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Process mapping for project execution from the perspective of the purchasing function

Case ABB Power Grids Finland Oy

The School of Technology and Innovations
Industrial Management Master's Thesis
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TIIVISTELMÄ:
Projektiliiketoiminta on toimialana monimutkainen eikä seuraa tiukkoja rutiineja. Projektien ominaispiirteet vaikuttavat suuresti myös hankintatoimintoihin, joilta vaaditaan joustavuutta ja uusia tapoja tukea projektien toteutusta, riippuen esimerkiksi erilaisista materiaaleista ja palveluista, joita tarvitaan projektin toteutuksen aikana. Tämä tutkielma on toteutettu yritykselle ABB Power Grids Finland Oy ja tutkimuskysymys on: Mitä kuuluu prosessikaavioon onnistuneeseen projektin toteutukseen hankintayksikön näkökulmasta? Tutkimuskysymyksen selventämisen tavoitteena on auttaa hankintayksikköä toimimaan proaktiivisemmin projektien toteuttamisen aikana ja tukea projektien tarpeita paremmin hankintatoimintojen näkökulmasta. Tutkielmalle on asetettu kolme tavoitetta, jotka ovat: 1) Tunnistaa projektin toteutuksen eri vaiheet, jotka ovat merkittäviä hankinnan näkökulmasta. 2) Tunnistaa erilaiset materiaalit ja palvelut, joita tarvitaan projektin toteutuksen eri vaiheissa. 3) Luoda prosessikaavio.

Tutkielman teoreettinen viitekehys käsittelee projektiliiketoiminnalle ominaisia piirteitä ja projektien toteuttamista, kuten myös hankintatoimintojen vastuita projektiliiketoiminnassa. Teoria kattaa myös prosessikaavioihin liittyvän teorian, joka tässä tutkielmassa toimii suuntaviivana itse prosessikaavion luomiselle. Projektiliiketoiminnan teoria kattaa tälle liiketoimintatyypille tyypilliset piirteet ja sen eri osa-alueita kuten projektinhallinta, aikataulutus, materiaalisuunnittelu ja kommunikaatio. Hankintaan keskittyvässä teoriaosuudessa käydään läpi toimitusketjun johtamisen ja hankinnan tarkoitusta, ja selvennetään näiden merkitystä ja tavoitteita erityisesti projektiliiketoiminnassa. Teoria prosessikaavioista sisältää teoriaa prosesseista ja laadun merkityksessä kaikissa toiminnoissa ja prosesseissa. Kappale tarjoaa lisäksi yksityiskohtaisempaa tietoa prosessikaavioista.

Tutkimus on toteutettu laadullisena toimintatutkimuksena, käyttäen apuna aineistotriangulaatiota. Ensisijainen aineisto kerättiin puolistrukturoiduilla haastatteluilla yrityksen sisällä. Toissijaista aineistoa, kuten yrityksen sisäistä dokumentaatiota, käytettiin tukemaan ensisijaista aineistoa. Tutkimuksen lopputuloksena kyettiin tunnistamaan seitsemän eri projektien toteutuksen vaihetta projektien aloituksesta asiakkaalle luovutukseen. Löydökset osoittivat, että kaikki vaiheet ovat omalla tavallaan tärkeitä myös hankinnan näkökulmasta. Materiaalien ja palveluiden hankinnat painottuvat kolmeen ensimmäiseen projektien toteutusvaiheeseen mutta hankintayksiköllä on myös monia muita erilaisia tehtäviä koko projektin toteutusprosessin ajan. Tulokset esitettiin graafisessa muodossa prosessikaaviona, jossa vastuualueet on eroteltu. Prosessikaavion lisäksi luotiin sivu, joka sisältää yleistietoa, vastuullisuustehtävämatriisin (RACI) ja arvovirtakartan (SIPOC), jotka sisältävät vaihekohtaista tietoa prosessikaaviosta.

KEYWORDS: Purchasing unit, Project Business, Process Mapping

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ABSTRACT:
Project business is a complex and nonroutine type of business. The features of projects' affect a lot also to purchasing, demanding flexibility and different ways to support the project execution depending, for example, the features of the different kinds of materials and services that are needed during the project execution. This thesis is conducted for ABB Power Grids Finland Oy and the research question is stated as: What is involved in process mapping for successful project execution from the purchasing function perspective? The aim of clarifying this is to help the purchasing function to operate more proactive during the project execution process and support the needs of projects' better considering different purchasing function tasks. The objectives for the thesis are to 1) Identify the different stages of project execution relevant for purchasing. 2) Identify the types of material and services needed in different identified project execution stages. 3) To design the process map.

The theoretical framework for the thesis handles the project business features and executing the projects as well as the purchasing responsibilities within the projects. The theory also covers the theory of process mapping to act as a guideline for conducting the actual process map. The theory of project execution covers the basic features of project business and the different elements of it, such as project management, scheduling, material planning, and communication. In the theory of purchasing the purpose of SCM and purchasing is explained and the key features and special needs for project purchases specifically are clarified. Process mapping includes the theory of processes and highlights the importance of high quality in processes in all operations and processes. The chapter offers also more detailed information about the process maps and conducting cross-functional process mapping.

The study is conducted as a qualitative case study using data triangulation. The primary data for the study was collected through semi-conducted interviews internally in the case company. In addition to primary data, secondary data such as internal documentation was used to support the primary data findings. In the results of the study, it was possible to identify seven different phases of the project execution process from the beginning of the project until handing over to the customer. Findings revealed that all the phases are important in some way also from the perspective of purchasing function. The purchasing of the materials and services happens mostly during the first three phases of project execution, but the purchasing unit had multiple different kinds of tasks throughout the whole project execution process. The findings of identified phases and materials were presented graphically using a cross-functional flowchart. The process map also included an activity detail sheet which includes general information of the project and RACI chart and SIPOC diagram.

KEYWORDS: Purchasing unit, Project Business, Process Mapping

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List of abbreviations

BOM = Bill of Materials
ERP = Enterprise Resource Planning
ETO = Engineer to Order
HV = High Voltage
LV = Low Voltage
MRP = Material Resource Planning
MTO = Make to Order
MTS = Make to Stock
MV = Medium Voltage
OC = Order confirmation
PM = project Manager
PO = Purchase Order
PPP = Project Procurement Plan
PR = Purchase Requisition
Project SCM = Project Supply Chain Manager
RACI = Responsibility chart (Responsible, Accountable, Consulted, Informed)
RFQ = Request for Quotation
SCM = Supply Chain Management
SIPOC = Supplier, Input, Process, Output, Customer
TQM = Total Quality Management

1 Introduction

1.1 Background

The main purpose of the purchasing function is to supply all the needed material and services for companies' primary activities. The project-related purchases can vary a lot between different projects and the purchases include purchasing both materials and services, and even construction contracting. All the purchasing cannot be made right at the beginning of the project but purchasing for different materials and services is done in different stages depending on the engineering and site activities during the project execution. (Peltola, 2012, p. 41, 44) This creates challenges for following up the progress of the project execution for the purchasing function if it is not clear what materials and services will be bought in different project execution stages.

This research is conducted for ABB Power Grids Finland Oy, Grid Integration unit in Vaasa (ABB Oy, 2019a). The unit delivers electrical substations which are an important part of the power grid (Nyberg, 2014, p.6). The nature of the project execution process in the case company is complex happening in many different stages. In the purchasing point of view, electrical substation projects include, for example, materials with very long delivery times, and scheduling for the site work is dependent on the delivery time of some materials. (Peltola, 2012, pp. 43-44)

1.2 Scope and objectives of the study

The thesis aims to support the ABB Power Grid Finland Oy Grid Integration unit's transparency in the project execution process from the perspective of the purchasing function. The thesis maps the different project execution stages in electrical substation projects that are relevant for the purchasing function. In this thesis context, the relevant stages for purchasing function in project execution include all that creates inputs for purchasing function's operations. The next step is to identify the different materials and services that are needed in identified project execution stages. In this way, this thesis aims to provide a deeper understanding of the purchasing function of the project execution process and help the planning of purchasing function resources in a multi-project environment and transform the purchasing operations even more to proactive direction instead of reactive. The results will be presented as a process map that gathers and summarises all the information in an easily read graphical form.

The research question is the following:

What is involved in process mapping for successful project execution from the purchasing function perspective?

The research question has three objectives:

- Identify the different stages of project execution relevant for purchasing
- Identify the types of material and services needed in different identified project execution stages
- To design the process map

The research is conducted as an action study with a qualitative method. The primary data for this thesis is collected through a semi-structured interview and as secondary data, the thesis uses existing data and documentation of the company like the process maps, and data from the ERP-system. The secondary data includes both qualitative and quantitative data to support the primary data findings.

1.3 Definitions and limitations

The theoretical framework of this thesis is constructed with a mix of theories from Project Business, Purchasing, and Process management. The project business and purchasing are handled to understand better the field of projects, especially turnkey projects:

how they are managed, and the special features of purchasing for project business. They create the main framework for understanding the project execution process itself and offer context for a research question. The theory of process mapping works as a guideline for conducting the process mapping and clarify the overall reasons and objectives for process mapping. This chapter goes through the key definitions and the limitations of this thesis more briefly.

Project business is "*the business that relates directly or indirectly to projects, with the purpose of achieving the objectives of a firm or several firms*" (Artto & Wikström, 2005). In literature, the project business is more often defined through a single project. Project is defined as "a temporary endeavour undertaken to create a unique product, service or result" (Bozarth & Handfield, 2008, p. 125; Project Management Institute, 2017). Project business activities have a defined starting and ending points and no clear routines (Bozarth & Handfield, 2008, p. 125).

Project execution is one phase of the project lifecycle (Bozarth & Handfield, 2008, p. 128). This thesis focuses on different stages of engineering and the project site activities happening during the project execution. Engineering and site activities are both affecting the timetable of the project and provide inputs for purchasing. This thesis handles the projects which include both materials and civil and installation works, in the literature referred to as turnkey projects. The project execution is handled mainly through operative operations.

Purchasing is traditionally defined as "*obtaining the correct materials and services in the right quality, quantity, cost at the right time and from the right source*" (Oakland, 2014, p. 20). Weele (2010, p. 3) has defined more detailed definition: *"The management of the company's external resources in such a way that the supply of all goods, services, capabilities and knowledge and knowledge which are necessary for running, maintaining and managing the company's primary and support activities are secured under the most favourable conditions."*

Purchasing includes numerous different tasks like determining the specifications, selecting suppliers, negotiating terms and conditions, placing the order and monitoring, controlling, and doing follow up and evaluation for the supply. The main task for purchasing is to support the company's primary activities and supply the needed materials and services. Concerning this thesis, the purchasing function activities are considered in the field of project execution to understand what the relevant project execution stages are for purchasing. The focus of the purchasing activities is limited mainly to operative purchasing activities for turnkey projects.

Process mapping is a symbolic representation of the process flow and it is most often used in defining the process. It is also a step-by-step description of how inputs are transferred into outputs by personnel (Harrington, 1991, p. 9). Process maps are a way of document all the activities taken by workers when transforming the inputs to outputs step-by-step within the specific process (Boutros & Cardella, 2016, pp. 35). The three basic components of processes are inputs, outputs, and activities (Harvard Business, 2010, p. 4).

This thesis introduces the basic definitions of the processes and process mapping. Process mapping theory in this thesis offers the objectives for the project mapping as well as the guideline for conducting the process mapping considering the thesis' topic. The thesis focuses only on the parts of the project execution process and subprocesses that are related and relevant to purchasing. In the process approach, the relevant processes for purchasing are the ones that provide inputs for purchasing. The process mapping in this thesis is done for observing and clarifying the current process in the company, thus it does not involve process improvement.

1.4 Structure of the thesis

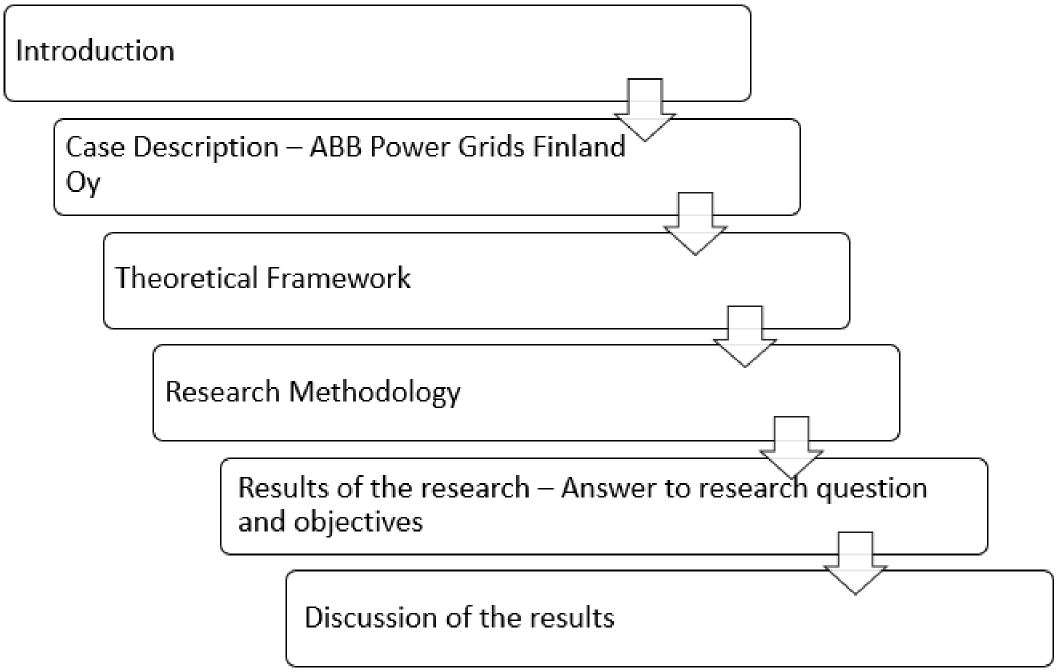

Figure 1. Structure of the thesis.

The thesis contains six chapters and it aims to systematically proceed to provide a coherent story. Chapter one offers an introduction to the topic and explains the background behind the thesis and the need for transparency in project execution from the purchasing function perspective in the Grid Integration unit. This includes also presenting the research question and objectives, which guide this study from the beginning to the end. The first chapter presents also the most important keywords: Purchasing unit, Project business, and Process mapping and limitations for the key words considering this thesis. Chapter one covers the outline for the whole study.

The purpose of the second chapter is to provide information about the case company ABB Power Grids Finland Oy and the Grid Integration unit and the electrical substation projects. This will help the reader to consider the theoretical part better in terms of this specific study and get an overview of the nature of the Grid Integration's projects.

The literature review is divided into three subchapters for the project execution from the perspective of the purchasing function, purchasing unit tasks in project execution, and process mapping for the project execution process. The two first subchapters handle the subject of the process mapping and the third subchapter handles the process mapping itself. The literature review creates an analytical framework for the thesis context for answering the research question and its objectives.

Before moving to the actual research part, the research methodology for action study is being presented more briefly in chapter four research methodology. The chapter covers the research collection for primary and secondary data as well as the analysing methods. The primary data was collected through the interviews and secondary data from existing documents and internal data of the case company. The main goal was to find similarities from primary data and use secondary data to support the findings from the interviews. The chapter ends with justifying the reliability and the validity of the conducted research.

Chapter five offers the answer to the research question and the objectives. The results will be presented accordingly to three objectives as project execution phases in purchasing function perspective, materials in different phases, and process mapping. The final goal is to identify the project execution process from the perspective of the purchasing function and also identify the materials and services needed in different stages. The results are then presented in the form of the process map.

Final chapter six summarizes the results presented in chapter five for the research question and objectives. Beyond this, the chapter offers a discussion between the theories and the results of the conducted research and represent conclusions and possibilities for future research.

2 Case Description

This chapter covers the background and information of the case company ABB Power Grids Finland Oy and its Grid Integration unit in Finland this thesis is conducted for. ABB Power Grids Finland Oy has been established as a legal company in Finland starting from 1.11.2019, yet it is fully owned by global ABB Group. In 2020 operations of ABB Power Grids Finland will be divested to Hitachi. The first subchapter will briefly tell about the carve-out of ABB Power Grids Finland Oy from ABB Oy and the future transition to Hitachi. Further on this chapter also explains more about the electrical substation projects which the Power Grid unit is delivering for its customers.

2.1 ABB To Hitachi

Before the establishment of ABB Power Grids Finland Oy, it was part of global ABB Group and ABB Oy. Current ABB formed in 1988 when two best-known names in European electrical engineering history ASEA and BBC merged as ABB (ABB, 2019b). Today ABB works over 100 countries and has a total of 147 000 employees and currently has globally four different business divisions: Electrification, Industrial Automation, Motion, and Robotics & Discrete Automation (ABB, 2019a). In Finland company Strömberg founded in 1889 by Gottfrid Strömberg was sold to ASEA in 1986 and two years later ABB was formed due to that former Strömberg came part of ABB (ABB Oy, 2019d). Nowadays ABB Oy is one of the biggest employers in the technology industry in Finland and it works approximately in 20 different cities with approx. 5400 employees. (ABB Oy, 2019b). ABB Power Grids Finland Oy has been established in Finland as a result of carve-out of one of ABB's former business division Power Grids.

The recent organizational changes are the impact of the announcement on December 17, 2018, that ABB and Hitachi expand and re-define their partnership originally announced in December 2014. As a result, Hitachi will acquire 80.1 percent equity in ABB's Power Grids business. (ABB Oy, 2018) The carve-out of ABB Power Grids Finland Oy from

ABB Oy is a part of divestment where ABB's Power Grids businesses globally are separated as independent legal companies each in their respective operating country, carrying on with ABB's entrepreneurial business culture. This is the first state before completing the joint venture with Hitachi which is expected closing by the first half of 2020. (ABB Oy, 2019c)

Hitachi has been founded by Namihei Odaira in 1910 and Hitachi headquarter is located in Tokyo, Japan. Hitachi has globally over 300 000 employees and 50% of the operations are in Japan, another half around the world. Hitachi's mission stated by its founder is *"Contribute to society through the development of superior, original technology and products."* and accordingly to that Hitachi is still today operating in a way which aims to resolve their customers' and society's issues with wide-ranging business activities aiming to build a more dynamic world. (Hitachi, 2019).

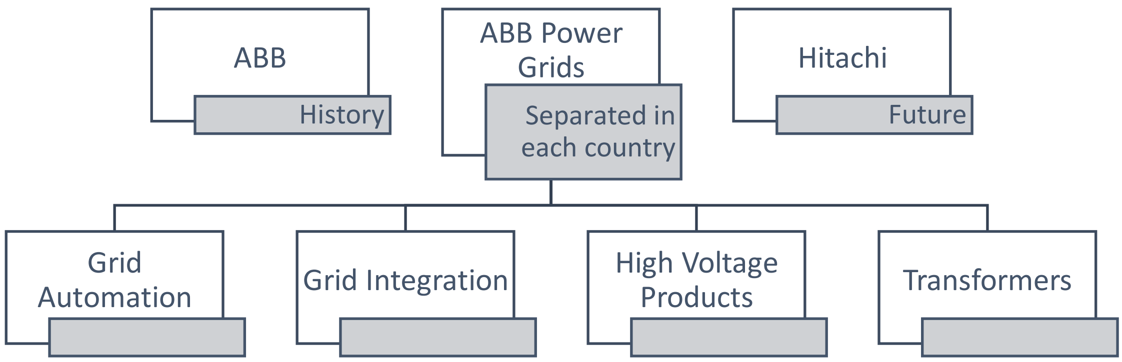

Figure 2. Hierarchy chart of ABB Power Grids business globally.

Power Grids is the industry leader in the digitalization of the electrical networks (ABB Power Grids Finland Oy, 2019). The Power Grids Business operates globally in four different segments: Grid Automation, Grid Integration, High Voltage Products, and Transformers (Hitachi, 2018), see Figure 2. Hierarchy chart of ABB Power Grids business globally. In Finland Power Grids has many different functions, like manufacturing, designing, supplying and maintaining reactors and transformers, management for power grid guidance, control, and automation systems and projects, and distribution and transmission network solutions for electricity and energy companies, infrastructure and industry like electrical substations what this thesis handles. (ABB Power Grids Finland Oy, 2019)

2.2 ABB Power Grids Finland Oy, Grid Integration unit

The ABB Power Grids Finland Oy, Grid Integration unit delivers electrical substations which is an important part of the electrical infrastructure (ABB Oy, 2019a). There any many different kinds of electrical substation projects from partial material deliveries to turnkey projects (Peltola, 2012, p. 38). Grid Integration has approximately 100 employees around Finland and it delivers substations in Finland but also globally, for example in Africa and Kazakhstan (ABB Power Grids Finland Oy, 2019).

The nature of the case company's business is different from the most typical business cases. The case company does not have its production, but it delivers projects with different scope including both work and/or material for its customers. Case company delivers mainly turnkey projects but also extensions for the existing entities, engineering packages including the materials, material package deliveries, and service for existing entities. (Peltola, 2012, p. 38)

A typical project involves many different materials and suppliers, and these vary depending on the type of project. With turnkey projects, some number of components and materials are the same but technical specifications may change a lot from project to project. These features of this business create the need for flexible operations.

2.3 Electrical substation projects

The electrical substation projects Grid Integrations delivers for its customers differ from each other and there are no projects which would be totally similar. This thesis focuses on the turnkey projects which include both material and site work such as civil and installation works, referred also as services throughout this thesis. These kinds of projects can be also delivered to the customer with a different kind of scope. With the turnkey project, the supplier takes care of all the project related issues as long as the project is handed over to the customer. This means that in turnkey projects Grid Integration is acting as a main contractor for the projects. Another option is that the customer acts as the main contractor himself in the project, but the scope still involves the civil and construction works. (Peltola, 2012, p. 38) The contractor in this context means the vendor who supplies the customer for a specific project (IEEE, 2019, p. 10).

The electrical substation projects in the case company are executed with the specific project team which includes at least project manager, one or multiple engineers from mechanical engineering, civil engineering, and electrical engineering and controller (Oja, 2017, p. 40; Peltola, 2012, p. 40). Many different stakeholders are taking part in the purchasing process (Peltola, 2012, p. 40) and the project has also designated project SCM who is responsible for purchasing all the materials and services. The number of engineers varies from 2 to even 12 depending on the size of the project (Oja, 2017, p. 41). The whole project team is responsible that the project will be executed in the timetable agreed in the sales phase and within a budget but the main responsibility lies with the project manager (Peltola, 2012, pp. 38, 40). Project personnel work parallels on several projects in a multi-project environment (Oja, 2017, p. 41).

3 Literature Review

This chapter will go through the theoretical framework needed for conducting the process mapping for successful project execution from the perspective of the purchasing unit. The framework covers the special characteristics and requirements of projects for better understanding. This begins with covering the theory for project business environment and the project execution operations as well as the features which effect also to the purchasing function tasks. The next subchapter goes through more the general SCM and purchasing frameworks and more specifically purchasing in a process environment. These two first subchapters are also covering the information about the different stakeholders and the coordination between these. The last subchapter covers firstly the basic definitions considering the processes, need for quality in processes, and finally process mapping. The main idea of the last chapter is to present the theoretical ground for conducting the process mapping.

3.1 Project execution from the perspective of the purchasing function

Project-related business differs from a normal day-to-day factory-run business. Projects do not necessarily possess clear routines and the nonroutine projects are harder to manage than a business that has, for example, clear repeating production cycles. (Bozarth & Handfield, 2008, p. 125) Projects create a unique product, service, or result. Even if the project might have repetitive characteristics, the different projects can be still defined as unique. (Project Management Institute, 2017, p. 1) They are conducted in a certain amount of time and they have clear duration including starting and ending points and the specific resources assigned for executing the project such as budget and people (Bozarth & Handfield, 2008, p. 125).

A turnkey project is a method of contracting where the contractor has full responsibility for the project execution including designing, procurement of goods and services, and other possible activities until the fully operating "product" is ready to be handed over to the customer (IEEE, 2019, p. 11). The turnkey method can be applied to both existing substation modifications (brownfield projects) or new substations (greenfield projects). The term turnkey is commonly used also as an engineer, procure, and construction (EPC) project. (Hosie, 2007, p. 2; IEEE, 2019, p. 10) The specification for turnkey projects usually includes discussion about: scope, schedule, and commercial issues (IEEE, 2019, p. 10).

Typically, the project scope of supply is changing between different projects. The geographical area might differ from country to another around the world and the time schedules are usually tight (Iloranta & Pajunen-Muhonen, 2018, pp. 59-60). Projects also require a lot of inter-organizational and cross-functional coordination (Bozarth & Handfield, 2008, p. 125). The electrical substations, for example, can be either delivered as air-insulated substations (AIS) or gas-insulated substations (GIS) (IEEE, 2019, p. 19). The scope of turnkey projects is different for each project but generally, they still include the following responsibilities on the behalf of a contractor:

1. Detailed design engineering for the substation, according to customer specification
2. Documentation of drawings and design, schedules and possible coordination with subcontractors
3. Purchasing of the material. Purchasing tasks will be covered more specifically on subchapter 3.2 Purchasing unit tasks in the project execution phase
4. Civil and installation works
5. Safety and security of the project personnel
6. Operation and maintenance training for the customer
7. Provide required permits for example for construction, environmental or development

   (IEEE, 2019, p.12)

As the turnkey projects include also work, the site activities for turnkey projects require some general conditions and they should follow the construction practices. These conditions and practices also generate the need for certain materials or services. Some of these general conditions are for example temporary facilities, following allowable construction work hours, waste management, and security. (IEEE, 2019, p. 16) The construction practices for turnkey projects are also indicated in the scope of supply and changing depending of the project but can include according to IEEE "Development of specifications of services for turnkey substation projects" (2019, pp. 26-27), for example, the following:

1. Grading/drainage
2. Trenching
3. Concrete/foundations
4. Conduit, cable trench, raceway
5. Grounding
6. Steel erection
7. Equipment installation
8. Bus work and connectors
9. Control building
10. Cable installation requirements
    a. Control
    b. High/medium voltage
    c. Overhead/underground
11. Station service equipment

Project management is a foundation for all construction projects and it has three constraints: scope, time, and cost (Martens & Carvalho, 2017, p. 29). The characteristics of projects demand the different tools and techniques for project planning and controlling (Bozarth & Handfield, 2008, p. 125). Project management is defined as "*the application of knowledge, skills, tools, and techniques to project activities to meet project* *requirements*." (Project Management Institute, 2017). Bozarth and Handfield have defined five phases of the project: Concept phase, Project definition phase, planning phase, performance phase, and post-completion phase. The performance phase, in this thesis referred to as project execution, is the phase where the organization executes the actual project plan. (Bozarth & Handfield, 2008, p. 125, 128)

Rough capacity planning is a technique for planning the capacity that monitors the requirements for key resources by using the master production schedule. Material Planning Requirements (MRP) is more accurate and it transforms the master production schedule into planned orders for the parts and components needed for the final output. It is based on the Bill of Material (BOM), backward scheduling, and the more accurate explosion of BOM. In industry, BOM is defined as a listing of all the raw materials and parts for the main product, including also the quantities. The master production schedule is based on the planned lead times for each component and when they're needed. The explosion of BOM is created with backward scheduling. (Bozarth & Handfield, 2008, pp. 486-488)

Schedules for projects are usually presented in a graphical form where the activities are listed as a bar chart. This kind of chart indicates the activities on time scale horizontally. (Nicholas & Steyn, 2012, p. 181) The timetable is decided according to the delivery times of the material but also the customer related issues (Peltola, 2012, p. 44). The different tasks in the timetable are put in order considering the different dependencies of the tasks. Some tasks cannot be started before the other one has been completed and this can be related to logical reasons, circumstances, technical reasons, or resources. (Viita, 2015, pp. 12-13; Koskenvesa, Sahlstedt, & Lahtinen, 2011p. 81-82)

Different kinds of timetables can be created and designed for the project. A general timetable is the one that lists all the most important working phases and the duration of the project. The working timetable lists the sub-activities for different tasks and the schedules can be created even individually for weeks or individual activities. (Viita, 2015, pp. 29-31; Koskenvesa et al., 2011, pp. 43, 45-47, 55-59)

The project schedule creates a baseline for the whole project execution and includes different milestones. The scheduling is a tool for managing and controlling the operations and it affects straight to cost, quality, and safety. The schedule might change during the project execution. The changes can occur mainly because of changes in design or an insufficient amount of information provided in earlier stages. The contractor is responsible for defining the timetable for the whole project from sales to handing over to the customer. (Viita, 2015, p. 9; Koskenvesa et al., 2011, p. 17, 19; Junnonen, 2010, pp. 62-63)

Scheduling and planning are generally required for all construction projects which include site works because these include several tasks and require coordination of multiple resources such as personnel, materials, and equipment. EPC phases can be classified as the most important phases related to project success for construction projects. The execution process of the EPC process has been identified as one of the three important aspects from the perspective of project success. Other aspects are project value and client satisfaction and according to some researchers also time, cost, quality, and customer satisfaction. (Kabirifar & Mojtahedi, 2019, p. 15; Nguyen & Bonaventura, 2017, p. 73-85)

Besides the project manager, many different internal and external stakeholders are included in projects, and the stakeholders can be defined as the entities who are working with the project to fulfil its objectives. (Olander, 2005, p. 327) Construction projects are carried out by personnel working with engineering, procurement, and construction (EPC). (Kabirifar & Mojtahedi, 2019, p. 2; Olanrewaju & Abdul-Aziz, 2015, pp. 79-129) The stakeholders like owners, consultants, suppliers, and subcontractors of the construction projects affect straight to the performance of the projects. Therefore, the collaboration, information sharing, continual improvement, problem-solving, mutual objectives, supplier and subcontractor selection criteria, etc. between the different parties are very important. (Pal, Wang, & Liang, 2017, p. 1226; Black, Akintoye, & Fitzgerald, 2000; Thomas Ng, Tang, & Palaneeswaran, 2009)

Kabirifat and Mojtahedi (2019, p. 8) have recognized based on literature 21 different EPC project critical factors. The list includes, for example, poor project planning, design incompletion, insufficient stakeholder engagement, long-lead-time delivery, changes in project execution, late delivery of materials, poor quality of materials, redo of deficient tasks.

Lack or failure of coordination or communication between relevant stakeholders creates deviations and quality defects with materials deliveries which affect costs and performance (Darvik & Larsson, 2010, p. 53). The lack of coordination or problems with processes can cause poor performance in projects. (Kabirifar & Mojtahedi, 2019, p. 2; Olanrewaju & Abdul-Aziz, 2015, pp. 79-129) Yaser and Rahman (2017, p.244) have researched the causes of poor communication in the construction industry which creates major challenges in dynamic and complex project environments which include many different stakeholders. Out of the 33 causative factors, Yaser and Rahman have identified, the most common factor was lack of effective communication between the different stakeholders and the second was a lack of effective communication system or platform. Others are for example poor planning and coordination, lack of clear objectives, inaccurate delivery of project information and lack of understanding among parties. The biggest effects perceived by Yaser and Rahman are for example, time overrun, conflict among construction parties and cost overrun.

3.2 Purchasing unit tasks in the project execution

In Finland, approximately 70% of the turnover of companies is used for purchasing different goods and services. Because of this, even the smallest improvements can provide big savings. The purchasing function operates on behalf of the rest of the organization in terms of buying goods and services. The purchasing process begins with the need and which normally comes from other functions. SCM and purchasing can be recognized as a key business driver. (Weele, 2010, p. 18)

Supply chain management

Supply Chain Management (SCM) means a transformation of the goods and services from raw material suppliers, component suppliers, and other suppliers so that the company's end-users' expectations are being met or surpassed through managing all workflows, activities, information, knowledge and financial resources. Manufacturing and logistics, and purchasing are part of SCM and additionally, SCM also includes the communication with suppliers like it can be seen in the figure below. (Weele, 2010, p. 18)

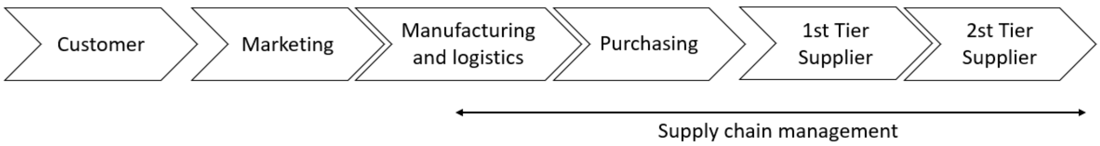

Figure 3. Supply chain management adapted from (Weele, 2010, p. 254).

The supply chain is one of the most important business operation for many organizations (Weele, 2010, p. 3). The objective of SCM is meeting end customer requirements in terms of supplying the required material and services at the right time and competitive cost (Slack & Brandon-Jones, 2018). SCM has four operational performance objectives / competitive capabilities: quality, speed/time, flexibility, cost (Bozarth & Handfield, 2008, pp. 29-32; Slack & Brandon-Jones, 2018, pp. 246-247). On top of these Slack and Brandon-Jones (2018, p. 246) have also defined one more performance objective - dependability.

- *Quality* in every part ensures error-free operation in each stage consistently. (Krajewski, Malhotra, & Ritzman, 2019) Quality includes three parts: quality of performance, conformance to requirements, and reliability quality. Quality of performance means the basic operational characteristics of goods or services.

Conformance to requirements and reliability quality means that the good or services can perform according to specifications and will continue doing so consistently. (Bozarth & Handfield, 2008, p. 29)

- *Speed/time* can be divided into the speed of delivery and reliability (Bozarth & Handfield, 2008, pp. 29- 30). It is highly dependable to lead times and inventory and the aim is to find balance with scheduling and planning and stock levels on production facilities.

- *Flexibility* measures the capability to cope with disturbances and changes in operations or customer demand (Slack & Brandon-Jones, 2018).

- *Cost* does not necessarily mean always the lowest price but all the costs occurring over the lifetime of the purchased product, which can be also referred as the total cost of ownership (TCO) (Weele, 2010, p. 10). Cost reduction should be supported through efficient processes by cutting down scrap and rework (Krajewski et al., 2019).

- *Dependability* is partly related to quality and partly to the speed of delivery. It is often described “on time, in full” in supply chain operations. All these five operational performance objectives define the performance of operations and processes when considering what the company itself will deliver for its customers. (Slack & Brandon-Jones, 2018)

A supply chain can help to achieve a competitive advantage for organizations. High-level performance with SCM translates into productivity but with innovative products or services, it takes a superior ability to shape and respond to the demand. (Weele, 2010, p. 306) The importance of paying attention to costs, quality, and lead or delivery times based on co-operation, teamwork, and coordination throughout the organization should be emphasized. All these elements should be considered more in all levels and decisions throughout the organization. (Akintoye, McIntosh, & Fitzgerald, 2000, p. 161-164; Ganeshan, R., Harrison, T.P., 1997)

Purchasing

Purchasing means management of all external resources which are necessary for managing, running, and maintaining both the company's primary and support activities in a way that all goods, services, knowledge and other possible resources are secured under the most favourable conditions (Weele, 2010, p. 3). It is part of SCM and the link between the organizations' operations and external suppliers. (Slack, Chambers, & Johnston, 2001, p. 415)

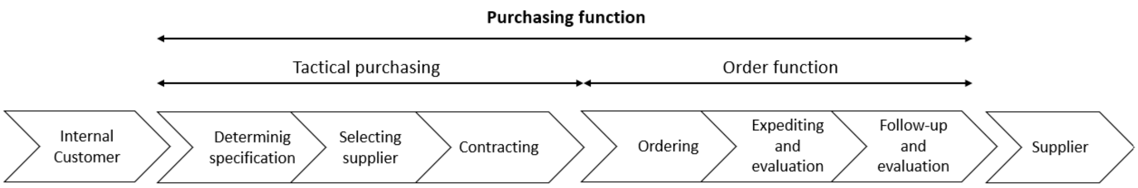

Figure 4. The purchasing process model, adapted from (Weele 2010, p. 9).

Figure 4. presents the purchasing process model and the purchasing function tasks. The tasks include numerous different activities like determining the specifications, selecting suppliers, negotiating the contract under the most suitable terms and specifications, placing the order or issuing the contract, expediting and doing follow up for the orders in different stages, and evaluating the supplier at the same time. These can be further divided into tactical purchasing and order function. (Weele, 2010, p. 9)

The purchasing unit works as a link within several different stakeholders such as engineering, production, suppliers, and subcontractors (Uusi-Rauva, Kouri, Miettinen, & Haverila, 2009, p.203-207). Because of this, the single purchase includes different decision-making roles. With standard products or services even, the purchaser can be the decision-maker but with the complex products or services engineer is usually the decision-maker. The product can be also, for example, designed in a way that only one supplier is applicable. Sometimes the decision-maker can be the end-user. (Uusi-Rauva et al., 2009, p.203-207, 394) Regardless of who makes the specification, the buyer is responsible for ensuring that the specifications are being met (Weele, 2010, p. 33) and the goods or services are delivered on-time (Bozarth & Handfield, 2008, p. 351). This can be measured as the speed of delivery and reliability. How quickly the need can be fulfilled after it has been identified and is the supplier able to deliver the goods or services in the promised timeframe. (Bozarth & Handfield, 2008, pp. 29-30)

Many different variables affect the purchasing process and buying activities. These are for example product characteristics, strategic importance, purchase value, purchasing market characteristics, risk level, purchasing department's role in the specific organization, and how much the product or service affects the existing routines in the organization (Weele, 2010, pp. 24-25). The amount of the purchasing volumes differs a lot from company to company (Bozarth & Handfield, 2008, p. 347) and in project-related purchases the scope is typically changing between the different projects (Iloranta & Pajunen-Muhonen, 2018, pp. 59-60). Project-related purchases usually involve purchasing materials, services, and construction contracts (Iloranta & Pajunen-Muhonen, 2018, pp. 59-60). Smeltzer and Odgen (2002, pp.67-68) also argue that pure service or materials exist seldom.

The way for the other functions to notify the purchasing department of the requirements is Purchase Requisition (PR). PR usually contains a request to purchase specific goods or services and authorization for the expense. (Baily, Baily, Farmer, Jessop, & Jones, 1994, p. 270, 273) The different types of buying can be a new-task situation, modified rebuy, or straight rebuy. In the new-task situation, the product or service is supplied from a new supplier. The modified rebuy means that the new product or service is purchased from an old supplier or new supplier but with a product that has been used before. Straight rebuy means buying a known product or service from an old supplier. (Weele, 2010, p. 31)

The purchases involve functional specification and technical specification which together are called purchase order specification which includes different dimensions like quality specification, logistics specification, maintenance specification, legal and environmental requirements, and target budget (Weele, 2010, p. 9). The different specifications can be also related, for example, requirements for a brand, industry standards, and performance characteristics. (Bozarth & Handfield, 2008, pp. 347-348)

Purchasing is documented and needed documentation can be for an example purchase order or technical specifications (Oakland, 2014, p. 77). Generally, the PO includes at least order number, product description, unit price, quantity, delivery time or date, delivery, and invoicing address (Weele, 2010, p. 408). PO includes also commercial content like general terms and conditions and administrative content for carrying out the specific transaction. On top of these are all the additional information and attachments considering the purchase. Some documentation might be needed only for internal operations. (Gadde & Håkansson, 1993, p. 59)

The construction industry materials can be divided into three categories and materials belonging in each of these categories should be handled differently. One important task of purchasing is to ensure the appropriate timing of material deliveries which is also related to the material categorisation in terms of delivery time. (Forbes & Ahmed, 2010, pp. 127-129)

1. Make to Stock (MTS), MTS products are items that are produced to stock based on market forecasts such as installation materials.
2. Make to Order (MTO), standard items that are produced according to PO specifications, for example, concrete products.
3. Engineer to Order (ETO), customized items produced according to engineering, for example, steel structures.

   (Forbes & Ahmed, 2010, pp. 127-129)

With engineer to order supply chains, the materials are specified totally according to customer order (Weele, 2010, p. 406). ETO supply chains are often used in large and complex projects like construction projects (Gosling, 2009, p. 741). In ETO supply chains no material stocks are existing, and the purchasing will be made according to customer specifications. The projects with ETO supply chains are executed for one customer and they often possess long lead times. Examples of ETO supply chains are construction businesses and shipyard businesses. Purchasing must be able to answer quickly to changing specifications and project planning. (Weele, 2010, p. 7, 259)

The purchasing in projects, especially for major equipment, is a subsequent phase of the engineering phase and the purchasing of major equipment could be even categorized as an integrated part of engineering project management. The major equipment has a big cost impact and long lead times. Therefore, it also has high uncertainty in on-time delivery perspective and the delays may affect the whole construction schedule. The critical supply chain should be scheduled, controlled, and synchronized. (Yeo & Ning, 2006, p. 133)

The material descriptions are usually more complete than the scope of work for services. The material specifications might also get more attention to achieve clearer specifications than services have. (Smeltzer & Ogden, 2002) The scope might differ from project to project, but the requirements for design also reveal the need for materials or services to be purchased. In civil projects and construction work, the specifications are described usually as scope-of-work (Weele, 2010, p. 33).

The electrical specification of the substation, layout, and equipment should be based in the single line diagram and fulfil the needs from a technical perspective. Sometimes the customer may have specified suppliers for specific equipment or a list of approved or acceptable manufacturers. (IEEE, 2019, p. 25) The design requirements for electrical substations in IEEE (2019, pp. 18-21) have been divided into five different groups which state the requirements that need to be identified in the specification of a substation projects.

1. Civil and structural design
2. Mechanical
3. Physical
4. Electrical
5. Temporary design and construction

For project-related purchases, it is typical that the knowledge is collected from previous projects and this information will be stored and used for later projects (Iloranta & Pajunen-Muhonen, 2018, pp. 59-60). The complexity of the purchases depends mainly on how precise and clear the statement of work or material description is. This can be dependent on the functional team which is involved in the purchasing - high level of professionalism and commitment lowers the complexity. (Smeltzer & Ogden, 2002)

The purchases must be scheduled separately so that the lead times, for example, asking for RFQs, negotiations, and determining the supplier will be considered. Some on the purchases will be made right after the project is started and others will be purchased during the project execution. The time for purchasing depends on when the material or service is needed on-site and how long is the lead time for the specific material or service. The purchasing schedule can be separated or integrated with the project schedule. (Viita, 2015, p. 27; Koskenvesa et al., 2011, p.51-52)

According to a study conducted by Sarhan, Xia, Fawzia, and Karim the most common type of waste in the construction industry is waiting (Sarhan, Xia, Fawzia, & Karim, 2017, p.62). Resource shortages are the most frequent reason causing cost overrun and delay in the procurement phase among the price fluctuation (Habibi, Kermanshachi, &

Safapour, 2017, pp. 385-386). Issues related to SCM and purchasing might result to delay and time impact on projects (Gonzalez, González, Molenaar, & Orozco, 2014, p. 7).

The SCM best practices have been adopted slowly in the construction industry. This can be because of the unique nature of the construction process and high-level customized product including various stakeholders and a variety of objects. (Akintoye et al., 2000, p. 167) SCM implementation in construction projects enables project planning and management. Information sharing is very important avoiding inefficiencies caused by for example self-serving actions of different divisions within the same company or individual companies or organizations. But the nature of construction industry can be very specialized and fragmented. (Forbes & Ahmed, 2010, pp. 127-129) Lack of planning in project purchases might lead to hurry and purchasers do not have time to discuss the prices or terms and conditions. This creates more risks and costs. (Iloranta & Pajunen-Muhonen, 2018, pp. 331-332)

Iloranta and Pajunen-Muhonen (2018, p.83-103) compare the traditional and modern purchasing process saying that modern purchasing should be more proactive instead of reactive. The traditional purchasing that begins only after-sales phase and could be characterized as an operative, reactive, and one-way. Modern purchasing and proactive operations offer more possibilities to continuously find the best solutions and consider the value for the customer.

3.3 Process mapping for the project execution process

Enterprises are the results of a century of evolution and nowadays enterprises are usually divided into different functions and workflows, and processes are happening all across these functions (Melan, 1993, p. 10). There are hundreds of processes going on every day in organizations, most of them are repetitive and play an important role in everyday functioning in the companies (Harrington, 1991, pp. 9-11). Total quality management adheres to managing quality across the organizations in every function and process (Evans & Lindsay, 2008, p. 18). Good performance in quality is a key strategic factor in succeeding in business (Oakland, 2014, p. 12).

Processes

Interrelated connected activities of work that have inputs and outputs are processes. The purpose of processes is to transform inputs to outputs while creating greater value than the inputs had. The output is an outcome of one or several transformations. (Melan, 1993, pp. 14-15, 24) Processes are a series of events that bind together technology, people, and information. Together these factors and processes create valuable outputs. (Harvard Business, 2010, p. 5) Processes today are complex, including many subprocesses and work of different functions within the organizations. This kind of processes are sometimes called also as cross-functional processes. (Melan, 1993, pp. 14-15, 24)

In the past, only manufacturing processes were seen as processes but at some point, also business operations were started to be handled as processes. This change provided crucial improvements in productivity, cost, and quality. (Melan, 1993, p. 10). The manufacturing process includes a physical product or service and business processes include all the processes that support the production process (Harrington, 1991, p. 9).

Core processes are vital for running the business and achieving a competitive advantage. They are critical in the value-creation process and creating customer satisfaction. Support processes are needed for daily operations for supporting the operation of core processes, but they do not add value directly to the product. (Evans & Lindsay, 2008, p. 332)

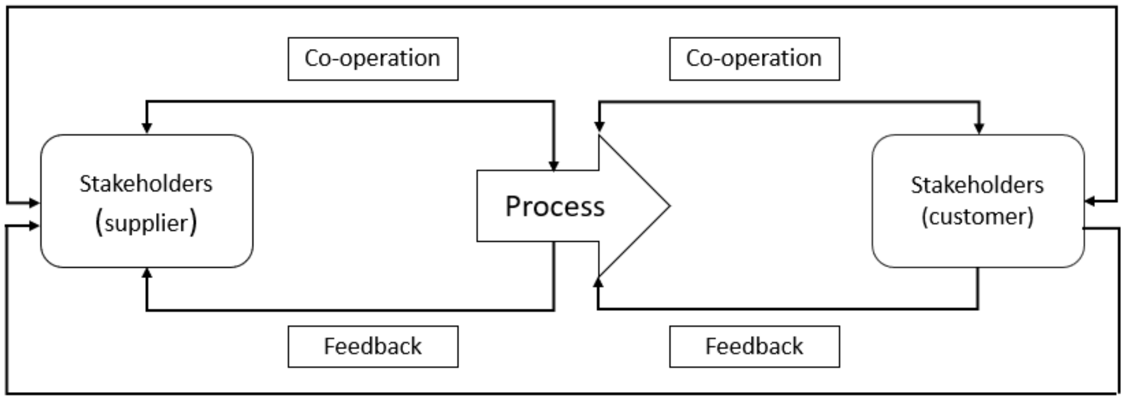

Figure 5. Process stakeholder model adapted from (Rentzhog, 1998).

Defined and controlled inputs are necessary to produce the output that will fulfil the customer requirements. The output of the process will be transferred to the customer – internal or external. (Oakland, 2014, p. 12) Rentzhog (1998) in his process stakeholder model seen in Figure 5. emphasis the communication between the process and different stakeholders such as suppliers and customers. This changes the point of view from a simple linear transformation process to including also the communication. In Rentzhog's the communication is carried out through co-operation and feedback.

Interfaces are points where one process output becomes an input for the next one. Many process-related problems occur because of the interfaces. The interface problems often create communication problems when the output does not fulfil the requirements of the next process input. (Melan, 1993, p.32) Poor performance in organizations is mainly caused by incapable processes and/or their interaction with technology or people (Oakland, 2014, p. 284). Very often all the personnel do not have a total understanding of all the processes and how those affect in business. Personnel who is working with specific processes may still believe that another person understands the processes they are working with even if that might not be true. (Boutros & Cardella, 2016, pp. 35)

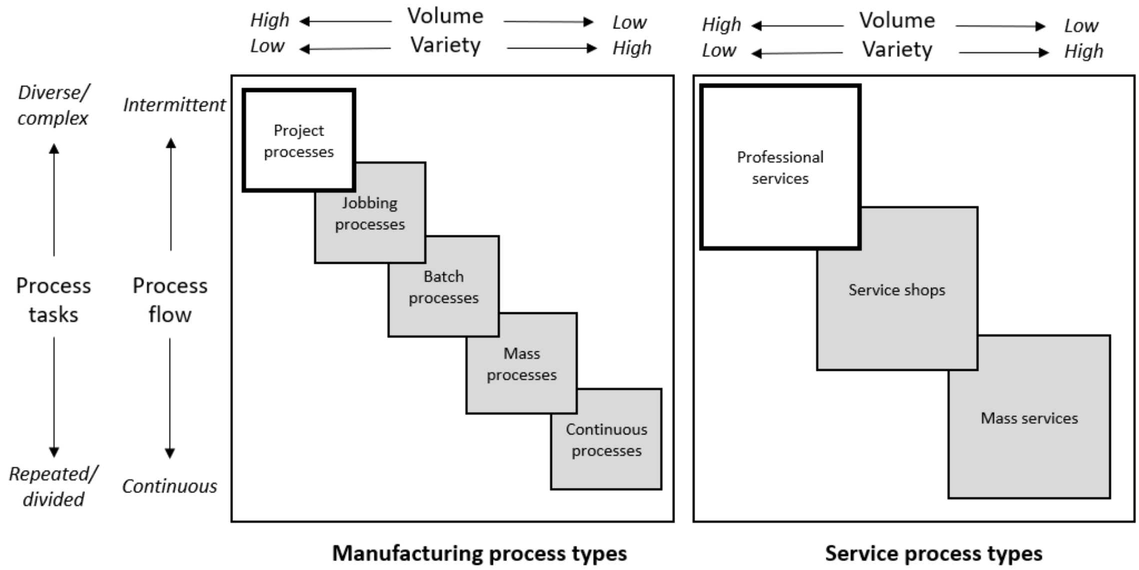

Figure 6. Different process types and volume-variety characteristics (Slack & Brandon-Jones, 2018, p. 168).

The individual processes could be further divided to match volume-variety requirements by project type like indicated in Figure 6. The "project processes" on manufacturing processes and "professional services" in service processes can be identified as different process types. The process types require a different kind of processes and they have differences also, for example, between the communication and process activities. (Slack & Brandon-Jones, 2018, p. 168)

Project processes deal with discrete and highly customized products that can have long lead times. The process activities in projects also have high uncertainty and they might not be fully defined. The changes in projects might also affect to the whole process. On the other hand, services that have the same features that project processes, such as high-variety and low-volumes in amounts of single services can be called professional services. (Slack & Brandon-Jones, 2018, pp. 168-170) In SCM perspective good processes support reducing lead times and on-time delivery. Processes should also support cross-functional involvement and integration. Processes must be designed flexibly so that they can handle customization, changes in volumes, and the occasional fluctuations. (Krajewski et al., 2019)

Quality and processes

Quality has been defined by known quality gurus Juran, Deming, and Crosby as "fitness for use", "conformance to requirements" and "a predictable degree of uniformity and dependability at low cost and suited to the market". (Crosby, 1994; Deming, 1986; Gryna et al., 1999). Quality is recognized as a key part of improving profitability and getting a competitive advantage (Melan, 1993, p. 10). The key to all different quality definitions is *meeting customer requirements*. Another important aspect of quality is reliability which means constantly meeting the customer requirements. (Oakland, 2014, p. 5)

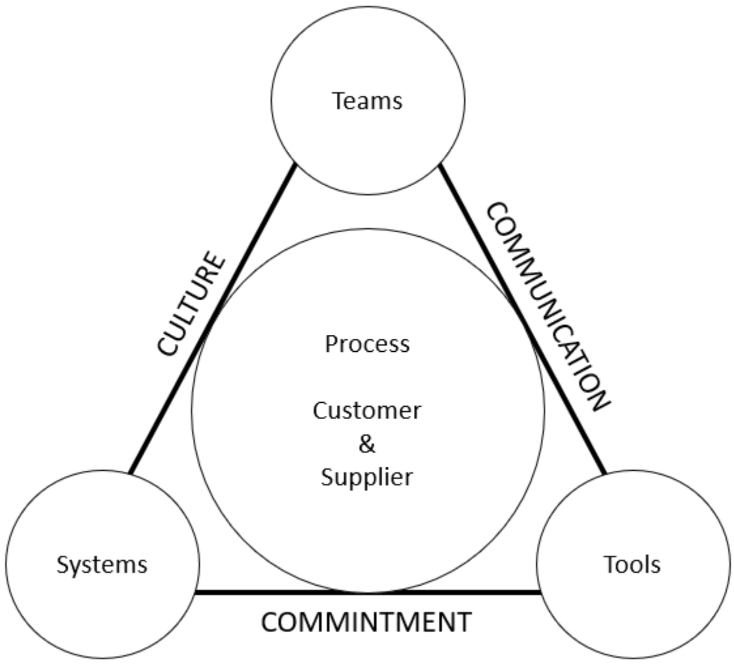

Figure 7. Total Quality Management model - major features (Oakland, 2014, p. 22).

In Total Quality Management (TQM) the main focus is on the needs of the customer through continuous improvement driven by the engagement of all the employees in the organization (Krajewski et al., 2019). Fundamentally TQM is about understanding and improving the organizations' all operations – processes. This can be seen also in Figure 7., where processes are located in the centre of the TQM model. TQM aims to improve the effectiveness, flexibility, and competitiveness of the whole organization, and also Deming, Crosby, and Juran all emphasized the importance of continuous improvement. (Oakland, 2014, p. 21)

Quality chains are a series of customers -both internal and external throughout the organizations. Quality chains are the key to the companywide improvement of quality and those can be traced to processes used in organizations. Communication within the quality chains is the key to meet customer requirements. (Oakland, 2014, pp. 9-11) The cost of quality can be divided into two – prevention costs and failure costs (Uusi-Rauva et al., 2009, pp. 319-324). Failure costs can be divided further into internal and external failure costs. External failure cost can be for example reclamations and loss of goodwill. Internal failure costs of bad quality can occur for example because of rework or rectification, re-inspection, and failure analysis. (Oakland, 2014pp. 126-127, 153)

A lot of time is wasted with useless activities because of quality issues and it creates costs. Errors also end up multiplying within the processes when the output of one process might be input for another. People end up spending time correcting errors, searching problems, rechecking work, reworking, and various other tasks. (Oakland, 2014, p. 16) In purchasing for projects, lack of planning might lead to a situation where purchasing decisions will be made in a hurry and this might, for example, expand the number of suppliers, add the overlapping work and add inefficiencies. (Iloranta & Pajunen-Muhonen, 2018, pp. 331-332)

The quality of products and services is the result of the quality of the operational processes of the organization (Uusi-Rauva et al., 2009, pp. 319-324). The well-designed high-quality process prevents poor quality by ensuring that the output of the process meets the requirement of the internal and external customers and the required level of performance (Evans & Lindsay, 2008, p. 334). In the purchasing process, the poor quality of materials and products can often be traced to incomplete of incorrect specifications or incorrect decision in sourcing. In this situation also the completeness of contract effects in a way that supplier cannot be claimed if there was no penalty clause indicated in the contract. (Weele, 2010, p. 29)

Process management

Processes that are designed and managed effectively throughout the value chain are the key to competitive operations and customer satisfaction (Evans & Lindsay, 2008, p. 322) as the final aim of the process is to meet the expectations of the end-customer (Oakland, 2014, p. 8). Activities concerning the design and management of processes help to prevent errors and defects in the processes and eliminate waste and redundancy. (Evans & Lindsay, 2008, p. 322)

Process management is an approach that includes planning and managing all the activities that are needed to achieve high-level performance in key business processes. It also involves identifying improvement opportunities for quality, operational performance level, and customer satisfaction. (Evans & Lindsay, 2008, p. 332) Process management involves a set of tools and working concepts to understand better and improve the processes. According to Melan (1993, p.27), process management is divided into three fundamentals which can be seen in Figure 8 below.

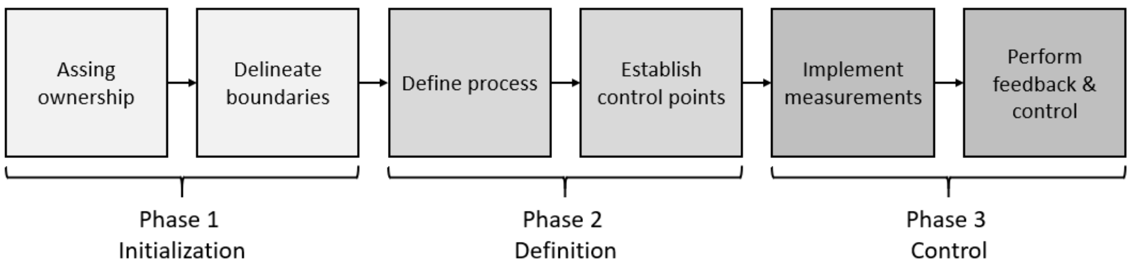

Figure 8. Phases of process management (Melan, 1993, pp. 21-22).

Phase 1 Process Initialization includes defining the process ownership and establishing boundaries and interfaces. Phase 2 Process definition offers a baseline for evaluation of the process itself and Phase 3 Process control includes control points and measurements for controlling the process. Control is carried out through feedback and corrective action. (Melan, 1993, p. 27)

Process mapping

Process mapping can be placed under two different phases of process management: Phase 1 Initialization and Phase 2 Definition. Phase 1 includes defining the process boundaries, the beginning and the endpoints (Deming, 1994), and the key interfaces in the workflow. (Melan, 1993, p. 59). The input and output requirements are also defined in this phase. The requirements of outputs track down providing value to customers and requirements of inputs must be defined in a way that inputs ensure the proper level of outputs. Requirements for inputs may include information like quantity, cost, timeliness, and quality characteristics. (Deming, 1994) In phase 2 permanent record of the process is created for a baseline for improvements and personnel for training purposes. The record can be for example flowcharts and process maps, assembly drawings, etc. (Melan, 1993, p. 59)

Simplifying the process by mapping helps to reduce possible rework and errors (Evans & Lindsay, 2008, pp. 663-664). Process mapping is a way to document the workflow and it can be used for analysing the current processes. It might also help to identify possible problems in the process. (Harvard Business, 2010, p. 28) Maps help to picture the actual flow of the process and in this way, they increase visibility. Process mapping can act as a base for improvement and understanding the process is the first step to improvement. (Damelio, 1996). As the weak coordination is often one of the biggest problems in construction projects, the process mapping can also help to define and formalize the processes and in this way help to achieve better coordination (Hijazi et al., 2018, pp. 18-19). To conclude, with the process mapping several benefits can be achieved. A list of benefits on organization, process, and customer level is indicated in Table 1. (Klotz, Horman, Bi, & Bechtel, 2008, p. 659; Tzortzopoulos, Sexton, & Cooper, 2005)

Table 1. Benefits of process mapping (Klotz, Horman, Bi, & Bechtel, 2008, p. 659; Tzortzopoulos, Sexton, & Cooper, 2005).

Organization	Processes	Client
- Competitiveness - Consistency through replication - Optimize predictability - Support partnering and contractual agreement - Basis for IT systems -Educate new employees	- Less time and costs - Better planning - Better and timely information exchanges - Better communications - Reduce error and rework - Benchmark for improvement	- Better product quality - Fitness for purpose - Delivered on time - Delivered to cost

Conducting process mapping requires collecting information about the process. This might include, for example, identifying the activities of the process, process cycles, and responsibilities (Harvard Business, 2010, p. 29), Process maps can describe also the material, information and document flow, and the essential interdependencies and interrelationships. It may include the tasks for division, business unit, individual department, workgroup, or one person. A flowchart is one type of process chart which is used to clarify the interrelated steps of processes. (Boutros & Cardella, 2016, pp. 50-52) They can be used for:

- Defining and analysing the current state of processes
- Communicating the process steps to other people who are involved in a process
- Identifying the bottlenecks or opportunities for improvement
- Standardizing the processes
- Visualizing the different steps
- Clarifying the roles and contributions
- Measuring performance
- Troubleshooting

(Boutros & Cardella, 2016, pp. 36-37; Krajewski et al., 2019 pp. 96-100)

A cross-functional map or swim lane map is similar to a flowchart, but it offers more information such as the responsibilities and the time attribute. Reasons for conducting the cross-functional map can be for example need to map cross-functional processes, complex processes, need for categorizing the areas where the process is working. (Boutros & Cardella, 2016, pp. 50-56) The cross-functional map has three key features which are:

1. Horizontal or vertical lanes that show to whom the responsibilities of activities belong. Often called also as Swim lanes.
2. Interrelated activities and the resources deployed to execute these create the workflow
3. The lanes show the interfaces between suppliers and customers, internal and external.

   (Boutros & Cardella, 2016, p. 55; Madison, 2005, pp. 24-25)

Swim lanes help to picture who is responsible for the process tasks, where the possible problems occur, which steps provide added-value, and helps to spot unnecessary steps (Madison, 2005, p. 23). The ready process maps offer a graphic presentation of an abstract or complex set of actions to complete the process (Boutros & Cardella, 2016, p. 37). Individual task procedures are not listed in the cross-functional map (Madison, 2005, p. 25).

The process mapping for projects is complex. This is because the outputs are usually large including a lot of information, and many activities are happening at the same time. The activities might also require significant choices and decisions based on professional judgement. It is rare that process mapping is created for the whole project but more likely to smaller parts of it. (Slack & Brandon-Jones, 2018, p. 168)

Conducting process mapping for cross-functional map

Flowcharts build-up with different shapes, descriptions of activities, and arrows. They aim to provide a representation of sequent performed activities in order. (Melan, 1993, p. 46-48) The cross-functional map is constructed in a similar way that basic flowchart (Boutros & Cardella, 2016, pp. 62-63). Symbols are useful because of the visualization helps to understanding and picturing the process. (Melan, 1993, pp. 45-50). There are seven most commonly used flowchart symbols. For example, Microsoft Visio uses these symbols. (Madison, 2005, pp. 19-21)

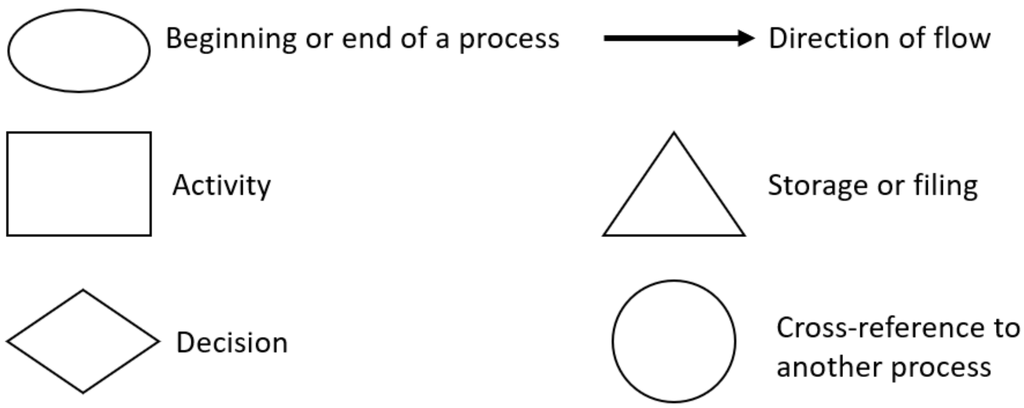

Figure 9. Process mapping symbols (Madison, 2005, pp. 20-21).

The Box / Rectangle stands for an activity (Madison, 2005, pp. 19-21) or process step (Boutros & Cardella, 2016, pp. 62-63). It is the most used flowchart symbol and the activity it represents can be for example: “Take an order” or “Install wiring” (Madison, 2005, pp. 19-21),

The Diamond represents a decision, inspection, or review. Diamond includes the decision and it contains multiple paths depending on the result. The process map should only involve the main variations to avoid too complicated maps with even the smallest decisions. (Madison, 2005, pp. 19-21) Usually it good to use only two arrows to avoid the complexity. The outcoming arrows should also always be labelled based on the options. (Boutros & Cardella, 2016, pp. 62-63)

The arrow shows the transport or the direction of the flow. (Madison, 2005, pp. 19-21) It comes from another symbol and ends to another showing the direction with an arrow. Often called as “flow of process” or “flow of control”. (Boutros & Cardella, 2016, pp. 62-63)

Ovals represent the beginning or end of the process map (Madison, 2005, pp. 19-21).

Circles indicate a cross-reference to another process (Madison, 2005, pp. 19-21).

Triangle is represented slightly differently in different sources. According to Madison (2005, pp. 19-21) and Harvard Business (2010, p. 29), it indicates storage or filing. According to Boutros and Cardella (2016, pp. 62-63), it indicates manual input such as signify form data-entry.

Process mapping can be done for example mapping the process with the help of interviews, observations, or review of pertinent documentation (Melan, 1993, p. 48). The purpose of the interviews, as well as other process mapping methods, is to obtain the necessary knowledge to create the process map. The interviews usually help to draft the map, but it might be reasonable to validate the map once it is ready to ensure completeness and accuracy. (Damelio, 1996, pp. 145-146) The interviews should be conducted with the different stakeholders who are working with it or affected by it (Harvard Business, 2010, pp. 33-34). Madison (2005, p.23, 25) represents that process mapping should be built on a process that has been executed in history. The process can be mapped horizontally or vertically.

There are many different steps for creating the process map represented in literature as well as different levels of conducting process mapping. The different levels go from high-level process mapping which does not involve many details, to micro detailed process map which includes every small movement. In between is outline process mapping which includes the sequence of activities at a general level. (Slack & Brandon-Jones, 2018, p. 202) The general steps for conducting the cross-functional map are presented below according to Boutros and Cardella (2016, p.50). Harvard Business Review Press (2010, pp. 33-33), Madison (2005, pp.24-45), and Melan (1993, pp. 48-54) have identified similar kinds of steps with slight differences.

1. The first step is to identify the process that is under investigation. Identifying the overall objectives for the key process and the main activity steps is important because the features of the process like included teams, time, costs, and complexity affect to analysing the information.
2. Identify the boundaries of a process. This can be done by establishing the starting and ending points.
3. Determine and document the lanes the cross-functional map will be divided so that it is the most applicable - departments, functions, or people.
4. Arrange the steps into a diagram in a logical order and under the correct lanes using the correct shapes.
5. Recommendation go from end to beginning to trace inaccuracies.
6. Ensure the alignment and agreement for the mapped and documented process

When conducting the process mapping it is good to follow some mapping conventions to improve the legibility. It is good to use the commonly known figures and arrowheads with the lines. The map is clearer when the workflow goes from left to right, so it is good to try to avoid the crossing lines or backward going arrows. (Boutros & Cardella, 2016, p.67) The aim is to create a process map so that it is simple enough so that it can be easily understood. Every small decision should not be indicated. The main variations might be better to be mapped in a separate flowchart. (Madison, 2005, pp. 23-25) Marking the inputs and outputs help to see the transformations or value of the steps. It is important also to mark all the other important information like labelling the different swim lanes. If the same step is conducted for several lanes, it is good to draw the box crossing all the applicable lanes. (Boutros & Cardella, 2016, p. 53)

Details of individual process activities within the process map

The process map can additionally have an activity detail sheet, a separate document from the process map. The activity sheet can include general information, brief description, task list, forms, policies, procedures, manual, end-work products or deliverables, applications, and corporate controls. The general information, brief description, and task list are mandatory for all activities, others might not be applicable for all. (Madison, 2005, pp. 35-38) According to Madison (2005, pp. 35-38), mandatory activities involve the following :

- General: Which activity and who performs the activity.
- Description: Overview of the mandatory requirements for completing the task.
- Task: More detailed than the description, but no work instruction. forms, policies, procedures
- Manual: A list of materials that are linked to the task.
- End-work products or deliverables: Excepted output at the end of the activity. this can be data entry, submitted documents, decisions for processing, verifications, etc.
- Applications: list of used information technology tools.
- Controls: The requirements that must be fulfilled, such as auditing or approval.

There are also other ways to understand better the processes, for example, SIPOC and RACI analysis. SIPOC analysis stands for Suppliers, Inputs, Process, Output, and Customer and it is a tool can be used to identify the different elements for processes and the process itself. (Slack & Brandon-Jones, 2018, p. 12) SIPOC is one kind of process map, which covers the whole value chain (Boutros & Cardella, 2016, pp. 157-158). The different elements of SIPOC is constructed with the following:

- Suppliers: The party who provides the material to work with
- Input: The material of information needed

- Process: The chain of internal activities
- Output: Output that is delivered to a customer of the process
- Customer: Can be the final customer or next party in the process
  (Boutros & Cardella, 2016, pp. 157-158)

SIPOC analysis can help personnel who are working with the specific process to understand what the process includes and the requirements for it. (Slack & Brandon-Jones, 2018, p. 12) It also enhances the effectiveness of the process, sharpens focus on the needs of the customer, and provides a better view of activities that are conducted cross-functionally (Boutros & Cardella, 2016, pp. 157-158).

RACI chart is also known as a responsibility chart. The aim of the RACI is to show the different participation roles for processes in different activities. RACI stands for responsible, accountable, or approver, consulted, and informed. RACI clarifies the roles and it enhances teamwork, communication, and cooperation within the different roles. (Boutros & Cardella, 2016, pp. 155-156) There are some rules for conducting the RACI:

- Responsible: is the person who is accountable for communication between the different parties
- Accountable: Should be only one party for one task and is the party who is ultimately responsible that the task will be completed successfully. Accountable might not still be the person who performs the activity.
- Consulted: The party who contributes in any way with the activity
- Informed: Parties who need to get the information about the task.
  (Costello, 2012, p. 64)

4 Research Methodology

This chapter represents the data collection method and data analysis that was conducted for this thesis to be able to answer the research question which was represented in the first chapter as "*What is involved in process mapping for successful project execution from the purchasing function perspective?"*. The question had also three objectives, identifying the different stages of project execution relevant for purchasing, identifying the types of material and services needed in different identified project execution stages, and finally designing the process map. The end of the chapter will cover the considerations for the validity and reliability of the research.

This research is an action study for ABB Power Grids Finland Oy, and it uses the qualitative approach, but some quantitative data have been used as secondary data to validate the qualitative data. The data was collected through semi-structured interviews and from existing information sources. Data triangulation has been applied in this thesis.

4.1 Data collection

Two different data collection methods were used for this thesis. Primary data was collected through semi-structured interviews which are good for collecting a deep understanding of the researched topic (Adams, 2015). The secondary data was collected from mainly internal but also from external documentation.

The respondents for the interviews were chosen internally from two different departments: engineering and project management. Two of the interviewees are the managers of their departments and the third respondent is a project planner who is responsible for example making the schedules for projects. The respondents were chosen from these departments because project managers, planners, and engineers are working closely with the project execution and are providing inputs for purchasing. Engineers and project managers also possess more technical understanding considering the different project execution phases and materials. The external interviews were decided not to use because the aim was to research the current process.

Table 2. Summary of interview respondents.

Respondent	Title	Duration of the interview
Peter Alaviitala	Project Management Manager	1 h 27 min
Seppo Pasto	Engineering Manager	1 h 5 min
Satu Koivumäki	Project planning and controls specialist	1 h 18 min

The interviewees were sent an email invitation in advance for 90 minutes long interview and the topic of the interview, as well as the interview questions, were presented beforehand for the respondents in the email. It was informed that the interview will be semi-conducted, and they will be able to expand their answers with related information outside of the questions if they want. The questions were divided into three different categories to guide the interview. The questions were the following:

Project execution phases

1. What is the normal duration of a domestic turnkey project?
2. What are the different project execution phases?
3. What are the purchasing tasks in project execution?
4. What phases are relevant for purchasing?

Materials in project execution phases

5. How would you categorize the project-related materials?
    a. What belongs to these different categories?
6. How would you categorize project-related services?
    a. What belongs to these different categories?
7. What materials are used in different project execution phases?

Process mapping

8. Who are the different stakeholders in the project execution?
9. Who provides inputs for purchasing?
10. What kind of inputs?

The questions were written as open-ended questions because they allow more flexibility when comparing to structured interviews and offer possibilities for deeper understanding (Kananen, 2017, p. 41, 89). For supporting the reliability some secondary data was used in the interviews and the interviewers were able to give comments on those and compare their answers based on the secondary data. The extra information was not shared until the respondent had first answered the question and all the respondents got to see the same documents after the same questions.

The questions were divided into three different categories. The interviewees are experts in their branches and the aim of semi-structured interviews and open-ended questions were to allow the interviewee to offer as valuable data as possible in their perspective and according to their expertise. The interviews were conducted as Teams meeting and the interviews were recorded for later research. The respondents were notified about the recording of the interviews.

Secondary data was collected mainly from internal data sources within the case company, but also external data sources were used. These internal data sources used were information from ERP-system, existing process charts, internal guidelines, schedules, and reports. The thesis that have been conducted for the same case company was used as the external data. The purchasing unit responsible was not interviewed but the SCM function reported workshop of the purchasing and logistics tasks were used to validate the purchasing unit perspective of the purchasing function tasks.

ERP-data was collected from the system from projects from years 2017-2019. Nine projects were chosen for the data analysis. The different kinds of projects were chosen based on the customer, size of the project, and type of project. The chosen projects were all domestic turnkey projects.

SCM tasks workshop was held in March 2020 and it was reported. The workshop was held to identify the different tasks of SCM function, covering tender support, purchasing, and logistics. The information used in this thesis was the report of the workshop. Other secondary data familiarized were schedules, thesis' and possible scope of supplies for individual projects.

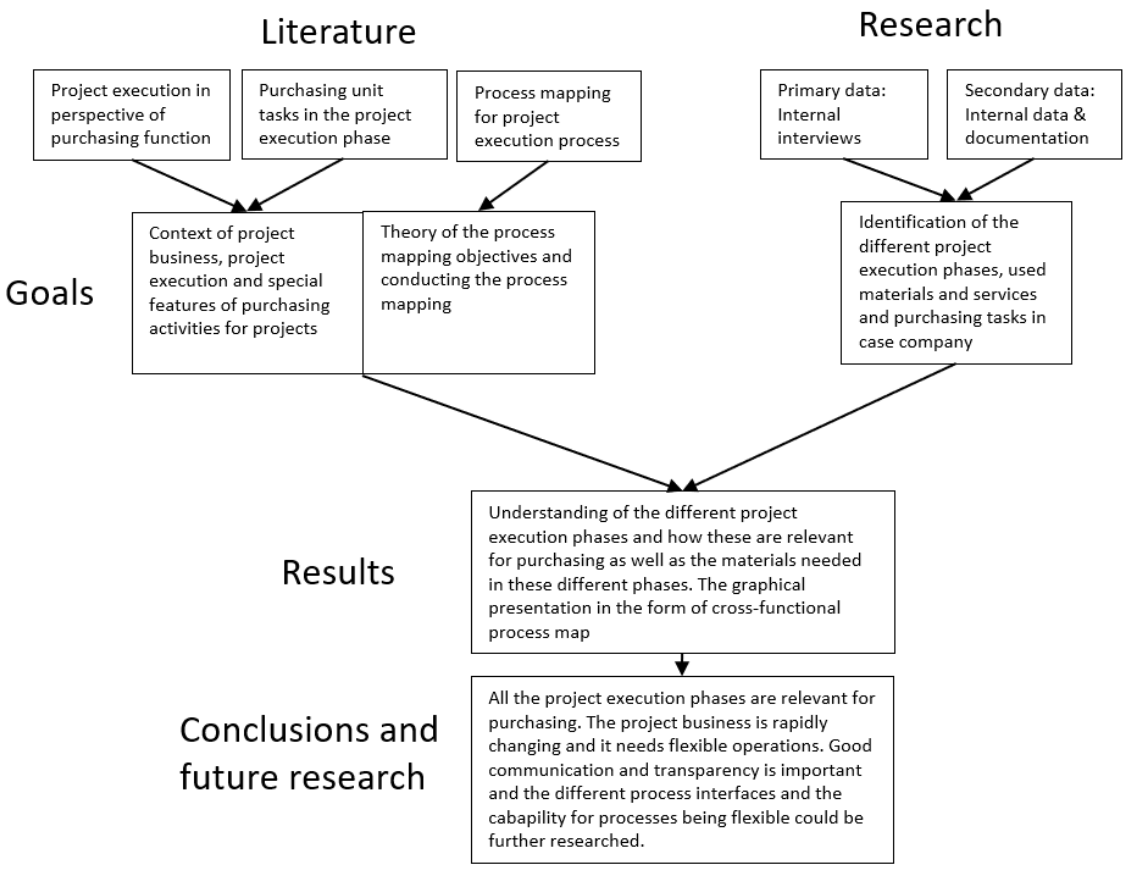

Figure 10. Structure of the thesis.

Finally, the thesis is built up with a mix of literature review and the findings from the research, using primary and secondary data as seen in Figure 10. The final aim is to understand the project execution phases from the perspective of the purchasing function and with the help of information of materials conduct the process mapping.

4.2 Data Analysis

The thesis uses the inductive approach, trying to find similarities from the data considering the topic and making assumptions based on that. In the data analysis the data were separated into three different categories according to research objectives:

1. Project execution phases
2. Materials in project execution phases
3. Process mapping

The recorded interviews were listened afterwards and written manually to text. All the comments were written down, but the textures of spoken language were left out as well as the things that were not related to the topic. The accuracy of the transcript is dependent on the research problem and the research methodology. (Nikander, Hyvärinen, & Ruusuvuori, 2010, pp. 424-425) If the used language or the interaction is not subject to the research but it is more subject matter, the transcribing does not have to be exact but it enough that all the comments are written down. It is better to first write everything down and narrow the material on a later phase. (Hirsjärvi & Hurme 2001, 138-141)

In this thesis, the transcription was not done from word to word because the purpose was not to research the language or the interaction. The purpose of the research was also not to research opinions but more to find out the information about the current processes of the case company. Based on this the answers should not be based on opinions but on the profession of the respondent. The answers were collected so that they covered all the comments but were later narrowed so that the applicable information for the research topic was left for further analysing.

The comments were after that divided into three categories according to categories used in interviews and the data from interviews were collected under different topics to a chart accordingly to the individual interview question. Because the chart topics were following the research questions, most of the answers were found under the corresponding question. But because the interview was conducted as a semi-structured interview there was some information what came up under different topic. Therefore, the answers to the chart were collected going through the interview transcript sentence by sentence and placed under the right topic in the chart. At this point, the irrelevant or repeated information was left out and answers might have been written in a clearer form. Some comments were collected individually if they revealed some new or extraordinary information. All the left data was put into a chart where it was possible to compare the answers from different respondents.

For the quantitative part, the sample projects represent domestic turnkey projects which include materials and services. The service projects and retrofit projects were not chosen because they usually involve a different kind of scope including fewer materials or more materials that are not usually used but needed for specific cases. The export projects were not included because they do not involve works or services. The projects have been executed during the past years' earliest PRs for the projects made in 2017 and the latest PRs made during this year 2020. The older projects were not considered to get a better picture of the current situation.

Data was taken from ERP-system and exported to Excel for further analysis. Data provided information for example of the materials, costs, PR releasing date, and the project. The data was cleaned to remove the rows that were not applicable considering the research. Some necessary new data was added for example for analyzing the duration. The steps of cleaning and modifying out the data were the following:

1. Delete deleted rows
2. Delete rows for packing materials, documentation, labels, transportation, rental real estate
3. Create a project week and project month for each project separately

The deleted rows were the rows that have been also removed from the ERP system. Other rows deleted rows were the PRs that are not straight related to materials or services like packing materials or transportation. PO's for documentation, labels, or rent are the PO's that are made for every project at the beginning of the project and they do not contribute with project execution but might have monthly costs.

The other secondary data was mainly used to verify and validate the primary data findings. The collected data was first explored and familiarized, and the data was reduced to be able to focus on meaningful data considering the research question. After familiarizing the data, it was possible to divide it under applicable categories and use it to support the findings of the primary data.

4.3 Reliability and Validity

In qualitative research, the reporting of the conducted steps in every phase adds the credibility of the research. The researcher should describe how the research proceeded, for example, describing the way how the research was conducted and how the data was transcribed. A researcher should also justify how the conclusion was conducted based on the research data. In a qualitative study, the different researchers might not end up in the same conclusion based on different personal experiences and knowledge. This does not mean that the qualitative study cannot be credible, but the researcher must report the steps that have been conducted for the research and preserve coherency throughout the research. (Hirsjärvi and Hurme 2008, 185-189; Kananen 2010, 69-70; Ruusuvuori 2005, 29-30.)

This thesis uses the triangulation of data which means using the different data sources. Data triangulation is a cumulative validation for the research results but more than that its enlargers the perspective of the subject area. (Flick, 2002, pp. 226-227) Collecting information with different methods and data triangulation supports the reliability and validity of the research. The results are also enforced with the theoretical overview.

The secondary data was used to support but also verifying the primary data findings. For example, the project execution phases identified based on the interviews were compared with the existing process charts for individual phases if separate documents were existing. The comparison was also involved n the interviews when the respondents were asked to compare their answer to the documentation after their answer like described earlier. This usually also added a deeper understanding of how things are linked to each other. During the interview at some points, the interviewer also repeated the answer of the respondent to make sure that the matter was understood correctly.

The process execution might not experience or have not experienced remarkable changes, but the used materials, services, or technical solutions might change. The research is conducted considering the current situation and it aimed to use recent data. After the results were done and the process mapping was conducted, the respondents were asked to verify the outcome of the process mapping. Additionally, also SCM manager verified the outcome. According to the comments, some minor changes were made.

5 Results

The results are based on the information that was found out during the interviews after data analysis. The main idea was to find similarities in the data. The primary data findings are supported by the findings from the secondary data information. Some comments from respondents have been brought up individually if they include extra information or good extra notices.

The respondents brought up the information according to their expertise but overall, the answers in the interviews followed the same process steps. This is not surprising as the project execution process is not dependent on opinions but the case company's internal processes. The perspective to the individual things might be different and every respondent fulfilled the common understanding from their viewpoint from engineering, management, or scheduling point of view. The purchasing viewpoint has been analysed through the reported SCM workshop held in March.

In the context of this thesis, the process mapping for project execution from the purchasing perspective included researching the theoretical framework of project execution, purchasing initiatives, and the theory for conducting the process mapping. Based on this theoretical information this thesis researched the respective topics and aimed to fulfil the objectives to represent the applicable project execution phases for project execution, the materials that are needed in these different phases, and finally conducting the process map, considering the perspective of purchasing function in each stage. The results have been divided to subchapters accordingly.

5.1 Project execution phases in case company from the perspective of the purchasing function

All the respondents shared the same overall opinion of proceeding of project execution phases even if they might use a little bit different names or they liked to categorize them a little different way depending on the viewpoint they had (engineering, project management, scheduling). The differences were not meaningful as the big picture remained the same. The results here are represented in the most specified way and including all the findings from interviews. First, the purchasing tasks in case the company will be presented, and after that the different project execution phases. At the end of this subchapter, the purchasing tasks will be brought together in the context of project execution phases to clarify the project execution phases from the purchasing perspective.

All the daily operational purchasing tasks of the case company were mapped in the SCM team workshop held in March and can be seen in Figure 11. Tasks include both purchasing and logistics tasks and they are mainly repetitive operational actions. The project procurement plan (PPP) is done at the beginning of the project and base for all the project purchases. Other steps could be described as repetitive operative tasks.

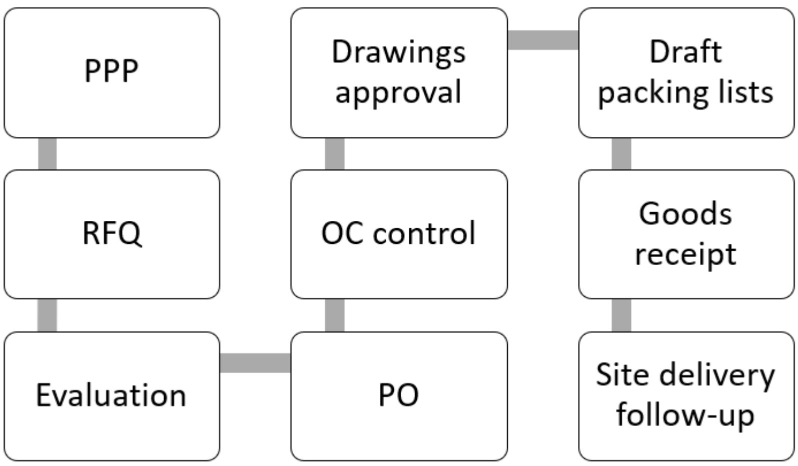

Figure 11. SCM tasks in project execution. Adapted from the SCM workshop report (ABB Power Grids Finland Oy, 2020).

All the purchasing tasks were also to be found in primary data findings even if they were not indicated again every time. For example, it was brought up that order confirmation control and following the drawings approval is purchasing function's task, but it was not indicated separately in every phase where the purchases were handled. The emphasis was more on request for quotation (RFQ) and PO phases where the purchasing receives inputs from engineering and project management.

Engineering is responsible for the technical specifications and design and project manager of the budget and schedule. Usually, an engineer will create the PR and the project manager approves the PR and gives needed additional input. After the PR has been submitted, purchasing function is responsible for asking the offer, according to the specifications from engineering and project manager. The received offers are evaluated for example based on prices, commercial conditions, and delivery times. Purchasing should also provide savings by negotiating prices. Some RFQs require communication with engineering or project manager.

The PO will be placed for selected suppliers according to PR information, with the offer price, agreed terms and conditions, and the project-specific requirements. After the PO has been placed, purchasing function will ensure that the order acknowledgement (OA) is received from the supplier, and it is in line with the order. Some components require also drawings approval which supplier will be sent with OA or later. Purchasing function is responsible for forwarding the drawings for approval to the engineer. The rest of the steps are related to logistics, but the interviews showed that goods receipt (GR) and follow-up are perceived also as purchasing tasks.

In addition to these tasks, the purchasing has many other tasks that have been discussed in the literature review and came up with the primary data findings. Throughout the project, execution purchasing is the link between the supplier and the rest of the project team which involved purchasing function in any activity where also supplier is involved.

Sometimes the engineering or project manager might be also discussing with the supplier if the matter is about technical information. The need for purchases comes usually from other functions because turnkey projects include complex products and services and the engineers are a decision-making party alongside project manager. This might affect to the communication as the purchasing is not always needed in technical discussion.

Considering all the operations, purchasing should possess the latest information about the delivery times, suppliers, and agreements. This includes the latest information on the delivery times for different components and on-time delivery status of individual suppliers as well as the quality level. Purchasing is also involved in any case of problems that offer information for example of the on-time delivery and quality.

Before moving to the actual results for project execution phases this thesis handles, it is necessary to start with briefly introducing the sales phase to understand that the project execution receives inputs already from the sales phase. All the respondents highlighted the importance of the sales phase in different contexts.

Peltola (2012, pp. 39-40) represents the sales and tender phase of the case company in his thesis “Scheduling of a substation project: Choosing the scheduling tool” which is conducted for the same company. The first engineering is done in the sales phase by the customer. According to this the sales responsible makes the proposition for system engineering and the offer for the customer. Preparing the offer for the customer includes finding out the costs, so some offers will be asked already in a tender phase, for example, for the main components and civil work. Alaviitala (2020) reminds that purchasing function has also an important role already in the sales phase. The offers from the sales phase may be used also in the execution phase if the technical specifications remain the same. After the project is won the project is handed over to the project team and engineering will be started based on the information from the sales phase. (Peltola, 2012, pp. 39-40)

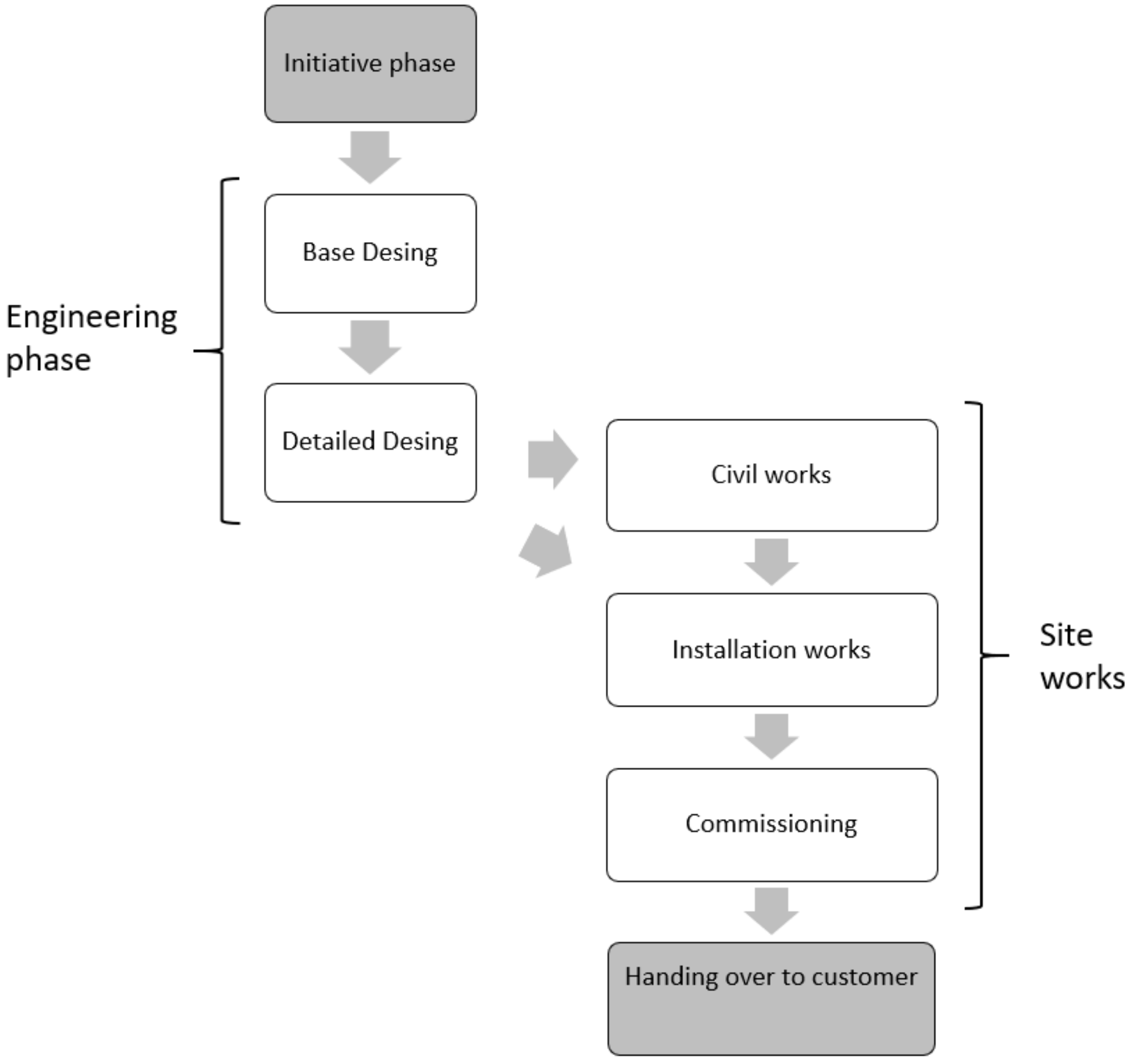

Figure 12. Project execution phases.

In Figure 12. it can be seen the different project execution phases. In the figure, it can be seen that the project execution has a clear starting and ending point. The phases between the beginning and ending can be further divided into the Engineering phase and Site works. Like it can be seen already in the figure, the engineering phase and site works can be ongoing parallel.

Right after the sales phase project begins the **Initiative phase**, might be called also as Start-up phase. The initial phase is fairly short in project execution, and it might go already parallel with base design in some cases. In this phase, the planning of the execution will be conducted, and the project team is assigned for the project. Planning includes, for example, preliminary planning, quality plan, and HSE plan. The project is also opened to ERP-system. Purchasing function has an important role to create the PPP which includes general information for the project and the lead times of the needed material. General information might be also applicable information for submitting further on to suppliers for example documentation requirements. PPP is done together with PM and project planner and it provides important information about delivery times and suppliers' on-time delivery for project scheduling. PPP is a guideline for purchasing throughout the project execution. This is a crucial step to detect critical components considering the schedule and it also provides information for purchasing about the overall project timetable.

The validity of existing offers for main components and long lead time products from the sales phase will be reviewed by purchasing function and project manager in this phase before submitting any purchases. Purchasing function is responsible also for contacting the supplier if the validity of the offer or something else needs to be updated. Sometimes the preliminary design might have been done already in the sales phase and some long lead time products are ordered right away when the project is started if they have long lead times. To conclude, from the purchasing perspective some individual tasks can be identified in the initializing phase:

- Creating PPP
- Reviewing the offers from the sales phase
- In some cases, issuing POs for suppliers

After the initiative phase begins the **Engineering phase** which can be divided into base design and detailed design. The engineering can be further on divided to Primary Engineering, Secondary Engineering, and Civil engineering:

- Primary engineering is responsible for example, of the substation's layout, placement of the main components, and drawings for steels.

- Secondary engineering is responsible for designing the electrical side
- Civil engineering includes, for example, construction-related engineering and detailed design for foundations. The civil team and primary team are working together with many tasks.

All these different functions of engineering will conduct both, base and detailed design. Some tasks are responsibility only for one engineering group, some designs need input from multiple engineering groups. The engineering in different teams is proceeding at the same time and in this phase, the project is moving forward at quite a fast pace. Sometimes engineering might be also purchased externally. The engineering phases are the most active phases for purchasing.

In **Base design,** the big picture of the substation will be designed. This includes the layout of the substation, single line diagram, interlocking diagram, and technical specifications for the main components. A single line diagram is a plan for how the substation will be executed from a technical perspective and the interlocking diagram ensures the safe functioning of the systems. All the designs and specifications will be sent to the customer for approval. After the approval, the main components can be purchased according to the specifications from the secondary team. The products purchased in this phase are the main components and other possible long lead time items. In this phase, the main task for purchasing is taking care of the purchasing of the main components. The civil works are also supplied during the base design. The contractors might have been already chosen on the sales phase or there might be existing offers. (Pasto, 2020).

After base design comes the **Detailed design** which can be started after customer approvals. The detailed design offers inputs both for upcoming site works, Civil and Installation works. Installation works itself are also purchased in this phase in according to specification made in cooperation with secondary engineering, primary engineering, and PM.

The material purchases will be done alongside when the detail engineering is progressing in different parts. Some materials in detail engineering phase have longer lead times so they might be prioritized in engineering. The detailed engineering gives more detailed information such as the lengths of the cables, quantities for the steels, drawings for relay panels, and everything that requires more detailed engineering.

The installation materials are specified at the end of the detailed design. The detailed engineering should be ready before the installation works begin but sometimes some specifications at least for installation materials might be still in progress. The best situation would be to have all the installation materials ordered before the installation works begin so that it could be ensured that all the required installation material is on-site when they are needed.

According to Alaviitala (2020), it should be achievable for engineering to specify the installation materials before the installation works begin but it would be good if at least majority, approx.75% of all installation materials would have been specified and ordered. He also states that from the project management perspective it would be good to get the purchases done as soon as possible in any case. Nevertheless, the majority of the purchases have been made when the detailed design is ready and site works begin. Accordingly, the main purchasing function tasks for this phase are to take care of all the material purchases that the engineering will generate as well as the purchasing of the site works.

As it was indicated the **site works** may begin already when the engineering phase is not fully ready. Site works include civil works, installation works, and commissioning works. Site works are done in some parts always in parallel with the engineering phase. This shortens the delivery time of the project. In domestic projects, the time of the year affects the site works timetable. Peltola (2012, p.44) states that the civil and installation works can be ordered also from the same contractor under the same contract.

Civil works could be further divided into construction works and concrete works, but for this study it does not make the difference so those are handled as one. Civil works are usually started before the detailed engineering is ready but when there is enough progress especially in detailed design of primary engineering so that all the required planning for starting the civil works is done. In the beginning, there might be for example some land works that do not require much planning. The civil works will continue alongside the detailed engineering and the first needed input from primary team detailed engineering is engineering for foundations.

The scheduling is easier if the engineering is done far enough in applicable parts for civil works and it also reduces risks as there is more time to negotiate about the contract and the scope. All the materials needed on civil works are usually included in civil contractors' scope but sometimes there might be some materials in case the company's scope as well. These will be handled more specifically on next subchapter.

The project type, that effects the progressing of the project is whether the electrical substation is GIS (Gas-insulated Switchgear) or AIS (Air-insulated Switchgear). Differences can be noticed mostly on civil works and later with the materials. With the GIS substation, the construction works can differ a lot from project to project, some having big and challenging buildings and other smaller made of ready concrete elements. The main difference is that the GIS substation does not have an outdoor field nor outdoor main components. The main phases for the different kinds of projects are still the same.

Installation works can be going on a little while at the same time with the civil works, but they are mainly are started after civil works. Like discussed earlier the detailed engineering should be ready when the installation works begin. The inputs for purchasing come from site works in this phase. This means that if something is missing, broken, or needed more it creates input for purchasing. The input can come also from the installation contractor through the project manager. To conclude in this phase purchasing will take care of any needs that come from the site. If something is broken or missing, purchasing is also responsible for claiming the supplier. This phase should offer information about materials' quality and supplier on-time delivery for the purchasing as most of the ordered materials are delivered to the site in this phase.

The **commissioning phase** will be done by the case company's personnel or bought externally. There will be no new purchases in this phase unless some new needs are identified, or materials are broken or missing. If materials are broken or missing, there might not necessarily be a new PO but claim or replacement PO for suppliers.

After the commissioning, there is only left **handing over** to the customer. After this begins the warranty phase so there might be also some purchases made after handing over. Purchasing should receive information about the quality of the materials if warranty cases appear.

Considering the whole project execution purchasing is involved in some way in every phase like it has been seen. Table 3 lists the different project execution phases and the purchasing function tasks that were identified in each phase. The materials are handled more in detail later in results, but the table 3. includes already some information about purchases to summarize why the project execution phase is important also in the purchasing perspective.

Table 3. Purchasing tasks in different project execution phases.

Project execution phase	**Purchasing tasks during/after the phase**
Initiative phase	- PPP - Review offers from the sales phase - Issue POs if applicable
Base Design	- Main components and long lead time items will be ordered - Civil works will be ordered
Detailed Design	- Rest of the materials will be ordered while the detailed design is progressing - Installation works will be ordered
Civil works	- Possible material orders for site work for missing or broken materials
Installation works	- Possible material orders for site work for missing or broken materials - In problem cases, purchasing will issue claims - Purchasing will also receive information about the quality and on-time delivery when materials are delivered to site
Commissioning	- Purchasing will take care of extra purchasing needs from the site for broken or missing material
Handing over (Warranty begins)	- Purchasing will take care of extra purchasing needs for warranty items

Alaviitala (2020) stated that purchasing is most active at the beginning of the project when the majority of the materials and services are bought during engineering phase. He also mentioned that purchasing is the function that supports project execution when any problems occur with materials. Purchasing receives information from many different stakeholders like the engineer, PM, and site activities. Engineer and PM create inputs for the planned purchases and site activities create more sudden needs.

During the discussion of the site works it was already indicated that purchasing function is involved is anything in the site is missing, broken, or needed quickly more. Issuing the reclamations for external suppliers is purchasing function responsibility, but the project manager might be involved in the reclamation if it is for example about site works where the project manager is the first point of contact for the contractor. Purchasing will get information about the quality of the materials in this way.

5.2 Materials and services in different project execution phases

Some discussion about the materials was already introduced before with the different project execution phases. This part aims to define more specifically the materials that belong to different phases. Sometimes materials can be ordered during different phases because of scheduling but here the materials are divided into the project execution phases where they are most often purchased, in the order they are most often purchased. The scope of the material is changing between the different projects, but many of the components remain the same. The materials could be categorized in several different ways based on:

- cost
- lead time
- engineering phase (base design or detailed design)
- engineering function (primary, secondary or civil engineering)
- required specification/engineering (MTS, MTO or ETO - material)
- use of the component (main components/installation components)

In this thesis context, the materials will be divided according to the different project execution phases, but the different features of the materials and services presented on the

list above are considered in applicable parts. Most of the different materials and services are purchased during base design and detailed design.
In the **base design,** the main components and long lead time components are ordered. The majority of the material costs occur in this phase. The main components require only definition for technical specifications which is made in the base design phase. Technical specifications for the main components are made mainly by the secondary engineering team. Switchgear differs a little bit from the other main components as the supplier will have to conduct engineering for that.

The substation type AIS or GIS affects the ordered components so that AIS substations include several different main components and GIS substations include only the GIS where the main components are built-in, but it needs additionally HV-cables and HV-terminations. The GIS and AIS materials are both listed in table 4., even though they are never purchased for the same project both. The components are divided into their boxes in the tables. The civil works are purchased also in this phase. The specification might have been done already in the sales phase and there might be even an existing offer from the sales phase. Koivumäki (2020) reminds that purchasing of work should include strategic planning and controlled use of the contractors.

Table 4. Project execution phases - Base Design.

Base Design		
	Supplied materials	**Comments**
	- GIS	- Long lead time
	- Power Transformer - Switchgear (SWG) - Circuit Breaker (CB) - Current Transformer (CT) - Voltage Transformer (VT) - Disconnector (DS) - Surge arrester (SA)	- The material will be ordered after customer approval - Design or engineering is made by the supplier; the drawings must be approved - Installed outdoor (excluding SWG)
	Supplied services	**Comments**
	- Civil works	- In cooperation with civil team and PM - RFQs sent already in the sales phase

Most of the purchases left will be done in the **detailed design** phase according to the proceeding of the detail engineering. The materials have shorter delivery time and most of the materials are cheaper than the main components, but the amount of single purchase requisitions and purchase orders is bigger. Pasto (2020) brings up that it is also a purchasing function's responsibility to follow PPP to know when materials should be ordered. Purchasing should be able to recognize if the lead time begins to be critical because the purchasing has the best knowledge of delivery times.

If engineering for some components is ready but the lead time is not critical it could be possible to bundle purchases for multiple projects to get better prices (Alaviitala, 2020). The detailed engineering includes engineering and specifications for types, lengths, and amounts. The materials and services are listed according to if they belong to Primary, Secondary, or Civil engineering because there are many different materials in this group.

Table 5. Project execution phases – Detailed Design, Primary engineering.

Detailed Design – Primary engineering		
	Supplied materials	**Comments**
	- HV cables	- Usually needed only for GIS - Sometimes small amounts for AIS substations - The secondary team is responsible for the cable type, the primary team of the routes and length - Type might be known right after the sales phase, length requires engineering
	- HV cable terminations	- Needed for HV cables
	- Earthing copper - Lightning materials	- Earthing copper is needed for civil works, will be done in the early phase - Engineered together with the civil team
	- Steel structures	- Can be purchased after the detailed engineering for those have been done and the quantities are known
	- Post Insulators	- Specifications are usually known in the early phase, but the amount will be specified in primary detailed engineering
	- HV-clamps	- long lead time, so it is necessary to try to specify them in the early phase
	- Installation materials: bolts and nuts, aluminium tubes, cable ladders	- Usually stock items - Might be ordered based on estimation of quantity

Detailed engineering in primary engineering includes materials that are placed on the outdoor field. HV-cables and HV-terminations are purchased mainly for GIS substations. Earthing network will be the first one engineered because the earthing copper will be placed on the ground during the civil works and they usually begin before all the detailed engineering is ready. Steels will be also installed during the civil works and steels, post insulators and HV-clamps all have quite a long delivery time. Installation materials will be specified lastly accordingly to installation drawings.

Table 6. Project execution phases – Detailed Design, Secondary engineering.

Detailed Design – Secondary engineering		
	Supplied materials	**Comments**
	- SCADA - Ethernet cables	- Expensive, long lead time - Ethernet cables can be specified when SCADA engineering is progressed enough
	- AC/DC system	- Can be designed and ordered quite early because they require only some detailed engineering
	- Relays - Relay panels	- Relays will be defined alongside with relay panels design and ordered for the panels
	- Marshalling boxes	- Ordered usually together with relay panels
	- LV-cables / Control cables - MV-cables	- Control cables can be ordered after the relay panels design in ready and cable list including lengths and types is ready - MV- cable types and lengths are defined usually by a secondary team. - MV cables are usually used between the power transformer and control building. The primary team is involved in designing the cable routes - The amounts are usually small
	- Fire alarm systems - Security systems	- After that will be purchased the supporting systems such fire alarm systems, security systems, etc. - Fire alarm systems and security systems are not engineered but the technical specifications are made by the secondary team.
	- Installation materials, bolts, and nuts, cable markings, cable glands	- Specified accordingly installation drawings. Are usually stock items. - Might be ordered based on estimations
	Supplied services	**Comments**
	- Installation works	- Might include also HV-termination works for GIS - Can be purchased when secondary engineering is ready with the control cable specifications

Detailed design in secondary engineering generates most of the purchased materials. SCADA is usually the first one to order because it has a long lead time and the engineering of SCADA might affect the ordering of some other materials. Some smaller materials like for example ethernet cables are needed for an ethernet network between panels and SCADA system and the types and lengths can be specified only after SCADA engineering is progressed enough. This means that external engineering for SCADA affects some purchases.

AC/DC panels are designed in the early phase because they do not need much engineering. The relays and relay panels are engineered after the circuit diagram is ready. After this, the relays and the panels will be purchased. Marshalling boxes might be purchased alongside the relay panels. Secondary engineering is having the main responsibility of the control cables, but they are engineered in cooperation with primary engineering. The engineering is done after the relay panels are defined. The last step is to specify the needed installation material for installation works according to used materials and cable lengths.

The installation works are also purchased in this phase after the secondary engineering has indicated the cable routes and the final lengths of the control cables. The installation works might have been also specified already in the sales phase. If the project is a GIS substation the installation works might also include the HV-cable works.

Table 7. Project execution phases – Detailed Design, Civil engineering.

Detailed Design – Civil engineering		
	Supplied materials	**Comments**
	- Foundations - Anchor bolts - Cable trenches	- Are usually in contractors' scope
	- Control building	- Needs some input from secondary team

The detailed design in civil engineering does not generate a lot of materials to be purchased as most of the materials are in civil contractors' scope as indicated earlier. The biggest single purchase is the control building. The materials that might be in case the company's scope are foundations, anchor bolts, and cable trenches.

The **civil works** might have begun already during the engineering phases and there should be no purchases during the civil works phase if all the materials are on civil contractors' scope or purchased before the works begin. **Installation works** should begin after civil works and detailed engineering should be ready and all the needed materials for installation work purchased. For the **commissioning phase** sometimes, the external workforce might be purchased as well as special supervision services needed for example for GIS substations. The different required individual services might be fire blocks or installations of security systems. Like discussed earlier all the site works might generate needs for purchasing if something is broken or missing, see also Peltola 2012 p.44.

The more precise defined purchasing time for any material or service is based on the project schedule. Project scheduling is done backward and the delivery time for the customer is the first point from where the scheduling is started. Commissioning takes approximately 4-6 weeks and installation works approx. 8 weeks. If the project duration is assumed as 12 months, at that point there are 8,5 months left at the beginning of the project. Civil works take approx. 12 weeks. That means that the site works are ongoing approx. 6 months and engineering take 6 months. The installation works should begin when 7-8 months have passed after the project start. (Alaviitala, 2020) This is the only example as it has been concluded, the projects have different kinds of schedules and the timetables are also dependent on the customer.

5.3 Process mapping

The process mapping for the project execution phases in the purchasing perspective is conducted with a cross-functional flowchart. Results from project execution phases in purchasing perspective and materials in corresponding phases offer a context for the process mapping. The process mapping was based on the primary data findings and internal process maps for engineering. Thus, the process mapping for project execution phases in the purchasing perspective is based on the history of executing the processes according to internal guidelines and processes. It was seen before that all the project execution phases are relevant also for purchasing since purchasing function has tasks in all phases.

The mapping process followed the process mapping steps introduced in the literature review. The layout and the use of different shapes follow mostly the layout and shapes used in the case company's internal process maps. This decision was made so that the process map is more comparable with the other existing process maps in the case company. The map indicates the output from other stakeholders but not all the purchasing steps. Also, the materials are indicated applicable parts. Control points of checking the input from stakeholders to another do exist in the process but the decision for approval or returning to previous responsible for corrections were not indicated in the map to avoid too much complexity. The aim in real life is that the inputs should fulfil the requirements and there would be no need to return it for corrections.

In the case company, the normal **duration** of the domestic turnkey project is 12 months, but the duration varies depending on the project. Some projects might have for example big buildings in scope which leads to longer lead time. According to findings from secondary data the duration of sample projects was the following:

Table 8. Sample project durations.

Project	**Exact duration on months based on PR date**
Project 1	10,55 months
Project 2	15,27 months
Project 3	8,74 months
Project 4	11,16 months
Project 5	11,94 months
Project 6	13,77 months
Project 7	15,23 months
Project 8	17,00 months

The average duration of these sample projects were 12,96 months which is quite much in line with the findings of the interviews. The projects represent only examples of different projects. The projects' exact duration has been also indicated based on the purchase requisition dates. The information on projects' durations was also shared with the respondents in the interview and they were asked their opinion of these. All the respondents indicated that all the projects have a different kind of durations. Pasto (2020) pointed out that the purchase requisition dates do not also tell the whole truth of the project duration. The project might have started at the same time as the first purchase requisition has been made but especially at the end of the project there might be purchase requisitions and purchases made even after the project has been handed over to the customer. This depends, for example, of the customer.

Because of the findings of the project duration, it was decided not to indicate the project duration on the process map. Regardless of the project duration, the project execution process should proceed similarly (Alaviitala, 2020). The process mapping was conducted as a cross-functional process map which also indicates the responsibilities of different departments. The different project execution phases have been identified in the process map.

The process map includes all the project execution phases from the initializing phase until the handing over to the customer. In this thesis context, it was crucial information to add all the identified phases of project execution in the process map. This helps also understanding the proceeding of the project. Individual site works could be also indicated as different phases, but they are happening partially at the same time with the engineering phase and offer inputs for purchasing. Therefore, it was decided to indicate "Site works" as one project execution phase and Civil works and Installation works as a process step.

The project execution includes also many different stakeholders which have all been presented earlier. The project team includes people from many different departments and Alaviitala (2020) reminds that in the end, all the stakeholders within the company should contribute somehow with project execution. The applicable stakeholders considering this thesis context can be defined as:

- Site activities
- Engineering: primary, secondary and civil engineering teams
- Project management team: project manager and project planner
- Purchasing

The different identified stakeholders are the ones who provide inputs for purchasing. The engineering provides the technical specifications and the project managers give his input about the budget, schedule, or other project-specific requirements and approves the PR before it will move forward to purchasing. The site activities have been indicated as one stakeholder group because the different site activities might generate inputs for purchasing and they go parallel with the other project execution phases.

The different purchasing tasks represented according to the SCM workshop will not be indicated individually in the process map. A process map will indicate the different inputs from other stakeholders according to materials and the purchasing function tasks are indicated as a link to a different process where the individual steps are indicated. The reason for the separation was that the final aim was to represent the project execution process as clearly as possible from the purchasing perspective. Purchasing tasks are important steps in different project execution phases but they are the same for all components. Only the process steps which are providing inputs for purchasing are indicated to obtain the clarity.

Some of the process steps might have been already started partially during the sales phase or they receive inputs from sales, but this is not indicated in the process map. The inputs for purchasing different material has been identified in the map. The purchasing tasks are not separated in the map to avoid too complex maps and give attention to the project execution process itself. For the process steps, there is a separate activity detail sheet which includes more exact information of the process steps.

Purchasing is included the most at the beginning of the project execution. Purchasing function might be involved in different kinds of challenges related to suppliers, but from a process perspective, these can be seen more as a corrective action than a repetitive operation in the process. The process mapping is focused on the process as it should be if everything goes according to the process. Purchasing also delivers information for other stakeholders for example about the suppliers and delivery times but these are not indicated in the mapping. Process map is included as Attachment 1. of this thesis.

In addition to process mapping, the additional information about the process on activity level was included in the Activity detail sheet. Adding the information on a separate sheet provides more information about the individual process steps but keeps the process map itself simple. The activity detail sheet was adapted from existing internal process maps for being able to compare the process activities better. The activity details sheet is a mix of general information about activities, RACI chart, and SIPOC diagram. The process activities were labelled with the number to create an activity detail sheet and identify the process activities there not only by text but also with the number. This helps to search for the specific activity from the activity detail sheet.

In addition to the label, the activity detail sheet includes a lot more information about the different activities which helps to identify details of the process. The general information included the name of the process step or activity, definition for the step, and the actions that are needed for conducting the step. The RACI chart for process steps includes responsible for the execution, accountable for approving results, consulted party, and informed party. All these indicate the different roles and responsibilities during the individual process step. Lastly, SIPOC includes suppliers, inputs, outputs, and customers. The process (P) was left out because it was already indicated in general information. On the next page can be seen the examples of activity detail sheet information for the first process step in the project execution process, project team assembly. The whole activity detail sheet is not indicated in attachments because the big amount of data.

Label		General information		
Process phase	**Number**	**Process step**	**Definition**	**Actions**
Initiative phase	1.1	Project team assembly	The project team is established	The needed resources for project are assigned and the team is informed

Figure 13. Activity detail sheet, label and general information example.

RACI			
Responsible for execution	**Accountable for providing results**	**Consulted**	**Informed**
Project Manager	Project Manager	Management team	The team members

Figure 14. Activity detail sheet, RACI chart example.

Process SIPOC			
Supplier	**Inputs**	**Output**	**Customer**
Sales	Contract, project information, as sold	Defined roles and resbonsibilities for different activities	End customer

Figure 15. Activity detail sheet, Process SIPOC example.

Process mapping is a logical way to represent the process. However, the projects in the real-world might not always follow the process precisely and it might be hard to capture all the dependencies and interfaces for example in this thesis' case considering the different engineering teams. Further on, all the engineering affects purchases and scheduling as well as to the proceeding of the project execution. (Koivumäki, 2020) The project business is also challenging for purchasing because there is a big number of suppliers and different materials used. The processes should somehow support more also the use of unique materials (Alaviitala, 2020). Also, in the current process, most of the costs are occurring right in the beginning in the Base design but the materials detailed design generate way more work for purchasing as the amount pf individual PRs is greater. (Pasto, 2020)

6 Summary and conclusions

This chapter summarizes the findings of this research and offers the conclusion based on the results. The study included the literature review which offered the context for the study considering the project business and purchasing in project business. Lastly, the literature of process mapping offered a guideline to represent the findings considering the research question and its objectives. The research findings offered information about the current state of the project execution process in the case company, but also helped critically analyze the role of purchasing function in the project business.

6.1 Summary of the research

Project business has many unique features comparing to the industrial business that still seems to be often the only business type referred to in theories and literature when representing, for example, tools and techniques. The rapidly changing environment of projects makes them hard to manage, also from the perspective of support functions such as purchasing. Purchasing should be able to fulfil its objectives flexible way, supplying materials and services with big variation and small quantities with competitive prices and in the right quality in the rapidly changing project environment. In order to do this, purchasing should be able to understand better the project execution process itself and be able to transform the activities into a proactive direction.

The purpose of this thesis was to familiarize the project execution process in the case company and clarify the role of purchasing in the process mainly from the operative point of view and identify the common materials and services used during the different process execution phases. The literature review of project business, purchasing in projects, and process mapping offered context and guidelines for conducting the research. The research was conducted through semi-conducted interviews and secondary data mainly received from the case company.

The research question and its objectives were the following:

What is involved in process mapping for successful project execution from the purchasing function perspective?

Objectives:

- Identify the different stages of project execution relevant for purchasing
- Identify the types of material and services needed in different identified project execution stages
- To design the process map

The seven main phases of the project execution process were identified: Initiative Phase, Base design, and Detailed design, that together form the engineering phase, Civil works, Installation works, and Commissioning that together form the Site work phase, and finally the handing over for the customer. The purchasing function can be seen having an important role in all the project execution phases throughout the whole process execution, planning the procurement for the project, offering information to other stakeholders of suppliers, lead times, on-time delivery and quality, supplying the materials and handling the challenges and claiming the suppliers. The findings revealed that it is hard to create a complete list of materials and services needed that would fit all projects because all the projects include engineering and different specifications. General materials and services for GIS/AIS turnkey substation projects were identified, and these were associated with the respective project execution phase in the order they are most often processed.

Finally, process mapping was conducted for the thesis topic. Process mapping can have many different purposes and benefits or organizational, process, and client level. In this thesis, the main reason for the process mapping was to offer a graphical representation in the form of the cross-functional process map, which helps to see the different roles and responsibilities. This was important considering especially because the different materials and services are purchased in different phases and different engineering team having the responsibility of making the specifications or drawings and submitting the PR. The process mapping also included other important tasks of purchasing that can be associated with different project execution phases. The activity detail sheet with general information, RACI chart, and SIPOC diagram was added to support the process map information and provide additional information.

6.2 Conclusions and future research

The features of the project business might make it harder to manage the projects or project purchasing but there are still some general features and guidelines to be found. In many parts, it was brought up that something should be handled in this project execution phase, but usually, instead of that, it is done already in this phase because, for example, of long lead times. The importance of careful planning already in sales can be seen crucial for project execution especially in these kinds of situations. The long lead time items might have already offer from the sales phase and it is purchasing responsibility to check these after the project is transferred into the execution phase. It is important that also, for example, terms and conditions, prices, delivery times, etc. of different suppliers have been evaluated already in the sales phase to avoid situations where the purchases have to be made in hurry with lacking agreement of all the purchase terms.

In project execution phases the changes in the process might be a result of missing inputs or the long lead times for certain materials. Something will be designed first because something else cannot be yet done, or something is more urgent considering the delivery time. In some cases, it might be better to do the decisions with partial information than to wait for the final confirmation. This is not a suitable way, for example, the components that are designed, but for example the amounts of small installation materials. Sometimes it is better ordered a little bit too much than end up in a situation where the needed materials like some bolts and nuts are missing from the site.

Based on the literature review and findings of this study, the project business could be described as balancing between the schedule and risks, requiring flexible management and processes. There are many different processes ongoing parallel and even more interfaces, and all the processes try to answer to the changing needs of single projects as well as possible. According to this, it can be concluded that the processes should be designed to support the flexibility that project business needs, or the projects need to be more standardized. In purchasing of point of view, it could be reasonable to categorize materials and services further to the most applicable way for the business. Usually, the costs are a good starting point, but in project business, even the lack of the smallest and cheapest component can stop the site works and cost a lot of money. In literature, it was presented that MTS, MTO, and ETO purchases should be managed differently.

For future research, it could be researched the ability of processes to answer changing needs for single projects or the possibilities of making the projects more alike. In addition to this good communication and transparency could offer a solution to more competitive operations. This might be hard since the amount of information is huge and everyone cannot know everything. The right information should be available at the right time and for the right people. Future research could be also conducted for the different subprocesses in more detail and the interfaces between them, for example in engineering because engineering provides almost all the inputs for purchases. The high-quality processes could be key to provide competitiveness and help planning.

Hopefully, the process mapping conducted for this thesis for the case company will provide transparency to the project execution process from the perspective of purchasing function and it can be used in the future for example to educational and improvement purposes.

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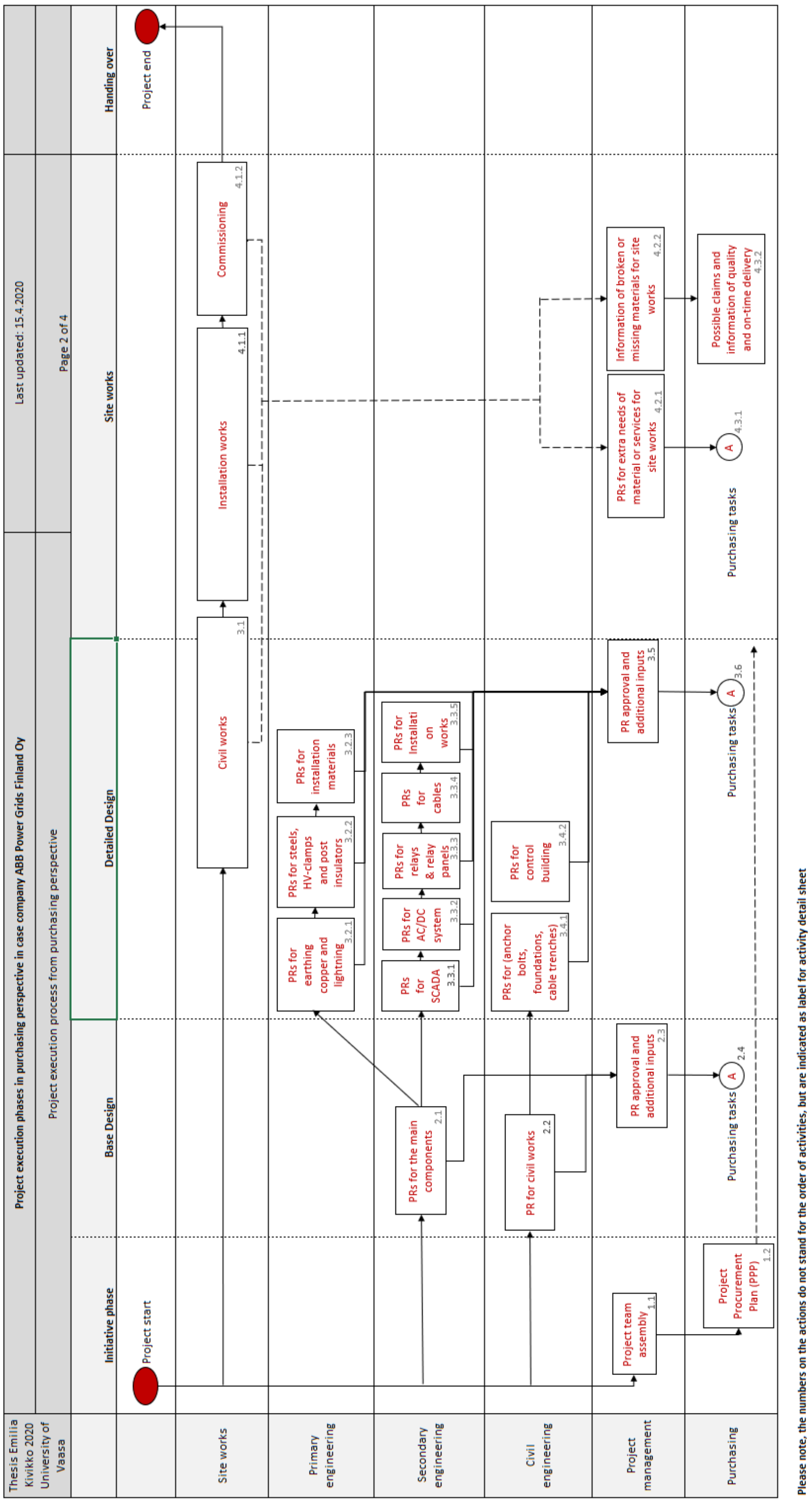
Attachments

Attachment 1. Process map from project execution process from the perspective of purchasing function



Attachment 2. Cross-reference from project execution process map to purchasing tasks