SAVONIA

OPINNÄYTETYÖ - **AMMATTIKORKEAKOULUTUTKINTO**
TEKNIIKAN JA LIIKENTEEN ALA

IMPLEMENTATION OF COMMON COST ESTIMATION TOOL IN KRP DIVISION

Andritz Oy, KRP Division, Varkaus

Author: Viivi Ylä-Viteli

SAVONIA-AMMATTIKORKEAKOULU

OPINNÄYTETYÖ
Tiivistelmä

Koulutusala Tekniikan ja liikenteen ala	
Koulutusohjelma/Tutkinto-ohjelma Energiatekniikan koulutusohjelma	
Työn tekijä(t) Viivi Ylä-Viteli	
Työn nimi Implementation of common cost estimation tool in KRP division	
Päiväys 14.11.2016	Sivumäärä/Liitteet 35/4
Ohjaaja(t) Yliopettaja Ritva Käyhkö, lehtori Seppo Ryynänen ja Jukka Hautamaa (Andritz Oy)	
Toimeksiantaja/Yhteistyökumppani(t) Andritz Oy – Varkauden toimipiste	

Tiivistelmä

Tämä opinnäytetyö on tehty Andritz Oy:n Recovery and Power (KRP) divisioonalle.
Opinnäytetyön aiheena oli projektien hinnoittelutyökalun kehitys Excelissä integroituna uuden hinnoittelutyökalu PreCalculation Toolin käyttöönottoon ja vaadittavien kehitystoimenpiteiden toteutus.

Opinnäytetyö käsittää PreCalculation Tool -ohjelmaa varten tarvittavat muutokset käytössä olevaan hinnoittelupohjaan, sekä tiedonsiirron testauksen. Teoriaosuus sisältää selvityksen hinnoitelusta, hinnoittelumalleista ja -ohjelmista, työn osituksesta, kustannusten osituksesta, hinnoittelun laadusta sekä yleisesti, että KRP divisioonassa. Pääasiallisena lähdemateriaalina käytettiin kahta Andritzille tehtyä diplomityötä, muutamien projektien hinnoittelutietoja, sekä hinnoittelijoiden kanssa käydyistä palavereista saatua tietoa.

Käytössä olevan, Excel -pohjaisen hinnoittelutyökalun kehitys perustui uuden sivun luontiin. Tämä sivu (PreCalculationUploadFile) koostuu taulukoista, jotka keräävät kustannustietoa hinnoitteluohjelman muilta sivuilta. Uusi sivu sisältää muuntimen, joka rakentaa taulukoista XML tiedoston. Luotu XML tiedosto viedään PreCalculation Tooliin, jossa hinnoittelua voidaan jatkaa ja muokata. PreCalculation Tool on tietokantapohjainen ohjelma, joka yhdenmukaistaa hinnoittelua divisioonien välillä.

Työ tehtiin kolmelle tuoteryhmälle: Voimakattiloille, Soodakattiloille ja haihduttamoille. Jokaisella tuoteryhmällä oli oma Excel -pohjainen hinnoittelutyökalunsa. Nämä työkalut erosivat toisistaan ulkoasun ja sijoittelun sekä kustannuksen osituksen kannalta, mikä aiheutti eroavaisuuksia kustannustietoa keräävän sivun rakenteeseen. Ensimmäiset versiot voimakattiloiden ja soodakattiloiden muokatuista hinnoitteluohjelmista olivat hyvin toimivat ja yhteensopivat PreCalculation Toolin kanssa, mutta Haihduttamoiden työkalun käytössä oli ongelmia hitauden suhteen. Ratkaisu voisi olla kustannustietoa keräävän sivun erottaminen muusta hinnoittelusta omaksi tiedostokseen, tai taulukoiden rakenteen muuttaminen yksinkertaisemmaksi.

Jatkokehitys ja uuden ohjelman käyttöönotto tapahtuvat vuoden 2016 loppuun mennessä.

Avainsanat
Työn ositus (WBS), hinnoittelu, hinnoittelutyökalut, hinnoitteluohjelmat, kulunseuranta, laadunhallinta, tililajit,

Excel, PreCalculation Tool, kulun ositus (CBS)

SAVONIA UNIVERSITY OF APPLIED SCIENCES

THESIS
Abstract

Field of Study Technology, Communication and Transport			
Degree Programme Degree Programme in Energy Technology			
Author(s) Viivi Ylä-Viteli			
Title of Thesis Implementation of Common Cost Estimation Tool in KRP Division			
Date	14.11.2016	Pages/Appendices	35/4
Supervisor(s) Ritva Käyhkö, Seppo Ryynänen, Jukka Hautamaa (Andritz Oy)			
Client Organisation /Partners Andritz Oy – Varkaus office			

Abstract

This thesis was commissioned by Andritz Oy, Recovery and Power division (KRP). The purpose of this thesis was to develop the existing cost estimation tools integrated to a common cost estimation tool to be used in KRP division at Andritz Oy. The purpose was also to study cost estimation in general and in KRP division.

This thesis covers the implementation of the PreCalculation Tool, the testing of data import and the study of cost estimation as well as Work –and Cost Breakdown Structure. Two Master's Theses, cost estimations of some projects and information gained from meetings with cost estimation engineers were used as main material sources.

The existing cost estimation tool in Excel was developed by adding a data collection sheet to XML builder. The created XML file with the cost estimation data could then be imported to the PreCalculation Tool. The cost estimation can be changed and modified in the new tool that unifies the cost estimations between divisions.

The study was carried out for three product groups, Power Boilers, Recovery Boilers and Evaporators. Cost estimation tools of each product group were slighty different considering layout and Cost Breakdown Structure, which caused differencies to the structure of the data collection sheet. The modified cost estimation tools for Power Boilers and Recovery Boilers were completed first, but the Evaporator estimation tool has challenges with the performance and it needs futher development. Solution could be separation of the data sheet as its own file, or simplifying the structure of the sheet.

Further development and release is set by the end of 2016.

Keywords
Work Breakdown Structure (WBS), Cost Breakdown Structure (CBS) cost estimation, cost estimation tools, cost control, cost elements, quality management, Excel, PreCalculation Tool

FOREWORD

I wish to thank Jukka Hautamaa for counselling and guiding me through the thesis. Also I wish to thank Ritva Käyhkö for trusting me the freedom to write at my own pace and Petteri Heino for this opportunity.

In Varkaus 14.11.2016
Viivi Ylä-Viteli

CONTENTS

1 INTRODUCTION

1.1 Background

The worldwide economical situation has been unsteady after the financial crisis of 2008. The intensive competition of the industrial investment projects has driven the companies within this area to reduce product costs and to pay attention to exact cost estimation. The development project to unify the project cost estimation and to increase transparency and comparability of the estimates was started in all divisions of Andritz Pulp and Paper division of Andritz AG in 2015. Many divisions and product groups used their own cost estimation tools, which were different from each other and mainly based on Excel spreadsheets before developing the new cost estimation tool. The benefits of uniformity in cost estimation by using one common tool are common division of cost structure and easier transfer of cost estimate to project budget in Enterprice Resourse Planning system. Unifying the project cost estimation also improves the quality of it by making the cost estimates of different product groups easier to compare and understand.

1.2 Objectives

The objective of this thesis was to modify the existing cost estimation templates in Excel in order to enable the import of data to the new cost estimation tool, PreCalculation Tool. The main effort was to develop an XML -builder to Excel. This was implemented by creating a new sheet that collects the relevant information from the cost estimation calculation sheets and then creates an XML file based on the tables of the collection sheet. Development work was done for three product groups of KRP division, Power Boilers, Recovery Boilers and Evaporators. Cost estimation is already divided according to WBS structure in the existing templates. PreCalculation tool also needed a lot of testing with the XML interface. Work Breakdown Sturcture, the cost estimation and different tools and techniques as well as the quality of cost estimation were studied in the theory part of this study.

1.3 Scope and Encryption

This thesis covers the development work of the current cost estimation tool in Excel, testing work for the new PreCalculation Tool and the report. The theory part of the work considers Work Breakdown Structure and Cost breakdown Structure, Cost Estimation and Quality management reflecting the practise.

This thesis contains trade secrets for cost estimation and pricing. The detailed description of the implementation and testing work has been left outside of the released version of this Thesis. All the pricing details and similar, sensitive data was also left out from the released version. The released version contains a simplified report of the work done in the Conclusion chapter.

1.4 Abbreviations and Definitions

KRP	Recovery and Power division
WBS	Work Breakdown Structure
CBS	Cost Breakdown Structure
ERP	Enterprice Resourse planning system
ASAP	ERP Tool, SAP tailored for Andritz
PreCalc	PreCalculation Tool, a cost estimation tool (in sales phase)
ZACE	Andritz Cost Estimation tool (in the project phase)

2 EMPLOYER

2.1 Andritz AG

"ANDRITZ is a globally leading supplier of plants, equipment, and services for hydropower stations, pulp and paper industry, the metalworking and steel industries, and for solid/liquid separation in the municipal and industrial sectors. The publicly listed technology Group is headquartered in Graz, Austria, and has a staff of around 25,700 employees. ANDRITZ operates over 250 sites worldwide. With the goal of maintaining high availability while keeping life-cycle costs to a minimum, ANDRITZ provides technical support, on-site services, spare parts, wear components, and specialized diagnostic tools for all its production systems. These capabilities are found within a single organization to ensure minimal interfaces and maximum productivity." (Andritz.com, 2016)

2.2 Andritz Oy

"ANDRITZ Oy is one of the leading global suppliers of systems, equipment and services for the pulp and paper industry - including wood processing, fiber processing, chemical recovery, stock preparation - as well as for biomass boilers, biomass pelleting plants, and gasifiers for energy production.

A growing part of the company's business includes the supply of engineered, customized and technologically advanced wear and spare parts." ANDRITZ Oy has over 1000 employees in Finland working at Lahti, Kotka, Savonlinna, Tampere, Varkaus, and also Helsinki, where it's headquartered. (Andritz.com, 2016)

3 WORK BREAKDOWN STRUCTURE

A Work Breakdown Structure (WBS) is a hierarchical and tree structural decomposition of a project. WBS is used in project management, where it organizes the team's work into manageable sections. WBS development starts with recognizing the objective and subdividing it into components in terms of size, duration, delivery and responsibility. These components can be systems, subsystems, subtasks, and work packages. WBS shows the total scope of work to be carried out by the project team to accomplish the project objectives and create the required deliverables. The WBS is organized around the primary products of the project instead of the work actions needed to produce the product. Since the deliverables (planned outcomes) are the desired project ends, they form a relatively stable list of the costs needed to achieve the result. In this way a WBS can provide the needed framework for detailed cost estimation and cost control as well as schedule developing. WBS can also be used to identify potential risks in a project. If a WBS has a branch that is not well defined, it is a scope definition risk. The WBS dictionary can be used to describe each component of the WBS with deliverables, activities and scope. Sometimes it can also be used to describe dates, resources, costs and quality. (PMBOK4, 2008, 116-122, Workbreakdownstructure.com, 2016)

3.1 The 100 % Rule

The 100% rule states that all the work defined by the project scope must be included in the WBS. WBS has to capture all deliverables (internal, external, and interim) in terms to complete the work. It is the most important rule when developing a WBS. The rule applies at all levels within the hierarchy: the sum of the work at the lower level must equal to 100% of the work represented by the higher level (see figure 1). The WBS should never include any work that is outside the actual scope of the project because it will cross over the 100% of the work. Another important thing is that there is no overlap in scope definition between different elements of a work breakdown structure. This could affect the work to duplicate and cause problems at project cost accounting. Such overlap could also lead to miscommunications about responsibility and authority. (Workbreakdownstructure.com, 2016)

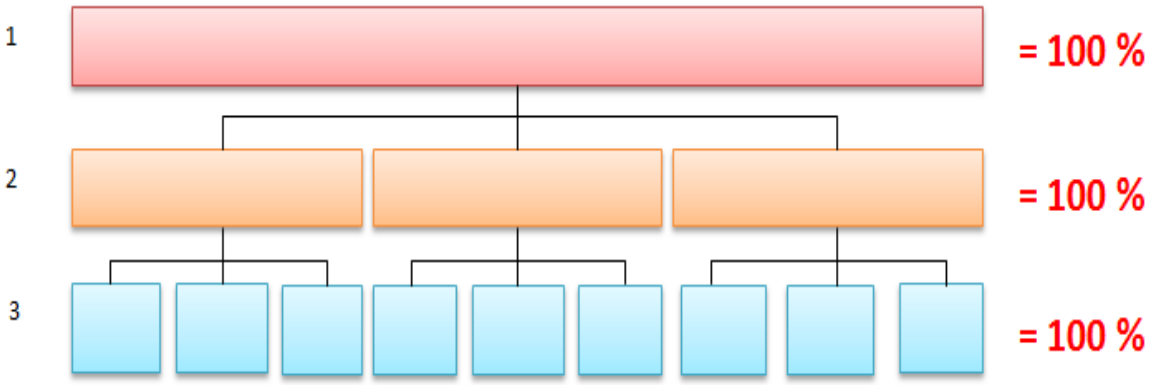

Figure 1. The 100% rule applies on all levels of WBS.

3.2 Different ways of approach

There are different ways to approach and contemplate the Work Breakdown Structure. WBS is either dissecting the product into structural parts or systems based on component deliverables. One way is to divide the project structurally into physical parts, that are indicated with a noun. The noun implies the part of the product, such as modul, system and subsystem. In System-based breakdown the project is divided into systems that are functionally independent and the number of subsystems depends on systems and equipment the product includes. The size of the project also affects the WBS. Additional way to approach the WBS is Geographical Breakdown, which divides the structure between different locations that come under the same project. Quite similar approach is to divide the product by departments. The actual development of WBS begins when the way of approach has been selected. After this the actual project work can be divided into types such as engineering, developing, and testing or into sequential independent work phases. (Nieminen Jere, 2015, 14–18)

3.3 Andritz Oy

Andritz Oy is using three levels in the WBS: product level, equipment level and component level (see figure 2). The WBS has been developed with system based approach and the component and equipment level are physically divided (see figure 3). Project work is divided from packgages gathered to global numbers. The total amount of, for example, engineering can be determined but without more specific information of engineering amount per equipment. This is a result of inadequate accounting accuracy of the work type costs. Specific cost information is needed to get more accurate cost estimations in the future and it is not possible without detailed information about work type amounts per equipment. (Nieminen Jere, 2015, 47)

The Enterprise Resource Planning (ERP) system has tools for project progress, schedule tracking and reporting, but it is only used to get the cost control done with ASAP by using the WBS numbers. Commissioning ERP brought up a problem with the old (working) WBS. A compromise between departments and their divergent WBS titles is in use at the moment which makes the WBS an incoherent ensamble. Andritz Oy being a part of a global enterprise, not much can be changed in the WBS anywhere else than in equipment and component levels. (Nieminen Jere, 2015, 47)

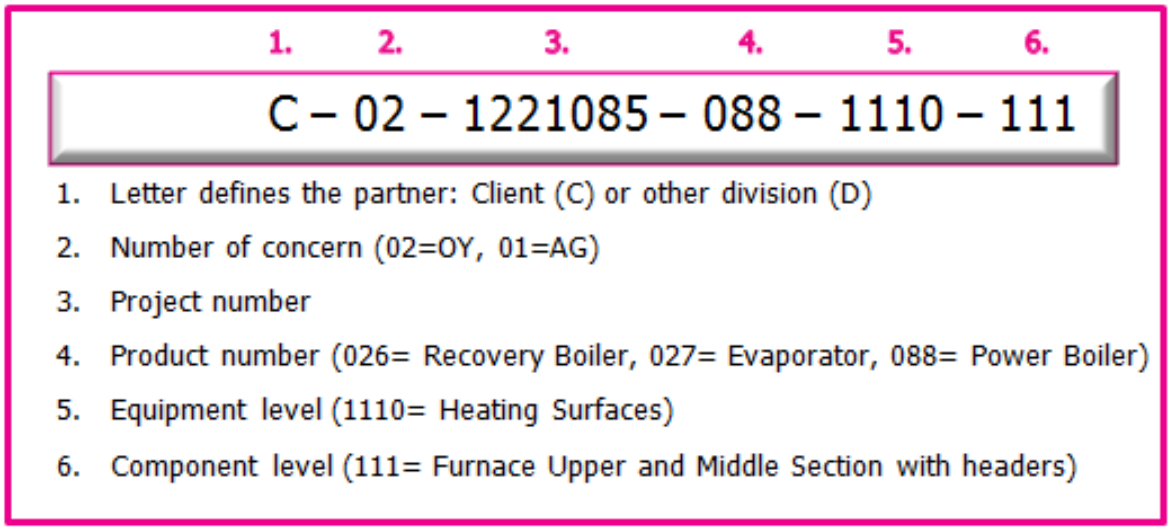

Figure 2. Example of three-level WBS number code used in Andritz Oy.

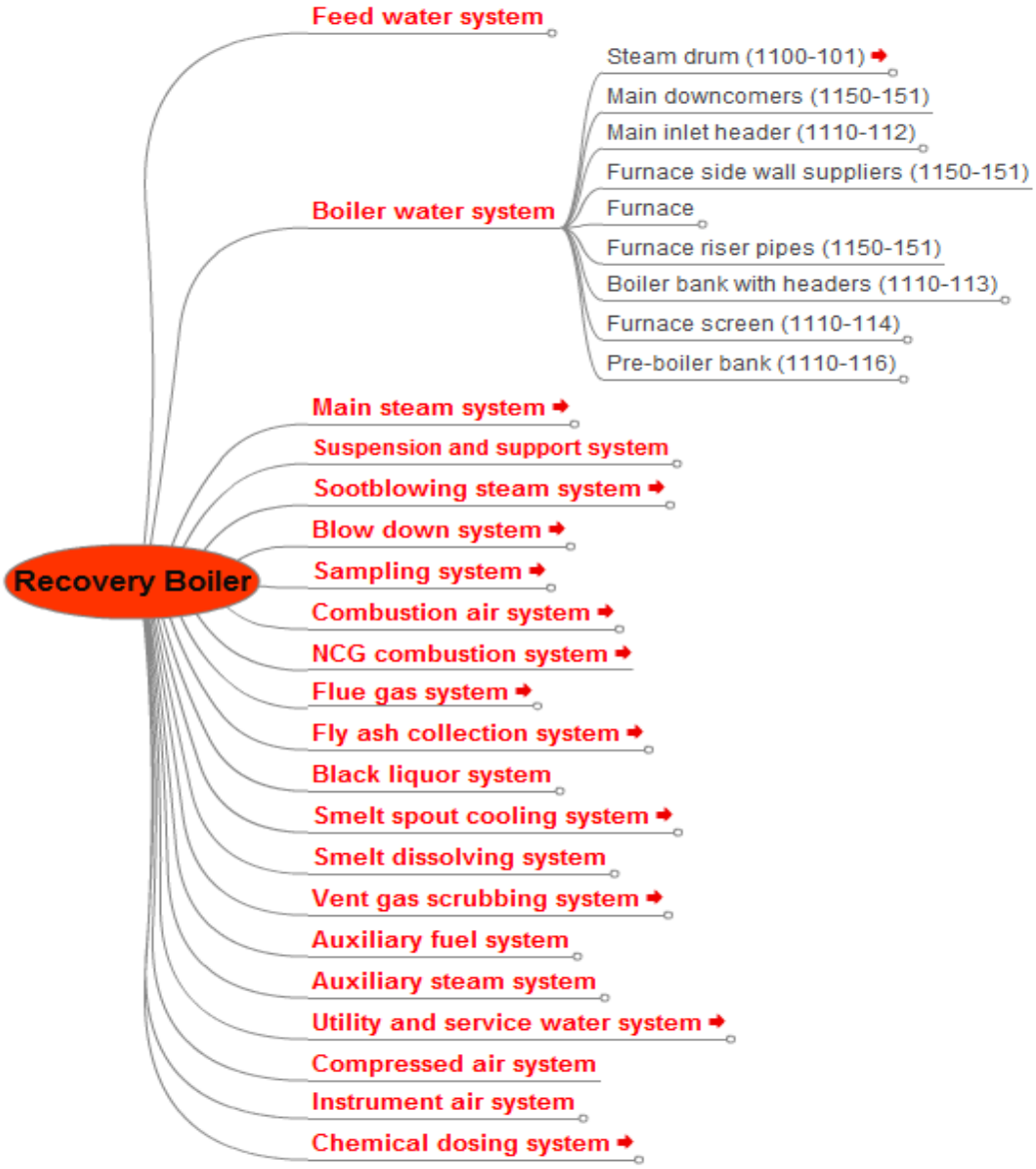

Figure 3. System based work breakdown structure mapped to WBS -numbers. (Andritz intranet 2016)

3.4 Cost breakdown structure in cost estimation

The cost control structure of the project is somewhat different than the cost structure in cost estimation, even if the WBS is practically the same. The WBS structure used in the project is divided to deliverables and it is used to control costs of the work packages with cost elements. Cost estimation is made in component level of WBS without using cost elements and only the costs have been divided to unchangeable cost elements. (Nieminen Jere, 2015, 47)

"Once costs have been assigned to tasks, it is possible to monitor the project in terms of actual, forecast and earned cost on a task. In order to be able to summarise costs across projects a Cost Breakdown Structure (CBS) needs to be developed. A CBS is a systematic process which identifies the individual elements that comprise the total cost of a package. Many organisations have a

standard CBS that is applied to all projects and is usually determined by the finance department." (http://2020projectmanagement.com/2013/10/the-cost-breakdown-structure-cbs/).
See figure 4 as an example of Cost Breakdown Structure where costs are assigned to the component level and then summed up in higher levels of CBS.

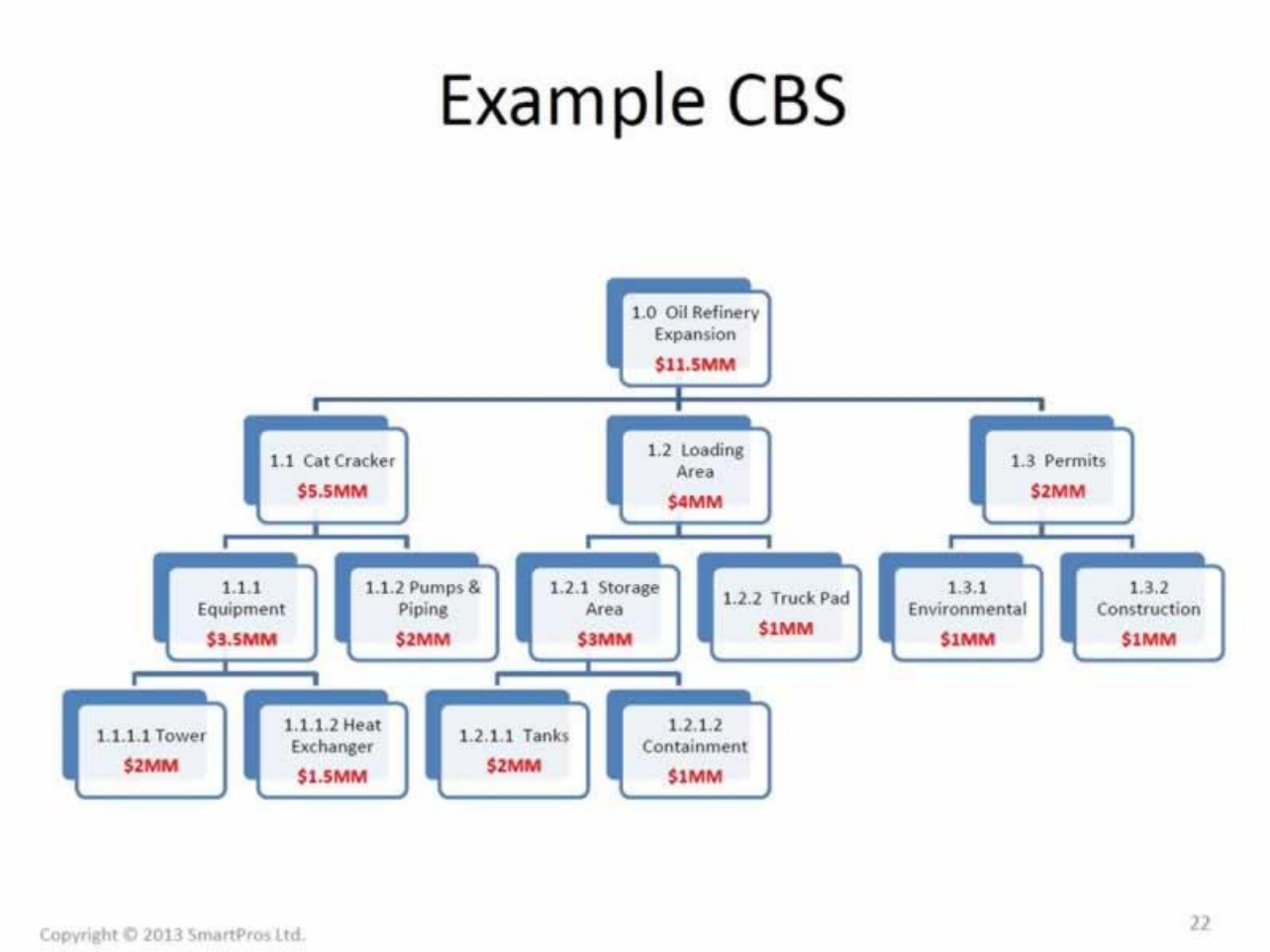

Figure 4. Example of CBS where costs are assigned to component level and summed up in the higher levels.

4 COST ESTIMATION

Project Management Body of Knowledge (PMBOK4) defines cost estimation as " *a process of developing an approximation of the monetary resources needed to complete project activities*." Certain documents and activities need to be done before proceeding to developing the cost estimation, such as creating the WBS (see figure 5). Project teams should estimate costs for all resources that will be charged to the project. This includes for example work, materials, equipment, services and so on. (Department of Information Technology 2016)

The goal of cost estimation is to set a price that will cover the costs of the product and make profit but also take notice of market situation. Cost estimation influences profitability and competitiveness on the market. To be effective, the cost estimation should be a relation between contribution margin and market share, that is maximizing the profitability in a long term. (Yrityssuomi 2016)

The estimate may include a contingency which is provided for unknown costs. These costs are indicated as likely to occur by experience, but are not identifiable. A contingency is often added to set a budget or to set aside funding, and to improve the probability that the budget or funding will be adequate to complete the project. The estimate or budget contingency is not meant to compensate for poor estimate quality. Generally more contingency is needed for earlier estimates due to the higher uncertainty of estimate accuracy. (PMBOK4 2008, 168)

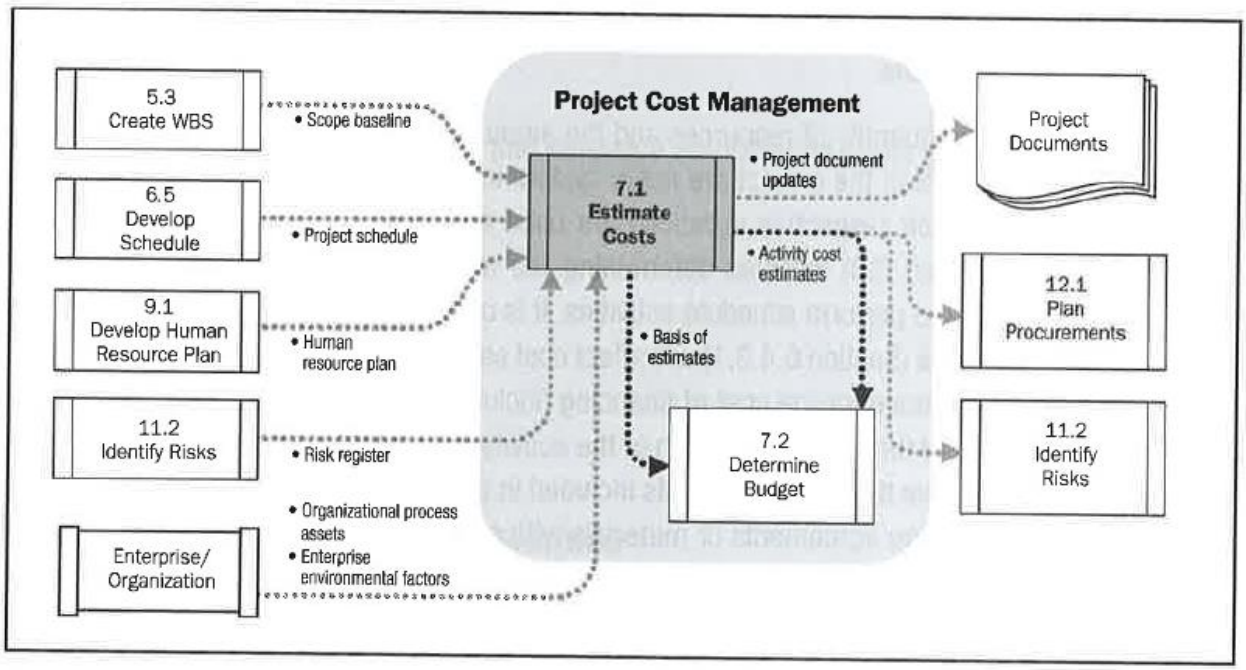

Figure 5. Inputs and outputs of cost estimating. (PMBOK4 2008, 169)

4.1 Cost estimation models

In Market-based cost estimation model the price depends on the price level set by competitors and the market. Product costs are set to the same level as target costs. Producer has to find out the price customers are willing to pay for a certain product on the market and after comparing the features of their own product, place it somewhere on the price scale. This type of cost estimation is becoming a common model although it needs to be supported with accurate market and shopping behavior analysis. (Kulmala, Harri 2015)

The idea of contribution margin based estimation is that the price has full coverige of all the manufacturing and procurement costs (changing costs). The remaining contribution margin has to cover a sufficient part of company's fixed costs such as wages and rents. The business makes profit if the sum of all of the products' contribution margins (gross profit) is greater than sum of all fixed costs. (Yrityssuomi 2016)

In Cost-based estimation the producer estimates or calculates beforehand the costs of delivering the product and adds the desired mark-up. Other opportunity is to get customer committed to paying costs of delivering the goods and the mark up. The cost-based estimation requires a good knowledge of costs and system for cost accounting. The problem with this model is dependence of the costs with time and the unit cost is affected by the volume. (Kulmala, Harri 2015)

Cost estimation based on previous products means that the producer aims to preserve its place static on the market by estimating a new product. The model is typical with car and cellphone markets, where they launch a new version of the product that replaces the old one. By doing this the product (like Toyota Corolla) maintains its status among other products. The new version of the product is usually a little more expensive than the older one, but at the same level as competitior's products. This model is typical, so called established market estimation model. (Kulmala, Harri 2015)

An estimation that secures the short-term sales targets means that the producer sets absolutic or relative sales volume targets for certain products so they can meet other requirements. This model is associated with strategical market share targets, influencing the competition or bringing new goods to the market. (Kulmala, Harri 2015)

4.2 Cost estimation tools and techniques

There are many different methods to work with cost estimation. These techniques can be used together or separately. Generally using combination of more than one technique will create more accurate estimation than using a single technique. A common technique is called Expert judgement. It uses data information of certain parameters (such as labor rates, material costs, and inflation) and historical information from previous projects with knowledge and expertise of the estimation engineer gaining a valuable insight. Expert judgement can be also used to determine which method to use for estimating or the need to combine methods. (PMBOK4, 2008, 171)

Another widely used method is Analogous Estimation that uses values of parameters like scope, cost, budget and duration of measures from previous, similar projects as a basis for estimating the same parameter or a measure for a current project. Estimating costs, this relies on the actual cost of previous as a basis. It's a gross value estimation approach, adjusted with known differences between the projects. Historical information and expert judgement are also used with this method. Analogous Estimating is generally less costly and time consuming than other tehniques but not as

accurate. Analogous Estimation method is frequently used when there is limited amount of detailed information about the project. (PMBOK4, 2008, 171)

Parametric estimating is a technique that uses a statical relationship between historcial data and other variables to calculate an estimate for parameters. Tehnique can provide more accurate estimation because of the sophistication and underlying data built into the model. (PMBOK4, 2008, 172)

Bottom-Up Estimating is used to estimate a component of work. The detailed costs of individual packages are estimated first and then summarized on higher levels for tracking and reporting purposes. Accuracy of this technique is influenced by size and complexity of the individual work package. (PMBOK4, 2008, 172)

Three-Point Estimates is a method for the estimate to be considered from three different points of view, which improves the accuracy of an estimate. This technique clarifies the range of uncertainty of the cost estimation. Three different estimations are made: most likely estimate C_M (realistic cost of the activity), Optimistic estimate C_O (cost for best-case scenarion based on analysis), and Pessimistic estimate C_P (cost based on analysis of the worst-case scenario).
The expected C_E activity cost is calculated by using a weighted average of these three estimates.

$$C_E = \frac{C_0 + 4C_M + C_P}{6} \qquad (1)$$

Reserve Analysis takes notice of the possible contingency reserves the cost estimation may include to account for cost uncertainty. Contigency may be a percentage of the estimated cost, a fixed number or developed by using quantitative analysis methods.

Cost Estimation methods may include analysis of what the project should cost, based on the bids from qualified vendors. This is called Vendor Bid Analysis. "*Where projects are awarded to a vendor under competitive processes, additional cost estimation work can be required of the project team to examine the price of individual deliverables and to derive a cost that supports the final total project cost.*" (PMBOK4, 2008, 173)

4.2.1 Commercial Applications

Cost estimation software applications are becoming more usual. There are for example computerized spreadsheets, simulations and statistical tools that can be used as assistance in cost estimation. Such tools can simplify the use of some cost estimation techniques and thereby ease the quicker review of cost estimate alternatives (PMBOK4, 2008, 173).
Database driven estimating systems have the same features as spreadsheets but are able to integrate multiple procedures into a single solution (For constuctor Pros, 2009).

Typical commercial applications and software of database driven cost esimation tools:

- Costimator (https://www.mtisystems.com/Cost-Estimating-Software.html)
- CostOS (https://www.nomitech.eu/costos-in-cloud)
- Cubit (http://www.buildsoft.com.au/cubit)
- Sigma (https://www.sigmaestimates.com/products/sigma/)
- iTWO (http://www.rib-software.co.uk/itwo-estimating/?gclid=CjwKEAjw97K_BRCwmNTK26iM-hMSJABrkNtby5MkeDysizj8CC1nk0aMwzepAQJBidMV5eiFPbIrchoCPRnw_wcB)
- Cleopatra Enterprice (http://www.costmanagement.eu/)

These applications are advertised as secure, flexible, cost saving and a green choice (they are in the cloud and there's no need for printing paper or buying tons of hardware). Software can be used from everywhere and by anyone and has a strong user support. Software provides a quicker way to make estimations of better quality.

4.3 The Budget

The budget is made after cost estimation. "*Determing the Budget is the process of aggregating the estimated costs of individual work packages to establish an authorized cost baseline*" (PMBOK4 2008, 174). The figure 6 shows the documents and actions needed to determine budget. Project budgets constitute the funds authorized to execute the project. Project cost performance will be measured against the authorized budget. Common tools and techniques to make a budget are Cost Aggregation meaning that cost estimates are aggregated by work packages in accordance with the WBS. Reserve Analysis is used to include contingency and management reserves. Expert Judgement and Historical Relationships can be used to develop mathematical models to predict total project costs. (PMBOK4, 2008, 175-178)

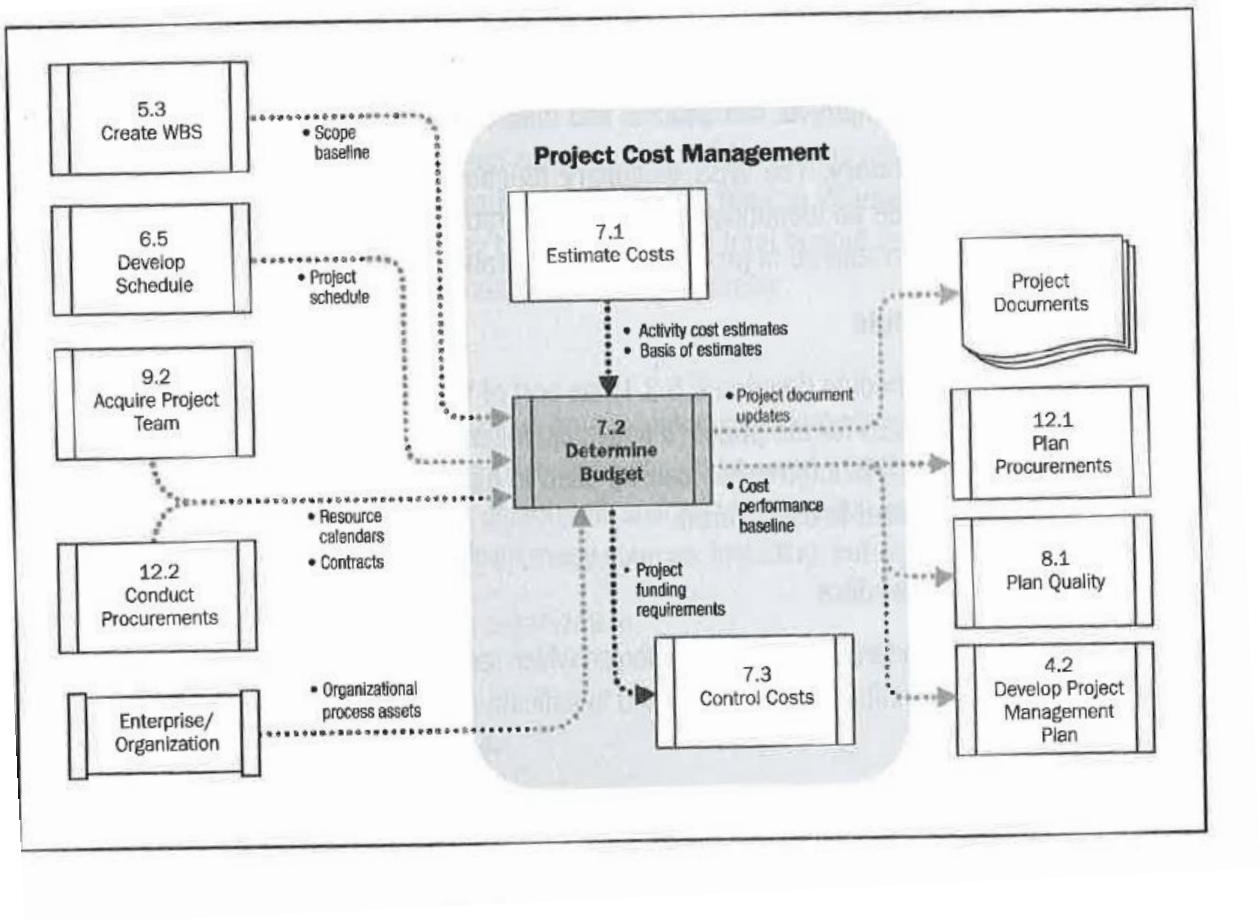

Figure 6. Inputs and outputs of determing the budget. (PMBOK4 2008, 175)

4.4 Cost control

In the PMBOK4 the cost control is defined as follows: "*Costs control is the process of monitoring the status of the project to update the project budjet and managing changes to the cost baseline*." (PMBOK4, 2008, 179)

Cost control allows the project team to stay within the authorized funding. The actual costs spent are recorded to date for updating the budget. Cost controlling has several functions for achieving its goals. These functions influence the factors that create changes to the cost baseline, managing all the change requests and ensuring that they are done in timely manner. Cost control keeps track on expenses so that they aren't exceeding the authorized funding neither in period nor in the total project and that the expected cost overruns would stay within acceptable limits. (PMBOK4, 2008, 179)

To control costs, it is needed to have certain documents from the project, such as project management plan, project funding requirements, work performance information and organizational process assets. These documents (see figure 7) are then used with cost control tools and techniques to make work performance measurements, budget forecasts, change requests, project management plan updates and project document updates. There are a few techniques to control costs. Earned value management (EVM) is a common method used to measure performance. It has various forms

and can be applied to projects in any industry. Each work package and control account is monitored by the three dimensions the EVM develops. These dimensions are planned value, earned value and actual cost. The dimensions can be monitored with software. As the project goes on, a technique called forecasting can be used to create an estimate at completion. Estimation at completion means the estimated cost to complete the remaining work of the project plus the actual costs already incurred. Performance reviews compare the cost performance to the budget regarding schedule andwork packages over running or under running. Variance analysis gives important aspects of project cost control by determing the cause and degree of variance relative to cost baseline. (PMBOK4, 2008, 179-188)

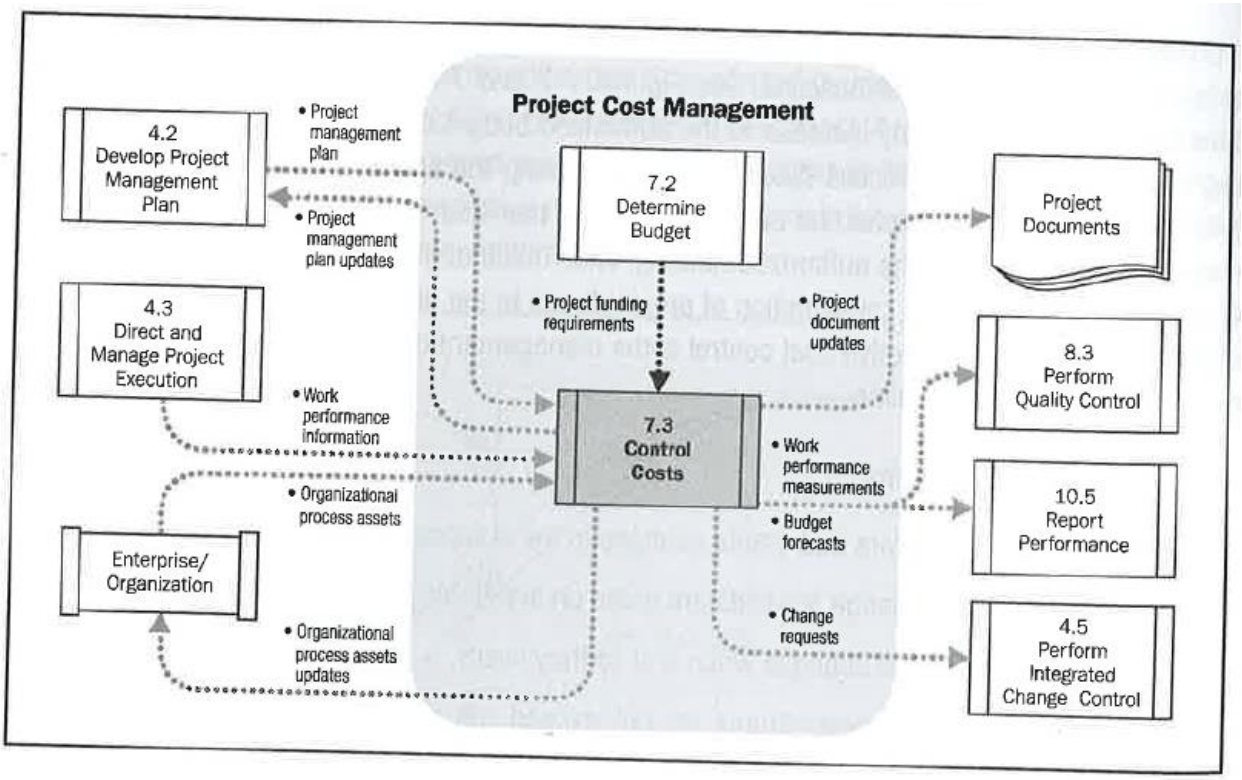

Figure 7. Inputs and outputs of cost controlling. (PMBOK4 2008, 180)

4.4.1 Cost element

Cost element accounting records and groups the costs incurred. Cost element describes the origin of cost. Cost element is used for representing specific costs incurred by the organization, where the actual cost occurred. It helps management to track costs according to internal accounting policies. Costs can be divided to elements like manufacturing, supplies, materials and labour for easier cost control. The following can also be used as a cost element: Overhead production, Administration, Selling overheads, Distribution, Maintenance and repair, Utilities, Salaries, Occupancy, Depreciation and other Fixed Expenses. Each cost element needs also to be defined as direct or indirect cost. (Apprisia 2016, Tutorials Point 2016)

4.5 Andritz Oy

The cost estimation in KRP division/PB product group in sales phase is a process including several disciplines, which use their own tools, mainly based on Excel. Cost estimates of AEI, Civil and Site operations will be combined in one Excel application where product configuration and design data is imported from the sales configurators. The estimation engineer of the product group then does the final cost estimation of the project. The cost estimation tool used to estimate the project is an old spreadsheet combination that has been in use since the 1990's. The Excel template has several tabs consisting of unit, material, weight and cost information of each equipment on the WBS. The cost estimation template also has tabs that consist of other information, like tube units and weights that are used in other tabs. One sheet is called cost summary and it is a summary of all the costs on WBS tabs (equipment prices, engineering, AEI, erection, freight, insurances and so on). The appendix 1 shows cost estimation summary gathered from costs assigned to WBS components. Cost summary sheet shows the total costs to complete the project and divides the costs into categories to show how the total sum was calculated. A sheet called Exesum shows the costs of the project and also the target profit and the sales price. This means that estimation engineers use a cost-based estimation model and estimate of the expenses with Bottom-Up technique with a help of historical information from previous projects and expert judgement. (Mynttinen, Jarkko 2012)

The project budget is determined from cost estimation and monitored in ASAP where also the cost control based on WBS numbers is. The WBS product level is used in internal cost accounting and WBS equipment level in both internal and external cost accounting. The component level is used in external cost accounting as a cost level in cost auditing. Cost elements are divided to external and internal elements. In the old cost estimation tool the cost elements were not defined. The PreCalc Tool demands every cost to be identified with the cost element, so they were added to PreCalc sheet made in Excel. Outsourced Manufacturing and External Supplies were the most often used cost elements. The cost estimation in project phase is made with ZACE. (Mynttinen, Jarkko 2012, Nieminen Jere 2015)

5 QUALITY MANAGEMENT

The quality of cost estimate depends on the quality requirements set for the estimate. These requirements are in line with the quality assurance standards of the company. Other expectations for the estimate can also affect the quality of the estimate. Quality requirements usually involve credibility, accuracy, risk, and validity of the estimate, as well as thoroughness, uniformity, consistency, verification and documentation.

The estimate accuracy measures how closely the estimate is able to predict the actual costs of the project. The accuracy can be known after the project is completed. Predictions of the estimate accuracy can be included in the estimate. A final estimate might have a -5/+10 % range of accuracy

with a 85 % confidence that the final value will be in that range. The estimate accuracy is measured by how well the estimated total cost compares to the actual total cost. Things affecting the accuracy are, for example, how the estimate was prepared and the amount of knowlegde of the project. Detailed documentation should be accompanying the estimate. The documentation shows the scope of the estimate, estimating methody, the results of the risk analysis, and a conclusion about whether the cost estimate is reasonable. It is also important to show who made the estimate and for what purpose.

"*Therefore, a good cost estimate—while taking the form of a single number—is supported by detailed documentation that describes how it was derived and how the expected funding will be spent in order to achieve a given objective*." (Wikipedia.com, 2016)

6 PRECALCULATION TOOL

Andritz AG has developed a new cost estimation program, PreCalculation Tool (PreCalc), the goal of which is to increase transparency and comparability of estimates in all of Andritz divisions. PreCalc's features are standardized calculation approach (WBS-oriented, partly automatic WBS- and Cost Element -Mapping) and flexibility for a worldwide, country/product independent usage. Data security will also increase with this approach. (ANDRITZ internal slideshow, 2015)

6.1 Background work

The work that was done is explained in the following chapters through a case scenario, a project chosen from Power Boiler product group. The project had actual prices and project structure in it. The cost estimation template needed a PreCalc import sheet which would collect all the important data from other tabs into a certain form dividing the CBS as a similar package with the dividing process by cost elements in project. A macro was also made to create a XML file that has compatible structure with PreCalc XML -interface requirements. PreCalc sheet consists of tables that have a match in the tool and each table has its own purpose depending on the final destination of data in the tool. Some tables are for detailed calculation, some for erection and start-up and some for financing cost data. The sheet has summary cells to compare prices between Precalc sheet and COSTSUM total price. These should be the same. See the appendix 2 for layout of the PreCalc sheet that includes the project information, summary checking and XML builder button.

Creation of the sheet took plenty of time. Each tab in the cost estimation tool had all the equipment, material and manufacturing costs considering the WBS in question. The judgement of WBS division to component or subcomponent level had to be done in every sheet. The decisions were mainly based on the need and quidance of the estimation engineers using the tools, but also on cost elements and my own reasoning.

The WBS number 111 (Furnace Upper and Middle Section with headers) for example includes all of the subcomponents showed in the figure 8. The figure only shows part of the large table on the WBS sheet. The sheet shows detaided information for each subcomponent row such as number, material, meters, and weight per meter, cost per unit, and total weight and cost of the component. These subcomponents couldn't be merged as one calculation item because of many different cost elements (materials, manufacturing and equipment) and because they are not manufactured or delivered simultaneously in one package. There might also be different materials and so on. Dividing every row would have been unnecessary for there being similar kind of subcomponents in the tab, such as wall materials (Length of front, side and rear walls 1, 2, 3 and 4). This particular WBS was divided to seven subcomponents: Wall manufacturing, wall materials, header manufacturing, header materials, frames, assembly and additional steel. The figure 9 shows a part of the same division made in the PreCalc sheet and the appendix 3 shows the same part (the structure and place of WBS number 111) in the XML file.

63								
64	**Length of front wall section I**							
65	Front wall tubes I		76	P265GH	63,5	5,0	2081	m
66	Front wall fins I			S235JRG2	24,5	6,0	2081	m
67								
68	**Length of side wall section I**							
69	Side wall tubes I		56	P265GH	63,5	5,0	1274	m
70	Side wall fins I			S235JRG2	24,5	6,0	1274	m
71	**Length of side wall section II**							
72	Side wall tubes II		56	P265GH	63,5	5,0	1274	m
73	Side wall fins II			S235JRG2	24,5	6,0	1274	m
74								
75	**Length of rear wall section I**							
76	Rear wall tubes I		76	P265GH	63,5	5,0	1575	m
77	Rear wall fins I			S235JRG2	24,5	6,0	1575	m
78								
79								
80	**BB screen**		74	P265GH	63,5		259	m
81								
82	**Additional steel**							
83	Saddles of buckstays							
84	Refractory boxes							
85	Sealing fins							
86	Miscellaneus							
87	Net weight of steels (total)						13176	kg
88	**Walls subcontract manufacturing**						**66955**	kg
89								
90								
91	**Assembly**						**76041**	kg
92								
93								
94								
95	Front wall outlet header		1	P265GH	273,0	32,0	6,9	m
96	Front wall inlet header		0	P265GH	273,0	32,0	6,9	m
97	Right sidewall outlet header		1	P265GH	273,0	32,0	5,0	m
98	Right sidewall inlet header		1	P265GH	273,0	32,0	5,0	m
99	Left sidewall outlet header		1	P265GH	273,0	32,0	5,0	m
00	Left sidewall inlet header		1	P265GH	273,0	32,0	5,0	m
01	Rear wall outlet header		1	P265GH	273,0	32,0	6,9	m
02	Rear wall inlet header		0	P265GH	273,0	32,0	6,9	m
03								
04								
05	**Headers subcontract manufacturing**						**9 086**	kg
06	Frames				17%	of net weight	12927	kg
07	Surface treatment							

Figure 8. The cost estimation sheet for WBS number 111.

Contract_Item	Text	ContractItem	1110-HEATING SURFACES
WBS_Equipment	Text	WbsElement	1110
WBS_Component	Text	WbsComponent	111
Active	Bool	Active	TRUE
Entitiy	Text	LegalEntity	Andritz AG
Quantity	Number	Quantity	1
WBS_Description	Text	WbsDescription	Furnace Upper and Middle Section with headers
	List	SubComponentItemViewModels	
Name	Text	Name	Walls subcontract manufacturing
Comment	Text	Comment	Walls subcontract manufacturing
Qt	Number	Quantity	66955
Material	Text	Material	
Data_Dimensions	Text	Data	
Weight_Qt_kg	Number	WeightPerQuantity	
Cost_Weight_kg	Number	CostPerWeight	
Cost_Qt	Number	CostPerQuantity	
FX	Text	Currency	EUR
NND	Number	Nnd	
Origin	Origin	OriginItem	Home
Cost_Element	Text	BookingProperty	Out Manufacturing
Name	Text	Name	Headers subcontract manufacturing
Comment	Text	Comment	Headers subcontract manufacturing
Qt	Number	Quantity	9086
Material	Text	Material	
Data_Dimensions	Text	Data	
Weight_Qt_kg	Number	WeightPerQuantity	
Cost_Weight_kg	Number	CostPerWeight	
Cost_Qt	Number	CostPerQuantity	
FX	Text	Currency	EUR
NND	Number	Nnd	
Origin	Origin	OriginItem	Home
Cost_Element	Text	BookingProperty	Out Manufacturing
Name	Text	Name	Frames
Comment	Text	Comment	Frames
Qt	Number	Quantity	12927
Material	Text	Material	
Data_Dimensions	Text	Data	
Weight_Qt_kg	Number	WeightPerQuantity	
Cost_Weight_kg	Number	CostPerWeight	
Cost_Qt	Number	CostPerQuantity	
FX	Text	Currency	EUR
NND	Number	Nnd	
Origin	Origin	OriginItem	Home
Cost_Element	Text	BookingProperty	Out Manufacturing
Name	Text	Name	Assembly
Comment	Text	Comment	Assembly
Qt	Number	Quantity	76041
Material	Text	Material	
Data_Dimensions	Text	Data	
Weight_Qt_kg	Number	WeightPerQuantity	
Cost_Weight_kg	Number	CostPerWeight	
Cost_Qt	Number	CostPerQuantity	
FX	Text	Currency	EUR

Figure 9. WBS number 111 divided into subcomponents for detailed calculation table in PreCalc sheet.

An other good example of the background work is WBS number 112 because it is different from the previous example. Number 112, Water cooled grid, is usually bought in one deliverable. For this reason it didn't need to be divided to subcomponents and could be left as a one unit called "calculation item". Calculation items have all the costs and weights of the WBS number as sums taken from the cost summary sheet. The figure 10 shows the cost estimation sheet for the WBS number 112 in the figure 11 shows the WBS number 112 in the PreCalc sheet as a calculation item. The calculation item needs to be duplicated in order to be able to use home origin or local origin. The structure and place of WBS number 112 in the XML file are shown in the appendix 4.

GRID ONLY					
Grid tubes		41	P265GH	63,5	5,0
Fins			S235JRG2	112,5	6,0
Bottom tubes			P265GH	63,5	5,0
Fins			S235JRG2	112,5	6,0
Opening tubes			P265GH	63,5	5,0
Fins			S235JRG2	112,5	6,0
Grid nozzles			AISI 304	48,3	2,9
Ash hoppers			AISI304L		
Support steel structures			S355J2		
Filler plates			16Mo3		
Filler plates			AISI304L		
Other steel			S235JRG		
Grid Supports Beams			HE 500B	4,0	pcs
Grid subcontract manufacturing					
Frames				17 %	of net weigh
Surface treatment					
TUBES TOTAL					
Front wall inlet header			P265GH	273,0	32,0
Rear wall inlet header			P265GH	273,0	32,0
Wall tubes lower part			P265GH	63,5	5,0
Fins			S235JRG2	24,5	6,0
Headers subcontract manufacturing					

Figure 10. Cost estimation sheet for WBS number 112 is simplier than the sheet of WBS number 111.

Contract_Item	Text	ContractItem	1110-HEATING SURFACES
WBS_Equipment	Text	WbsElement	1110
WBS_Component	Text	WbsComponent	112
Active	Bool	Active	TRUE
Entitiy	Text	LegalEntity	Andritz AG
Quantity	Number	Quantity	1
WBS_Description	Text	WbsDescription	Water cooled grid
Origin_Own_Engineering	Origin	OriginOwnEng	Home
Own_Engineering_Hours	Number	OwnEngHours	
Own_Engineering_Hourly_Ra	Number	OwnEngHourlyRate	
Own_Engineering_Costs	Number	OwnEngCosts	
Origin_Outsourced_Engineer	Origin	OriginOutEng	Home
Outsourced_Engineering_Ho	Number	OutEngHours	
Outsourced_Engineering_Ho	Number	OutEngHourlyRate	
Outsourced_Engineering_Co	Number	OutEngCosts	
Origin_Intercompany-Enginee	Origin	OriginInterEng	Home
Intercompany-Engineering_H	Number	IcEngineeringHours	0
Intercompany-Engineering_H	Number	IcEngineeringHourlyRat	0
Intercompany-Engineering_C	Number	IcEngineeringCosts	0
Origin_Outsourced_Manufac	Origin	OriginOutMan	Home
Outsourced_Manufacturing_	Number	OutManHours	
Outsourced_Manufacturing_	Number	OutManHourlyRate	
Outsourced_Manufacturing_	Number	OutManCosts	[illegible]34
Origin_External_Supplies	Origin	OriginExternalSupplies	Home
External_Supplies_Weight	Number	ExternalSuppliesWeigh	[illegible]
External_Supplies_Price	Number	ExternalSuppliesPrice	
External_Supplies_Costs	Number	ExternalSuppliesCosts	[illegible]74
Origin_Other_Ic_Supplies	Origin	OriginOtherIcSupplies	Home
Other_Ic_Supplies_Weight	Number	OtherIcSuppliesWeight	
Other_Ic_Supplies_Price	Number	OtherIcSuppliesPrice	
Other_Ic_Supplies_Costs	Number	OtherIcSuppliesCosts	
Contract_Item	Text	ContractItem	1110-HEATING SURFACES
WBS_Equipment	Text	WbsElement	1110
WBS_Component	Text	WbsComponent	112
Active	Bool	Active	FALSE
Entitiy	Text	LegalEntity	Andritz AG
Quantity	Number	Quantity	0
WBS_Description	Text	WbsDescription	Water cooled grid
Origin_Own_Engineering	Origin	OriginOwnEng	Local
Own_Engineering_Hours	Number	OwnEngHours	
Own_Engineering_Hourly_Ra	Number	OwnEngHourlyRate	
Own_Engineering_Costs	Number	OwnEngCosts	
Origin_Outsourced_Engineer	Origin	OriginOutEng	Local
Outsourced_Engineering_Ho	Number	OutEngHours	
Outsourced_Engineering_Ho	Number	OutEngHourlyRate	
Outsourced_Engineering_Co	Number	OutEngCosts	

Figure 11. WBS number 112 left as a calculation items (home and local) for detailed calculation table in PreCalc sheet.

The data had to be linked and calculations made into certain cells after making the decision of either subdividing or leaving the components as a calclulation item. The most important cells in the subcomponents in PreCalc sheet tables were: Quantity, Cost per Weight, Cost per Quantity and Weight per Quantity. With these cells all the cost data was collected for subcomponents. When imported to PreCalc Tool, the tool automatically calculates the cell as follows:

$$Quantity * Cost\ per\ Quantity\ = Cost\ (€) \quad (2)$$

$$Quantity * Weight\ per\ Quantity\ = Weight\ (kg) \quad (3)$$

If the data is in other cells, the cost is calculated:

$$Quantity * Cost\ per\ Weight * Weight\ per\ Quantity\ = Cost\ (€) \quad (4)$$

Leaving a cell empty is understood as a zero when imported to PreCalc Tool.

For most of the materials and equipment it was easy to find a right cell to get the needed information from cost estimation sheets to PreCalc sheet. Gross weights from estimation sheets were mostly used on the weight cells to make the costs in PreCalc sheet match the calculated costs in the estimation sheets. With manufacturing and assembly the quantity was linked from total weights on estimation sheets. In these cases the data for Cost per Quantity cells was taken from €/kg costs from estimation sheets (see figure 12, red arrows). An other technique used with manufacturing, assembly and so on, was to type ”1” to the Quantity cell, leave the weight cells empty and to use the total cost of the component row from estimation sheet in the Cost per Quantity cell. The same technique was used when combining rows and calculating sums from estimation sheets. For example all the rows of Front wall tubes were combined as a group that has one sum of the costs and one sum of weights of each row (see figure 12, green arrows). Cost data for calculation items was linked from cost summary sheet as sums of costs and weights.

Name	Text	Name	Assembly
Comment	Text	Comment	Assembly
Qt	Number	Quantity	76041
Material	Text	Material	
Data_Dimensions	Text	Data	
Weight_Qt_kg	Number	WeightPerQuantity	
Cost_Weight_kg	Number	CostPerWeight	
Cost_Qt	Number	CostPerQuantity	0,00
FX	Text	Currency	EUR
NND	Number	Nnd	
Origin	Origin	OriginItem	Home
Cost_Element	Text	BookingProperty	External Supplies
Name	Text	Name	Front wall tubes I
Comment	Text	Comment	Walls
Qt	Number	Quantity	1
Material	Text	Material	P265GH
Data_Dimensions	Text	Data	
Weight_Qt_kg	Number	WeightPerQuantity	55392
Cost_Weight_kg	Number	CostPerWeight	
Cost_Qt	Number	CostPerQuantity	60 023,11
FX	Text	Currency	EUR
NND	Number	Nnd	
Origin	Origin	OriginItem	Home
Cost_Element	Text	BookingProperty	External Supplies

Figure 12. Data collecting cells in detailed calculation table in PreCalc sheet.

The origin of the costs needed to be defined based on weather the costs in each tab were divided into subcomponents or left as calculation items. Usually two origins were used, Home and Local. Home origin means the home legal entity where the costs come from own manufacturing or equipment purchased. Local origin means the portion of the project supplies that are managed by Andritz local company in the target country. For example Andritz Oy delivers a power boiler plant to China, where also an office of Andritz can be found. The legal entity of China manages the supplies they have a contract within OY's project. So the local project will be kept separate from the home project and both projects will be controlled in ASAP separately. The origin needs to be defined for every cost in the XML –file so the cost will go in the correct package in the summary. The cost estimation sheet has a selection list for each row in each WBS to define the origin. So the WBS numbers that were divided into subcomponents in PreCalc Sheet can take the info straight from the cell considering the cost. WBS numbers left into a calculation item however needed to be duplicated. The information of the origin for these costs comes from Cost Summary sheet, considering the total cost of the WBS number. It means that some of the cost in that WBS can be Home origin and some Local Origin. By creating a copy of the calculation item and by using different Origins in each item it will be possible to take the data from two different cells. The Cost Summary sheet has columns for both Home and Local costs that collect the data from WBS tabs.

6.2 Import

When the PreCalc sheet in Excel was completed, it was converted to XML-file to be imported to the PreCalc Tool. The Test Version (OFFLINE) of the PreCalc Tool was used for testing the import of XML -files. A new project was done first and in it a new calculation (see figure 13). There can be more than one calculation in one project. The import procedure was tested with several projects and calculations, making a new one every time the tool was updated for more reliable usability. When a new calculation is made it can be opened as an empty template.

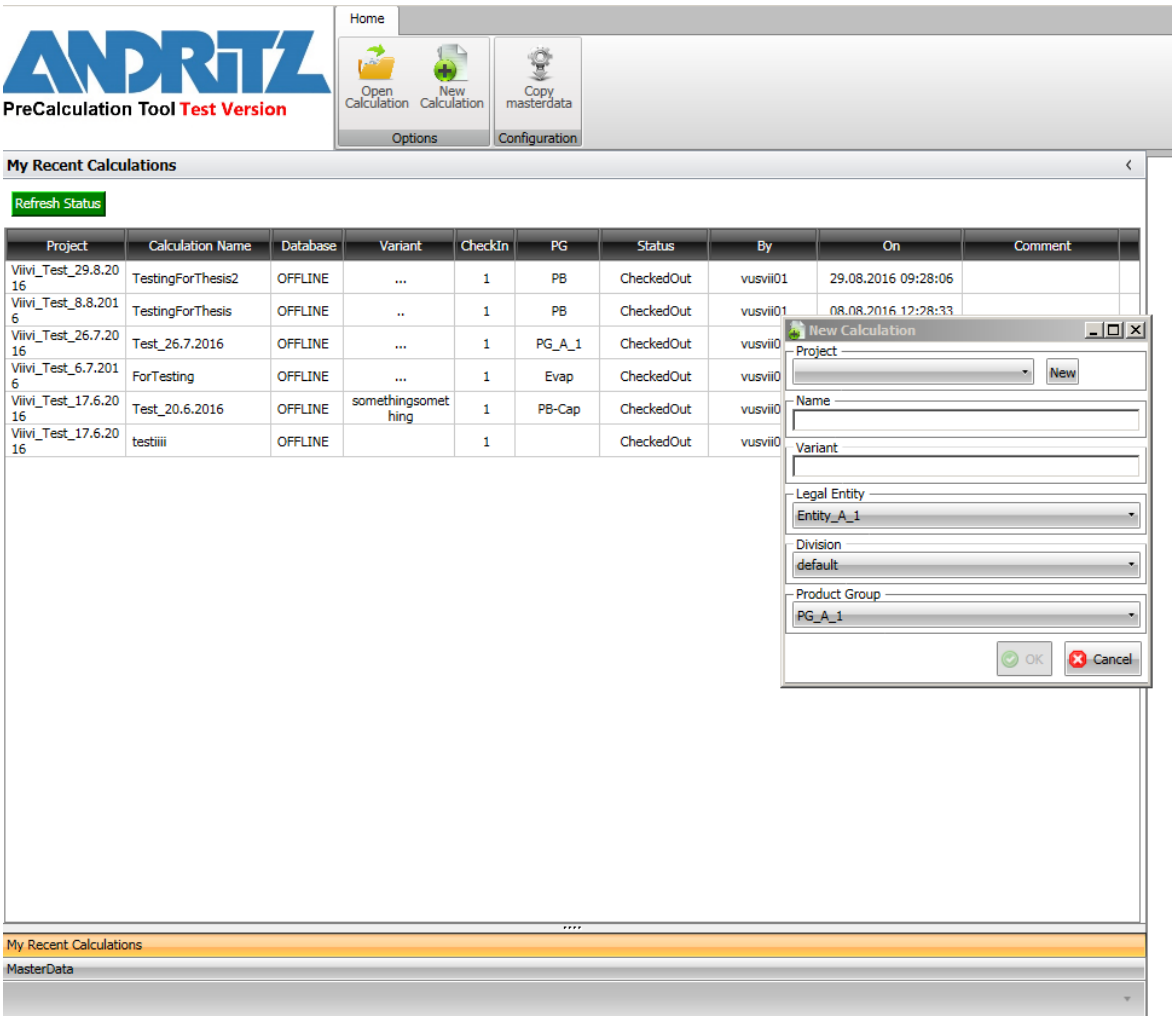

Figure 13. Making a new calculation in PreCalc Tool.

Empty calculation base has two options in the toolbar for import, "from Excel" and "from XML document". "From XML document" was tested in this case; "from Excel" is used to insert data from ASAP. A window called XmlImportDialog will be opened first, which allows one to select the XML -file from the computer. When the right file is selected, "Start Import" will start the import of data (see figure 14). XML import dialog shows if any errors occur in the upload process and also gives coordinates to find the mistakes from the XML –file (see figure 15). If no errors occur in the XML file, the import dialog is empty. This was achieved after approximately four months of testing. The XML structure is very specific and allows no spelling mistakes or loose characters or especially any

special characters. Most common errors during the testing were spelling mistakes of the attributes in the XML structure, invalid characters and attribute names that had been changed during the application development. The import dialog shows in which row the problem is in the XML file. Error can be corrected to the Excel sheet after checking first from the XML file.

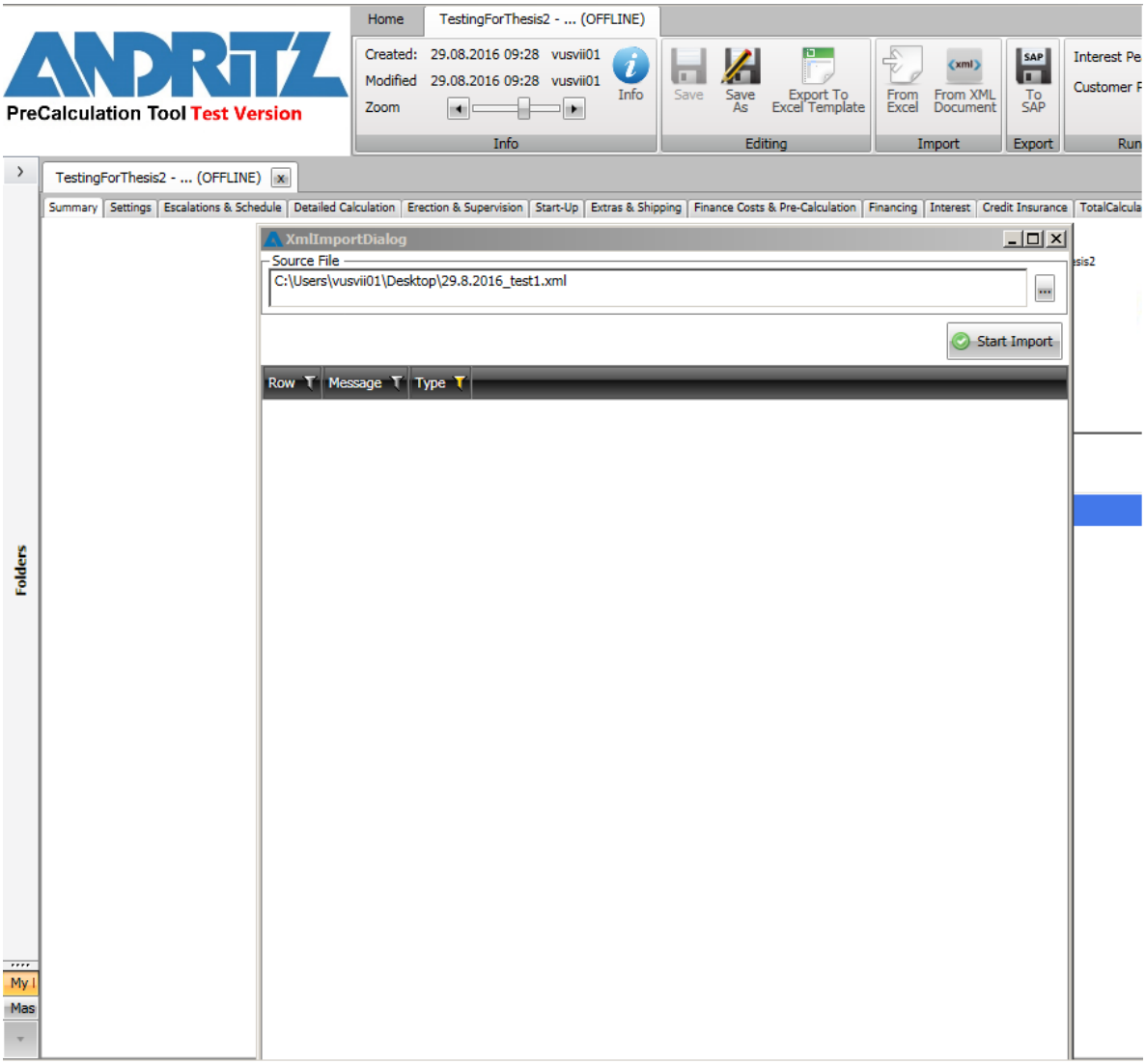

Figure 14. XML import dialog has a button for selecting the file for import.

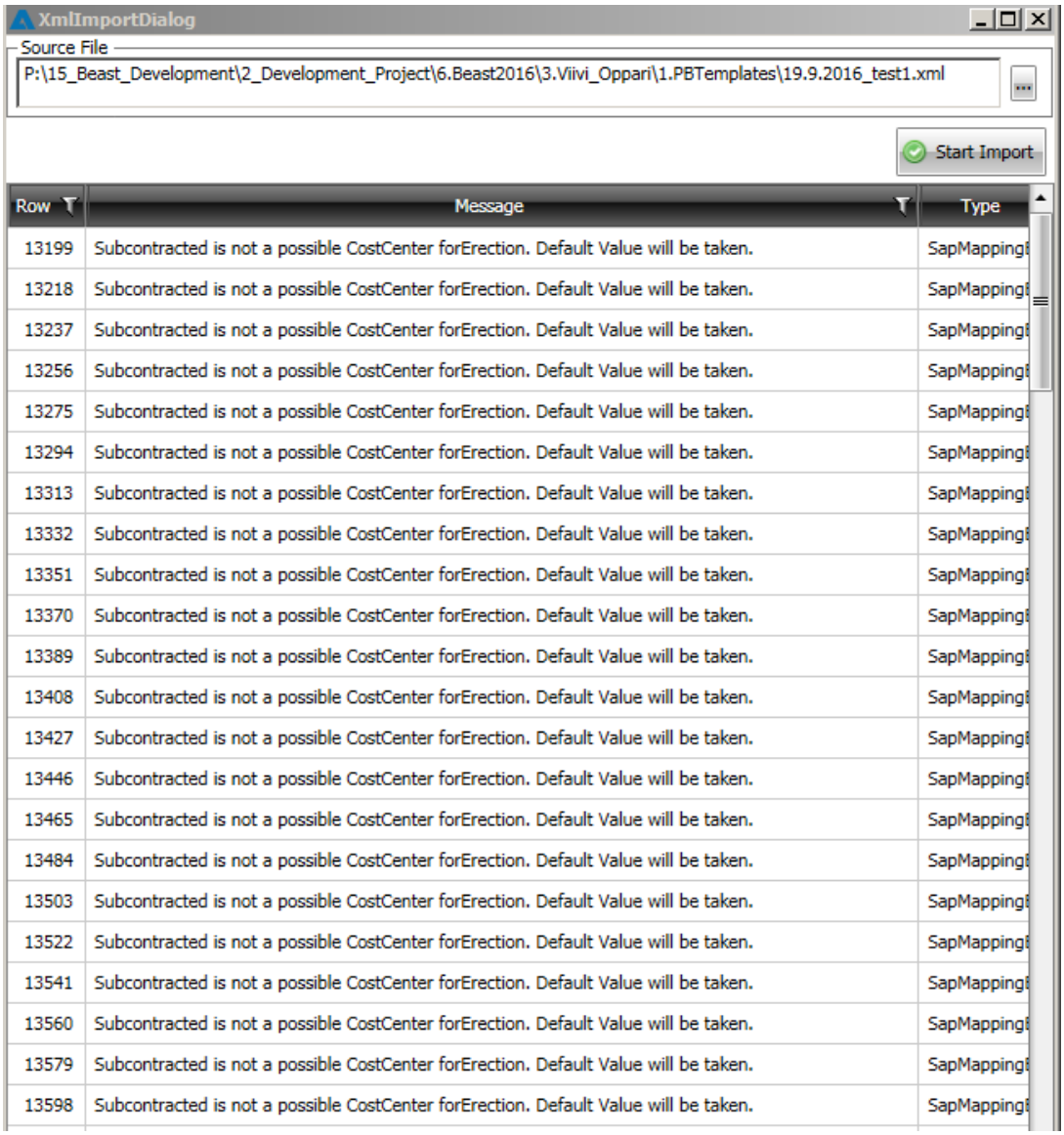

Figure 15. XML import dialog shows the error in the XML file after the import is done.

6.3 Consideration and further development

All the three estimation templates (PB, RB and EV) were slightly different from each other, and therefore the excecution of PreCalcsheet was somewhat dissenting too. Also the different CBS in the product groups affected the layout of each template. The PB template came out usable and consistent. The EV template has problems due to the length of the sheet. Over 20 thousand rows make the estimation template to blur and affect the performance of calculation speed. Length of the sheet consists of too many subcomponents caused by the WBS structure and the layout of the estimation template being in difficult order in terms of data collecting.

All the templates are heavily linked and that is why they are fragile and will calculate defective if the template is changed from a wrong place. It is risky to add or delete any rows or columns either from the cost estimation sheets or from the PreCalc sheet. Moving the rows can make the calculations in the cells also move. For example, adding or deleting a row in Costsum sheet might make the "TRUE/FALSE" cell in detailed calculation table change its value which then shows in PreCalc Tool incorrectly after the import. An other example of fragile structure can be seen when moving cells in cost estimation sheets or leaving invalid characters to cells causing an error to PreCalc sheet. Typical errors in this case are #VALUE and #REF!. The error can move from the calculation cell in detailed calculation table to the check column and from there to PreCalcCheck sheet causing the entire checking to fail.

All of the estimation templates need further development. RB template has already been improved by adding the miscellaneous group to every material WBS group that has been divided into subcomponents. The calculation in this subcomponent is done by reducing the sum of costs in other subcomponents from total costs of the particular WBS. Some improvements have also been done with RB templates conforming ability when adding new rows to the WBS sheets. In PB template corrections to the PreCalcUploadFile for some WBS numbers are needed because they have changed in the Costsum sheet. Template needs similar kind of reconciliation that was done to RB template. Some of the cost elements need to be corrected as well.

EV template on the other hand needs bigger changes. In its current form it is too slow to be used. There are a few ways to fix the problems with usage. The main action is to reduce the number of rows of the PreCalc sheet from current over 20 000 rows to a maximum of 15 000 rows. This can be achieved by simplifying or changing the division of costs and in this way reduce the number of subcomponents. An other way is to dismiss the subcomponents and keep the costs only on calculation item level. The PreCalculation sheet could also be separated into its own file from the cost estimation sheets still keeping the links to cells collecting data. The separation would improve the usage by letting the cost estimation sheets work normally and still transferring the costs to PreCalc sheet. Separating the PreCalc sheet from the cost estimation file wouldn't be completely unproblematic. PreCalc sheet could be forgotten when not in the eyesight and linked online. An other problem is the uncertainty of the links being kept and right version of the cost estimation template is used.

Developments are done in the near future and after that the complete cost estimation tools will be released before the end of the year. Responsibility of developing and maintaining the tools and PreCalc sheet is transferred to estimation engineers of each product group.

7 CONCLUSIONS

The purpose of this thesis was to develop the existing cost estimation tools and to integrate them with a common cost estimation tool to be used in KRP division at Andritz OY. The purpose was also to study cost estimation in general and in KRP division.

The development project to unify the project cost estimation and to increase transparency and comparability of the estimates was started in Andritz Pulp and Paper divisions in 2015. The cost structure of project cost controlling slightly differs from the cost structure used in sales phase cost estimation. The WBS structure in the project is used to control costs with cost elements. Cost estimation in the sales phase is made in the component level of WBS without using cost element division. The cost estimation in sales phase is made with PreCalculation Tool and in project phase with ZACE. One objective of the work was to get these dissenting cost structures in sales phase and in projects to meet each other by bringing the wider use of the cost elements into the sales phase cost estimation.

The Work Breakdown Structure and Cost Breakdown Structure were studied at the beginning of the theory part. WBS and CBS are an important part in cost estimation, which was the main subject of the theory part of the thesis. Cost estimation was studied more closely, looking into different estimation strategies along with tools, techniques and software to help in the estimating process. Quality of cost estimates was also contemplated because it is in crucial role when thinking of the profit gained from projects and maintaining the status in the competition. Studying cost estimation and working with the cost estimation tools gave the author a sight of project cost estimating and its processes.

The main work was to build a XML builder to the existing estimation tool. The XML builder consisted of a PreCalculation sheet collecting estimation data into tables and a macro that creates a XML file of the tables. The PreCalculation sheet and the structure of XML file were made to match the new common cost estimation tool, PreCalculation Tool. The existing cost estimation tools worked as they should and were usable before the development work, but the implementation of PreCalc Tool had to be made to unify the cost estimations in all divisions. Using one common tool to create cost estimations enables the estimates to be comparable with each other and increases the quality of cost estimation in divisions.

The development work and implementation went as planned, although the work took more time than was estimated in the beginning. There were some challenges along the development process mainly with the subdivision, origins and constantly changing name of attributes in PreCalc. The estimation tools for Power Boilers and Recovery Boilers came out usable except for minor changes, but the Evaporator tool needs some further development due to performance in usage. The further development and release will be done by the end of 2016. After the release the responsibility of developing the cost estimation tools will pass back to the estimation engineers of each product group.

REFERENCES

A guide to the project management body of knowledge (PMBOK guide) 2008. Project Management Institute, Inc. Pennsylvania.

Nieminen, Jere 2015. Työn osituksen kehittäminen kustannusten kirjaamisen ja seurannan tarkentamiseksi projekteissa. Lappeenranta University of Technology. Department of Industrial Management. Master's thesis. Library of Andritz Oy.

Mynttinen, Jarkko 2012. Development of cost estimation with feedback information in EPCM business. Lappeenranta University of Technology. Department of Industrial Management. Master's thesis. Library of Andritz Oy.

Kulmala, Harri I. Hinnoittelu – mitä se on käytännössä? 2015 (Referred 2016-08-25). Available:

http://www.kulmat.fi/images/tiedostot/Artikkelit/hinnoittelu_stateoftheart.pdf

Hatavkar, Dipak. SAP Cost Element Accounting – Know How To Track Costs (Referred 2016-08-31). Available: http://www.apprisia.com/blog/sap-ecc/sap-cost-element-accounting/

Tutorials Point, Cost Accounting - Elements of Cost (Referred 2016-08-31). Available: https://www.tutorialspoint.com/accounting_basics/cost_accounting_elements_of_cost.htm

Department of Information Technology – Cost Estimating. (Referred 2016-08-10). Available:

http://doit.maryland.gov/sdlc/documents/cost_estimating.pdf

Yrityssuomi – Hinnoittelu. (Referred 2016-08-09). Available:

https://www.yrityssuomi.fi/hinnoittelu

Work Breakdown Structure - Work Breakdown Structure (WBS) 2014. (Referred 2016-08-08). Available: http://www.workbreakdownstructure.com/index.php

20/20 Business Insight – Cost Breakdown Structure (CBS) 2015. (Referred 2016-08-08). Available:

http://2020projectmanagement.com/2013/10/the-cost-breakdown-structure-cbs/

For consturction Pros - Database Driven Estimating Software versus Excel Spreadsheets 2009 (Referred 2016-08-25). Available:

http://www.forconstructionpros.com/article/10292038/database-driven-estimating-software-versus-excel-spreadsheets

Wikipedia - Cost Estimate 2016 (Referred 2016-09-05). Available:

https://en.wikipedia.org/wiki/Cost_estimate

APPENDIX 1: Cost summary sheet

MATERIALS, MANUFACTURING & EQUIPMENT			NET WEIGHT	MATERIALS	MANUF.	EQUIPMENT	MISC.	UNIT PRICE	TOTAL
			kg	EUR	EUR	EUR	EUR	EUR	EUR
DRUMS			[illegible]						[illegible]
1100	101	Steam drum with hanger rods	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] EUR/kg	[illegible]
1100	103	Drum internals	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] EUR/kg	[illegible]
HEATING SURFACES			[illegible]					[illegible] EUR/kg	[illegible]
1110	111	Furnace Upper and Middle Section with headers	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] EUR/kg	[illegible]
1110	112	Water cooled grid	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] EUR/kg	[illegible]
1110	117	Second pass wall (Water cooled)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] EUR/kg	[illegible]
1110	122	Economizer with headers	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
1110	123	Finned tube economizer with headers	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] EUR/kg	[illegible]
1110	131	Superheater with headers	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] EUR/kg	[illegible]
1110	133	Reheater with headers	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
1110	134	Second pass walls (Steam cooled)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
HEATERS AND DESUPERHEATERS			[illegible]						[illegible]
1140	141	Spray desuperheaters	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] EUR/kg	[illegible]
1140	143	Sweet water condenser, Dolezal	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
1140	145	Preheaters	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] EUR/kg	[illegible]
HIGH PRESSURE PIPING			[illegible]					[illegible] EUR/kg	[illegible]
1150	151	Downcomers, suppliers and risers	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] EUR/kg	[illegible]
1150	152	Feed water piping	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] EUR/kg	[illegible]
1150	153	Interconnecting steam piping	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] EUR/kg	[illegible]
1150	154	Other interconnecting piping	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] EUR/kg	[illegible]
1150	158	Code piping supports	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] EUR/kg	[illegible]

PreCalcUploadFile | COSTSUM | Material Summary | PM & Eng. & site manag. | Equipment eng. | AEI | Civil | Freight | Erection weights | Erection | Tubes&pipes price list

APPENDIX 2: PreCalcUpLoadFile sheet (PreCalc sheet)

Upload file summary for PreCalculation tool

Project number	C-02-825021-088
Quotation number	1221085
Project name	[illegible]
Version	5
Sold-to Party	[illegible]
Ship-to Country	[illegible]
Quotation Date	29.07.2015

Create a XML-file for PreCalc upload

CHECK before upload!	Costs, EUR
PreCalculation import	[illegible]
COSTSUM	[illegible]
Difference	[illegible]

Summary tab- table

Summary	View Name	PropertyType	PreCalcProperty	Value
	Project_Number	Text	OrderNumber	C02825021088
	Quotation_Number	Text	SapNumber	1221085
	Project_Name	Text	Password	[illegible]
	Version	Text	Version	5
	Sold-to_Party	Text	EndCustomer	[illegible]
	Ship-to_Country	Text	Country	[illegible]
	Scope_of_Delivery	Text	DeliverContent	EPS-Non-EU
	Quotation_Date	Text	OfferDate	29.07.2015
	Legal_Entity	Text	LegalEntity	Andritz AG
	Division	Text	Division	KRP
	Product_Group	Text	ProductGroup	PB

APPENDIX 3: Part of the XML-file showing WBS number 111.


```xml
<Contract_Item PropertyType="Text" PreCalcProperty="ContractItem">1110-HEATING SURFACES</Contract_Item>
<WBS_Equipment PropertyType="Text" PreCalcProperty="WbsElement">1110</WBS_Equipment>
<WBS_Component PropertyType="Text" PreCalcProperty="WbsComponent">111</WBS_Component>
<Active PropertyType="Bool" PreCalcProperty="Active">True</Active>
<Entitiy PropertyType="Text" PreCalcProperty="LegalEntity">Andritz AG</Entitiy>
<Quantity PropertyType="Number" PreCalcProperty="Quantity">1</Quantity>
<WBS_Description PropertyType="Text" PreCalcProperty="WbsDescription">Furnace Upper and Middle Section with headers</WBS_Description>
<SubCompItems PropertyType="List" PreCalcProperty="SubComponentItemViewModels">
    <SubCompItem>
        <Name PropertyType="Text" PreCalcProperty="Name">Walls subcontract manufacturing</Name>
        <Comment PropertyType="Text" PreCalcProperty="Comment">Walls subcontract manufacturing</Comment>
        <Qt PropertyType="Number" PreCalcProperty="Quantity">[illegible]</Qt>
        <Material PropertyType="Text" PreCalcProperty="Material"/>
        <Data_Dimensions PropertyType="Text" PreCalcProperty="Data"/>
        <Weight_Qt_kg PropertyType="Number" PreCalcProperty="WeightPerQuantity"/>
        <Cost_Weight_kg PropertyType="Number" PreCalcProperty="CostPerWeight"/>
        <Cost_Qt PropertyType="Number" PreCalcProperty="CostPerQuantity">[illegible]</Cost_Qt>
        <FX PropertyType="Text" PreCalcProperty="Currency">EUR</FX>
        <NND PropertyType="Number" PreCalcProperty="Nnd"/>
        <Origin PropertyType="Origin" PreCalcProperty="OriginItem">Home</Origin>
        <Cost_Element PropertyType="Text" PreCalcProperty="BookingProperty">Out Manufacturing</Cost_Element>
    </SubCompItem>
    <SubCompItem>
        <Name PropertyType="Text" PreCalcProperty="Name">Headers subcontract manufacturing</Name>
        <Comment PropertyType="Text" PreCalcProperty="Comment">Headers subcontract manufacturing</Comment>
        <Qt PropertyType="Number" PreCalcProperty="Quantity">[illegible]</Qt>
        <Material PropertyType="Text" PreCalcProperty="Material"/>
        <Data_Dimensions PropertyType="Text" PreCalcProperty="Data"/>
        <Weight_Qt_kg PropertyType="Number" PreCalcProperty="WeightPerQuantity"/>
        <Cost_Weight_kg PropertyType="Number" PreCalcProperty="CostPerWeight"/>
        <Cost_Qt PropertyType="Number" PreCalcProperty="CostPerQuantity">[illegible]</Cost_Qt>
        <FX PropertyType="Text" PreCalcProperty="Currency">EUR</FX>
        <NND PropertyType="Number" PreCalcProperty="Nnd"/>
        <Origin PropertyType="Origin" PreCalcProperty="OriginItem">Home</Origin>
        <Cost_Element PropertyType="Text" PreCalcProperty="BookingProperty">Out Manufacturing</Cost_Element>
    </SubCompItem>
    <SubCompItem>
        <Name PropertyType="Text" PreCalcProperty="Name">Frames</Name>
        <Comment PropertyType="Text" PreCalcProperty="Comment">Frames</Comment>
        <Qt PropertyType="Number" PreCalcProperty="Quantity">[illegible]</Qt>
        <Material PropertyType="Text" PreCalcProperty="Material"/>
```

APPENDIX 4: Part of the XML-file showing WBS number 112.


```
<CalculationItem>
    <Contract_Item PropertyType="Text" PreCalcProperty="ContractItem">1110-HEATING SURFACES</Contract_Item>
    <WBS_Equipment PropertyType="Text" PreCalcProperty="WbsElement">1110</WBS_Equipment>
    <WBS_Component PropertyType="Text" PreCalcProperty="WbsComponent">112</WBS_Component>
    <Active PropertyType="Bool" PreCalcProperty="Active">True</Active>
    <Entitiy PropertyType="Text" PreCalcProperty="LegalEntity">Andritz AG</Entitiy>
    <Quantity PropertyType="Number" PreCalcProperty="Quantity">1</Quantity>
    <WBS_Description PropertyType="Text" PreCalcProperty="WbsDescription">Water cooled grid</WBS_Description>
    <Origin_Own_Engineering PropertyType="Origin" PreCalcProperty="OriginOwnEng">Home</Origin_Own_Engineering>
    <Own_Engineering_Hours PropertyType="Number" PreCalcProperty="OwnEngHours"/>
    <Own_Engineering_Hourly_Rate PropertyType="Number" PreCalcProperty="OwnEngHourlyRate"/>
    <Own_Engineering_Costs PropertyType="Number" PreCalcProperty="OwnEngCosts"/>
    <Origin_Outsourced_Engineering PropertyType="Origin" PreCalcProperty="OriginOutEng">Home</Origin_Outsourced_Engineering>
    <Outsourced_Engineering_Hours PropertyType="Number" PreCalcProperty="OutEngHours"/>
    <Outsourced_Engineering_Hourly_Rate PropertyType="Number" PreCalcProperty="OutEngHourlyRate"/>
    <Outsourced_Engineering_Costs PropertyType="Number" PreCalcProperty="OutEngCosts"/>
    <Origin_Intercompany-Engineering PropertyType="Origin" PreCalcProperty="OriginInterEng">Home</Origin_Intercompany-Engineering>
    <Intercompany-Engineering_Hours PropertyType="Number" PreCalcProperty="IcEngineeringHours">[illegible]</Intercompany-Engineering_Hours>
    <Intercompany-Engineering_Hourly_Rate PropertyType="Number" PreCalcProperty="IcEngineeringHourlyRate">[illegible]</Intercompany-Engineering_Hourly_Rate>
    <Intercompany-Engineering_Costs PropertyType="Number" PreCalcProperty="IcEngineeringCosts">[illegible]</Intercompany-Engineering_Costs>
    <Origin_Outsourced_Manufacturing PropertyType="Origin" PreCalcProperty="OriginOutMan">Home</Origin_Outsourced_Manufacturing>
    <Outsourced_Manufacturing_Hours PropertyType="Number" PreCalcProperty="OutManHours"/>
    <Outsourced_Manufacturing_Hourly_Rate PropertyType="Number" PreCalcProperty="OutManHourlyRate"/>
    <Outsourced_Manufacturing_Costs PropertyType="Number" PreCalcProperty="OutManCosts">[illegible]</Outsourced_Manufacturing_Costs>
    <Origin_External_Supplies PropertyType="Origin" PreCalcProperty="OriginExternalSupplies">Home</Origin_External_Supplies>
    <External_Supplies_Weight PropertyType="Number" PreCalcProperty="ExternalSuppliesWeight">[illegible]</External_Supplies_Weight>
    <External_Supplies_Price PropertyType="Number" PreCalcProperty="ExternalSuppliesPrice"/>
    <External_Supplies_Costs PropertyType="Number" PreCalcProperty="ExternalSuppliesCosts">[illegible]</External_Supplies_Costs>
    <Origin_Other_Ic_Supplies PropertyType="Origin" PreCalcProperty="OriginOtherIcSupplies">Home</Origin_Other_Ic_Supplies>
    <Other_Ic_Supplies_Weight PropertyType="Number" PreCalcProperty="OtherIcSuppliesWeight"/>
    <Other_Ic_Supplies_Price PropertyType="Number" PreCalcProperty="OtherIcSuppliesPrice"/>
    <Other_Ic_Supplies_Costs PropertyType="Number" PreCalcProperty="OtherIcSuppliesCosts"/>
</CalculationItem>
```