Service for Craft Brewing Industry

Finding an optimal after-sales service provision for a new beer membrane filtration system

Bachelor Thesis Industrial Engineering & Management

Melanie Blume
S1719874

UNIVERSITY OF TWENTE.

PENTAIR

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Author
Melanie Blume
S1719874
BSc Industrial Engineering & Management

Pentair Enschede
Marssteden 50
7547 TC, Enschede
The Netherlands

Supervisor Pentair
Rolf Huttenhuis

University of Twente
Drienerlolaan 5
7522 NB, Enschede
The Netherlands

Supervisor University of Twente
Dr. Ir. E.A. Lalla
Dr. I. Seyran Topan

Preface

Dear reader,

You are about to read the bachelor thesis 'Finding an optimal after-sales service provision for a new beer membrane filtration system'. This research is conducted at Pentair Enschede, as the final assignment for my bachelor Industrial Engineering and Management at the University of Twente. I researched the possibilities of providing after-sales service for a new developed filtration system. The biggest challenge during this research was to find a way to approach the problem of the company in such a way it would fit with my area of expertise. Besides, it was a challenge to set up this research since it was a preventive research and little information was available because it concerns a relatively new product of the company. Therefore it was hard to think of a way to 'make something out of nothing'. These challenges made that I learned a lot during this bachelor thesis in several ways.

I would like to thank Rolf Huttenhuis, my supervisor from Pentair, for his help and support during this research. The time he invested to help me to get familiar with the company and explaining their activities was really helpful. Besides, I would like to thank all other employees of Pentair who were involved with my research.

At last, without a doubt I would like to thank my supervisor from the University of Twente, Eduardo Lalla. I would like to thank him for providing me all the feedback and insights, so I could write and finish this thesis in a best possible way.

Melanie Blume

Executive summary

Due to confidentiality, all quantitative values in this thesis regarding costs are multiplied with a factor X.

Pentair plc (NYSE) is a global company dedicated to building a safe and sustainable world. This research is conducted at the service department of Pentair Water Process Technology BV located in Enschede, that designs, builds and supplies installations for water, beer and food companies. This research is focused on the after-sales service of a beer membrane filtration installation.

Currently, Pentair has about 200 larger beer filtration systems running at breweries all over the world, which vary from a capacity of 100-900 hectoliters per hour. Pentair has an after-sales service model running, containing five different service items which can be offered to these breweries.

Pentair Water Process Technology BV has developed a new smaller filtration installation named BMF+ flux Compact S4 (BMF S4). These new installations only have a capacity of approximately 30-60 hectoliters per hour. The problem is there is no after-sales service provision set up for these smaller systems and the current service-model is too extensive and expensive for the breweries with a BMF S4. However, when Pentair wants to continue selling BMF S4 installations, a service provision is needed because otherwise problems will occur in terms of costs and customer satisfaction and therefore negative publicity.

In order to prevent these problems, the main goal is *finding an optimal after-sales provision that can be used in developing the service contracts for the BMF S4*. To make this manageable, the research is divided into smaller research questions. First, the current situation is described so it is clear how the current service provision of Pentair is arranged. Here, the five service items Pentair offers are explained, which are d: data connection, m: monitoring & reporting, t: technical helpdesk service, s: site visit and e: 24/7 emergency help line. A second important question is on the solution generation. It is decided what service items can be used for the after-sales service model and how finding the possibilities of combinations of service items will be approached. From researching and analyzing all possibilities, a basis of potential service item combinations are retrieved.

From a basis of service item combinations, a tool in Microsoft Excel is developed. With the use of this tool, different scenarios of locations, budgets and service items are analyzed. From this analysis an advice is written on what the best service provision for the BMF S4 of the different scenarios would be. In the tool, the brewery can give the input on whether they are interested in the service items, so these items can be included or excluded from the possibilities of combinations. Furthermore, the country/continent and budget of the brewery will be asked as input. Besides the input of the brewery, Pentair has to give input on the costs of all service items. When the input is filled in, the tool will calculate the possibilities without a site visit, with a site visit and with an outsourced site visit. It provides information on the total costs, the budget that is left or by what the budget should increase to make a combination of service items possible. In addition to this, it gives the best possibilities of combining as many service items possible within the budget.

The tool is the outcome of the research which can be used by Pentair in order to further develop the service contracts for the BMF S4. The input of the tool can be fully adjusted to the specific case and preferences of a brewery, so in consultation with the brewery the output can be used in order to find the optimal after-sales service provision.

In this research, the results of the tool are analyzed for the countries/continents the Netherlands, Europe, Africa, Russia, Asia, North America and South America, for breweries with a budget of €2500, €4750 and €7500. The conclusion on what the optimal service provision would be is given in Table 1 and 2, where the abbreviations for the service items are used. Here, the possibilities including a site visit are only given for a budget of €7500 since for breweries with a budget of €2500 or €4750 this is not an option. Besides, the possibilities where the site visit is excluded did not differ per country or continent, so this advice is only given per budget.

With site visit	
Country/Continent	**Budget €7500**
The Netherlands	1. d,t,s,e / d,m,s,e with outsourced site visit
	2. t,s,e / d,s,e / d,t,s / d,m,s or d,t,s,e / d,m,s,e with 3% increase of budget
Europe	1. d,t,s,e / d,m,s,e with outsourced site visit
	2. s / s,e / d,s or t,s,e / d,s,e with 1%/2% increase of budget
Africa	1. s, when brewery is not interested in other items
	2. d,s,e / t,s,e with outsourced site visit
Russia	Site visit has to be outsourced. Amount of service items can be determined when travel possibilities are specified for the exact location of the brewery.
Asia	
North America	
South America	

Table 1: Best possibilities per country/continent with budget €7500, including a site visit

Without site visit	**Service items**
Budget €2500	d,t,e or d,m,e
Budget €4750	d,m,t,e
Budget €7500	d,m,t,e

Table 2: Best possibilities per budget, without a site visit

In addition to the tool that is delivered to Pentair and the conclusion on the optimal service provision, six recommendations to Pentair are formulated on the use of the results and on future research.

1. Make use of the tool to show all possibilities on combinations of service items within the budget to the brewery, so it can be discussed what their preferences are and an optimal configuration can be established.
2. Besides showing the possibilities that are an option within the budget, do shown the possibilities on what service you have to offer when the budget is increased. In this way the brewery can make a trade off whether they would think it is worth it to pay some more.
3. In this research fixed costs per year for the service items are used in the calculations. In the future, it can be interesting to research whether a slight change in these costs by for example offering a few less hours of help for a certain item can lead to adding an extra item to the service provision.
4. In this research, for the costs of the site visit only a distinction is made between seven countries/continents. In a future research this can be extended by for example dividing these areas

into smaller ones. It can be researched what the effect is on the possibilities of offering the site visit is by specifying the costs of the site visit even more.

5. In addition to recommendation 4, a future research can be performed on the location of employees to offer the outsourced site visits. In this research the possible amount of kilometers that can be traveled by the employee were derived. When in the future it is more clear in what specific areas the breweries are located who are willing to install a BMF S4, it can be researched where an employee should be optimally located in order to perform the site visits in that area. In this way, an even better insight in the possibilities of outsourcing the site visit can be obtained.
6. When in the future with use of the tool it is explored what the more likely preferences of the breweries are and the service contracts are developed a bit further, research can be done on the possibilities of incorporating the hectoliter fee in the contracts.

Table of contents

Readers' guide

To give the reader a better understanding of the structure of this bachelor thesis, this readers' guide is written. A short overview of what is covered in each section is provided below.

Chapter 1 | Introduction

The first chapter covers the introduction to this bachelor assignment. It contains an introduction to the company, an introduction to the assignment, the problem identification, the problem approach and the research design.

Chapter 2 | Current situation

The second chapter covers the current situation. Firstly, the current after-sales service model that is in use is described. Secondly, the product portfolio with the relevant technical aspects of the new filtration system is given and the current situation of the service for this new installation is described.

Chapter 3 | Theoretical framework

The third chapter covers the theoretical background of this bachelor assignment. Firstly, a literature research is performed to describe different perspectives of after-sales service. Besides, the different types of after-sales service support that are known in literature are stated so the service items in this bachelor thesis can be classified. In addition to this, it can be used to discover potential new after-sales service items to include. Secondly, approaches found in literature to redesign after-sales services in order to save costs are discussed. In this way, the method used in this research can be substantiated.

Chapter 4 | Potential after-sales service models BMF S4

The fourth chapter covers the solution generation. Firstly, it is described how the service items can be used and combined to fit in an after-sales service model for the BMF S4 installation. Secondly the potential optimal after-sales service models are determined which will serve as a basis for the further development and choice of the optimal after-sales service model for the BMF S4 installation.

Chapter 5 | Choosing the optimal after-sales service model

The fifth chapter covers the solution choice. Firstly, a tool is developed in Excel to provide the company results for the optimal after-sales service model for the BMF S4 and the usage of the tool is explained and showed. Secondly, the results obtained from the tool are analyzed in order to conclude what the optimal after-sales service model for the BMF S4 will be.

Chapter 6 | Evaluation and validation

The sixth chapter covers the evaluation and validation of the solution. After giving a presentation and demonstration of the tool for three employees who work with the BMF S4, an evaluation form is filled in by them. The functionality and usability of the tool and the usefulness of the results of the research are evaluated. With the results of this evaluation, the tool is validated, an advice on the implementation and further research is written and it is described on to what extend the research contributes to solving the problem.

Chapter 7 | Conclusions and recommendations

The seventh and final chapter covers the conclusions and recommendations of the research. A conclusion on the research questions is given, recommendations and advice on future research are given and the contribution of this research is described.

Definitions

To ensure the reader will not misunderstand the content in this bachelor thesis by terms that are used, a list of definitions is created.

BMF S4
Abbreviation of the new beer filtration system BMF+ flux Compact S4

Items d, m, e, t and s
The service items d, m, t, s and e are abbreviations for respectively the service items: data connection, monitoring & reporting, technical helpdesk service, site visit and 24/7 emergency help line.

Larger breweries
Breweries which have a beer filtration system with a capacity of 100-900 hectoliters per hour. These breweries make use of the current after-sales service model.

Smaller breweries
Breweries which are the (potential) customer of the new beer filtration system (BMF+ flux Compact S4) which has a capacity of 30-60 hectoliters per hour.

Type 1 brewery
Smaller brewery with a capacity of 24,000 HL per year and a budget of €2,500 for service items.

Type 2 brewery
Smaller brewery with a capacity of 52,000 HL per year and a budget of €4,750 for service items.

Type 3 brewery
Smaller brewery with a capacity of 80,000 HL per year and a budget of €7,000 for service items.

1. Introduction

1.1. Introduction to the company

Pentair plc (NYSE: PNR) is a global company dedicated to building a safe and sustainable world. Pentair delivers industry-leading products, services and solutions that help people make the best use of the resources they trust most. Pentair's technology moves the world forward by amongst others ensuring that there is more than enough usable and pure water, by maximizing the productivity of energy processes and by providing reliable and efficient solutions of the global food and beverage industry. With an annual revenue (2016) of $ 4.9 billion, Pentair is employing approximately 19,000 people worldwide. Figure 1 shows an overview of the different industries and verticals for which Pentair offers their products, services and solutions.

Figure 1: Different industries and verticals in which Pentair is operating

Pentair has two departments in Enschede. The first department is a production department X-Flow BV, which manufactures filtration membranes and modules used for water and food & beverage (beer and wine) in more than 140 countries. The second department is the Pentair Water Process Technology BV (PWPT) that designs, builds and supplies installations for these water and food companies. These technological installations must be serviced to maintain capacity well during their lifetime. PWPT has an after-sales service organization to guarantee this constant quality. This bachelor assignment is executed at this service department, focused on the beer membrane filtration (BMF) which is introduced in the next section.

1.2. Introduction to beer membrane filtration systems

The main reason for beer filtration is to create bright beer by the removal of solids like yeast, proteins and suspended particles (Figure 2). In order to do this Pentair offers breweries beer membrane filtration systems. In Figure 3 the filtration line where the beer membrane filtration system is part of is displayed. The unfiltered beer is stored in the Unfiltered Beer Tank (UBT). With use of a pump the unfiltered beer is pushed through the beer membrane filtration system (BMF). The filtered beer leaves the beer filtration system and will be stored at the filtrated beer tank (FBT). The beer which is not filtrated yet goes back into the unfiltered beer tank and will be pumped through the beer membrane filtration system again.

Figure 2: Unfiltered vs. Filtered beer

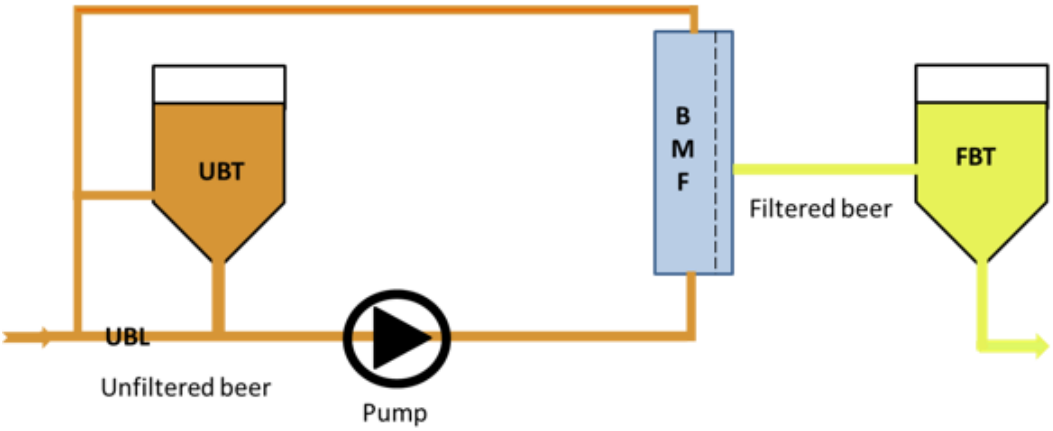


Figure 3: Beer filtration process (source: Pentair)

The beer membrane filtration system consists of a so named skid, shown in Figure 4. The storage tanks are connected with this skid by pipes. The skid is the framework, including a pump and the mounted membrane modules.

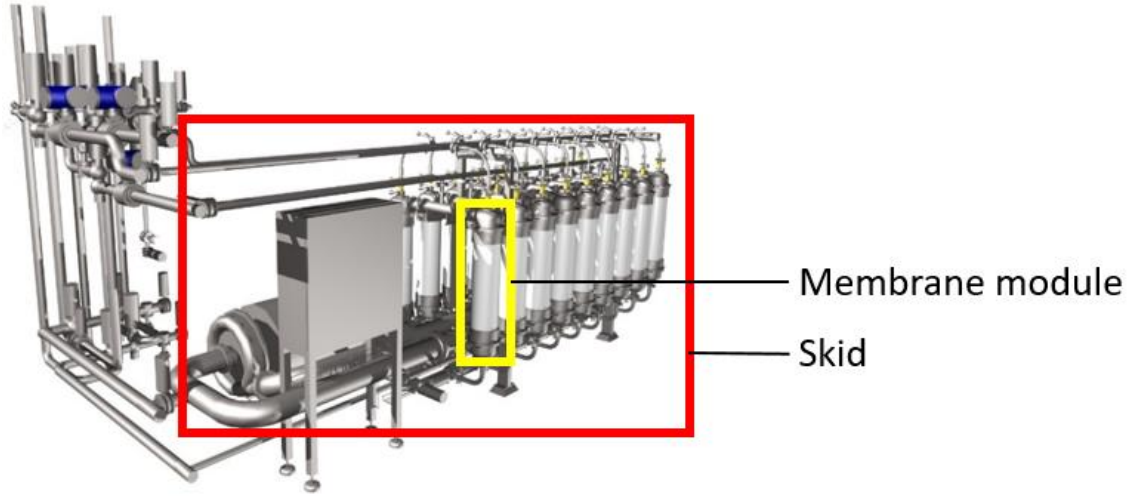


Figure 4: Skid with mounted membrane modules

The membrane modules that are mounted in the skid are shown in Figure 5a. The skid of Figure 4 contains 18 of these membrane modules, 9 on each side. Each membrane module contains almost 3000 fibers, the membranes (Figure 5b), which ensure the filtration of the beer.

Figure 5a: membrane module; 5b: membranes

1.3. Motivation for the research

At the moment about 200 larger beer membrane filtration systems are operating worldwide. An after-sales service provision had been set up and is running for these systems. Pentair Water Process Technology BV has developed a new smaller filtration installation named BMF+ flux Compact S4 (BMF S4). These new smaller installations have a capacity of approximately 30-60 hectoliters per hour while the larger installations have a capacity of 100-900 hectoliters per hour. These BMF S4 installations are used in small 'Craft' breweries to filter the beer. Currently, 20 breweries have the new developed BMF S4 system operating. Figure 6 shows where these breweries are located.

Figure 6: Locations of current BMF S4's operating

Pentair has no after-sales service provision set up for these new installations. From now on Pentair expects the interest of breweries in this new installation and therefore the number of BMF S4 systems operating may grow every year. Since Pentair foresees potential success in this new filtration system, in the

upcoming years the goal is to have approximately 100 to 150 BMF S4's operating all over the world. Because of this expansion, the service activities will also expand. With an eye on the future, research has to be done on the possibilities to set up an after-sales service provision for these BMF S4 installations. In order to find out how Pentair should continue selling these new installations, Pentair would like to know what the optimal after-sales service provision would be for this new system and therefore also what the most important factors are to guarantee optimal service support for this product.

1.4. Problem identification

As introduced in Section 1.3, Pentair wants to continue the sale of the BMF S4 systems, while Pentair is not able to do this in a suitable way since Pentair foresees problems with their current after-sales services. This discrepancy between norm and reality is stated as the action problem (Heerkens & van Winden, 2012):

"Pentair wants to continue the sale of the BMF+ flux Compact S4 systems, while Pentair is not able to do this in a suitable way since it will cause problems in terms of man-hours and costs."

To determine the core problem which have to be solved in order to find a solution for this action problem, a problem cluster is made which is shown in Figure 7. This cluster shows the causal relations between the problems.

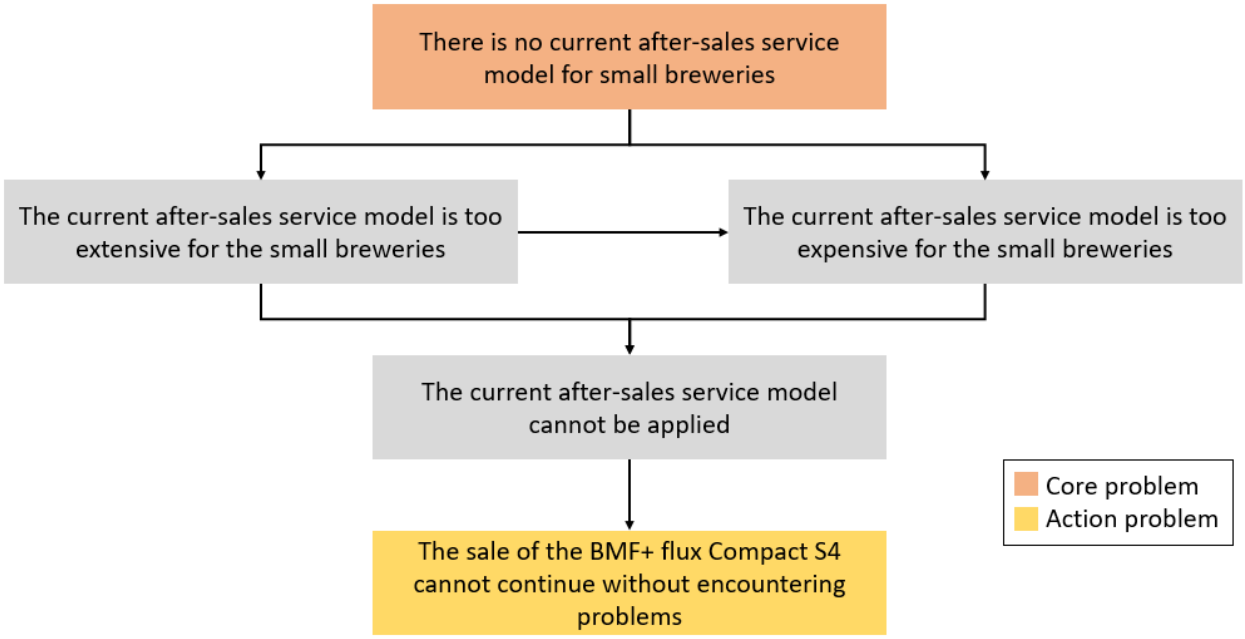


Figure 7: Problem cluster of Pentair

At the bottom of Figure 7 the action problem is stated. At the few BMF+ flux Compact S4 systems that are already sold, only the most necessary service is provided. These tasks, starting up the filtration system at the brewery and answering calls when the brewery is encountering problems, are now managed by the employees at the service department in Enschede, without knowing in advance how much time and costs this will take. Since just 20 of these BMF S4 installations are running yet, these tasks are still manageable. However, when more and more installations will be sold this will cause problems because Pentair will not

have a clear overview on whether enough costs are covered in exchange for the service that is given. It can also lead to having too few man-hours to handle the service of all BMF S4 installations.
It means that Pentair would not be able to manage even the most necessary tasks, which would lead to customer dissatisfaction and therefore also negative publicity. So in the current situation Pentair cannot continue with the sale of the BMF S4.

Heerkens & van Winden (2012) states the following four rules of thumb for choosing the core problem:

1. A problem is only included in the problem cluster if you are sufficiently sure the problem does actually occur. You have to be convinced of the relations it has with other problems.
2. In the chain of problems you go back to the problems that no longer have a cause.
3. What you cannot influence, cannot become a core problem.
4. If multiple problems are left, choose the most important problem to solve. This is the problem of which you estimate the solution would have the most effect.

Based on this criteria the following core problem can be derived from the problem cluster in Figure 7:

"There is no current after-sales service model for small breweries."

The current after-sales service model of Pentair is set up and running for larger beer membrane filtration systems of bigger capacity than the new developed BMF S4 system (100-900 hl/h versus 30-60 hl/h, respectively). This caused that the current service model is too extensive and too expensive for the smaller breweries. The larger breweries that make use of the current after-sales service model are bigger and therefore have more to spend then the smaller breweries which will make use of the new developed smaller BMF S4 system. Besides this, the current service model might contain service aspects which are not applicable or relevant for the smaller breweries. Therefore the current service model cannot be applied. The core problem as stated above is chosen because solving this will give a solution for the action problem, "*The sale of the BMF+ flux Compact S4 cannot continue without encountering problems*". The foundation for this statement is that Pentair experienced with the larger systems that a suitable service model makes it possible to sell the filtration systems without encountering problems and to manage an optimal service provision for the breweries, which also serves as a unique selling point.

1.5. Research approach

In order to solve the action and core problem as stated in Section 1.4, a research is conducted by answering knowledge questions. To do so in a structured way, the following 7 phases of the Management Problem Solving Method (MPSM) will be used as a guideline (Heerkens & van Winden, 2012):

1. Problem identification
2. Solution planning
3. Problem analysis
4. Solution generation
5. Solution choice
6. Solution implementation
7. Solution evaluation

The first phase, the problem identification is already performed in Section 1.4 by establishing the action problem and making the problem cluster which leaded to the core problem. Phase 3 to 7 are performed by answering research questions related to the phase, which are constructed and explained in Section 1.6, which is phase 2 of the MPSM.

1.6. Research questions

Phase 2 of the MPSM , the solution planning, is performed in this section by describing the research questions. In the problem identification in Section 1.4, it is concluded that the core problem that has to be solved is "There is no current after-sales service model for small breweries". Solving this core problem will give a solution to the action problem "The sale of the BMF+ flux Compact S4 cannot continue without encountering problems", as also explained in Section 1.4. Therefore, the following main research question is formulated:

What would be the optimal after-sales service provision for the BMF+ flux Compact S4?

The answer to this main research question will be the solution for the action problem (Figure 7) of this research. To do so, for phase 3 to 7 of the MPSM, sub-questions are formulated below.

1.6.1. Problem analysis

1. *What is the current situation of the after-sales service model for the larger filtration systems?*
2. *What is the current situation of the BMF+ flux Compact S4?*
3. *What different types of support does after-sales service contain?*
4. *What methods can be used to redesign an after-sales service provision, considering costs?*

From the problem identification follows that Pentair already has an after-sales service model which is used for the larger breweries. In Chapter 2, research question 1 gives an insight in the current after-sales service model on what service items it contains and how this model is arranged cost-wise. This is done for later use, to determine if and how parts of this model can be incorporated in the new model for the smaller breweries.

In order to find an after-sales service model, the current situation of the BMF S4 should be clear. Research question 2 gives insight in the relevant technical aspects of the BMF S4 and gives an overview of what costs and revenues will be involved which will be used to construct the new after-sales service model. This question is answered in Chapter 2.

In Chapter 3, a literature review is performed to get insight in the different types of support that after-sales service contains, which will be the answer on research question 3. This can be used to categorize the existing after-sales service items of the company which is useful when the a new service model containing service items has to be developed. Question 4 is also answered by a literature review. It will describe the methods found in literature that are used to redesign an after-sales service provision. This can be used to substantiate the method that will be chosen to find the new after-sales service model for the BMF+ flux Compact S4 in this research.

1.6.2. Solution generation

5. *How can service items be combined to fit in an after-sales service model for the BMF+ flux Compact S4?*

6. *What are the potential basis after-sales service models for the BMF+ flux Compact S4?*

The fourth phase is the solution generation. In this phase the decisions that have to be made are described and potential solutions will be generated. In this research the decision will be what service items can be used for the after-sales service model and how these service items can be combined to a service model that can be provided to the customers. This will be answered by research question 5 in Chapter 4.

To come up with potential basis after-sales service models for the BMF S4, the service items Pentair provides will be analyzed to describe whether it can be used in the service model for the BMF. This may immediately include or exclude items for further consideration when compiling the potential new after-sales service model. Also all combinations of the service items will be explored. When it is clear what the after-sales service model would look like when certain service items will be combined, it has to be determined what potential after-sales service models are left to serve as the basis model for the BMF S4. In Chapter 4 this answers research question 6, which can be used in the next phase, the solution choice.

1.6.3. Solution choice

7. *What would be the optimal service provision for the BMF+ flux Compact S4?*

With use of the potential solutions which are established at the solution generation, it has to be decided which solution would be optimal which is done in Chapter 5. To do so a tool in excel is created, so it can be determined for the different countries/continents what the best after-sales service provision would be. In consultation with the company, additional preferences can be defined. The outcomes of the tool, will contribute to a general conclusion and advice per country/continent what the best service model will be. Besides, the tool can be used by the company when at a later stadium the contracts have to be established and adjusted to a more specific case of a brewery, by for example adjusting some costs and preferences.

1.6.4. Solution implementation and evaluation

8. *How can the optimal after-sales service model be implemented?*
9. *Does the optimal after-sales service model found solve the problem?*

The last two phases, the solution implementation and evaluation are combined, by answering research question seven and eight and nine. The after-sales service model cannot be implemented and tested in the time this research takes place because it is a preventive research. Therefore, with answering question 8 and 9 in Chapter 6, a review will be done on the usefulness of the tool and the contribution to solving the problem. With use of a survey the after-sales service model that is found during the research will be evaluated and the outcomes will be provided. In this way, an advice on the steps for implementation and further research can be written and it will provide insights in the contribution of this research to the company.

As a final step the main recommendations and conclusions will be written down after conducting this research at Pentair.

1.7. Scope

The research applies in the field of after-sales services. As described in the problem approach, the goal of the research is to find an optimal after-sales service provision for a new smaller filtration system. In the overall area of after-sales the research can be approached from different sides. For example, the after-sales can be viewed from a marketing point of view. A good after-sales service can be an important

consideration for a potential customer to buy the installation at Pentair. That is why marketing will be pleased with an optimal service provision. Within this assignment, however, there is no room to look at the effects of sales. After-sales can also be viewed from the customer who receives the services. Before compiling the optimal service package, the customer satisfaction of the 20 customers who have the beer filtration system operating could be investigated. However, considering the short research time, the focus will be at the content of the after-sales service items itself.

This research is held with respect to the specific after-sales service situation of Pentair. Since the focus is on the cost perspective of the after-sales service provision of Pentair, this is an unique situation and it would not be likely the findings of this research can be used in other situations. Another limitation is that the solution that is found cannot be tested within this research time. Therefore, the performance of the solution cannot be evaluated within this research and it will only be evaluated on its expected usefulness.

1.8. Deliverables

Based on the research a report is written. This will consist of:

- Overview of after-sales service typology, based on literature
- Overview of service items which Pentair provides, categorized based on the literature
- An overview of all costs and revenues involved around the possibilities of the BMF+ flux Compact S4
- Analysis of possibilities of service provisions for the BMF+ flux Compact S4
- A tool in Excel to compute the optimal after-sales service model for a specific case of a brewery
- An advice about what the optimal service provision for the BMF+ flux Compact S4 will be
- An advice about future research

2. Current situation

In this chapter the current situation is described in two parts. Firstly, Section 2.1 gives an answer to research question 1: *What is the current situation of the after-sales service organization for the larger filtration systems?*. It is described what service items Pentair provides and how the current after-sales service model is arranged cost-wise so this can be used later on when constructing the new after-sales service model. Secondly, Section 2.2 gives an answer to research question 2: *What is the current situation of the BMF+ flux Compact S4?*. It first describes the relevant technical aspects of the BMF S4 and how the service of the BMF S4 is currently organized. Secondly it explains all relevant costs and other numerical values related to the BMF+ flux Compact S4 which will be used in this research.

2.1. Current situation larger filtration systems

Currently Pentair has about 200 larger beer filtration systems running at breweries all over the world. These systems vary from a capacity of 100-900 hectoliters per hour. In Figure 8 an example is given. Pentair provides after-sales service to these breweries to bring potential failures to a minimum, so the loss of the breweries will be as less as possible. Keeping the idle time to a minimum also contributes to the guarantee the breweries can give the end users of the brewed beer. Besides the benefits the after-sales service has for the breweries, it contributes to customer retention and customer satisfaction for Pentair.

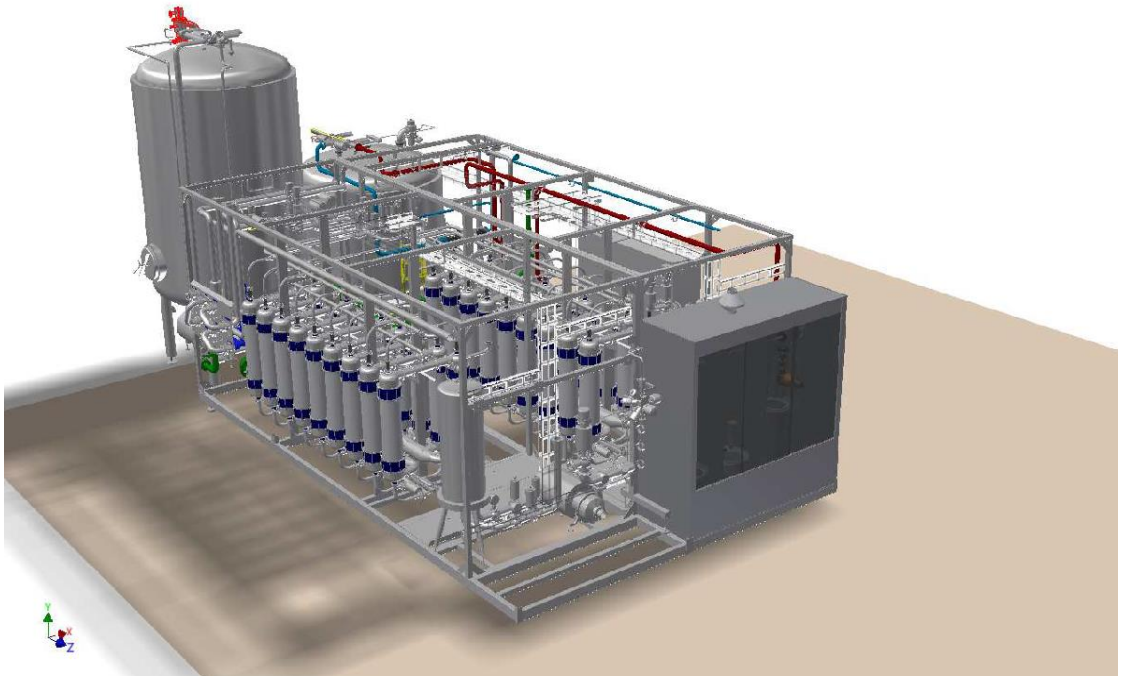


Figure 8: Larger beer filtration system (source: Pentair)

2.1.1. Explanation service items

The after-sales service Pentair provides to the current larger breweries consist of the five different service items (1) Data connection, (2) Monitoring & reporting, (3) Technical helpdesk service, (4) Site visit and (5) 24/7 emergency help line. These items are explained below.

(1) Data connection

The minimum service for warrantee on the membrane modules is based on historical data. Through a secure connection, the data of the brewery is uploaded to the Pentair database. This data consist of relevant values of the filtration line. It gives for example the filtration time, the cleaning time, the idle time, the amount of filtered beer, the net capacity and production efficiency.

(2) Monitoring & reporting

Until now the data obtained with the data connection is monitored and reported on a monthly bases. Pentair provides status reports with trending, logbooks and recommendations. Via a web portal the brewery will get access to this. The reports help the breweries on reducing costs and optimizing the performance of the filtration line.

At the moment Pentair is developing a new way to provide the reported data to the breweries. The goal is to save the data in a cloud, which will be accessible for the brewery with a login code. The results of the filtration line will be displayed in a dashboard, either available on a computer or a mobile device. The benefit of this new application will be that the brewery can look into the results at any time and it is no longer necessary to monitor the process frequently because when a problem occurs, the employees at the brewery will get a notification. In the dashboard the values of the current filtration run and the history of runs can be found. In Appendix A an example of the dashboard is presented.

(3) Technical helpdesk service

During working hours, Monday to Friday 08:00 to 17:00 hours CET the Enschede service office provides a helpdesk service to help on. The breweries can contact Pentair by telephone or mail, to get help on for example:

- Troubleshoot and resolve unplanned downtime events
- Problems affecting critical operations
- Problems affecting automation-related issues
- Support on achieving operational continuity
- Technological coaching
- Optimization
- Recommendation

With use of the data connection the service manager will look at the filtration line of the brewery. The service manager can control the filtration line remotely, for example every pump or valve can be operated and the filtration of cleaning process can be stopped and started. With this remote support most of the problems can be solved in an easy way.

(4) Site visit

During a site visit by a service manager of Pentair, the performance of the filtration system since the last visit will be evaluated where after the necessary adjustments can be made. Besides this, technical-operational trainings will be held. In addition to this a report with results and/or advises will be provided.

(5) 24/7 emergency help line

The 24/7 emergency help line enables the breweries to contact the help line by telephone 24 hours per day, 7 days per week to get support when a sudden problem occurs. The service manager of Pentair will

contact the customer within 30 minutes to discuss the problem. The first thing to do for the service manager is to connect with the filtration line and try to solve the problem remotely. Most of the problems can be solved this way. When it really cannot be solved and it is urgent, an agreement for a site visit should be made and an engineer will make his way to the site as soon as possible.

2.1.2. Current after-sales service model

To provide the service items as explained in Section 2.1.1 to the breweries, Pentair has an after-sales service model. This service model consist of three different levels A, B and C in which the service items are provided to the breweries. Level A contains only basic service, level B some more additional service items and level C contains all service items Pentair provides. The service model consists of these three levels since it differs per brewery which service items they are interested in. Based on the amount of skids the filtration installation contains, it is stated how much the annual fee will be for the breweries to receive the service of the items in the corresponding service level. In Table 3 the service packages of the three different level with the corresponding annual fee given, based on a skid with 18 modules.

Level A				
Item no.	**Activity**	**Annual fee**		
		1-2 skids	3-5 skids	6-9 skids
1	Data connection	€3,500	€5,500	€7,500
2	Verification & warrantee	€4,000	€6,000	€8,000
	Total	**€7,500**	**€11,500**	**€15,500**
Level B				
Item no.		**Annual fee**		
		1-2 skids	3-5 skids	6-9 skids
1	Data connection	€3,500	€5,500	€7,500
2	Monitoring & reporting	€5,500	€7,500	€10,000
3	Technical helpdesk service	€4,500	€6,000	€7,500
	Total	**€13,500**	**€19,000**	**€25,000**
Level C		**Annual fee**		
Item no.				
		1-2 skids	3-5 skids	6-9 skids
1	Data connection	€3,500	€5,500	€7,500
2	Monitoring & reporting	€5,500	€7,500	€10,000
3	Technical helpdesk service	€4,500	€6,000	€7,500
4	Site visit	various	various	various
5	24/7 emergency help line	€4,000	€5,500	€6,000
	Total	**€17,500**	**€24,000**	**€31,000**

Table 3: Service levels current after-sales service model

2.1.2.1. Hectoliter fee

The guarantee for the membrane modules is fixed with a hectoliter fee. For every filtrated hectoliter beer, the brewery will pay a fee between €0,07 and €0,12, depending on the filtration per year which variates from 500,000 to 2,000,000 hectoliter per year. This fee will be fixed to for example the first 3 years of the

contract, so in the end Pentair is ensured the minimum amount necessary for the modules is paid. This leads to that when the membrane modules need to be replaced, the breweries do not need to pay the amount of the modules at once.

2.2. Current situation BMF+ flux Compact S4

2.2.1. Product portfolio

The BMF+ flux Compact S4 is the newest beer filtration system of Pentair. In Figure 9 the BMF S4 is shown.

Figure 9: BMF+ Flux Compact S4 (source: Pentair)

The BMF+ flux Compact S4 is developed to meet the needs of craft and small breweries because the system has a capacity of only 30-60 hectoliter per hour. The benefits of this system are the low beer loss and easy maintenance. Besides this, Pentair describes the system as a so called plug-and-play system, because it is easy to install.
The BMF+ flux Compact S4 consist of four membranes modules (Figure 10), two on the front side and two behind. Besides this the system consists of the following main parts:

- Connections for beer inlet, beer outlet, water, power, air and CO_2
- Electrical cabinet
- Chemical agents cabinet.

Furthermore, there is the possibility of remote access to regulate the filtration system from any place.

Figure 10: Membrane modules BMF S4 (source: Pentair)

2.2.2. Current after-sales service and costs

For the breweries that already have a BMF S4 running, Pentair sets up individual contracts for the brewery in question. Now Pentair offers minimum service for the breweries with a BMF S4 running. Engineers from Pentair go to these breweries to offer commissioning. This means they help to install the filtration systems, and give training about how to work with and to maintain the system. After that, the breweries have to work autonomously with the filtration system, since no other specific agreement on service is made. However, when complications arise, the breweries can contact the service department of Pentair Enschede and the employees in Enschede will provide their help. Depending on the extensiveness of the support the engineer from Enschede has to perform, an invoice is sent to the brewery. All the other agreements in the contracts with the breweries with a BMF S4 are for example about the performances of Pentair, membrane replacement and liability.

To do computations in order to find an after-sales service provision for the BMF S4, the relevant aspects and its costs that are taken into account in this research are stated below. Besides, it is stated what the restrictions will be in terms of how much the smaller breweries are able to spend.

Commissioning

Different types of costs are involved when Pentair offers commissioning to a brewery. Engineers will travel to the brewery to help to install the filtration system and give training about how to work with and to maintain the system. Therefore hourly loans, travel costs and overnight stays all have to be taken into account. A distinction is made between several areas in the world, because the current standard prizes are based on traveling from Pentair Enschede. The standard costs are for 5 working days of commissioning, all costs included, shown in Table 4.

Country/Continent	**Costs**
Netherlands	€5,250.-
Europe	€6,350.-
Africa	€7,500.-
Russia	€8,700.-
Asia	€10,450.-
North America	€8,900.-
South America	€9,950.-

Table 4: Standard costs for 5 working days of commissioning, all costs included, per country/continent (source: Pentair)

Labor hours

In practice there are different types of engineers involved in the after-sales service process, with slightly different loans. Since these differences will give no big changes in the calculations in this research, for simplicity reasons the assumption is made that all types of engineers are the same. Therefore in all further computations, for all activities by an engineer of Pentair, the salary of a process engineer of €106,- per hour will be taken into account. Besides, a full working day will be considered as a day of 8 working hours.

Site visit

Above, the standard costs for 5 working days of commissioning per country/continent are stated, all costs included. However, when more precise calculations have to be done, there are costs available per component of the visit. It will consist of working hours, traveling hours, accommodation costs, visa and

different travel costs as a plane ticket, taxi or kilometer declaration when traveling is done by car. In consultation with Pentair, these costs are set to use in this research, which are shown in Table 5.

Component of visit	**Costs**
Working hours	€106.- per hour
Traveling hours	€106.- per hour
Accommodation	€100.- per day
Visa	€250.-
Plane ticket	€1000.-
Taxi	€3.- per km
Kilometer declaration	€0.75 per km

Table 5: Costs per component of site visit of Pentair (source: Pentair)

Budget

In consultation with Pentair, an estimation on the budget of the smaller breweries for the service items is made. This will depend on the amount of hectoliters the brewery filtrates per year, since this differs from a filtration of 24,000 to 80,000 HL per year. The range of the budget of the breweries for service items is therefore set at €2,500 to €7,500 per year.

2.3. Conclusion

To summarize and to answer the first research question, the current situation of the larger breweries is well developed. Currently Pentair has about 200 larger beer filtration systems running at breweries all over the world, which vary from a capacity of 100-900 hectoliters per hour. The after-sales service model that is offered for the larger breweries consist of a combination of the five service items (1) data connection, (2) Monitoring & reporting, (3) Technical helpdesk service, (4) Site visit and (5) 24/7 emergency help line. The items are offered to the larger breweries in 3 different levels A, B and C. Level A is the basis, with only containing the data connection and monitoring and reporting. The package of level B is a bit more expensive and contains in addition to the data connection and monitoring and reporting also the technical helpdesk service. At last, level C costs the most, and is the most complete package containing all five service items Pentair has to offer.

The current situation of the BMF+ flux Compact S4 can be summarized easily by saying, there is no clear arrangement set. The BMF+ flux Compact S4 is made for craft and small breweries with a capacity of only 30-60 hectoliters per hour. Currently only 20 breweries have a BMF S4 running, for whom only the most necessary after-sales service is given, based on an agreement individually made per brewery. However, there are costs known that can be used to do calculations for the development of an after-sales service model for the BMF+ flux Compact S4. These costs concern the costs for commissioning, labor hours and the different components of a site visit. Besides, the budget of a smaller brewery for the service items is known, what differs from €2,500 to €7,500 per year, depending on the amount of filtration per year.

3. Theoretical framework

In this section the theoretical framework of the research is described. In Section 3.1 a framework of after-sales service is given by answering the research question: *What different types of support does after-sales service contain?.* It is explained what different types of support are known in literature. This can be used to determine what service items the new after-sales service model for the BMF S4 of Pentair should contain, and potential new after-sales service items can be discovered by this. Section 3.2 answers the research question: *What methods can be used to redesign an after-sales service provision, considering costs?.* It discusses different approaches in redesigning an after-sales service provisions, which can be used to substantiate the approach which will be used in finding the service model for the BMF+ flux Compact S4 in this research.

3.1. After-sales service support types

After-sales service contains all the help and information that the company provides to the customer after they have bought a product. It becomes more and more important in the global market because it can serve as a source of differentiation and market share and it can serve as a strategy for customer's retention (Legnani et al., 2009). In this way the after-sales can give a competitive advantage and it can be beneficial for a good long-term relationship with the customer (Goffin, 1998). Despite the benefits of the after-sales services, Altekin et al. (2016) state that delivering after-sales services is challenging since designing the right after-sales supply chain strategy involves two perspectives. When a strategy is designed with a centralized approach, service targets on cost reduction and efficiency are important. However, when a strategy is designed on with a distributed approach, the availability and quick response do serve as the important targets.

Before going into detail on the support types, it has to be clear what an after-sales service supply chain is. Goswami et al. (2020) state a typical after-sales service supply chain consist of a manufacturer, retailers and customers. The flow of the product goes from the manufacturer, to the retailer and ends with the customer. However, the after-sales service flow goes the other way around. The supply chain starts with the customer, going to the retailer ending at the manufacturer. For example, when a customer has a broken part of a machine, the customer asks the retailer for a new part , which will go to the manufacturer to get this new part.

Saccani et al. (2007) describe that the configuration of a supply chain refers to how it is designed, with respect to the activities carried out within it. The three configuration choices of after-sales service which are analyzed by them, is the vertical integration, the centralization of activities and decoupling of activities. Increasing the vertical integration refers to increasing the number of activities performed internally. However this is a way of expanding the activities towards the customer, many manufacturers choose to outsource activities what causes a decrease in vertical integration so the focus can be on the core competences of the manufacturer. The second configuration choice is the centralization of activities. Centralization is mainly chosen to save money by for example reducing number of locations of warehouses. The third configuration, the decoupling of activities, is described to be the separation of activities of an organization and placing them under separate supervision.

In literature, different types of support are classified as being part of after-sales service. Durugbo (2019) describes the after-sales services activities consist of activities during warranty periods, that include

technical assistance, spare parts distribution, customer care and accessories sale. It is described these activities are used to replace or repair products parts or make accessories available to promote safety, comfort and pleasure for the end users.

Rolstadaas et al. (2008) state the after-sales services can be categorized in the following four categories:

1. General support: General support contains the basic means of communication. It covers contact with a helpdesk, training and spare parts management. The contact with a helpdesk can also be defined as on-line support. The user training is an important part of the general support since some type of equipment can be very complex (Goffin & New, 2001).

2. Self-support: Self-support contains the availability of information what can be used by the customer. It covers amongst others product information, product news and a troubleshooting database.

3. Remote support: Remote support contains the ICT supported interaction between the company and the customer. It covers remote consulting, remote optimization and remote control.

4. On-site support: On-site support contains the service where the employee of the company is present at the location of the customer. It covers process support, optimization, maintenance and repair. Goffin & New (2001) also state that the first-element of product support after the sale is the installation of the product, which is done on-site.

In addition to these four categories, Legnani et al. (2007) state after-sales services can be:

5. Indirect support: Indirect support covers appropriate documentation provided to the customer who is able to perform the diagnosis, identification and application of the solution. Goffin & New (2001) state that good documentation on for example installation, maintenance and repair can reduce support costs.

6. Off-site support: Off-site support contains service where the employee of the company is not present at the location of the customer. The company can collect the faulty product, repair it and gives it back to the customer. Besides, next to general support, on-line support can be seen as off-site support. Advice per telephone about for example the usage of products is important in many industries (Goffin & New, 2001).

3.2. Redesigning after-sales services

After-sales services are used by companies to increase the customer loyalty and trust in their products. Therefore it may be the case that companies want to redesign their current after-sales services in order to make it more suitable for the customer and to save costs.

Januantoro & Sarno (2018) describe an after-sales service model where the company will implement two processes: the replacement of goods or repair of goods. Both the replacement and repair do have advantages and disadvantages in terms of costs, so the company wanted to find a service provision that would reduce the current costs. The method that is used to solve the problem is Integer programming.

Since this method makes use of a 0 or 1 notation in order to decide to replace or not and to decide to repair or not, this method was well suited to apply. To apply integer programming, formulating the problem as a mathematical model is required. The decision variables will be the variables on which you have to decide, so in the case of Januantoro & Sarno (2018) it would be a variable which represents repair and a variable which represents replacement, which both can take a value of 1 when it is included and 0 when it is not. The constraints are all limitations on the decisions, written in a mathematical way. At last, an objective function is formulated which represents the total costs that have to be minimized, so the total sum of all repairs and replacements. Solving this model resulted in a reduction in costs, and therefore showed a successful method in optimizing and redesigning the after-sales services.

Esmaeili et al. (2021) describe the redesigning of an after-sales service model that concerns the supply of spare parts until the end of the warranty period. The study considered three different options for supplying spare parts, namely (1) producing extra parts while the product is still being produced and store the extra parts for later, (2) remanufacturing defective parts, and (3) purchasing parts just in time they are needed. The problem is solved by using a mixed-integer linear optimization model. Compared to the integer programming model of Januantoro & Sarno (2018), it differs in the restriction of the variables. At the mixed-integer linear optimization model of the study of Esmaeili et al. (2021) some of the decision variables were constrained to be integer values, while at the integer programming model of Januantoro & Sarno (2018) all decision variables had to be integer, and in addition to this it was the special case that all variables should be binary, so 0 or 1. Esmaeili et al. (2021) solved the problem with the scenario-based mixed-integer optimization approach and in this way redesigned the supply of the spare parts for the lowest possible costs.

3.3. Conclusion

After-sales service, the help and information that the company provides to the customer after they have bought a product, became more and more important because it can serve as a source of differentiation and market share. Besides, it can be beneficial for a good long-term relationship with the customer.

In literature, 6 different support types found that are classified as being part of after sales service: (1) General support, (2) Self-Support, (3) Remote support, (4) On-site support, (5) Indirect support and (6) Off-site support. In Chapter 4, these categories will be used to classify the service items of Pentair. In this way it can be established whether all types of support are covered and new service items should be found or not, in order to make the service model of Pentair complete.

To redesign after-sales services in order to save costs, two different methods are found in literature. Januantoro & Sarno (2018) described the use of an integer programming model and Esmaeili et al. (2021) did use a scenario-based mixed-integer optimization approach. The integer programming model of Januantoro & Sarno (2018) makes use of binary integer variables, so the variables can take a value of 0 or 1 when it is included or excluded. At the mixed-integer optimization approach of Esmaeili et al. (2021) the variables can also take a non-integer value. Both approaches can make sure the configuration of variables can be found resulting in the lowest possible costs.

4. Potential after-sales service models BMF S4

In this chapter is described what potential basis after-sales service models for the BMF S4 are found, and how these are determined. Firstly, Section 4.1 gives an answer to research question 3: *How can the service items be combined to fit in an after-sales service model for the BMF S4?.* It describes the choice on what service items are considered, how it is determined which combination of items can be used and the numerical elaboration of this method is performed. Secondly, Section 4.2 gives an answer to research question 4: *What are the potential basis after-sales service models for the BMF S4?.* It describes what the criteria are and the combinations of service items that can form a basis for the after-sales service model for the BMF S4 are found.

4.1. Use of service items in the service model

To decide on the potential after-sales service models, it is determined what service items should be included and what combination of service items can be provided to the customer. When in this section the possibilities are explored and the basis potential models are established, the next chapter will build on this to end with the optimal service provision.

4.1.1. Choice of items

As described in Section 2.1.1, Pentair offers the following service items to the larger breweries:

- Data connection;
- Monitoring & reporting;
- Technical helpdesk service;
- Site visit;
- 24/7 emergency help line.

These items can be classed in the after-sales service categories that are found in the literature review, described in Section 3.1. The classification can be seen in Table 6.

Category	**Service item of Pentair**
General support	Technical helpdesk service 24/7 emergency help line
Self-support	Monitoring & reporting
Remote support	Data connection
On-site support	Site visit
Indirect support	Monitoring & reporting
Off-site support	Technical helpdesk service 24/7 emergency help line

Table 6: Classification service items of Pentair in categories found in literature (Section 2.1)

As can be seen in Table 6, all categories that are found in the literature review are covered by service items of Pentair. Therefore there is no direct reason to look for potential new service items that Pentair could include in their service. Besides this, Pentair has stated to be more interested in finding a model with the service items they already use, instead of exploring new items. Therefore in the search for the optimal after-sales service model only the current service items of Pentair will be taken into consideration.

4.1.2. Formula to explore combinations of service items

All of the five service items of Pentair could be used in the service provision for the smaller breweries. However, which service items are preferred may vary from brewery to brewery. In this research there is no contact with the breweries so the individual interests of the breweries cannot be discussed. Therefore, only the cost criterion, how much the breweries are able to spend in a year, will be used to determine how the service model can be set up. To get an insight in the possibilities to combine the service items above, a formula is formulated based on the objective function in the integer programming approach of Januantoro & Sarno (2018), as described Section 3.2. The objective function of the integer programming approach was suitable for the problem in this research since the variables will be either 0 or 1, when the variable is included or excluded. In this way, the five service items can be set to either 0 or 1 when it is excluded or included in the service model, and the total costs can be determined of a certain combination of service items. Based on this, the following formula is formulated:

$$C = c_d * d + c_m * m + c_t * t + c_s * s + c_e * e \qquad (1)$$

With:

- $d, m, t, s, e = 1\ if\ the\ corresponding\ service\ item\ is\ used, 0\ otherwhise$, where:
  - d = data connection
  - m = monitoring & reporting
  - t = technical helpdesk service
  - s = site visit
  - e = 24/7 emergency help line.

- $c_i : costs\ per\ year\ for\ using\ item\ i\ (i = d, m, t, s, e)$
- $C: total\ costs\ per\ year$

The outcome of Formula 1 represents the total costs per year for a certain combination of service items.

4.1.3. Numerical elaboration of combinations of service items

In Section 4.1.2 Formula 1 is formulated to get an insight in the possibilities of combining the service items. With this formula the total costs per year of all combinations of service items can be computed. Each of the five service items can take either of the two values 0 or 1 when it is excluded or included in the model, so the total number of service item combinations will be $2^5 = 32$. By determining the total costs of all 32 combinations, it can be determined what combination of service items does not exceed the maximum costs a brewery has to spend. Since this problem is relatively small, with only 32 possible solutions it is chosen to solve it by enumeration and exploring all possible solutions instead of solving the problem to optimality by solving an integer linear program as is done in the literature by Januantoro & Sarno (2018).

First the costs c_i per year for using the service items have to be determined. Some of the service items will result in a fixed cost per year. For example the costs for the site visit depends on the distance. In coordination with Pentair, the costs c_i per year are fixed and are shown in Table 7.

Service item i	Costs c_i
d	€800,-
m	€1200,-
t	€1200,-
s	variable
e	€500,-

Table 7: Costs c_i per year of service items for BMF S4 (source: Pentair)

The costs per year for the items d, m, t and e are fixed. For the service item s, the site visit, it depends on the travel distance. In this research the distinction will be made between breweries within the Netherlands, Europe, Africa, Russia, Asia, North America and South America.

For further computations the standard costs per country or continent for 5 working days of commissioning will be used for the item s, all costs as hourly loans and travel costs included. These costs, as earlier described in Section 2.2.2, are shown in Table 8.

Country/Continent	Costs s for site visit
Netherlands	€5,250
Europe	€6,350
Africa	€7,500
Russia	€8,700
Asia	€10,450
North America	€8,900
South America	€9,950

Table 8: Costs site visit (item s) per country/continent

Now it is established what the costs for the service items are, the total costs per year of all possible combinations of service items can be computed. To do so, a table with all 32 possible combinations is created in Excel (Table 25 in Appendix B). If an item is included, it is denoted by a 1 and 0 otherwise. With this table and Formula 1, the total costs per year of all combinations of service items are computed. The outcomes are shown in Table 9.

		Total Costs (€)						
Combination number	**Service items**	**Netherlands**	**Europe**	**Africa**	**Russia**	**Asia**	**North America**	**South America**
1	-	0	0	0	0	0	0	0
2	e	500	500	500	500	500	500	500
3	s	5250	6350	7500	8700	10450	8900	9950
4	s,e	5750	6850	8000	9200	10950	9400	10450
5	t	1200	1200	1200	1200	1200	1200	1200
6	t,e	1700	1700	1700	1700	1700	1700	1700
7	t,s	6450	7550	8700	9900	11650	10100	11150
8	t,s,e	6950	8050	9200	10400	12150	10600	11650
9	m	1200	1200	1200	1200	1200	1200	1200
10	m,e	1700	1700	1700	1700	1700	1700	1700

11	m,s	6450	7550	8700	9900	11650	10100	11150
12	m,s,e	6950	8050	9200	10400	12150	10600	11650
13	m,t	2400	2400	2400	2400	2400	2400	2400
14	m,t,e	2900	2900	2900	2900	2900	2900	2900
15	m,t,s	7650	8750	9900	11100	12850	11300	12350
16	m,t,s,e	8150	9250	10400	11600	13350	11800	12850
17	d	800	800	800	800	800	800	800
18	d,e	1300	1300	1300	1300	1300	1300	1300
19	d,s	6050	7150	8300	9500	11250	9700	10750
20	d,s,e	6550	7650	8800	10000	11750	10200	11250
21	d,t	2000	2000	2000	2000	2000	2000	2000
22	d,t,e	2500	2500	2500	2500	2500	2500	2500
23	d,t,s	7250	8350	9500	10700	12450	10900	11950
24	d,t,s,e	7750	8850	10000	11200	12950	11400	12450
25	d,m	2000	2000	2000	2000	2000	2000	2000
26	d,m,e	2500	2500	2500	2500	2500	2500	2500
27	d,m,s	7250	8350	9500	10700	12450	10900	11950
28	d,m,s,e	7750	8850	10000	11200	12950	11400	12450
29	d,m,t	3200	3200	3200	3200	3200	3200	3200
30	d,m,t,e	3700	3700	3700	3700	3700	3700	3700
31	d,m,t,s	8450	9550	10700	11900	13650	12100	13150
32	d,m,t,s,e	8950	10050	11200	12400	14150	12600	13650

Table 9: Total costs per country/continent of all possible combinations of service items

4.2. Potential after-sales service models

In Section 4.1 the combinations of service items are explored. From this, it can be determined what combination of items constitute a potential after-sales service model, what can be used as a basis to further develop the model in the next chapter. To decide which combinations are sufficient to become part of the after-sales model, the following two criteria are used:

1. $m \leq d$

   When service item m, monitoring & reporting, is included, the data connection, service item d is necessary to be included too. Because, without having a data connection with the brewery, Pentair is not able to give the monitoring and reporting support.

2. $c_d * d + c_m * m + c_t * t + c_s * s + c_e * e \leq Budget$

   The total costs should be less or equal to the maximum budget the brewery has to spend on the service agreement.

To check the combinations on the first criterion, no further information is needed. To check the second criterion, the amount the breweries are willing to pay for the services has to be established. Despite the fact that Pentair finds it hard to indicate how much the breweries are able to spend, the sales apartment made an estimate that can be used in this research. As described in Section 2.2.2, it will depend on the size of the brewery, since it can differ from a filtration of 24,000 to 80,000HL per year. Therefore the range

of €2,500 to €7,500 is given as the budget of the breweries. In further calculations, €2,500, €4750 and €7,500 are the scenarios that are taken into consideration to make sure the possibilities for the service model are explored for different brewery sizes. For convenience, further on, the brewery with a budget of €2,500 will be denoted by brewery type 1, the brewery with a budget of €4,750 as type 2 and the brewery with a budget of €7,500 as type 3.

Table 26, 27 and 28 in Appendix B show what items are excluded by criterion 1 and 2 or both for breweries with a budget of €2,500, €4,750 and €7,500, respectively. This results in the combinations of service items that are left for the potential service model, shown in Table 10. Per combination of service items it is stated per country or continent for which type of breweries the concerning combination is still an option. When a combination number is excluded from the table, it did not meet the criteria for either of the countries or continents.

Combination number	Service items	Netherlands	Europe	Africa	Russia	Asia	North America	South America
1	-	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3
2	e	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3
3	s	3	3	3	-	-	-	-
4	s,e	3	3	-	-	-	-	-
5	t	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3
6	t,e	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3
7	t,s	3	-	-	-	-	-	-
8	t,s,e	3	-	-	-	-	-	-
17	d	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3
18	d,e	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3
19	d,s	3	3	-	-	-	-	-
20	d,s,e	3	-	-	-	-	-	-
21	d,t	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3
22	d,t,e	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3
23	d,t,s	3	-	-	-	-	-	-
25	d,m	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3
26	d,m,e	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3
27	d,m,s	3	-	-	-	-	-	-
29	d,m,t	2,3	2,3	2,3	2,3	2,3	2,3	2,3
30	d,m,t,e	2,3	2,3	2,3	2,3	2,3	2,3	2,3

Table 10: Combinations of service items that constitute a potential service model per country/continent, indicated per brewery type

From Table 10 the following conclusions can be made:

- For any of the countries or continents the potential service model does not contain all five service items.
- The potential models for Russia, Asia, North America and South America never contain the service element s, the site visit. Also for brewery type 1 and 2 item s is never in the potential model. Item s is only included for the Netherlands, Europe and Africa, for brewery type 3.

- There are four potential models left containing one service item, seven potential models containing two service items, seven potential models containing three service items and one potential model containing four service items.

4.2.1. Outsourcing site visit

It is concluded that including the site visit in the model is only possible for brewery type 3 in the Netherlands, Europe and Africa. Per brewery it might differ whether they would be interested in the site visits or not. Since the site visit item entails the highest costs, it is discussed with Pentair that it would be an option to outsource the site visits, so it could still be part of the after-sales service provision in continents that cost much travel time from the Netherlands. In this way it would involve less costs since less travel costs have to be paid. To determine the options for the potential models when the site visit would be outsourced, it is analyzed on what traveling distance the employee should maximal be from the brewery so it could fit cost-wise in the after-sales service model. To do so, the costs of the components of a site visit are used which are shown in Table 5, Section 2.2.2.

First, the costs of the site visit of 5 working days of 8 hours are determined per country/continent without the travel costs. Based on the costs for the working hours and accommodation, this results in $€106 \cdot 5 \cdot 8 + €100 \cdot 5 = €4740$,-. Then, the total costs are calculated for the combinations of service items that were left after excluding the combinations that did not meet criterion (1) in Section 4.2. Here, for the site visit, the €4740,- is used, so the costs for the site visit without travel costs. The total costs for the combinations can be found in Table 29 in Appendix B. To determine what budget would be left for the travel costs of the visit, the total costs in Table 29 are subtracted from the budget of €2,500, €4,750 or €7,500. This is the budget minus the costs for the other service items included the loan costs of the site visit and the accommodation costs of the site visit. This results in the budget left for traveling, shown in Table 11.

Costs left for traveling		**Budget for traveling (€ per year)**		
Combination number	**Service items**	**Brewery type 1 (budget €2500)**	**Brewery type 2 (budget €4750)**	**Brewery type 3 (budget €7500)**
3	s	-2240	10	2760
4	s,e	-2740	-490	2260
7	t,s	-3440	-1190	1560
8	t,s,e	-3940	-1690	1060
19	d,s	-3040	-790	1960
20	d,s,e	-3540	-1290	1460
23	d,t,s	-4240	-1990	760
24	d,t,s,e	-4740	-2490	260
27	d,m,s	-4240	-1990	760
28	d,m,s,e	-4740	-2490	260
31	d,m,t,s	-5440	-3190	-440
32	d,m,t,s,e	-5940	-3690	-940

Table 11: Budget left for traveling to site visit per year, per brewery type

As can be seen in Table 11, combination number 31 and 32 can be eliminated since the budget left for traveling is negative for all brewery types. Also for all combinations for brewery type 1 it is still not possible to contain the site visit in the service model even though it is outsourced since the budget left is negative. This means that the budget of the brewery is exceeded by this amount, even though the traveling costs were not included yet. This means, the budget of the brewery should be increased by more than the negative amount that is given in Table 11, to include the site visit service item. For example, for combination number 3 for brewery type 1, when the budget will be increased by €2240,- there will be €0,- left for traveling. Since no traveling at all is no realistic scenario in practice, the budget should be increased even more to make traveling possible.

For brewery type 2, only combination number 3 which contains only the site visit item, there is €10 left for traveling. This means that, using the costs of €0.75/km it would be possible for breweries of type 2 to have a site visit, when the employee can drive there by car with a maximum single ride of $0.5 * \frac{10}{0.75} \approx 6.7$ km.

For brewery type 3, there are more possibilities left. The combinations of only traveling by car, traveling by plane and car and traveling by plane and taxi are calculated. It is calculated how many kilometers the employee can travel in total (so a retour trip), which can be seen in Table 12.

Travel options (retour)		**Brewery Budget €7500**		
Combination number	**Service items**	**Travel by car (km)**	**Travel by car with airplane ticket (km)**	**Travel by taxi with airplane ticket (km)**
3	s	3680,00	2346,67	586,67
4	s,e	3013,33	1680,00	420,00
7	t,s	2080,00	746,67	186,67
8	t,s,e	1413,33	80,00	20,00
19	d,s	2613,33	1280,00	320,00
20	d,s,e	1946,67	613,33	153,33
23	d,t,s	1013,33	Flight not possible	Flight not possible
24	d,t,s,e	346,67	Flight not possible	Flight not possible
27	d,m,s	1013,33	Flight not possible	Flight not possible
28	d,m,s,e	346,67	Flight not possible	Flight not possible

Table 12: Travel distance possibilities brewery type 3 if site visit is outsourced

The results of Table 12 can be combined with the previous combinations that were found as a potential service model, shown in Table 102. Combining the potential models with and without outsourcing the site visit results in the possibilities of combinations of items for the after-sales service model shown in . When the combination is possible with outsourcing the site visit, it is denoted by the number of the brewery type with an ‘o’ as subscript. It still does have the requirement that it has to meet the maximum travel distance restriction as denoted in Table 12.

Outsourcing results in extra possibilities for all countries/continents for the combination numbers that already were present in Table 10 which contained the service item s. Besides, combination number 24 and 28 were added, since it turned out these combinations are only possible when the site visit is outsourced. Table 13, the final table of potential service item combinations is used in the next chapter to develop the tool, in order to decide on what the optimal after-sales service model will be per country/continent.

Combination number	Service items	Netherlands	Europe	Africa	Russia	Asia	North America	South America
1	-	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3
2	e	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3
3	s	2_o,3,3_o	3,3_o	3,3_o	3_o	3_o	3_o	3_o
4	s,e	3,3_o	3,3_o	3_o	3_o	3_o	3_o	3_o
5	t	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3
6	t,e	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3
7	t,s	3,3_o	3_o	3_o	3_o	3_o	3_o	3_o
8	t,s,e	3,3_o	3_o	3_o	3_o	3_o	3_o	3_o
17	d	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3
18	d,e	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3
19	d,s	3,3_o	3,3_o	3_o	3_o	3_o	3_o	3_o
20	d,s,e	3,3_o	3_o	3_o	3_o	3_o	3_o	3_o
21	d,t	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3
22	d,t,e	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3
23	d,t,s	3,3_o	3_o	3_o	3_o	3_o	3_o	3_o
24	d,t,s,e	3_o	3_o	3_o	3_o	3_o	3_o	3_o
25	d,m	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3
26	d,m,e	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3
27	d,m,s	3,3_o	3_o	3_o	3_o	3_o	3_o	3_o
28	d,m,s,e	3_o	3_o	3_o	3_o	3_o	3_o	3_o
29	d,m,t	2,3	2,3	2,3	2,3	2,3	2,3	2,3
30	d,m,t,e	2,3	2,3	2,3	2,3	2,3	2,3	2,3

Table 13: Final combinations of service items that constitute a potential service model per country/continent, indicated per brewery type, with or without outsourcing site visit

4.3. Conclusion

The five service items Pentair offers can be classified in the after-sales service item categories that were found in literature. Since all categories are covered and especially because Pentair stated not to be interested in exploring new types of service items, it is decided to only take the current service items of Pentair in consideration for the potential new after-sales service model.

To get an insight in the possibilities on what combinations of service items are possible to constitute the service model, a formula is formulated to calculate the total costs per year of all possible combinations of items. Since there is no contact with the breweries, the individual interests of the breweries cannot be considered in this research. Therefore only the cost criterion, the budget the brewery has to spend on the service items is considered in determining how the service model can be set up.

After taking criteria into consideration and analyzing the possibilities of outsourcing the site visit service item, it resulted in the combinations of service items that are used as a basis potential after-sales service provision. Here the distinction is made between the three different brewery types, having a budget of €2,500, €4,750 or €7,500 and outsourcing the site visit or not. These combinations of service items conduct the potential basis service models which will be used in the next chapter to develop the tool in Excel to determine the final optimal after-sales service model per country/continent.

5. Choosing the optimal after-sales service model

This chapter is dedicated to the development of a tool in Excel in order to provide the company results for the optimal after-sales service model per country/continent so the following research question can be answered: *What would be the optimal service provision for the BMF+ flux Compact S4?.* First, Section 5.1 explains the working of the tool in Excel. Secondly, Section 5.2 contains the analysis of the results which can be obtained by the tool, which will be used to conclude what the optimal service provision for the BMF+ flux Compact S4 will be, per country/continent.

5.1. Excel tool explanation

The tool made in Excel is based on the results of Chapter 4. The combination of items that were left at the end of Chapter 4 after exclusion of combinations are used as possible combinations in the tool. Since it will differ per brewery what the preferences and the budget are, the tool is designed in a way multiple options for service item combinations can be explored. An overview of the form is shown in Figure 11. The tool consists of 2 parts, the input and the output form. The blue and yellow part are the input form of the brewery and Pentair, respectively. The grey and orange part are the output of all possibilities and the best possibilities within the budget, respectively. In Section 5.1.1. First, the necessary information should be filled in in the input form, where after the solve button can be clicked in order to get the output on the possibilities of combinations of service items and the advice on the best possibilities. In Section 5.1.1 and 5.1.2 respectively the input form and the output form will be explained in more detail.

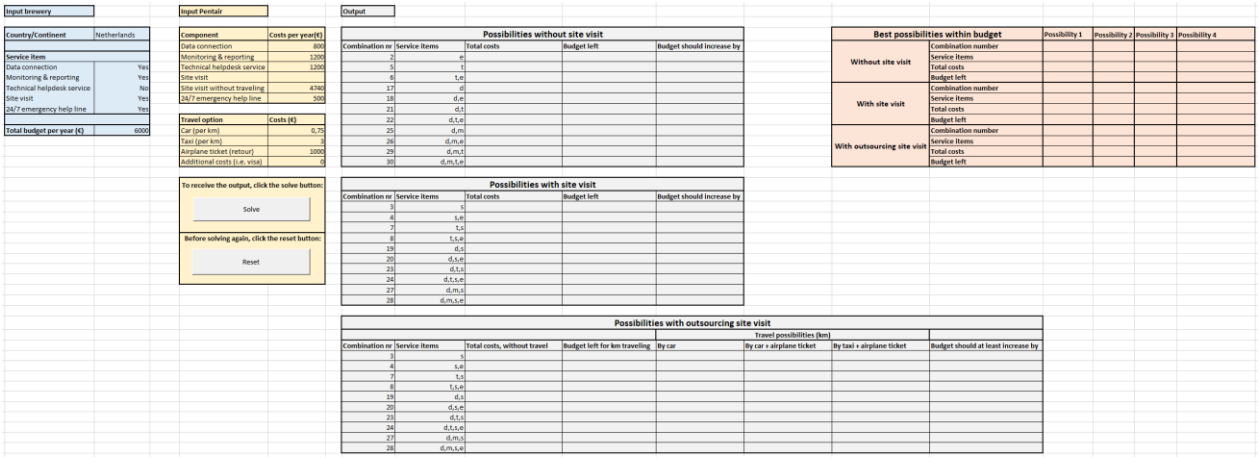


Figure 11: Overview of tool in Excel

5.1.1. Input form

The input of the tool consists of two parts, the input of the brewery and the input of Pentair. Figure 12 shows the input of the brewery. Here, first the country/continent of the brewery should be chosen. When the cell is selected, it is stated the country/continent of the brewery has to be selected, which can be chosen from the list (Figure 13). When something other than one of the countries or continents from the lists is given as input, an error occurs.

After selecting the country/continent of the brewery, the preferences of service items can be indicated. In Figure 14 can be seen it is asked whether the brewery is interested in the corresponding service item, for which 'Yes' or 'No can be selected. When 'No is selected, it means the brewery is not interested in having this item included, so this item will be left out of consideration when finding the possibilities of the service provision. Again, when something else than 'Yes' or 'No' is given as input here, an error occurs.

At last, the total budget of the brewery per year should be specified, which can be filled in manually in the input form. When the input is established, the user can click on the solve button, to generate the costs and the output.

Input brewery	
Country/Continent	
Service item	
Data connection	
Monitoring & reporting	
Technical helpdesk service	
Site visit	
24/7 emergency help line	
Total budget per year (€)	

Figure 12: Input form of the brewery

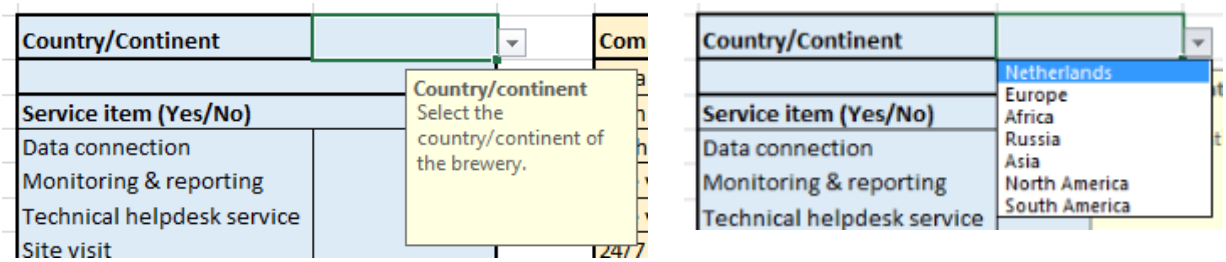


Figure 13: Input form country/continent selection

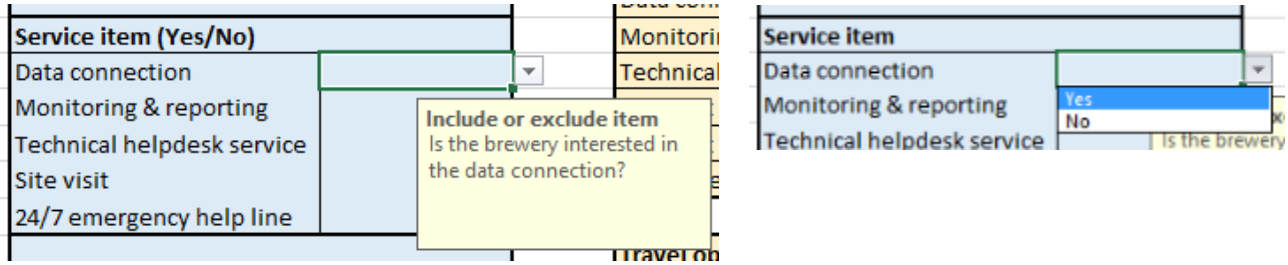
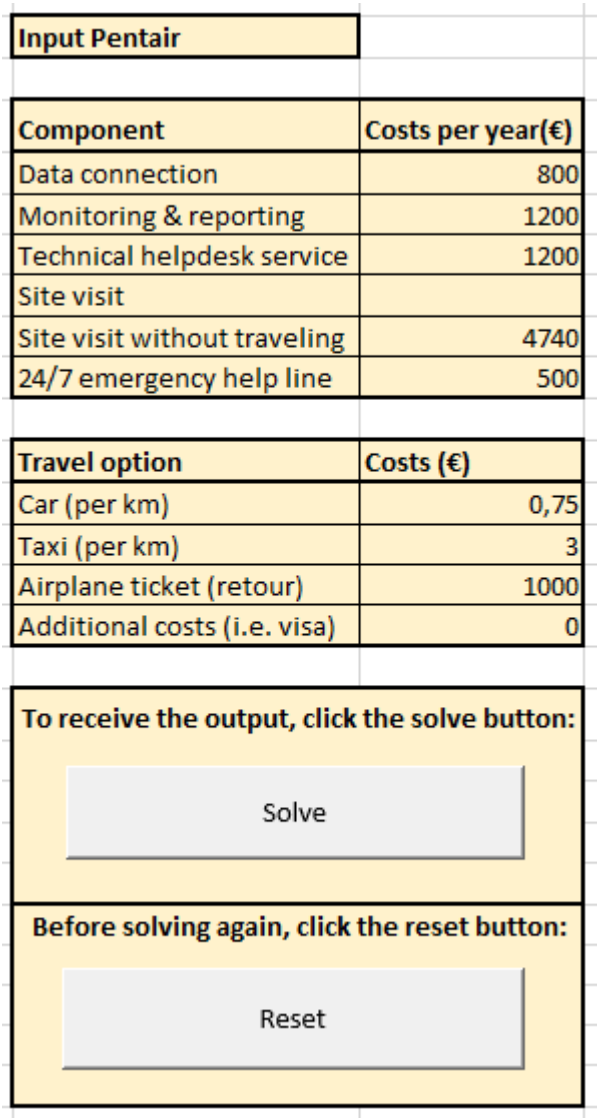


Figure 14: Input form service item selection

The second part of the input form is the input of Pentair, which is shown in Figure 15. First, the costs per year of each service item is specified. Except for the site visit, the costs are filled in manually, which can be adjusted by Pentair when these costs will change. The costs for the site visit depend on the country or continent of the brewery. Therefore these costs corresponding to the right country or continent will be filled in automatically when the user clicks on the solve button, of which its working will be explained later

on. After specifying the costs per year of the service items, the costs per kilometer traveling by car and taxi, costs for a plane ticket and additional costs such as a visa needed for the corresponding country or continent of the brewery have to be filled in by Pentair.

When both input forms are completed, the user can click on the 'Solve' button to receive the output. When the user wants to solve the model again with other input, the output first has to be reset, by clicking on the 'Reset' button. The working of the buttons will be explained in the next section.



Input Pentair

Component	Costs per year(€)
Data connection	800
Monitoring & reporting	1200
Technical helpdesk service	1200
Site visit	
Site visit without traveling	4740
24/7 emergency help line	500

Travel option	Costs (€)
Car (per km)	0,75
Taxi (per km)	3
Airplane ticket (retour)	1000
Additional costs (i.e. visa)	0

To receive the output, click the solve button:

Solve

Before solving again, click the reset button:

Reset

Figure 15: Input form of Pentair

5.1.2. Output form

The output form of the tool consist of four parts, the possibilities with site visit, the possibilities without site visit, the possibilities with outsourcing the site visit and the best possibilities within the budget. The possibilities without or with outsourcing the site visit are three tables containing the combination of service items which were left as the potential models from Chapter 4 after exclusion of combinations which did not meet the conditions. When the user clicks the solve button, Formula (1): C = $c_d * d + c_m *$

$m + c_t * t + c_s * s + c_e * e$ of Section 4.1.2. is used to calculate the total costs for all possible combinations of service items. In Figure 16, 17 and 18, the output tables for the possibilities of combinations of items without a site visit, with a site visit and with outsourcing the site visit are shown, respectively. In Figure 16, 17 and 18 the output is shown for the example of a brewery in the Netherlands, interested in all five service items and with a budget of €4750,- per year.

Possibilities without site visit				
Combination nr	Service items	Total costs	Budget left	Budget should increase by
2	e	500	4250	0
5	t	1200	3550	0
6	t,e	1700	3050	0
17	d	800	3950	0
18	d,e	1300	3450	0
21	d,t	2000	2750	0
22	d,t,e	2500	2250	0
25	d,m	2000	2750	0
26	d,m,e	2500	2250	0
29	d,m,t	3200	1550	0
30	d,m,t,e	3700	1050	0

Figure 16: Example output table possibilities without site visit

Possibilities with site visit				
Combination nr	Service items	Total costs	Budget left	Budget should increase by
3	s	5250	0	500
4	s,e	5750	0	1000
7	t,s	6450	0	1700
8	t,s,e	6950	0	2200
19	d,s	6050	0	1300
20	d,s,e	6550	0	1800
23	d,t,s	7250	0	2500
24	d,t,s,e	7750	0	3000
27	d,m,s	7250	0	2500
28	d,m,s,e	7750	0	3000

Figure 17: Example output table possibilities with site visit

Possibilities with outsourcing site visit							
				Travel possibilities (km)			
Combination nr	Service items	Total costs, without travel	Budget left for km traveling	By car	By car + airplane ticket	By taxi + airplane ticket	Budget should at least increase by
3	s	4740	10	13,33	-1320	-330	0
4	s,e	5240	-490	-653,33	-1986,67	-496,67	490
7	t,s	5940	-1190	-1586,67	-2920	-730	1190
8	t,s,e	6440	-1690	-2253,33	-3586,67	-896,67	1690
19	d,s	5540	-790	-1053,33	-2386,67	-596,67	790
20	d,s,e	6040	-1290	-1720	-3053,33	-763,33	1290
23	d,t,s	6740	-1990	-2653,33	-3986,67	-996,67	1990
24	d,t,s,e	7240	-2490	-3320	-4653,33	-1163,33	2490
27	d,m,s	6740	-1990	-2653,33	-3986,67	-996,67	1990
28	d,m,s,e	7240	-2490	-3320	-4653,33	-1163,33	2490

Figure 18: Example output table possibilities with outsourcing site visit

Besides determining the total costs, the solve button ensures it is calculated what amount of the budget is left when a certain combination of service items is chosen, or by what amount the budget should increase in order to be able to receive the corresponding combination of service items. The amount the

budget should increase with when it is not within the budget is given so the brewery can make a trade off whether it would be worth to spend this additional amount of money to get the indicated service in return.

For the possibilities with outsourcing the site visit (Figure 18), additional information is gained by clicking the solve button. It is determined what budget is left to travel followed by what the travel possibilities of an employee would be in kilometers for the scenario of using a car, a car in combination with a plane flight or a taxi in combination with a plane flight.

Besides the calculations, the solve button makes sure the output is made visually clear. When a combination of service items is within the budget, the combination will be colored green. When the combination is too expensive, the amount the budget should increase with is colored red. In the example of the output in Figure 16, 17 and 18 all service items were included in the input form of the brewery. However, when a brewery is not interested in for example the 24/7 emergency help line, the results which contain the service item e will be faded, which is shown in all three tables. Figure 19 shows the example of the table for the possibilities without a site visit, when the 24/7 emergency help line item is excluded from the input. When the brewery is not interested in the site visit item, the tables of the possibilities with site visit and with outsourcing the site visit as shown in Figure 17 and 18 will remain empty.

Possibilities without site visit				
Combination nr	Service items	Total costs	Budget left	Budget should increase by
2	e	500	4250	0
5	t	1200	3550	0
6	t,e	1700	3050	0
17	d	800	3950	0
18	d,e	1300	3450	0
21	d,t	2000	2750	0
22	d,t,e	2500	2250	0
25	d,m	2000	2750	0
26	d,m,e	2500	2250	0
29	d,m,t	3200	1550	0
30	d,m,t,e	3700	1050	0

Figure 19: Example output when service item e is excluded

The fourth part of the output form is an overview of the best possibilities of combination of service items within the budget of the brewery, shown in Figure 20. Since it is likely a brewery would like as many service items as possible for the budget they have to spend, the best possibilities within the budget based on the amount of service items are given. To illustrate this, an example of this output table is given for the scenario of a brewery in the Netherlands, interested in all service items and having a budget of €7500,- per year. In Figure 20 the possibilities with the maximum number of service items possible within the budget are given for each of the three output tables as explained before (with, without or with outsourcing the site visit). For each of the three output tables it is determined of the green colored combination of service items, so which would be within the budget, what number of service items is the maximum. All combinations within the budget containing this maximum number of service items is then given in this final output table shown in Figure 20.

Best possibilities within budget		Possibility 1	Possibility 2	Possibility 3	Possibility 4
Without site visit	Combination number	30			
	Service items	d,m,t,e			
	Total costs	3700			
	Budget left	3800			
With site visit	Combination number	8	20	23	27
	Service items	t,s,e	d,s,e	d,t,s	d,m,s
	Total costs	6950	6550	7250	7250
	Budget left	550	950	250	250
With outsourcing site visit	Combination number	24	28		
	Service items	d,t,s,e	d,m,s,e		
	Total costs	7240	7240		
	Budget left	260	260		

Figure 20: Output table best possibilities within budget, based on maximum number of service items possible

5.2. Analysis of results

The tool in Excel as explained in Section 5.1. can be used by Pentair in order to find a suitable service item combination for a new brewery who is planning to install a BMF+ flux Compact S4. It can be used for the specific preferences and budget of that brewery. To analyze and conclude on the results of the tool, for this research the results are analyzed based on different scenarios. For each of the seven countries/continents, the Netherlands, Europe, Africa, Russia, Asia, North America and South America, the results for the three brewery types having different budgets per year of €2500, €4750 and €7500 are analyzed. The analysis is structured as follows.

- Section 5.2.1. General possibilities without site visit: First, the combinations of service items will be analyzed for the scenario without having the site visit. Since the results will be the same for each country/continent when the site visit is excluded, the analysis is performed generally for each of the three brewery types.
- Section 5.2.2. Possibilities with (outsourcing) the site visit: After analyzing the possibilities without including the site visit, the possibilities for including the outsourced site visit and the site visit when it is not outsourced are analyzed.
    - Section 5.2.2.1: The possibilities for the outsourced site visit are analyzed generally for all countries/continents since the results will not depend on the country/continent but only on the budget of the brewery because it is all done on remote.
    - Section 5.2.2.2 to 5.2.2.5: The possibilities on including the site visit without outsourcing are analyzed per country/continent. Since it turned out the results for the countries/continents Russia, Asia, North America and South America were comparable, Section 5.2.2.5 covers the analysis of these four countries/continents at once, instead of having a separate section as is done for the Netherlands, Europe and Africa.

To make sure no possibilities are left out of the analysis, for all scenarios all service items will be included in the input form of the brewery. With use of the results of this analysis a conclusion on the optimal service provision can be given per country or continent. It can be concluded what combination of service items would be the best per country/continent in the case of excluding the site visit, and in the case of including the site visit, where it will be stated whether it should be outsourced or not.

5.2.1. General possibilities without site visit

Brewery type 1, budget €2500,- per year

To analyze the results of the table with possibilities without the site visit for a brewery with a budget of €2500,- per year, the results of the table in the tool are illustrated in Figure 21. It can be seen that nine of the eleven possibilities are within the budget. Combination number 29 and 30 do exceed the budget, and it is shown that the budget should be increased with 28% and 48% respectively in order to get it as the service provision. The combinations containing only one or two service items do result in a leftover of the budget varying from 20% to 80%.

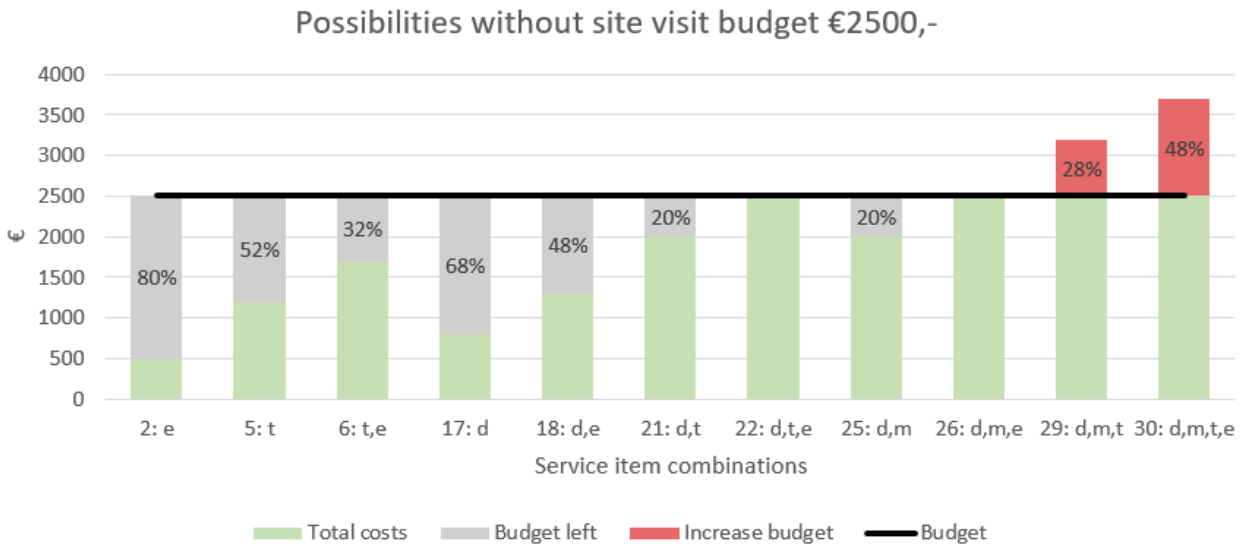


Figure 21: Results possibilities without site visit for a brewery with budget of €2500,-

As can be seen in Table 14, combination 22 and 26 are the best possibilities within the budget. These combinations contain the maximum of three service items, so the brewery will make the most of their budget. For these two combinations of items, the budget of €2500,- will be fully spend. Both combinations contain the data connection and the 24/7 emergency help line. In addition to this, combination 22 contains the technical helpdesk service and combination 26 contains the monitoring and reporting item. Which possibility would be best to choose depends on the preferences of the brewery. When the brewery is interested in monitoring the performance of the filtration system so the brewery can for example work on optimization by themselves, combination 26 containing the service item m is advised. However, When the brewery is more interested in the possibility of having remote support on troubleshooting and having technological coaching, combination number 22 containing service item t would be the better option.

Best possibilities within budget		**Possibility 1**	**Possibility 2**	**Possibility 3**	**Possibility 4**
Without site visit	**Combination number**	22	26		
	Service items	d,t,e	d,m,e		
	Total costs	2500	2500		
	Budget left	0	0		

Table 14: Best possibilities without site visit within budget of €2500,-

Brewery type 2, budget €4750,- per year

In the same way as for brewery type 1, the results of the table in the tool for brewery type 2 are processed into a diagram shown in Figure 22. It immediately stands out that for any of the combinations no increase of budget is necessary. The amount of the budget that is left when one, two or three items are included, differs from 33% to 89%. Table 15 shows the best possibility within the budget of €4750,- will be combination number 30. This combination contains all service items, except for the site visit, so the most possible service is received. Since still 22% of the budget is left, Pentair can look in consultation with the brewery for possibilities for the remainder of the budget when the brewery is interested. An example could be providing more hours of helpdesk service. However, how this remainder of the budget could be spend exactly fully dependents on the preferences of the brewery, which is out of scope of this research since contact with future breweries that will install the BMF S4 is not possible.

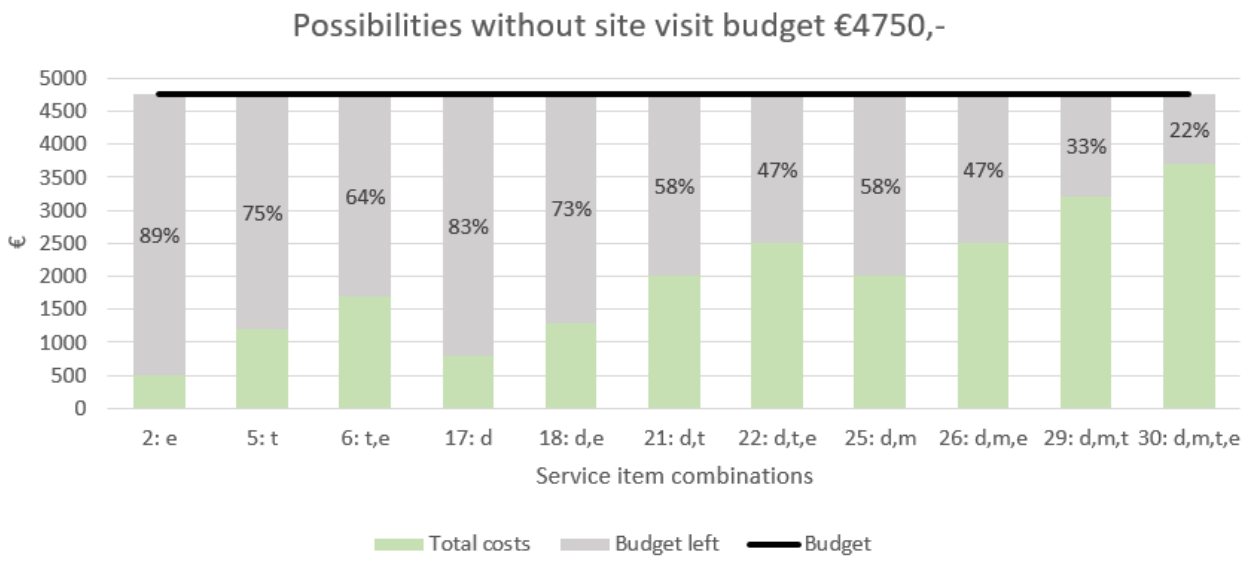


Figure 22: Results possibilities without site visit for a brewery with budget of €4750,-

Best possibilities within budget		Possibility 1	Possibility 2	Possibility 3	Possibility 4
Without site visit	Combination number	30			
	Service items	d,m,t,e			
	Total costs	3700			
	Budget left	1050			

Table 15: Best possibilities without site visit within budget of €4750,-

Brewery type 3, budget €7500,- per year

As for brewery type 1 and 2, the results for brewery type 3 are derived with the tool. Figure 23 shows the illustration of these results. As for the brewery with a budget of €4750,- already was stated all combination of service items did fit within the budget, it is a logical outcome that for brewery type 3 with an even higher budget again no of the combinations of items will exceed the budget. However, the budget that is left when a certain combination of service items will be chosen is even higher. At least half of the budget will be left, when the brewery will choose for the service item combination without a site visit. In Table 16

again be seen the best possibility within the budget is combination number 30, which contains all four service items d, m, t and e. Since a relatively high percentage of the budget is left, especially for this type of brewery it is interesting to find out what the possibilities are for the site visit which is discussed in Section 5.2.2. As the advice given for brewery type 2, Pentair could also look for other possibilities on how the budget of the brewery can be spend in exchange for additional service.

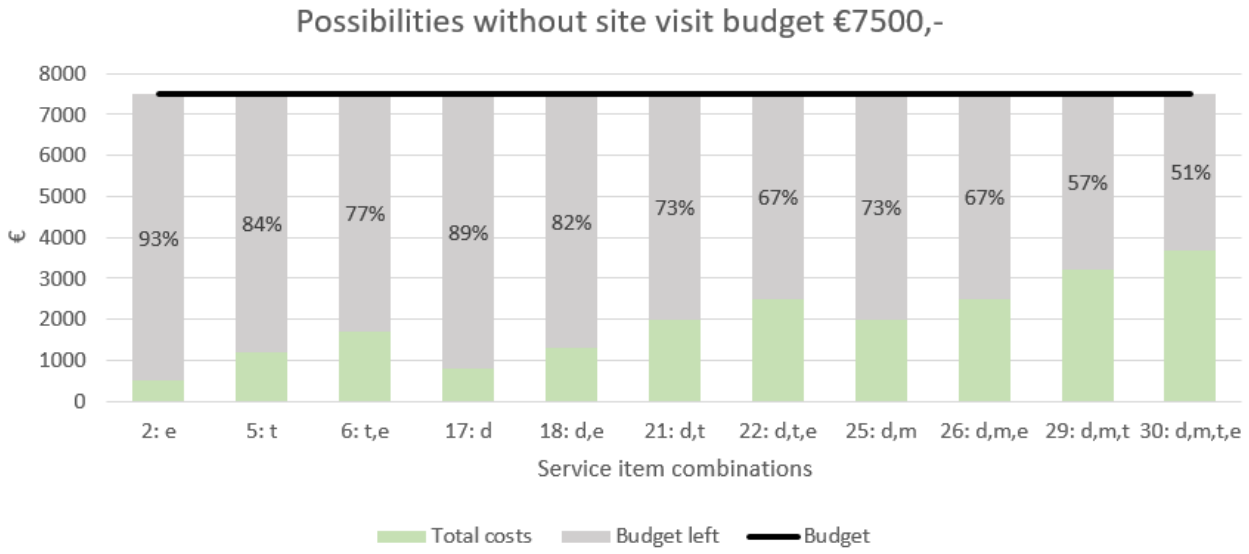


Figure 23: Results possibilities without site visit for a brewery with budget of €7500,-

Best possibilities within budget		Possibility 1	Possibility 2	Possibility 3	Possibility 4
Without site visit	Combination number	30			
	Service items	d,m,t,e			
	Total costs	3700			
	Budget left	1050			

Table 16: Best possibilities without sit visit within budget of 7500,-

5.2.2. Possibilities with (outsourcing) site visit

To analyze the results of the possibilities with the site visit or with outsourcing the site visit, the tool is used to execute the scenarios of all three budgets, so €2500, €4750 and €7500, for all seven countries/continents. Since the table of the outsourced site visit is not dependent on the country or continent, but only on the budget, a general analysis on this for the three budgets is given in Section 5.2.2.1. Next, in Section 5.2.2.2 to 5.2.2.5 per country the possibilities on including the site visit without outsourcing are discussed and a conclusion can be given on whether the site visit can be included for that country, whether it should be outsourced, or whether it is not possible at all. For the analysis in these sections, the output tables of the tool are combined into figures in order to have a better overview to write the conclusions on these results. The additional output tables of the tool of the possibilities per country/continent can be found in Appendix C.

5.2.2.1. Outsourcing site visit

Brewery type 1, budget €2500,- per year

In Table 17, the results of the possibilities with outsourcing the site visit are shown when the brewery has a budget of €2500,- per year. As can be seen, the total costs of all combinations of service items do exceed the budget. It has to be consulted with the brewery whether it is possible to increase the budget, but since the budget should approximately be at least twice as much for only containing the site visit service item in the service provision, this is not a likely possibility. Therefore, the conclusion on this will be that a site visit with a budget only a budget of €2500 is just not possible. Since containing the outsourced site visit is not possible for breweries with a budget of €2500, the scenario of this budget is left out of consideration when analyzing the possibilities of the site visit per country when it is not outsourced, since the total costs in that case would be even higher.

Possibilities with outsourcing site visit, budget €2500,-							
				Travel possibilities (km)			
Combination number	Service items	Total costs, without travel	Budget left for km traveling	By car	By car + airplane ticket	By taxi + airplane ticket	Budget should at least increase by
3	s	4740	-2240	-2986.67	-4320	-1080	2240
4	s,e	5240	-2740	-3653.33	-4986.67	-1246.67	2740
7	t,s	5940	-3440	-4586.67	-5920	-1480	3440
8	t,s,e	6440	-3940	-5253.33	-6586.67	-1646.67	3940
19	d,s	5540	-3040	-4053.33	-5386.67	-1346.67	3040
20	d,s,e	6040	-3540	-4720	-6053.33	-1513.33	3540
23	d,t,s	6740	-4240	-5653.33	-6986.67	-1746.67	4240
24	d,t,s,e	7240	-4740	-6320	-7653.33	-1913.33	4740
27	d,m,s	6740	-4240	-5653.33	-6986.67	-1746.67	4240
28	d,m,s,e	7240	-4740	-6320	-7653.33	-1913.33	4740

Table 17: Possibilities with outsourcing site visit for breweries with a budget of €2500

Brewery type 2, budget €4750,- per year

The results of the possibilities with outsourcing the site visit when the brewery has a budget of €4750,- per year are shown in Table 18. It can be seen that for combination number 3 it is possible to have the outsourced site visit in the service provision. However, then this will be the only service item that would be included in the service provision since the little amount of budget left is needed for the travel costs. Besides, the budget that is left for traveling is only €10,- which means a travel by car of only 13,3 km. In addition to this, for all other combinations containing more service items, it is not possible since it exceeds the budget. When the site visit is outsourced only 10 km can be traveled, so there has to be an employee really near the brewery who can perform the site visit, or the budget still has to be increased. Furthermore, in general it is more likely the brewery would want a combination of more service items instead of only the site visit, so it will be unlikely the brewery is willing to increase the budget for only receiving the site visit as service. Combining this all, it is therefore advised to let the outsourced site visit out of the service provision when the brewery has a budget of €4750. As for the breweries with a budget of €2500, containing the outsourced site visit is not possible for breweries with a budget of €4750, so the scenario

of this budget is also left out of consideration when analyzing the possibilities of the site visit per country when it is not outsourced, since the total costs in that case would be even higher.

Possibilities with outsourcing site visit, budget €4750,-							
				Travel possibilities (km)			
Combination number	**Service items**	**Total costs, without travel**	**Budget left for km traveling**	**By car**	**By car + airplane ticket**	**By taxi + airplane ticket**	**Budget should at least increase by**
3	s	4740	10	13,33	-1320	-330	0
4	s,e	5240	-490	-653.33	-1986.67	-496.67	490
7	t,s	5940	-1190	-1586.67	-2920	-730	1190
8	t,s,e	6440	-1690	-2253.33	-3586.67	-896.67	1690
19	d,s	5540	-790	-1053.33	-2386.67	-596.67	790
20	d,s,e	6040	-1290	-1720	-3053.33	-763.33	1290
23	d,t,s	6740	-1990	-2653.33	-3986.67	-996.67	1990
24	d,t,s,e	7240	-2490	-3320	-4653.33	-1163.33	2490
27	d,m,s	6740	-1990	-2653.33	-3986.67	-996.67	1990
28	d,m,s,e	7240	-2490	-3320	-4653.33	-1163.33	2490

Table 18: Possibilities with outsourcing site visit for breweries with a budget of €4750

Brewery type 3, budget €7500,- per year

In Table 19, the results of the possibilities with outsourcing the site visit when the brewery has a budget of €7500,- per year are shown. It can be seen that for all combinations of service items the total costs without travel are within the budget. Per combination of service items it differs what amount of the budget is left for traveling. For example, for combination number 24 and 28 containing four service items, a travel by car or taxi in combination with a flight is not possible. So, there has to be an employee available who can travel by car with a maximum of 346 km, retour. This means it has to be determined by Pentair whether it is possible to send an employee to the brewery to do the site visit that lives close enough to the brewery so the travel possibilities in kilometers will not be exceeded, in order to decide whether the combination of service items can be offered to the brewery or the budget should be increased to cover extra travel costs. However, keeping the travel possibilities in mind, all combinations of service items are possible when the site visit is outsourced, so when the brewery is interested in the site visit this can be realized. Whether the site visit has to be outsourced, or if it can also be performed by the employees from Pentair, the possibilities for the site visit without outsourcing is analyzed in the coming sections per country/continent for the scenario of a budget of €7500,- per year.

Possibilities with outsourcing site visit, budget €7500,-							
				Travel possibilities (km)			
Combination number	Service items	Total costs, without travel	Budget left for km traveling	By car	By car + airplane ticket	By taxi + airplane ticket	Budget should at least increase by
3	s	4740	2760	3680	2346.67	586.67	0
4	s,e	5240	2260	3013.33	1680	420	0
7	t,s	5940	1560	2080	746.67	186.67	0
8	t,s,e	6440	1060	1413.33	80	20	0
19	d,s	5540	1960	2613.33	1280	320	0
20	d,s,e	6040	1460	1946.67	613.33	153.33	0
23	d,t,s	6740	760	1013.33	-320	-80	0
24	d,t,s,e	7240	260	346.67	-986.67	-246.67	0
27	d,m,s	6740	760	1013.33	-320	-80	0
28	d,m,s,e	7240	260	346.67	-986.67	-246.67	0

Table 19: Possibilities with outsourcing site visit for breweries with a budget of €7500

5.2.2.2. Site visit in the Netherlands

In Figure 24 the total costs of the service item combinations including a site visit are shown per service item combination, with the budget limit of €7500,- per year. It can be seen that all combination of service items are possible within the budget, except for combination number 24 and 28. As can also be seen in Figure 25, the maximum number of service items within the budget when the site visit is included, is three service items, namely combination number 8, 20, 23 and 27. However, to include an extra fourth service item, the budget has to be increased with only 3%. Therefore, when the brewery is interested in the site visit from Pentair, it would be interesting whether the budget can be increased with this relatively low amount. When this is not possible, the brewery will receive only three service items for this budget when the site visit is included, or it should be decided to outsource the site visit. Therefore the advice will be, when the site visit is preferred to be included in the service provision, to outsource the site visit when the restrictions on travel possibilities do allow this. If not, the advice will be to make a trade-off between increasing the budget and receiving an additional service item, or being satisfied with only three service items.

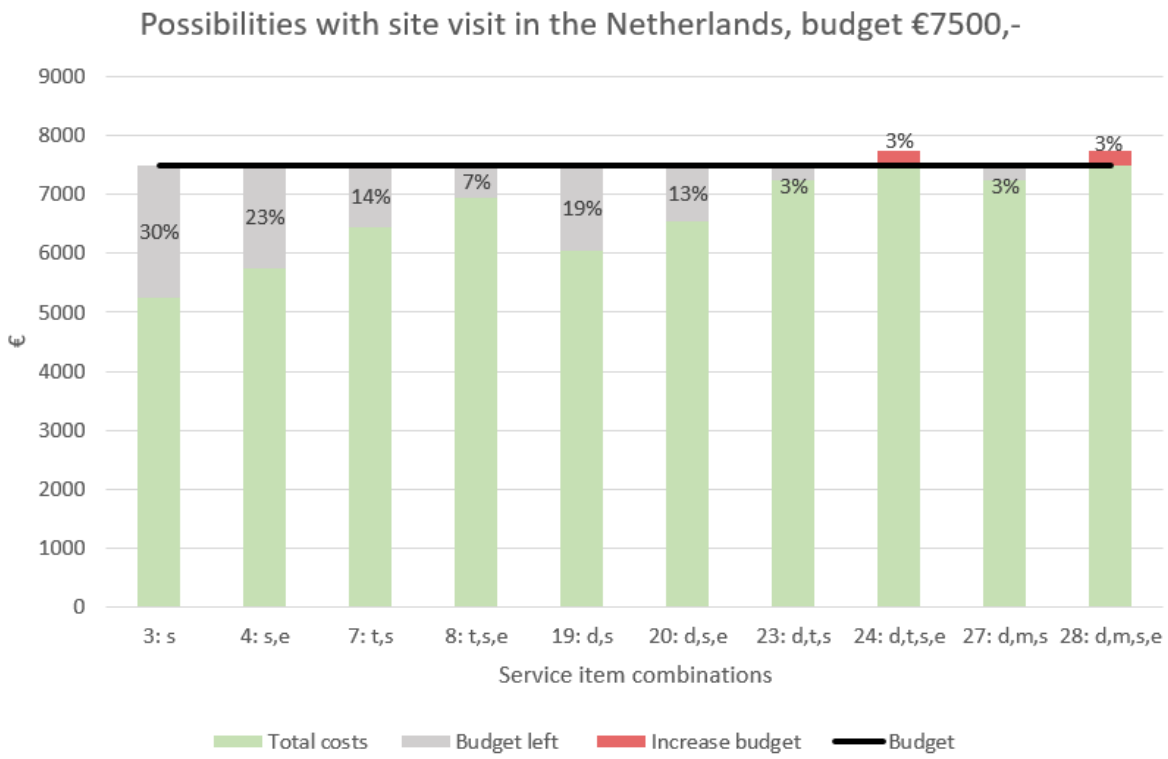


Figure 24: Total costs with site visit in the Netherlands, with budget limit of €7500,-

Best possibilities within budget		Possibility 1	Possibility 2	Possibility 3	Possibility 4
Without site visit	Combination number	30			
	Service items	d,m,t,e			
	Total costs	3700			
	Budget left	3800			
With site visit	Combination number	8	20	23	27
	Service items	t,s,e	d,s,e	d,t,s	d,m,s
	Total costs	6950	6550	7250	7250
	Budget left	550	950	250	250
With outsourcing site visit	Combination number	24	28		
	Service items	d,t,s,e	d,m,s,e		
	Total costs	7240	7240		
	Budget left	260	260		

Figure 25: Best possibilities in the Netherlands, with a budget of €7500.

5.2.2.3. Site visit in Europe

The total costs of the service item combinations including a site visit for breweries in Europe with a budget limit of €7500,- are shown in Figure 26. From these results it follows that only a service provision containing one or two service items is possible when the site visit is included. As can also be seen in Figure 27, it concerns the combination number 4 and 19. Figure 26 shows that when the budget is increased with only 2%, combination number 20 is also possible, which consist three service items. Since it will yield one extra service item, for only 2% increase of the budget, this is a good option for the brewery to take in to consideration. However, when the location of the brewery allows the site visit to be outsourced so it meets

the travel limit, the service provision can contain four service items. Since this is twice as much items as when the site visit is not outsourced, the advice will be for Pentair to look for the possibilities in having employees through Europe so the site visit can be outsourced. Being able to offer two more service items and still being within the budget can gain much customer satisfaction because this will be the most appealing possibility when the brewery prefers to contain the site visit in the service provision.

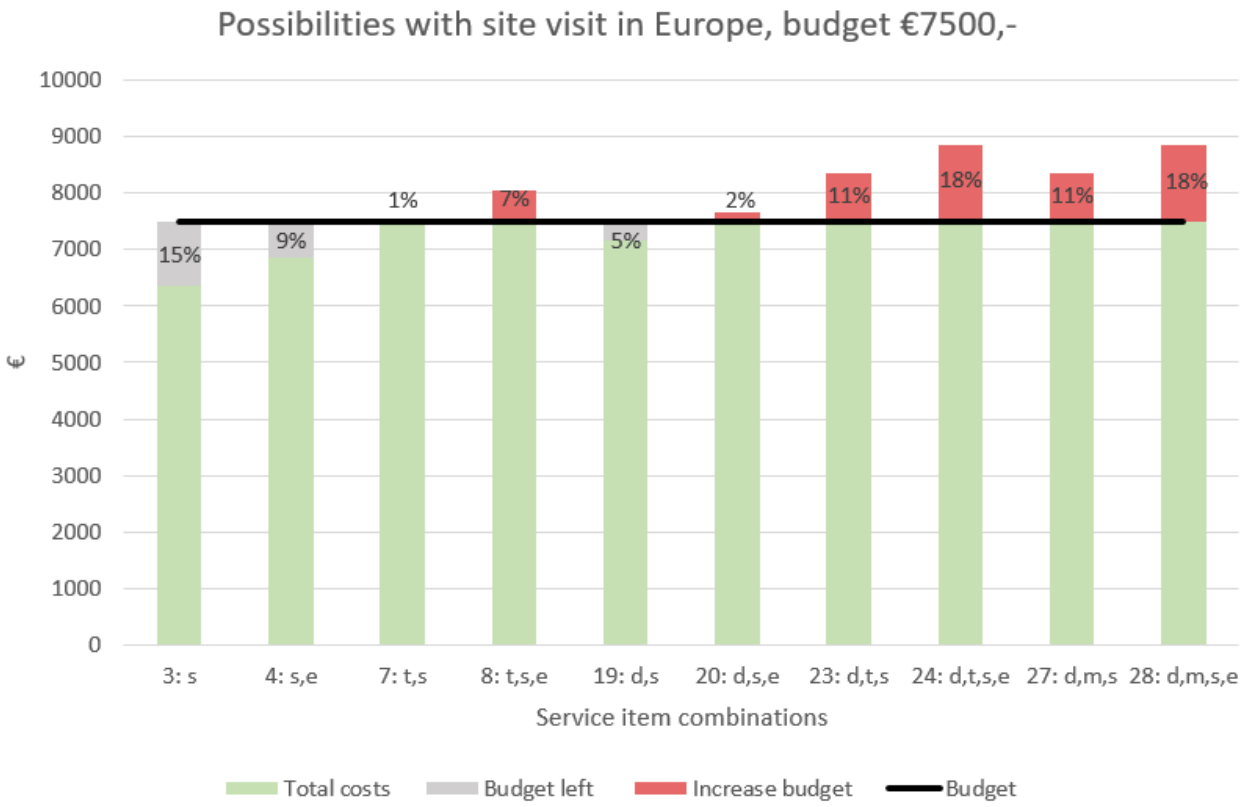


Figure 26: Total costs with site visit in Europe, with budget limit of €7500,-

Best possibilities within budget		Possibility 1	Possibility 2	Possibility 3	Possibility 4
Without site visit	Combination number	30			
	Service items	d,m,t,e			
	Total costs	3700			
	Budget left	3800			
With site visit	Combination number	4	19		
	Service items	s,e	d,s		
	Total costs	6850	7150		
	Budget left	650	350		
With outsourcing site visit	Combination number	24	28		
	Service items	d,t,s,e	d,m,s,e		
	Total costs	7240	7240		
	Budget left	260	260		

Figure 27: Best possibilities in Europe, with a budget of €7500,-

5.2.2.4. Site visit in Africa

For the service item combinations containing a site visit in Africa, the total costs are shown in Figure 28, with the budget limit of €7500,-. Form this figure follows the only service item combination containing a site visit in Africa within the budget €7500,- is combination number 3, the site visit itself. To add an extra service item, the budget should at least increase with more than 5% and to add an extra third service item the budget should increase with at least 23%. Since this is more unlikely scenario, the only possibility for having a site visit in Africa will be to only offer the site visit service item. However, in Figure 29 can be seen that when the site visit is outsourced, in the best possible case four service items can be included in the service provision. However, the kilometer travel restriction still has to be met. Since Africa is big, it is likely traveling cannot be done by car only, which has to be the case when choosing the four service items of combination number 24 or 28. However, from Table 19 in Section 5.2.2.1. can be seen that combinations containing one service item less, so containing three items, already gives the possibility to travel by plane in combination with a car or taxi. Since the only option for the site visit in Africa without outsourcing would be to contain only one service item in the service provision, the advice would be for Pentair to look for the possibilities in outsourcing the site visits in Africa.

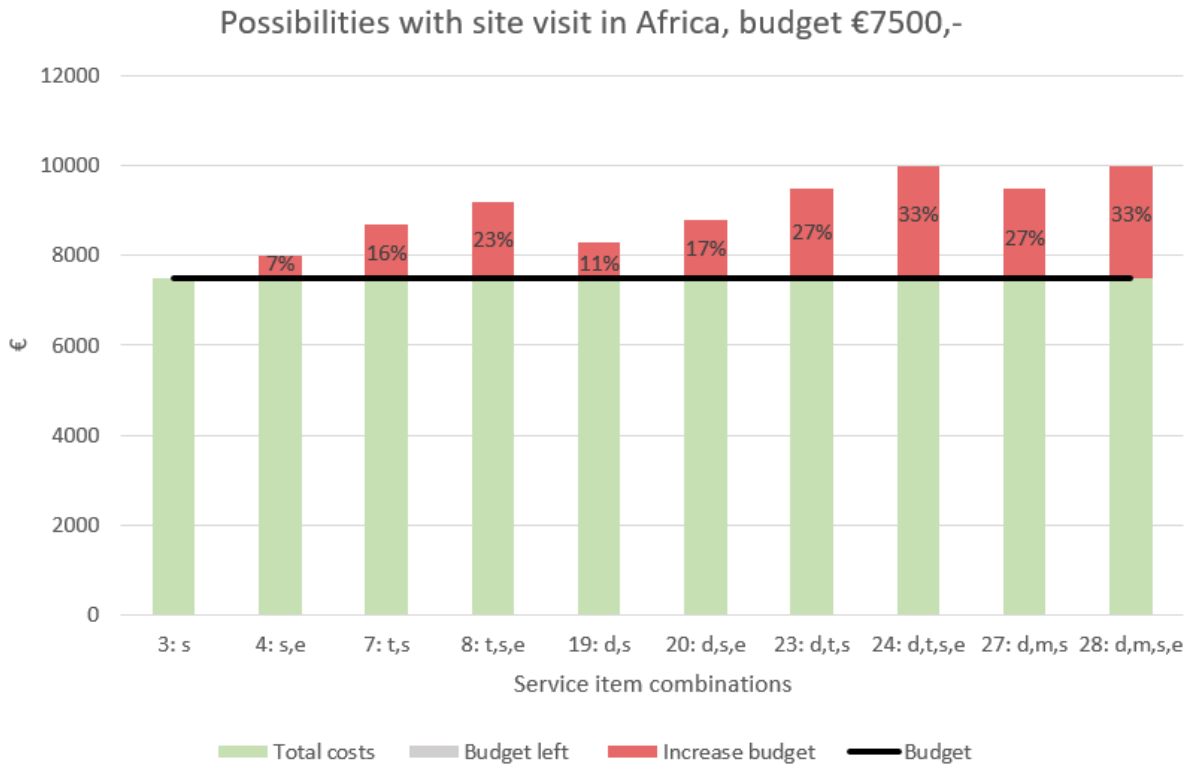


Figure 28: Total costs with site visit in Africa, with budget limit of €7500,-

Best possibilities within budget		Possibility 1	Possibility 2	Possibility 3	Possibility 4
Without site visit	Combination number	30			
	Service items	d,m,t,e			
	Total costs	3700			
	Budget left	3800			
With site visit	Combination number	3			
	Service items	s			
	Total costs	7500			
	Budget left	0			
With outsourcing site visit	Combination number	24	28		
	Service items	d,t,s,e	d,m,s,e		
	Total costs	7240	7240		
	Budget left	260	260		

Figure 29: Best possibilities in Africa, with a budget of €7500,-

5.2.2.5. Site visit in Russia, Asia, North America and South America

In Figure 31 to 34, showed on the next page, the results of the possibilities with a site visit with a budget of €7500,- in Russia, Asia, North America and South America are illustrated, respectively. For all of these four countries/continents it is not possible to contain the site visit in the service model without increasing the budget. For only the minimal service provision of combination number 3 which contains only the site visit, the budget should be increased with 16%, 39%, 19% and 33% for Russia, Asia, North America and South America, respectively. These increases of the budget are relatively high, for only receiving the site visit itself and no other additional service items. Since for the other service item combinations consisting of more service items the budget has to increase even more, this is not considered a realistic possibility. Therefore, it can be concluded the site visit from Pentair in Russia, Asia, North America and South America is just not possible. The best possibilities within the budget are shown in Figure 30. When the breweries in these countries/continents are interested in receiving the site visit, the only possibility in doing so is when the site visit can be outsourced. At the time, when looking for this possibility in consultation with the brewery, the travel limit has to be taken into consideration for the specific case of the brewery.

Best possibilities within budget		Possibility 1	Possibility 2	Possibility 3	Possibility 4
Without site visit	Combination number	30			
	Service items	d,m,t,e			
	Total costs	3700			
	Budget left	3800			
With site visit	Combination number				
	Service items				
	Total costs				
	Budget left				
With outsourcing site visit	Combination number	24	28		
	Service items	d,t,s,e	d,m,s,e		
	Total costs	7240	7240		
	Budget left	260	260		

Figure 30: Best possibilities in Russia, Asia, North America and South America, with a budget of €7500,-

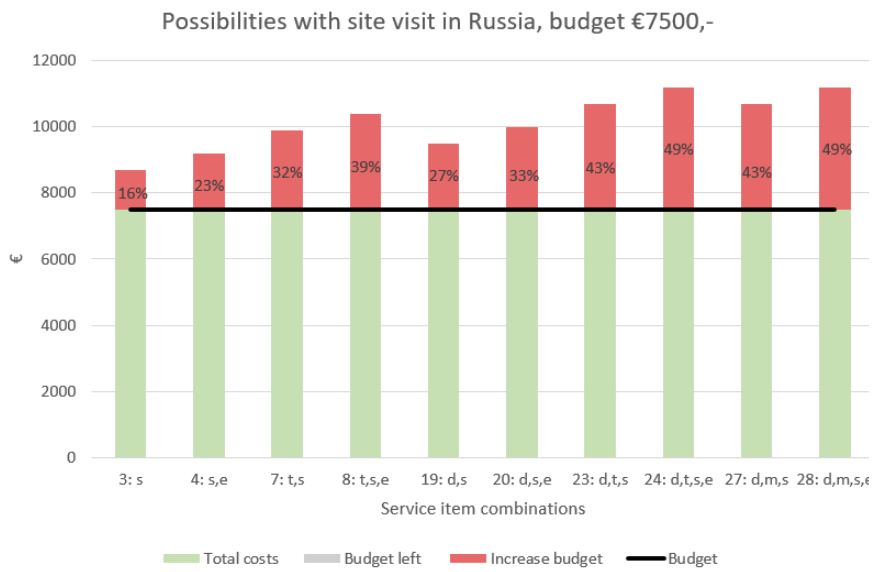


Figure 31: Total costs with site visit in Russia, with budget limit of €7500,-

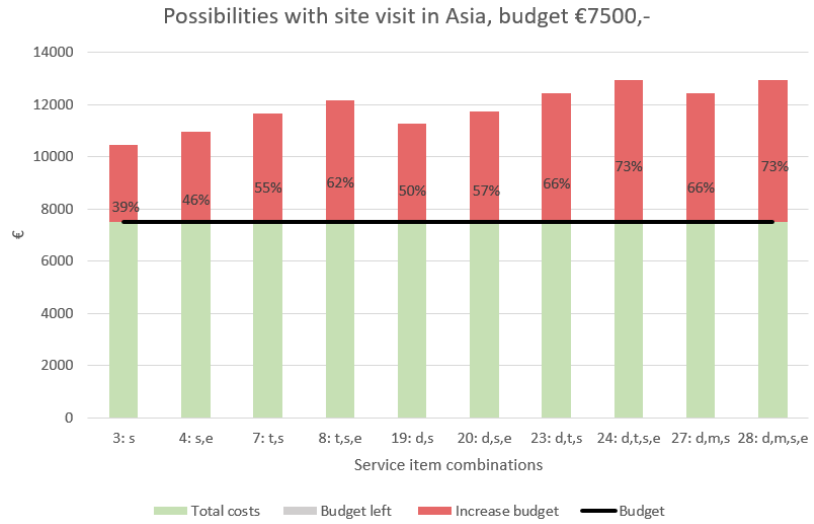


Figure 32: Total costs with site visit in Asia, with budget limit of €7500,-

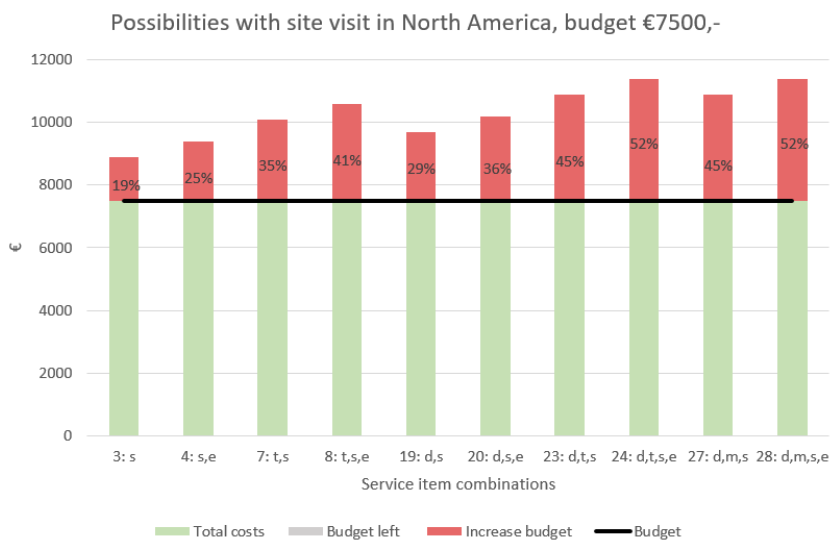


Figure 33: Total costs with site visit in North America, with budget limit of €7500,-

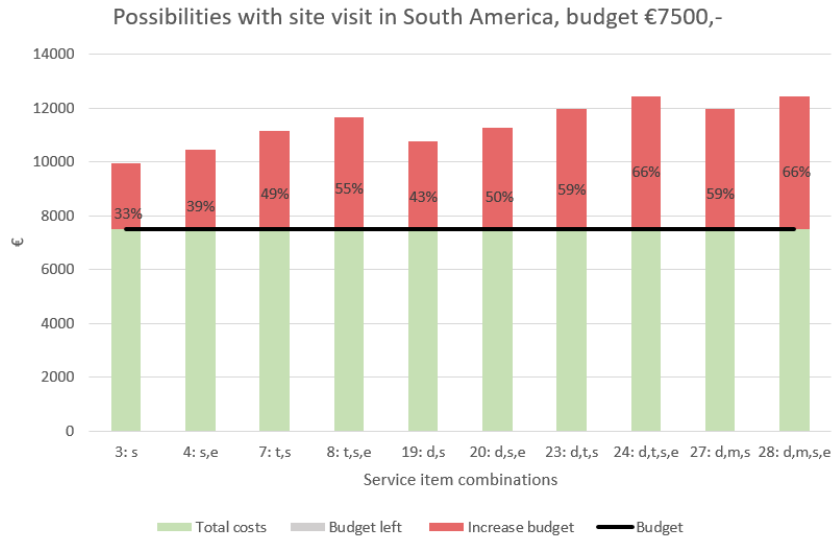


Figure 34: Total costs with site visit in South America, with budget limit of €7500,-

5.3. Conclusion

The tool developed in Excel can be used by Pentair to find the best service provision, provided the specific case of the brewery. The input on in what country/continent the brewery is filtrating, the preference in service items and the budget can be fully adjusted to the specific case of the brewery. Besides, the costs can also be adjusted, when it turns out the costs for a certain service item or certain travel costs will differ in a specific case. In this way, the tool can be used by Pentair to find the possibilities in combinations of service items with our without a site visit. Besides, for the possibilities when outsourcing the site visit, information is received on the maximum kilometers that can be traveled by the employee who is performing the site visit. This can be used in the future in order to decide on where to locate employees, which will depend on where the breweries are located who are interested in installing an BMF S4.

To analyze the results of the tool and give an advice on what the best service provision would be, the scenarios of three budgets of €2500, €4750 and €7500 are executed with the tool and discussed for each of the countries/continents the Netherlands, Europe, Africa, Russia, North America and South America. It can be concluded that with a budget of €2500, the site visit is not possible within the budget. When the budget is increased to €4750, this is still not possible for all countries/continents. However, when the budget is €7500 the site visit becomes possible, either outsourced or not. When the budget is only €2500, the best possibility of combinations contain three service items. However, when the budget is €4750 or €7500, it becomes possible to include four service items in the service provision.

To summarize, and conclude on the best possibilities of combination of service items Table 20 and 21 are derived. The distinction is made between the case the brewery prefers to include the site visit in the service provision (Table 20), and when the brewery is not (Table 21). Table 20 shows the advice on combination of service items per country/continent for a brewery with a budget of €7500,-. For breweries with a budget of €2500,- or €4750,- it is advised to exclude the site visit from the service provision. Table 21 shows the best possibilities of combination of service items without a site visit, which is the same for all countries/continents.

With site visit	
Country/Continent	**Budget €7500**
The Netherlands	1. d,t,s,e / d,m,s,e with outsourced site visit
	2. t,s,e / d,s,e / d,t,s / d,m,s or d,t,s,e / d,m,s,e with 3% increase of budget
Europe	1. d,t,s,e / d,m,s,e with outsourced site visit
	2. s / s,e / d,s or t,s,e / d,s,e with 1%/2% increase of budget
Africa	1. s, when brewery is not interested in other items
	2. d,s,e / t,s,e with outsourced site visit
Russia	Site visit has to be outsourced. Amount of service items can be determined when travel possibilities are specified for the exact location of the brewery.
Asia	
North America	
South America	

Table 20: Best possibilities per country/continent with budget €7500, including a site visit

Without site visit	Service items
Budget €2500	d,t,e or d,m,e
Budget €4750	d,m,t,e
Budget €7500	d,m,t,e

Table 21: Best possibilities per budget, without a site visit

6. Evaluation and validation

To evaluate the tool and results provided during this research, a presentation is given for three employees working with the BMF+ flux Compact S4. In this presentation, the working of the tool is explained, a demonstration of the tool is given and the results of the research are explained. Afterwards, an evaluation from is filled in by the three employees that attended the presentation. The evaluation form consists of questions about the functionality of the tool, the usability of the tool and the usefulness of the results of this research. In this way the results of the research and the tool can be evaluated and validated. First, Section 6.1 shows the results of the evaluation form. Next, Section 6.2 evaluates the results so the following research questions can be answered: *How can the optimal after-sales service model be implemented?* and *Does the optimal after-sales service model found solve the problem?*.

6.1. Results of the survey

Using an evaluation form, the design and functionality of the tool in Excel and the results and advices of this research have been evaluated. In this section the results of the evaluation form are presented, which have been filled in by 3 employees working with the after-sales service provision of the BMF+ flux Compact S4. The evaluation form that is handed to the employees can be found in Appendix D.

For the evaluation form, a five-level scale was used. The options the employees had to answer to the questions were strongly disagree, disagree, neutral, agree and strongly agree. Besides, some additional open questions are asked. To process the results of the evaluation forms, a scale of values from 1 to 5 are used, corresponding to the most negative feedback answer strongly disagree to the most positive feedback answer strongly agree. The only exception is question 4, for this question the assigned values of 1 to 5 are reversed. Here, the best value of 5 is assigned when strongly disagree is answered and the worst value of 1 is assigned when strongly agree is answered, since strongly disagree is the most positive answer possible for question 4. Table 22 shows the results per question, and the average per question category. The open questions are left out of the table and are discussed below.

Questions	**Minimum value**	**Maximum value**	**Mean**	**Standard deviation**
Functionality of the tool				
1. Information in the input form of the tool is complete	4	4	4	0
2. Information in the costs form of the tool is complete	4	4	4	0
3. Information in the output form of the tool is complete	4	4	4	0
4. The tool contains unnecessary information	4	5	4.67	0.58
5. The tool is useful in order to further develop the service contracts for the BMF+ flux Compact S4	4	5	4.67	0.58
6. The tool is useful in order to further develop the outsourcing of site visits	4	5	4.67	0.58
Usability of the tool				
9. The layout of the tool is user friendly	4	5	4.33	0.58
10. The usage of the tool is well understandable	4	4	4	0
11. The use of colors is well understandable	4	5	4.33	0.58

12. My knowledge of Microsoft Excel is well enough so I can adjust the design of the tool if necessary	4	5	4.67	0.58
13. My knowledge of the Visual Basics Application in Microsoft Excel is well enough so I can adjust the programming code of the tool if necessary	4	4	4	0
Usage of results of the research				
14. The research did contribute to get more insights in the after-sales service provision for the BMF+ Flux Compact S4	4	5	4.33	0.58
15. I have the intention to make use of the conclusions and recommendations of the research in further developing the service contracts for the BMF+ Flux Compact S4	4	5	4.33	0.58
Average results of Functionality of the tool	**4**	**4.5**	**4.33**	**0.29**
Average results of Usability of the tool	**4**	**4.6**	**4.27**	**0.35**
Average results of Usage of results of the research	**4**	**5**	**4.33**	**0.58**

Table 22: Results of evaluation form

Results open questions

Functionality of the tool

7. If question 1,2 and/or 3 is answered with disagree or strongly disagree, which information do you think is missing in the tool?
8. If question 4 is answered with agree or strongly agree, which information do you think is unnecessary?

Question seven and eight were not applicable, since no of the employees did answer question 1,2 and/or 3 with disagree or strongly disagree or question 4 with agree or strongly agree.

Usage of results of the research

16. Do you have additional feedback?

The additional feedback points given by the employees are:

- Include for traveling costs a line for additional costs like visa.
- The tool is a great start and we need to work with the tool to develop it further and if necessary add fields/information.
- Thanks for your research, it will be a very useful tool.

8.1. Analysis of results survey

In Section 6.1 the results of the evaluation form are shown in Table 22. The average opinion of the employees about the tool and the results of the research is given, where 1 is the most negative possible result and 5 the most positive possible result. Since the value 3 is neutral, value 1 and 2 are negative feedback and value 4 and 5 are positive feedback. Next to the minimum and maximum value and the mean of the responses, the standard deviation is given. The higher the standard deviation, the more the opinion of the employees differed.

For all questions, the minimum value is 4 out of 5, so it can be concluded that the feedback on all questions is positive. On the first part, the functionality of the tool, all employees agreed on that the information in the tool is complete, there is no unnecessary information which validates the tool. The average value given

to the functionality of the tool is 4.33, with a standard deviation of 0.29. The standard deviation of the answers on question 1, 2 and 3 is equal to zero, so all employees shared the same opinion. Questions 4, 5 and 6 were answered with a value of 4 or 5, which resulted in a reasonable standard deviation of 0.58. One comment given in the additional feedback is that Pentair has to work with the tool in order to find out whether some information should be added. To implement the tool, initially no further work has to be done, since Pentair stated no information is missing by now. Pentair finds the tool useful in order to further develop the service contracts for the breweries when a new BMF+ Compact Flux S4 will be installed. With this tool, a clear and structured starting point is created, so it can be developed in the future, when adding other aspects that are out of scope and depend on the preferences of the breweries.

The second part, the usability of the tool is also evaluated positively. Again the questions are answered with a value of 4 and 5, which resulted in an average value of 4.27 with a standard deviation of only 0.35. So, the employees agreed on that the layout and use of colors make the information easy to understand and it is well understandable how to use the tool. Besides, the employees do have enough knowledge of Microsoft Excel and the Visual Basics Application in order to adjust the tool if necessary in the future.

The tool, combined with the conclusions and recommendations of the research make this research contribute to the development of new service contracts of the BMF S4. The results on the questions about the usage of the results of the research do have on average the highest standard deviation. However, it is still only 0.58, where the minimum value given is 4 and the average value is 4.33, so all employees responded positively to these questions. The employees do intend to make use of the conclusions and recommendations of this research. With making use of the tool, Pentair is able to set new service contracts in a more structured way than before and a lot of insights in the possibilities of the service provision are created.

8.2. Conclusion

Pentair is positive on the results of the research. The tool made in Excel gives useful insights in the possibilities of the service provision for the BMF S4 and is easy adjustable and applicable to the different preferences of the breweries. To implement the tool, initially no extra work is needed since the information in the tool is complete. When Pentair will work with the tool in the future and actually apply the results when setting up new contracts for the BMF S4, further development may be needed since new information can be gained by being in consultation with the future breweries. However, on the cost perspective this research contributed to solving the problem of not knowing how to arrange the service provision for the BMF S4. With use of this research, Pentair made an actual step in the development of the service contracts for the BMF S4.

9. Conclusions and recommendations

Within this thesis the possibilities for an optimal after-sales service provision of the new filtration system BMF+ flux Compact S4 are researched. Through analyzing multiple scenarios and building a tool, suggestions were provided for service combinations which can be offered in a service contract for the BMF S4. In Section 7.1, the main conclusions and answers to the research questions are discussed. Then, in Section 7.2 the recommendations to Pentair conducted from this research are explained together with the advices on future research. At last, Section 7.3 reviews the contribution of the research.

9.1. Conclusion on research questions

In Section 1.6, nine research questions were formulated in order to answer the main research question:

What would be the optimal after-sales service provision for the BMF+ flux Compact S4?

The answers to the nine sub-questions lead to an answer on this main research question, so recommendations can be given to Pentair on the optimal after-sales service provision for the BMF+ flux compact S4. The answers to the sub-questions are summarized below.

What is the current situation of the after-sales service model for the larger filtration systems?

Nowadays Pentair has about 200 larger beer filtration systems running, which vary from a filtration capacity of 100-900 hectoliters per hour. These breweries are located all over the world, which makes Pentair a global company. The after-sales service provision that is offered to the larger breweries distinguish three different levels of service packages, denoted by level A, B and C. These service packages consist of a combination of some of the five service items Pentair provides: (1) Data connection, (2) Monitoring and Reporting, (3) Technical helpdesk service, (4) Site visit and (5) 24/7 emergency help line. Level A is a basic package, with only containing the data connection and monitoring & reporting. Level B is more expensive and extensive, because in addition to level A it also contains the technical helpdesk item. Level C is the most complete package, since all five service items Pentair has to offer are included.

What is the current situation of the BMF+ flux Compact S4?

Nowadays the situation of the BMF+ flux Compact S4 can be described by there is no structured organization. The BMF+ flux Compact S4 is a much smaller installation which is used by craft breweries or other small breweries with a capacity of only 30-60 hectoliters per hour. Currently 20 breweries have a BMF S4 running. Only the most necessary service is provided to these breweries, based on an agreement which is individually made per brewery by hand.

What different types of support does after-sales service contain?

By performing a literature review, a discussion on different aspects of after-sales service is given. Besides, it is found that after-sales service support items can be classified as (1) General support, (2) Self-Support, (3) Remote support, (4) On-site support, (5) Indirect support and (6) Off-site support. The different categories are used to classify the service item of Pentair. In this way it was concluded all types of support were covered by the service items Pentair offers.

What methods can be used to redesign an after-sales service provision, considering costs?

In literature, two different methods to redesign after-sales services are found in order to save costs. The first method makes use of an integer programming model. In this model, the variables are specified as binary variables, so the variables can only take a value of 0 or 1, when it is excluded or included, respectively. The second method makes use of a mixed-integer optimization approach. Besides integer

values, the variables can also take non-integer values in this model. A part of the first method, the integer programming model, is used as a basis for the method in searching for the best service provision for the BMF S4. In this way, the derived formula, which will be discussed later on is substantiated by literature.

How can service items be combined to fit in an after-sales service model for the BMF+ flux Compact S4?

Since all service item categories found in literature were covered and Pentair stated not to be interested in exploring new service items, it is researched how the current service items of Pentair can be combined to fit in an after-sales service provision of the BMF S4. Since there is no contact with the future breweries, the individual interests of the breweries cannot be considered in this research. Therefore only the cost criterion, the budget the brewery has to spend is considered when finding combinations to fit in an after-sales service provision. To do so, the following formula is formulated, to calculate the total costs of all 32 combinations of the five service items: C = $c_d * d + c_m * m + c_t * t + c_s * s + c_e * e$. Here, the letters d/m/t/s/e stand for the five service items of Pentair and c_i for the costs per year of the corresponding service item i. The variables for the service items will take the value of 1 when it is included in the combination of items and 0 when it is excluded. When determining the total costs of all combinations of items, a distinction is made between the countries/continents: the Netherlands, Europe, Africa, Russia, Asia, North America and South America. This is done since the service item site visit depends on the travel costs.

What are the potential basis after-sales service models for the BMF+ flux Compact S4?

From the results on all possible combinations of service items, combinations are excluded by using the following two criteria: (1) when service item m, monitoring & reporting, is included, the data connection, item d, is necessary to be included too, and (2) the total costs should be less or equal to the maximum budget the brewery has to spend on the service agreement. To do calculations and determine the potential basis after-sales service models, the scenarios of a budget of €2500, €4750 and €7500 per year are used so the possibilities for the service model are explored for different brewery sizes. Besides the exclusion of combinations by the criteria, the possibilities in outsourcing the site visit is explored. In this way the site visit would cost less since the travel costs will decrease when a local employee offers the site visit. In this way there are more possibilities for including the site visit, since this is the most expensive service item. As potential basis after-sales service models, a table is given containing the 20 combination of service items that are left, for which is stated per country/continent and brewery type whether the combination is possible within the budget or not. This table is used as basis for the tool that is developed in order to find the optimal service provision.

What would be the optimal service provision for the BMF+ flux Compact S4?

The tool developed in Excel can be used by Pentair in order to find the optimal service provision for the BMF+ flux Compact S4 for the specific cases of the future breweries. The brewery can give input on what service items they are interested in and what their budget is and Pentair can adjust all costs involved to the specific case. The results of the tool are analyzed for the scenarios of the three different budgets of €2500, €4750 and €7500, for all countries/continents. A distinction is made between the scenario of when a brewery is interested in having a site visit, or not. In Table 23 and 24 the conclusion on the optimal service provision is given with and without a site visit, respectively. For breweries with a budget of €2500 and €4750 including the site visit does not fit within the budget.

With site visit	
Country/Continent	**Budget €7500**
The Netherlands	1. d,t,s,e / d,m,s,e with outsourced site visit
	2. t,s,e / d,s,e / d,t,s / d,m,s or d,t,s,e / d,m,s,e with 3% increase of budget
Europe	1. d,t,s,e / d,m,s,e with outsourced site visit
	2. s / s,e / d,s or t,s,e / d,s,e with 1%/2% increase of budget
Africa	1. s, when brewery is not interested in other items
	2. d,s,e / t,s,e with outsourced site visit
Russia	Site visit has to be outsourced. Amount of service items can be determined when travel possibilities are specified for the exact location of the brewery.
Asia	
North America	
South America	

Table 23: Best possibilities per country/continent with budget €7500, including a site visit

Without site visit	Service items
Budget €2500	d,t,e or d,m,e
Budget €4750	d,m,t,e
Budget €7500	d,m,t,e

Table 24: Best possibilities per budget, without a site visit

How can the optimal after-sales service model be implemented?

From the evaluation form on the tool and the results and advices of the research, it can be concluded there is no much needed yet to implement the optimal after-sales service model. The information in the tool in Excel is complete and there is no unnecessary information. The tool gives clear insights in the possibilities of the service provision for the BMF S4. Pentair finds the tool useful in order to further develop the service contracts for the breweries when a new BMF S4 is installed. Since the tool is fully adjustable to the specific preferences and cost aspects of the future breweries, Pentair stated to be able to use the tool immediately. When the tool will be in use for a while, it may occur some aspects are for example missing or should be adjusted in the tool. This can in the future be implemented by the employees of Pentair themselves, since it is concluded from the evaluation form that the knowledge on Microsoft Excel and the Visual Basic Application is well enough to do so.

Does the optimal after-sales service model found solve the problem?

Pentair is positive on the results of the research and have the intention to use the results and recommendations. Developing a whole finished service contract to offer to breweries in the future is out of scope of this research. To do so, contact with the breweries is needed to further elaborate on their preferences and aspects such as sales do come in, which is beyond the scope. Therefore the problem is approached from the cost perspective. In this perspective, useful findings on the optimal after-sales service provision for the BMF S4 are found. This clear overview on possibilities can be used by Pentair as a start of developing and finalizing the service contracts for the BMF S4. So, from the cost perspective the optimal after-sales service model found in this research does solve the problem.

9.2. Recommendations and future research

Based on the performed research and the conclusions on the research questions, six recommendations to Pentair are formulated on the use of the results of this thesis and future research.

1. Show the breweries all possibilities on combinations of service items in the budget, so it can be discussed what their preferences are and an optimal configuration can be established.
2. Besides showing the possibilities that are an option within the budget, do shown the possibilities on what service you have to offer when the budget is increased. In this way the brewery can make a trade off whether they would think it is worth it to pay some more.
3. In this research fixed costs per year for the service items are used in the calculations. In the future, it can be interesting to research whether a slight change in these costs by for example offering a few less hours of help for a certain item can lead to adding an extra item to the service provision.
4. In this research, for the costs of the site visit only a distinction is made between the countries/continents the Netherlands, Europe, Africa, Russia, Asia, North America and South America. In a future research this can be extended by for example dividing these areas into smaller ones. It can be researched what the effect is on the possibilities of offering the site visit is by specifying the costs of the site visit even more.
5. In addition to recommendation 4, a future research can be performed on the location of employees to offer the outsourced site visits. In this research the possible amount of kilometers that can be traveled by the employee were derived. When in the future it is more clear in what specific areas the breweries are located who are willing to install a BMF S4, it can be researched where an employee should be optimally located in order to perform the site visits in that area. In this way, an even better insight in the possibilities of outsourcing the site visit can be obtained.
6. When in the future with use of the tool it is explored what the more likely preferences of the breweries are and the service contracts are developed a bit further, research can be done on the possibilities of incorporating the hectoliter fee in the contracts.

9.3. Contribution

This research is performed for the specific case of Pentair. The practical contribution to the company is the tool build in Excel. By using this tool, the company is able to make decisions when offering a service contract to future breweries based on actual facts in terms of costs, instead of doing it just by hand hoping it will turn out well. The tool is fully specified to the case of Pentair. Therefore, it is not likely the tool can be used by other companies. However, the thesis can be used as a guideline in order to tackle a similar problem in the same structured way. Besides a practical contribution, this research is also a theoretical contribution to the company. By performing the literature review followed by defining the formulas and restrictions in a mathematical way it gave Pentair new insights on how to write down these aspects of the problem in a correct mathematical way.

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Appendix A Dashboard reporting filtration line

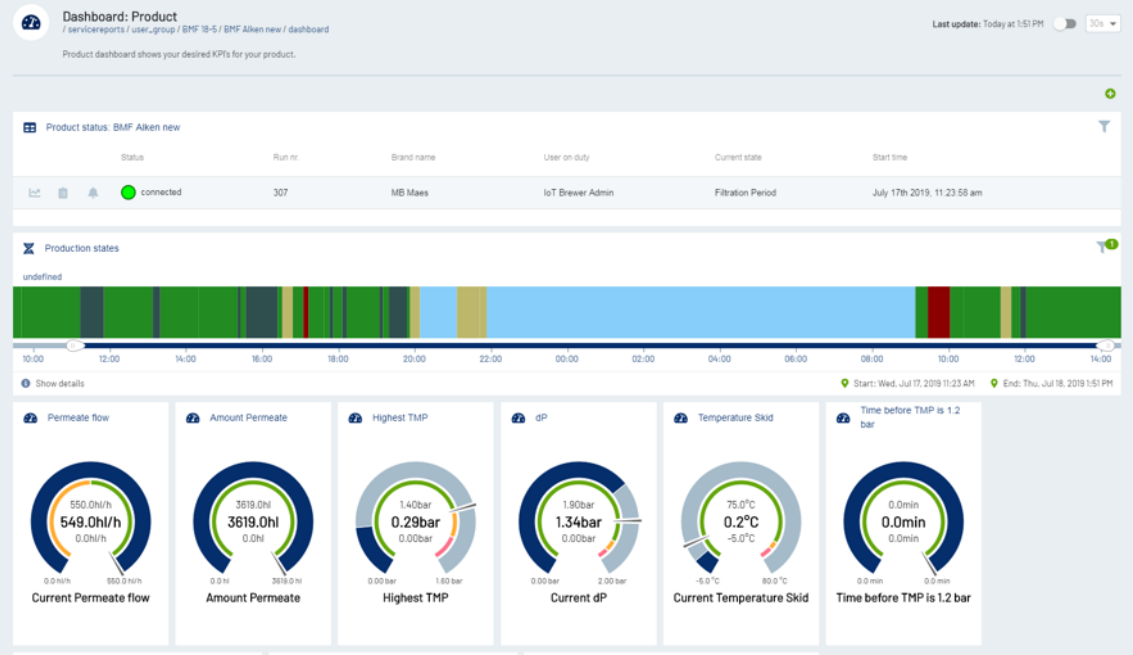

Figure 35: Dashboard, visual representation of values (source: Pentair)

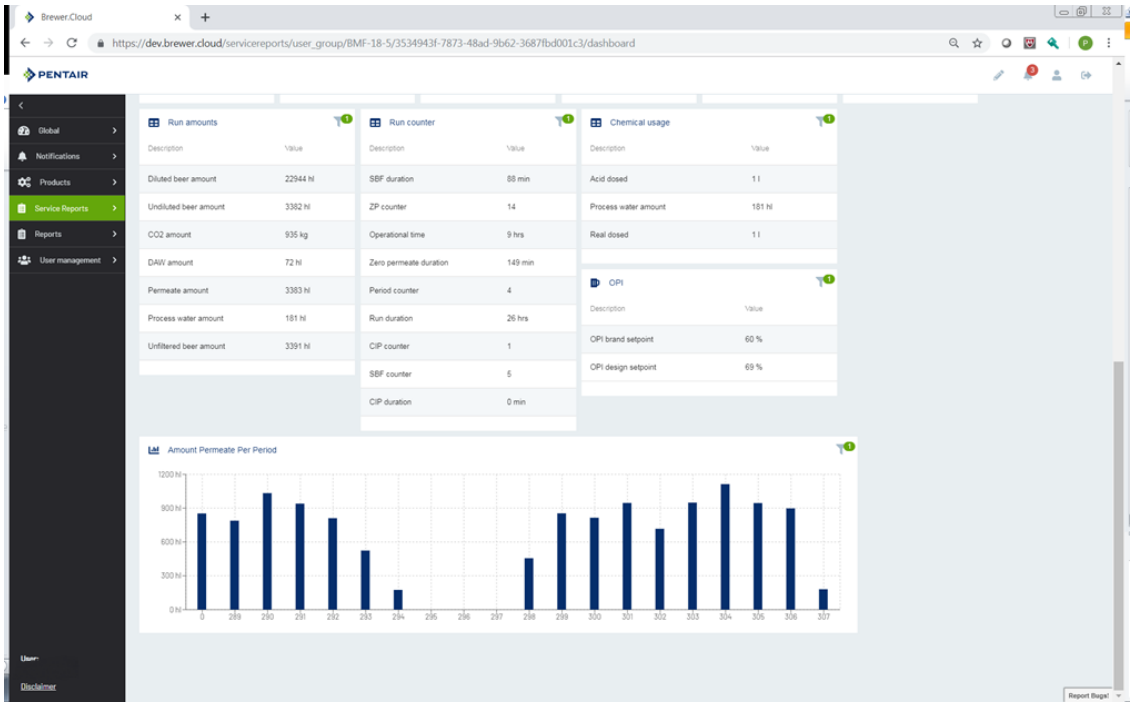

Figure 36: Dashboard, more detailed values (source: Pentair)

Appendix B Service items combinations

Combination number	d	m	t	s	e
1	0	0	0	0	0
2	0	0	0	0	1
3	0	0	0	1	0
4	0	0	0	1	1
5	0	0	1	0	0
6	0	0	1	0	1
7	0	0	1	1	0
8	0	0	1	1	1
9	0	1	0	0	0
10	0	1	0	0	1
11	0	1	0	1	0
12	0	1	0	1	1
13	0	1	1	0	0
14	0	1	1	0	1
15	0	1	1	1	0
16	0	1	1	1	1
17	1	0	0	0	0
18	1	0	0	0	1
19	1	0	0	1	0
20	1	0	0	1	1
21	1	0	1	0	0
22	1	0	1	0	1
23	1	0	1	1	0
24	1	0	1	1	1
25	1	1	0	0	0
26	1	1	0	0	1
27	1	1	0	1	0
28	1	1	0	1	1
29	1	1	1	0	0
30	1	1	1	0	1
31	1	1	1	1	0
32	1	1	1	1	1

Table 25: All possible combinations of service items

Brewery Budget €2500		Total Costs (€)						
Combination number	**Service items**	**Netherlands**	**Europe**	**Africa**	**Russia**	**Asia**	**North America**	**South America**
1	-	0	0	0	0	0	0	0
2	e	500	500	500	500	500	500	500
3	s	5250	6350	7500	8700	10450	8900	9950
4	s,e	5750	6850	8000	9200	10950	9400	10450
5	t	1200	1200	1200	1200	1200	1200	1200
6	t,e	1700	1700	1700	1700	1700	1700	1700
7	t,s	6450	7550	8700	9900	11650	10100	11150
8	t,s,e	6950	8050	9200	10400	12150	10600	11650
9	m	1200	1200	1200	1200	1200	1200	1200
10	m,e	1700	1700	1700	1700	1700	1700	1700
11	m,s	6450	7550	8700	9900	11650	10100	11150
12	m,s,e	6950	8050	9200	10400	12150	10600	11650
13	m,t	2400	2400	2400	2400	2400	2400	2400
14	m,t,e	2900	2900	2900	2900	2900	2900	2900
15	m,t,s	7650	8750	9900	11100	12850	11300	12350
16	m,t,s,e	8150	9250	10400	11600	13350	11800	12850
17	d	800	800	800	800	800	800	800
18	d,e	1300	1300	1300	1300	1300	1300	1300
19	d,s	6050	7150	8300	9500	11250	9700	10750
20	d,s,e	6550	7650	8800	10000	11750	10200	11250
21	d,t	2000	2000	2000	2000	2000	2000	2000
22	d,t,e	2500	2500	2500	2500	2500	2500	2500
23	d,t,s	7250	8350	9500	10700	12450	10900	11950
24	d,t,s,e	7750	8850	10000	11200	12950	11400	12450
25	d,m	2000	2000	2000	2000	2000	2000	2000
26	d,m,e	2500	2500	2500	2500	2500	2500	2500
27	d,m,s	7250	8350	9500	10700	12450	10900	11950
28	d,m,s,e	7750	8850	10000	11200	12950	11400	12450
29	d,m,t	3200	3200	3200	3200	3200	3200	3200
30	d,m,t,e	3700	3700	3700	3700	3700	3700	3700
31	d,m,t,s	8450	9550	10700	11900	13650	12100	13150
32	d,m,t,s,e	8950	10050	11200	12400	14150	12600	13650

Table 26: Exclusion of combinations of service items for breweries with a budget of €2500, per country/continent

Brewery Budget €4750		Total Costs (€)						
Combination number	**Service items**	**Netherlands**	**Europe**	**Africa**	**Russia**	**Asia**	**North America**	**South America**
1	-	0	0	0	0	0	0	0
2	e	500	500	500	500	500	500	500
3	s	5250	6350	7500	8700	10450	8900	9950

4	s,e	5750	6850	8000	9200	10950	9400	10450
5	t	1200	1200	1200	1200	1200	1200	1200
6	t,e	1700	1700	1700	1700	1700	1700	1700
7	t,s	6450	7550	8700	9900	11650	10100	11150
8	t,s,e	6950	8050	9200	10400	12150	10600	11650
9	m	1200	1200	1200	1200	1200	1200	1200
10	m,e	1700	1700	1700	1700	1700	1700	1700
11	m,s	6450	7550	8700	9900	11650	10100	11150
12	m,s,e	6950	8050	9200	10400	12150	10600	11650
13	m,t	2400	2400	2400	2400	2400	2400	2400
14	m,t,e	2900	2900	2900	2900	2900	2900	2900
15	m,t,s	7650	8750	9900	11100	12850	11300	12350
16	m,t,s,e	8150	9250	10400	11600	13350	11800	12850
17	d	800	800	800	800	800	800	800
18	d,e	1300	1300	1300	1300	1300	1300	1300
19	d,s	6050	7150	8300	9500	11250	9700	10750
20	d,s,e	6550	7650	8800	10000	11750	10200	11250
21	d,t	2000	2000	2000	2000	2000	2000	2000
22	d,t,e	2500	2500	2500	2500	2500	2500	2500
23	d,t,s	7250	8350	9500	10700	12450	10900	11950
24	d,t,s,e	7750	8850	10000	11200	12950	11400	12450
25	d,m	2000	2000	2000	2000	2000	2000	2000
26	d,m,e	2500	2500	2500	2500	2500	2500	2500
27	d,m,s	7250	8350	9500	10700	12450	10900	11950
28	d,m,s,e	7750	8850	10000	11200	12950	11400	12450
29	d,m,t	3200	3200	3200	3200	3200	3200	3200
30	d,m,t,e	3700	3700	3700	3700	3700	3700	3700
31	d,m,t,s	8450	9550	10700	11900	13650	12100	13150
32	d,m,t,s,e	8950	10050	11200	12400	14150	12600	13650

Table 27: Exclusion of combinations of service items for breweries with a budget of €4750, per country/continent

Brewery Budget €7500		**Total Costs (€)**						
Combination number	**Service items**	**Netherlands**	**Europe**	**Africa**	**Russia**	**Asia**	**North America**	**South America**
1	-	0	0	0	0	0	0	0
2	e	500	500	500	500	500	500	500
3	s	5250	6350	7500	8700	10450	8900	9950
4	s,e	5750	6850	8000	9200	10950	9400	10450
5	t	1200	1200	1200	1200	1200	1200	1200
6	t,e	1700	1700	1700	1700	1700	1700	1700
7	t,s	6450	7550	8700	9900	11650	10100	11150
8	t,s,e	6950	8050	9200	10400	12150	10600	11650

9	m	1200	1200	1200	1200	1200	1200	1200
10	m,e	1700	1700	1700	1700	1700	1700	1700
11	m,s	6450	7550	8700	9900	11650	10100	11150
12	m,s,e	6950	8050	9200	10400	12150	10600	11650
13	m,t	2400	2400	2400	2400	2400	2400	2400
14	m,t,e	2900	2900	2900	2900	2900	2900	2900
15	m,t,s	7650	8750	9900	11100	12850	11300	12350
16	m,t,s,e	8150	9250	10400	11600	13350	11800	12850
17	d	800	800	800	800	800	800	800
18	d,e	1300	1300	1300	1300	1300	1300	1300
19	d,s	6050	7150	8300	9500	11250	9700	10750
20	d,s,e	6550	7650	8800	10000	11750	10200	11250
21	d,t	2000	2000	2000	2000	2000	2000	2000
22	d,t,e	2500	2500	2500	2500	2500	2500	2500
23	d,t,s	7250	8350	9500	10700	12450	10900	11950
24	d,t,s,e	7750	8850	10000	11200	12950	11400	12450
25	d,m	2000	2000	2000	2000	2000	2000	2000
26	d,m,e	2500	2500	2500	2500	2500	2500	2500
27	d,m,s	7250	8350	9500	10700	12450	10900	11950
28	d,m,s,e	7750	8850	10000	11200	12950	11400	12450
29	d,m,t	3200	3200	3200	3200	3200	3200	3200
30	d,m,t,e	3700	3700	3700	3700	3700	3700	3700
31	d,m,t,s	8450	9550	10700	11900	13650	12100	13150
32	d,m,t,s,e	8950	10050	11200	12400	14150	12600	13650

Table 28: Exclusion of combinations of service items for breweries with a budget of €7500, per country/continent

Combination number	Service items	Total Costs (€)
3	s	4740
4	s,e	5240
7	t,s	5940
8	t,s,e	6440
19	d,s	5540
20	d,s,e	6040
23	d,t,s	6740
24	d,t,s,e	7240
27	d,m,s	6740
28	d,m,s,e	7240
31	d,m,t,s	7940
32	d,m,t,s,e	8440

Table 29: Total costs of combinations that include item s, without traveling costs (after excluding combinations with criterion (1))

Appendix C Results tool with (outsourcing) site visit

Without site visit

Budget €2500

Possibilities without site visit				
Combination nr	Service items	Total costs	Budget left	Budget should increase by
2	e	500	2000	0
5	t	1200	1300	0
6	t,e	1700	800	0
17	d	800	1700	0
18	d,e	1300	1200	0
21	d,t	2000	500	0
22	d,t,e	2500	0	0
25	d,m	2000	500	0
26	d,m,e	2500	0	0
29	d,m,t	3200	0	700
30	d,m,t,e	3700	0	1200

Figure 37: Possibilities without site visit, budget €2500

Budget €4750

Possibilities without site visit				
Combination nr	Service items	Total costs	Budget left	Budget should increase by
2	e	500	4250	0
5	t	1200	3550	0
6	t,e	1700	3050	0
17	d	800	3950	0
18	d,e	1300	3450	0
21	d,t	2000	2750	0
22	d,t,e	2500	2250	0
25	d,m	2000	2750	0
26	d,m,e	2500	2250	0
29	d,m,t	3200	1550	0
30	d,m,t,e	3700	1050	0

Figure 38: Possibilities without site visit, budget €4750

Budget €7500

Possibilities without site visit				
Combination nr	Service items	Total costs	Budget left	Budget should increase by
2	e	500	7000	0
5	t	1200	6300	0
6	t,e	1700	5800	0
17	d	800	6700	0
18	d,e	1300	6200	0
21	d,t	2000	5500	0
22	d,t,e	2500	5000	0
25	d,m	2000	5500	0
26	d,m,e	2500	5000	0
29	d,m,t	3200	4300	0
30	d,m,t,e	3700	3800	0

Figure 39: Possibilities without site visit, budget €7500

The Netherlands

Budget €7500

Possibilities with site visit				
Combination nr	Service items	Total costs	Budget left	Budget should increase by
3	s	5250	2250	0
4	s,e	5750	1750	0
7	t,s	6450	1050	0
8	t,s,e	6950	550	0
19	d,s	6050	1450	0
20	d,s,e	6550	950	0
23	d,t,s	7250	250	0
24	d,t,s,e	7750	0	250
27	d,m,s	7250	250	0
28	d,m,s,e	7750	0	250

Figure 40: Possibilities with site visit, The Netherlands, budget €7500

Europe

Budget €7500

Possibilities with site visit				
Combination nr	Service items	Total costs	Budget left	Budget should increase by
3	s	6350	1150	0
4	s,e	6850	650	0
7	t,s	7550	0	50
8	t,s,e	8050	0	550
19	d,s	7150	350	0
20	d,s,e	7650	0	150
23	d,t,s	8350	0	850
24	d,t,s,e	8850	0	1350
27	d,m,s	8350	0	850
28	d,m,s,e	8850	0	1350

Figure 41: Possibilities with site visit, Europe, budget €7500

Africa

Budget €7500

Possibilities with site visit				
Combination nr	Service items	Total costs	Budget left	Budget should increase by
3	s	7500	0	0
4	s,e	8000	0	500
7	t,s	8700	0	1200
8	t,s,e	9200	0	1700
19	d,s	8300	0	800
20	d,s,e	8800	0	1300
23	d,t,s	9500	0	2000
24	d,t,s,e	10000	0	2500
27	d,m,s	9500	0	2000
28	d,m,s,e	10000	0	2500

Figure 42: Possibilities with site visit, Africa, budget €7500

Russia

Budget 7500

Possibilities with site visit				
Combination nr	Service items	Total costs	Budget left	Budget should increase by
3	s	8700	0	1200
4	s,e	9200	0	1700
7	t,s	9900	0	2400
8	t,s,e	10400	0	2900
19	d,s	9500	0	2000
20	d,s,e	10000	0	2500
23	d,t,s	10700	0	3200
24	d,t,s,e	11200	0	3700
27	d,m,s	10700	0	3200
28	d,m,s,e	11200	0	3700

Figure 43: Possibilities with site visit, Russia, budget €7500

Asia

Budget €7500

Possibilities with site visit				
Combination nr	Service items	Total costs	Budget left	Budget should increase by
3	s	10450	0	2950
4	s,e	10950	0	3450
7	t,s	11650	0	4150
8	t,s,e	12150	0	4650
19	d,s	11250	0	3750
20	d,s,e	11750	0	4250
23	d,t,s	12450	0	4950
24	d,t,s,e	12950	0	5450
27	d,m,s	12450	0	4950
28	d,m,s,e	12950	0	5450

Figure 44: Possibilities with site visit, Asia, budget €7500

North America

Budget €7500

Possibilities with site visit				
Combination nr	Service items	Total costs	Budget left	Budget should increase by
3	s	8900	0	1400
4	s,e	9400	0	1900
7	t,s	10100	0	2600
8	t,s,e	10600	0	3100
19	d,s	9700	0	2200
20	d,s,e	10200	0	2700
23	d,t,s	10900	0	3400
24	d,t,s,e	11400	0	3900
27	d,m,s	10900	0	3400
28	d,m,s,e	11400	0	3900

Figure 45: Possibilities with site visit, North America, budget €7500

South America

Budget €7500

Possibilities with site visit				
Combination nr	Service items	Total costs	Budget left	Budget should increase by
3	s	9950	0	2450
4	s,e	10450	0	2950
7	t,s	11150	0	3650
8	t,s,e	11650	0	4150
19	d,s	10750	0	3250
20	d,s,e	11250	0	3750
23	d,t,s	11950	0	4450
24	d,t,s,e	12450	0	4950
27	d,m,s	11950	0	4450
28	d,m,s,e	12450	0	4950

Figure 46: Possibilities with site visit, South America, budget €7500

Appendix D Tool evaluation form

Evaluation form after-sales service tool BMF+ flux Compact S4

This survey is made to get insights in the opinion of the employees of Pentair working with the BMF+ flux Compact S4 on the tool made in Excel to determine the possibilities in after-sales service for the smaller breweries. The responses to this evaluation form will be processed anonymously. The from consists of 16 questions divided into three subjects, (1) Functionality of the tool, (2) Usability of the tool and (3) Usage of results of the research. With use of the responses to this evaluation form, an evaluation and advise on the implementation of the result of this research will be written and it will be evaluated to what extend the problem is solved.

(1) Functionality of the tool

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1. Information in the input form of the tool is complete	◯	◯	◯	◯	◯
2. Information in the costs form of the tool is complete	◯	◯	◯	◯	◯
3. Information in the output form of the tool is complete	◯	◯	◯	◯	◯
4. The tool contains unnecessary information	◯	◯	◯	◯	◯
5. The tool is useful in order to further develop the service contracts for the BMF+ flux Compact S4	◯	◯	◯	◯	◯
6. The tool is useful in order to further develop the outsourcing of site visits	◯	◯	◯	◯	◯

7. If question 1, 2 and/or 3 is answered with disagree or strongly disagree, which information do you think is missing in the tool?

8. If question 4 is answered with agree or strongly agree, which information do you think is unnecessary?

Usability of the tool

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
9. The layout of the tool is user friendly	○	○	○	○	○
10. The usage of the tool is well understandable	○	○	○	○	○
11. The use of colors is well understandable	○	○	○	○	○
12. My knowledge of Microsoft Excel is well enough so I can adjust the design of the tool if necessary	○	○	○	○	○
13. My knowledge of the Visual Basics Application in Microsoft Excel is well enough so I can adjust the programming code of the tool if necessary	○	○	○	○	○

(2) Usage of results of the research

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
14. The research did contribute to get more insights in after-sales service provision for the BMF+ Flux Compact S4	○	○	○	○	○
15. I have the intention to make use of the conclusions and recommendations of the research in further developing the service contracts for the BMF+ Flux Compact S4	○	○	○	○	○

16. Do you have additional feedback?

End of evaluation form.