsistencies relating to information available to the customer through the configurator and provide actual updated information within the company.

7.2.3. Allow download of 3D drawings from the configurator

Regarding the 3D drawings, another Politecnico di Milano team was responsible for taking the drawings already developed in the company, parametrize them and expand them to all dimensions of the same motor series. We instead agreed to provide the software infrastructure to match the characteristics of the configured motor to the right drawing and make it available to download from the configurator.

However, the other team experienced technical complications and several other obstacles, so the available drawings could not be parametrized and scaled to other shaft heights. This is because a motor with bigger dimensions is not a scaled version of a smaller one, yet it is a completely different motor. This obliged them to make one new drawing for each shaft height. This created further complications, causing a change of scope and eventually postponing the project indefinitely.

This significantly impacted on our project, whereby we couldn't address the root cause related to the accessibility of 3D drawings for customers to reduce the proposal lead time. Instead of abandoning this task, we then collected the variables that would determine the drawing of a motor, e.g. shaft height, terminal box location, double shaft, shaft brush. We imagined that if the drawings were developed in the future, a database sheet containing the characteristics of the motor and the location of the drawing in the server would be populated. We therefore created the code to extract the 3D drawing, corresponding to the selected motor, and make it available on the configurator.

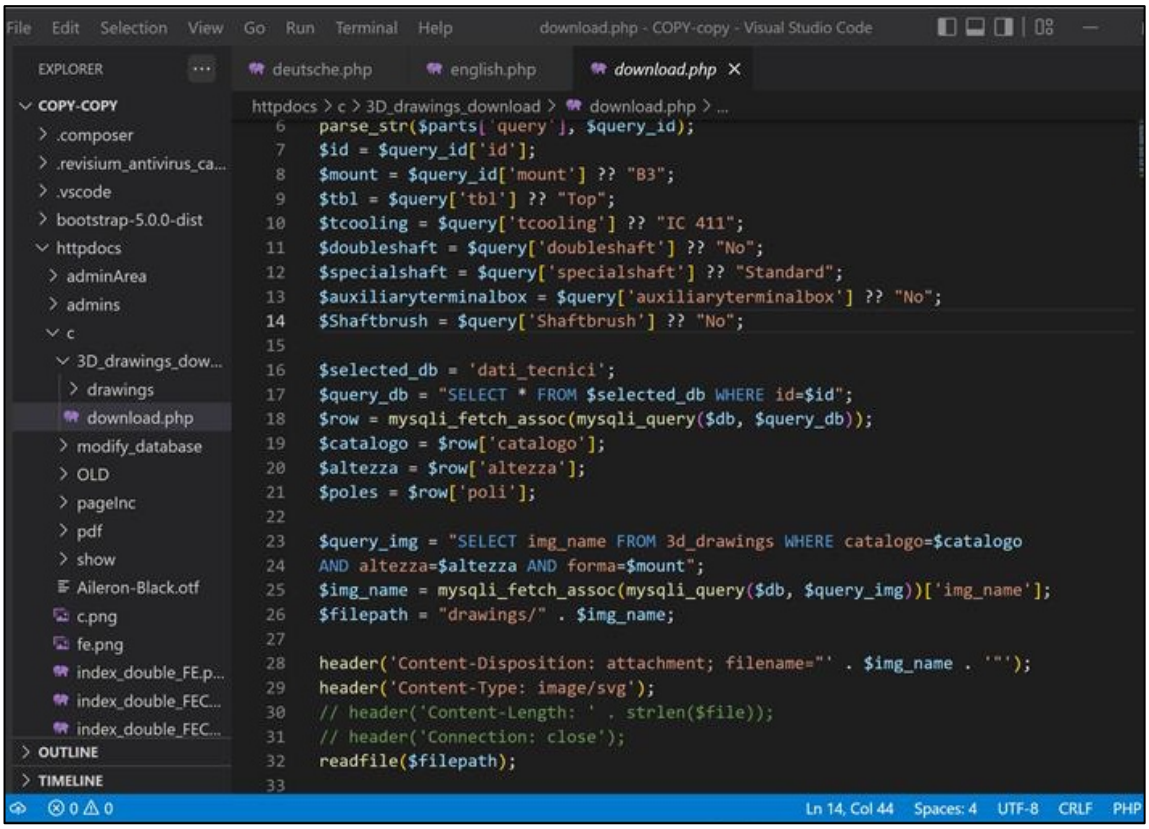


Figure 35: Image to show the code that will allow the 3D drawings to be downloaded on the configurator, although there are no 3D drawings currently in the database

It is not possible to check if this solution works perfectly, however the code works when used with another image used in place of the 3D drawing. The next step for whoever works on the 3D drawings needs to consider

the nomenclature of the 3D drawing names. If the naming of the files are consistent with one another, changing the code to reflect the specified nomenclature should allow the easy download of the drawings saved onto a specific location in the database. This will be communicated to the company effectively to ensure that this project can continue autonomously at a later stage.

7.2.4. Expand configurator to other series

Since only the C Series motors were available on the configurator, the tool was rendered ineffective since it was missing other major motor types. We therefore discussed the configurator expansion with the management team of Electro Adda, who then specified that we need to focus upon the FE series motors. The FE series motors, being brake motors, also include FECC and FECCL within this category. We began to inspect the database to check the data quality, although the database had not yet been completed as mentioned in the previous countermeasures. This meant that the missing information and incorrectly formatted values firstly had to be corrected. This task was set in the beginning of the implementation plan as the company management expected to have the FE series operational as soon as possible to aid the sales team. Therefore the coding knowledge and understanding of existing code had not yet been developed. The database was corrected using the digital catalogues as a reference point, although each value was edited manually one-by-one. This method was not time efficient, so we invested time instead to learn the coding language for the database, namely SQL. After spending adequate time learning SQL, we were able to replace incorrect or inconsistent values using a SQL query. The IE3 efficiency data was also added to the database for the FE series, as mentioned previously.

The next step was to replicate the code for the C series motors and create the same script for all FE series motors. This method was rather crude since we had limited understanding of the code in its entirety, so more time was dedicated to understanding the major elements within the code. Simultaneously we spent time with the technical and engineering departments to better understand the technical requirements of the FE series motors to better develop the configurator to these specific needs. Some of the major differences included the lack of inverter supply, which was only present in the C series motors. Another difference was that FE series contained brakes, therefore requiring more information on the brake type and torque within the configurator's options. The filters were thus modified from the original C series to better fit the technical requirements of the FE series.

Although this countermeasure had very few steps, it was initially very challenging since the coding language was unknown to our team and the previous code had not been documented. Learning the new languages such as php, html and SQL were very tedious and required a lot of dedicated effort to understand the old code and develop it further. Therefore this countermeasure was done in parallel with the others since the preliminary steps were related to the coding languages. The figure below displays the new FE series (FE, FECC, FECCL) motors that were not present in the previous configurator:

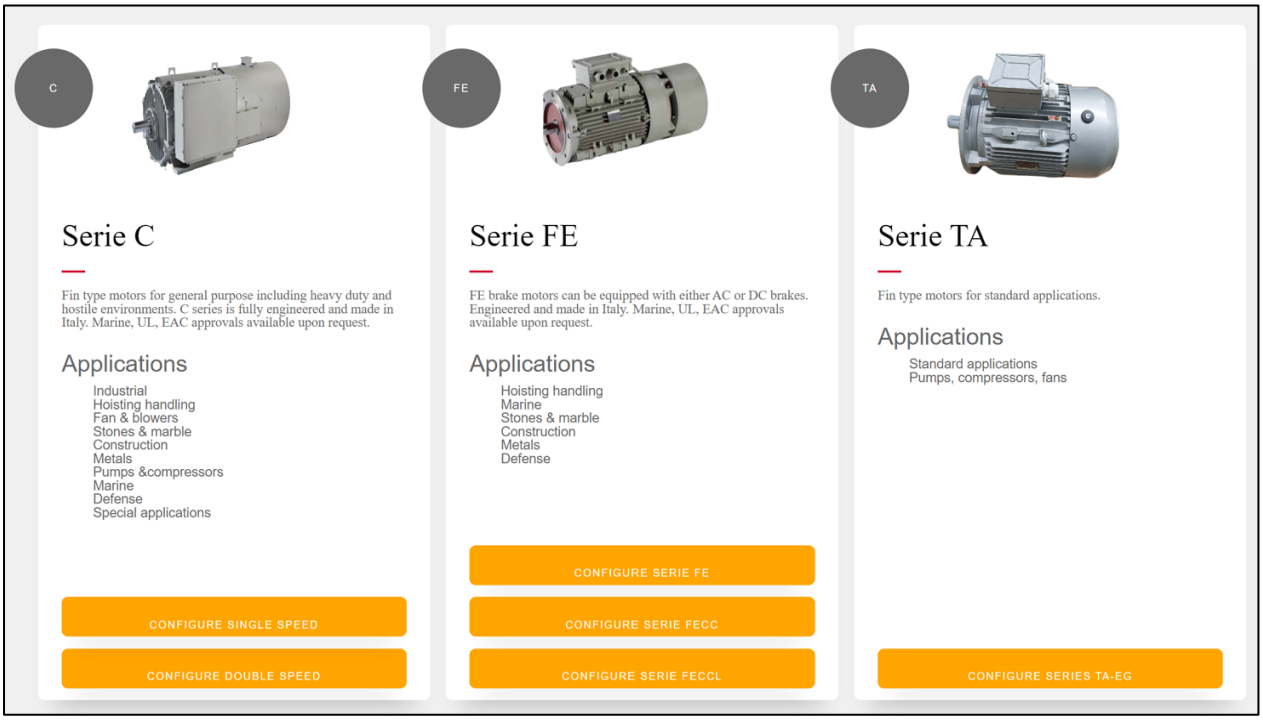


Figure 36: Image to show the updated configurator window to customise C Series, FE Series and TA Series motors

On 27 April 2022, during the meeting and presentation with the Electro Adda board of directors and relevant stakeholders, it was identified that the TA-EG motor series needed to be added to the configurator's options. This was not identified earlier as the motors were not manufactured by the company, but were imported from China instead. This decision was made since the TA-EG motors correspond to approximately 78% of the volume for new orders, as shown previously in the Pareto analysis. The database was once again inspected, which did in fact contain all the relevant information. This meant that the code from the C series could be replicated for this other series.

However, the data on the database was checked with the most recent datasheet from the Chinese suppliers and it was discovered that some of the values were inconsistent. We performed technical calculations to evaluate whether the values were drastically different or possibly reported in different units, but the results were inconclusive since we were not certain which data source was most correct. This issue was escalated to the management of Electro Adda where they contacted the supplier for clarification. One of the TA-EG motor supplies then visited the company in mid-June to assess our queries, whereby the latest and most accurate data was shared with Electro Adda and our team. The database was thereby updated with this new information and was made available by late June on the latest version of the configurator. The sales department therefore had access to the TA-EG information on the configurator, although the customisation and additional features did not apply to this motor series.

7.2.5. Automatically calculate the motor price from the configurator

As discussed previously, the pricing information for the standard motors and selected options were readily available to the relevant departments in the form of digital or printed price sheets. We then discussed with the technical manager about using these values (available on Excel spreadsheets) for the configurator by cleaning, standardising and uploading it to the database in a new table. The response was that the pricing information was too sensitive, especially if it became visible to competitors, so this task was put on hold until

further clarification was available. During the meeting held on 27 April 2022 with the board of directors, we explained our idea to the senior management and the countermeasure was approved, whereby we were allowed to upload the information onto the database.

We then had to clean the data thoroughly to ensure that the values were correctly formatted to match the other tables in the database for matching the correct motors to their prices. Once the pricing Excel sheet was prepared, it was uploaded onto the database. The image below is an example of the pricing table on the database.

Showing rows 0 - 24 (3288 total, Query took 0.0365 seconds.)

```
SELECT * FROM `pricelist_sp`
```

Profiling [Edit inline] [Edit] [Explain SQL] [Create PHP code] [Refresh]

1 > >> | Number of rows: 25 Filter rows: Search this table

+ Options

id	potenza_kw	altezza	tipo_motore	prezzo	forma	poli	efficienza	sheet	catalogo	carcassa
1	0.18	63	TBD		B3	2	IE2	Serie T IE2	SERIE TA	alluminio
2	0.25	63	TBD		B3	2	IE2	Serie T IE2	SERIE TA	alluminio
3	0.37	63	TBD		B3	2	IE2	Serie T IE2	SERIE TA	alluminio
4	0.37	71	TBD		B3	2	IE2	Serie T IE2	SERIE TA	alluminio
5	0.55	71	TBD		B3	2	IE2	Serie T IE2	SERIE TA	alluminio
6	0.75	80	CB08AA10502B__C		B3	2	IE2	Serie T IE2	SERIE TA	alluminio
7	1.1	80	CB08AA10702B__C		B3	2	IE2	Serie T IE2	SERIE TA	alluminio
8	1.5	90S	CB09AA10602B__C		B3	2	IE2	Serie T IE2	SERIE TA	alluminio
9	2.2	90L	CB09CA10902B__C		B3	2	IE2	Serie T IE2	SERIE TA	alluminio
10	3	100L	CB10CA10703B__C		B3	2	IE2	Serie T IE2	SERIE TA	alluminio
11	4	112M	CB12BA10903B__C		B3	2	IE2	Serie T IE2	SERIE TA	alluminio

Figure 37: Image to show the pricing table on the database with consistent headings and formatting

Now that the first step had been completed, it was important to develop the logic required to match the prices with the motors and thereby develop the appropriate code. Another issue encountered was that not all standard motors and pricing options contained the pricing logic, whether it is a flat fee or percentage of the base price. The logic therefore had to be checked with the technical manager to ensure that the correct pricing options were indeed chosen when selecting the desired motor on the configurator. The feedback was that some price options were not available at all motor sizes e.g. the encoder option is not available for smaller motor sizes (less than shaft height 160 mm).

We then coded a conditional statement if the pricing option was available, followed by a SQL query to call the motor price or option price and display it on the test version of the configurator. If one of the selected items was not priced, the configurator would display a warning message saying “price not available”, otherwise all options and total price would be displayed. The results were once again shown to the technical manager, whereby it was decided that we need to show the base prices and all available priced options on the configurator, with another row stating all the options that were not on the pricelist. These changes resulted in several bugs, but were eventually solved and shown back to the company for approval. The

company thereby accepted the new functionality on the configurator, which can be seen in the example below.

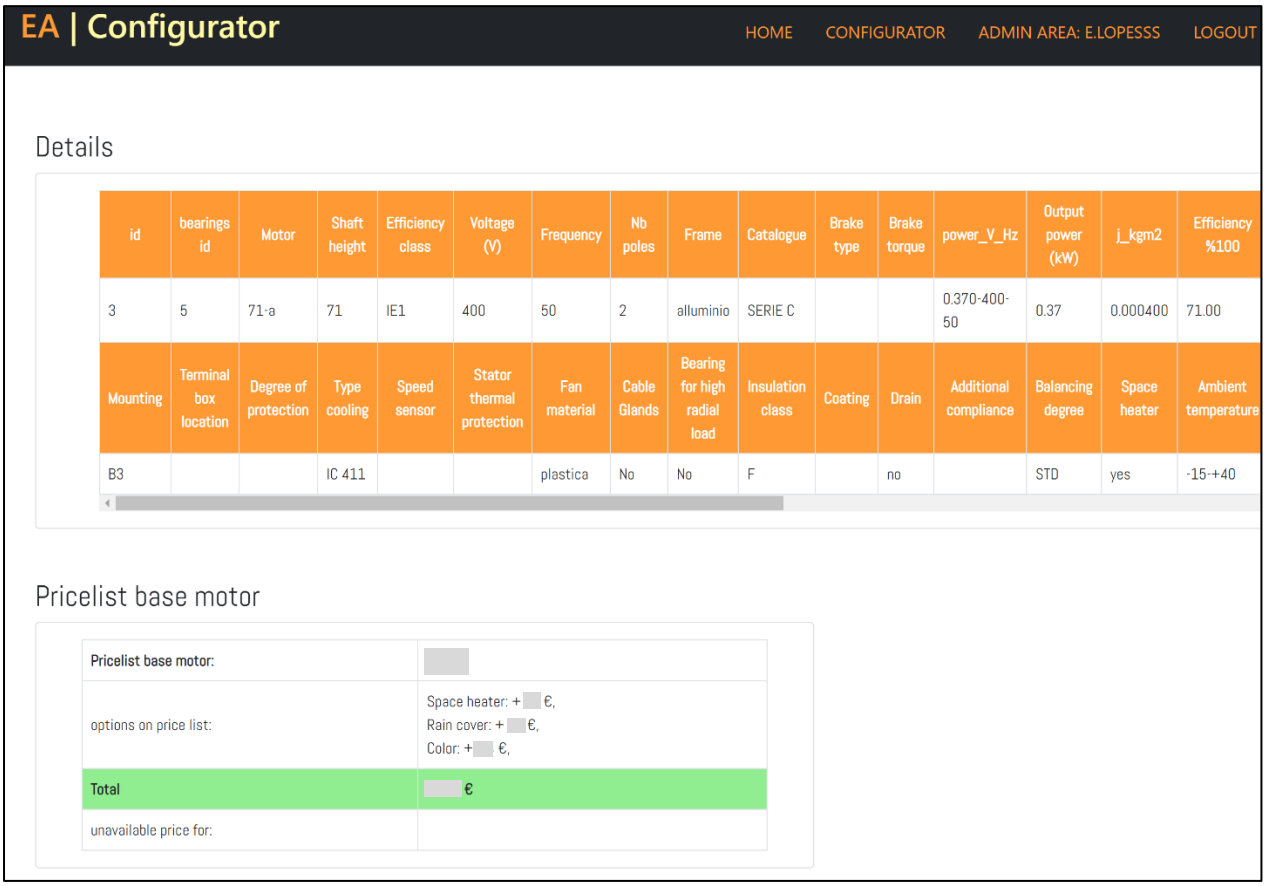


Figure 38: Image to show a pricing example on the configurator based on the selected motor and options, although hiding the base price, options prices and total price of the configured motor

The pricelist functionality is therefore available to all Electro Adda employees with user login credentials. Although several smaller bugs were encountered, this countermeasure was completed and shown to the entire sales team both locally and internationally. It was important to show the sales team how to use it and most importantly why it would aid their own work. Positive feedback was received for this new tool, which should eliminate the need to refer to pricing catalogues. The sales team will still have to refer to the technical and costing departments when an item is not available on the price list, however the time taken to price a standard motor should decrease.

7.2.6. Display lead time estimates from the configurator

The countermeasure to link the sales department with the planning department proved to be the most complex throughout the project. This was not because of a lack of technical knowledge, but rather from the lack of communication and cooperation between the planning department and other departments. Once we had concluded through the root cause analysis that a link between the sales and planning team should be established, the technical manager decided that the way forward requires a bill of materials (BoM) to be automatically generated on the configurator and sent to the planning team to plan the production schedule accordingly. This method was suggested as it is standard practice in several other manufacturing businesses.

This idea was brought to the planning department, with the technical manager present, although the planning team did not seem to engage or act interested in the idea. There was clearly a breakdown in communication, therefore before continuing with this countermeasure it was decided to step back and take a different approach.

Whilst completing the other countermeasures, we often visited the planning department to understand their work process, the tools utilised and already existing communication with the sales department. We were told that every Monday the planning team sends a planning sheet (as seen in Figure 27) to the sales department to inform them when the motors will be available for delivery to customers. We also realised that the planning department mostly utilise Excel spreadsheets to capture and store data, even if the information is sent to them online directly via AS400 from the sales department. Another realisation was that the stock management was handled manually without any stock management software or system in place. We therefore understood that the planning department was currently overloaded with product orders with a limited team of four members and lack of suitable planning tools such as a materials requirements planning (MRP) software. The previous request to create a BoM for the planning team would not be suitable to the current working environment.

We then established a good working relationship with the planning department and ensured them that the goal of our project was not to simply give them more work, but actually to alleviate part of the workload when communicating information with the sales department and ensuring it is more accurate. We proposed many ideas, such as creating a critical parts list that flags components with a high lead time. The problem however is that obtaining this information weekly requires high effort from the planning department and the information is not always accurate. Another idea was to use production data available on AS400 to create a machine learning algorithm using python script. The information was collected through the head of IT, cleaned and prepared in Excel and executed using python code. The results took several days to become available, and whilst the model seemed realistic with a mean absolute error of two weeks, the date information supplied to us did not correspond to the actual date ready for delivery, but simply the estimated date of delivery. This meant that this AI neural network could not be used as these date values were inconsistent and did not generate any value for the company.

At the end of May, the planning team sent us a document they prepared stating a lead time linked to several motor characteristics, components, and options. We then proposed to create a platform on the configurator to display the total lead time of the motor based on selected characteristics, however the planning department were not sure about the idea because currently there is high variability since they depend on the production capacity, the suppliers, and the other characteristics of the motor. We therefore decided to model the idea based on the planning sheet that is sent weekly to the sales department, whereby the motors are split between small and large as well as motor type, namely C Series, FE Series and ATEX (known as cast-iron motors that have different production characteristics). This segmentation of motors meant that less information was required for manual input as there were fewer categories, as well as less effort need by the planning team since much of this information can be derived from the weekly planning sheet. It was very important that this solution was sustainable for weekly updates.

The different categories and respective lead times were then prepared and added into a new table on the database. This table was populated either with older values provided by the planning department and

estimated values derived from the planning sheets. Fortunately the feature to edit the database directly from the configurator had already been established, therefore it was possible for the planning team to edit this information once they receive the appropriate user access. To ensure that this solution is scalable in the future, all options on the configurator were added into the lead time table on the database with a value of zero. This meant that if this motor characteristic or option did have a significant impact on the future lead times, the lead time (measured in weeks) could be updated, saved and displayed on the configurator. It is also important to mention that some motor characteristics can be completed either in parallel or series with other characteristics, so the coding logic to reflect this consideration also included the labels “Max” and “Sum” for parallel or series configurations, respectively. This meant that if the characteristics could be completed together in parallel, then the maximum (“Max”) value of the lead times would be chosen. Alternatively, if the characteristics could be completed together in series then the total (“Sum”) value of the lead times would be calculated and selected. The ability to change this logic for each characteristic is also available on the configurator if needed in the future.

Finally, after developing the component lead times and coding logic, the estimation of delivery times was made available on the latest version of the configurator (June 2022). This information was displayed below the price calculations for logged-in users, and was split between the base motor (dependent on size, series and material) and all additional options (add-ons) to display the total estimated time for delivery.

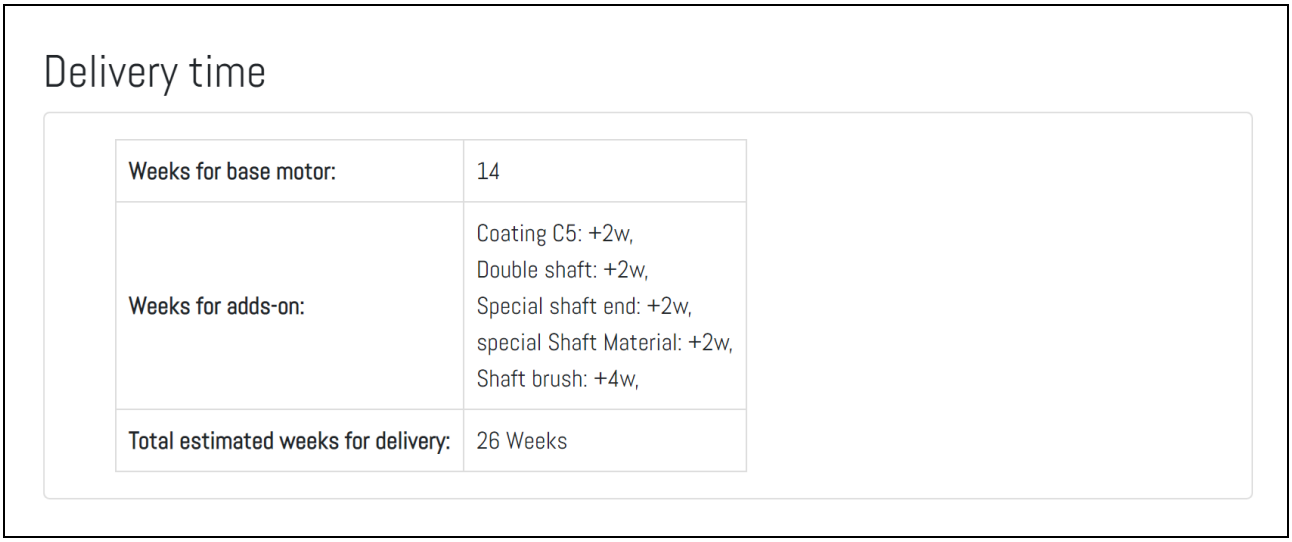


Figure 39: Image to show an example of the estimated delivery time for a customised motor on the latest configurator

This result was not intended to be entirely accurate from the start, but the procedure and estimation of individual components can be revised and improved continuously to better represent the actual delivery times. The aim was also to replace the planning sheet (as seen in Figure 27) so that the sales department did not have to spend time calculating and estimating possible lead times, as well as to create a more direct link between both sales and planning departments.

7.2.7. Correct bugs in the current test configurator

Many of the early bugs were rectified at the beginning stages of the project (such as fixing the database columns *coppia freno* and *cusci_ID*), however many new bugs were exposed from the previous version of the configurator, as well as several errors in the development of the new code. The majority of these bugs were

low-effort but necessary for creating an accurate sales tool, both for potential customers and for the sales teams.

Some of the major bugs experienced were the drawings on the downloadable technical sheet, whereby they appeared elliptical as opposed to circular. This was clearly incorrect and posed an issue for potential customers. The code was manipulated to set the drawing to full scale and shift other information onto a new page. More information was also added to make the technical sheet more comprehensive, such as the motor bearing codes.

Some non-technical bugs referred to language translations, as many of the German words and phrases used were incorrectly translated. This issue was flagged by one of the German sales representatives, whereby they offered to correct the language file. This change was swiftly implemented into the latest version of the configurator. Another issue was the motor descriptions on the home page, therefore these descriptions were edited in consultation with the Electro Adda technical team to ensure that clear and concise descriptions of each motor type was displayed.

Many of these bugs were made aware through close contact and communication between several departments at the company, whereby most became evident whilst working on the other countermeasures. Therefore this countermeasure was part of continuous improvement to ensure that the sales department felt confident in using the configurator as a tool to generate customer proposals, whilst customers would have clear yet concise information regarding their desired motors. Although some bugs may not have appeared throughout this project, many of the bugs encountered and solutions were documented to allow others to effectively deal with similar situations.

7.2.8. Test Configurator Deployment

In order to maximise the success of the project, the team focused on firstly completing the quick wins (updating, manipulating and correcting the database and configurator) as well as the major investments (expanding to other series and calculating the price). These countermeasures were worked on in parallel to one another and were completed by 20 May 2022 and all the relevant files and code were forwarded to the Head of IT at Electro Adda. Therefore by 23 May, all files had been implemented and the latest version of the configurator was available for use. We then spent the next week (until 27 May) informing the sales department of the latest changes, including live demonstrations, video tutorials and dedicating time in person to ensure that they had complete access and understood the relevant changes. Once the remaining countermeasures were completed, the most recent version of the configurator was available on 24 June 2022. This was considered the final version as part of our work, completing all countermeasures whilst excluding the countermeasure regarding 3D drawings.

8. Monitoring of Results

The countermeasures were completed at different stages of the project, which were then available to the company between version 1 (completed 27 May 2022, including training) and version 2 (completed and shared 24 June 2022). The table below summarises the availability of each countermeasure to the sales department between each version.

Table 11: Table to show each countermeasure and the different stages of implementation in the configurator

Root Causes	Countermeasure	Impact on Lead Time	Configurator Deployment
1.4 & 3.1	1) Expand existing configurator to the other series	Large-Direct Impact	Version 1 (FE+ Series)
			Version 2 (TA-EG Series)
1.5	2) Calculate the price automatically on the configurator	Large-Direct Impact	Version 1
1.3 & 2.1	3) Create configurator link & downloading of 3D drawings	Medium-Direct Impact	Postponed (TBD)
1.6	4) Display precise estimate of the delivery time directly on the configurator	Medium-Direct Impact	Version 2
1.1	5) Update the database with FE series data	Low-Indirect Impact	Version 1
1.2	6) Editing and manipulation of database from configurator	Low-Indirect Impact	Version 1
3.1	7) Correct bugs in the existing configurator	Low-Indirect Impact	Version 1

The table highlights that the majority of countermeasures were completed and shared as version 1 of the configurator, whilst only the lead time estimation and TA-EG series were available as version 2. Therefore, the quantitative analysis of each countermeasure effect on the process lead time was only completed for version 1 of the configurator. In order to understand the sales department's perception of all countermeasures, a survey was conducted as part of the qualitative analysis. Both quantitative and qualitative results will be discussed below.

8.1. Analysis of Countermeasures on Process Lead Time

The lead times for creating customer proposals from 30 May to 14 June were collected, cleaned and analysed following the same methodology as *Order Proposal Lead Times* analysis. Many data points were retrieved, however only the most reliable were used in the analysis. The figure below displays the new boxplot diagram of standard and special orders after implementing version 1 of the configurator, as well as the associated descriptive statistics.

Figure 40: Boxplot to show the lead time distribution between standard and special motors after implementing the countermeasures (June 2022)

Table 12: Table to show the descriptive statistics between standard and special motors after implementing the countermeasures (June 2022)

Date	Variable	N	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3	Maximum
March 2022	Standard Orders	49	3,04	0,30	2,09	1,00	1,00	3,00	5,00	9,00
	Special Orders	11	12,73	3,77	12,49	4,00	6,00	8,00	14,00	45,00
June 2022	Standard Orders	22	2,14	0,49	2,32	0,00	0,00	1,50	3,00	7,00
	Special Orders	9	6,33	2,33	6,98	1,00	1,00	3,00	13,50	19,00

The results above therefore show that the average time for creating customer proposals reduced from 3.04 to 2.14 days for standard orders and 12.74 to 6.33 days for special orders. This is a significant improvement in lead time, almost reaching the must-have targets for each order type. Another important observation is that the extreme lead times for special orders also decreased, shifting the histograms to the left, as shown in the figure below:

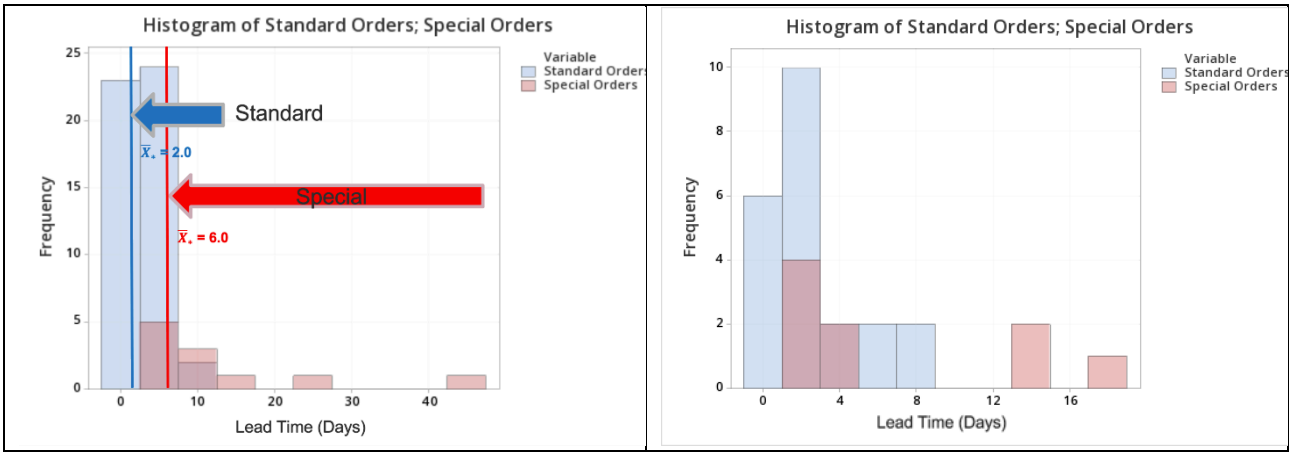


Figure 41: Histogram to show the reduced lead time dispersion, comparing the previous values recorded in 2021 (left) and new values after implementing countermeasures in June 2022 (right)

This shift in lead times indicates that the possibility of abnormal values has been minimised, thus reducing the lead times range. The table below compares the previous lead times (before version 1 of the configurator), the new values and the established targets. The lead times have therefore been reduced significantly and are almost at the desired level.

Table 13: Table to show the new average lead time (days) compared to previous and target lead times for standard and special motors

Mean Value of Lead Times (Days)	Standard Order	Special Order
Previous Value ($\bar{X}$)	3.0	12.7
New Value ($\bar{X}_1$)	2.1	6.3
Must-Have Target ($\bar{X}_*$)	2.0	6.0
Nice-to-Have Target ($\bar{X}_{**}$)	1.0	4.0

To better understand the perceptions, attitudes and adoption of the updated configurator by the sales team, a survey was created and distributed to all sales personnel that had access to the latest configurator (version 2). This included the Italian sales team (6 people) that were used for the quantitative analysis, as well as the

German and UK sales representatives (3 people). Therefore, 9 employees were used for the basis of this survey.

The questions were developed using ratings (from 1-7 points), open-ended questions and a general poll to provide concise insights. The first three questions were used to better understand the impact of the new configurator on their work and whether it provides actual assistance. The results below show an overall positive impression of the configurator with above-average results. The most positive perception relates to the ease of use regarding the new features, followed by the ability to reduce the lead time of customer proposals. This shows that the sales department value the new tool to speed up the order proposal process.

Table 14: Table to show the survey results relating to the sales department's perception of the updated configurator

Survey Questions (1 = strongly disagree, 7 = strongly agree)	**Rating (1-7)**	**Percentage (%)**
1) Do the new features on the configurator help you save time when dealing with customer proposals?	5,6	79%
2) Are the new features easy to understand and use?	5,7	81%
3) Do you feel the new configurator assists your work?	5,0	71%

The survey poll below, corresponding to the perception of usefulness, highlights that all sales representatives view the latest configurator as either somewhat useful (4) and extremely useful (5) to save time whilst working. This means that the implemented changes were viewed as successful, with room for further improvement.

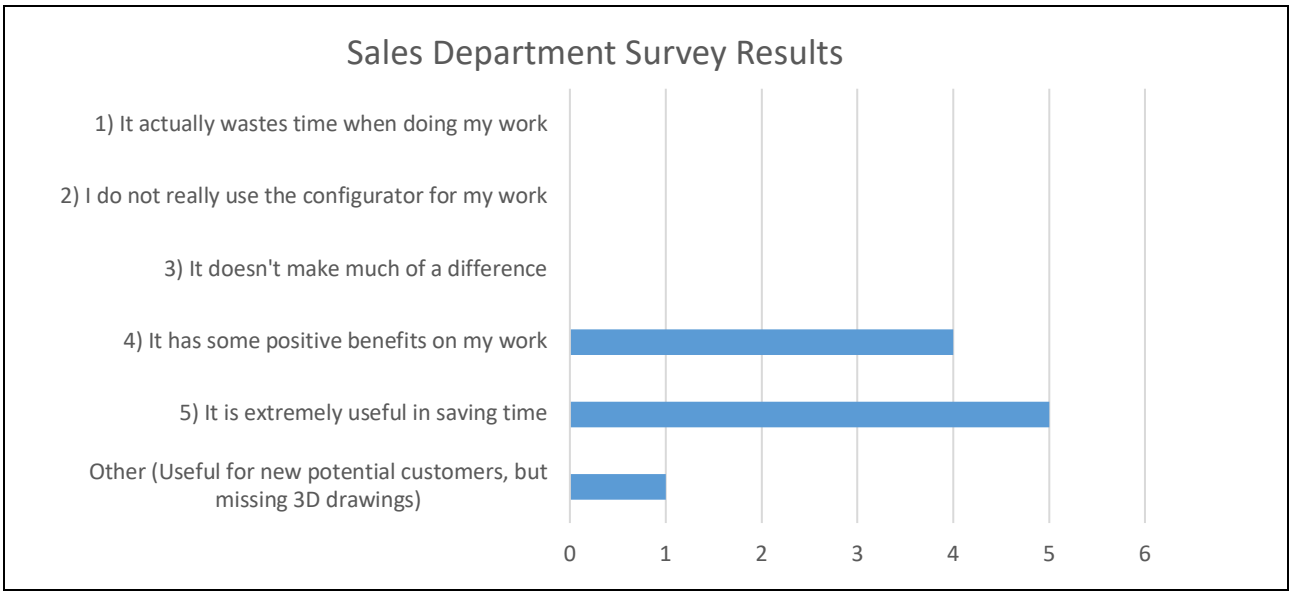


Figure 42: Figure to show the polling results relating to the sales department's perception of the updated configurator and its impact on their work

However, the least positive aspect in Table 14 relates to the use of the tool to assist their work. This also relates to Figure 42 above, since the "*Other*" category contained comments related to the absence of 3D drawings. The general comments regarding the configurator, including suggestions, criticisms and overall feedback will thus be discussed in detail to better understand the sales department's perception of the tool.

8.2. Critical Survey Feedback

The survey tool also contained open-ended questions to receive more constructive feedback. Much of the feedback was positive, calling the latest configurator “graphic and intuitive”, “new, interesting features” and helpful with regards to “having the new pricing options and variants online”. However, many of the criticisms related to either the lack of 3D drawings and other technical inquisitions. The 3D drawing countermeasure, as discussed previously, was suspended until further notice although this was considered a significant bottleneck identified in the *Order Proposal Flow Diagram*. The team therefore waits for the completion of the technical drawings by the engineering department, whereby they expected this issue to be resolved during our project timeline. Unfortunately, owing to external circumstances, the project was suspended and thereby impacted on the perception of the updated configurator.

Many of the additional suggestions were related to technical matters e.g. the configurator did not include special mounting options, factoring power efficiency reduction from increased temperatures, and not having detailed descriptions available for each item. The issue however is that when defining the scope of the project, the management team explicitly stated to us that the configurator was to only include items available on the catalogues. Therefore, the absence of these technical features were not included into the configurator design, although expected by the sales department. This shows that there is more work to be done to better aid the sales force whilst working, now that the configurator functions considerably better compared to the previous versions.

9. Standardise and Share Success

9.1. New Process development

The management at Electro Adda stated that using the configurator will become standard practice to ensure that all sales personnel will follow the same operating procedure. The use of the configurator will also be tracked to check the utilisation of the tool and highlight shortfalls related to the lack of use. It is important that the sales department feel comfortable with the sales configurator, therefore all demonstrations and instructions for the new features have been well documented and shared with the company to continually improve their working process. The code used to create and interact with the configurator has also been carefully logged to ensure the configurator can be further improved in the future.

9.2. Project Successes

The sales department now has access to new features and capabilities on the digital sales configurator, namely a broader selection of motor series, price calculations, lead time estimates, data accessibility and manipulation, as well as better confidence in using the tool. The quantitative results showed that the proposal lead time had decreased significantly, almost reaching the target for both standard and special orders. Additionally, the range in lead times for special orders decreased significantly, resulting in fewer extreme values. Qualitatively, the sales department were very satisfied with the updated configurator, highlighted by the survey results. The tool was described as intuitive, clear, helpful to their work, therefore also making the adoption of the tool more likely.

9.3. Challenges Faced

As discussed throughout the countermeasure implementation, the first major barrier encountered was the required coding languages. Our team had never used these particular languages previously, therefore

considerable time was invested to ensure that our coding knowledge was sufficient to tackle this project. Another issue was the other language barrier, as the team consisted of one Italian and one international student. This issue was also present for the Electro Adda staff, whereby many of the Italian employees did not engage in English, whilst many of the international sales representatives did not speak Italian. Therefore many of the conversations whilst visiting the company were repeated twice (each in Italian and English) to ensure that all parties understood the discussions. This barrier thereby caused several delays when requesting information, and required communicating to all sales teams simultaneously in both languages. Lastly, a major challenge corresponded to the lack of cooperation between our team and the planning team. When we were introduced to their team, it was stated by management that we will essentially track their work and make it available to the sales team. This initial interaction made the planning team hesitant, especially since they were already overwhelmed with orders and not equipped with the required software to plan accordingly. We therefore carefully and independently approached the planning department, understood their needs and concerns throughout our visits, and devised a strategy to link production information to the sales department without significantly increasing their workload.

9.4. Experience at the Company

The time spent at the company was an enriching experience with many key takeaways. It was incredibly interesting to learn the technical knowledge of electric motors and how they operate, as well as the many factors that influence their operations and sales. Working closely with the management team was also helpful to understand many core skills required when handling complex situations in the workplace to overcome certain challenges. Our team was actively encouraged to learn from all departments and interactions with various service providers, strengthening our knowledge of the industry. Some interactions were challenging with regards to the language barrier, but overall the experience was very beneficial to leaning many technical skills and soft skills, as well as exposing us to new environments and testing our capabilities. It was a great pleasure to work at the company and we wish them the best for their future business endeavours.

9.5. Project Recommendations

As the A3 methodology follows the lean approach, continuous improvement is a key aspect. This project can be further improved by contracting a dedicated team to the parameterisation of the motor catalogue and creation of detailed 3D drawings. This would significantly reduce the waiting time for the sales department to complete the order proposals sent to customers, thereby reducing time lost and improving customer satisfaction.

Another suggestion is that the company adopts other tools such as customer relationship management (CRM) and enterprise resource planning (ERP) to better understand customers and link the work between all departments, respectively. Although the configurator is used to help customers as well, the use of CRM software can improve the knowledge base of both old and new customers, allowing better targeting of products. The CRM could also replace the Excel sales tracking sheets, since many of the values are inconsistent or missing. The use of an ERP system would also help the planning department to better understand their current and future workload, thus creating more efficient operations. The company currently relies on a basic ERP system (AS400), although this system is outdated and can be replaced with a system with more features.

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[Accessed 25 May 2022].

LIST OF TABLES

LIST OF FIGURES

Appendix:

A. A3 Framework

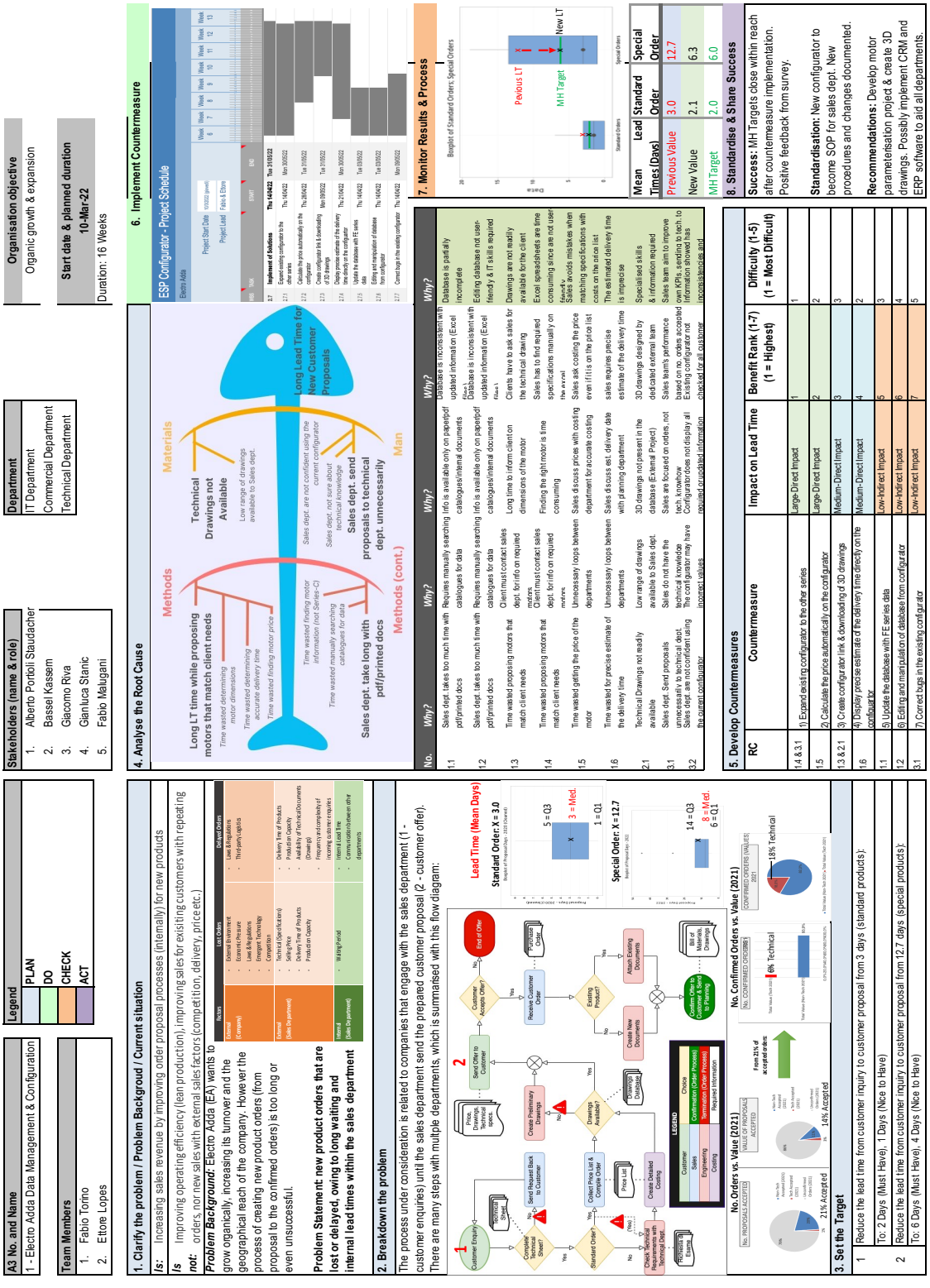

Figure 43: Figure to show the final A3 Framework as part of the lean methodology

B. Full Process Flow Diagram

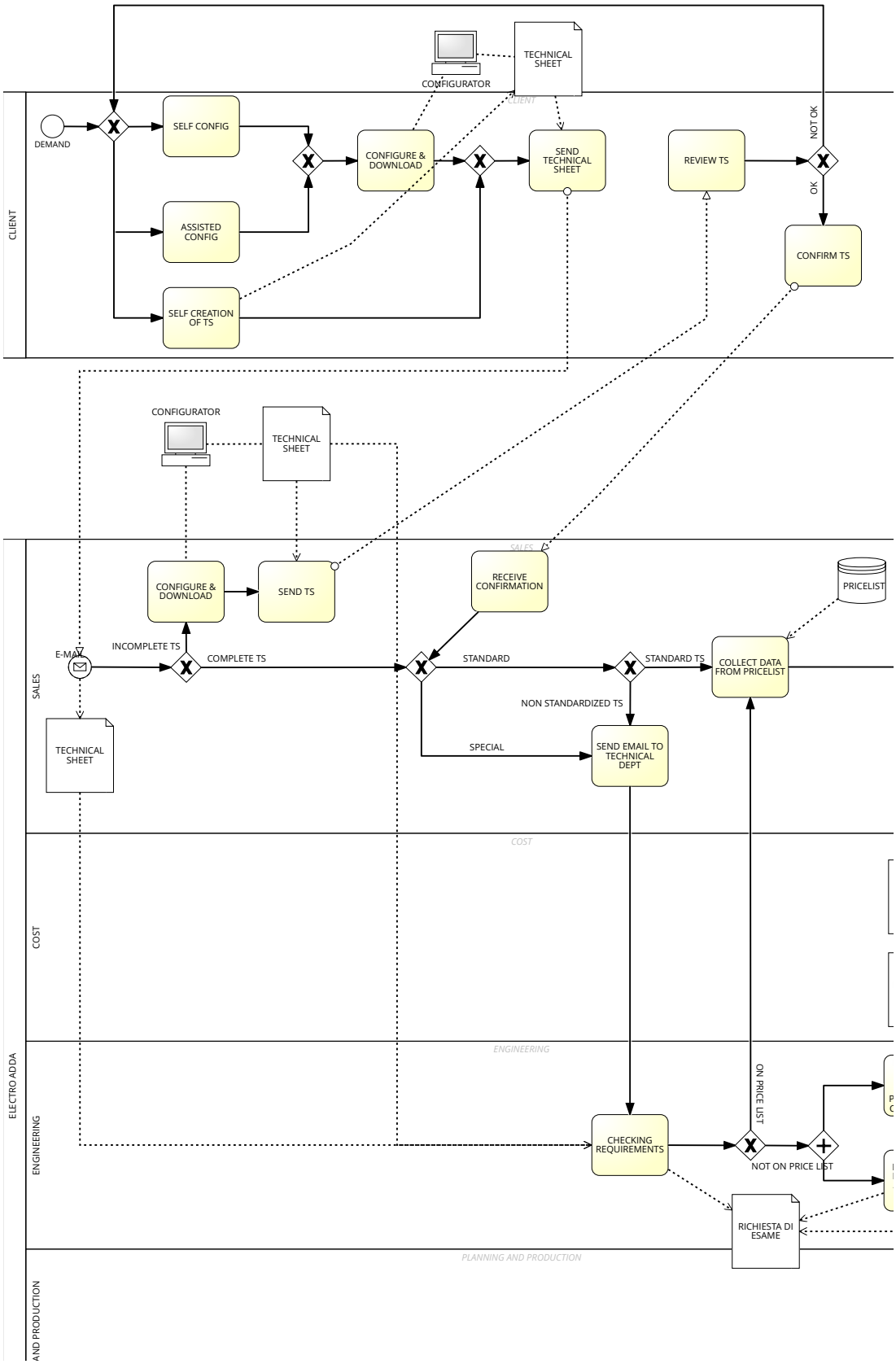

Figure 44: Figure to show the process flow diagram from customer enquiries until the order has been processed (1 of 3)

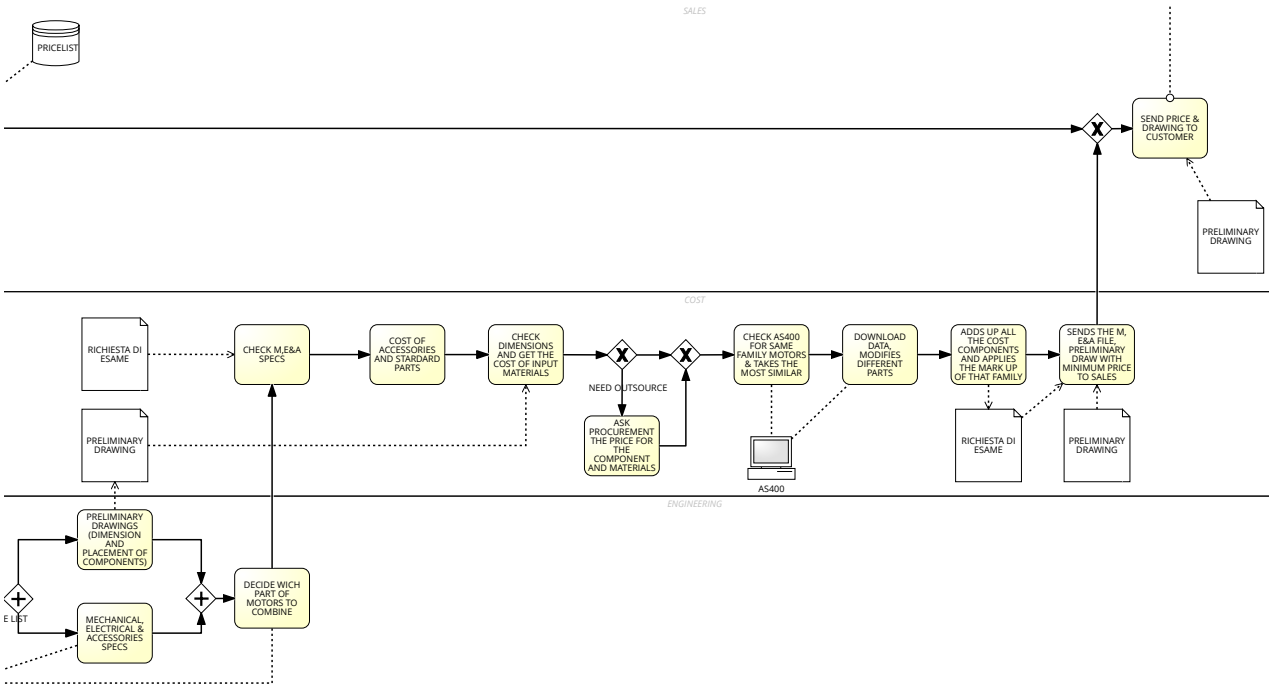

Figure 45: Figure to show the process flow diagram from customer enquiries until the order has been processed (2 of 3)

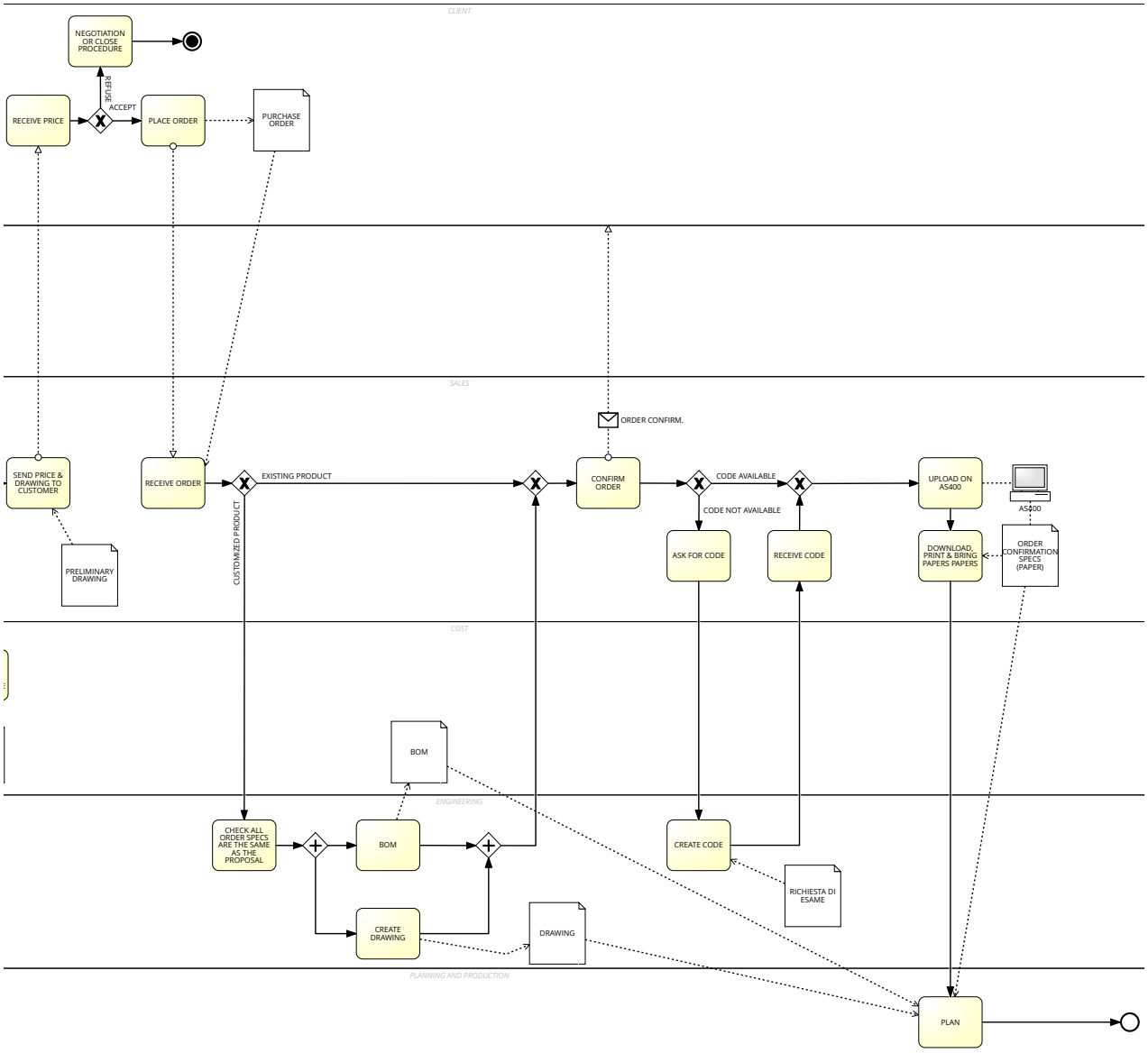

Figure 46: Figure to show the process flow diagram from customer enquiries until the order has been processed (3 of 3)

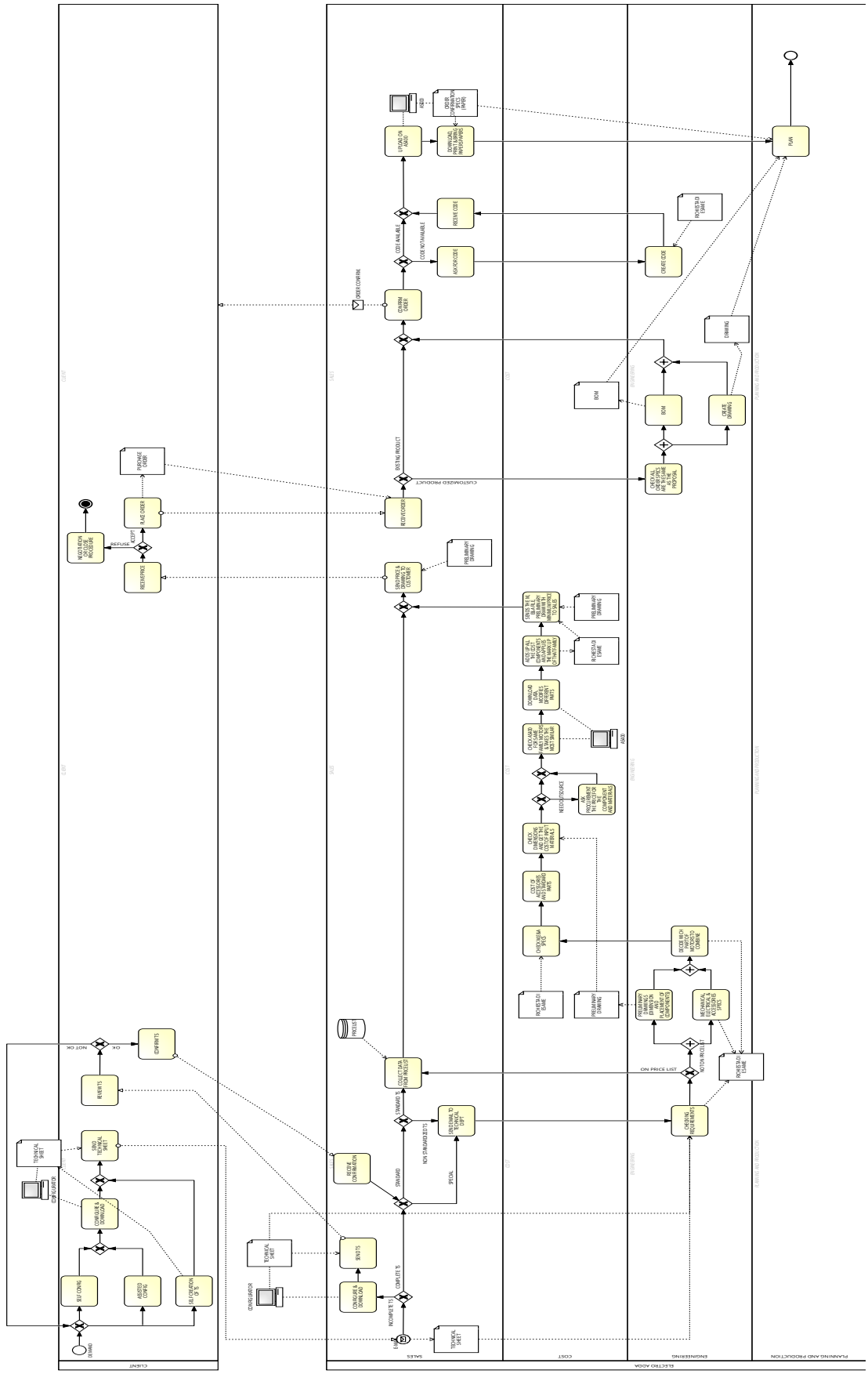

Figure 47: Figure to show the full process flow diagram (as-is) from customer enquiries until the order has been processed

C. Gantt Chart

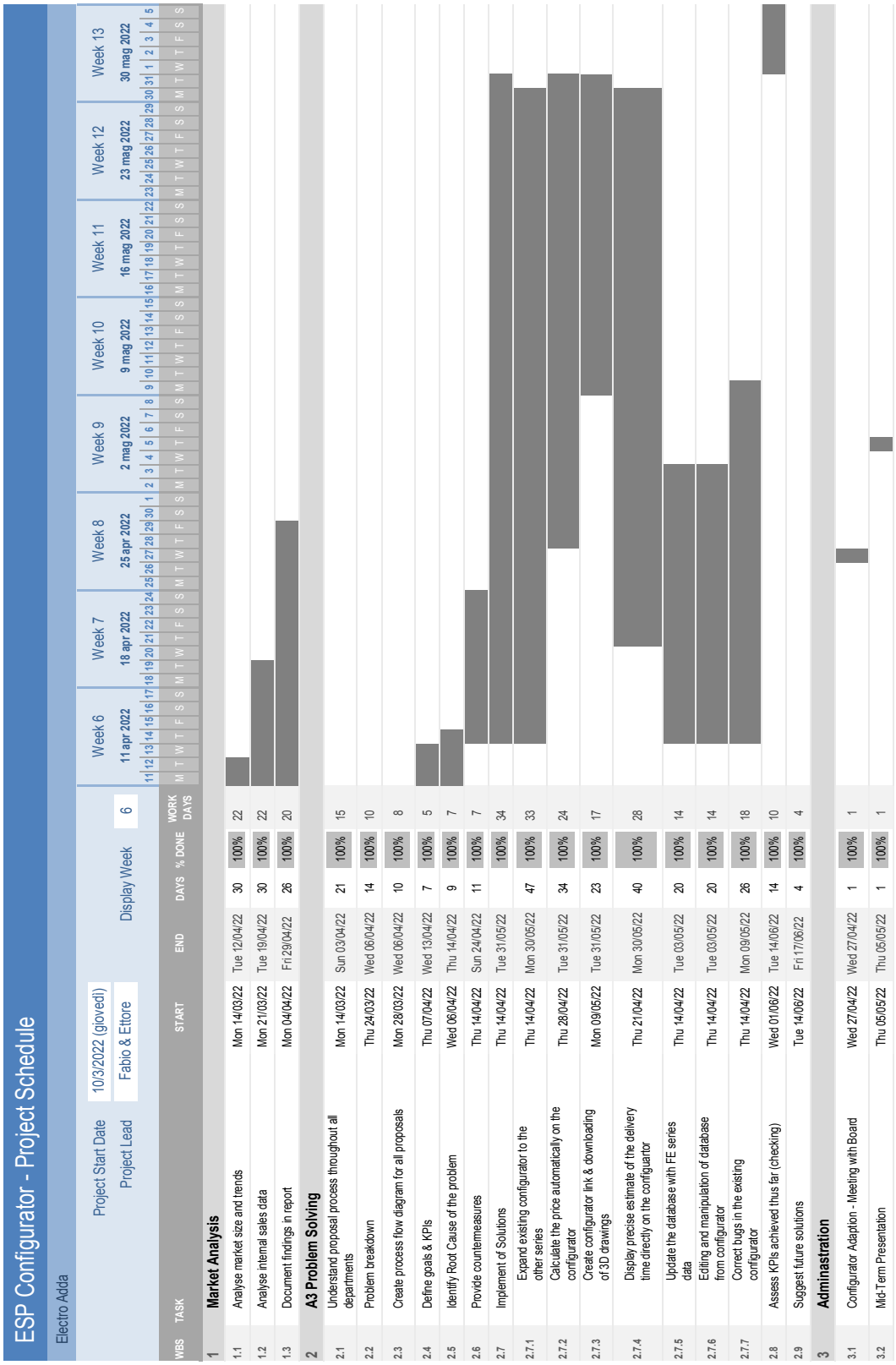

Figure 48: Figure to show the completed Gantt chart for this project

D. Configurator code

The images below are examples of the various coding languages (i.e. php, HTML, JavaScipt) required for the updated configurator. The code shown below was either edited or entirely created by our team.

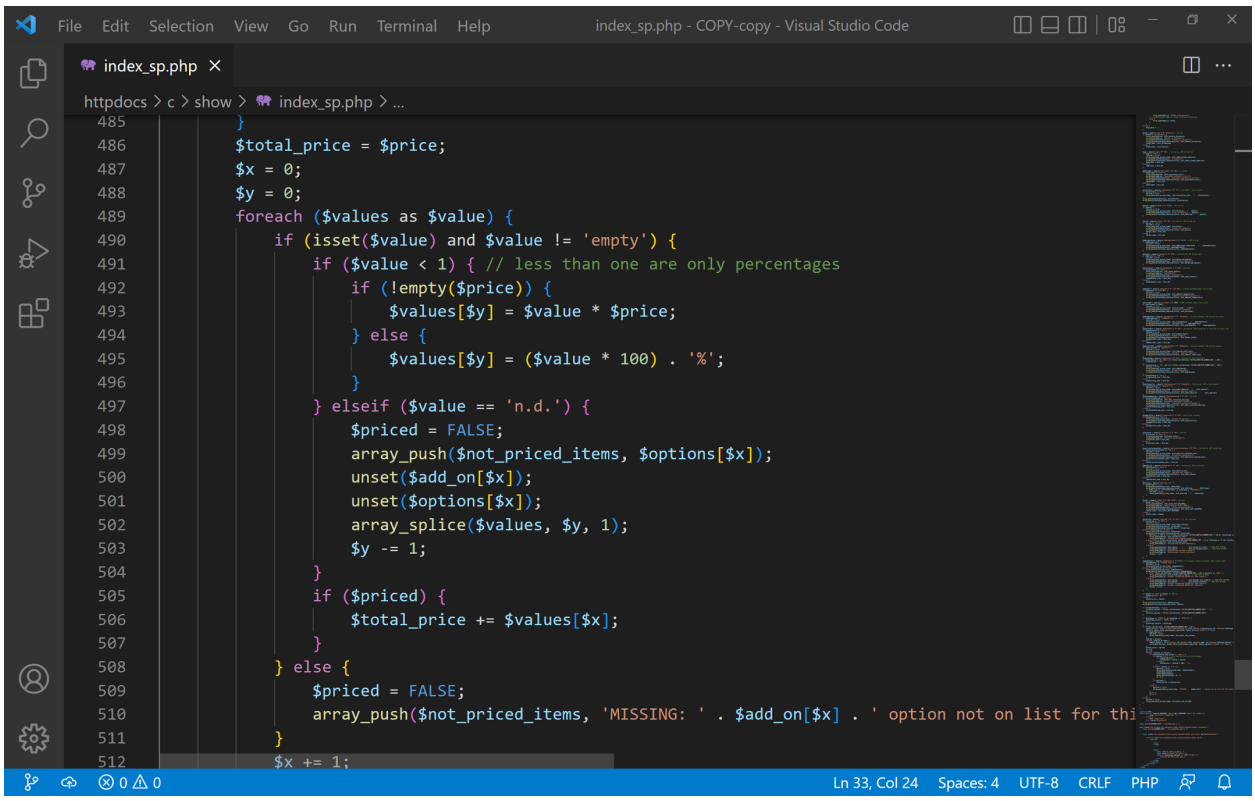

Figure 49: Image to show an example of the coding language (php) required for the updated configurator, showcasing the new price calculations

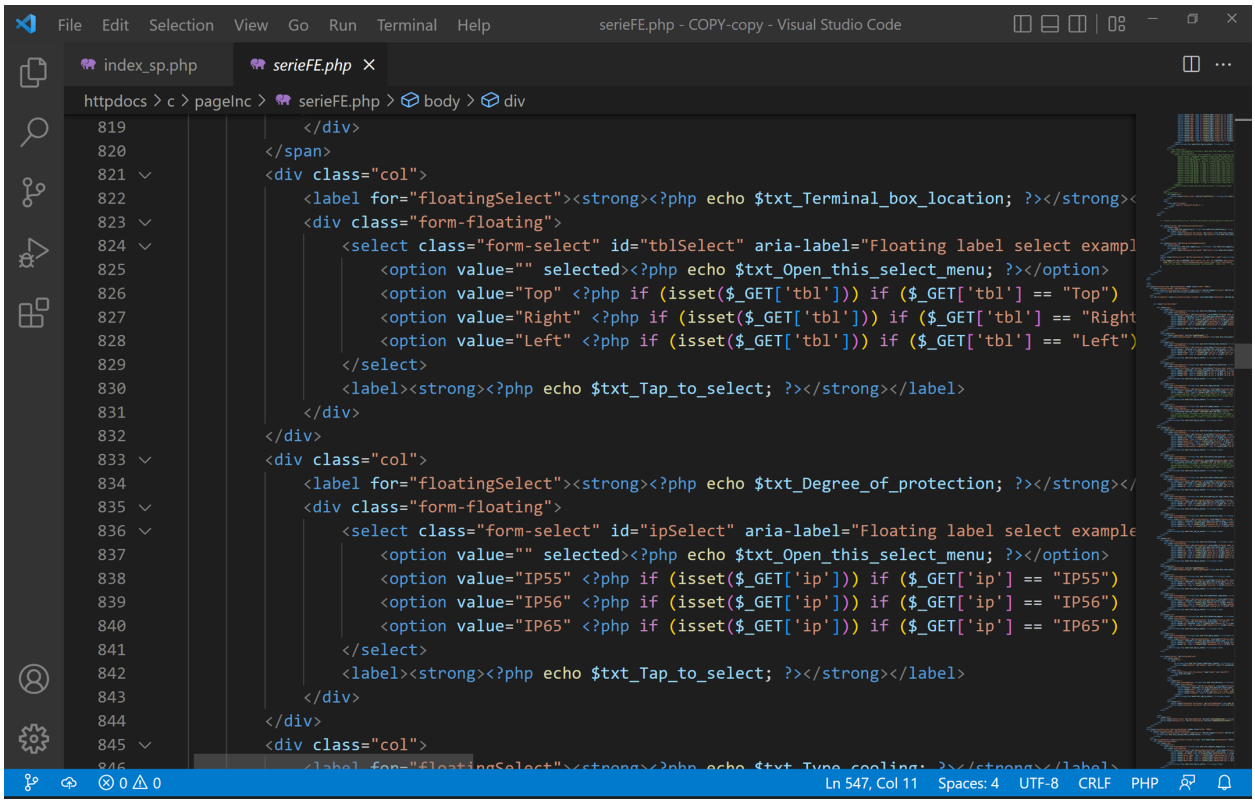

Figure 50: Image to show an example of the coding language (HTML) required for the updated configurator, showcasing several customisation options for the FE Series motors

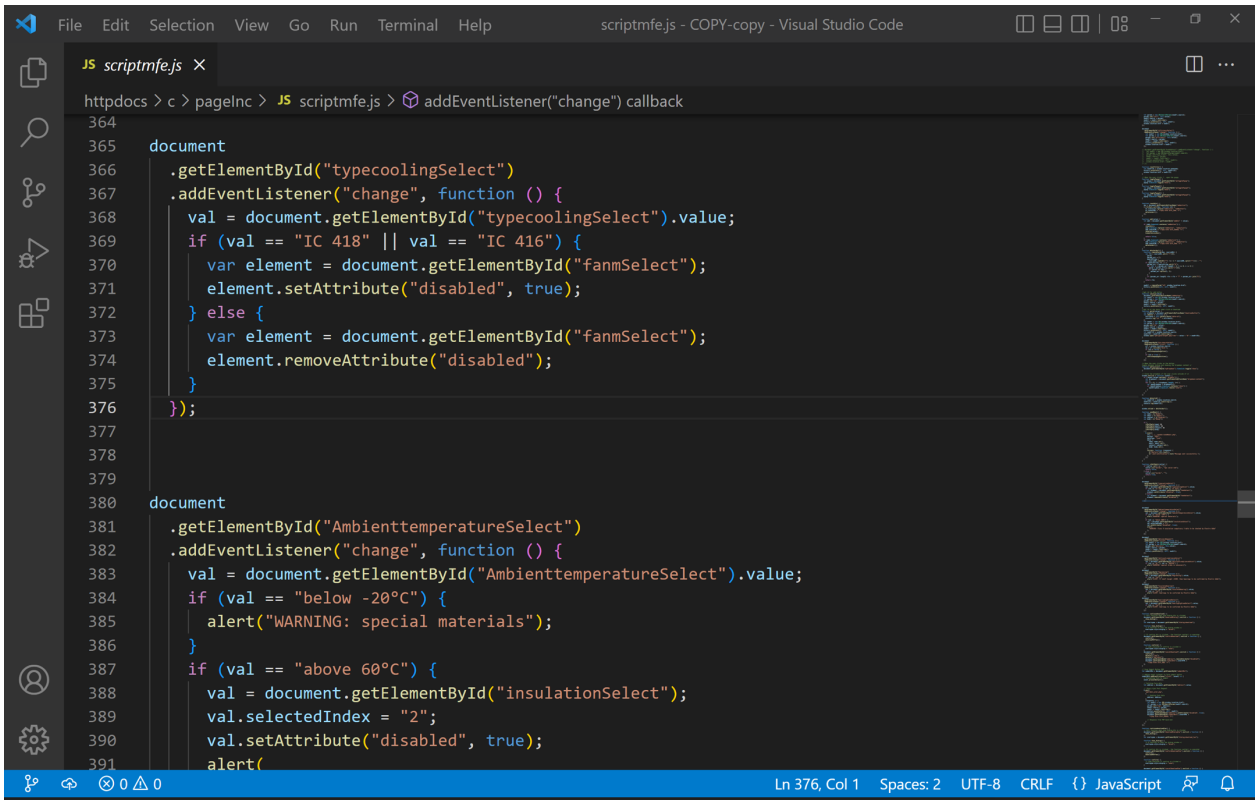

Figure 51: Image to show an example of the coding language (JavaScript) required for the updated configurator, showcasing several special customisation

E. Sales Department Survey Results

Table 15: Table to show the full results of the survey (9 people) completed by the sales department and representatives

ID	1	2	3	4	5	6	7	8	9
Start time	6/10/22 15:25:55	6/10/22 16:20:03	6/11/22 3:53:31	6/13/22 14:39:45	6/14/22 10:13:49	6/14/22 10:25:12	6/14/22 10:26:19	6/14/22 10:26:35	6/14/22 19:15:58
Language	Italiano	Italiano	English	Italiano	Italiano	English	Italiano	English	English
Le nuove funzionalità del configuratore riducono il tempo necessario	6	7	5	4	6	6	5	5	6
Le nuove funzionalità so semplici da capire e usare?	4	7	6	5	6	6	5	5	7
Senti che il nuovo configuratore ti sia di supporto nel tuo lavoro?	4	7	7	6	6	1	5	4	5
Cosa ti piace e non del configuratore aggiornato?	Rispetto a quello precedente si può scegliere il voltaggio ed è positivo	grafica e intuitività	Wish to have a information for the full range of the product.	Mi piace che ti guida passo passo alla creazione del motore con tutti gli accessori desiderati. Non mi piace che gli accessori scelti non sono dettagliatamente descritti nel	Le nuove feature sono molto interessanti	pricing new description of the Offered Motors	La possibilità di avere i prezzi online con le varianti	Configurator is great for producing data sheets and drawings to support offers, this is great and has been needed for a long time to highlight our professionalism. However, we	Like that the drawings are better readable and that more data are available
Hai dei suggerimenti per come il configuratore possa supportare il tuo lavoro e diminuire il tempo per gestire le	Nei motori autofrenanti manca la scelta del motore IE2	quando sarà completo con motori serie import e possibilità di generare in automatico prezzo e tempi di consegna penso che sarà ancora	Hope to get down load of torque & current curve and 2D /3D drawing of configured motor	Diversi, scriverò una e-mail di dettaglio	Al momento no	yes please you can indicate references in the configurator for each motor type and list of recommended leading customers	Potremmo arrivare a generare le offerte	Additional features - expansion on mounting positions etc	Next version should be able to derate power for example for higher temperatures or inverter supply if necessary
Scegli tutte le opzioni che rispecchiano la tua opinione sull'aggiornamento del configuratore	E' molto utile per risparmiare tempo - (It is extremely useful in saving time);	Ha qualche effetto positivo - (It has some positive benefits on my work);	E' molto utile per risparmiare tempo - (It is extremely useful in saving time);	E' utile perchè, con nuovi potenziali clienti si possono influenzare le scelte e, se ci fossero i disegni in formato CAD sarebbe più facile far inserire	E' molto utile per risparmiare tempo - (It is extremely useful in saving time);	Ha qualche effetto positivo - (It has some positive benefits on my work);	E' molto utile per risparmiare tempo - (It is extremely useful in saving time);	Ha qualche effetto positivo - (It has some positive benefits on my work);E' molto utile per risparmiare tempo - (It is extremely useful in saving time);	Ha qualche effetto positivo - (It has some positive benefits on my work);