Towards an effective layout design and improved inbound logistics via Direct Line Feed

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Management Summary

The research was conducted at the headquarters of HEINEKEN Netherlands established in Zoeterwoude, which is also the largest brewery of HEINEKEN worldwide. The research consists of two consecutive researches (i.e., phases), both concerning the inbound supply to the packaging lines.

Research phase I – Logistical organization and layout redesign of the Foleyplein

Problem description and research objective

HEINEKEN has decided to build a new packaging line (line 52) that will serve the export markets. This means that it will produce one-way bottles (i.e., non-returnable bottles), which need to be supplied from several bottle plants to the brewery. The empty bottle supply to line 52 will occur via the Foleyplein, which is the square that is also used for the supply to the existing packaging lines 51 (bottles supplied via DLF) and 6 (cans supplied via conventional). The specific supply method for line 52 however is yet unknown. Meanwhile the amount of space on this square is limited. Therefore there is reasonable doubt whether, with the introduction of line 52, it is still possible to supply line 6 on the Foleyplein as is carried out in the current situation.

Central research question A

The research objective of phase I is to determine the most cost effective way to supply the packaging lines 52 (bottles) and 6 (cans) on the Foleyplein, while solving the limitation problem on the Foleyplein. The supply method for packaging line 51 will remain unchanged. The research question is defined as follows:

"What is the most cost effective layout design and logistical way to organize the supply of bottles and cans for the packaging lines 52 and 6?"

Results and conclusions

Several feasible alternatives are developed for the supply to line 52 (3 options) and line 6 (4 options).

Bottle line 52:

- Direct Line Feed (DLF) and Direct Docking (DD): The bottles are supplied by smaller trucks (26 pallets) and unloaded directly on the buffer conveyor of the packaging line. In this way no handling and storage on the brewery is needed. A part of the supply is carried out via the warehouse of the logistics service (i.e., Direct Docking), which is also the location where the safety stock is held.
- Conventional: The bottles are supplied by large trucks (42 or 30 pallets) and then unloaded and stored on a storage square, till a buiscar (internal transport mode) transports them to the packaging line. The conventional method is divided in two different options (A and B), which are the same till the moment they are transported internally (from the storage location to the Foleyplein) by buiscars. In option A the pallets are transferred from the buiscar to the packaging line by forklift trucks (FLT). In option B the buiscar is docked against the packing line and unloaded directly.

Can line 6:

- Direct Docking (DD): Similar method as for line 52, but completely supplied via the warehouse.
- Conventional: The cans are supplied by large trucks (42 or 30 pallets) and then unloaded and stored on the Foleyplein, till FLT's transport them to the packaging line. The conventional method is divided in three different options (A, B and C), which differ in the unloading on the Foleyplein. In option A and B the truck is parked on different locations on the Foleyplein. In option C the main road alongside the square is repositioned to create more space.

After the development of the alternatives, we evaluated the alternatives based on several quantitative (OPEX and CAPEX) and qualitative (e.g., safety) criteria to determine the preferred layout design and logistical organization.

Quantitative (financial) criteria evaluation						
Subject	Lines	DLF	Conventional A	Conventional B	Conventional C
Initial investment costs (CAPEX)	Line 52	Confidential			n/a
	Line 6				
Operational expenses (OPEX) *	Line 52				n/a
	Line 6				

* OPEX do not consist of all cost calculations associated with the alternatives. Only costs aspects that differ are taken into account

Qualitative (non-financial) criteria evaluation												
Line 52	DLF				Conventional A				Conventional B			
Line 6	DD	Conv. A	Conv. B	Conv. C	DD	Conv. A	Conv. B	Conv. C	DD	Conv. A	Conv. B	Conv. C
Score	++	□	+	+	n/a	--	--	-	+	-	□	□

We have concluded that, for the supply of packaging line 52 (bottles), the 'DLF' alternative is preferred. The 'DLF' alternative scored (much) better on the non-financial criteria. Considering the financial criteria, the difference in CAPEX is earned back within a reasonable time period (less than two years) as the OPEX are (much) lower.

For packaging line 6 (cans) we concluded that the 'conventional B' option is the preferred alternative. It is chosen over 'conventional A', since 'conventional B' scores better on the non-financial criteria, while the financials are equal. While both the 'DLF' and 'conventional C' alternative are (slightly) preferred on the non-financial criteria, they require a significant (i.e., too high) investment.

Recommendations

The main recommendations of phase I are (1) to supply line 52 via the DLF method and line 6 via the 'conventional B' method and (2) to design the Foleyplein as prescribed by these alternatives, with the required constructions and taking into account the required safety measures on the Foleyplein.

Research phase II – Improving the supply process via the Direct Line Feed method

Problem description and research objective

With the introduction of packaging line 52 (supplied via DLF) the total amount of packaging lines supplied via DLF will become 5 (lines 51, 52, 7, 81 and 82) in 2017. During phase I of this research some inefficiencies in the current DLF process have been encountered, which has given rise to phase II.

Central research questions B

The research objective of phase II is to develop an improvement plan for a more efficient process regarding the supply of empty bottles to the packaging lines via the DLF method, which reduces the cost associated with the process. The research question is defined as follows:

"How is the current DLF process organized and in what ways could the process be improved to organize the inbound supply of empty bottles via the DLF method more efficiently?"

Results and conclusions

We have developed an understanding of the DLF process, revealed several improvement opportunities that would reduce the costs associated with the process, estimated their benefit-effort ratio and selected only the most promising improvements (see RACI on next page).

The research has indicated that the DLF requirements have a low priority in several procedures and activities related to the inbound supply process of empty bottles. In some process steps it is the case that other aspects are more important, making the DLF performance subservient. However, in several procedures the subordination of the DLF process is unnecessary and could be improved.

Most of the improvement opportunities aim to improve the DLF performance and reduce the associated warehousing costs. The DLF performance is the percentage of the supply volume that has been supplied directly and hence did not need to use the intermediate warehouse. Savings related to the DLF performance could be obtained by:

- Improving the match between the production volume of DLF lines and the supply volume from the DLF location (opportunities 1, 3a and 3b (and 10b). Data suggests that this mismatch causes more than €X additional warehousing costs per year.
- Improving the match between the DLF supply and the DLF needs of the packaging lines during the week, by reducing the occurrences in which planned DLF trailers are forced to deviate to the warehouse (opportunities 8b, 9 and 10b). Data suggests that this mismatch causes more than €X additional warehousing costs per year.

These costs would probably increase even more with the additional DLF supply volume of line 52.

DLF performance analysis - Based on KPI overviews of LS (week 21 - 27 of 2016)					
Causes for DD	# Rides	DD%	# Pallets	H&B Costs	Yearly costs
Total amount					
DLF trailers rides					
DLF trailers planned			Confidential		
Sol or Desperados					
Mismatch					

The other improvements are related to the DLF process, but do not add to the DLF performance. They would improve the process and/or reduce the costs associated with the process by developing enhanced procedures, using the trailers more efficiently and increasing the focus on the DLF performance (opportunities 5, 8a, 8b and 10b).

Recommendations

The recommendations of phase II are summarized in a RACI, which shows the selected improvement opportunities and the associated responsibilities for further development and implementation.

RACI for DLF Concept

RESPONSIBLE = Executes
ACCOUNTABLE = Is end responsible
CONSULTED = Needs to be involved for advice
INFORMED = Needs to be informed

	Improvement opportunities	Heineken Global Procurement (HGP)	Contract Manager Packaging Materials (CM)	Manager Supply Chain Planning	Supply Chain Planner (TSCP)	Teammanager Operational Scheduling	Operational Scheduling (OS)	Manageer Inbound and Domestic Logistics	Logistic Support (LS)	Contract Manager Logistics Services (CM)	Hartog & Bikker (H&B)
1	Tune the bottle allocation agreements (with manufacturers) with the objective of DLF performance as much as possible	A	R		C						
3a	Asses DLF requirements during quarterly reviews to check improvement opportunities in allocation agreements		A R		C		C		C		
3b	Improve current procedure of determining material plan bottle allocations per week and increase focus on DLF performance		I	A	R		C		C		
5	Improve current procedure of determining supply plan, which enables to obtain an efficient DLF-supply planning in AS			A	I	R**	R*		C		
8a	Focus on an efficient trailer usage prior to the production week						C	A	R*	R**	C
8b	Focus on an efficient DLF-supply during the production week							A	R*	R**	C
9	Increase the ability to deviate from original supply route to other packaging lines							A	C	R	C
10b	Improve the KPI overview to continously improve the DLF performance and the related communication between departments		I		I		C	A	R*	R***	R*
	Required analysis										
-	Optimal trailer capacity						I	A	C	R	R

* Responsible for execution of chosen procedure
** Responsible for the determination of the optimal procedure
*** Responsible for creation and anticipation of KPI results

While all improvement opportunities could be carried out at the same time and while they need to be carried out by several stakeholders, we have provided a suggestion for the implementation priority.

Prioritization for implementation:	1	2	3	4	5	6	7	8
Improvement opportunities:	5	1	10b	8a	3a	3b	8b	9

Preface

Dear reader,

This document is the result of the graduation research that I have conducted at HEINEKEN Netherlands for the completion of my Master Industrial Engineering and Management (IE&M) at the University of Twente. Within IE&M I followed the specialization of Production and Logistics Management, which has provided a solid foundation of knowledge related to Supply Chain Management and logistics. To get acquainted with the real world of Supply Chain, I was eager to perform my graduation research in a large FMCG organization. I am very thankful for the opportunity and experience provided by HEINEKEN.

During this research I was part of the project leaders' team of the Customer Service and Logistics department, who enabled me to conduct the two consecutive researches. I would like to thank my supervisor Johan van de Bor, team manager Pieter van Kooten and team member Merel van Engelshoven for the opportunity, the experience, the guidance and support throughout the research. Additionally, I would like to thank all the stakeholders and other staff members that supported me during the research and freed up time to provide me with the required help and information. I really enjoyed working with all the (many) stakeholders that were involved in the research.

Lastly, I would like to thank Peter Schuur and Sipke Hoekstra for their advice and support, but also for the flexibility that enabled me to conduct my graduation research the way I have done.

I wish you much pleasure in reading my master's thesis. If there are any further questions, please feel free to contact me.

Kind regards,

Sander de Graaff

Concept explanations

Direct Line Feed (DLF) methodology: In the DLF methodology the empty bottles are supplied by smaller trucks (26 pallets), which are automatically loaded at the manufacturer and unloaded directly on the buffer conveyor of a packaging line. In this technique the trailer as well as the buffer conveyors of a packaging line (and at the manufacturer) consist of roller conveyors, which facilitates that the trailer can be loaded and unloaded without any handling. When the truck driver docks his trailer directly against the buffer conveyor and turns on the switch, the pallets will roll out automatically.

DLF locations: Bottle manufacturing facilities that support the DLF method. Which means that they are in relative close range of HEINEKEN and possess a loading conveyor. Moerdijk is the only DLF location in the original situation, but Leerdam has been added in week 20 of 2016.

DLF percentage: The percentage of supply volume that have been supplied via the DLF method, i.e., which has been transported directly and did not need to use the intermediate warehouse, relative to the total supply of empty bottles to that packaging line.

DLF volume: The bottle volume that could be supplied via DLF. In other words the joined production volume of the DLF locations that is processes on all (or a particular) DLF line(s).

Direct Docking (DD): When the transportation of empty bottles is not carried out directly from the supplier to the packaging lines (i.e., via DLF), but via the intermediate warehouse of Hartog & Bikker in Zoeterwoude, this transportation at HEINEKEN is called Direct Docking (DD). In this case the empty bottles are initially transported by combi's or LZV's (30 - 42 pallets) to the intermediate warehouse, where these larger trucks are unloaded by FLT's and the pallets are stored in the warehouse. When the bottles are needed at the packaging lines the FLT's place these pallets on the loading conveyor, next one of the 'shuttle trailers' is automatically loaded and subsequently the trailer will transport the bottles to the packaging line where it will dock against the buffer conveyor as is done in the DLF methodology.

Logistic services (i.e., 3PL): We use this concept for the organizations that are responsible for the transport and intermediate storage of the empty bottles and cans, which is mainly Hartog & Bikker.

Manufacturers or suppliers: We use the concepts of manufacturers and suppliers interchangeably for the organizations that produce the empty bottles and cans.

One-way bottles: One-way bottles are those bottles that do not contain a deposit and are meant to be thrown away after the usage by the customer.

One-way botte lines: One-way bottles lines are those lines that produce one-way bottles, mainly for the export markets. The difference with the returnable bottle lines lies in the fact that the returnable bottles lines are supplied by crates filled with returnable bottles, while one-way bottle lines need to be supplied by new empty bottles continuously.

Returnable bottles: Returnable bottles are those bottles that HEINEKEN would like to receive back after they have been used by the customer, which is the reason that those bottles contain a returnable deposit.

Abbreviations

3PL	-	Third-Party Logistics
AS	-	Advanced Scheduling (software program)
BPO	-	Business Process Optimization
CAPEX	-	Capital Expenditures
CM - LS	-	Contract Manager Logistic Services
CM - PM	-	Contract Manager Packaging Materials
CSE	-	Customer Service Export (department)
CSD	-	Customer Service Domestic (department)
DB	-	Den Bosch (brewery location)
DD	-	Direct Docking
DLF	-	Direct Line Feed
FLT	-	Forklift Truck
FTE	-	Full Time Equivalent
H&B	-	Hartog & Bikker (Logistics services / 3PL organization))
HGP	-	Heineken Global Procurement
HNL	-	Heineken Nederland
HNS	-	Heineken Nederland Supply
KPI	-	Key Performance Indicator
LD	-	Leerdam (DLF-location)
LS	-	Logistic Support (department)
LZV	-	Longer and Heavier Vehicles
MES	-	Manufacturing Execution System
MD	-	Moerdijk (DLF-location)
MTO	-	Make To Order
MTS	-	Make To Stock
OPEX	-	Operating Expenses
OPI	-	Operational Performance Indicator
OS	-	Operations Scheduling (department)
PO	-	Purchase Order
PLUTO	-	Database of SAP
SAP	-	Systems, Applications and Products (ERP system of HEINEKEN)
SIPOC	-	Supplier-Input-Process-Output-Customer (model/method)
SSCP	-	Strategic Supply Chain Planning (department)
TPM	-	Total Productive Management
TSCP	-	Tactical Supply Chain Planning (department)
WMS	-	Warehouse Management System
ZW	-	Zoeterwoude (brewery location)

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Research Introduction

Introduction to the entire research – phase I and phase II

1. Research introduction

In the framework of completing my Masters Industrial Engineering & Management at the University of Twente, I conducted my graduation research at HEINEKEN Netherlands. During this research I was part of the project leaders' team, where my research, separated in two different phases, focused on the inbound supply of empty bottle and cans to the packaging lines of Zoeterwoude. Direct Line Feed (DLF) is one of the supply methods and is a central concept in our research. The first phase focusses on the most preferred layout design and logistical organization of the Foleyplein to supply packaging lines 51, 52 (bottles) and 6 (cans). The second phase focusses on the bottle packaging lines that are supplied via Direct Line Feed (DLF), where we assess if the DLF process is carried out efficiently and which improvement opportunities could be identified to improve this process.

This first chapter contains the introduction to the project in which we discuss the motivation and structure. It starts with some required information about HEINEKEN in section 1.1. Thereafter in section 1.2 and 1.3 we explain the problem and discuss the problem statement and the scope of the research. In section 1.4 and 1.5 we discuss the objectives, deliverables and the research questions. In section 1.6 and 1.7 we elaborate on the methodology that has been applied and present an overview of the project and thesis structure.

1.1 Company information

In this first section a brief description of the company is given. More detailed background information is provided in appendix A.1.

HEINEKEN

HEINEKEN is established in 1864 and has expanded and acquired multiple companies over the years to become the international brewer it currently is, with brands like Heineken, Amstel, Desperados and Wieckse (HEINEKEN, 2016a). With a portfolio of 250 beers and ciders sold in 178 countries, HEINEKEN is the number one brewer in Europe and the second brewer by volume in the world (HEINEKEN, 2016c).

HEINEKEN Netherlands (HNL) consists of three breweries in Zoeterwoude, 's Hertogenbosch and Wijlre and a soft drink company Vrumona in Bunnik. Heineken Netherlands Supply (HNS) is part of HNL where about 1300 employees are responsible for the production and distribution of the beers and ciders that are brewed in the Netherlands for the domestic and export markets. Approximately 17.5 million hectolitre is produced by HNS in three breweries on more than 30 production lines, which is approximately 14% of the total production of Heineken worldwide. About 30% from this is designated for the Dutch market, approximately one third is exported to the United States and the rest is exported to more than 150 countries worldwide.

Brewery in Zoeterwoude

This research is conducted at the brewery in Zoeterwoude, which contains 14 packaging lines for 5 different types of products based on their primary packaging (e.g., bottles or cans), see Figure 1-1. Lines 11, 12, 21, 22, 3, 51, 81 and 82 produce bottles, line 6 produces cans, lines 41, 42 produce draught kegs, line 43 produces air kegs and line 9 produces returnable kegs.

For this research an (extra) distinction need to be made between returnable bottles (line 11 & 12) and one-way bottles (on the other lines). Returnable bottles are those bottles that HEINEKEN would like to receive back after they have been used by the customer, which is the reason that those bottles contain a returnable deposit. The one-way bottles on the other hand do not contain this deposit and are meant to be thrown away. The consideration for which concept to use is primarily based on the most cost effective option comparing the production costs with the distribution costs. For this reason the division to serve the different markets with one-way bottles or returnable bottles is mainly a result of the difference in distance of domestic versus export markets.

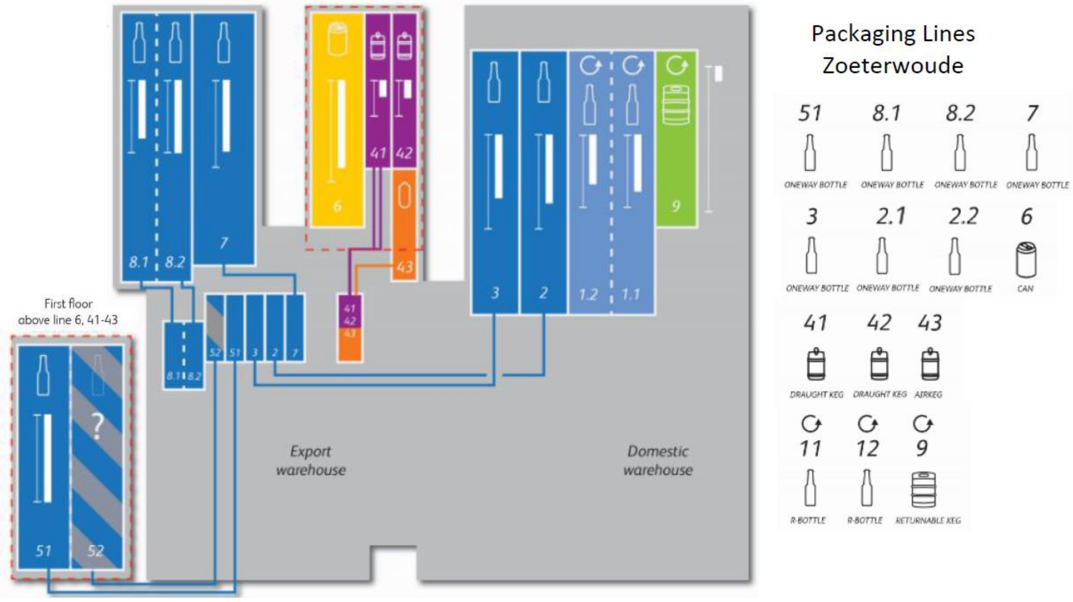


Figure 1-1: Layout of the packaging lines at the brewery in Zoeterwoude (van Kooten, 2016) [modified]

1.2 Problem description

The brewery in Zoeterwoude will need to increase the one-way bottle capacity (see appendix A.2 for the underlying reasons). This will be resolved by an additional packaging line named 'line 52', which will be build alongside the existing packaging line 51 throughout the entire brewery. Packaging line 52 will mainly absorb some of the production volume of the other one-way bottles lines, as explained in section 3.1.1 in further detail, which means that the overall production volume of Zoeterwoude will not increase too much initially.

The supply of empty bottles to line 52 will occur via the Foleyplein, which is the square via which also existing packaging lines 51 (bottles supplied via DLF) and 6 (cans supplied via conventional) are supplied. In this section a brief description of the current situation and the current layout design is given, see Figure 1-2. Section 3.1 shows the brewery overview and elaborates in further detail.

The methods that HEINEKEN uses in the current situation to supply the bottles and cans to the existing one-way bottle and can lines can roughly be divided in two ways:

- Conventional: In this method the empty bottles and cans are supplied in large trucks (30 to 42 pallets) and stored on the premises of the brewery till a forklift truck (FLT) will bring them to the required packaging lines.
- Direct Line Feed (DLF): In this method the empty bottles and cans are supplied by smaller trucks (20 or 26 pallets), which are automatically loaded at the manufacturer and unloaded directly on the buffer conveyor of a packaging line. In this technique the trailer as well as the buffer conveyors consist of roller conveyors, which facilitates that the trailer can be loaded and unloaded without any handling. When the truck driver docks his trailer directly against the buffer conveyor and turns on the switch, the pallets will roll out automatically.

In the current situation the supply of line 51 is provided via DLF, see Figure 1-2. All pallets with empty bottles are supplied directly to the buffer conveyor of packaging line 51, which results in the fact that there is no other storage location needed. The supply to the can packing line 6 works in the conventional way. Hereby the truck is parked as shown in Figure 1-2, where it is unloaded by a FLT.

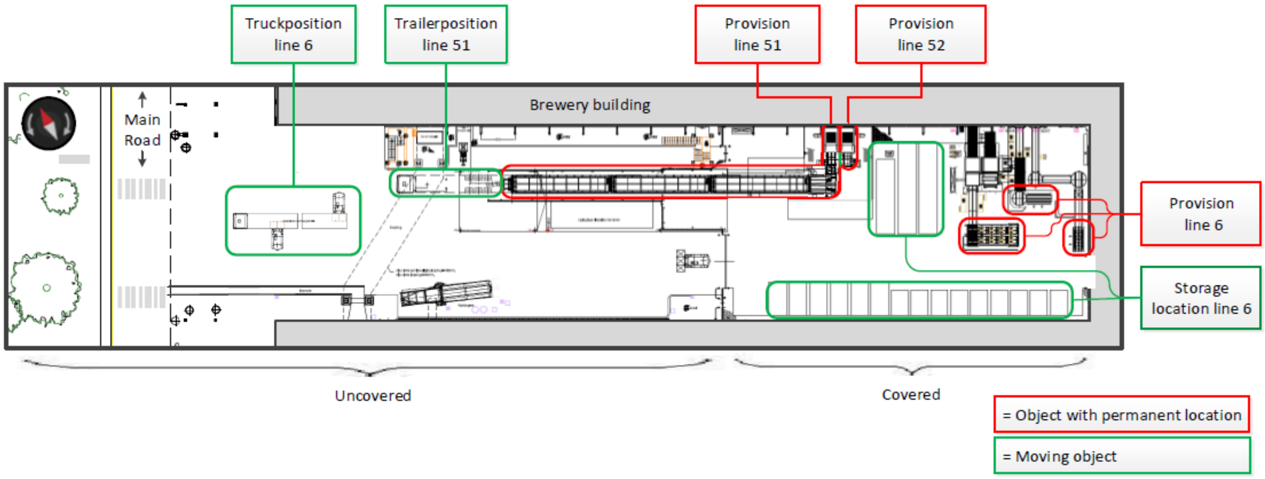


Figure 1-2: Overview of the Foleyplein (version I)

This FLT temporarily stores the pallets with empty cans on the assigned storage location, as also indicated in Figure 1-2, until packaging line 6 requires them. At that moment the FLT lifts the pallets with empty cans from the storage location and places them on one of the loading conveyors of line 6.

We consider two problem situations in this research, which we aim resolve in two consecutive phases.

Problem situation of Part I

Packaging line 52 will be supplied via the Foleyplein. However, the specific supply method from the manufacturers to the packaging line is yet unknown, because it is unclear what the most preferred supply method would be. Besides that, the amount of space for the supply of bottles (line 51 and 52) and cans (line 6) via the Foleyplein is limited, as can be seen in Figure 1-2. Due to this space limitation the expectation is that the implementation of line 52, including the physical construction of a new conveyor, will have a direct impact on the supply method of line 6. The problem statement is defined as follows:

"A space limitation problem on the Foleyplein as a result of the introduction of packaging line 52 and a lack of clarity related to the preferred supply methods"

The primarily need for the research of phase I is to indicate what the possibilities are for the supply of bottles and cans via the Foleyplein to lines 52 and 6 to resolve the limitations problem. Additionally it needs to determine the pros and cons associated with these supply possibilities to facilitate a well-founded decision. The supply method for packaging lines 51 will remain unchanged.

Problem situation of Part II

One of the conclusion of phase I, is that the DLF method is the most preferred supply method for packaging line 52. In phase II the scope of the research shifts from the packaging lines on the Foleyplein (lines 51, 52 and 6) towards all packaging lines in Zoeterwoude that will be supplied via the DLF method (lines 51, 52, 7, 81, 82). During phase I of our research we have encountered some inefficiencies in this DLF process, which has given rise for the research of phase II. The problem statement is defined as:

"Inefficiencies and a lack of understanding or priority throughout the supply chain concerning the DLF process"

This research of phase II needs to indicate how the current DLF process is organized and which improvement opportunities can be identified to resolve the challenges associated with the DLF method and organize the DLF process more efficiently.

1.3 Research scope

The scope of this research includes the required analyses to obtain the results and conclusions for the Central Research Questions (CRQ A and B).

- Phase I includes the aspects required in the decision making process concerning the layout design of the Foleyplein and the inbound supply to the packaging lines 52 (bottles) and 6 (cans).
- Phase II focuses on the inbound supply of bottles via the DLF method to the one-way bottle lines (line 51, 52, 7, 81 and 82). The assessed DLF process stretches from the production agreements with the manufacturers in the preceding year till the moment of unloading the pallets on the buffer lanes of the packaging lines.

The returnable bottle lines (11 and 12) and the keg lines (41, 42, 43 and 9) are completely left out of the research. In consultation with HEINEKEN some parts are specifically excluded from the research:

Spatial and logistical scenarios:

- Building an internal storage location for cans or bottles.
- Examine the supply techniques or methods of existing lines other than:
    - In phase I: line 52 and 6
    - In phase II: line 51, 52, 7, 81 and 82

Transportation:

- Employment of transportation companies other than Hartog & Bikker.
- Consideration of other transportation vehicles than the usual.
- Negotiation with Hartog & Bikker about agreements and prices.

1.4. Research objectives and deliverables

This section discusses the research objectives and the deliverables of the research.

1.4.1 Research objectives

According to Visser & van Goor (2011) the common formulation of a general logistical objective consists of the improvement of the customer-service level, while decreasing the integrated costs. The authors suggest however that the objective should be focusing on either the improvement of the customer service level while maintaining the current integrated costs or decreasing the integrated costs while maintaining the current customer service level. This project is conducted in accordance with the second option. Both parts of our research focus on an efficient approach to maintain the current performance and decrease the costs.

Phase I

Determine the most cost effective way to solve the limitation problem on the Foleyplein and to supply the packaging lines on the Foleyplein in a cost effective manner.

Phase II

Develop an improvement plan for a more efficient process concerning the supply of empty bottles to the packaging lines via the DLF method.

1.4.2 Deliverables

In this section we describe the deliverables that need to be delivered to solve the earlier mentioned problem statements (section 1.2) and reach the objectives (section 1.4.1).

Phase I

- An overview of the different feasible alternatives to supply packaging lines 52 and 6 via de Foleyplein.
- An overview of the pros and cons associated with the alternatives.
- A well-founded choice for particular alternatives.

Phase II

- A written and graphical process description of the current process.
- An overview of the improvement opportunities and their estimated priority.
- An overview of the plan consisting of the improvement possibilities and the related stakeholders responsible for the further development and/or the implementation.

1.5 Research questions

Since our research consists of two phases, we split our research by a bifocal research question, consisting of part A and B.

A. *"What is the most cost effective layout design and logistical way to organize the supply of bottles and cans for the packaging lines 52 and 6?*

CRQ A focuses on the development of the most desired layout design and logistical organization on the Foleyplein for the supply of packaging lines 52 and 6. With most 'cost effective way' we mean the alternative that obtains the preference after the considerations of the relevant financial and non-financial criteria's.

B. *"How is the current DLF process organized and in what ways could the process be improved to organize the inbound supply of empty bottles via the DLF method more efficiently?*

CRQ B focuses on the development of a more efficient process for the supply of bottles to the packaging lines supplied via the DLF method. First we need to determine how the current process is organized and next which improvements opportunities can be identified to organize the process more efficiently. By 'more efficiently' we mean, the organization of the process in a more transparent and more effective way, while reducing the associated costs.

Sub questions supporting CRQ A

The following sub questions are composed to support the CRQ A:

1) What is the 'current' situation at HEINEKEN concerning:
   a. The production characteristics of packaging line 52?
   b. The inbound supply methods currently employed?
   c. The space limitation problem on the Foleyplein?
2) What are the feasible alternatives for (a) the layout design and (b) the logistical organization of (1) the bottle packaging line 52 and (2) the can packaging line 6?
3) Which quantitative and qualitative criteria should be evaluated and how well do the alternatives perform on these criteria?
4) What is the most desired alternative to organize the supply of line 52 and 6 when we compare the alternatives based on a complete overview of all the (estimated) pros and cons?

Sub questions supporting CRQ B

The following sub questions are composed to support the CRQ B:

1) How is the current DLF process organized and which stakeholders are involved?
2) Which improvement opportunities can be identified in the current process and which should be included in the research based on their priority?
3) How should the process be improved and who should be made responsible for the further development and implementation of the improvement opportunities?

1.6 Methodology

In this section we describe the methodology that is used in this research, which consists of multiple elements throughout the project.

Observations, consultations and presentations

According to Hicks & Matthews (2010) a key barrier to successful process improvement is the resistance to change. Senior managers appear to be committed to improvement programs, while middle and junior management are less dedicated. If the members of the shop floor, who are to be the hands-on users of such process, do not understand the benefits to themselves or in general, the implementation is bound to falter (Hicks & Matthews, 2010). The authors conclude that most of the barriers arise from either a lack of understanding, an inability to communicate understanding or an inability to generate the necessary understanding.

With these statements in mind, the stakeholders of the relevant departments are involved as much as conveniently possible by asking their opinions, estimations and concerns. The aim is to create a shared understanding and enable the stakeholders to express their beliefs via interviews and several meetings. We had interviews and meetings with all significant stakeholders during the research to get a good understanding of the (problem) situation at HEINEKEN, to ensure that we gathered all significant information and to enlighten and inform the different stakeholders of the progress of the project. At the end of each research phase a plenary presentation is held at HEINEKEN to presenting the findings and recommendation.

Literature studies

The literature has been consulted throughout the project, with the focus on the project as a whole and subsequently on part I and II separately to gain insight in the methods and approaches to resolve both problem situations. The literature studies for phase I and II are explained in chapter 2 and 4.

Integral Logistic Concept

The logistical concept can be defined as the design of the desired layout for the logistic function in an organization, in which is described how the product, cash and information flows are aligned with each other (Visser & van Goor, 2011). Figure 1-3 shows the integral logistical concept as is should be used according to Visser & van Goor (2011). It starts with determination of the logistical objectives, followed by the implementation of the four areas in the consecutive order and considers the logistical performance indicators as the end point. Appendix B.1 discusses the integral logistic concept in more detail.

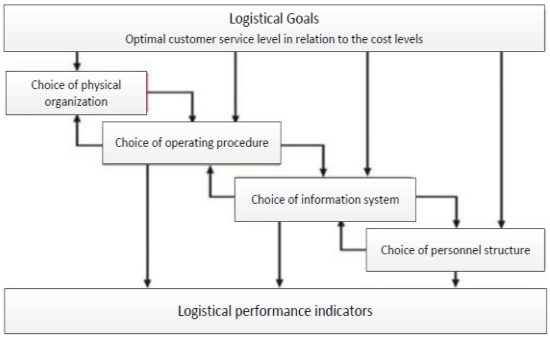


Figure 1-3: Integral logistic concept (Visser & van Goor, 2011) [modified]

In this research the integral logistical concept is used to structure the project, since it gives us a general understanding of our problem situations and provides a basis for the project as a whole. Besides that it is able to support both our research questions.

- In the first chapter the research objectives and associated deliverables are discussed.
- In phase I the main objective is to determine the most preferred physical construction and operating procedure. To achieve this several feasible alternatives are developed for the supply to line 52 (3 alternatives) and line 6 (4 alternatives). After that these alternatives are evaluated based on several quantitative (OPEX and CAPEX) and qualitative (e.g., safety) criteria to determine the most desired layout design and logistical organization.
- In phase II the research continuous by focussing on the improvement of the process, related to the operating procedure, information systems and personnel structure. In phase II the aim is to understand how the current DLF process is organized, reveal the improvement opportunities in the process, prioritize the most important ones and develop an improvement plan for a more efficient process.

1.7 Project structure

In this section we present our process model for this research, which visualizes the main steps that we perform in the project. The 'research start' covers the content of chapter 1, 'Phase I' and 'Phase II' are explained in respectively chapter 3 and 5 and the research completion is explained in chapter 6. Chapters 2 and 4 elaborate on the literature that supported our research in respectively phase I and II.

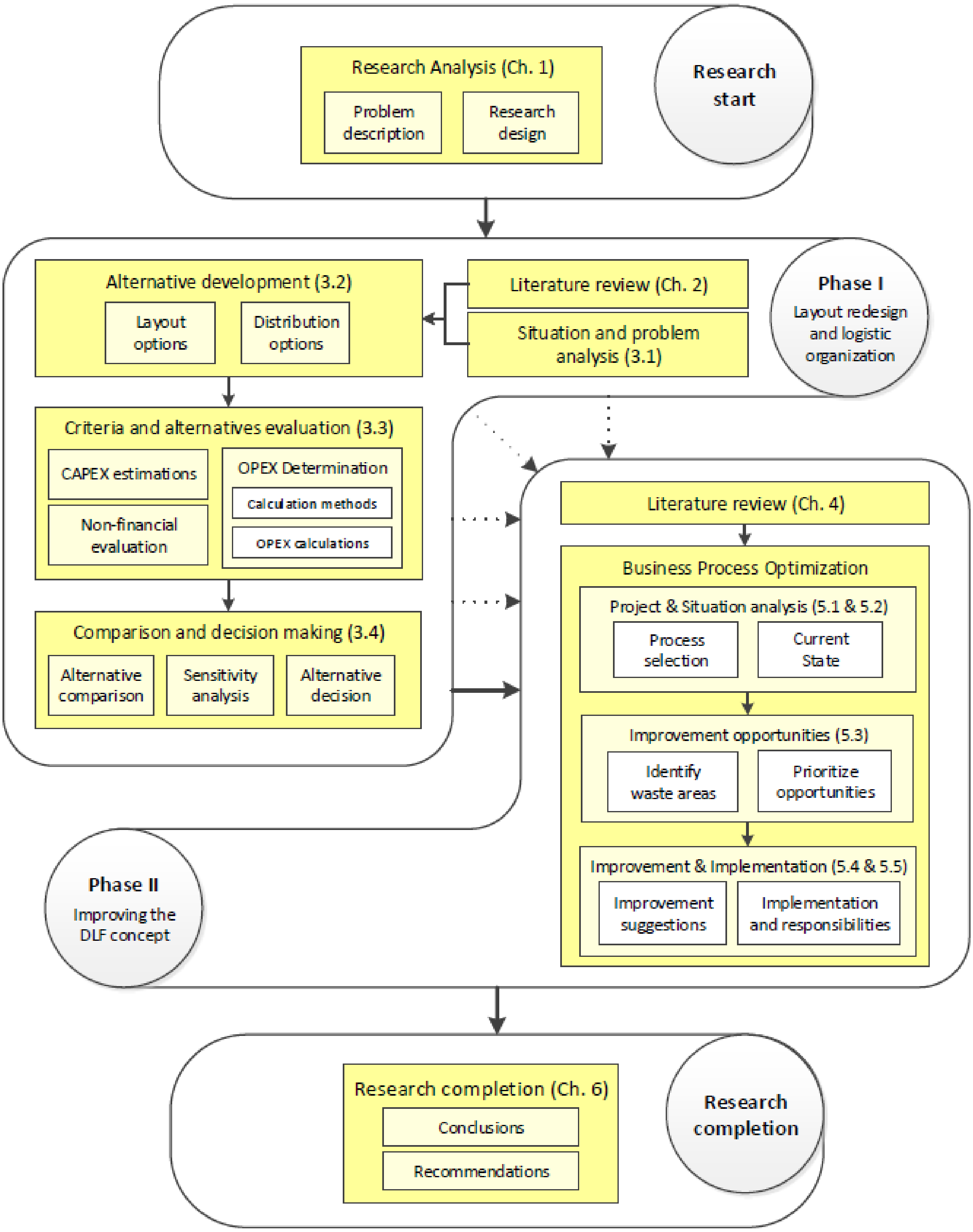


Figure 1-4: Complete research overview

Research Phase I

Layout redesign of the Foleyplein and logistic organization of the inbound supply of empty bottles and cans to packaging lines 52 and 6.

2. Literature study of phase I

In this chapter we explain the literature that supports phase I of our research. In section 2.1 we pay attention to the layout design problem and the related tools and approaches for the development and evaluation of alternatives. In section 2.2 we briefly elaborate on the distribution logistics and relevant strategies. Finally in section 2.3 we discuss the quantitative and qualitative evaluation criteria relevant for our research. The theories supporting phase II are explained in chapter 4.

2.1 Layout design problem and approach

This section pays attention to the layout design problem and the related tools and approaches that have supported the development of the evaluation approach that we use in this research.

2.1.1 Introduction

According to Wiyaratn & Watanapa (2010) industrial factories need to increase their potential in production to compete against their market rivals, with an production process that has the ability to produce with low cost and high effectives. One way to facilitate this is an efficient plant layout, which reduces cost of manufacturing and increase the productivity. Furthermore it increases good workflow in production route (Wiyaratn & Watanapa, 2010).

Layout design problems focus on finding the most efficient arrangement of the facilities and equipment within the available floor area. According to Yang, Su, & Hsu (2000) the existing literature about layout design problems often fall into two categories: algorithmic and procedural approaches.

- Algorithmic approaches usually simplify the design constraints and objective in order to reach an objective function from which a solution can be obtained. These approaches generally incorporate quantitative input data. Their solutions are easier to evaluate by comparing the objective values, however the outputs often need further modifications to satisfy detailed design requirements.
- Procedural approaches on the other hand can combine qualitative and quantitative data in the design process. These approaches have divided the design process in several steps, which are solved subsequently till the objective has been reached (Yang et al., 2000).

We use a procedural approach as graphically shown in Figure 2-4.

2.1.2 General problem-solving model

No matter which approach is adopted in problem solving and decision making, the process generally runs through a number of the same steps (Hicks, 2004). While many variations in the required steps are suggested by the literature, the mains steps, shown in Figure 2-1, can be identified according to Hicks (2004) as follows:

- It starts with the 'the mess', which should really be seen as a process step to prevents rushing in to conclusions. This step consists of the realization of the problem situation, creating order in the chaos and structure the project.
- The second step is the 'data gathering' step, in which it is necessary to gather information as objective data (the who, what, where, when, why and how of the problem situation), subjective data (opinions, attitudes, feelings and beliefs), details of the constraints relevant for the situation and other information that seems relevant.
- The problem-solving model continuous with the 'problem identification' step, which involves formulating the problem situation at the beginning and redefining it during the project.
- Then the ideation step, which consist of generating ideas about (alternative) solutions. The authors emphasize that although some selection of ideas will be necessary, it is important to prevent too much judgement and criticism, whilst we are trying to generate ideas.

- The next step in the model is the 'problem resolution' step, in which the most promising ideas should gently be evaluated and developed. Rarely does it happen that an idea is completely suitable and are the merits obvious from the beginning. Most of the time the ideas need further development till we have several possible solutions. When we have determined the alternatives, the process continuous with evaluating them against appropriate criteria in order to select the best one(s) to implement.
- The final step in the process is the implementation step, which is often a problem on its own. Often it is required to 'sell' the merits of the solution, gain acceptance and elicit the commitment necessary to implement it. The brilliance of a solution is rarely sufficient to guarantee its implementation.

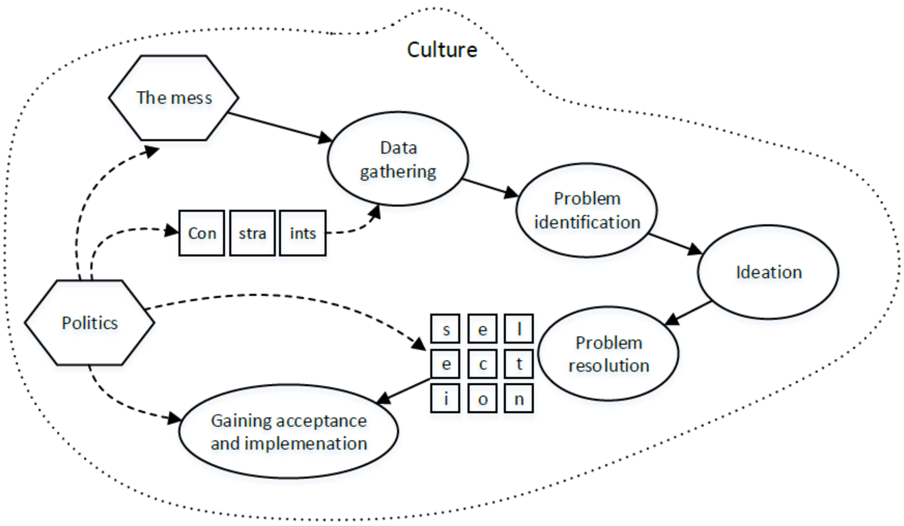


Figure 2-1: General problem-solving model (Hicks, 2004) *[modified]*

Hicks (2004) suggests that it is useful to understand the main steps in general problem-solving, but in the meanwhile he points out that it is possible that some steps are skipped or run through in different order, that some steps need repetition or that some steps overlap each other. Furthermore he points out that organizational problem solving is often a group process and most of the time other groups have a stake in the solution. A decision is often not made by the problem-solving team (alone) and may be constrained by wider interactions and political considerations. Politics and the organizational culture will influence the problem solving process continuously, adds (new) constraints to the process and the solution and will have impact on the final decision making, which can result in a complex decision making process.

2.1.3 Systematic Layout Planning

Systematic Layout planning (SLP) approach, developed by Richard Muther, is suggested to be the most popular procedural layout design approach in practice. It is relatively straightforward, however it is a proven tool in providing layout design guidelines in practice (Yang et al., 2000) and is very useful when a new layout need to be designed or adjustment in the layout need to be made in a new or already existing area (Visser & van Goor, 2011). The SLP method is a step-by-step approach of plant design from input data and activities to the evaluation of the plant layout (Wiyaratn & Watanapa, 2010).

The complete design process can be distinguished in 4 phases (Visser & van Goor, 2011):

Phase 1: Determining the location of the facility
Phase 2: Defining the general layout and fundamental material streams
Phase 3: Defining the detailed version of the layout

Phase 4: Installing and arranging the selected layout

Figure 2-2 gives a graphical representation of the SLP procedure, which concerns the following steps (Visser & van Goor, 2011; Yang et al., 2000):

Step 1: The SLP procedure starts with the PQRST analysis for the overall production activities. It concerns the data collection and examining the following elements: (1) Product: which products need to be processed? (2) Quantity: in which quantity? (3) Routing: In what process and in which sequence of operations and handlings? (4) Supporting: with which supporting services and activities? (5) Time: with which timing and over which time horizon?

Step 2 - 4: In the 'flow of materials analysis' all movements and material flows that are involved in the process need to be analysed and visualized in a comprehensive way. In the 'activity relationship' step a qualitative analysis is performed to determine the closeness of relationship between the concerning departments. The 'relationship diagram' is then a graphic overview of the interaction and closeness of these relationships.

Step 5 - 7: In the 'space requirements' and 'space available' steps is the space needed, the space available and the amount of floor space to be allocated to each department determined. Subsequently the space relationship diagram adds the departmental size information to the relationship diagram from step 4.

Step 8 - 9: In the 'modify constraints' and 'practical limitations' step the situations that give reason for change and the additional design constraints and practical limitations are determined.

Step 10: In de 'develop layout alternatives' the design candidates are created. According to Yang et al. (2000) the success of a procedural approach implementation depends to a great extent on the generation of quality design alternatives that are often from the outputs of an experienced designer. The inputs from area experts during the design process are thus considered to be a must toward an effective layout design.

Step 11: In the evolution phase the different design candidates are evaluated and the final design is chosen. The evaluation of layout alternatives is difficult, since it includes multiple quantitative and

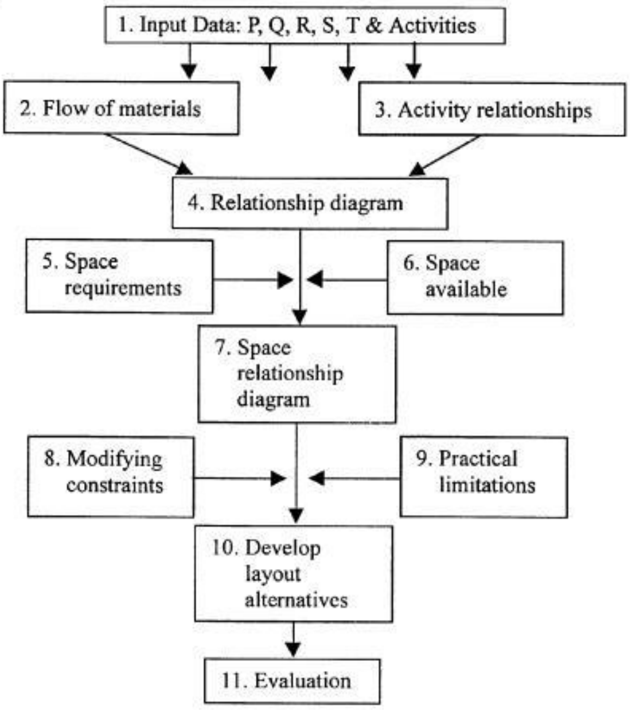


Figure 2-2: Systematic Layout Planning approach [original from R. Muther, figure from Yang et al. (2000)]

qualitative objectives and many of those objectives are subjective in nature. Careful consideration of the objectives and criteria is required. A detailed layout of the facilities and the equipment follows from this final step.

The Systematic Layout Planning (SLP) approach is a very popular and straightforward tool for a layout design problem. For our research project the SLP approach is useful to generate our own layout design approach, explained in section 2.1.5. However we do not apply every step. According to Visser & van Goor (2011) there are 4 types of production flows: divergent flows, parallel flows, series flows and convergent flows. The flow of material within the narrow scope of our research can be identified by a parallel material flow, which means that the flows run parallel without any relationships between the different material streams. In these flows the operations that are carried out are most of the time the same, but on different kind of products. The only existing relations between these flows are related to the employees and the resources (Visser & van Goor, 2011). This is also the case in our research. The equipment and flows that need to be build and organized in our project do not interact with each other. The only relationships that can be found are related to the employees and the handling equipment. Consequently not every detail of step 2 till 7 is completely relevant for our research and therefore not every detail of this approach is used in our own approach (see section 2.1.5).

2.1.4 Experimenting with the system

A system can be defined as a collection of entities (e.g., people and machines) that act and interact together toward the accomplishment of some logical end. During the existence of these system there is often the need to study them to gain some insight into the relationships among various components or to predict the performance under some new conditions (Law, 2007). According to Law (2007) there are several ways in which a system might by studied, which are graphically shown in Figure 2-3. Studying the system in this context is not about just figuring out, exploring and understanding the system by interviews, data and observations, it is about experimenting with the system to gain the insights mentioned above. The ways of studying the system that we use in this research project are marked in yellow and explained below.

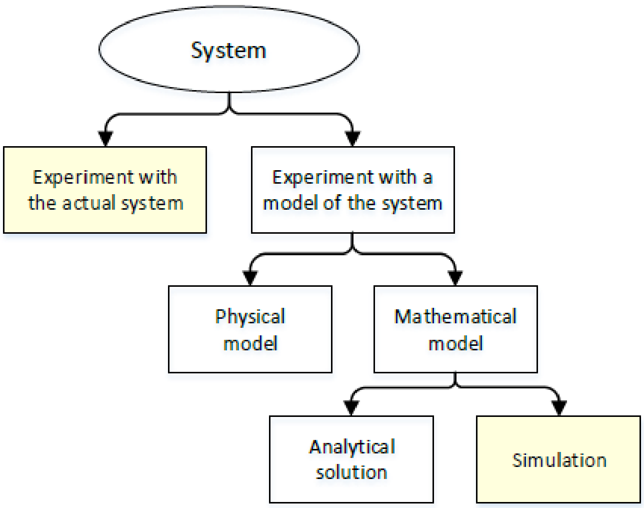


Figure 2-3: Ways in which a system can be studied (Law, 2007) *[modified]*

The first distinction in ways to study the system, that is made by Law (2007), is between experimenting with the actual system or experimenting with a model of the system. Here, a model can be defined as a representation of the real-world systems that enables effective and efficient problem-solving as it formalises only the relevant relations between the concepts of interest (Keppens & Shen, 2001). According to Law (2007) it is probably preferred to experiment with the actual system by letting it operate under the new circumstances if this is possible and cost-effective, because in that case there is no question about whether the study is valid. At the same time the author points out that it is rarely feasible to do this, because such an experiment would be too costly or too disruptive to the system. For that reason it is usually necessary to create a model. Using a model as representation of the system to study the actual system on the other hand, does always raise the question whether it accurately reflects the system for the purpose of the decisions made (Law, 2007). In our case we want to 'study the system', as meant by Law (2007) and explained previously, in both ways.

Experimenting with actual system

At some point of time in our research we want to know, which alternative scenarios can be obtained. For the distribution options this is done by examine the materials flows and the production capabilities at the different facilities (i.e., not done by experimenting with the system). For the layout options on the other hand this needs to be done by examining the spatial and material flow requirements and possibilities at the brewery and especially at the Foleyplein. The most important study related to the Foleyplein concerns the ways we can build and organize the equipment and materials flows on the Foleyplein, while maintaining the required safety levels. Since it is quite difficult to estimate if a particular option should be considered as a safe and pleasant working environment, it would be very helpful to study the possibilities in real life, i.e., with the actual system.

Experimenting with model of the system

As we can see in Figure 2-3, Law (2007) suggests that using a model to experiment with the system can be divided in using a physical model (e.g., pilot training) or a mathematical model. Physical models are usually not the type of models that are of interest in operations research, but mathematical models are. Mathematical models can be defined as models that represent a system in terms of logical and quantitative relationships that are manipulated and changed to see how the model reacts and thus how the system would react. These mathematical models are further divided in models that obtain an analytical and exact solution and models that use simulation. If the model is simple enough, it could be possible to work with the relationships and quantities to get an exact and analytical solution. Otherwise Law (2007) proposes the use of simulation, i.e., numerically exercising the model for the inputs in question to see how they affect the output measures of performance.

During the evaluation of our alternatives we want to study the distribution system to understand the relationships between the different cost elements and to easily compare the total distribution costs of the different scenarios. As stated by Lin & Sharp (1999b) it is often the case that data is only available after the operations start and that very detailed data is required from which no record has been kept. As is explained in section 3.1 in further detail, both situation are relevant in our research, since we want to obtain the distribution costs of a production line that does not exist yet and it is unclear which products will be produced in which quantity. Additionally the production is market driven, which means that the production plan will differ every week and every year depending on the market demand. This results in the fact that we need to work with the previous data that is available and use these data as basis for our forecast and distribution cost calculations. According to Hopp & Spearman (2008) there are three laws in forecasting: (1) forecasts are always wrong, (2) detailed forecasts are worse than aggregate forecasts and (3) the further in the future, the less reliable the forecast will be. Based on this, the use of a model that involves an exact solution does not seem really relevant in our research. However, what does seem relevant is the use a model to understand the relationships between cost elements, examine the impact of the input variables and assess the total distribution costs per scenario.

Modelling a given system consist of the three elements: the problem (1), a task that must be solved with respect to the system, that is resolved by the problem solver (2), a procedure capable of generating one or more solutions for the problem by the use of the representation formalism (3), a language that allows the representation of relevant aspects of the system and their relations (Keppens & Shen, 2001). The problem is explained in chapter 1 and section 3.1. The procedure and the representative model is explained in respectively section 2.1.5, section 3.3.2 and appendix C. According to Angerhofer & Angelides (2000) the process of business modelling comprises four phases. The first phase comprises the project definition and objective determination. The second phase involves the model conceptualisation in which we need to aggregate the information and relationships about the material flows and distribution in a coherent model. In the third phase the model is actually created and validated and in the last phase the scenario and sensitivity analysis are carried out and the knowledge is spread and used.

2.1.5 Layout design and distribution costs evaluation approach

Besides the most popular layout design approach, systematic layout planning, more plant layout and logistics costs evaluation approaches are suggested by the literature (L. C. Lin & Sharp, 1999a, 1999b; Voordijk, 2010; Zeng & Rossetti, 2003), which all have their differences in comparison to each other. The authors put emphasize on different aspects and use slightly different evolution criteria. However, in general we can distinguish a more generic approach from the literature that contains the most important steps for our decision making process.

In section 2.3 we elaborate on the different criteria that we have used. In this section we show the generic approach that we have used in Figure 2-4, which is based on the general problem-solving model, the SLP approach, simulation and modelling approach and the other suggestions for layout design and logistic cost evaluation.

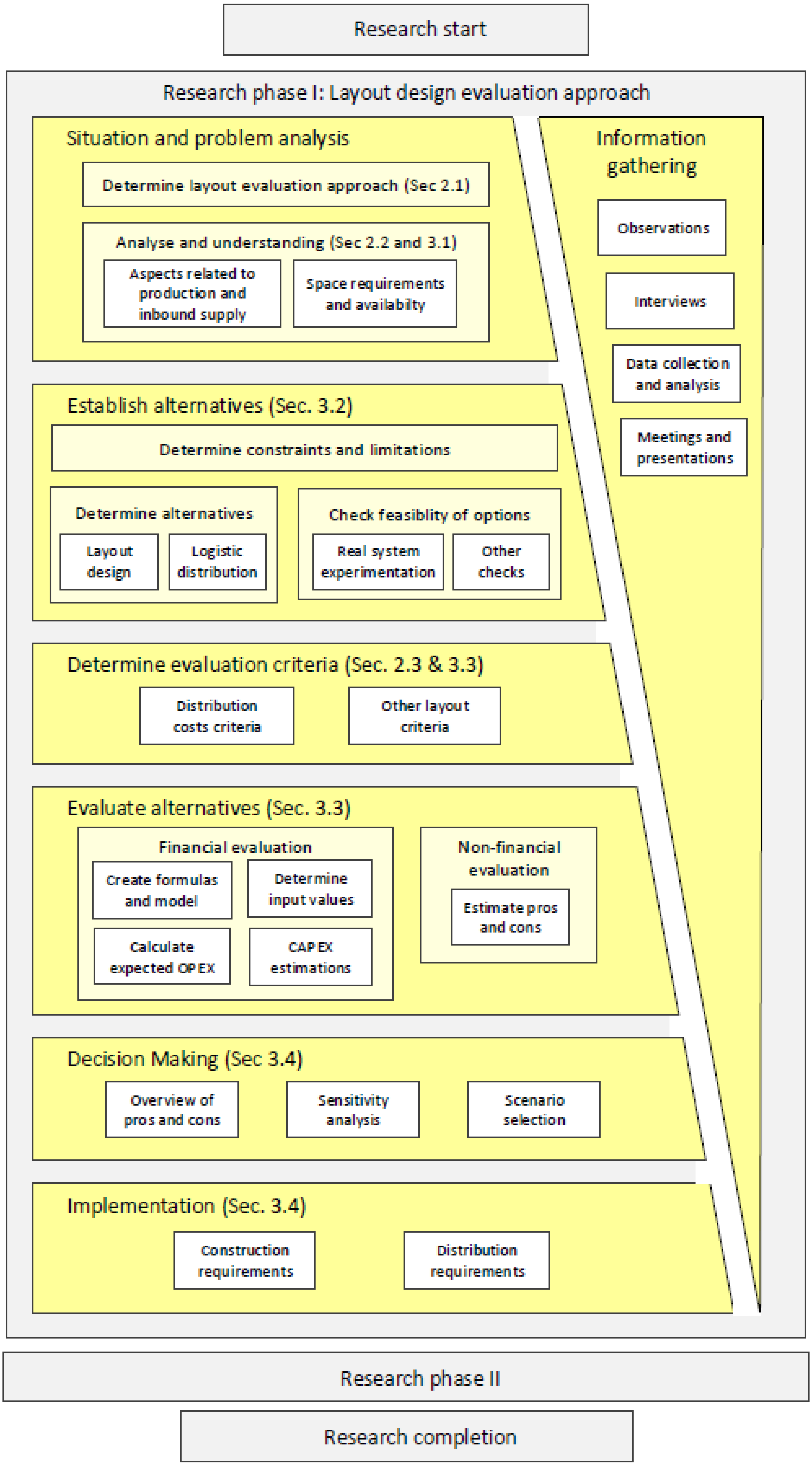


Figure 2-4: Layout design and distribution costs evaluation approach of phase I

2.2 Distribution logistics

In this section we briefly elaborate on the distribution logistics and strategies, which are helpful for understanding the current situation at HEINEKEN Zoeterwoude.

2.2.1 Introduction

Distribution logistics can be defined as that part of the supply chain process that plans, implements and controls the effective and efficient flow of goods, services and related information from the point of origin to the point of consumption in order to meet customer requirements (B. Lin, Collins, & Su, 2001; Shujuan & Xin, 2008). A typical logistic process in a manufacturing company consist of demand forecasting and planning, procurement, material handling, inventory management, warehousing, order processing and transportation (Shujuan & Xin, 2008). The goal in distribution logistics is to fulfil the requirements of the market and to build lasting relationships with the customer, while maintaining low costs and capital usage (Visser & van Goor, 2011).

2.2.2 Distribution strategies

When items are produced and ready to leave the manufacturer the next challenge is to distribute these items efficiently to the customer. According to Simchi-Levi, Kaminsky & Simchi-Levi (2008) there are two main options in distribution strategies. Items can either be shipped directly from the manufacturer to the customer or an organization can use one or more intermediate storage locations. When employing the direct shipment strategy, the supplier delivers goods directly from the production facilities of the manufacturer to the customer. In a traditional warehousing strategy the items are hold in stock in intermediate warehouses and provided to downstream customers when they needed. The most important incentives of using direct shipment according to Simchi-Levi et al. (2008) are that the downstream customer avoids the expenses of operating a storage centre and that the lead times can be reduced. On the other hand a downside is that the distribution of items often needs to be done with more and smaller trucks to more locations. For these reasons direct shipment is a common method when a downstream customer requires a full truckload of materials (Voordijk, 2010).

2.2.3 Third-Party Logistics (3PL)

To remain competitive companies have increasingly had to find efficiencies in all operations, to focus on core competencies and to outsource the functions that can be performed more efficiently by third-parties (Zacharia, Sanders, & Nix, 2011). According to these authors logistics has been identified as the function where significant cost savings and improved responsiveness can be obtained, which makes it attractive for outsourcing and results in the fact that 3PL organizations are nowadays engaged in (strategic) coordination of their customers supply chain activities. Initially is was about offering transportation services, while 3PL nowadays offer a broad and integrated set of services including warehousing, inventory management, packaging, cross docking and technology management (Zacharia et al., 2011). The most important benefits of outsourcing are the ability to focus on the core business, the shift from fixed to variable costs and lower operational risks (Visser & van Goor, 2011). A downside it the loss of control, which is inherent to outsourcing a particular function (Simchi-Levi et al., 2008). Appendix A.2 elaborates on the evaluation and (dis) advantages of 3PL in more detail.

2.2.4 Direct Line Feed (DLF)

As we explained in section 1.2, including Figure 1-2, DLF is the supply method at HEINEKEN in which the empty bottles are supplied from the manufacturers by smaller trucks and unloaded directly and automatically on the buffer conveyor of a packaging. For this reason there is no handling and no storage location needed for the supply of these bottles on the premises of HEINEKEN. In this supply chain strategy the aim is to distribute the empty bottles directly from the supplier to the production line without the use of an intermediate storage. This is however not always the case. For multiple reasons the DLF approach needs a back-up storage location close to the premises (see section 3.1).

Direct Line Feed is not a widespread subject in the literature. A common subject in the literature is cross docking, which is a logistic technique that seeks to reduce the inventory holding, order picking and transportation costs and the delivery time (Larbi, Alpan, Baptiste, & Penz, 2011). Supply chains using cross-docking are different from the supply chains using warehouses, since cross-docks offer no storage (Zeng & Rossetti, 2003). This seems similar to the DLF-technique that is used at HEINEKEN, however the cross docking process covers way more than just the logistic supply technique of DLF.

Direct Line Feed is known for being the process of making sure that you get the supplies you need, when you need them. Suppliers effectively 'feed' the supplies to the production line in such a way that there is a constant supply of all components that are required. The process of Direct Line Feed is usually outsourced, which means that also the responsibility for the supply rest with the supplier. In these instances the supplier actually takes responsibility for the inventory control, electronically assessing how many items have been used by the use of an electronic data systems, which keeps the supplier constantly updated with regard to the number of items that need to be replenished. (Valuestreamguru, 2016). There are quite some benefits of using DLF for the inbound supply. Most importantly it can reduce the overall logistic costs. Supplies no longer have to be stored in great storages, since they are supplied almost constantly and the technique reduces staff time in handling the incoming supplies. Some other benefits that are mentioned are increased productivity, reduction of WIP, reduction of paperwork, clear responsibilities, simplified shop floor practice and removal of non-value added activities (Stag Group, 2016; Valuestreamguru, 2016). A few drawbacks that are mentioned is that the supply method can cause some reluctance of the staff and the fact that it takes a great deal of trust on the material providers and procurement teams to ensure that the right levels of materials are available at the right time.

2.3 Quantitative and qualitative evaluation criteria

In this section we elaborate on the criteria that are proposed by the literature and that we use in our research to evaluate the different alternative scenarios and to support decision making.

2.3.1 Introduction

While there exist many publications presenting successful implementations, Hicks & Matthews (2010) suggest that there are many initiatives that fail to meet the expectations and sometimes fail to deliver improvement at all. Furthermore they state that of those projects that do deliver many are short term. These projects not only require a high investment, but also incur an indirect cost which can be representing a magnitude of the cost and lost opportunity which far exceeds the cost of the original investment (Hicks & Matthews, 2010). As suggested in section 2.1 we are dealing with multiple quantitative and qualitative objectives, which are difficult to evaluate. Careful consideration of all the objectives and criteria is required to support decision making. Section 2.3.2 pays attention to the distribution logistic costs criteria that are relevant for our evaluation approach and section 2.3.3 focuses on the qualitative layout design criteria.

2.3.2 Quantitative logistic costs criteria

There is no end to the number of activities and cost drivers within an organization, hence it is important to avoid getting bogged down with all pretty details that cannot be explained or do not provide any added benefit (Lin et al., 2001). According to these authors some activities may not be identifiable or measurable without a significant amount of effort and cost. Therefore it is important to keep this lack of perfect data in mind when making important business decisions and only focus on the relevant cost information. Examining firm expenses could start by interviewing relevant staff members to determine what principal activities are performed, what factors determine how long an activity takes and which costs are associated with these activities. Once this information is obtained, one can start mapping the operational expenses (Stapleton, Pati, Beach, & Julmanichoti, 2004).

Derived from all activities in an organization there are many criteria that need to be determined and evaluated to assess the layout alternatives to support a well-founded decision. Many suggestions for evaluation criteria are done by the literature (Kivinen & Lukka, 2004; B. Lin et al., 2001; L. C. Lin & Sharp, 1999a; L. C. Lin & Sharp, 1999b; Visser & van Goor, 2011; Voordijk, 2010; Zeng, 2002; Zeng & Rossetti, 2003). In the remainder of this section we present and explain the costs criteria that are suggested by these authors and are relevant for our research.

Initial investment costs

The first criterion is about the initial investment costs, which we can relate to the term Capital Expenses (CAPEX), which is the expression used at HEINEKEN. The initial investment costs can be defined as all upfront investments needed to enable a functioning production system (Wagner & Silveira-Camargos, 2011) and consist of all investment costs related to the land, buildings, production machinery and equipment and material handling equipment (Lin & Sharp, 1999b). Here, material handling equipment accounts for a great deal of the physical distribution costs in terms of capital expenses (Voordijk, 2010). According to Wagner & Silveira-Camargos (2011) the extent of the required investments varies according to the logistic complexity, the characteristics of the production site and even further to the capabilities of the supplier or the involved logistics service provider.

Transportation costs

Transportation costs are related to external movement of materials and products in the supply chain between manufacturers and their downstream customers, which generally operates both ways (Visser & van Goor, 2011). As discussed in section 2.2.2 and as suggested by Simchi-Levi et al. (2008) and Voordijk (2010) we can distinguish three main routes in transportation. In the direct shipment strategy the supplier delivers the goods directly from the production facilities of the manufacturer to the downstream customer. In the traditional warehousing strategy, where materials or products are hold in intermediate warehouses, we can distinguish two routes. Initially, when the products need to leave the manufacturers premises, the transportation from the manufacturer to an intermediate warehouse is carried out. Later on, when the customer needs the products, the materials or products are transported from the intermediate warehouse to the downstream customer.

The transportation costs depend primarily on the type and amount of goods carried from location to location, the distance between these locations, the mode of transport and the vehicle and shipment size (Voordijk, 2010). According to van Amstel & van Goor (2006) the share of transportation costs in comparison to the total distribution logistic costs is growing, because of the increased amount of traffic jams and the trend that transportation to downstream customers is increasingly done in smaller shipment sizes

Material handling costs

Material handling is an important activity in warehousing and accounts for a great deal of the physical distribution cost (Voordijk, 2010). Material handling costs are those costs associated with internal transport, loading and unloading, lifting up and putting down, picking, moving and storing materials or (semi-finished) products (Visser & van Goor, 2011; Voordijk, 2010). The amount of costs primarily depend on the volume, the packaging density and the handling methods employed (Voordijk, 2010). The handling method in our project vary among the different alternative options and therefore depends on the chosen alternative. The major cost categories in material handling are the cost of labour and the material handling equipment used to move goods within the warehouse of the receiving customer. Both cost categories can be calculated by using a tariff per time period or per amount of unit multiplied by respectively the amount of time needed per unit or the amount of units (Voordijk, 2010; Zeng & Rossetti, 2003).

In addition to the material handling costs on the premises of the organization itself, the supplier and manufacturer will also incur costs to load and unload, store and move the units. The supplier will charge these costs for using the facilities and equipment, labour costs and other material handling costs and therefore need to be taken into account (Zeng & Rossetti, 2003).

Inventory costs

Inventory and warehousing costs include the storage space needed, costs of risk, the interest and opportunity costs, costs of obsoletes and the out of stock costs. We take into account the first two criteria, since we expect that the costs differ for the alternatives. The other criteria are left out of this research, since we assume that they would not differ significantly and thus would not influence our decision, as explained in appendix B.5 in more detail.

The storage space needed refers to the square meters used to store the materials or semi-finished products. These storage costs can include rent, depreciation and maintenance of the building (or other storage location) and storage shelves, electricity and heating. They vary largely with the number of different products (Wagner & Silveira-Camargos, 2011), the type of product, the type and location of the building and the storage location in the building (Visser & van Goor, 2011). These inventory costs could be calculated based on an average quantity of stock held per year expressed in euros per unit stock (Voordijk, 2010). As explained in appendix B.5, we assume that the safety stock levels and the associated inventory costs do not differ significantly for the alternatives. The only inventory costs that we do take into account are the costs for pallets that are transported via the warehouse during the week in case of DLF supply, because these are additional inventory costs that only occur in the DLF alternatives.

Cost of risk refers to the risk that products could get lost or be damaged when holding products in stock. This includes both preventive and corrective measures and costs (Visser & van Goor, 2011; Zeng & Rossetti, 2003). Wagner & Silveira-Camargos (2011) divide the possibility that these defects can arise in three time spans: (1) before it arrives at the customer (2) between the incoming delivery of goods up till it provision at the production line or (3) during the production process.

Other logistic costs

Other costs elements that could be taken into account according to the literature are procurement costs, order processing and transaction costs and production planning and control costs. We did not take into account these costs, since we assume that they would not differ significantly and thus would not influence our decision, as explained in appendix B.5 in more detail.

2.3.3 Qualitative layout design criteria

The logistic distribution and investment costs are the most extensive part of our layout evaluation and selection approach. Partially because the cost elements are a significant part of our alternative selection and to some extent because the cost elements are relatively difficult to evaluate. While this is the case, some non-financial element are very important in our selection as well and cannot be omitted. We briefly discuss the non-financial criteria mentioned by the literature and relevant for our research.

An essential criterion that we find in the literature is the human-related safety and worker-related comfort. Lin & Sharp (1999a) suggest that the safety matter relates to the likelihood of accidents, the amount of human and vehicle crossings and amount of human-machinery interfaces and relate comfort to working conditions. Furthermore Tadic, Zecevic, & Krstic (2014) state that the safety aspect is related to the amount of traffic and the amount of congestion that it causes, which can lead to conflict situations. Inappropriate storage methods should be avoided, the amount of vehicle crossing should be reduced, separate pedestrian walkways should prevent worker-vehicle crossings and warning signs should indicate conflicting situations (Lin & Sharp, 1999a).

Another element is the space sufficiency and utilization. According to Lin & Sharp (1999b) this consist of two points. Firstly the assurance that enough space is available and a definite space is provided for the required activities. Obviously it is important that the constructions are build and the layout is organized such, that there is sufficient space for manoeuvring and parking of the different vehicles. Secondly it consist of the examination of the effectiveness of the space usage. The objective should be to handle the vehicle and material movement without wasting (too much) space. Travel distances, spaces occupied by aisles and the density of these flows should be minimized when this is possible.

Furthermore we briefly discuss the supply chain complexity, the flexibility of the material flow and the robustness of equipment for changes. Here, complexity refers to the amount of stops in the material flows and the transformation inside a logistic centre. The more it increases, the more it requires a high degree of cooperation and consolidation (Tadic et al., 2014). The robustness of equipment relates to the estimation of the equipment and layout design to adjust to future changes and satisfy different capacity requirements (Lin & Sharp, 1999b). Kocaoğlu, Gülsün, & Tanyaş (2011) mention supply chain flexibility, reliability and responsiveness as non-financial criteria for the performance measurement of a logistic system. The latter two refer to the accuracy and velocity of the supply chain to provide the right products. Supply chain flexibility can be described as the agility of the supply chain in responding to the (market) changes. It comprises the ability to react purposefully and within an appropriate time scale to significant events and the ability to upgrade or downgrade the production within a particular period and in a sustainable matter.

In Table 2-1 we present an overview of the quantitative (financial) criteria and the qualitative (non-financial criteria that are taken into account in this research.

Table 2-1: Overview of quantitative and qualitative criteria taken into account in this research

Layout design evaluation criteria	
Quantitative criteria	Qualititative criteria
Initial investment costs (CAPEX)	Safe working environment
Upfront investments related to buildings, production machinery and material handling equipement	Human-related safety and worker-related comfort related to likelihood of accidents, number of crossings and congestion
Logistic Costs (OPEX)	Efficient layout utilization
Transport costs	Ensurance of enough space for the constructions and required manouvres and effectiveness of space usage during vehicle and material movement and storage
Costs of shipment differing by producttype and -amount, distance, day of the week, transport mode and size	
Material handling costs at HEINEKEN	Supply chain flexibilty
Cost of labour and equipment related to internal transport and (un)loading differing by volume, density and method employed	Complexitiy of material flow, robustness of equipment and the agility to respond to market changes
Material handling and inventory costs of 3PL	
Additional cost of labour, equipment and (internal) transport of 3PL and costs of the required storage space	
Costs of risk	
Preventive and corrective measures related to lost or damaged products	

Conclusion of chapter 2

In this chapter we explained which literature supported phase I of our research. We explained the layout design problem and have discussed several improvement approaches, which has resulted in our own layout design and evaluation approach, visualized in Figure 2-4. Further we discussed some logistic strategies and have described the (cost) evaluation criteria proposed by the literature that are relevant for our research. In Table 2-1 we provided an overview of the criteria that are used in this research.

3. Research of phase I

In this chapter we elaborate on the research that we have conducted in phase I. In the first section we discuss the current situation at HEINEKEN. In section 3.2 we pay attention to the different alternative options that we have developed to resolve the problem situation. Section 3.3 presents the criteria and evaluation process of these different alternatives and in section 3.4 we present an overview of the pros and cons per alternative that has led to the conclusion of phase I.

3.1 Situation and problem analysis

In the first section we discuss the motivation for the introduction of packaging line 52, next we explain the current inbound supply methods for empty bottles and cans used at HEINEKEN and in the last section we discuss the limitation problem on the Foleyplein. Observations, obtained data and several interviews with staff members of HEINEKEN (Bos, 2016; Dijksma, 2016; Schrama, 2016; Schreuder, 2016; Stevens, 2016; van de Bor, 2016; van der Meijden, 2016; Verbunt, 2016) and Hartog&Bikker has enabled the understanding of the current situation and available supply methods at HEINEKEN.

As shown in Figure 1-1 already, the current production facility of HEINEKEN Zoeterwoude contains 7 one-way bottle lines (21, 22, 3, 51, 7, 81 and 82) and one can line (6). Figure 3-1 shows the overview of the HEINEKEN brewery in Zoeterwoude, with the relevant parts of these lines indicated.

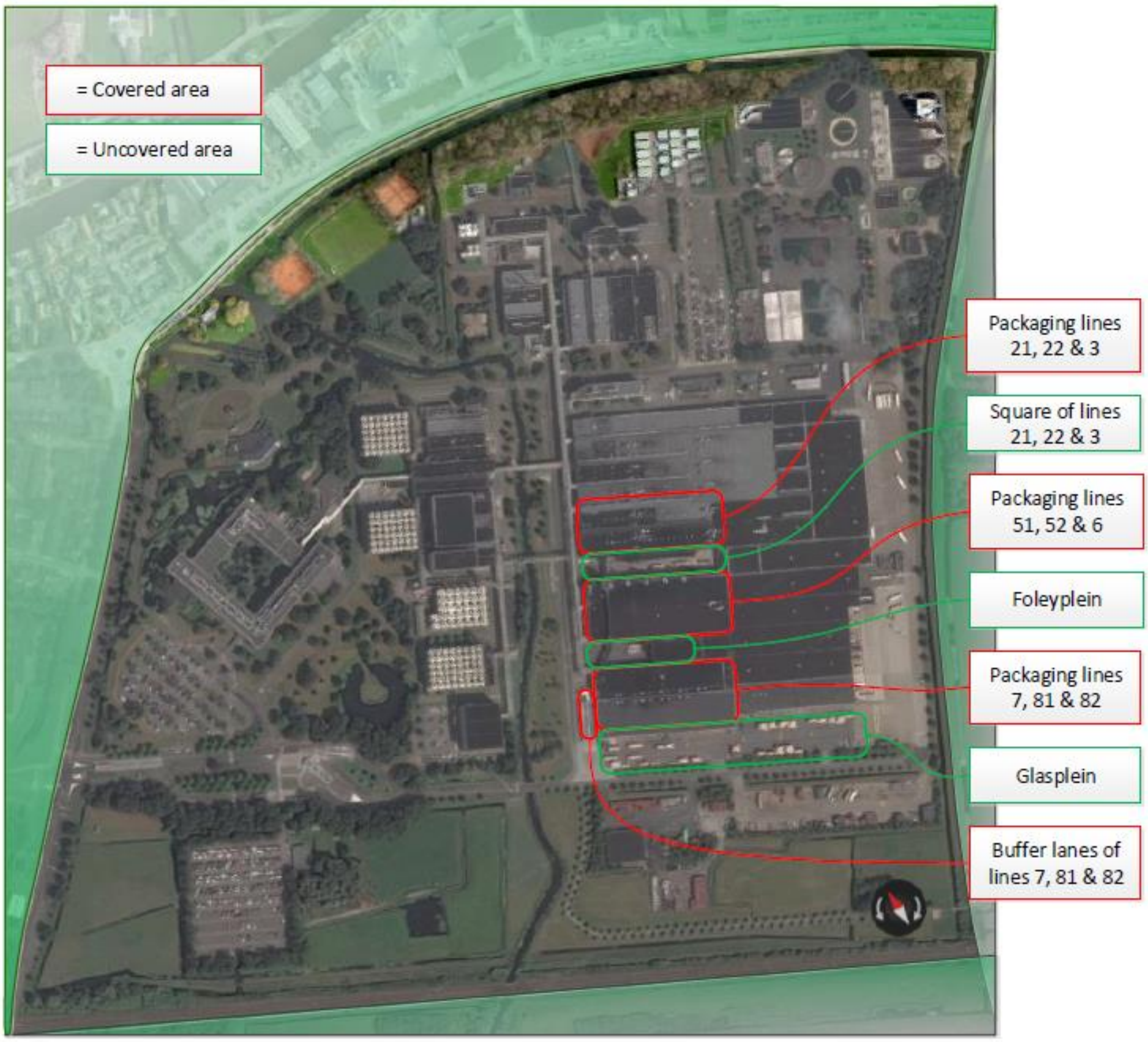


Figure 3-1: Brewery overview of HEINEKEN Zoeterwoude

3.1.1 Motivation for the introduction of packaging line 52

For all packaging lines at HEINEKEN a shift system is used, which means that a day of production (24 hours) is divided in 3 shifts of 8 hours each. These 'teamshifts' take turns such that the packaging line can continue producing overnight. While this is the case, not all packaging lines at HEINEKEN are deployed 7 days a week. The 'teamshift systems' at HEINEKEN can roughly be divided in two. When a packaging line produces 5 days a week and 24 hours a day it is called a '3 shifts system'. When a packaging line continues in the weekend it is called a '5 shifts system'.

The objective for packaging line 52 is (1) to take over the weekend production volume of the production lines that produce in a '5 shifts system', so that all one-way bottle lines can produce in a '3 shifts system' and the weekends can be used for additional production if required, (2) to take over some production volume of Den Bosch (see appendix A.2) and (3) to absorb some potential increase in demand. The vast majority of the production volume that will be produced on line 52 comes from these weekend productions of the other production lines of Zoeterwoude. The origin of the production volume of line 52 is graphically shown in Figure 3-2.

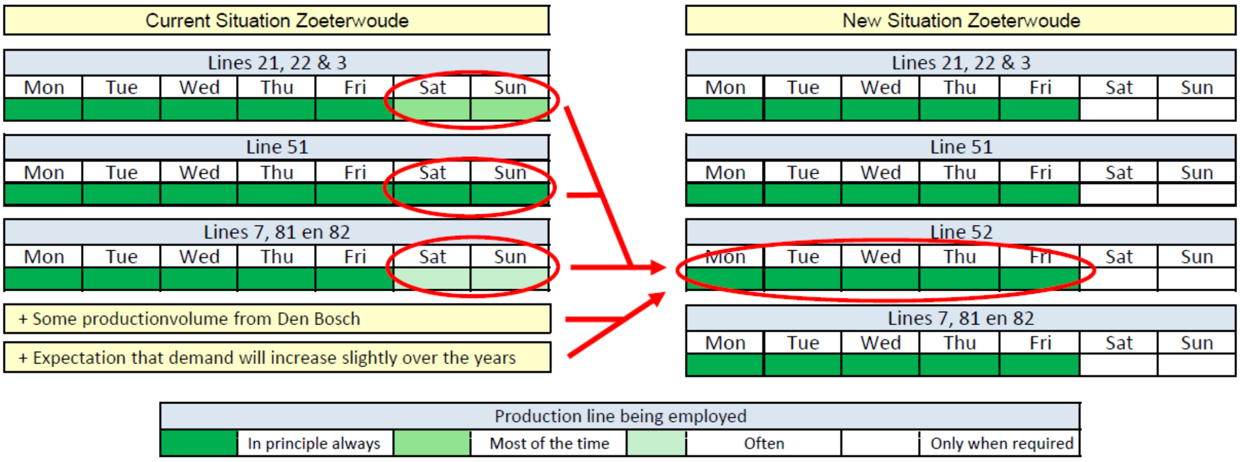


Figure 3-2: Origin of production volume of the new one-way bottle line 52

In the current situation bottle lines 51, 21, 22 and 3 and can line 6 work in a '5 shifts system' whereas bottle line 7, 81 and 82 work in a '3 shifts system'. While this is the case the production of the packaging lines is not that straightforward, as also indicated in Figure 3-2. All lines shown in this figure are (in principle) always producing during the weekdays. With regard to the weekend, lines 51, 21, 22 and 3 are still producing most of the time, while lines 7, 81 and 82 are just sometimes in use. This 'weekend volume' is intended to be produced by production line 52 in the new situation. As will be explained in section 3.3.2 we assume that the line will produce approximately X million bottles per year. About X million will be absorbed from line 21, 22 and 3 and about X million from packaging line 51. Knowing that this 'weekend volume' is the much greater part of the total production volume that will be produced on line 52, we can state that the total one-way bottle production in Zoeterwoude will not increase too much. This is explicable since the production depends on the market demand, which does not suddenly increase radically next year.

3.1.2 Inbound supply methods currently employed at Heineken

The methods that HEINEKEN uses in the current situation to supply the empty bottles and cans to the existing one-way bottle and can lines can roughly be divided in two ways: Conventional or Direct Line Feed (combined with Direct Docking). We briefly describe how these methods are currently employed. In the remainder of phase I, described in this chapter 3, only the packaging lines that are supplied via the Foleyplein are considered (line 51, 6 and the new line 52).

Conventional supply method

In the conventional method the empty bottles or cans are supplied in large trucks (30 or 42 pallets) and stored on the required storage location on the premises of HEINEKEN until they are required on the packaging lines. The manufacturers, the use of intermediate warehouses, the precise location of internal storage and usage of internal transport differs between the bottle packaging lines and the can packaging line. For can line 6 the cans flow directly or via an intermediate warehouse and are stored on the Foleyplein. From there they are transported to the packaging lines by FLT's. The bottles for line 21, 22, and 3 flow directly to the brewery and are stored on the Glasplein from where they need additional transport via a buiscar from the Glasplein to the packaging lines on the Foleyplein. Figure 3-3 visualizes the logistic distribution network of the different packaging lines that are supplied via the conventional way in the current situation. A more detailed explanation is provided in appendix A.3.

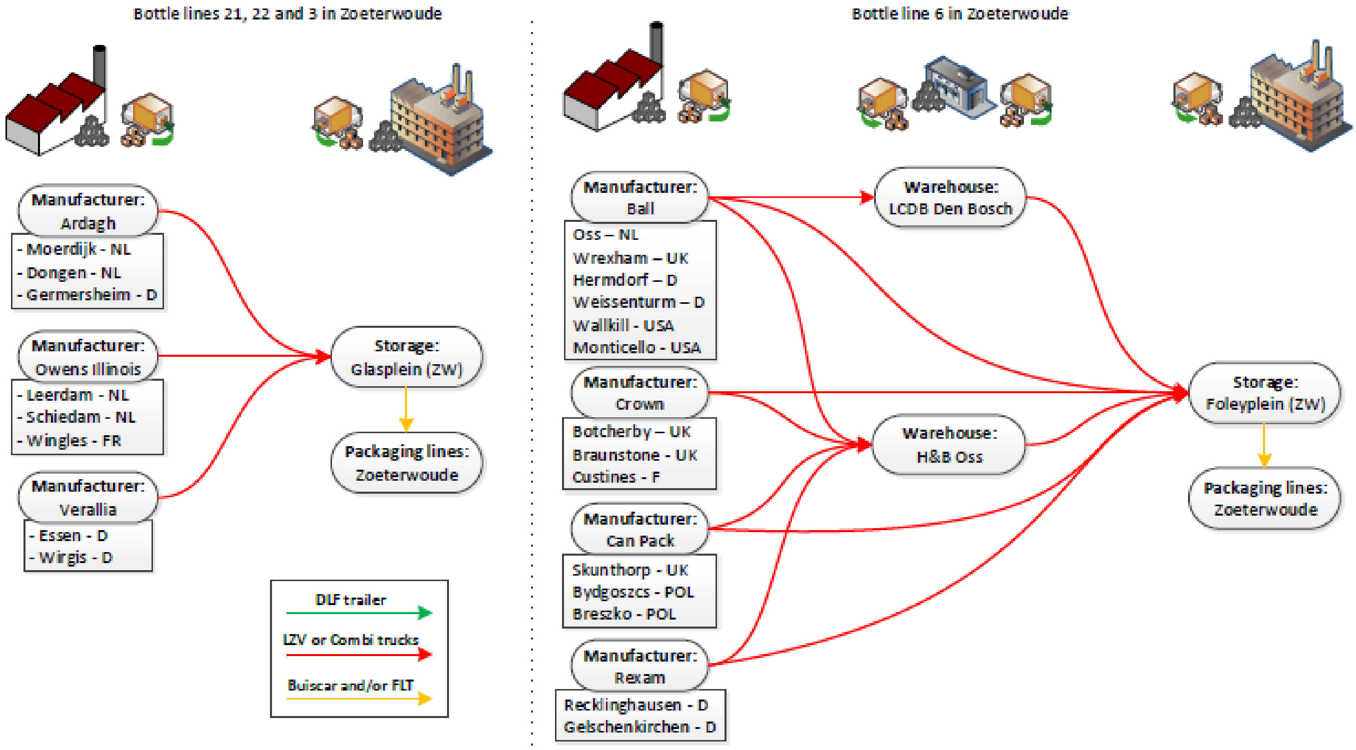


Figure 3-3: Logistic network of inbound supply via conventional [A: Bottle lines 21, 22 and 3; B: Can line 6]

Direct Line Feed (DLF) and Direct Docking (DD) supply method

In the DLF method the empty bottles are supplied by smaller trucks (26 pallets), which are automatically loaded at the manufacturer, driven to the brewery of HEINEKEN in Zoeterwoude and unloaded directly on the buffer conveyor of a packaging line. In this technique the trailer as well as the buffer conveyor of a packaging line and the loading conveyor at the manufacturer consist of roller conveyors, which facilitates that the trailer can be loaded and unloaded without any handling. When the truck driver docks his trailer directly against the buffer conveyor and turns on the switch, the pallets will roll in or out automatically. In Figure 3-4 the DLF method at the brewery for line 51 is graphically shown. The main image of Figure 3-4 shows us the Foleyplein, from the point of view as indicated with yellow in Figure 3-6, where we see a trailer filled with empty bottles docked to the buffer conveyor of line 51. The smaller images on the side display the DLF technique. The upper left image shows the roller conveyors in the trailer and the upper right image shows the buffer conveyor of packaging line 51. Since all pallets with empty bottles are supplied directly to the buffer conveyors, in this case to the buffer conveyor of line 51, there is no other storage location for empty bottles for this packaging line.

Therefore the buffer conveyors are constructed such that they are able to contain a buffer of empty bottles equal to the volume of three trailers.

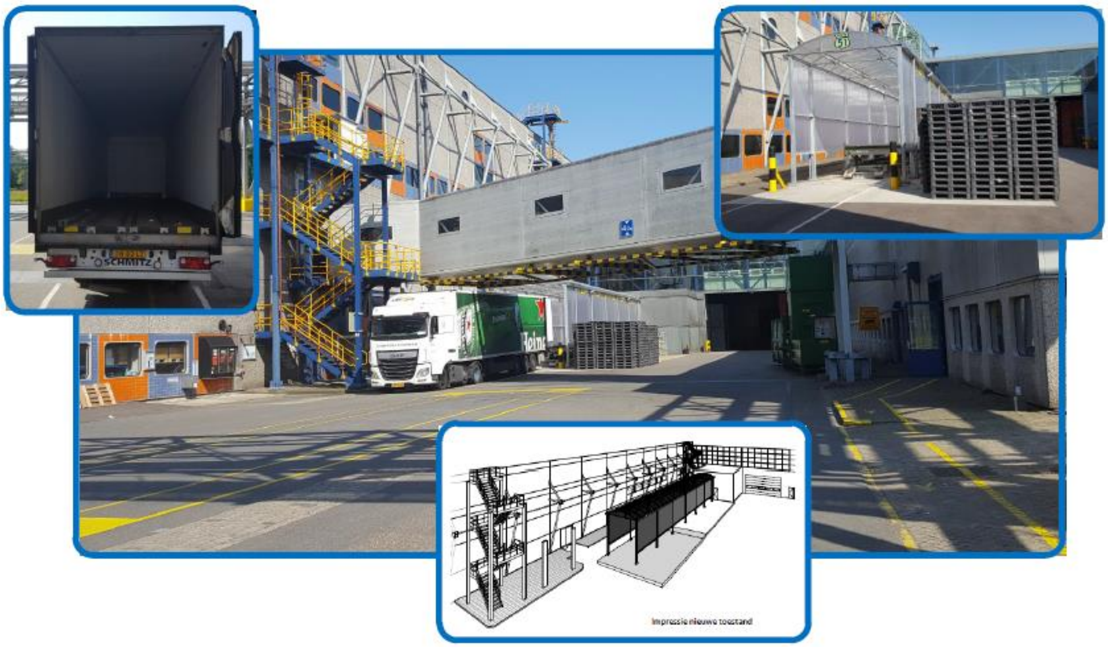


Figure 3-4: DLF method for line 51 on Foleyplein

When the transportation of, in our case, empty bottles or cans is not carried out directly from the supplier to the packaging lines (i.e., via DLF), but via the intermediate warehouse, this transportation at HEINEKEN is called Direct Docking (DD). In this case the empty bottles or cans are initially transported to the intermediate warehouse, where the pallets are temporarily stored. When the bottles or cans are needed at the packaging lines the FLT's place these pallets on the loading conveyor of the warehouse, one of the 'shuttle trailers' is automatically loaded and the trailer will transport the bottles or cans to the concerning packaging line. Unloading the trailers on the packaging line is carried out as explained for DLF supply.

The bottle supply to packaging lines 51, 7, 81 and 82 is carried out via the DLF (and DD) method and consists of several routes. Most of the transport is carried out directly to the packaging line. In some cases the transport needs to be carried out via DD. Reason for this need to use an external storage location close to the packaging lines is (see appendix A.4 for more detailed explanation):

- Not all supplier's facilities are able to support the DLF method (i.e., non-DLF locations), because they are located to far or do not possess a loading conveyor.
- The DLF method requires an alternative location to deviate to when the buffer conveyor of the packaging line is full at the time the trailer arrives.
- Supply sometimes needs to be supported with an additional trailer, causing the need of a safety stock location close by.

The can supply to the packaging lines in Den Bosch is similar. An important difference however is that cans are not supplied directly to the packaging lines, but completely via the intermediate warehouse. The reason for 100% DD is explained in section 3.2.1. Figure 3-5 visualizes the logistic distribution network of the different packaging lines that are supplied via the DLF and DD way in the current situation. A more detail explanation is provided in appendix A.3.

A main advantages of the DLF method is the reduction of material handling activities and FLT usage, since most of the pallets are supplied directly to the packaging lines. Material handling activities are

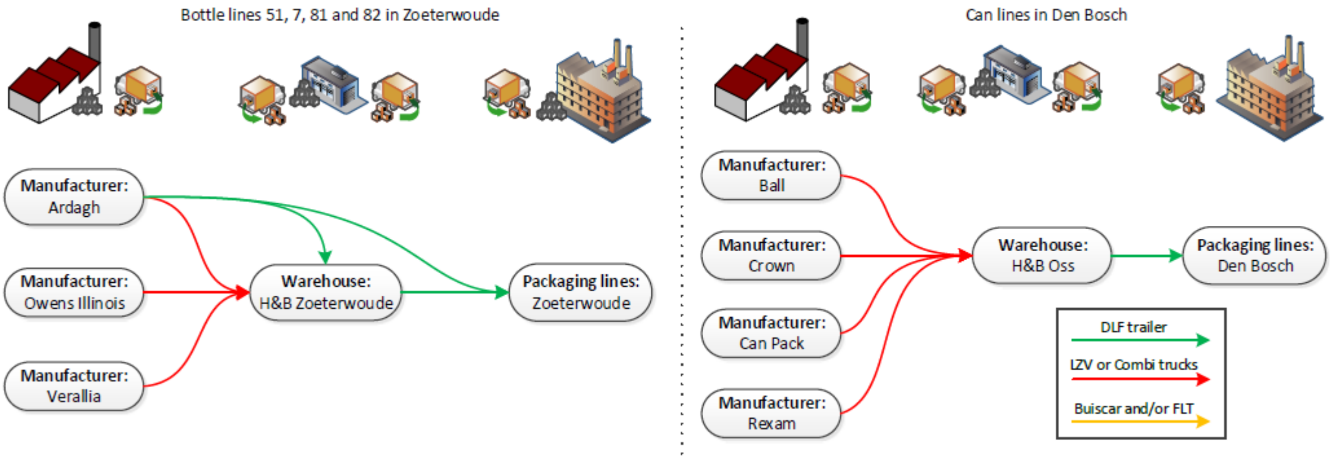


Figure 3-5: Logistic network of inbound supply via DLF and DD [A: Bottle lines 51,7,81 and 82 in Zoeterwoude; B: Can lines in Den Bosch]

only carried out in the intermediate warehouse and is only required for the pallets that are supplied via the warehouse. Another advantage of the DLF method in comparison to the conventional method used at HEINEKEN, is the fact that these pallets are dry when they enter the packaging line. In the conventional method the pallets are stored on the Glasplein for a while, which is an uncovered square. When the weather is bad the cardboard covers on the top of the pallets can get soaked, despite the fact that these pallets are wrapped in foil. When these pallets with soaked cardboard covers enter the packaging line, the chances of disturbance on the line is determined to be higher. Especially at the 'unwrapper', which is the device that pulls off the foil of the pallets. At HEINEKEN an OPI loss of X% is assumed for the additional disturbance on the packaging line, because it results in a lower utilization of the packaging line and thus less production.

A main advantage of the conventional way is that the transport from the manufacturer to the brewery is done by larger trucks consisting of two wagons. This use of multiple wagons is (yet) impossible in the DLF technique. Therefore more pallets are transported per ride in case of conventional supply, resulting in lower transportation costs per pallet (van Amstel & van Goor, 2006; Voordijk, 2010). With regard to the bottle supply, the conventional method has another important advantages. As explained above the DLF method requires the use of an external storage location close to the packaging lines. The conventional method does not require an intermediate storage and does not has the associated costs. The advantages and disadvantages of the DLF method are explained more extensively in appendix A.4.

3.1.3 Space limitation problem on the Foleyplein

In the first part of this section we explain the current activity on the Foleyplein, next we explain the impact and characteristics of the new production line 52.

Current situation of Foleyplein

In Figure 3-1 an overview of the brewery is given, which indicates the location of the Foleyplein. In Figure 3-6 an overview of the Foleyplein itself in the current situation is given. In this schematic representation of the Foleyplein we can distinguish the relevant elements of the inbound supply methods explained in the previous section for the packaging lines 51 and 6. We discuss the relevant details about the material flow on the Foleyplein more extensively.

Activities, flows and constructions for line 51 on the Foleyplein

The supply of empty bottles to packaging line 51 is performed via the DLF method. In Figure 3-6 the spatial layout of the construction and the trailer position for the inbound supply of this line is

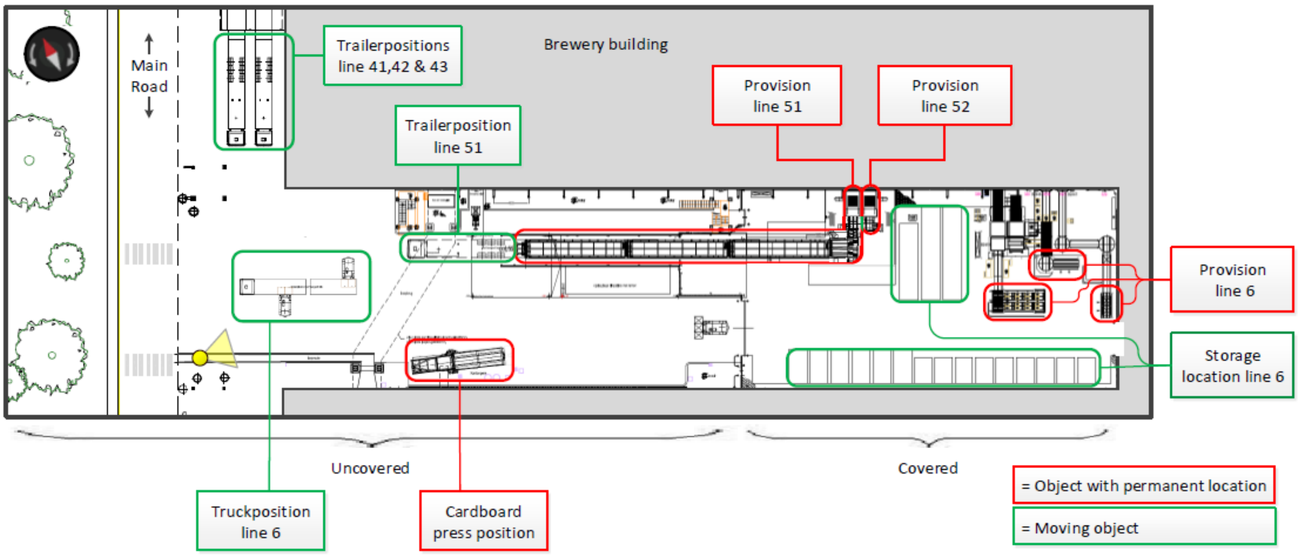


Figure 3-6: Overview of the Foleyplein (version II)

visualized. The buffer conveyor and the location of the 'depalletizer' are circled in red and indicated by 'provision line 51'. The 'depalletizer' is the device that feeds the bottles to the packaging line per pallet layer. In front (left side in figure) of this buffer conveyor a trailer is visualized in the situation that it is docked against the buffer conveyor to unload the empty bottles. Each day approximately X trailers arrive on the Foleyplein for the supply of line 51. These trailers arrive via the main road, enter the Foleyplein, turn around, dock against the buffer conveyor to unload the trailer and leave the Foleyplein when it is unloaded, which in total takes less than half an hour.

Activities and constructions for line 6 on the Foleyplein

The supply of empty cans for packaging line 6 is carried out in the conventional way, which is shown in Figure 3-6. On the left side the truck position is visualized and on the right side the storage location for empty cans and the loading conveyors are visualized. When a truck arrives at the brewery it is parked on the Foleyplein as circled in green in Figure 3-6, where it is unloaded by a forklift truck (FLT). This FLT temporarily storages the pallets of empty cans on the assigned storage location at the Foleyplein, as indicated in green in Figure 3-6, till packaging line 6 needs it. At that moment the FLT lifts the pallets with empty cans from the storage location and places those on one of the loading conveyors of line 6 circled in red. Each day approximately X trucks arrive on the Foleyplein for the supply of line 6. They arrive via the main road, enter the Foleyplein, turn around and park on the assigned location indicated with a yellow square on the ground. The truck driver opens the sail on both sides of his truck so that it can be unloaded by a FLT from both sides (in consecutive order). Unloading the truck means that a FLT is shuttling between the truck on the left side to the storage location on the right side. When it is unloaded the truck leaves the Foleyplein via the main road again. The time period between entering and leaving the Foleyplein takes approximately half an hour.

Other activities and constructions on the Foleyplein

Three other activities on the Foleyplein which we discuss briefly are related to the supply of line 41, 42 and 43, the removal of cardboard of line 7, 81 and 82 and the return flow.

- At the upper left of Figure 3-6 we see the trailer positions of line 41, 42 and 43 indicated. While these lines are completely left out of the scope of this research, the only relevant aspect is the fact that the trailers of these lines cross the Foleyplein. They enter via the main road, use the Foleyplein to turn around and dock against the buffer conveyors via the same technique as line 51. Obviously these trailers leave via the Foleyplein as well.

- At the bottom of Figure 3-6 the construction of the cardboard press from line 7, 81 and 82 is visualized. Residual cardboard from these lines is transport via tubes into this press. Once in a while this press needs to be emptied, which is done by a truck that enters the Foleyplein from the main road, docks on the right side of the press (not visualized) and leaves the area again. When there is no can-truck parked on the square, the truck turns around on the Foleyplein and leaves the square in forward direction. In case there is a truck parked, there is not enough space to turn around, which forces the truck to leave the Foleyplein backwards and use the main road to turn around.
- Once in a while the empty pallets, slip sheets and can remainders are retrieved from the Foleyplein by a truck and sometimes empty one-way pallets are supplied via the Foleyplein. These trucks alternate with the trucks for line 6 and thus enter, park and leave the Foleyplein the same way.

Introduction of packaging line 52 on the Foleyplein

As explained in section 1.2 the brewery in Zoeterwoude will need to increase the one-way bottle capacity. This will be resolved by an additional packaging line named 'line 52', which will be build alongside the existing packaging line 51 throughout the brewery building. Also the depalletizer of line 52 will be located next to the depalletizer of line 51, which is shown in Figure 3-6 and indicated by 'provision line 52'. The supply method of empty bottles to line 52, which need to be determined in phase I of this research, needs to connect to this depalletizer. Roughly speaking the scope of our research of phase I ranges from the moment that products (empty bottles and cans) are placed on pallets at the manufacturers till the moment these pallets reach this 'depalletizer' at Heineken, which is the device that feeds the bottles to the packaging line per pallet layer.

As explained before and shown in Figure 3-6 the amount of space on the Foleyplein is limited, which raises the question what the most cost-effective way is to organize the inbound supply of line 51, 52 and 6 via the Foleyplein. The complete space limitation problem on the Foleyplein comes down to a space limitation for all following constructions and activities:

I. The (1) physical construction, (2) trailer position and trailer movement required for the supply of bottles to line 51 using the DLF method. The supply method for line 51 will remain unchanged.
II. The (1) physical construction, (2) trailer or buiscar position and movement on and off and (3) FLT movement required for the supply of bottles to line 52, which depends on the alternative that is chosen.
III. The extra required amount space required for all packaging materials (e.g., cardboard) of line 52. It is unclear if the storage space in the brewery is enough to store this and if additional storage space on the Foleyplein is required (see also 'simultaneous research').
IV. The (1) physical construction, (2) truck or trailer position and movement, (3) FLT movement and (4) storage space required for the supply of cans to line 6, which depends on the alternative that is chosen. This storage buffer includes buffer stock, remainders, empty pallets and slip sheets (see also 'simultaneous research').
V. The trailer movement crossing the Foleyplein for the inbound supply of lines 41, 42 and 43
VI. The standing site and the truck movement for emptying the cardboard press from line 7 and 8.
VII. The truck and FLT movement for the return flow and inbound of one-way pallets.

Simultaneous research about other packaging materials

While phase I of this research was conducted, a colleague at HEINEKEN was focussing on the inbound supply of the other packaging materials and the return flow. We leave out the details of this research and only discuss the main results and the conclusion. The estimation is that X additional pallets locations where needed in the new situation, from which X could be obtained relatively easy. For the other pallet places some effort (i.e., costs) is required, but the costs that need to be incurred in these solutions are low in proportion to the costs in this project. Therefore the main conclusion is that the (extra) required amount of storage space needed for the packaging materials of line 51, 52 and 6 do not influence the conclusion in our research. Subsequently this aspect is not taken into account any further in this research.

3.2 Development of alternatives

In this section we discuss the alternative scenarios that we have developed to resolve the problem situation of phase I in a cost effective manner. First we describe some limitations, then we describe the obtained alternatives and associated CAPEX and finally we perform some checks upon the feasibility of the alternatives. Observations and several interviews (Bos, 2016; Jalink, 2016; Schreuder, 2016; van de Bor, 2016; van der Meijden, 2016) supported this part of our research.

3.2.1 Limitations that restrict the possible alternatives

Before we draw up the alternative scenarios for our research we first need to understand the limitations and constraints that are relevant to our spatial and logistical organization of the Foleyplein and the supply of packaging lines 52 and 6.

Limitations on the Foleyplein

The amount of space on the Foleyplein is limited, which easily leads to (the perception of) an unsafe working environment. A few limitations that arise from the beginning are:

- HEINEKEN has stated that is does not want a situation in which trailers or trucks are blocking each other, resulting in the fact that trailers need to get around another truck with difficult and cluttered manoeuvres on the Foleyplein. An alternative in which a position or a passageway is blocked (temporarily) by one supply method for another supply method is therefore unsuitable and left out of the alternatives.
- HEINEKEN has stated that the supply of cans and bottles happens too often, too diverse and too unreliable to regulate and plan the situation in such a way that the supply of bottles for line 51 and 52 and cans for line 6 alternate on the Foleyplein.
- The space next to the buffer conveyor of line 51, see Figure 3-6, seems quite spacious in the drawings, but the space is limited in the real situation. HEINEKEN has stated that this location is suitable for a buiscar, FLT movement and movement required for the cardboard press, but is not spacious enough as standing site and unloading area for a can or bottle truck.
- The main road alongside the Foleyplein (on the left side in Figure 3-6) is used by trucks, trailers and commuter traffic of HEINEKEN. The road is not very crowded, but it is used during the day. A quick turn on the road is possible, but occupying (a part of) the road for any longer is not desirable.

Limitations related to a covered storage location

While there seems to be a possible gain, the building of an internal storage location for cans or bottles has been kept outside the scope of this research. For bottles it could be the case that a saving in the OPEX would be obtained when the H&B warehouse can be left unused (in case of DLF supply) or when soaked cardboard covers can be prevented (in case of conventional supply). For cans an internal storage location could mean that an 'internal Direct Docking' system could be applied. However the building of an internal storage location involves quite an initial investment and it seems that it would take a long time to earn back this investment by the OPEX savings. Also if all production lines would be involved. HEINEKEN has stated that the payback period seems to too long, which placed the building of a covered storage location outside the scope.

Limitations related to the vulnerability of cans

The first limitation, with regard to storage, is that cans cannot be stored outside or in regular warehouses, because of the risk of corrosion. Cans are very vulnerable with regard to bad weather and therefore need to be stored properly. Another limitation, with regard to (internal) transport, is that cans are very vulnerable for damage as well. Empty cans are very fragile which results in the requirement that cans need to be transported as less as possible and only by the right equipment. FLT's or buiscars do not fall into the category of the right equipment and therefore HEINEKEN has stated that transportation of cans by that transport equipment from outside the Foleyplein to the loading conveyors of line 6 is not an option. Moreover we briefly discussed the possibilities of moving or adjusting the supply routes to the loading conveyors (e.g., adjustments that line 6 can be supplied via the Glasplein), but came to the quick assumption that the required investments would be to large. Therefore the location of the loading conveyor for line 6 will remain unchanged.

Limitations related to the supply of cans

Can supply via DLF is not plausible for line 6, only DD could be employed, because of two reasons:

- The distances of the can manufacturers is too far away from the brewery in Zoeterwoude. Just one manufacturer is located in the Netherlands, while the others are located in other countries of Europe and even the United States. A DLF process requires an (almost) constant supply of empty bottles that complements the buffer conveyor before all cans are used. Unpredictable delay at the can manufacturers (e.g., during loading) or during transport (e.g., traffic jams) will result in the fact that the supply takes longer than expected and that the supply of the lines is no longer carried out alternately. The further away the facilities are located, the bigger the risk that the required constant supply is completely out of balance, which makes the supply of cans via DLF impossible.
- Bottles are diversified by the labels, which allows HEINEKEN to work with just a few types of bottles to serve all markets. Cans need to be diversified by the primary packaging material (i.e., the can itself). This means that every changeover on the packaging line (i.e., every moment that a slightly different product is produced) requires that the inbound material needs to change as well. In other words, the number of different bottles that are needed is much lower than the number of different cans. The variety in different type of products, and thus the variety in different types of cans, is so large that there is often not enough cans of one specific type to fill a complete trailer. This results in the fact that different types of cans need be transported together in one truck and, in case of DLF or DD, these cans need to be placed in the truck in the exact correct order as they will be needed in the particular order on the production line. This makes it (almost) impossible to use DLF (instead of DD). First of all because sorting the cans would be an additional and difficult activity for the manufacturer, but more importantly the products that are produced in consecutive order on the packaging lines of HEINEKEN are often manufactured in different facilities.

3.2.2 Layout redesign and logistic network alternatives

In this section we discuss the alternatives that have been developed. As stated by Yang et al. (2000) the success of the implementation of a procedural approach depends to a great extent on the generation of quality design alternatives that are often from the outputs of an experienced designer. They state that the inputs from area experts during the design process should be considered as a must toward effective layout design. Therefore we involved all relevant stakeholders in the determination of the alternatives and used an expert to make the relevant drawings. In Table 3-1 we provide an overview of the alternatives that have been developed. Next we explain them for line 52 and after that for line 6.

Table 3-1: Developed alternatives for the supply of line 52 and line 6

Developed alternatives			
Bottle line 52		Can line 6	
Alternative	Short description	Alternative	Short description
DLF	DLF supply (and DD when required)	DD	Complete DD supply
Conventional A	Conventional supply where buiscar is unloaded via FLT's on Foleyplein	Conventional A	Conventional supply where the truck is parked against the building
Conventional B	Conventional supply where buiscar is unloaded by docking to the buffer lane	Conventional B	Conventional supply where the truck is located alongside the imiginary extension of line 52
		Conventional C	Conventional supply with repositioning the main road and truck parked alongside the new road

Alternatives for packaging line 52

For the supply of packaging lines 52 we have developed three alternatives. In this part we only focus on alternatives for the supply to line 52. Therefore the positions and constructions for line 6 remains unchanged in this section and the figures. A conclusion that can be derived already is that none of these alternatives is possible when the can-truck would stay on the original position. Whichever alternative we chose for the supply of line 52, the supply method of line 6 will need modification.

The first alternative for line 52 is to be supplied via DLF. The layout design and logistical network as shown in Figure 3-7. In this alternative the bottles from the DLF locations are transported (1) most of the time directly to the packaging line by DLF trailers (i.e., DLF), (2) sometimes by DLF trailers with a deviating route to the warehouse when the buffer conveyor is full (i.e., DD) and (3) occasionally by larger trucks to the warehouse when the capacity of the trailers is not enough (i.e., DD). The transport of bottles from the non-DLF locations is carried out by larger trucks via the warehouse either way (i.e., DD). Transport from the warehouse to the packaging line is done by shuttle trailers stationed at the H&B warehouse with the same size as the normal DLF trailers.

As visualized in the layout overview of the Foleyplein the buffer conveyor of line 52, indicated in orange, would be build alongside the buffer conveyor of line 51 and the truck would dock against the buffer conveyor as done for line 51. The CAPEX (i.e., initial investment costs) is estimated on €X.

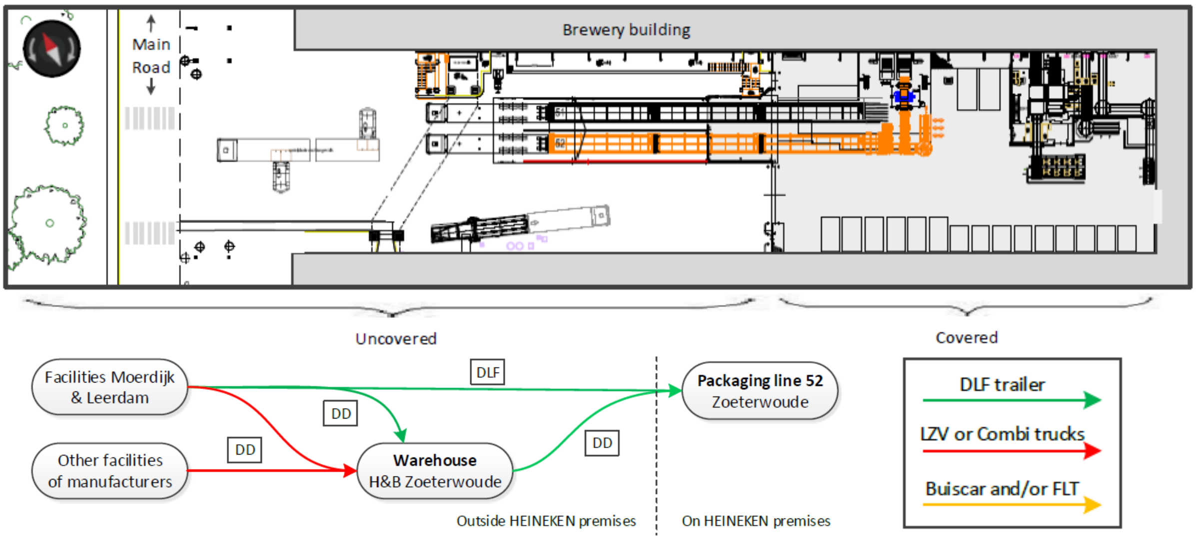


Figure 3-7: Layout design and logistic network in the option that line 52 is supplied via DLF

The second alternative for line 52 is to be supplied via conventional, whereas this could again be divided in two options (A and B). The logistic network, which is the same for both options, and the layout design for both options is shown in Figure 3-8. The logistic network of this alternative is simple. The complete bottle volume from all locations would be transported by larger trucks and stored

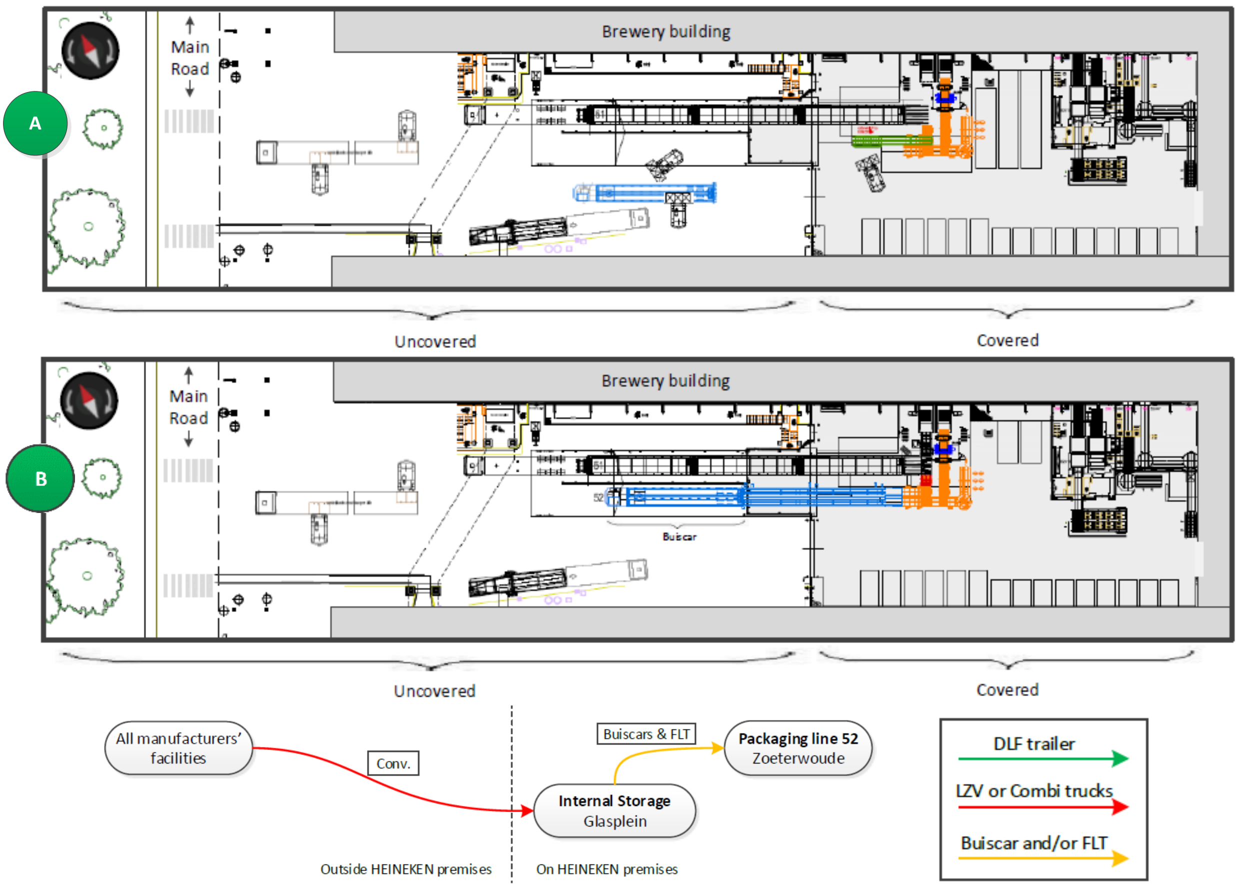


Figure 3-8: Layout designs options and the logistic network in the option that line 52 is supplied conventionally

temporarily on the Glasplein. When the packaging line needs them, the pallets would be placed on a buiscar by a FLT and driven to the Foleyplein.

Arrived on the Foleyplein the conventional A and B alternatives differ. In the first layout option (option A) we would employ the method where the buiscar is positioned close to the packaging lines and the pallets with empty bottles are transferred from the buiscar to the loading conveyor of the packaging line by a FLT. The second layout option (option B) would employ the method where the buiscar is docked against the loading conveyor of the packaging line and where the pallets are lifted from the buiscar by use of the metal forks in the loading conveyor. Obviously these different methods require a slightly different construction of the loading conveyors. The CAPEX (i.e., initial investment costs) for respectively option A and B is estimated on €X and €X.

Alternatives for packaging line 6

In this section we pay attention to the alternatives of packaging line 6. To emphasis on the four alternatives for line 6 that we have developed, we keep the positions and constructions for line 52 stable in this section. In all figures line 52 will be visualized as in the DLF alternative.

In the first alternative packaging line 6 is supplied via the DD method, see Figure 3-9. As explained in section 3.2.1, DLF supply is not plausible for can supply, which results in the fact that 100% DD supply would by employed. All cans from all manufacturers' facilities would be transported to the intermediate warehouse of H&B in Zoeterwoude by large trucks. At the H&B warehouse the pallets with empty cans would be unloaded by FLT's and temporarily stored. At the moment packaging line 6 would require the empty cans, the pallets would be placed on the loading conveyor by FLT's, loaded in the shuttle conveyors, transported to the packaging lines, docked to the buffer conveyor and automatically unloaded.

As shown in the layout overview the buffer conveyor for line 6, indicated in green, would in this alternative be build alongside line 51 and 52 and the trailer would dock to the buffer conveyor as done for line 51. The construction for the buffer conveyor of line 6 would inquire higher CAPEX than the buffer conveyor of line 52, because it includes the need of a shuttle conveyor (i.e., a traverse car) between the buffer conveyor and the loading conveyor. Furthermore the construction should overcome a little height difference. The estimation for the construction to facilitate the DD process is therefore estimated on €X.

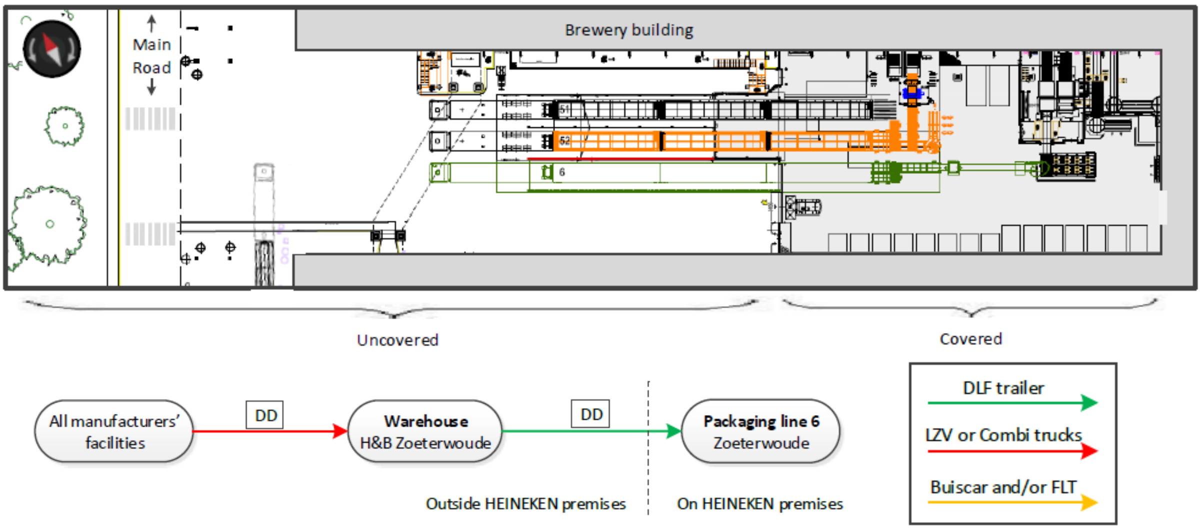


Figure 3-9: Layout design and logistic network in the option that line 6 is supplied via DD

The other three alternatives for line 6 that we have developed are via the conventional way and are in general supplied via the same method and thus the logistic network for all of these alternatives is the same. The logistic network and the layout design for the three options is shown in Figure 3-10.

The cans are supplied directly from the manufacturers' facilities to the Foleyplein as much as possible. However the buffer storage on the Foleyplein is limited (approximately equal to X hours of production) and therefore in some cases and from some facilities (e.g., from the United States) it is required to use the intermediate warehouse. In all routes the supply is carried out with larger trucks (30 or 42 pallets). When a truck arrives (direct or indirect) at the brewery it is parked on the Foleyplein and unloaded by a FLT which stores the pallets of empty cans on an assigned storage location at the Foleyplein. At the moment the line needs them, the FLT lifts the pallets with empty cans from the storage location and places them on one of the loading conveyors of line 6.

The difference between these alternatives is related to the parking location of the truck. In the first option (conventional A) the truck location is shifted to the wall at the bottom of the figure, in the second option (conventional B) the truck is placed alongside an 'imaginary extension of line 52' and in the third option (conventional C) we would create more space on the Foleyplein by repositioning the main road and placing the truck in the same direction in this freed space, see Figure 3-10.

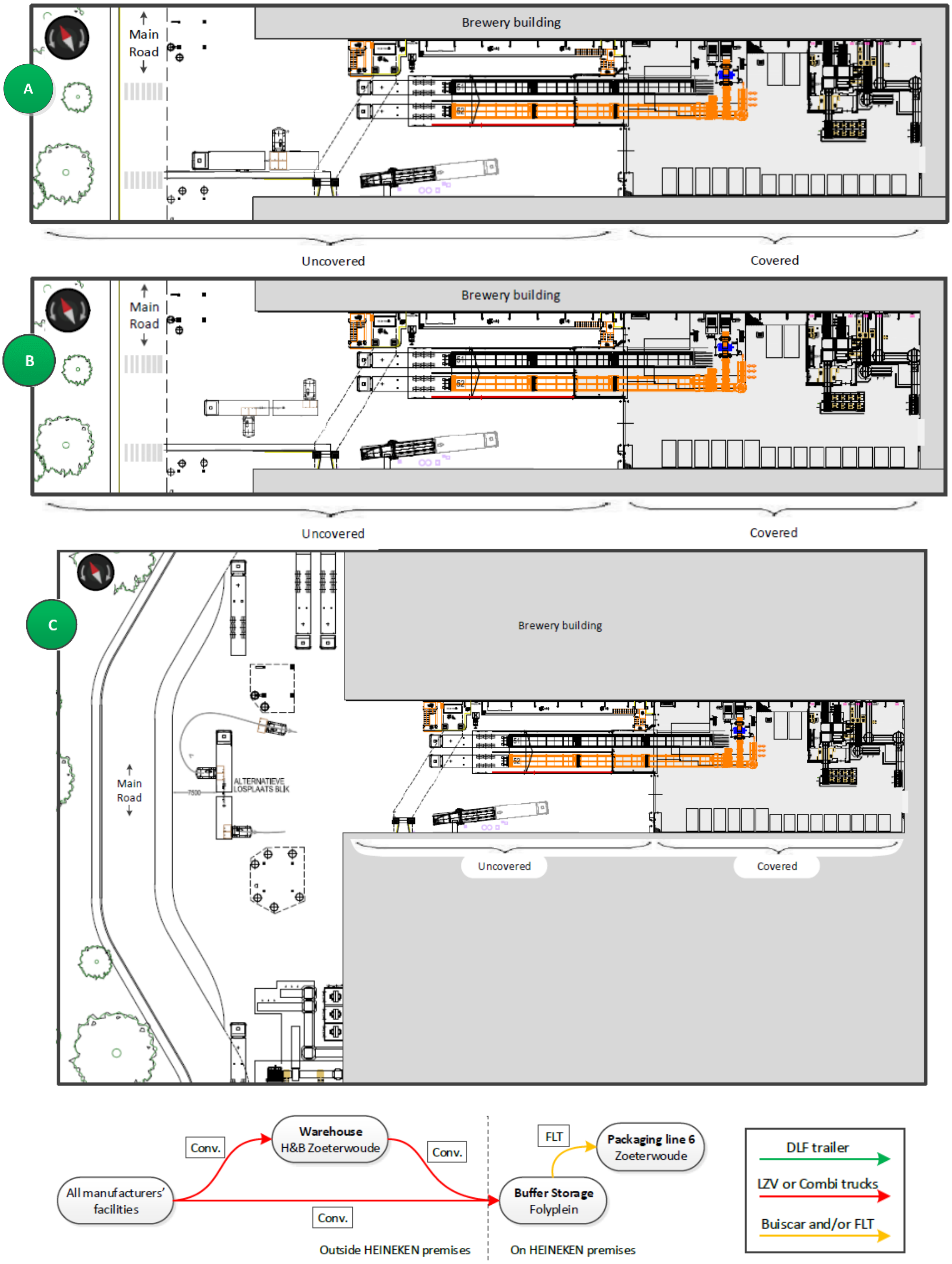


Figure 3-10: Layout design of all 3 options and the logistic network for the option that line 6 is supplied conventionally

3.2.3 Feasibility checks of developed alternatives

In this section we briefly explain the two feasibility checks that we have performed before we start the calculations and evaluation of the different alternatives in the following sections.

Experimentation to check feasibility of alternatives on Foleyplein

As explained in the previous section we involved all relevant stakeholders for the determination of the alternatives and used an expert to draw up the layout designs. While the drawings are creating insight and feeling for the situations that arise, it is very difficult to ensure from the drawings if the alternatives create a safe and pleasant working environment. Since safety is the number one priority at HEINEKEN and the alternatives need to meet the safety restrictions, we decided to check the alternatives in real life (i.e., with the actual system) together with the relevant stakeholders. In this 'experiment' we represented the situations by borrowing a large truck and a DLF trailer from H&B and parking these in the positions of the alternatives. Together with the staff of H&B and some significant staff members of HEINEKEN (e.g., safety staff and team leader) we assessed the different alternatives in terms of safe working environment and discussed the modification on the Foleyplein that would be required.

In Figure 3-11A the scenario is represented in which line 52 is supplied via DLF and line 6 is supplied via the conventional way with the original can truck position. In other words the DLF trailer is placed in front of the imaginary buffer conveyor of line 52 and the can truck on the original can truck location. As expected, it was very obvious that this was an unsafe and undesired situation. The trailer for line 52 could not be parked if a can truck was parked as well and as discussed in section 3.2.1 it is impossible to alternate the trucks and trailers over time. From the other alternatives it was quite clear that situations would be safe and feasible, except for two situations:

- It was not clear immediately if line 6 could be supplied via the conventional B option. In option B the can truck position is located alongside an 'imaginary extension of line 52' as shown in the picture above in Figure 3-11B. In consultation with the involved stakeholders we have decided that this could result in a safe working environment if it remains possible (1) for the DLF trailers to pass the can truck in as safe manner (and straight line) for the supply of line 52 and 51 and (2) for the FLT's to unload the can truck on both sides in a safe manner. During the experiment on the Foleyplein we have decided that both requirements could be fulfilled. The first requirement is fulfilled by shifting the can truck a few meters to the right* as shown in Figure 3-11B. The second requirement can also be fulfilled, but needs a bit more effort and some agreements:
  - When a DLF-trailer of line 51 of 52 is moving on the Foleyplein, the FLT's are not allowed to unload the can truck on the left* side. They temporarily stop there activities when necessary till the trailer has left the Foleyplein or is docked to the buffer conveyor.
  - On the right* side of the can truck there is too limited space for the FLT to unload the can truck in a safe manner. To resolve this, the walkway marked in yellow (see Figure 3-11B) needs to be shifted to the wall and shielded by a fence to prevent accidents.
  - The truck that empties the cardboard press will be forced to leave the Foleyplein backwards when a can truck is parked. In this case, the FLT's are not allowed to unload the truck on the right* side.
  - The trailers that dock against lines 41, 42 and 43 will be forced to enter the Foleyplein backwards when a can truck is parked. When this occurs, the FLT's are not allowed to unload the can truck on the left* side.
- In the conventional option C we want to create more space on the Foleyplein by repositioning the main road and placing the truck in the same direction in this freed space. We discussed this plan with the relevant engineers who suggested that the scenario was feasible. However we were not able to experiment this scenario as easily as the others, because the main road need to be demolished and rebuild. In consultation with the relevant stakeholders we have decided that the safety aspect needed to be checked in more detail, when this scenario would seem the most desired one based on all the other criteria.

*Right and left is meant from the viewers' perspective in the upper picture in Figure 3-11B.

Figure 3-11: Experimental situations on the Foleyplein [A]: line 52 via DLF and line 6 via conventional with original position [B] line 52 via DLF alternative and line 6 conventional B alternative

Loading capacity of manufacturers as restrictions on DLF performance

The loading capacity is a possible limitation from the manufacturer's perspective. In case we would supply line 52 via the DLF method, a total of 5 lines would be supplied via DLF and thus probably X DLF trailers would shuttle between Moerdijk or Leerdam and the packaging lines. The amount of time that a loading conveyor on the premises of the manufacturer is occupied is approximately 30 minutes per trailer. Placing the pallets on the loading conveyor by a FLT takes about 15 minutes and docking and loading a trailer takes about the same time period.

As shown in Table 3-2 the maximum amount of trailer rides that can arise for all 5 packaging lines is X trailers rides a week. Furthermore we calculated the maximum amount of trailers that Moerdijk and Leerdam could process, which is respectively X and X trailers a week. Since the trailers will always shuttle to both Moerdijk and Leerdam each week, we can state that none of the locations need the loading capacity to supply all X DLF trailers together. In the meantime we also know that there will be some inefficiencies during the loading of the trailers. Therefore we estimated that the maximum amount of loading capacity that could be required at Moerdijk and Leerdam is respectively X and X trailers a week. For clarification: this means that we estimate that in the situation that unusually many bottles are supplied from Moerdijk in a week, the maximum amount would be X trailers. For Leerdam this would be X trailers. When we take a look at the available loading capacity we can conclude that this will not result in a limitation for the supply of bottles via the DLF method.

Table 3-2: Estimation of the different aspect relevant to the loading capacity at the DLF locations

Maximum amount of trailer rides			
Line 51	Line 51	Line 7, 81 and 82	# Trailers Total

Loading Capacity Available in Current Situation				
Location	# Loading Conveyors	# Trailers per loading conveyor in 24 hours	Capacity	
			# Trailers per 24h	# Trailers per 5 days
Moerdijk		Confidential		
Leerdam				

Maximum loading capacity required	
Location	# Trailer rides
Moerdijk	
Leerdam	

Conclusion of section 3.2

In section 3.2 we discussed the limitations that restricted the possible alternative (3.2.1), the developed alternatives (3.2.2) and the feasibility check of these alternatives (3.2.3). We concluded that there are 3 feasible alternatives for the bottle supply to line 52 and 4 alternatives for the can supply to line 6, which should be evaluated in the next section.

3.3 Evaluation of the alternatives

In this section we discuss the logistic costs calculations and other evaluation criteria. The first section provides an overview of the CAPEX, next we explain our costs calculations for line 52 (section 3.3.2) and for line 6 (section 3.3.3) and discuss the results of these calculations (section 3.3.4). The last section (3.3.5) pays attention to the qualitative evaluation criteria. Several interviews with and data from staff members at HEINEKEN (Bos, 2016; Dijksma, 2016; Kögeler, 2016; Schrama, 2016; Schreuder, 2016; Sommeling, 2016; van de Bor, 2016; van der Meijden, 2016; van Oost, 2016; Verbunt, 2016) and H&B (Zoeterwoude & Oss) have supported this part of the research.

3.3.1 CAPEX estimations for line 52 and line 6

In this section we provide an overview of the different investment costs (i.e., CAPEX), which we had mentioned in section 3.2.2 already.

Table 3-3: Initial investments for the different alternatives

Estimated Investment Costs (CAPEX)					
Line 52			Line 6		
Scenario	Costs		Scenario	Costs	
DLF	Buffer conveyor + Shelter		DLF	Buffer conveyor + Traverse car + Shelter	
Conventional A	Loading conveyor Buiscar	Confidential	Conventional A	FLT with long forks Modification pathway	Confidential
Conventional B	Buffer conveyor Buiscar		Conventional B	Modification pathway	
			Conventional C	Modification main road	

* Low investment
** Costs are covered by other project

3.3.2 OPEX calculations for the different alternatives of line 52

As explained earlier we did not use more specific or extensive models (e.g., an optimization model or (Monte Carlo) simulation), since there is very much uncertainty in the variables. Most data and estimations are based on rough expectation instead of facts or real data, which makes it undesirably to optimize or work with statistic divisions. We rather use the calculation and evaluation model to create a better understanding of the relationships between the costs elements, to calculate the different logistic distributions costs easily, to perform sensitivity checks easily and to use these calculations during the evaluation of the different alternatives. The model in Excel consist of multiple elements, which are all incorporated in a user friendly overview of the system:

- Several (user) input variables and parameters
- Expected production volume calculation
- Multiple cost calculation formulas

Since the overview of model in Excel itself is quite large, we placed the overviews in appendix C.2. The input variables and parameters that are used in the model and the formulas are shown in Figure 3-12 and explained in detail in appendix C.4.

Variables	Parameters
A = Total amount of bottles	L = Maximum production capacity of line 52
X_o = Amount of production weeks o	R_{jyw} = Transport price in particular transport mode (j) from particular location (y) during a particular moment of the week (w)
G = OPI of line 52	H = Transport price per pallet for the shuttle from the warehouse to the lines
V_e = Amount of hours per week in particular shift system e	Q_j = Pallets in particular transport mode j
D_w = Percentage during that particular moment of the week w	N_x = Amount per pallet of a particular bottle type x
B_x = Percentage of particular bottle type x	S_a = Duration per material handling activitiy a
F_y = Percentage from manufacturers facility y	K_a = Amount of pallets per material handling activity a
T = Percentage of the DLF performance	C = Costs per logistic FTE
P_{iyw} = Transport price per pallet via a particular route (i) from particular location (y) during a particular moment of the week (w)	E = Effective hours per shift
	M_u = Inefficiency factor for packaging line u
	Z = TARA (e.g. illness)

Indices

- x = Bottle types; 1 = 250K2, 2 = 330K2, 3 = 355K2
- y = Locations; 1 = Moerdijk, 2 = Leerdam, 3 = Dongen, 4 = Germersheim, 5 = Schiedam, 6 = Essen, 7 = Wirgis
- w = Day of the week; 1 = Mon - Fri, 2 = Sat, 3 = Sun
- i = Transport route; 1 = DLF, 2 = Conventional, 3 = Via Warehouse
- j = Transport mode; 1 = DLF trailer 2 = Combi & LZV (25% / 75%)
- o = Period of time; 1 = 1 week, 2 = 48 weeks (1 production year)
- e = Shift systems; 1 = 3 shift system, 2 = 5 shift system
- a = Material handling activity; 1 = Unload truck and place in storage, 2 = Lift from storage place on buiscar/ to loading track, 3 = Shuttle buiscar, 4 = Transfer pallets from buiscar to loading track
- u = Packaging lines; 1 = Packaging line 52, 2= Packaging line 6

Figure 3-12: Overview of the variables, parameters and indices employed in the calculation model (See appendix C.4)

3.3.2.1 Production volume characteristics of line 52

While the main goal and the origin of the production volume of line 52 is clear, as explained in section 3.1.1, the detailed production plan is not. As suggested by Lin & Sharp (1999b) it is often the case that data is only available after the operations starts, which is the situation in our research as well. The production line does not exist yet and the production is market driven, meaning that the type and quantity of products can vary over the weeks and over the years depending on the market demand. We need to base our forecasts about the production details of line 52 on previous data of other production lines and experiences and expectations of staff member, while remembering that forecasts are always wrong (Hopp & Spearman, 2008). As suggested in section 2.1.4 already, the unclearness about these production details is one of the reasons we use the model. By the use of this model we can easily understand the relationship between cost elements, examine the impact of the input variables on the objective, calculate the distribution costs in the different alternative scenarios and perform sensitivity analysis on the results.

The first calculation that we explain briefly is the one that underlies the estimation of the total bottles production of line 52. This estimation is used in all costs calculation that follow. The formula is as follows:

$$\textbf{Total amount of bottles (A)} = X_o * V_e * (L * G)$$

Line 52 will have the same ideal production capacity (i.e., in the unrealistic case of 100% OPI) as the existing line 51 of X bottles an hour. The estimated OPI NONA and 'normal' OPI, based on data of 2015 and estimations of staff members, is respectively X% and X%, see appendix C.3, which results in an expected production volume of X million bottles per year.

Empty bottles division estimation for line 52

One of the production details that has been decided already for the new production line is the type of products that it is going to produce, namely the bottle types: 250K2, 330K2 and 355K2. The quantity of these bottles during the week (and year) is however not clear and will probably vary much between the weeks. A very rough estimation that has been done about the year production suggests the following division: X% of type 250K2, X% of type 330K2 and X% of type 355K2. While this estimation could be wrong and gives no accurate estimation for each week, it gives some support for our distribution costs estimations.

Since it is not known yet which type of bottles in which quantities will be produced on packaging line 52 and what the agreements with the manufacturers about the division of the total bottle production will be for 2017, it is unclear which types of bottles in which quantity from which location will need to be transported to line 52. This is however an important aspect for the OPEX calculations, since not all manufacturers' facilities are able to support the DLF process. The performance of the DLF method and the associated warehousing costs depends on this division. Besides that, the transportation costs and the usability of the transport modes differ for the facilities as well. Consequently, we need to make an assumption concerning the bottles division to make is possible to calculate the expected OPEX and check the feasibility of the different alternatives. Some important aspect are:

- The security of supply concept: HEINEKEN considers it important to spread the bottle production over several facilities (and several manufacturers), to 'secure' a continuous supply of empty bottles. Obviously it would be very harmful for HEINEKEN if a particular part of the supply of empty bottles would suddenly end, when for example a production facility would encounter a major malfunctioning. Even more damaging would be if the complete supply of a particular packaging line would stop. In an attempt to spread the risk and to avoid the situation that a production line needs to be shut down completely, HEINEKEN spreads the bottle production for each production line over multiple facilities. This prevents that a packaging line is completely dependent on the supply of one facility and makes it possible to counteract on the situation such that other facilities could step in. The results from this is particularly important for the DLF method, since it incurs that the bottles for the DLF-lines will partly be manufactured by non-DLF locations, which means that, if a line is supplied via the DLF method, there will always be a part that is supplied via Direct Docking, no matter how well organized the process is.
- DLF locations Moerdijk and Leerdam: In the original situation, explained in section 3.1.2, the DLF method is only performed from one of the eight bottle producing facilities. Moerdijk is the only location that can support the DLF method, because it possess two loading conveyors, while none of the other facilities possess one. This is quite disadvantageous for the supply of all packaging lines that are supplied via DLF, since all the empty bottles that are manufactured in other facilities need to be transported via the H&B warehouse, which brings along high costs. Data from 2015 (see appendix C.7) show that X% of the bottles for packaging line 51, 7, 81 and 82 have been manufactured in Moerdijk and X% have been manufactured in the other locations, which means that at most X% of the inbound supply has been supplied directly in 2015 and thus at least X% via Direct Docking. This fact has been noticed by HEINEKEN as well, resulting in the decision to add Leerdam as DLF location in week 20 of 2016. When we take a look at the data from 2015 again, we see that this would have increased the proportion of the DLF volume (i.e., the joined bottle production volume of the DLF locations) in relation to the total empty bottle production to X%.
- Production and supply data of 2015 and 2016: We have evaluated much data (see appendix C.1). With this data and the aspect mentioned above in mind, we created an estimation of the bottles division as shown in Table 3-4A.

In Table 3-4B we see the expected restriction on the DLF performance (in %) that results from this estimated division. It shows that X% of the bottles in our estimation will come from the DLF locations (i.e., Moerdijk and Leerdam) and thus X% from the remaining locations. This bottle supply from the remaining locations (X%) will either way be transported via DD (i.e., via the intermediate warehouse) and at most X% of the bottle volume can be transported via DLF.

Table 3-4: [A] Estimation of the bottle division for line 52 and [B] the restrictions that follows for the DLF performance

Production division estimation for line 52		
	355 K2	
Ardagh	Moerdijk	
Owens Illinois	Leerdam	
	330 K2	
Ardagh	Moerdijk	
Owens Illinois	Leerdam	
	Schiedam	
Verallia	Essen	
	250 K2	
Ardagh	Dongen	
Owens Illinois	Leerdam	
Verallia	Essen	

Restriction for the DLF performance	
DLF volume for line 52	
Total volume line 52	
Remaining DLF performance	

3.3.2.2 Cost calculation formulas for packaging line 52

In this section we discuss the formulas of the costs calculations that are incorporated in the model.

Calculations for transportation costs

As suggested in section 2.3.2, transportation costs are related to the external movement of materials and we can distinguish three main routes: direct shipment, shipment to the warehouse and from the warehouse to the production lines. We recognize these routes and have noticed that the usage differs per alternative. The costs associated with transportation depend primarily on the type and amount of good carried, the distance between locations, day of the week, the mode of transport and the shipment size. We gathered all relevant data and information from the involved stakeholders and developed the calculation of Figure 3-13, which has been incorporated in the calculation model in Excel (see appendix C.2). These calculations include the transport from the manufacturers to the warehouse, the Glasplein or the packaging lines. The transportation costs from the warehouse to the packaging lines are included in the calculations of Figure 3-15.

$$\text{Transportation Costs} = \sum_{W=1}^{3} \sum_{Y=1}^{7} \sum_{X=1}^{3} \left(\frac{(A * B_x * F_y * D_w)}{N_x} * P_{iyw} \right)$$

i = 1 in alternative with DLF supply
i = 2 in alternatives with conventional supply

$$P_{1yw} = \frac{R_{1yw}}{Q_1} \quad \text{for y = 1 or 2}$$

$$P_{1yw} = \tfrac{1}{4} * \frac{R_{2yw}}{Q_2} + \tfrac{3}{4} * \frac{R_{3yw}}{Q_3} \quad \text{for y = 3,4,5,6 or 7}$$

$$P_{2yw} = \tfrac{1}{4} * \frac{R_{2yw}}{Q_2} + \tfrac{3}{4} * \frac{R_{3yw}}{Q_3}$$

Figure 3-13: Formulas for the expected transportation costs of all alternatives for line 52

Besides the OPEX for the transportation described in Figure 3-13, we expect that we need two more DLF-trailers to shuttle between the manufacturer and the packaging lines and one more DLF-trailer to shuttle between the warehouse and the packaging lines, in case the DLF alternative for line 52 would be chosen. HEINEKEN leases these trailers from H&B for €X per trailer per month. So, for the DLF alternative we need the add €X to the yearly expenses, as shown in the formula below. On the other hand approximately €X need to be calculated for additional internal transport costs (e.g., fuel) that is only required in case of conventional supply.

$$\text{Lease costs of additional trailers} = €X * 12 \text{ months} * X \text{ trailers} = €X$$

Calculations for material handling at HEINEKEN

In case we supply the lines via DLF and/or DD, we do not have additional material handling costs at the brewery, since these trailers dock automatically to the packaging line, which requires barely any effort. The little effort for the trailer driver is included in the transport prices. In case of conventional supply we would have material handling costs at the brewery. The calculations that we have used for these expected costs are shown in Figure 3-14.

As notified in Figure 3-14, these calculations for the material handling costs apply for packaging line 52 as well as line 6. There are just two differences, which are related to (I) the required activities and the duration of these activities and (II) the inefficiency in the material handling proceedings (X for line 52). The material handling activities that need to be carried out in the alternatives for line 52 (Conventional A and B) are (see appendix C.6):

1) Unloading the truck by FLT's and place the pallets on the Glasplein
2) Lift the pallets from the Glasplein to the buiscar
   - Option A:
     3) Shuttle the buiscar to the Foleyplein and park close to the loading track
     4) Transfer the pallets from the buiscar to the loading track.
   - Option B:
     3) Shuttle the buiscar to the Foleyplein and dock against the buffer conveyor.

$$\text{Total FTE logistic Costs} = \frac{\left(\dfrac{\sum_{y=1}^{n}\left(\dfrac{A * B_x}{N_x} * \dfrac{S_a}{K_a}\right)}{60} * M_u\right)}{E * 5 * 46} * Z * C$$

n = 4 in calculations for line 52 in scenario A
n = 3 in calculations for line 52 in scenario B
n = 2 in calculations for line 6

i = 1.28 for line 52
i = 1.31 for line 6

Figure 3-14: Formula for the FTE costs for both line 52 and line 6 in case of supply via conventional

Calculations for material handling, transport and inventory costs at H&B warehouse

As suggested in section 2.3.2, besides the direct transport and material handling costs on the premises of HEINEKEN, we also need to calculate the additional costs that are made when the pallets of empty bottles are transported via the H&B warehouse. This costs consist of the costs at the H&B warehouse to load, unload, store and move the units in the warehouse and the additional transport costs for the shuttle between the warehouse and the brewery. We use the calculations presented in Figure 3-15 to determine the expected costs. In these calculation we use €X as transported price for each pallet that is shuttled from the warehouse to the packaging line. This price, charged by H&B, is composed of the different aspects as suggested in section 2.3.2 and shown in Table 3-5. We have incorporated these calculations in our calculation model in Excel.

Table 3-5: Shuttle price per bottle pallet for transport from warehouse to the packaging lines

Shuttle Costs H&B per bottle pallet	
Activity	Estimated costs
Handling in	Confidential
Storage	
Handling out	
Shuttle	
Total	

$$\text{Logistic services (H\&B) Costs} = \sum_{X=1}^{3}\left(\left(\frac{A * B_X * \sum_{X=1}^{2} F_y}{N_X} * (1 - T)\right) + \left(\frac{A_T * B_X * \sum_{X=3}^{7} F_y}{N_X}\right)\right) * H$$

Figure 3-15: Formula for the expected H&B costs of line 52 in case of supply alternative via DLF

Calculations for costs of risk on damage

With regard to the costs of risk and damage we found two cost elements that do (significantly) differ for the alternative scenarios. Both cost elements are related to the fact that cardboard covers get soaked when they are stored outside, which is the case in the conventional alternatives. As explained in section 3.1.2 these soaked covers increase the disturbance on the packaging lines, especially at the 'unwrapper', which is the device that pulls off the plastic foil of the pallets. This disturbance leads to an estimated OPI loss of X% and requires additional FTE costs at the packaging line to enable the continuation of the packaging line and to clean up the mess. The expected cost calculations for the OPI are shown in the formula below.

$$\text{Costs of OPI loss} = X\% \quad * \quad €X \quad = \quad €X$$

The expected costs calculations for the additional FTE at each shift required at the packaging line is shown in this formula.

$$\text{Additional FTE packaging line} = 3 \quad * \quad €X \quad = \quad €X$$

3.3.3 OPEX calculations for the different alternatives of line 6

While the evaluation approach for line 6 contains similar cost elements as for line 52, the calculations for line 6 are less difficult and thus do not require such an extensive approach. The reason for this is the fact that the DLF alternative is not an option for line 6. As explained 3.2.1, the facilities are located too far and the can types are too diverse for the restricted covered storage space available at HEINEKEN, forcing HEINEKEN to supply all cans via the intermediate warehouse (i.e., via DD completely). This results in the fact that we do not have to incorporate trade-offs and cost differences between the can types, facility locations and most importantly: the effect of the DLF performance and the different transportation modes, on the transportation costs. The supply of cans to either the warehouse or the brewery would be done by the same transport modes regardless of the chosen alternative. Since the transportation cost to the warehouse or the brewery are the same, the initial transportation cost will be the same in the different alternatives.

To evaluate the different OPEX of the alternatives we only need two calculations: The saved material handling costs in case line 6 would be supplied via DD and the additional transportation (including material handling and storage) costs caused by the additional use of the warehouse.

- For the saved material handling costs we use the same formula as we used for packaging lines 52, explained in section 3.3.2.2 and shown in Figure 3-14. As explained in this section as well, there are just two differences, which are related to (I) the required activities and the duration of these activities and (II) the inefficiency in the material handling proceedings (X for line 6). The material handling activities that need to be carried out in the alternatives for line 6 (Conventional A, B and C) are (see appendix C.6):
    1) Unload the truck by FLT's and store them on the Foleyplein
    2) Lift the pallets from the storage locations and place them on the loading tracks.

- The calculation for the additional transportation costs caused by the additional use of the warehouse, when the DD alternative would be chosen, is shown in Figure 3-16.

$$\textbf{Additional Transportation Costs} = \frac{A}{N} * T * H$$

A = Total amount of cans

N = Average amount of cans per pallet

T = Percentage of supply currently transported directly

H = Transport price per pallet for the shuttle from the warehouse to the lines

Figure 3-16: Formula for the additional transportation costs

In the current situation approximately X% percent of the supply is transported via the warehouse, which means that the remaining X% percent is transported directly to the Foleyplein. This means that if we would chose to supply line 6 via DD, this amount of pallets would require the use of the warehouse as well. This amount of pallets multiplied by the H&B costs per pallet is an estimation of the difference in transportation costs between the alternatives. The estimation of the price that H&B will charge per pallet for the unloading, storing, loading and transportation from the warehouse to the packaging line is shown in Table 3-6. This is an estimation of the price, because the shuttle with empty cans between the warehouse and the brewery of Zoeterwoude does not exist in the current situation. Negotiations should result in a new shuttle price, when we intend to choose the DD alternative for line 6. These estimations are based on the shuttle price for bottle pallets and the shuttle price for can pallets in Den Bosch. Finally we expect that HEINEKEN will need to lease an additional trailer for the shuttle between the warehouse and the packaging line as is also needed for line 52, which means that we need to add €X to these costs.

Table 3-6: Shuttle price per can pallet for transport from warehouse to packaging line 6

Shuttle Costs H&B per can pallet	
Activity	Estimated costs
Handling in	Confidential
Storage	
Handling out	
Shuttle	
Total	

3.3.4 OPEX results for alternatives of line 52 and 6

In this section we briefly discuss the result of the logistic cost calculation, which are explained in the previous sections. We start with the overview for line 52 and next we pay attention to line 6.

Results of OPEX calculations for line 52

The calculations for the transportation and H&B costs are too extensive to visualize in an overview, which is why we only show an overview of the results in Table 3-7.

Table 3-7: Overview of the logistic costs for the different alternatives for the supply of line 52

OPI	Alternative	DLF performance		Logistic Distribution Costs (i.e. OPEX)						
		DLF Routes	Total:	Transport	H&B costs	FTE Logistiek	FTE Verpakken	Material lease and usage	OPI	Totaal
Shift system	DLF	0%								
		25%								
3 shifts		50%								
Weeks of production		60%								
		70%								
48 weken		80%								
		90%								
		100%								
	Conventional A	n/a								
	Conventional B	n/a								

On the left side we see the three important input variables used for the production amount, namely the OPI, shift system and weeks of production. The bottle division and facilities division that are used are explained already in section 3.3.2.1 and have led to the 'restriction on the DLF performance' of X%, as also shown in Table 3-4B. The remainder of Table 3-7 shows the results of the cost calculations of all relevant cost elements for the different alternative scenarios. For the alternatives conventional A and B we calculated that the OPEX would be €X and €X. For the DLF alternative several estimated costs are shown related to the different DLF performances. As explained below, we expect a DLF performance of 74% and thus an OPEX of €X when the DLF alterative would be chosen.

When we consider production line 51 in the data overview of 2015, see appendix C.7, we see that X% of the bottles came from Moerdijk (Ardagh) and the remaining (X%) came from Leerdam (Owens Illinois). Hence, the DLF volume for line 51 was X% in 2015 (i.e., X% of the bottles came from a DLF location). During this same period in total X% of the empty bottles is supplied by Direct Line Feed and thus X% by Direct Docking. In other words: The DLF performance for the supply of empty bottles to packaging line 51 in 2015 was X% with a DLF volume of X%. For packaging line 52 we estimated the DLF volume at X%. Therefore it seems reasonable to assume that 74% would be a realistic estimation for the DLF performance and thus €X seems a realistic estimation for the OPEX of the DLF alternative, as shown in Table 3-7.

Results of OPEX calculations for line 6

In this section we present the calculations explained in section 3.3.3. We start with the additional transportation costs that would be required in case we would supply line 6 via DD, which are shown in Table 3-8.

Table 3-8: Calculations of the additional transportation costs for line 6 in case of DD supply

Additional transportation costs - In case of DD supply for Col 6								
Total amount of cans per year	Average number of cans per pallet	Total pallet amount per year	Current Division		H&B price per pallet	Additional costs	Lease costs trailer	Total
			Direct	Via Oss				
			Confidential					

As explained earlier the calculations for the FTE costs are similar to the calculations that we have used for line 52. We only notice a difference between the number of activities and their duration and the inefficiency ratio during the material handling proceedings. The calculations for the FTE costs that are required in case would supply line 6 via the conventional way, are shown in Table 3-9.

Table 3-9: Calculations of the FTE costs for line 6 in case of conventional

FTE costs - In case of conventional supply for line 6										
Material handling activity		Duration per activity		# Pallets per activity	# Pallets per year	Hours required	Hours per FTE per	FTE required per year	Costs per FTE	Total costs
From (Start)	To (Finish)	Duration	Unit							
Unload pallets from truck	To buffer storage		Minutes							
Lift pallets from storage	To packaging line		Minutes			Confidential				
									Total costs	

Pallet amount	
Total amount of cans per year	
Average number of cans per pallet	Confidential
Total pallet amount per year	

Hours per FTE per year	
Effective hours per FTE per shift	Confidential
Effective hours per FTE per year	

Inefficiencies	
Material handling proceedings	Confidential
TARA	

We conclude that the OPEX would increase by approximately €X in case we would supply line 6 via the DLF way, as shown below.

OPEX increase = € X - € X = € X

3.3.5 Qualitative Layout design criteria evaluation

In this section we briefly discuss the non-financial criteria that we use in our layout evaluation approach. We divide the non-financial elements into three criteria: safe and comfortable working environment, efficient layout utilization and supply chain complexity and flexibility. We briefly explain these criteria below and discuss the performance of the different alternatives. For the evaluation of our alternatives we use a relatively simple approach, assessing the different criteria in comparison to each other with the symbols indicated in Table 3-10.

Table 3-10: Non-financial evaluation scores

Non-financial evaluation	
++	Scores very well on criteria
+	Scores good on criteria
□	Scores average on criteria
-	Scores poor on criteria
--	Scores very bad on criteria

Safe and comfortable working environment criteria

Considering the safety aspect of the alternatives for line 52 and line 6 on the Foleyplein we can distinguish some differences. Table 3-11 shows an overview of the results of this criteria for the joined alternatives in comparison to the others.

Table 3-11: Scores of the alternatives on the criteria safe and comfortable working environment

Safe and comfortable working environment												
Line 52:	DLF				Conventional A				Conventional B			
Line 6:	DD	Conv. A	Conv. B	Conv. C	DD	Conv. A	Conv. B	Conv. C	DD	Conv. A	Conv. B	Conv. C
Score	+ +	□	+	+	n/a	- -	- -	- -	+	-	□	□

We take into account that some alternatives consist of many truck-FLT, truck-truck or FLT-FLT crossing, while some alternatives barely contain them. For instance when we would deploy both conventional A options, we would create the situation in which the FLT's for line 6 (with longer forks) need to pass the buiscar and FLT's continuously in the narrow pathway. When we would supply line 52 via DLF or via conventional B we see far less crossings regardless of the choosing for line 6. When we would choose to supply line 6 via DLF either, crossings are almost excluded. Furthermore, we take into account the amount of traffic (and thus possible congestion) the alternatives create on the Foleyplein. For line 52 the option of DLF and conventional B create much less traffic than conventional A. For line 6, the DD alternative scores best on this aspect, followed by Conventional C, B and A in this consecutive order. Finally, we take into account that the conventional supply of line 52 causes collapsing pallets at the packaging line. Besides the costs that are associated with this explained in the previous sections, it causes dis-comfort and decreases the safety at the packaging department.

Efficient layout utilization criteria

In the efficient utilizations of the space we notice some relevant differences as well. Again, the results of the criteria for the joined alternatives are shown in an overview, see Table 3-12.

Table 3-12: Scores of the alternatives on the criteria efficient layout utilization

Efficient layout utilization												
Line 52:	DLF				Conventional A				Conventional B			
Line 6:	DD	Conv. A	Conv. B	Conv. C	DD	Conv. A	Conv. B	Conv. C	DD	Conv. A	Conv. B	Conv. C
Score	+ +	□	□	+	n/a	- -	- -	-	+	-	-	□

We mainly take into account the space required for the handling and internal transport activities on the Foleyplein, on the Glasplein and in between. DLF/DD supply for line 52 and line 6 are obviously the highest scoring alternatives on this criteria, since it minimalizes the material handling and the space required. Both conventional supply methods for line 52 score less, since they require handling on the Glasplein, internal transport to the Foleyplein and handling on the Foleyplein. Arrived on the Foleyplein, the conventional A alternative requires quite some space during the unloading of the buiscar, resulting in a poor score. For line 6 the conventional options score less on this criteria as well, since the unloading of the truck requires continuous transport by FLT's over the Foleyplein. Conventional C requires a slightly longer distance, but in the meantime in creates more space on the Foleyplein and enables an efficient flow of can trucks on the repositioned main road. Additionally, we take into account the required storage space on the Foleyplein and the Glasplein in the different alternatives. When line 52 is supplied via DLF, no storage space is required on the Glasplein. When line 6 is supplied via DLF we would free up some covered storage space on the Foleyplein.

Supply chain complexity and flexibility criteria

The last criteria that we assess is the supply chain complexity and flexibility in the different alternatives, with the overview shown in Table 3-13.

Table 3-13: Scores of the alternatives on the criteria supply chain complexity and flexibility

Supply chain complexity and flexibility												
Line 52:	DLF				Conventional A				Conventional B			
Line 6:	DD	Conv. A	Conv. B	Conv. C	DD	Conv. A	Conv. B	Conv. C	DD	Conv. A	Conv. B	Conv. C
Score	-	□	□	□	n/a	+	+	+	□	+	+	+

When we take a look at the complexity we notice that the DLF alternatives for both line 52 and 6 score less than the conventional options. As explained earlier the DLF/DD concept require some additional effort in the purchasing and planning department. Especially for line 52 it increases the complexity as the pallets of empty bottles cannot be ordered and stored close by till they are required, since direct transport is preferred. From the perspective of robustness of equipment we notice that the DLF alternatives score (slightly) lower either. There is no difference in the adjustment to capacity requirements, but when the required investments are done for the constructions, the layout design is less likely to adjust later on. With regard to the flexibility of the supply methods, we notice the same lower scores for the DLF alternatives. Again, especially for line 52 this is the case, since an adjustment or upgrade in production would require slightly more effort and time, because as less storage as possible is maintained, direct transport from the manufacturers' facilities to the lines is preferred and the last stage of loading the buffer lane takes longer in DLF supply in comparison to the case of FLT supply from the internal storage on the Glasplein.

Conclusion of section 3.3

In section 3.3.1 we have presented the CAPEX estimations for the alternatives of line 52 and 6, shown in Table 3-3. Next we provided the OPEX calculations for all alternatives (section 3.3.2 – 3.3.4). The results are shown and explained in section 3.3.4. Finally, we have evaluated the non-financial criteria for the different alternatives. The results are shown and explained in section 3.3.5.

3.4 Alternative comparison and decision making

In this section we summarize the results of the analyses and alternative evaluation that we have performed in the previous section. Section 3.4.1 provides the evaluation of the alternatives in several overviews and explains the preferred alternatives based on these overviews. Section 3.4.2 explains the sensitivity checks and analysis and section 3.4.3 pays attention to some implementation requirements that need to be carried out.

3.4.1 Alternative overview and selection

In this section we provide several overviews of the evaluations, analysis and calculations that we have done. Table 3-14 and Table 3-15 show the logistic costs evaluation overview for respectively line 52 and line 6.

Table 3-14: Logistic costs evaluation overview for line 52

Logistic cost evaluation for line 52				
Subject		DLF	Conventional A	Conventional B
Initial investment costs (CAPEX)				
Logistic Costs (OPEX)*	Transport costs			
	H&B Costs			
	FTE logistics		Confidential	
	FTE packaging*			
	Lease and usage			
	OPI costs*			
	Total			

* OPEX do not consist of all cost calculations associated with the alternatives. Only costs aspects that differ are taken into account

Table 3-15: Logistic costs evaluation overview for line 6

Logistic cost evaluation for line 6					
Subject		DLF	Conventional A	Conventional B	Conventional C
Initial investment costs (CAPEX)					
Logistic Costs (OPEX)*	Transport*		Confidential		
	H&B Costs*				
	FTE logistics				
	Lease and usage				
	Total				

* OPEX do not consist of all cost calculations associated with the alternatives. Only costs aspects that differ are taken into account

Furthermore Table 3-16 provides an overview of the non-financial evaluations explained in the previous section. Note that the total score is not the average of the three criteria, which is the case because the safety requirement is more important than the other two.

Table 3-16: Non-financial evaluation overview for the joined scenarios of line 52 and 6

Non-financial evaluation of alternatives												
Line 52:	DLF				Conventional A				Conventional B			
Line 6:	DD	Conv. A	Conv. B	Conv. C	DD	Conv. A	Conv. B	Conv. C	DD	Conv. A	Conv. B	Conv. C
Safe working environment *(e.g. accidents, crossings and congestion)*	+ +	□	+	+	n/a	- -	- -	- -	+	-	□	□
Efficient layout utilization *(e.g. Layout usage, pathways, storage space)*	+ +	□	□	+	n/a	- -	- -	-	+	-	-	□
Supply chain flexibilty *(e.g. Flexibility, complexity and robustness)*	-	□	□	□	n/a	+	+	+	□	+	+	+
Total score	+ +	□	+	+	n/a	- -	- -	-	+	-	□	□

Decision making of supply alternative to packaging line 52 and 6

First we take a look at the score of the non-financial criteria of the alternatives of line 52. Here, we notice that the conventional A option scores very low as it is considered an unsafe and uncomfortable working environment. The DLF option and the conventional B option are preferred. When we take a look at the financial aspect, we see that the estimated CAPEX of conventional A are very low in comparison to the others, but in the meantime the OPEX estimations are quite high. The difference in CAPEX would be earned back in a reasonable time period. Taken these criteria together, but mainly because of the safety aspect, we exclude alternative A. When we compare the DLF option and the conventional B option, we notice that the estimated CAPEX for the DLF scenario are a bit higher. However, when we compare the CAPEX with the calculated OPEX, we expect that the difference in CAPEX is earned back within the year. Furthermore we see that the DLF option is preferred over the conventional B option when we assess the non-financial aspects.

The conclusion for line 52 is that the DLF option is preferred over the other options based on the financial and non-financial criteria, as the payback period is within a very reasonable time period and it scores better on the non-financial aspects. Taking into account all aspects and in collaboration with the relevant stakeholders and the steering committee, we concluded that the DLF option is the best choice for the supply of packaging line 52.

When we take a look at the scores of the non-financial criteria of the alternatives of line 6 we consider the DLF alternative preferred. While this is the case, the DLF concept does not score very well on the financial aspect. First of all the CAPEX investment is estimated to be very high and additionally we estimate that the OPEX will increase in this alternative as well, which means that the investment would not be paid back at all. The option of conventional A does not have any advantage over the option of conventional B and since we agreed with all relevant stakeholders that the scenario of conventional B is feasible (i.e., safe), the option of conventional A is eliminated. When we compare conventional B and conventional C, we notice that options have the same OPEX. The conventional C option is slightly preferred regarding the non-financial aspect, but in the meantime conventional C requires quite an investment.

Knowing that the option of conventional B is determined to be feasible and safe by all relevant stakeholders, we conclude that the CAPEX investments for the DLF option or Conventional C option are not required to obtain a safe working environment on the Foleyplein. Taking into account all aspects and in collaboration with several stakeholders and the steering committee, we concluded that the conventional B option is the best choice for the supply of packaging line 6.

3.4.2 Sensitivity analysis

In a realistic business environment the changing values of some of the key parameters may significantly alter the final decision regarding the alternative selection and the magnitude of the logistics costs. A sensitivity analysis is a technique to assess the impact of the important variables and parameters and thus to determine how these different values influence the annual logistic costs under a given set of assumptions (Clarke, 2006; Zeng & Rossetti, 2003). Changing one value over a specific range, while keeping the other values constant, gives us an overview of the impact of this specific variable on the logistic costs.

As can be seen in section 3.3.2 and 3.3.3, there are many variables and parameters that underlie the calculation. Not all values influence the logistic costs as much as others. When for instance the total production amount would increase, this would increase the costs of all options. Furthermore most assumptions about the values of variables are based on (and checked with) the measured data. For line 52 this is done with data of the other packaging lines that have a comparable production portfolio. Line 6 is checked with the data of the current situation. Examples for line 52 are the assumptions for the OPI of the packaging lines and the inefficiency for material handling used in the material handling calculations, as shown in Table 3-17. For the values that could not (or partially) be supported by data, we consulted the relevant stakeholder(s) for their best estimates or judgement. However, there is one variable we want to assess in more detail: the DLF performance.

Table 3-17: Data checks for assumptions [A]: OPI performance and [B] Material handling inefficiency

OPI Check	
Line	OPI NONA
Line 21	
Line 22	
Line 3	
Line 51	
Line 7	Confidential
Line 81	
Line 82	
Line 52	

Handling inefficiency	
Line	OPI NONA
Line 21	
Line 22	
Line 3	
Line 51	
Line 7	Confidential
Line 81	
Line 82	
Line 52	

DLF performance

The DLF performance is the most important check in our research, since it is revealed to be an unknown and uncertain element for all the involved stakeholders with meanwhile quite an impact on the logistic costs and therefore a potential impact on the decision making. It has shown to be a difficult to estimate variable for all the different stakeholders involved in the research, because it consists of much uncertainty.

The DLF performance depends in general on two aspect:

(1) The bottle volume supplied from DLF locations (i.e., the DLF volume of line 52). This assumption in the DLF volume is explained in section 3.3.2 and shown in Table 3-4A. The restriction for the DLF performance caused by this assumption is shown in Table 3-4B. Note that this division depends on two aspects:
   (a) The bottle type division (250K2, 330K2 and 355K2)
   (b) The manufacturers' facility division for each bottle type.

(2) The amount of bottles from the DLF volume of (1) supplied directly (and thus not via the warehouse). In section 3.3.4 we compared the case of line 52 with line 51, concluded that this is very similar and thus based our DLF estimate for line 52 (74%) on the performance of line 51.

While the case seems similar in (2) and therefore the estimation seems legit, the assumption (especially in (1)) is a bit rough. It is yet not known what the division in type of bottles will be for next year, the division (i.e., production portfolio) will differ over the week and probably also over the years and the final bottle allocation per week depends on the circumstances at several manufacturers' facilities, two breweries and many packaging lines. In the meanwhile the production of bottles by the manufactures is done as constant as possible. The manufacturer prefers to produce in large batches, while HEINEKEN produces all different type of bottles during the week.

The planning departments try to facilitate an efficient DLF supply. They can slightly deviate from the prescribed division and the storage capacity at the manufacturers can accommodate some flexibility as well. Moerdijk and Leerdam consist of a storage capacity for bottles intended for HEINEKEN of respectively X pallets (X% of the total capacity) and X pallets (X% of the total capacity). These aspects can support the DLF performance. While this is the case, the DLF performance is just one of the elements that the planning department needs to optimize every week, which means that sometimes it will be subservient to other aspects.

Conclusion is that the assumptions about the bottle type division (1a), the facility division (1b) and the DLF-supply performance (2) are substantiated, but could easily differ because of unforeseen circumstances during the week and coming years. Therefore we consider it of importance to check the impact of the DLF performance on the logistic costs and thus the decision making. It this sensitivity analysis, it is not very important to understand how these three elements cause the DLF performance. We only want to assess the impact of the total DLF performance on the total costs. In Table 3-7, which shows the logistic cost results, we already showed the range for the DLF performance and associated costs. Figure 3-17 shows the sensitivity analysis.

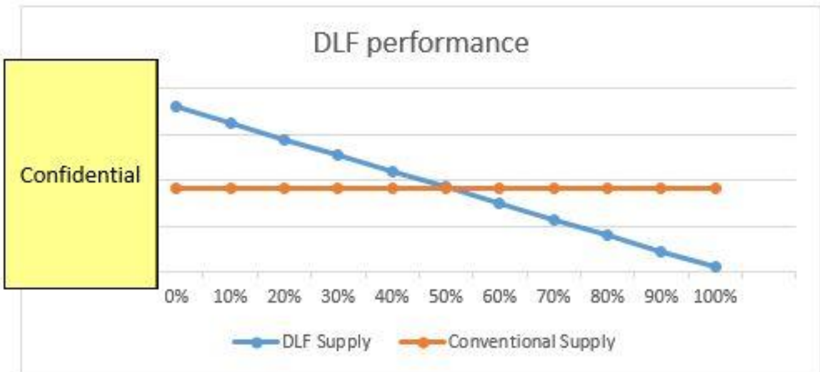


Figure 3-17: Sensitivity analysis on the DLF performance

We can see that, under the current assumptions and variable and parameter values, the DLF performance should remain above the 50% percent to outperform the conventional options with regard to the OPEX. We consider this (very) achievable. Knowing that the difference in CAPEX is estimated to be just €X and knowing that the DLF supply option is chosen because of the financial and non-financial aspects, we conclude that the DLF option remains the best choice.

3.4.3 Implementation requirements

In this section we briefly discuss to aspects that follow from the decision making. While the real implementation phase will be carried out in 2017, we already consider two aspects: the amount of trailers to lease for the bottle supply to line 52 and the adjustment to the Foleyplein.

Trailer lease for the supply of line 52

Besides the production capacity, discussed in section 3.3.2, and the loading capacity at the manufacturers, discussed in section 3.2.3, there is a third element which is important and could be a restriction for the DLF supply: the transportation capacity of a trailer. At HEINEKEN the estimation is that one trailer is able to shuttle X times a day between the manufactures facility of Moerdijk or Leerdam and the packaging lines in Zoeterwoude. So, one trailer is estimated to transport X bottles a day.

$$\text{Trailer capacity} = \underset{\text{shuttles per day}}{X} * \underset{\text{pallets per trailer}}{26} * \underset{\text{bottles per pallet}}{3700} = X \text{ bottles per day}$$

To estimate the amount of trailers that are required for the new situation we consider the data of 2015 and try to obtain the total DLF volume for all DLF lines of Zoeterwoude, see Table 3-18 . In the current situation we had a total DLF volume of approximately X bottles (i.e., produced in DLF locations and supplied to DLF lines). Taking into account that production line 51 was producing in a 5 shift system, this would have led to a need of X trailers. For the production of line 52, we estimate that approximately X million of production volume is absorbed from line 51 and approximately X million (potential) DLF volume from line 21, 22 and 3. Furthermore we expect a little improvement of the allocation in comparison to the allocation of 2015. In total this lead to an estimated DLF volume of X bottles, which is produced in a 3 shift system and leads to an estimation of the required trailer capacity of X trailers (see Table 3-18). Taking into account that there will be some inefficiency in the trailer usage and that some deviating production over de weeks will occur, but in the meantime that we do not want useless trailers, we estimate that X trailers would be the preferred number of trailers when the new packaging line 52 is introduced.

Table 3-18: Trailer capacity estimation for DLF supply to all DLF lines of Zoeterwoude

Trailer capacity	
Based on data of 2015	
Current DLF volume (= DLF locations + DLF lines)	
Trailers per day:	
Estimation of DLF volume, including: - Estimation for line 52	
Trailers per day:	
Estimation of DLF volume, including: - Estimation for line 52 - Estimation improvement 2017	Confidential
Trailers per day:	
Trailers per day:, including: - Inefficiency in trailer usage	

Required modification to Foleyplein

As explained in 3.2.3 the alternative of conventional B for line 6 is feasible when some modifications on the Foleyplein will be carried out:

- Clear agreements should be made about material handling activities and vehicle crossings to ensure the safety. The most important agreement is that, when a DLF-trailer for line 51, 52, 41, 42 or 43 is moving on the Foleyplein, the FLT's are not allowed to unload the can truck on the left* side. They temporarily stop there activities when necessary till the trailer has left the Foleyplein or is docked to the buffer conveyor.
- On the right* side of the can truck the walkway needs to be shifted against the wall to create enough space for the FLT to unload the can truck in a safe manner. To avoid the situation of human-vehicle crossings (and thus accidents) this walkway needs to be shielded by a fence. This will be taken into account in another project at HEINEKEN.
- The truck that empties the cardboard press will need to leave the Foleyplein backwards when a can truck is parked. When this occurs, the FLT's are not allowed to unload the can truck on the right* side.
- Finally it should be determined if any of the situations require warning signs to indicate conflicting situations.

*Right and left is meant from the viewers' perspective in the above picture in Figure 3-11

Conclusion of Chapter 3

In this chapter we have explained the research that we have conducted phase I. First we have discussed the current situation at HEINEKEN and on the Foleyplein (section 3.1). Next we have determined which alternatives could resolve the problem situation and concluded that there are 3 feasible alternatives for the bottle supply to line 52 and 4 alternatives for the can supply to line 6 (section 3.2). We assessed the alternatives based on the quantitative and qualitative criteria (section 3.3) and summarized the results (section 3.4). We concluded that the most 'cost-effective' solution is to supply packaging line 52 via the 'DLF method' and packaging line 6 via the 'conventional A' method.

Research Phase II

Improving the supply process of empty bottles to packaging lines
51, 52, 7, 81 and 82 via the DLF methodology

4. Literature study of phase II

In this section we elaborate on the improvement approach used in phase II of the research. The first section will give an introduction to the improvement theories and in the second section we discuss the method employed: The Business Process Optimisation approach.

4.1 Improvement theories

The (original) concept behind Total Productive Maintenance (TPM) is to proactively eliminate the machine failures related to maintenance breakdowns with the goal to improve the overall machine availability (Martin, 2007). Currently this theory of Total Productive Maintenance (TPM) is an important part of the more comprehensive philosophy: Total Productive Management (also TPM). This more comprehensive Total Productive Management (TPM) approach aims for a continuous and consistent search to eliminate waste in all processes through active participation of all staff members in the organisation (Heiport, 2016b). Within the Total Productive Management approach many tools are provided to achieve this objective, from which the improvement theories are the most important ones. We briefly discuss the general idea of improvement theories and elaborate on the two most important improvement approaches used at HEINEKEN: Value Stream Mapping (VSM) and Business Process Optimization (BPO).

Process improvement approaches are largely quite similar and pursue the same goal of identifying and reducing or eliminating the waste throughout a company's value stream, where a value stream can be defined as the specific activities required to design, order and provide a specific products to the customer (Hicks & Matthews, 2010; Hopp & Spearman, 2008; Kjeld, Aij, Simons, Visse, & Widdershoven, 2014). Process improvement approaches generally start by drawing up an elementary process map to identify the muda (waste) in the system, then they project how the system could work by preparing a future state and finally attempt to bridge the gap between those two maps (Hopp & Spearman, 2008). They focusses on what the process are, how the processes are organized, which part of the processes consist the most waste and how these waste should be eliminated. Often an important part is about the interpretations of the process related to the difference how people think the process is, how it actually is and how it should be (Symbol, 2014b). After streamlining the internal processes, companies are nowadays increasingly optimizing the processes over the whole supply chain. The current (or 'as is') state is mapped to capture a snapshot of how things are done over the supply chain and where the improvement potentials lie. The Future (or 'to be') state map is discussed to show how things should be done (Seth & Gupta, 2005).

Value Stream Mapping (VSM) is an improvement approach for mapping processes related to physical flows of materials and products. It helps to understand the transformation from raw materials to finished goods through the process (Seth & Gupta, 2005; Symbol, 2014a). The method starts with a visual representation of the process (i.e., current state) to be studied or improved and provides information about, for instance, the cycle time, the inventory status, the manpower deployment and the quality issues of parts that flow through the process. When the current state and waste is identified the approach continuous by creating a future state map showing how the system will look once all improvements are in place (Hopp & Spearman, 2008; Martin, 2007; Seth & Gupta, 2005). The Business Process Optimization approach used at HEINEKEN is a similar improvement approach, since it does also aim to identify waste and to improve the process using similar steps, see Figure 4-1. An important difference however is that the BPO approach is focused on the business, communication and information process flows that pass through different people and departments rather than the physical movement or product flows through the supply chain (HEINEKEN, 2014). In the physical flow of products the waste is generally well understood, but in parts of the process where the product is not directly visible the waste is often less clear and more difficult to identify (Hicks, 2007; Kjeld et al., 2014).

Figure 4-1: Business Process Optimization approach of HEINEKEN

In this project we use the BPO approach used at HEINEKEN, since our objective is to improve the DLF concept from the procurement department till the supply of the packaging lines. The biggest part of this process does not even contain a physical flow, but more importantly we want to focus on the agreements, the internal and external communication and the information flow that facilitate the DLF process through this part of the supply chain.

4.2 Business Process Optimisation approach

As explained in the previous section the BPO approach used at HEINEKEN is used in this project and shown in Figure 4-1. This section explains the approach and some practical implications from our own research in more detail.

Step 1 and 2: Process selection and Current State

Before an organisation can start with identifying limitations of existing systems and targeted improvements or implementing change, it is first necessary to possess the fundamental understanding of the product, the processes and their combined interaction. This understanding will provide the structure against which an organization can reason and communicate about a process to realise improvements and overcome particular problems and conflicts (Hicks & Matthews, 2010). The Business Process Optimization approach uses tools (SIPOC and Makigami) in the first two steps to create this understanding of the current process with regard to the communication and information flows. The SIPOC is used to define the effectiveness of the process. It is a tool to assess if the process is doing the right things. After that the Makigami is used to focus on the efficiency, which means that it is about doing the things the correct way (HEINEKEN, 2014).

Step 1 in the BPO process is the process selection phase. In this phase the focus is on defining the core process, scope and objective using the SIPOC tool, determine the relevant stakeholders and collecting relevant information of the process. As stated the SIPOC tool is a high level process description used to assess the effectiveness of the process. It helps to clarify the core process that the project is focused on and to identify the boundaries of the project. Besides that it can be used to check both these elements with the stakeholders (HEINEKEN, 2014; Symbol, 2014a, 2014b). The SIPOC contains the parts as shown in Figure 4-2.

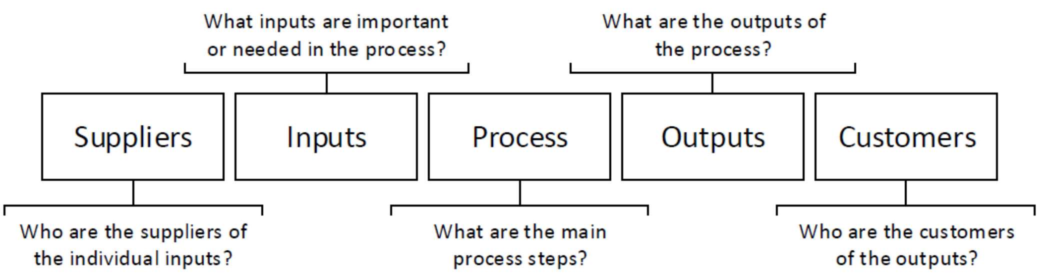


Figure 4-2: SIPOC tool (Symbol, 2014b) *[Modified]*

A significant aspect of step 1 is to determine the relevant stakeholders. The stakeholders that are involved should include the key representatives from the impacted operations. The people who are part of the process under investigation as well as those who either supply or receive materials, labour, or information at the process input and output boundaries (Martin, 2007). It is important to understand that stakeholders are from different organizational functions and that they have other assignments, making it important to ensure the focus on project goals and objectives (Martin, 2007).

The activity of step 2, the Current State, is related to the term process mapping in the literature. Process mapping is a way of visually representing a process with the most upstream process on the left and the most downstream process on the right (Seth & Gupta, 2005). It is a fundamental tool within process improvement, since it helps to understand how the process actually works and is a foundation for further analysis. By documenting how a process actually works it stimulates questions and provides useful insights, which enables to start thinking about potential improvements (Hicks & Matthews, 2010; Symbol, 2014a). Additionally it works as a communication tool towards all the relevant stakeholders involved (Symbol, 2014b). A process map (or flowchart) is the diagram showing the flow of materials and information through all the process operations as well as their inter-relationships. The more highly quantified the process map is, the more useful its information is to potential process improvements (Martin, 2007). Furthermore it is advised to create the process map on a visible location on paper on a wall, so that people can easily make necessary modifications to the map (Martin, 2007).

At HEINEKEN this visualization tool is called a Makigami, which is Japanese for “Roll of paper”. This tool look at (1) the who: the different departments and people responsible and involved in the process, indicated by swim lanes, (2) the what: the activities and the relationships between them (i.e., the way the process moves between the departments) and (3) the when: the process over a timeline (HEINEKEN, 2014; Kjeld et al., 2014). Furthermore the relevant information and documentations are added to the process steps (HEINEKEN, 2014; Kjeld et al., 2014).

We performed the first two steps described above mainly individually, based upon several interviews with all relevant stakeholders (Bos, 2016; Derksen, 2016; Kögeler, 2016; Schreuder, 2016; Sommeling, 2016; Stevens, 2016; van de Bor, 2016; van der Meijden, 2016; Verbunt, 2016). The reason for this was the restriction on the time. The project involved quite an amount of stakeholders and therefore it was difficult (and undesirable) to facilitate (too) many meetings where (most of) the relevant stakeholders could participate. Knowing that it was more important to have as much stakeholders as possible together in the steps that follow (step 3 – 5), we decided to create these overviews individually. Over the period that we held the interviews we checked the SIPOC and the Makigami regularly with the involved stakeholders and again at the start of the first meeting of step 3. At the start of this first meeting we had the Current State printed on paper and placed on the wall and discussed the whole Current State, so that final modifications could be made when required. The results of step 1 and 2 are explained in section 5.1 and 5.2.

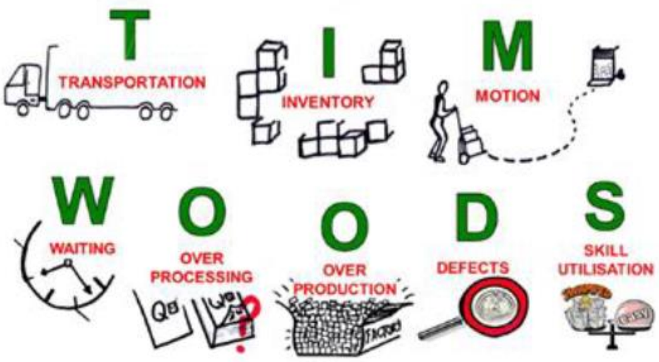
Step 3: Identify Waste

In the literature (Kjeld et al., 2014; Martin, 2007; Seth & Gupta, 2005) and in the approach used at HEINEKEN we can distinguish two different methods to obtain the future state out of the Current State.

- Current State (As is) → Future State (To be) → Gap analysis
- Current State (As is)→ Determine improvement opportunities → Future State (To be)

In the first method the current state and the future state (i.e., the desired state) are constructed first and then the gap analysis is performed, which assess the differences between them. In the second approach the current state is constructed, next the improvement opportunities are discussed knowing how the process works and then the future state is constructed based on these improvements. In our research we have used the last approach. Most importantly because of the time restriction we had during the meetings. As stated before the project involved quite an amount of stakeholders and therefore it was difficult to facilitate a meeting where (most of) the relevant stakeholders could participate. Planning the meeting required approximately at month and two hours was the maximum amount of time available. Drawing up a complete Future State during this meeting would have taken (too) much time. It contained the risk of ending up with a partially finished Future State or needing another meeting for that same step in the BPO approach. Discussing the current state (activities) and the potential improvements seemed a faster approach and more importantly it seemed better manageable during the meeting.

Any process takes resources from the organization and converts them to outputs and a particular amount of waste. Waste is related to those actions that consume resources but are not required and do not add any value to the product. It takes many forms and can be found at any time and in any place, for example hidden in policies, procedures, process and product designs, and in operations (HEINEKEN, 2014; Seth & Gupta, 2005). The goal is to improve the process, i.e., achieve the Future State, with as less waste as possible (HEINEKEN, 2014; Visser & van Goor, 2011). The elements of waste are often related to the elements of Figure 4-3.



Potential areas of improvement opportunities	
Transportation	Unnecesarry transportation of products, materials, documentation or information
Inventory	Products, materials, documentation or information wating to be processed
Motion	Searching, walking and other unnecessary movements of staff members
Waiting	Idle waiting in process on materials, information, equipement or approval
Overprocessing	Undertake unneeded steps for managing products, quality or information
Overproduction	Produce an unnessary high amount of products or information (documents)
Defects	Generation of defects, rework or incorrect or inaccurate information
Skill utilisation	Extra effort due to not using expertise, knowlegde, creativty or other potential

Figure 4-3: Areas of improvement opportunities (HEINEKEN, 2014; Symbol, 2014b; Visser & van Goor, 2011) *[modified]*

Step 3 can roughly be divided in two parts: (1) determining and (2) prioritizing the improvement opportunities. First we need to analyse the process (map) that we constructed in step 2 and use this as a guide to identify what should be changed in the process to simplify and/or improve it (i.e., identify the improvement opportunities), which is done by tagging (e.g., by coloured sticky notes) the areas of opportunity or concern (HEINEKEN, 2014; Martin, 2007). Second we need to prioritize these improvement opportunities based on the (positive) impact on the objective versus the difficulty, time and costs it will bring along by the use of a benefit versus effort (or ease and effect) matrix (HEINEKEN, 2014; Martin, 2007; Symbol, 2014b), which visualization is shown in section 5.3.2.

In step 3 we held two meetings with as much relevant stakeholders involved as possible. The first meeting covered the final check if the current state was correct and continued with the determination of the improvement opportunities. The second meeting covered the prioritizing of the obtained improvement opportunities from the first meeting by the use of a benefit versus effort matrix. The results are explained in section 5.3.

Step 4 and 5: Future State and Improve Process

As explained in the previous section, there are two ways in obtaining the future state and we have chosen to obtain it via the improvement opportunities that we determine in step 3. The future state is the suggested process map that shows the improved process that will meet the future needs, solve key problems and has eliminated the undesired operations and activities (Martin, 2007; Symbol, 2014b). When obtaining this future state one should take a look at which elements can be eliminated and which processes and activities could be simplified, combined, automated or be carried out parallel, earlier or later.

In step 4 and 5 the improvements and new standards should be updated and communicated to ensure understanding and to ensure that they will be maintained (HEINEKEN, 2014). If those responsible for the implementation and allocation of resources are not well informed about the pros and cons, it is highly likely that they will underestimate the effort, in terms of time and cost, needed for successful completion of the project (Hicks & Matthews, 2010). The aim of the project should be that all stakeholders connected with the process work together to improve the overall flow with little or no waste (Seth & Gupta, 2005). Responsibilities for the processes and solutions that need implementation or further research should be assigned to dedicated teams or stakeholders (Hicks & Matthews, 2010). When required, training should be provided, stakeholders should be motivated and team work should be promoted to ensure that changes to working practices and operating procedures are effectively taken-up (HEINEKEN, 2014; Hicks & Matthews, 2010). Another important aspect of the improvement step is that the results of the improvements should be monitored daily to ensure their positive effect (HEINEKEN, 2014). The use of Key Performance Indicators (KPI) facilitates that the results of the process itself and the improvements are measurable and insightful. By visualizing the performance by KPI's the impact, potential improvement or fall back, can be measured and performance can be assured over time (Heiport, 2016b).

As is shown in section 5.4 and 5.5 these last two steps about the development and implementation of the solutions is to some extent carried out during this research. We have found several potential improvements and from some of them the solutions and implementations are in an advanced state. However, some other aspects will need some further research, discussion and/or decision making about the desired solution and implementation and yet others lack priority and/or are placed out of scope because of several reasons. In consultation with HEINEKEN we composed a RACI, which indicates which stakeholders are responsible and accountable for the further development, decision and implementation of the solutions for the different obtained improvement opportunities and which stakeholders should be consulted and informed in this process.

Conclusion of chapter 4

In this chapter we have discussed the improvement approach employed in this research. The BPO used consist of the following step: Determine scope and stakeholders, develop Current State, identify and prioritize improvement opportunities, determine improvements and facilitate implementation.

5. Research of phase II

In the research of phase I we have chosen to supply line 52 via the DLF methodology, which brings the total amount of DLF lines in Zoeterwoude to five. During this first phase we have noticed some limitations in the DLF concept, which became increasingly restrictive with the addition of Leerdam as DLF location. The impact will increase even more when the new packaging line will be introduced. Phase II of this research we focus on the ways to improve the DLF process in such a way that the empty bottles are supplied more efficiently and the associated costs are reduced.

Section 5.1 discusses the scope, objective and presents the main process steps and stakeholders. Next in section 5.2 we explain the current DLF process. In section 5.3 we describe the improvement opportunities that we found and we prioritize them. Section 5.4 elaborates on the improvements in the process in more detail with the associated responsibilities and required implementation steps and in section 5.5 we briefly discuss some additional improvement and further research suggestions.

5.1 Process selection

As explained in the previous chapter the first step, the process selection, focusses on defining the scope and main objective, determining the relevant stakeholders, collect relevant data and capture these parts by the use of a SIPOC tool.

Research scope and objective

As extensively explained in phase I of our research, there are multiple ways in which empty bottles are supplied to the one-way packaging lines in Zoeterwoude. An overview of all the supply flows that will take place in the new situation (i.e., with the new packaging line 52 and with Leerdam as additional DLF location) is shown in Figure 5-1. In this research we focus on the supply of empty bottles via the DLF method to packaging lines 51, 52, 7, 81 and 82. This comprises the process from the procurement agreements, via the planning activities till the unloading of the bottles on the packaging lines. The main objective for this part is to improve the process regarding the supply of empty bottles to these packaging lines via the DLF method and reduce the costs that are associated to this process. An important part of this objective is to reduce the use of the H&B warehouse and thus improve the DLF performance.

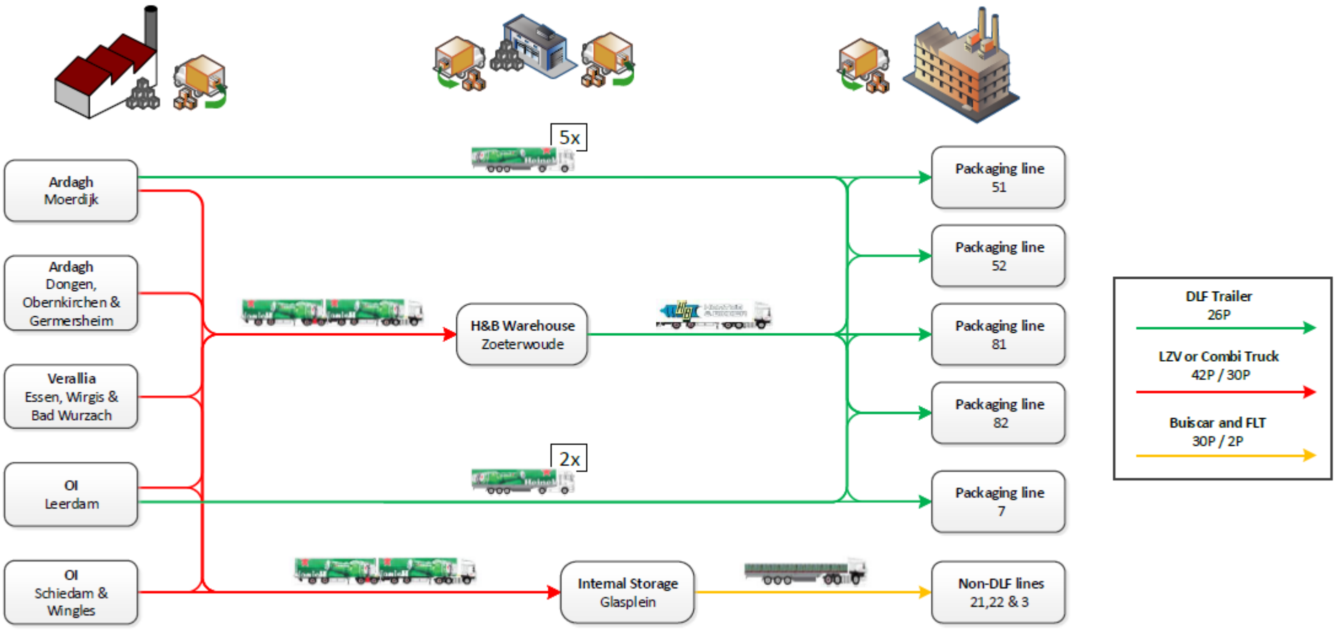


Figure 5-1: Overview of supply flows for all one-way packaging lines in the new situation

Table 5-1 shows the current DLF performance, based on the KPI overview monitored by Logistic Support. We can see that the addition of Leerdam as DLF location in week 20 had a significant positive impact on the DLF performance. While this is the case, the improved average DLF performance for all packaging lines is just 69%, which means that still 31% is supplied via DD. On annual basis this would result in €X additional warehouse costs when we calculate with €X per pallet and assume that these weeks are representative for the year.

Table 5-1: DLF performance overview (week 1-20 and 21-27 in 2016)

DLF performance in 2016						
Scope	Week 1-20**			Week 21-27**		
	Produced*	DLF supply*	DLF %	Produced*	DLF supply*	DLF %
Total	Confidential					
Line 51						
Line 7, 81 & 82						

* Production and DLF supply numbers are expressed in trailer amount
** Till week 20 the only DLF location was Moerdijk. From week 21 Leerdam is added as DLF

As explained in 3.3.4 (phase I), we estimated that the DLF performance of the new packaging line would be about 74%. We expect that the 'DLF volume' for line 52 would be X% of the total production volume of line 52 and we compared this to the situation of line 51 in 2015, where X% of production volume was 'DLF volume' and led to a DLF performance of X%.

Main process and stakeholders

In Figure 5-2 (next page) we show the SIPOC tool, which is a general overview of the DLF process and shows the relevant stakeholders. In the centre column the main process steps are shown and on respectively the left and the right the important suppliers as well as their inputs and the outputs for the specific customers for the different steps are shown.

Suppliers	Input	Process	Output	Customers
HGP	Initial bottle allocation (year)	**CM** Optimize allocation (1) Challenge allocation with HGP (2) Check efficiency of allocation with TSCP	Final bottle allocation (year)	TSCP
CM Order dep. (CSD, CSE, TSCP)	Final bottle allocation (year) Forecast information	**TSCP** Compose: (1) Brewery allocation rules (2) 13 weeks production plan	Allocation rules 13 weeks production plan	TSCP Suppliers
CM / TSCP Order dep. (CSD, CSE, TSCP)	Allocation information Availability Order information	**TSCP** Compose: *(1) Production plan over lines* *(2) Scheduling proposal for all lines* *(3) Material plan and week allocation percentages*	Scheduling proposal via AS Weekallocations	OS
TSCP	Scheduling proposal via AS Weekallocations	**OS + LS** Compose: *(1) Scheduling plan for all lines* *(2) Supply proposal*	Supply proposal	H&B planning department (Vuren)
OS Suppliers	Supply Proposal Availability	**H&B Vuren** Check and adjust the supply plan	Supply plan *(Type, time & amount)*	OS
H&B Planning department	Supply plan *(Type, time & amount)*	**OS** Read in supply plan and compose outputs	Material order Production orders Shipping notifications Purchase order	Logistic Support Brewery* H&B planning department Suppliers*
OS / SAP WMS & MES H&B planning department	Material order Production & Inventory data Suppliers stock data	**LS** Compose final supply plan by determine supply destinations	Supply details Final supply plan	WMS / WHC* H&B Zoeterwoude
OS / LS	Final supply plan	**H&B ZW** Shuttle bottles to lines (a1) Compare stock level & location truck (a2) Control stock level (b1) Check stock level (b2) Sent trailer when needed	Supply route to control provision	Truck drivers*
Brewery / OS	Changeover information Breakdown information Supply/Production update	Change shuttle trajectory (a) Supplier – line (b) Supplier – Warehouse Change shuttle amounts	Trajectory change	Truck drivers*

Figure 5-2: SIPOC concerning the supply of empty bottle to packaging lines 51, 52, 7, 81 and 82 via the DLF concept

5.2 Current process of DLF concept

In this section we explain how the current DLF process is organized, i.e., which activities are performed and how they relate to each other (the what), how these activities follow-up on each other (the when) and which stakeholders and departments are responsible and involved in which activities, indicated by the swim lanes (the who). The graphical representation is shown in Figure 5-3. The most upstream activities are shown on the left and the most downstream activities on the right. Furthermore we added the relevant outputs to the involved activities. The current state described includes Leerdam as DLF location. This addition has resulted in some small changes in the process steps 3, 4 and 5 and 9, which is explained in these steps.

1. Contract Manager Packaging Materials (CM-PM)

The DLF process starts with the negotiations and agreements of HEINEKEN Global Procurement (HGP), Contract Manager (CM-PM) and Tactical Supply Chain Planning (TSCP) with the empty bottle manufacturers about the year allocations (i.e., the division of empty bottles over the manufacturers), which are carried out in the last months before the start of the next year. This involves the followings steps:

a. The CM-PM receives an initial allocation plan based on negotiations of HGP with the manufacturers.
b. The CM-PM discusses this initial plan with HGP to challenge the security of supply. As is explained in phase I, this means that they want to prevent a dependency on a particular bottle manufacturer to minimize the risk of an insufficient bottle supply, when for instance one manufacturer has a significant production disturbance.
c. The CM-PM discusses the improved initial plan with the TSCP department to check if the allocations are well-tuned with the production desires of the packaging lines.

The output of this part of the process is the final bottle allocation plan, which is the overview of the bottle production allocation agreements with the different manufactures, which will be used the next year.

2. Tactical Supply Chain Planning (TSCP) department

The TSCP department manages the planning with the main focus on ‘week buckets’. The steps that are carried out by the TSCP department are explained below.

Before the start of the year:

a. The TSCP department receives the final bottle allocation plan from CM-PM. This year allocation is leading in the week allocations obtained by the TSCP department.
b. The TSCP departments creates rules of thumb for the bottle allocation between the breweries of HEINEKEN (i.e., Zoeterwoude and Den Bosch), which is used in the week allocations as well.

13 Weeks before production:

c. The TSCP department creates a 13 weeks production plan, with the associated material requirements and sent this to the manufacturers, so that they can tune their own bottle production plan with this forecast.

Week before production:

d. Based on the order information, received from the Customer Service Domestic (CSD) and Customer Service Export (CSE) departments and the replenishment orders, the expected total demand for the next week is drafted.

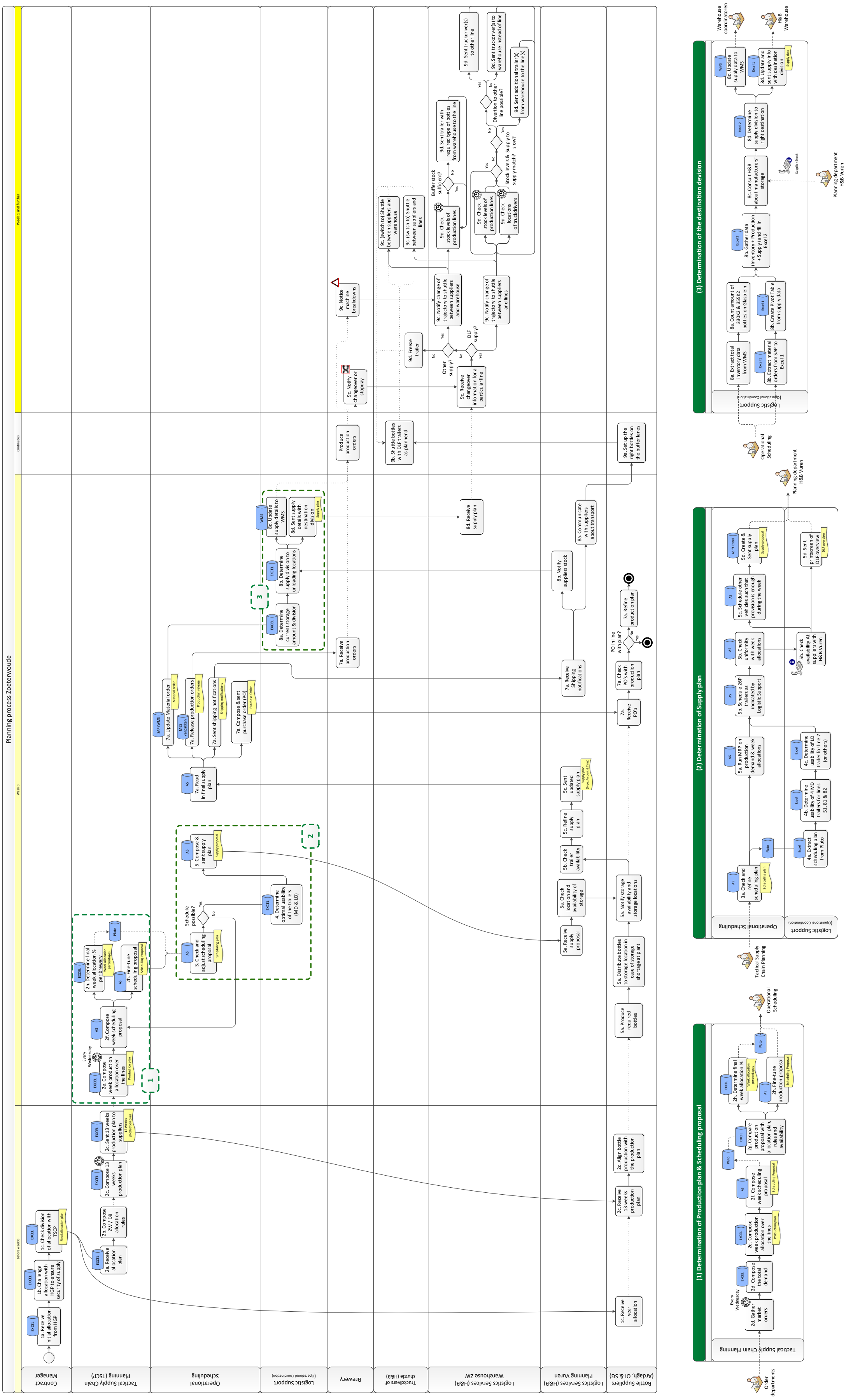


Figure 5-3: Current State concerning the supply of empty bottles to packaging lines 51 52, 7, 81 and 82 via the DLF concept

e. By the use of Excels the production plan (i.e., capacity planning) for that next week is created:
    - First the total expected demand is divided over the packaging lines by the use of an Excel that only takes into account the most preferred lines for the different products that need to be produced.
    - Next another Excel is used to add the overflowing production from lines that are over utilized to the lines to that are underutilized to create a smooth flow of production over all the packaging lines.

f. Next the TSCP department creates a scheduling proposal for the production of Zoeterwoude in AS and places all details in Pluto, which is a database used by SAP. For Den Bosch they only sent the associated orders.

g. Another team within TSCP, the material planning team, acquires the data of the production plan from Pluto and places it in their Excels. Next, they (1) assess to which extent the production plan corresponds to the bottle allocation from CM-PM of step 2a and try to smooth this as much as possible, (2) they determine the brewery division based on the rules of thumb of step 2b, which means that they determine which bottles from which facilities are allocated to which brewery and they (3) check if the material plan is possible with regard the inventory levels of empty bottles at the manufacturers facilities. In this way a material plan arises from the production plan, the bottle allocation, brewery division rules and the availability. In this material plan is thus determined for all types of bottles in which amount there are allocated from which manufacturers' facility to which brewery.

h. The different teams of TSCP communicate about the issues that arise in the previous step and, if required, the production plan is slightly adjusted. In the end they will come to a conclusion and will obtain the final material plan and an associated scheduling proposal for next week. The material plan is placed in Pluto and the scheduling proposal is sent to OS.

The final output of this part of the process is thus: (1) the 13 weeks plan that has been sent to the manufacturers, (2) the scheduling proposal for next week sent to OS, (3) the material plan (i.e., material allocation) for next week placed in Pluto.

3. Operational Scheduling (OS) department

The OS department is responsible for the development of a detailed and correct production scheduling plan and a detailed material supply plan that follows from it. In this process of obtaining a supply plan, some intermediate activities of other departments are identified (see 3 - 7). Before the introduction of Leerdam as DLF location processes 3, 4 and 5 were slightly different (simpler) and carried out by the OS department only. The current situation has two DLF locations and requires a bit more attention. In the current state the first step is still carried out by the OS department:

a. As described in step 2h, the OS department receives the scheduling proposal from the TSCP department. The first task of the OS department is to transform this scheduling proposal for next week in a detailed and correct scheduling plan. When particular conflicts can't be solved the OS department will interact with the TSCP department. When a correct final scheduling plan is obtained, the OS department places the details in Pluto.

The output of this process is thus a detailed scheduling plan for next week.

4. Logistic Support (LS)

This intermediate activity of LS is 'new' in the current situation (as explained above), since it became of importance to schedule the trailers more actively. The following steps are carried out by LS alone:

a. LS obtains the details of the scheduling plan for the different production lines from Pluto.

b. LS determines in what way the 4 DLF-trailers used for the supply of empty bottles from Moerdijk could be deployed most effectively.
c. LS determines in what way the DLF-trailer used for the supply of empty bottles from Leerdam could be deployed most effectively.

The output is the supply proposal for the 5 trailers, which is sent to the OS department by LS.

5. Operational Scheduling (OS) department & Logistic Support (LS)

This collaborative activity is also 'new' in the current situation. Here, the supply plan is created in more detail.

a. The OS department runs an update in the Advanced Scheduling software (AS), which combines (1) the production requirements from the scheduling plan of step 3a (i.e., the information related to which bottle types are required when, in what amount and on which lines) with (2) the week allocations of the material plan obtained by TSCP in step 2 (i.e., the information related to which bottle types need to be supplied in what amount from which facilities).
b. Next the OS department places the DLF-trailers on the positions as proposed by LS.
   - The OS department and LS check together if the empty bottle volume that would be ordered by the proposal of LS corresponds to the allocation percentages.
   - The OS department and LS check together if the empty bottle volume is really available and located at the different manufacturers' facilities.
c. When all DLF-trailers are planned and checked, the remainder of the empty bottle supply (which is not supplied via the DLF trailers) is planned such that the total amount of bottles is supplied during that week.
d. This supply plan with both the DLF-trailers (detail plan) and other vehicles (rough plan) is transferred from AS to an Excel file and sent to the planning department of H&B in Vuren. This file contains thus the complete empty bottle supply for next week. Additionally a print screen of the final DLF-trailer planning is sent to H&B in Vuren.

The final output from this process part is thus (1) the initial supply plan for next week (2) the DLF-trailer planning for next week.

6. Planning department of H&B in Vuren

The planning department of H&B is responsible for the fine-tuning of the supply plan, because they possess the required information about the available trucks and manufacturers' storage location levels.

a. The manufactures produces as continuous as possible and will sometimes encounter a shortage of storage space at the plant. In that case the manufacturers will transport the empty bottles to other locations (e.g., the H&B warehouse). When H&B in Vuren receives the initial supply plan of OS they check with the manufacturers where the bottles need to be picked up.
b. Next they determine the availability of their own trucks.
c. Then they determine the final supply plan (with truck types and correct times) by allocating the different truck to the required transportations. When the supply plan is complete, they sent it back to the OS department.

The output from this process part is thus the final supply plan, which includes the correct storage locations, truck types and times.

7. Operational Scheduling (OS) department

This is the final process part of creating the final supply plan.

a. The OS department reads in the supply plan (Excel) from H&B in Vuren and sends out quite some outputs as explained below.

The outputs from this part are: (1) the material orders in SAP, (2) the production orders in MES, (3) the shipping notification to H&B and (4) the purchase orders to the bottle manufacturers.

8. Logistic Support (LS)

In this process part the activities from LS comprise the determination whether the larger vehicles should transport the pallets to the warehouse or to the brewery.

a. The LS obtains the storage levels form the different bottles types that are produced on DLF as well as non-DLF lines from WMS. Next LS determines the amount of bottles that are stored on the Glasplein by counting the pallets.
b. Next LS acquires the material orders from SAP and the production order from MES and compares them with the storage information that he obtained to determine whether the pallets need to be transported to the warehouse or the brewery.
c. Next LS consults H&B in Vuren about the amount of bottles that manufacturers have stored in the H&B warehouse.
d. LS determines the division of all large trucks, places the results in an Excel, sent this Excel to H&B Zoeterwoude and updates the supply information to WMS for the Warehouse Coordinators at HEINEKEN.

The final outputs of this part of the process are thus the final supply plan updated with the destinations of all large trucks (brewery or H&B warehouse) in Excel and to WMS.

9. H&B Zoeterwoude

The warehouse of H&B contains empty bottle inventory from HEINEKEN and the manufactures. Besides that H&B controls the continuous supply of empty bottles to the DLF lines. The addition of Leerdam as DLF location has slightly expanded the process. We explain the transport from both Moerdijk as Leerdam.

a. The employees at the DLF locations (Leerdam and Moerdijk) place the pallets with empty bottles of the required bottle type on the buffer lanes.
b. The truck drivers are continuously shuttling the empty bottles from the DLF locations to the required destination, which is, in principle, the packaging lines.
c. In case (one or multiple) packaging lines are going to produce a bottle that cannot be supplied via DLF or when a packaging line will have a stop day, the trajectory of the trailers will change to the shuttle between the DLF locations and the H&B warehouse. This occurs as follows:
    - The operators of HEINEKEN notify the production changeover of a particular line to the staff members of H&B Zoeterwoude.
    - H&B Zoeterwoude notifies the truck drivers, who are supplying that particular line, what they should do. When the trailer(s) can be unloaded on another packaging line, this will be carried out. Otherwise the trailer will be sent to the H&B warehouse.
    - Subsequently the trailer will continue shuttling but with an adjusted trajectory, namely between the DLF location and the warehouse, till he receives a contrary message.
d. H&B is equipped with a system that monitors the storage on the buffer lanes as well as the current location of the trucks. With this system H&B controls the storage levels on the buffer lanes of the packaging lines.
    - In case the trailers are shuttling between the DLF locations and the packaging lines the staff members in the H&B warehouse monitor the storage levels as well as the locations of the truck and undertake action when required.
        - When trailers are not able to satisfy the need of a packaging line, they sent an additional trailer from the warehouse to support it.
        - When the buffer lane of a packaging lines is still full when a trailer is almost arriving, they tell the truck driver to unload the trailer at the H&B warehouse.

- In case the trailers of a particular packaging line are shuttling between the DLF locations and the H&B warehouse the staff members only need to check the storage levels on the buffer lanes. When these levels drop below a certain storage level, H&B sends a trailer to supply the packaging line.
- In case a trailer cannot be used during the week it is parked at the H&B warehouse and thus not used that week.

The trailers from Moerdijk are mainly transporting 355K2 bottles to packaging lines 51, 81 and 82, while the trailer from Leerdam is mainly transporting bottles to line 7. When line 7 is only producing DLF volume during a part of the week, the trailer will be used to support the other trailers. When all the trailers together are not able to supply all bottles, the remainder will be transported by large trucks to the warehouse, from which it will be shuttled when required as explained above.

5.3 Improvement opportunities

Now we have documented how the process actually works in the previous section, we use this as a communication tool towards all stakeholders involved and we can start thinking about potential improvements. The first section discusses the identification of the improvement opportunities, the second section explains the prioritization. We only discuss the improvement suggestions briefly in this section. We explain the 'prioritized' improvement suggestions in more detail in section 5.4.

5.3.1 Identify the improvement opportunities

After the development of the current state, which we have discussed in the previous section, we discuss the identification of the improvement opportunities. As explained in chapter 4 the literature suggests that documenting the current state stimulates questions and provides useful insights, which enables to start thinking about potential improvements. We gathered as much relevant stakeholders as possible in a meeting and jointly performed the final check on the current state, analysed the process and tagged the aspects of opportunity or concern with coloured sticky notes with the waste principles in mind, see Figure 5-4. The Current State with the tags is shown in appendix A.5.

Figure 5-4: Improvement opportunities identification meeting. From left to right: Logistic Support, CM logistic services, Planner OS, Researcher, CM Packaging materials and logistic Coordinator. Also present: Project Leader CS&L.

The main objective of phase II is to improve the process regarding the supply of empty bottles to the DLF lines and reduce the costs that are associated to this process. An important part of this objective is to reduce the use of the H&B warehouse and thus improve the DLF performance. This results in that the improvement opportunities that we found are in the end all related to the transportation and inventory costs. For that reason we do not divide the improvement into the different waste areas proposed by the literature, but in the areas as shown below. In this section we briefly discuss all opportunities that we concluded from the meeting. We explain the important opportunities, selected in the next section, more comprehensively in section 5.4.

Improvement opportunities related to the year allocation:

1) Tune the allocation agreements, made with the bottle manufacturers, with the objective of maximum DLF performance as much as possible.

Improvement opportunities related to planning and scheduling:

2) Increase the communication with the bottle manufacturers about the preliminary transport of empty bottles with regard to the bottle types, the locations and the volumes.
3a) Assess the DLF requirements during the half yearly or quarterly reviews to check improvement opportunities in the allocation agreements.
3b) Improve the current procedure of determine the material plan and bottle allocations per week and increase the focus on the DLF requirements.
3c) Increase insights in the finalized scheduling plan when the material plan (i.e., the bottle week allocations) is obtained.
3d) Take into account the downtimes of the packaging lines in the material plan.
4) Create distinction in all vendor numbers in the information systems of HEINEKEN to obtain insight in the origin of all empty bottles. Most importantly for the DLF location Leerdam.
5) Improve the current procedure of determine the supply plan, which enables OS to obtain an efficient DLF-supply planning.

Improvement opportunities related to inventory:

6) Create insight in the different storage locations in the information systems, so that the inventory levels of the brewery and the H&B warehouse can be distinguished.
7) Assess the safety storage levels used on the Glasplein at the HEINENEN brewery and in the H&B warehouse.

Improvement opportunities related to the trailer usage:

8a) Increase the focus on an efficient trailer usage prior to the production week.
8b) Increase the focus on an efficient DLF-supply during the production week.

Improvement opportunities during the production week:

9) Improve the ability to deviate from original supply route to other packaging lines.

Improvement opportunities related to performance measurement and continuous improvement:

10a) Create KPI to monitor the performance of H&B and make them accountable for particular performance level.
10b) Improve the KPI overview to measure and continuously improve the DLF performance and improve the communication between departments with regard to this DLF.

5.3.2 Prioritizing the improvement opportunities

In this section we discuss the prioritization of the improvement opportunities that we have found in the previous section. We have set a meeting with as much relevant stakeholders as possible to develop a benefit versus effort matrix, see Figure 5-5 and Figure 5-6. Based on the shared estimation of the

Figure 5-5: Meeting concerning the prioritization of the improvement opportunities. Present at meeting: Logistic Support, CM logistic services, Planner OS, Planner TSCP and Researcher

(positive) impact on the objective versus the difficulty, time and costs it will bring along, we placed all improvement opportunities on the grid. Two opportunities have been placed outside the grid, because they seem not completely related to the objective and thus they are considered out of the scope during the meeting. Next we divided the grid in three sections, as shown in Figure 5-6. We explain the valuable and potential options in the next section in more detail. The less valuable options are considered too much effort in comparison to the possible gain and are therefore left out of further research.

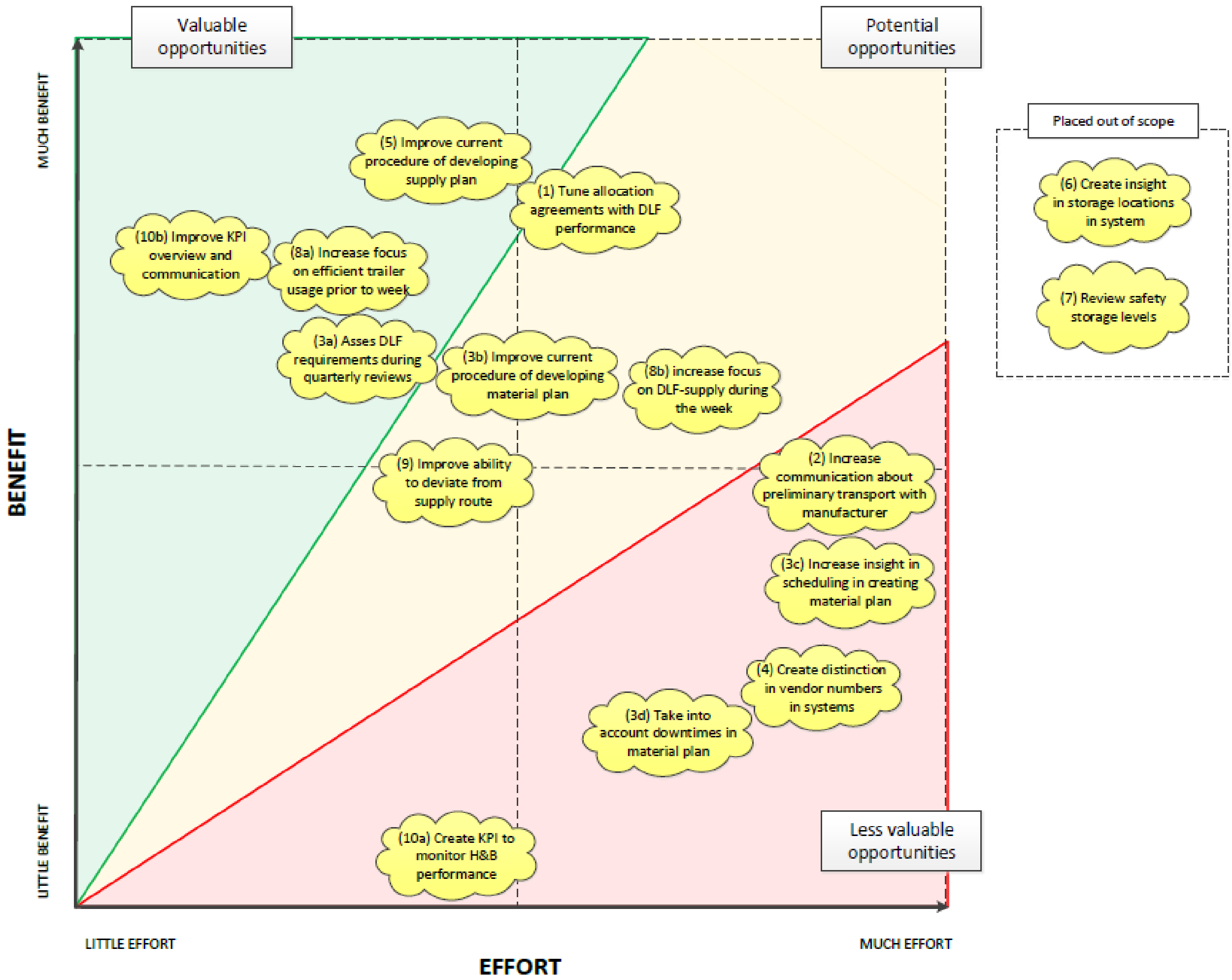


Figure 5-6: Benefit versus effort matrix concerning the improvement opportunities

5.4 Process improvements and implementation

In this section we elaborate on the selected improvement opportunities in more detail. Section 5.4.1 explains the improvements and the responsibilities for implementation or further research in the same order as they are discussed in section 5.3.1. Section 5.4.2 discusses the data review that supports the improvement suggestions. Section 5.4.3 provides an overview of the implementations.

5.4.1 Process improvements and responsibilities

In this section we discuss the valuable and potential improvements possibilities, which we have selected in the previous section, in more detail. Furthermore we add, which people are responsible for the different activities to obtain the desired improvement.

1. Tune the allocation agreements with DLF performance

To obtain a high DLF performance it is important to aim for a match in the allocation agreements, developed at the end of each year, between the production (e.g., amount and bottles type) of the DLF locations and the bottle requirements of the DLF lines. The agreements are made by HEINEKEN Global Procurement (HGP) based on many criteria. The Contract Manager Packaging Materials has an advising role in this process, in which he assesses amongst others the security of supply and the DLF requirements for the packaging lines of HEINEKEN Netherlands.

The negotiations take into account many (cost) aspects, most importantly the bottle prices per type (procurement costs). Taking into account (an estimation of) the DLF requirements for next year is challenging and thus providing a good advice for obtaining a good match, taken into account all aspects, is complex. However, when the DLF volume could be aligned more optimally, this would result in quite an improvement of the DLF performance and reduction of the DLF costs.

Main actions and responsibilities		
1	HGP	Endresponsible for the allocation agreements
	CM Packaging Materials	Responsible for the alignment of the DLF concerns during the bottle allocation negotiations each year. Aim for the objective to match the bottle production as much as possible with the DLF requirements
	Manager Logistics	Consultation with Manager Contractmanagement regarding the procedure to assure the continuity of this alignment

3a. Assess the DLF requirements during the quarterly reviews

During the year the production and thus the material orders occur (slightly) different than had been estimated during the allocation agreements (see previous point). This can results in that particular material orders need to be developed, that are disadvantageous for the DLF performance, to equalize the agreements later on during the year. From the DLF perspective it would be beneficial if the ordered volume would be compared to the allocation agreements continuously, but certainly during the quarterly reviews of CM-PM and TSCP, in an attempt to consult with the manufacturers and adjust particular allocations prematurely.

Main actions and responsibilities		
3a	CM Packaging Materials	(End)responsible for monitoring the ordered volume and adjusting beneficial modification in allocation agreements when possible
	TSCP	Providing input for desired modifications in allocations
	Manager Logistics	Consultation with Manager Contractmanagement regarding the procedure to assure the continuity of this alignment

3b. Review current procedure of determining the material plan and bottle allocation per week

As explained in section 5.2 the TSCP develops rules of thumb for the brewery division at the beginning of the year. The current procedure of obtaining the material plan and botte allocation per week is shown in Figure 5-7. For each week the material plan is obtained based on the production plan and via the evaluation of the allocations percentages, brewery allocation rules and the availability. In this simplified procedure, and also in the brewery allocation rules itself, the DLF performance is not considered a priority. Obviously, it is the case that a lot of aspects and interests need to be taken into account in the development of the material plan, which all bring along different (operational) costs. Consequently is has clear advantages that the procedure is simplified by allocations and rules of thumb. However in the meantime this procedure has quite an impact on the DLF performance, since the OS department and the supply plan is bounded by the week allocations determined in this material plan. This seems underestimated in the simplified procedure currently employed. Consequently it would be worthwhile to analyse which improvement step in the procedure (and in the development of the brewery allocation) would be most desired to support the DLF performance.

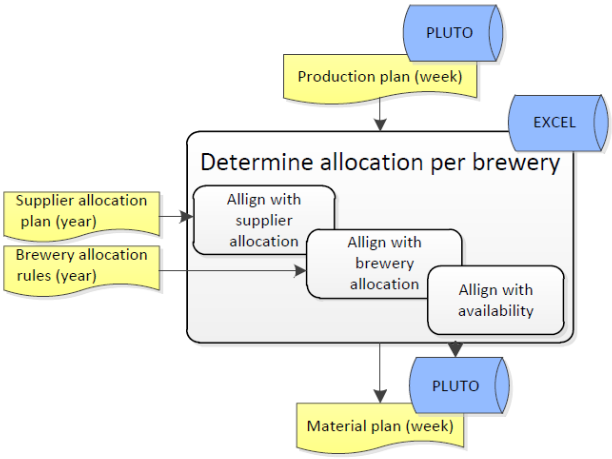


Figure 5-7: Procedure of obtaining the material plan

From the DLF perspective is seems preferable to replace the simplified procedure by a new tool that evaluates as much aspects and costs as possible and tries to obtain an optimum in the material allocations. It seems reasonable to assume that this would benefit other cost elements as well. When this is determined to be too much effort, other substantial improvements could be: a periodic evaluation of the brewery allocation rules, create insight in consequences for the DLF performance by adding a check to the current simplified procedure and/or the development of minimum order quantities at the DLF locations.

Main actions and responsibilities		
3b	Manager Planning	(End)responsible for the determination of the desired procedure for obtaining the material plan in consultation with the TSCP department
	TSCP	Responsible for the obtaining and execution each week of the desired procedure for obtaining the material plan

5. Review current procedure of determining supply plan

In the original situation the DLF-trailers were mainly planned on intuition and continuous DLF supply from Moerdijk to the DLF lines and only transported one type of bottle: 355K2. Reason for this is that the supply plan in the Advanced Scheduling (AS) software is determined based on 'total bottle amount' instead of 'packaging line level' and AS is currently not capable to do this differently. Since the addition of Leerdam as DLF location, a detailed DLF planning was required, which could not be performed in AS. Therefore the procedure for planning the DLF trailers was not sufficient anymore and changed (temporarily) to the devious process explained in section 5.2 (step 3-5).

The required improvement should reorganize this temporary procedure explained in section 5.2. First of all the planning activities should be carried out by the Operational Scheduling (OS) department and next the procedure should facilitate an efficient development of a detailed line or trailer planning. The conceived improvements to carry out this procedure can be divided in two ways:

- Modification to AS in such a way that it can develop a detailed supply plan on line and trailer level. This option would bring along some effort and investment costs, but seems the desired solution, because it would reduce the effort to create a detailed supply plan, could increase the accuracy and ability to control the supply plan and would reduce the chance on mistakes.
- Manual tool (e.g., Excel) to support AS by obtaining the required trailer division. This approach will be used temporarily, but is not preferred in the long term.

Main actions and responsibilities		
5	Manager Planning	Endresponsible for the development of the procedure
	Team manager OS	Responsible for the determination of the desired procedure for obtaining a detailed supply plan on trailer and packaging line level
	OS	Responsible for the execution of the desired procedure each week for obtaining a detailed supply plan on trailer and packaging line level

8a. Focus on efficient trailer usage prior to production week

In the lease agreements with H&B is assumed that the trailers are used continuously, which means that the trailer lease needs to be paid to H&B regardless of their usage. While this is the case, the varying production of the packaging lines causes that the trailers are not always fully employed. Besides that the trailers will generally not be used during the weekend, as long as these DLF lines will produce in a 3 shift system. Consequently it would be beneficial to determine for which transport activities the trailers could be used, when they are not usable in the DLF supply process.

Main actions and responsibilities		
8a	Manager Logistics	Endresponsible for efficient trailer usage
	CM Logistic Services	Responsible for the determination of the possible tranpsort activities that could be carried out with the unusable trailers
	LS	Responsible for the execution of the efficient trailer management each week
	OS	Responsible for the notification of the amount of unusable trailers each week

8b. Focus on an efficient DLF-supply during the production week

When (one of) the packaging lines falls behind schedule or is confronted with a disturbance it occurs that the buffer lane of the packaging line becomes full, causing that trailer cannot be unloaded on the packaging line for particular time period. In the current process the trailers continue the shuttle and unload all the pallets in the H&B warehouse, which brings along the known costs. An analysis should be conducted to determine what the preferred procedure is during the week, without causing storage problems at the manufacturers' facilities. Some possibilities could be:

- Temporarily freeze the DLF trailers till the disturbance is resolved.
- Compensate the supply excess by reducing the supply by larger trucks during the same week. When we want to carry this out for line 21, 22 or 3 it would require the installation of a (un)loading track on the Glasplein.

Main actions and responsibilities		
8b	Manager Logistics	Endresponsible for efficient DLF supply
	CM Logistic Services	Responsible for the determination of the possibilities and important considerations
	LS	Responsible for the execution of the efficient DLF supply each week

9. Increase ability to deviate from original supply route

Bottles that are supplied from Moerdijk and to line 51 could have been stored outside temporarily, because the covered storage is limited. For line 51 this causes no problem, since it contains a blower, which can dry the pallets as long as they are not soaked. Lines 7, 81 and 82 do not contain this blower and are therefore more vulnerable for wet pallets. In the current situation it is not known by any involved stakeholder, if the trailer content has been stored outside temporarily or not. This makes it impossible to switch the supply from line 51 to one of these packaging lines, forcing these trailers to unload in the warehouse, which brings along the known costs. This could be improved by:

- The addition of a blower on the packaging lines 7, 81 and 82
- Create a (almost) faultless procedure (e.g., stamp on the shipping notification), which indicates if a trailer is allowed to deviate to the other packaging lines. This requires some accuracy, because a mistake could result in quite some disturbance.

Main actions and responsibilities		
9	Manager Logistics	Endresponsible for the efficient logistic supply
	CM Logistic Services	Responsible for the determination of the preferred procedure and consultation with H&B about the agreements

10b. KPI to measure and improve DLF performance and stimulates communication

In the current situation the DLF performance is already monitored by LS based on data of the DLF lines. However, the data on which the KPI is based is limited, the overview is not very insightful and does not support substantial improvements. Besides that is it not very well communicated and discussed with the relevant stakeholders. An improved KPI overview with relevant information about the causes of DD supply from HEINEKEN and H&B, could facilitate that the performance is monitored closely. Structural improvements could be reached by assessing causes and deployments and by close communication between the relevant stakeholders.

Main actions and responsibilities		
10b	Manager Logistics	Endresponsibel for DLF performance
	CM Logistic Services	Responsible for the determination of the KPI overview, the communication with H&B and the anticipation on the KPI results
	LS	Responsible for monitoring the DLF performance, KPI and causes of deviating trailers and for the communication to the relevant stakeholders
	OS	Responsible for the notification of causes of undesired orders
	H&B	Responsible for monitoring the causes and frequenties of deviating trailers

5.4.2 Data review supporting the improvement suggestions

In the previous section we explained the improvement opportunities that we have identified during the interviews and meetings with the relevant stakeholders. In this section we discuss some data analysis that support the suggestions of the previous section.

Data review: Production data of 2015

When we evaluate the production data of 2015 shown in appendix C.7, we can generate the data overviews as shown in Table 5-2 and Table 5-3. From this data perspective we notice that the production volume of 'DLF bottles types' (i.e., bottle produced by DLF locations and on DLF lines) is higher than the production volume of the DLF lines will be in 2017, even with addition of the new packaging line 52. As shown in Table 5-2 the production volume of the DLF lines together in 2015 was X million bottles and, as explained in section 3.1.1, the expected added volume is X million bottles, which makes a total of X million bottles on the DLF lines. In the meantime the volume of empty bottle that have been produced by the DLF locations and supplied to Zoeterwoude is X million bottles (X million + X million) and on top of that we see in Table 5-3 that quite an amount of 'DLF bottle types' is supplied to the packaging lines in Den Bosch.

Table 5-2: Production data of packaging lines Zoeterwoude of 2015 (based on data of (Verbunt, 2016))

Production data Zoeterwoude (2015)			
Lines	Bottles types	From DLF locations	From non-DLF locations
DLF lines	250 K2		
	330 K2		
	355 K2		
	EU Brown		
	Sol		
	Non-DLF types	Confidential	
Non-DLF lines	250 K2		
	330 K2		
	355 K2		
	EU Brown		
	Sol		
	Non-DLF types		

Table 5-3: Bottle division between the breweries in 2015 (based on data of (Stevens, 2016))

Production division over the breweries (Data 2015)			
From location to Den Bosch	355K2	330K2	250K2
Moerdijk (115075)			
Leerdam/Schiedam (115071)			
From location to Zoeterwoude	355K2	Confidential	250K2
Moerdijk (115075)			
Leerdam/Schiedam (115071)			

While it is the case, that the DLF volume exceeds the required volume for the DLF lines, the tables show that quite an amount of bottles is supplied from the DLF locations to non-DLF lines in Zoeterwoude (Table 5-2) and Den Bosch (Table 5-3), while at the same time quite an amount of the supply to DLF lines is carried out from non-DLF locations (Table 5-2). When we assume that the data of 2015 is still representative, we can conclude that quite an amount of cost savings can be obtained, when the match between the production volume of DLF lines and the supply volume from the DLF location would be improved, which is the collaborative aim of the improvement possibilities 1, 3a and 3b, explained in section 5.4.1. It is important to understand that this objective is not easily obtained, since HGP, CM-PM and TSCP are dealing with many aspects during the development of the allocations (e.g., procurements costs and security of supply) and because the specific production during the week is market driven. However, knowing that an efficient DLF supply did not have much priority yet in several process steps, it does support the suggestion that quite some cost savings could be obtained when the attention for the DLF concept would increase at the beginning and during the year (see improvement suggestions 1, 3a and 3b).

Data review: DLF performance in 2016

Logistic Support (LS) monitors the DLF performance in the current situation. As we stated in section 5.1 already we have noticed quite an impact on the DLF performance since the addition of Leerdam as DLF location in week 20, which has increased the weighted average DLF performance of all packaging lines from X% to 69%. For further analysis of this KPI overview we only evaluated week 21 till 27 of 2016, since this represents the new situation.

Table 5-4: DLF performance overviews (based on data of (van der Meijden, 2016))

DLF performance analysis - Based on KPI overviews of LS (week 21 - 27 of 2016)							
Lines	Bottle types	Production (# trailers)	DLF supply (# trailers)	Trailers planned	Supplied from warehouse	DLF %	DD%
Total	-						
Line 51	355K2						
Line 7	330K2						
	Sol						
	Desperados			Confidential			
Line 81	355K2						
	330K2						
	EU Brown						
Line 82	355K2						

DLF performance analysis - Based on KPI overviews of LS (week 21 - 27 of 2016)					
Causes for DD	# Rides	DD%	# Pallets	H&B Costs	Yearly costs
Total amount					
DLF trailers rides					
DLF trailers planned			Confidential		
Sol or Desperados					
Mismatch					

As shown in Table 5-4 the DLF performance in the reviewed period was 68.9% and thus the DD% is 31.1%, which equals €X additional warehouse costs when we calculate with €X per pallet. On annual basis the additional warehouse costs would be €X, if we assume that these weeks are representative. Based on these data we can splits these costs as follows:

- First we compare the trailers that have been planned and the trailers that actually supplied the DLF lines. We assume that this DD percentage (X%) is caused by a mismatch between the supply of empty bottles and the production on the packaging lines (e.g., disturbance on the line, lines behind schedule and trailers supply faster or slower then scheduled). These causes seem difficult to overcome completely, but would be improved by suggestions 8b, 9 and 10b. An additional analysis based on the improved KPI overview, see improvement opportunity 10b, with the associated causes and frequencies of occurring, could possibly reveal even more possible improvements.
- Next we notice that X% of the production on the DLF lines has been Sol and Desperados, which cannot be supplied via DLF, since these bottles are only produced in X and X, which are non-DLF locations. In section 5.5 we pay more attention to the potential improvement that could be obtained related to this.
- The remaining X% are thus bottle types that could be produced on the DLF lines, but are not planned to be supplied via DLF. We assume that this bottle volume could not be supplied via DLF because of one of the following reasons:
    - Insufficient trailer capacity during a particular week
    - Insufficient bottle volume of the required bottle types available at the DLF locations during the particular week, resulting in a bottle supply from a non-DLF location. This could be caused by the fact that the DLF locations did not produce enough of one or several bottle types to fulfil the DLF requirements or by the fact that too much volume is allocated to non-DLF lines of Zoeterwoude or the lines in Den Bosch during that week. The improvement for this aspect would need to be obtained by revising the

allocation agreements (opportunities 1 and 3a) and reviewing the procedure of developing the material plan (opportunity 3b).

5.4.3 Implementation overview

In section 5.4.1 we already explained the responsibilities for the further development or implementation of the different process improvements, which we have determined in consultation with the relevant stakeholders of HEINEKEN individually and during the 3th (and final) meeting of phase II. In this section we present the RACI of the improvement project, see Figure 5-8, which is an overview that indicates who is responsible, accountable for the different process steps and who should be consulted and informed during the process.

RACI for DLF Concept

RESPONSIBLE = Executes
ACCOUNTABLE = Is end responsible
CONSULTED = Needs to be involved for advice
INFORMED = Needs to be informed

	Improvement opportunities	Heineken Global Procurement (HGP)	Contract Manager Packaging Materials (CM)	Manager Supply Chain Planning	Supply Chain Planner (TSCP)	Teammanager Operational Scheduling	Operational Scheduling (OS)	Manageer Inbound and Domestic Logistics	Logistic Support (LS)	Contract Manager Logistics Services (CM)	Hartog & Bikker (H&B)
1	Tune the bottle allocation agreements (with manufacturers) with the objective of DLF performance as much as possible	A	R		C						
3a	Asses DLF requirements during quarterly reviews to check improvement opportunities in allocation agreements		A R		C		C		C		
3b	Improve current procedure of determining material plan bottle allocations per week and increase focus on DLF performance		I	A	R		C		C		
5	Improve current procedure of determining supply plan, which enables to obtain an efficient DLF-supply planning in AS			A	I	R**	R*		C		
8a	Focus on an efficient trailer usage prior to the production week						C	A	R*	R**	C
8b	Focus on an efficient DLF-supply during the production week							A	R*	R**	C
9	Increase the ability to deviate from original supply route to other packaging lines							A	C	R	C
10b	Improve the KPI overview to continuously improve the DLF performance and the related communication between departments		I		I		C	A	R*	R***	R*
	Required analysis										
-	Optimal trailer capacity						I	A	C	R	R

* Responsible for execution of chosen procedure
** Responsible for the determination of the optimal procedure
*** Responsible for creation and anticipation of KPI results

Figure 5-8: RACI for the improvement of the DLF concept

In the remainder of this section we provide a roadmap in which we explain the required implementations steps in more detail. We discuss which activities should be carried out in which order and by which stakeholder to obtain the desired improvements. Next, we provide an overview in which we indicate our suggestion for the implementation priority. Finally, we briefly review the potential savings.

Improvement opportunity 1

For 'improvement opportunity 1' we suggest that CM-PM consults with TSCP, at the end of each year, to determine the expected DLF requirements for next year (i.e., the bottle types and amounts that will be produced on the DLF lines). Next when CM-PM advices HGP regarding the bottle allocation agreements with the manufacturers, CM-PM should aim to align the DLF requirements with the allocations of the DLF locations as much as possible. The Manager Logistics should consult with the Manager Contract management to assure the continuity of this alignment over the coming years.

Improvement opportunity 3a

For 'improvement opportunity 3a' we suggest that CM Packaging Materials (CM-PM) ensures that the DLF requirements are included in the quarterly reviews. Prior to this meeting, CM-PM would gather the information related to the ordered bottle volume and consult LS and OS about inefficiencies in the current allocations. During this meeting CM-PM and TSCP should check for beneficial adjustments in the allocation agreements. Next, CM-PM should check the applicability of these adjustments with the manufacturers. When adjustments in the allocation are made, TSCP should review the brewery allocation rules. The Manager Logistics should consult with the Manager Contract management to assure the continuity of this alignment over the coming years.

Improvement opportunity 3b

For 'improvement opportunity 3b' we suggest that the Manager Planning organizes a meeting with TSCP, OS and LS to discuss (1) the limitations of the current simplified procedure (including the brewery allocation rules) and the impact on the DLF performance and (2) to determine the most desired procedure for obtaining the material plan, based on the improvement that it will obtain and the effort that is will cost (see suggestions in 5.4). Next we suggest that TSCP would be responsible for the development (and execution) of the new procedure (and new tool when preferred).

Improvement opportunity 5

For 'improvement opportunity 5' we suggest that the Team manager OS organizes a meeting with the planners of OS and LS, to determine how the advanced software program should be modified, to obtain a software system that is able to develop the required detailed supply plans. First they should acquire a complete understanding of the requirements, then they should determine the most desired organization of AS, based on the efficiency and improvement that it will obtain and the effort that it will cost. When the organization of AS is determined, the Team manager OS would be responsible for the development of the improved AS system. The OS department would be responsible for the correct usage during the week.

Improvement opportunity 8a

For 'improvement opportunity 8a' we suggest that CM-LS would develop a procedure (or decision tool) for the unusable trailers in consultation with LS and H&B. This would be obtained by determining (1) the possible activities that could be carried out by these unusable trailers and (2) the potential benefit that these activities could obtain. During each production week, we suggest that OS is responsible for the notification of the amount of unusable trailers for that week and subsequently LS is responsible for an efficient deployment of these trailers by the use of the decision tool and communication with H&B.

Improvement opportunity 8b

For 'improvement opportunity 8b' we suggest that CM-LS would develop a procedure, in consultation with LS and H&B, for the situations that a trailer is unable to unload on the packaging lines. This would be obtained by determining (1) what the possibilities are in these situations, (2) what the important considerations are related to this matter and (3) deciding which possibilities are applicable. When CM-LS has established this procedure, we suggest that LS is responsible for managing these situations during the particular production week, in consultation with H&B.

Improvement opportunity 9

For 'improvement opportunity 9' we suggest that CM-LS examines, in consultation with LS and H&B, the most preferred improvement regarding the ability to deviate from the original supply route. This would be obtained by determining the improvement opportunities (see suggestions in 5.4), assessing the pros and cons and decide the most preferred procedure. Next CM-LS would be responsible for the implementation.

Improvement opportunity 10b

For 'improvement opportunity 10' we suggest that CM-LS is responsible for the development of an improved KPI overview, in consultation with LS, which clearly indicates the DLF performance and includes the causes of DD supply. We would suggest that OS and H&B would be responsible for providing information related to the causes and frequencies of undesired orders and deviating trailers.

LS should be responsible for monitoring the KPI overview (performance and input OS & H&B) and for the communication to the stakeholders each week. Finally, CM-LS would be responsible for the anticipation on the results with deployments and improvement projects.

Optimal trailer capacity

Besides the improvement opportunities, the new packaging lines 52 requires the lease of some additional trailers. As explained in section 3.3.2, we expect that 3 additional trailers are required for the supply of line 52. Two trailers for the shuttle between the manufacturers and the packaging lines and one for the shuttle between the warehouse and the packaging lines. CM-LS is responsible for the final check if the expected trailer is right, based on more updated data, and for the agreements with H&B. H&B should be made responsible for purchasing the required trailers.

Prioritization for implementation

While all improvement opportunities could be carried out at the same time and while they need to be carried out by several stakeholders, Table 5-5 provides an overview in which we indicate the suggestion for the implementation priority, based on the benefit versus effort analysis that we explained in section 5.3.2.

Table 5-5: Prioritization for implementation

Prioritization for implementation:	1	2	3	4	5	6	7	8
Improvement opportunities:	5	1	10b	8a	3a	3b	8b	9

Review regarding the potential savings

Most of the improvement suggestions explained in section 5.4.1 and shown in Figure 5-8 aim to improve the DLF performance and reduce the associated warehousing costs. Some improvement are related to the DLF process, but do not add to the DLF performance. They would improve the process and/or reduce the costs associated to the DLF process in another way.

Improvement suggestions focused on the DLF performance

Improvement suggestion 1, 3a and 3b (and 10b) focus on an improved match between the production volume of DLF lines and the supply volume from the DLF location. Considering the data shown in Table 5-2 and Table 5-3 (explained in section 5.4.2) we notice that that the DLF volume (data of 2015) exceeds the required volume for the DLF lines in 2017, which means that this mismatch is not a result of the production of the DLF location being too low. As explained in section 5.4.2, it is caused by the fact that DLF lines are supplied by non-DLF locations, while non-DLF lines are supplied by DLF locations. When we assume that week 21 till 27 are representative, this mismatches causes more than €X additional warehousing costs each year (see section 5.4.2 and Table 5-4). Improvement suggestions 8b, 9 and 10b focus on an improved DLF supply process during the week. Their aim is to reduce that bottles, which are planned to be supplied via DLF, need to be transported to the warehouse nonetheless. Assuming that week 21 till 27 are representative, this mismatch causes more than €X additional warehousing costs each week (see section 5.4.2 and Table 5-4).

Knowing that the introduction of line 52 in 2017 will increase the total DLF volume, the costs would probably increase even more if these improvement suggestions would be neglected. Savings would be obtained by implementing the improvements suggestions as it will improve the DLF performance and thus reduce the additional warehouse costs. The total amount of savings obtained, depends on the increased focus on the DLF performance, the achieved allocation improvements and the improved procedures chosen in 3b, 8b and 9 based on the further analysis.

Improvement suggestions focused on other aspects

Improvement suggestion 5 focuses on the improvement of the process regarding the development of the supply plan in a more efficient manner (i.e., improve the AS software). The obtained savings would relate to the reduction of manpower required each week (less effort in developing the supply plan), the savings related to the improved ability to control the supply during the week and the savings related to the reduction of (the chance on) mistakes in the supply process.

Improvement suggestions 8a (and 8b) focus on the efficient trailer usage. The trailers need to be paid to H&B regardless of their usage, but are not always needed in the DLF process. Savings can be obtained in other processes at HEINEKEN by using these (already paid) trailers. While the total saving is highly dependent on the usage possibilities, we expect that the trailers could be used each weekend and, when available, during each week. Further analysis of CM-LS should indicate the precise savings.

5.5 Additional improvement and further research suggestions

In this section we briefly discuss some other potential improvements that we have found but for several reasons were not considered to be within the scope of our research.

Procedure of monitoring the inventory levels and reduction of safety stock levels

Two opportunities have been placed out of the scope of the project, because they seemed not completely related to the objective. While this is the case, there seems to be an improvement potential, which is why we briefly discuss them. First of all there is no insight in the storage levels of the different storage locations in the Warehouse Management System (WMS) of HEINEKEN. The only information that can be found in WMS is the total inventory level. Secondly, the safety stock levels used (both Glasplein & warehouse) seem quite high.

As explained in section 5.2, the information about the separate inventory levels of the Glasplein and the H&B warehouse is required for the determination of the large trucks division. Therefore it is obtained by LS by obtaining the total inventory, counting the amount of pallets on the Glasplein and (thus) assigning the remainder to the storage level in the H&B warehouse. Next LS divides all large trucks in such a way that the safety stocks on both locations are replenished. Besides the fact that this procedure seems devious, inefficient and prone to errors, the lack of transparency of the inventory levels during the week seems inefficient as well. When this information could be obtained from the information systems, it seems even possible to shift this planning activity completely to the OS department by integrating this activity in the AS system. This situation could be improved by:

- Making H&B responsible for delivering a reliable inventory update. It could be argued that you can expect an accurate storage update from the logistic services organization. They could obtain this by counting their storage themselves or by using an own WMS, instead of HEINEKEN's which is currently the case. When they would deploy their own WMS, inventory information could be retrieved from the WMS systems any moment in time.
- Another improvement, which could have even more advantages, would be to scan all the incoming pallets at HEINEKEN and at the warehouse using barcodes or RFID. This would provide that pallets properties (e.g., location, origin) are always known, which could reduce effort during the process. For instance in the situation that a particular batch is determined to be defect and should be retrieved from production.

When the manufacturers' inventory levels in the warehouse could be obtained as well (as result of one of the above improvements), this would add another advantage. The information concerning the 'manufacturers' storage levels' could be used to lower the own safety storage levels in the H&B warehouse.

Addition of Direct Line Feed locations and adjustments in production allocation

Besides the improvement opportunities described in section 5.4.1, the DLF performance could also be improved by increasing the amount of DLF locations and by the reallocation of the production of these DLF location. As explained in appendix A.4, DLF locations need to be relatively close to the brewery and the installation of loading track to facilitate DLF supply. As shown in Table 5-6A, there are two location that are could qualify: Dongen and Schiedam. A downside of Schiedam however is that supply during the night and weekends is impossible, because the facility is located in the middle of a residential area.

Considering the data of 2015 Table 5-6C we notice that X million and X million bottles have been produced by respectively Dongen and Leerdam and supplied to the DLF lines. The majority of this volume contains Sol bottles (X million bottles), which is completely supplied from these location, since Moerdijk and Leerdam do not produce white coloured bottles. Considering the allocation agreements for 2016 (see Table 5-6B), we notice that Dongen will produce X million 'DLF bottles' and Schiedam will produce X million Sol bottles. If one or both locations could be added as DLF locations, this could definitely improve the DLF performance. Even more when this would be taken into account during the evaluation of the bottle allocation agreements of improvement suggestion 1.

Table 5-6: Production and allocation data of 2015 and 2016 supporting the addition of DLF locations

A

Travel times to Zoeterwoude	
Location	Travel time
Moerdijk	46 minutes
Dongen	63 minutes
Obernkirchen	199 minutes
Germerheim	267 minutes
Leerdam	42 minutes
Wingles	167 minutes
Schiedam	27 minutes
Essen	122 minutes
Wirgis	190 minutes

B

Allocation agreements for HNS (2016)		
Bottle types	MD and LD + SD	Dongen
250 K2	Confidential	
330 K2		
355 K2		
EU Brown		
Sol		
Non-DLF types		

C

Production data Zoeterwoude (2015)					
Lines	Bottle types	From DLF locations	From Dongen	From Schiedam	From other locations
DLF lines	250 K2	Confidential			
	330 K2				
	355 K2				
	EU Brown				
	Sol				
	Non-DLF types				
Non-DLf lines	250 K2				
	330 K2				
	355 K2				
	EU Brown				
	Sol				
	Non-DLF types				

Another business case should reveal what the most desired situation is concerning the DLF location. However it seems reasonable to assume that it would be beneficial to (1) add both facilities as DLF locations or (2) add one of the facilities as DLF location and allocate as much 'DLF bottles' to this location as possible. Additional costs would consist of a new loading conveyor at the manufacturers' facilities (€X each) and additional trailer lease, but the saving seems to exceed these costs in the long term.

Supplying all one-way bottle line via DLF and creating a covered storage location

From the start of this research HEINEKEN has stated that a covered internal storage was out of the scope of this project. Besides that we have been told that research has shown that it would not be beneficial to change the supply method of line 21, 22 and 3 to DLF as well. However, this research was carried out a few year ago and obviously did not take into account (1) the addition of packaging line 52, (2) the potential improvements in the DLF process revealed during this research, (3) the potential improvements for the DLF process because of the added DLF location(s) Leerdam (and possibly Dongen and Schiedam) and (4) the recent arisen idea of developing longer DLF-trailers, which would reduce the transport costs per pallet.

If Dongen and/or Schiedam would be added as DLF location, the allocation of 2016 show that the production amount of these facilities exceeds the total production amount of all one-way bottle lines in Zoeterwoude, which is why we assume that this would not have to be a restriction on the DLF performance. When the DLF performance would improve, the longer DLF-trailer project would succeed and thus the costs associated with the DLF process would be reduced, the DLF process becomes more appealing. Therefore it seems interesting to analyse if there is a positive scenario for the supply for line 21, 22 and 3 via DLF as well. The first question that needs answering is if there is enough space on the square to supply the lines via DLF. When this is the case, the analysis need to determine what the required investment would be, to which extent the OPEX of these packaging lines could be reduced and subsequently what the payback period would be.

An aligned or integrated project could analyse what the impact would be of the creation of an internal Direct Docking possibility for the DLF lines. This would eliminate the H&B warehouse costs completely and additionally it would facilitate that the total amount of safety stock could be reduced, since all safety stock would be stored on one location. Interesting analysis would be if the costs savings of the elimination of the warehouse costs and the reduction of safety stock, would exceed the additional costs required for the internal DD (e.g., FTE logistics) to the extent that the required investments (storage building and loading conveyors) would be paid back within reasonable time.

Conclusion of chapter 5

In this chapter we explained the research conducted in phase II. First we developed an understanding of the current process (sections 5.1 and 5.2). Next, we revealed several improvement opportunities and selected 8 of them in consultation with the relevant stakeholders (section 5.3), which we explained in further detail. We provided a RACI and a roadmap, which indicate who are responsible for the further development and implementation of the improvement opportunities and explain the suggested actions (section 5.4). We finished with some additional improvement and further research suggestions (section 5.5).

The main conclusion from phase II is that the DLF requirements have a low priority in several procedures and activities related to the inbound supply process of empty bottles. In some process steps it is the case that other aspect are more important, making the DLF performance subservient for a reason. However, in several procedures the subordination of the DLF process is unnecessary and could be improved. Most of the improvement suggestions aim to improve the DLF performance and reduce the associated warehousing costs. Savings related to the DLF performance could be obtained (1) by improving the match between the production volume of DLF lines and the supply volume from the DLF location (opportunities 1, 3a and 3b (and 10b) and (2) by improving the match between the DLF supply and the DLF needs of the packaging lines during the week, by reducing the occurrences in which planned DLF trailers are forced to deviate to the warehouse (opportunities 8b, 9 and 10b). Some other improvement are related to the DLF process, but do not add to the DLF performance. They would improve the process and/or reduce the costs associated to the DLF process by focusing on a more efficient supply, an increased focus on the DLF requirements and a more efficient usage of the DLF trailers (opportunities 5, 8a, 8b and 10b).

Research Completion

Conclusion and recommendations of the entire research - Phase I and II

6. Conclusion and Recommendations

In this research we have conducted two consecutive researches concerning the inbound supply to the packaging lines of the brewery of HEINEKEN in Zoeterwoude. In phase I the focus was on the layout redesign of the Foleyplein and logistical organization of the inbound supply to the packaging lines 52 (bottles) and 6 (cans). In phase II the research focused on the improvement of the supply process via the Direct Line Feed concept to all one way bottle lines (51, 52, 7, 81 and 82). This chapter summarizes the final results, presents the conclusions and provides the recommendations.

6.1 Conclusions and recommendations of phase I

The space limitation problem on the Foleyplein, as a result of the introduction of a packaging line 52, and a lack of clarity related to the preferred supply methods, has given rise to the research of phase I. The research question of phase I is defined as follows:

"What is the most cost effective layout design and logistical way to organize the supply of bottles and cans for the packaging lines 52 and 6?

Conclusion of phase I – Logistic organization and layout redesign of the Foleyplein

Several feasible alternatives are developed for the supply of packaging lines 52 (3 alternatives) and 6 (4 alternatives) via the Foleyplein, which are explained in section 3.2.2. After that, we evaluated those alternatives based on several quantitative (OPEX and CAPEX) and qualitative (e.g., safety) criteria to obtain the summarized results of Table 6-1.

Table 6-1: Summary of the evaluation results for the alternatives of line 52 and 6

Quantitative (financial) criteria evaluation					
Subject	Lines	DLF	Conventional A	Conventional B	Conventional C
Initial investment costs (CAPEX)	Line 52	Confidential			n/a
	Line 6				
Operational expenses (OPEX) *	Line 52				n/a
	Line 6				

* OPEX do not consist of all cost calculations associated with the alternatives. Only costs aspects that differ are taken into account

Qualitative (non-financial) criteria evaluation												
Line 52	DLF				Conventional A				Conventional B			
Line 6	DD	Conv. A	Conv. B	Conv. C	DD	Conv. A	Conv. B	Conv. C	DD	Conv. A	Conv. B	Conv. C
Score	++	□	+	+	n/a	- -	- -	-	+	-	□	□

We have concluded that, for the supply of packaging line 52 (bottles), the 'DLF' alternative is preferred. The 'DLF' alternative scored (much) better on the non-financial criteria. Considering the financial criteria, the difference in CAPEX is earned back within a reasonable time period (less than two years) as the OPEX are (much) lower. Hence, the 'DLF' alternative is preferred on the financial criteria as well.

For packaging line 6 (cans) we concluded that the 'conventional B' option is the preferred alternative. It is chosen over 'conventional A', since 'conventional B' scores better on the non-financial criteria, while the financials are equal. While both the 'DLF' and 'conventional C' alternative are (slightly) preferred on the non-financial criteria, they require a significant (i.e., too high) investment.

We conclude that the preferred layout design for the Foleyplein and logistical organization for the supply of packaging lines 52 and 6 is obtained as shown in Figure 6-1, with the required constructions and taking into account the required safety measures on the Foleyplein. Several feasibility checks (e.g., production and loading capacity of manufacturers, spatial experimentation on Foleyplein) and the sensitivity check on the DLF performance have supported this decision.

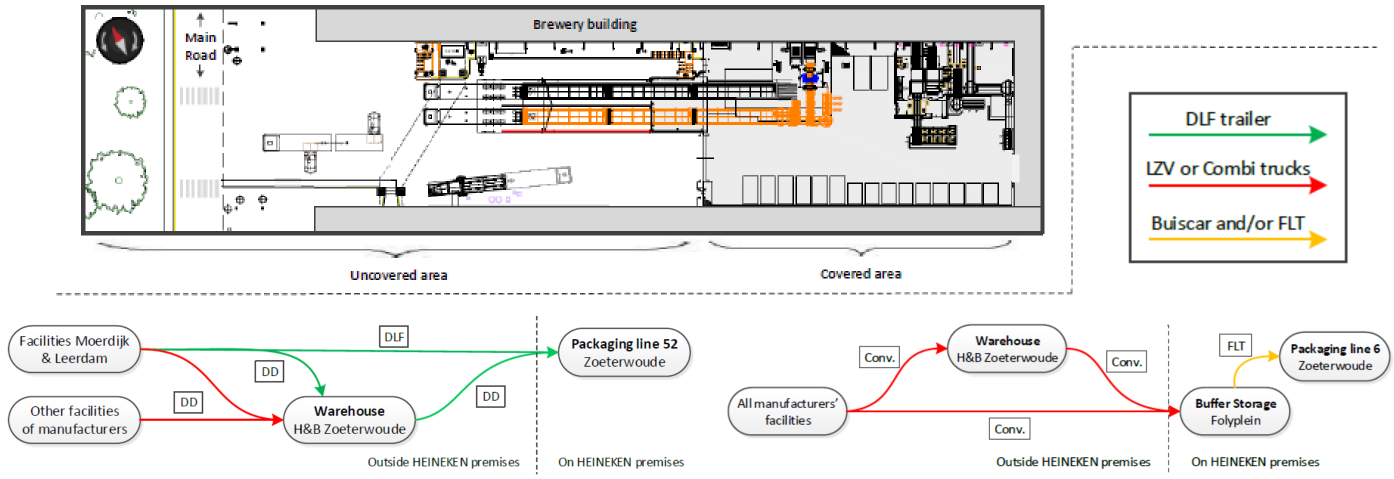


Figure 6-1: Overview of the preferred layout design of the Foleyplein and logistic organization of the supply to line 52 and 6

Recommendations of phase I – Logistic organization and Layout Redesign of the Foleyplein

The main recommendation for phase I of this research is to implement the layout design and logistic organization as described in the conclusion.

6.2 Conclusions and recommendations of phase II

During phase I of our research we have encountered some inefficiencies in the DLF process, which has given rise to phase II of the research. The research question of phase II is described as follows:

"How is the current DLF process organized and in what ways could the process be improved to organize the inbound supply of empty bottles via the DLF method more efficiently?"

Conclusions of phase II – Improvement of the Direct Line Feed concept

We have developed an understanding of the DLF process and revealed several improvement opportunities that would reduce the costs associated with the process. The research has indicated that the DLF requirements have a low priority in several procedures and activities related to the inbound supply process of empty bottles. In some process steps it is the case that other aspects are more important, making the DLF performance subservient. However, in several procedures the subordination of the DLF process is unnecessary and could be improved.

Most of the improvement opportunities aim to improve the DLF performance and reduce the associated warehousing costs. The DLF performance is the percentage of the supply volume that has been supplied directly and hence did not need to use the intermediate warehouse. Savings related to the DLF performance could be obtained by:

- Improving the match between the production volume of DLF lines and the supply volume from the DLF location (opportunities 1, 3a and 3b (and 10b). Data suggests that this mismatch causes more than €X additional warehousing costs per year.
- Improving the match between the DLF supply and the DLF needs of the packaging lines during the week, by reducing the occurrences in which planned DLF trailers are forced to deviate to the warehouse (opportunities 8b, 9 and 10b). Data suggests that this mismatch causes more than €X additional warehousing costs per year.

These costs would probably increase even more with the additional DLF supply volume of line 52.

Table 6-2: Overview of the current DLF performance and associated costs

DLF performance analysis - Based on KPI overviews of LS (week 21 - 27 of 2016)					
Causes for DD	# Rides	DD%	# Pallets	H&B Costs	Yearly costs
Total amount					
DLF trailers rides					
DLF trailers planned			Confidential		
Sol or Desperados					
Mismatch					

The other improvements are related to the DLF process, but do not add to the DLF performance. They would improve the process and/or reduce the costs associated with the process by developing enhanced procedures, using the trailers more efficiently and increasing the focus on the DLF performance (opportunities 5, 8a, 8b and 10b).

Recommendations of phase II – Improvement of the Direct Line Feed concept

The improvement opportunities that have been selected (based on their benefit-effort ratio) are shown in the overview of Figure 6-2 and explained together with the recommendations below. The RACI provides an overview of the improvement opportunities and the associated responsibilities for further development and implementation.

RACI for DLF Concept

RESPONSIBLE = Executes
ACCOUNTABLE = Is end responsible
CONSULTED = Needs to be involved for advice
INFORMED = Needs to be informed

	Improvement opportunities	Heineken Global Procurement (HGP)	Contract Manager Packaging Materials (CM)	Manager Supply Chain Planning	Supply Chain Planner (TSCP)	Teammanager Operational Scheduling	Operational Scheduling (OS)	Manageer Inbound and Domestic Logistics	Logistic Support (LS)	Contract Manager Logistics Services (CM)	Hartog & Bikker (H&B)
1	Tune the bottle allocation agreements (with manufacturers) with the objective of DLF performance as much as possible	A	R		C						
3a	Asses DLF requirements during quarterly reviews to check improvement opportunities in allocation agreements		A R		C		C		C		
3b	Improve current procedure of determining material plan bottle allocations per week and increase focus on DLF performance		I	A	R		C		C		
5	Improve current procedure of determining supply plan, which enables to obtain an efficient DLF-supply planning in AS			A	I	R**	R*		C		
8a	Focus on an efficient trailer usage prior to the production week						C	A	R*	R**	C
8b	Focus on an efficient DLF-supply during the production week							A	R*	R**	C
9	Increase the ability to deviate from original supply route to other packaging lines							A	C	R	C
10b	Improve the KPI overview to continously improve the DLF performance and the related communication between departments		I		I		C	A	R*	R***	R*
	Required analysis										
-	Optimal trailer capacity						I	A	C	R	R

* Responsible for execution of chosen procedure
** Responsible for the determination of the optimal procedure
*** Responsible for creation and anticipation of KPI results

Figure 6-2: RACI overview presenting the recommendations of phase II

The explanations of the recommendations are as follows:

1) To obtain a high DLF performance it important that the production of the DLF locations, documented in the allocation agreements each year, and the production of the DLF lines is aligned. While taken into account all relevant aspects, CM Packaging Materials and TSCP should also aim for a match between the bottle allocation agreements concerning the DLF locations and the bottle requirements of the DLF lines.

3a) The actual material orders will be slightly different during the year than agreed in the bottle allocations. To prevent that disadvantageous material orders need to be done, CM Packaging Materials should monitor the ordered bottle, check for beneficial adjustments in the allocation agreements during the quarterly reviews and check their applicability with the manufacturers.

3b) In the current situation the material plan (and thus bottle allocation per week) is obtained via a simplified procedure that is based on the production plan and evaluates the bottle allocation percentages, the brewery allocation rules of thumb and the availability. In this simplified procedure, and also in the brewery allocation rules itself, the DLF performance is not considered a priority, while it has quite an impact on the DLF performance. TSCP should asses the limitations of the current procedure and determine the most desired improvement(s) in the process of obtaining the material plan (e.g., procedure redesign, rules of thumb evaluation, minimum order levels).

5) The current way of obtaining the supply plan is revealed to be quite devious, due to the limitations of the scheduling system AS. Since AS is only capable of planning on ‘total bottle level’, the required trailer scheduling is currently performed with a supporting Excel by LS. OS should be able to perform all scheduling activities themselves and be able to perform them efficiently. Therefore, OS should determine and implement the desired modifications to AS and improvements to the procedure, to enable them to obtain a detailed and accurate supply plan in an efficient manner.

8a) The trailers are not always fully employed during a particular week, while the lease costs of these trailers need to be paid to H&B regardless of their usage. CM Logistic Services and LS should therefore determine which activities could be carried out with the trailers that are temporarily unneeded in the DLF process. LS should be able to plan trailers efficiently during the week.

8b) The continuous supply of trailers and the production of the packaging line is not always aligned during the week, causing that trailers cannot be unloaded on the packaging lines and are unloaded in the warehouse, with the associated costs. CM Logistic Services should determine what the most cost effective solutions would be in these situations (e.g., trailer freeze, compensation with LZV). LS should be able to regulate the supply efficiently during the week.

9) It is not possible to unload trailers, planned for line 51, on any of the other packaging lines, because these pallets could have been stored outside temporarily. Line 51 contains a blower, which can dry the pallets as long as they are not soaked. Lines 7, 81 and 82 do not contain this blower and are therefore more vulnerable for wet pallets. To reduce the pallets that need to be transported to the warehouse, CM Logistic Services should consult with H&B and determine the preferred improvement (e.g., blower investment, procedure that indicates suitability).

10b) The DLF performance is currently monitored based on limited data, the KPI overview is not very insightful and it is not discussed or well communicated with the relevant stakeholders. Hence, the KPI does not support continuous improvement. CM Logistic Services and LS should create an improved KPI overview that can monitor the DLF performance closely, based on the relevant supply data and information about imperfections provided by OS and H&B. Structural improvements should be pursued by assessing the causes and by close communication between the relevant stakeholders.

While all improvement opportunities could be carried out at the same time and while they need to be carried out by several stakeholders, we have provided a suggestion for the implementation priority.

Table 6-3: Prioritization for implementation

Prioritization for implementation:	1	2	3	4	5	6	7	8
Improvement opportunities:	5	1	10b	8a	3a	3b	8b	9

6.3 Discussion and suggestions for further research

6.3.1 Discussion

Phase I:
We did not take into account all possible alternatives and did not evaluate all thinkable criteria for the determination of the most preferred alternatives. However, we did evaluate all criteria from which we assume, in consultation with HEINEKEN, that they would significantly differ and thus would influence the decision making. The same applies for the evaluation of the alternatives.

There is (only) one alternative that has not been evaluated during this research, while we think that the alternative might be beneficial: building a covered storage location, which is placed out of the scope by HEINEKEN (see further research suggestions IV in section 6.3.2). For the alternative of 'DLF with internal DD supply' this causes no obstruction. When further research would indicate that the warehouse would be beneficial, the supply method for line 52 is adjusted easily. The alternative of 'conventional supply with a covered storage location' is not as easily obtained, since it would require a reinvestment in the supply construction. However, we assume that it is not likely that the 'conventional supply with a covered storage location' would be a better alternative than the 'DLF with internal DD supply', based on a brief consideration of both the financial as the non-financial aspects.

Phase II:
With the current data available at HEINEKEN it is difficult to determine what the explicit reason is for every pallets that has been supplied via the warehouse. Therefore it is difficult to pinpoint the exact improvement that could be obtained by the different improvement opportunities. Furthermore, we have not been able to determine the detailed solutions for all the improvement opportunities within the time period of phase II, since many aspects need to be taken into account (again). The responsible stakeholders, described in the RACI, will need to continue with the development and implementation of the improvements.

6.3.2 Suggestions for further research

We have discussed some other improvement suggestions in section 5.5, which were considered out of the scope of this research, but do contain some potential benefit. These improvement suggestions are:

I. There is no insight in the storage levels of the different storage locations (Glasplein or H&B warehouse) in the Warehouse Management System (WMS) of HEINEKEN, while this information is required in the process. This lack of transparency leads to devious and inefficient processes that seem prone to errors and result in the fact that OS is not able to carry out all scheduling activities. Further research should indicate the possibilities and determine the most desired improvement (e.g., H&B using a separate WMS system or scanning the pallets using barcodes or RFID).

II. The current safety stock levels on both the Glasplein as the H&B warehouse seem to be quite high. Further research should asses if these levels are required or could be reduced. When suggestions I is implemented, the information concerning the 'manufacturers' storage levels' could be obtained as well, which could be used to lower the own safety storage levels in the H&B warehouse.

III. The DLF performance could be improved by increasing the amount of DLF locations and by the reallocation of the production to these (new) DLF locations. Schiedam and Dongen could qualify, since they are located relatively close to the brewery and produce quite an amount of 'DLF bottle types'. Further research should assess if the required investments would be earned back by the savings obtained by the addition of Schiedam and/or Dongen as DLF location.

IV. An internal covered storage location and supplying all one-way bottles lines (i.e., adding lines 21, 22 and 3) via DLF were placed out of scope by HEINEKEN, because previous research would have shown that the CAPEX would not be earned back within a reasonable time period. However, this research was carried out a few year ago and obviously did not take into account (1) the addition of packaging line 52, (2) the potential improvements in the DLF process revealed during this research, (3) the potential improvements for the DLF performance because of the added DLF location(s) Leerdam (and possibly Dongen and Schiedam) and (4) the recent idea of developing longer DLF-trailers, which would reduce the transport costs per pallet. When the DLF performance would improve and the longer DLF-trailer project would succeed, the costs associated with the DLF process would be reduced, making the DLF process more appealing. Further research should reveal if the required investments would be earned back by the savings (financial and non-financial) when we would (1) supply all one-way bottles lines via the DLF method and/or (2) create a covered storage location on the premises of HEINEKEN (i.e., an internal Direct Docking possibility).

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Appendices

Additional background information, more extensive explanations and data overviews that support the research conducted.

Appendix A: Background information related to the situation at HEINEKEN and the brewery of Zoeterwoude

This appendix discusses some background information related to HEINEKEN and the current situation at HEINEKEN. In the title is indicated which section it supports.

Appendix A.1 Additional company information (section 1.1)

In this appendix we provide some additional background information, which guides through the structure of Heineken from the top, via Heineken Nederland Supply to the customer service and logistics department, which is the department where the project is carried out. Furthermore we explain some basic principles and differences to enlighten the reader.

HEINEKEN

HEINEKEN is established in 1864 by Gerard Adriaan Heineken who acquired a small brewery in the heart of Amsterdam. Under the supervision of four generations of the Heineken family it became the company it currently is. A period in which HEINEKEN has faced some challenges over the years, expanded the Heineken brand over the world and acquired multiple companies, including the soft drink producing company Vrumona and breweries like Amstel, Wieckse, Brand, Desperados, the beer business of FEMSA (e.g., Sol) and Asia Pacific Breweries (e.g., Tiger) (HEINEKEN, 2016a). The operations are spread out over more than 70 countries and carried out by a team of over 85,000 employees. The portfolio of HEINEKEN contains more than 250 international, premium, regional, local and specialty beers and ciders sold 178 counties around the world, which makes HEINEKEN the number one brewer in Europe and the number two brewer by volume in the world (HEINEKEN, 2016c).

From all the different brands that HEINEKEN has to offer the Heineken brand itself is the largest, most important and strongest brand and can be seen as number one priority. HEINEKEN has the aim to be the fastest growing company in terms of naturally brewed beverages and besides that the company with the highest amount of innovative products of the best quality with brands that are preferred above the brands of competitors (HEINEKEN, 2016a).

HEINEKEN Netherlands (HNL)

Nowadays, HEINEKEN Netherlands consists of three breweries in Zoeterwoude, ‘s Hertogenbosch and Wijlre and a soft drink company Vrumona in Bunnik. HNL can be seen as an exceptional entity within HEINEKEN. As explained in the previous section the establishment in the Netherlands was the first of all production facilities of HEINEKEN. Besides that the brewery in Zoeterwoude is the largest brewery of Europe and the largest within HEINEKEN worldwide. In addition to those remarkable facts the brewery in Zoeterwoude has an exceptional production character, since it serves as back-up facility. All production entities of HEINEKEN worldwide operate as separate organizations, whereas the brewery in

Production facilities HNL (van Oost, 2016) *[modified]*

Zoeterwoude has a broader scope. It does not only focus on serving the own markets, but also on the (expected) shortage worldwide. This means that the facility should be able to increase the production utilization in case of shortage throughout the world.

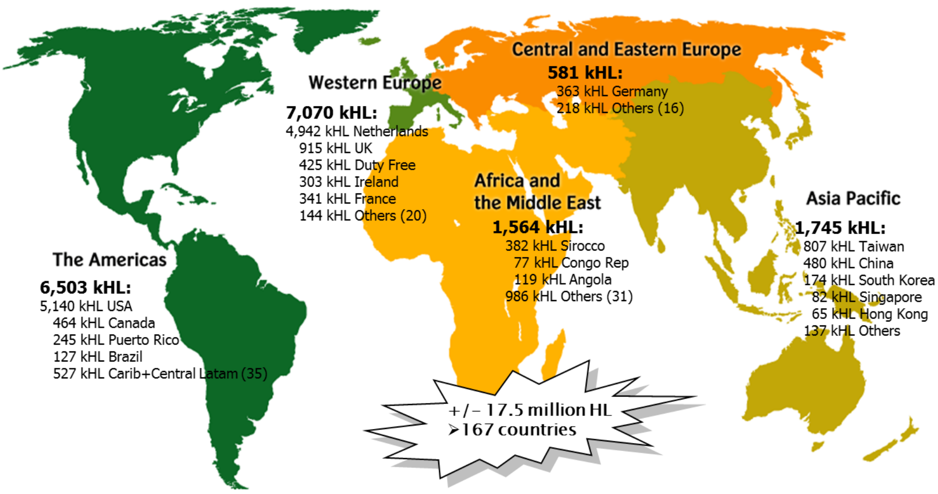
HNL consists of more than 3000 employees divided over the three breweries, eight regional facilities and the soft drink company. From an organizational point of view HNL consists of four divisions, namely Heineken Netherlands Supply (HNS), Commerce (e.g., marketing department) , Vrumona and Business Support (e.g., Human resource department) (HEINEKEN, 2016a).

HEINEKEN Netherlands Supply (HNS)

Heineken Netherlands Supply (HNS) is part of HNL where about 1300 employees are responsible for the production and distribution of the beers and ciders that are brewed in the Netherlands for the domestic and export markets. Approximately 17.5 million hectolitre is produced by HNS in three breweries on more than 30 production lines, which is approximately 14% of the total production of Heineken worldwide. About 30% from this is designated for the Dutch market, approximately one third is exported to the United States and the rest is exported to more than 150 countries worldwide (HEINEKEN, 2016b).

Customer Service & Logistics (CS&L)

Customer Service & Logistics (CS&L) is part of HNS and responsible for the logistical activities of HNS, which means that they manage all logistical activities for the three breweries. Roughly speaking the responsibility for CS&L can be split into two parts, since each order starts with the inbound logistics and ends with either domestic or export logistics (Heiport, 2016a). Initially, CS&L is responsible for a smooth process concerning the forecast, the planning and the regulation of inbound materials and warehousing. After these planning and supply activities the responsibility shifts to the production department of the different breweries till they transformed all semi-finished products in the final products. From that moment the responsibility shifts back to CS&L to facilitate that all products find their way to the domestic and exports markets.

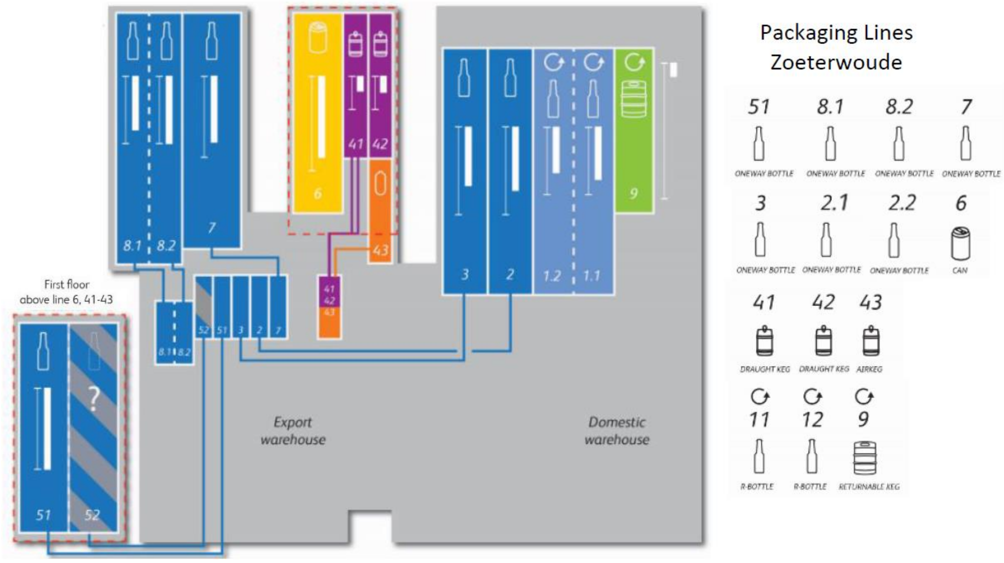


Production and distribution of HNS in 2014 (van Oost, 2016)

Brewery Zoeterwoude

The brewery of Zoeterwoude contains 14 packaging lines for 5 different types of products based on their primary packaging (e.g., bottles or cans). Lines 11, 12, 21, 22, 3, 51, 81 and 82 produce bottles, line 6 produces cans, lines 41, 42 produce draught kegs, line 43 produces air kegs and line 9 produces returnable kegs. For this research an extra distinction need to be made between returnable bottles (line 11 & 12) and one-way bottles (on the other lines). Returnable bottles are those bottles that

HEINEKEN would like to receive back after they have been used by the customer, which is the reason that those bottles contain a returnable deposit. The one-way bottles on the other hand do not contain this deposit and are meant to be thrown away. The consideration for which concept to use is primarily based on the most cost effective option. The production costs of a new Heineken bottle is a little less than €X (Bos, 2016). The costs for returning the bottle to Zoeterwoude depends obviously on the distance. For this reason the division to serve the different markets with one-way bottles or returnable bottles is mainly a result of the distinction in the distance of domestic versus export markets.



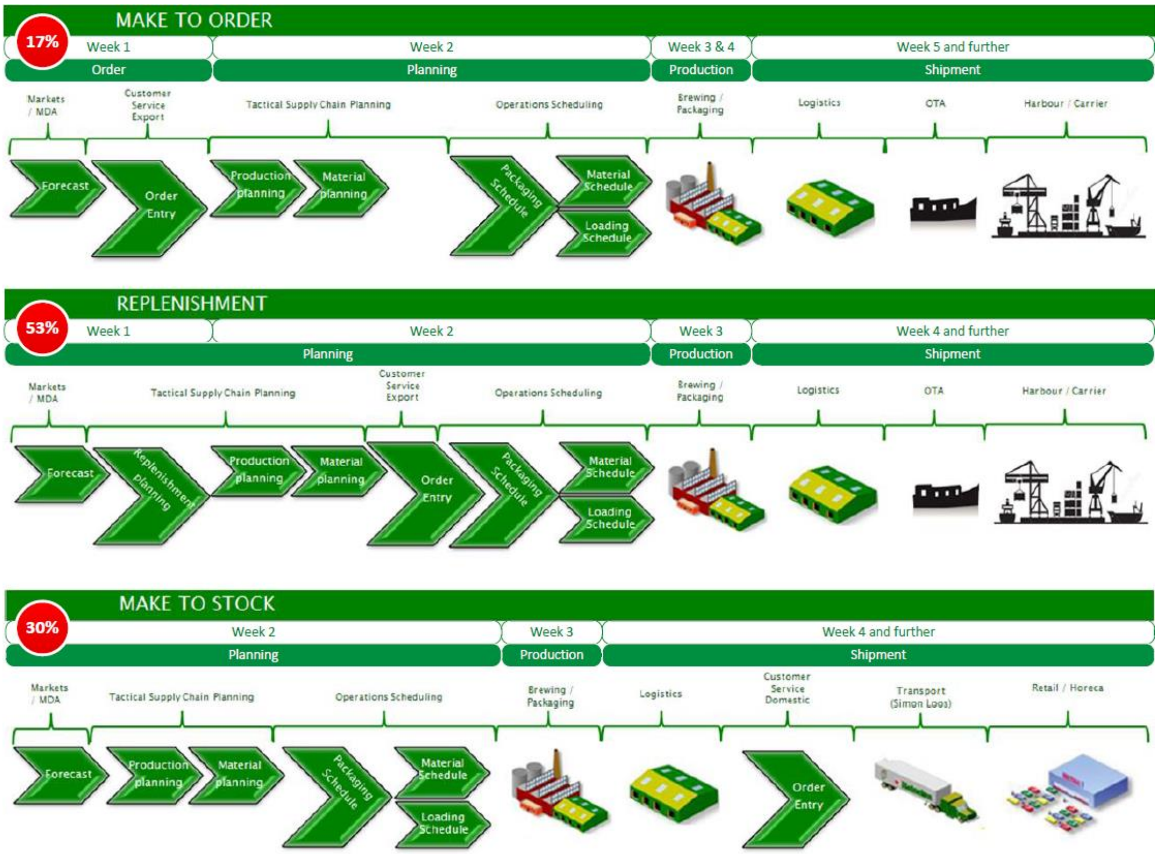
Layout of the packaging lines at Zoeterwoude (van Kooten, 2016) *[modified]*

Market types and Drumbeat

The 'standard drumbeat' is a period of 4 weeks which is perceived at HEINEKEN as the standard flow for an order to pass the different phases: order (week 1), planning (week 2) and production (week 3 and 4) (van Oost, 2016). The transportation to the customer follows after this drumbeat. While this is perceived as standard it is actually only used for a particular market type: the Make To Order market. We can distinguish three different market types that are served by HNS, namely: Make To Order (MTO), Replenishment and Make To Stock (MTS). All these types have their own process from receiving the order till production and shipment to the customer.

MTO is the market in which HEINEKEN starts producing after the order of the customer has been received. As stated before the MTO market follows the 'standard drumbeat', which means that the first week is devoted to handle to incoming orders, the second week comprises the planning phase, the third and fourth week embraces the production and the weeks after that cover the transportation to the customer. Not every SKU is produced every week, which is the reason that 2 weeks of production is included in this drumbeat. The MTO type covers approximately 17% of the total production of HNS, which consist of one way bottles for the export markets.

The Customer Order Decoupling Point (CODP) in the MTO market lies at the beginning of the process, which means that HEINEKEN start the process after receiving the specific orders. The process for the MTR and MTS market work slightly different and gain on flexibility, since HEINEKEN does not have to wait for the specifics of the orders. In the replenishment market HEINEKEN has agreed with the customer to keep the storage level of finished goods at the customer between a minimum and a maximum amount. This market type covers approximately 53% of the production amount of HNS and contains one-way bottle production for the export markets. In the MTS market HEINEKEN (only) has to fulfil the own storage levels. It covers approximately 30% of the production amount of HNS and consists of returnable bottle production for the domestic markets. The CODP in these markets is located at a later point in time compared to the MTO market, which means that HEINEKEN produces before explicit orders are received. This results in a more flexible way of planning, since HEINEKEN is able to combine the (expected) demands of different customers over multiple weeks.



Different processes for the different market types (van Oost, 2016) *[modified]*

Appendix A.2 Reasons for increasing the production capacity (section 1.2)

HEINEKEN Global wants to increase the capacity of one-way bottles at HEINEKEN Zoeterwoude. The main incentive to do so can be split into two parts: (1) the back-up functionality of HEINEKEN Zoeterwoude and (2) the need to increase the emphasis on New Product Innovations (NPI).

The first and most important reason for enlarging the capacity in Zoeterwoude is the fact that HEINEKEN Global expects a shortage on one-way bottle capacity in Western Europe. Therefore they have decided that the capacity in Zoeterwoude should be increased, since this seems the easiest way to cover this forecasted shortage. As explained in the previous section all production facilities of HEINEKEN throughout the world operate as separate entities. While this is the case, HEINEKEN Zoeterwoude has an exceptional character due to the fact that this plant has been assigned as a back-up facility. When the situation occurs that one of the other plants of HEINEKEN is not able to meet their demand and the available stock is not sufficient to back up this shortage, HEINEKEN Zoeterwoude should be able to assist by temporarily increasing the production utilization (van Kooten, 2016).

The second reason for the enlargement of the one-way bottle capacity is the fact that Heineken Nederland Supply (HNS) needs to enhance the ability to focus on New Product Innovations (NPI). HEINEKEN has set specific goals for every four years and manages Key Performance Indicators (KPI's), which concern the revenue percentage that arise from these NPI's. To reach these goals and the associated Key Performance Indicators (KPI's), HNS needs to increase the overall capacity to facilitate the development of these NPI's. The brewery in Den Bosch has been designed as flexible production facility that enables short production cycles, while Zoeterwoude on the other hand is merely focused on effectively producing large amount of products. Therefore the brewery in Den Bosch is more suitable to focus on these NPI's. For the brewery in Den Bosch to be able to focus on these NPI's, the production plant in Zoeterwoude should take over some of the 'standard' production volume from Den Bosch that is suitable for large production quantities (van Kooten, 2016).

Appendix A.3: More detailed explanation of supply methods (section 3.1.2)

Packaging lines currently supplied via the Conventional way

Figure 3-1 shows the overview of the brewery and Figure 3-3 visualizes the logistic distribution network of the different packaging lines that are supplied via the conventional way in the current situation.

- Can line 6 (Zoeterwoude): The empty cans are produced by four different manufacturers and supplied from many production facilities, from which almost all locations are located outside the Netherlands, as indicated in Figure 3-3B. Transport to the brewery of Zoeterwoude flows direct or via an intermediate warehouse. When a truck arrives (direct or indirect) at the brewery it is parked on the Foleyplein as shown in Figure 3-1 and Figure 3-6. Subsequently it is unloaded by a forklift truck (FLT), which stores the pallets of empty cans on an assigned storage location at the Foleyplein. At the moment the line needs them the FLT lifts the pallets with empty cans from the storage location and place them on one of the loading conveyors of line 6.
- Bottle lines 21, 22 and 3 (Zoeterwoude)**:** The empty bottles are produced by three manufacturers with together eight production facilities. In contrast to the can supply, most of the production facilities are located in the Netherlands, as shown in Figure 3-3A. Transport to the brewery flows directly from the manufacturer to the Glasplein, which location is indicated in Figure 3-1. When the truck arrives at the Glasplein it will be unloaded and the pallets with empty bottles will be temporarily stored. When the production lines 21 or 22 need the bottles the process continuous as follows. The pallets with empty bottles are placed on a buiscar by a FLT and the buiscar is driven to the square where these lines are supplied, see Figure 3-1. At the square the buiscar is parked close to the packaging lines and the pallets with empty bottles are transferred from the buiscar to the buffer conveyor of the packaging line by a FLT. When production line 3 requires the bottles the process is slightly different. The pallets are also placed on a buiscar and driven to the same square, but once arrived at the square (and thus the packaging line) the buiscar is docked against the loading conveyor of the packaging line. The difference is caused by the fact that the loading conveyor of packaging line 3 consist of special metal forks that can lift the pallets from the buiscar on the loading conveyor.

Packaging lines currently supplied via Direct Line Feed and Direct Docking

Figure 3-5 visualizes the logistic distribution network of the different packaging lines that employ the DLF and DD method in the current situation. Note that for the supply of empty cans we visualize the situation in Den Bosch. Reason for that is that, in the current situation, there is no packaging line of cans in Zoeterwoude that is supplied via DLF (or DD), while Den Bosch has two lines supplied via DD. Therefore we visited the brewery of Den Bosch to understand the current process, key opportunities and key barriers of DLF for cans.

- Bottle lines 51, 7, 81 and 82 (Zoeterwoude): In the current situation the supply of empty bottles is provided via the DLF technique, see Figure 3-5A (and Figure 3-1). The bottles are produced by the same three manufacturers with together eight production facilities, from which almost all of them are located in the Netherlands, as displayed in Figure 3-3A. DLF is in the current situation only performed from one of the facilities, namely the facility of Ardagh in Moerdijk. The supply from this location flows most of the time directly to the packaging lines, with some deviate supply via Direct Docking (DD), as explained on the previous page (see the last two reasons for the intermediate warehouse). While Moerdijk is just one of the eight facilities and the only facility that is able to support DLF, the facility has quite a share of the total amount of empty bottles. Data from 2015, see appendix A, show that the 4 production lines together produced X million bottles, from which X million are manufactured in Moerdijk, so X% has been supplied from this single facility. The other X% have been manufactured in one of the other facilities and are completely supplied via DD.

- The two can lines in Den Bosch are supplied via Direct Docking completely and thus not via DLF because of two reasons, which is explained in section 3.2.1. The cans for Den Bosch are manufactured by the same 4 manufacturers as displayed in Figure 3-3B and Figure 3-5B. The flow of these cans starts with the transportation from the supplier to the intermediate warehouse of H&B in Oss by combi's or LZV's (30 - 42 pallets). In the warehouse the pallets are unloaded and stored. When required the right amount of the right type of cans are loaded to the trailer in the right order, the trailers drives to the brewery of Den Bosch and the pallets are unloaded on the buffer conveyors of the can lines.

Appendix A.4: Explanation of the (dis)advantages of DLF (section 3.1.2)

Advantages of DLF: Less handling and dry pallets

The main advantage of the DLF methodology is the reduction of handling and FLT usage. The required handling differs for the two methods at the manufacturer and at the brewery, but the advantage is obtained at the brewery side:

- Manufacturer side: In the conventional way the pallets with empty bottles are loaded by a FLT to the truck. In the DLF method the pallets with empty bottles are loaded to the loading conveyors positioned on the manufacturer's premises, from which the pallets are subsequently loaded to the truck automatically.
- Brewery side: In the conventional way the pallets are unloaded from the truck and stored on the Glasplein till the packaging lines needs them. As explained before, the process continuous then with placing the pallets on a buiscar by a FLT, driving the buiscar to the right square and transfer these pallets from the buiscar to the buffer conveyors of the packaging line. In the DLF method on the other hand, there is zero handling (i.e., use of a FLT or buiscar) at the brewery. The truck is unloaded on the buffer conveyor of a packaging line and the pallets with empty bottles continue their way through the packaging line automatically.

Another advantage of the DLF method in comparison to the conventional method used at HEINEKEN, is the fact that these pallets are dry when they enter the packaging line. In the conventional method the pallets are stored on the Glasplein (see Figure 3-1) for a while, which is an uncovered square. When the weather is bad the cardboard covers on the top of the pallets can get soaked, despite the fact that these pallets are wrapped in foil. When these pallets with soaked cardboard covers enter the packaging line, the chances of disturbance on the line is determined to be higher. Especially at the 'unwrapper', which is the device that pulls off the foil of the pallets. At Heineken an OPI loss of X% is assumed and used for the additional disturbance on the packaging line, which results in a lower utilization of the packaging line and thus less production. The problem of soaked cardboard could, besides the DLF method, also be resolved by an internal storage location, but as already indicated in section 1.2.4, this solution is out of the scope of our research. Another way we could think of to resolve this problem is by improving the quality of the foil. This is however also outside of the scope. Therefore we consider the OPI loss, with the associated costs, as disadvantage of the conventional method.

Disadvantages of DLF: Higher transportation cost and the need of Direct Docking

An advantages of the conventional way and thus a disadvantage of DLF has already briefly been discussed. In the conventional way the transportation of empty pallets can be done with large trucks consisting of two wagons. This use of multiple wagons is (yet) impossible in the DLF technique. Therefore less pallets are transported per ride, resulting in higher costs per pallet.

Another disadvantage of the DLF method is the need for an external storage location close to the premises of HEINEKEN and the costs that are associated with this. This covered external storage location is a warehouse of Hartog & Bikker in Zoeterwoude less than 5 minutes away from the HEINEKEN brewery, where many different products of HEINEKEN are hold. Empty bottles intended for the packaging lines, waiting for the moment they are needed, is one of these products. There are several reason why this intermediate warehouse and the safety stock is required in the execution of the DLF process:

(1) An important reason is that not all supplier's facilities are able to support the DLF method, because (a) the distance between the facility and the HEINEKEN brewery is too large or (b) the facility does not have a loading conveyor on their premises. For these reasons the supply from these facilities need to be done via Direct Docking (DD), which is explained on the next page.
    (a) In the DLF process an (almost) constant supply of empty bottles is required that complements the buffer conveyor before all empty bottles are used. Since the buffer conveyor only contains a buffer capacity equal to the volume of X trailers, the constant supply would be difficult to ensure when the facilities are not located relatively close to the brewery. Besides the fact that the supply takes (too) long, the variability would be too large as well. Unpredictable delay at the manufacturer (e.g., during loading) or during transport (e.g., traffic jams) can result in the fact that the supply takes longer than expected and that the different trailers no longer supply the lines alternately, which is planned and required for a successful DLF process. The further away the facility is located, the bigger the risk that the required constant supply is completely out of balance.
    (b) From the facilities that are located (relatively) close to the HEINEKEN brewery not all facilities possess a loading conveyor. The DLF-trucks cannot be opened and loaded from side, which means that it is undoable to load these trucks with a FLT. Therefore the availability of a loading conveyor is considered a requirement for the participation in the DLF process.

(2) Another reason why an intermediate warehouse is required is because of the need for an alternative location to deviate to when the buffer conveyor is full at the time a new trailer arrives. The supply of bottles is not the only process that experiences unexpected delays, the production process encounters unexpected delays as well (e.g., machine failures). In the meanwhile, as explained above, the supply of empty bottles is done in a (relatively) constant flow. For this reason it can occur that a new (scheduled) trailer arrives at the buffer conveyor, while the buffer conveyor is filled to such an extent that there is no space for a new complete filled trailer. It that case the trailer deviates from the original plan and brings the pallets with empty bottles to the warehouse of H&B, where the trailer will be unloaded with use of a loading conveyor and the pallets are stored in the warehouse. As is explained extensively in chapter 5 the responsibility for the coordination of these trailers and the continuous supply to the DLF-lines lies with H&B.

(3) The last reason why a safety stock is required is that there are a particular amount of trailers that are employed for the supply of these packaging lines. Most of the time the capacity of these trailers is enough to supply the packaging lines, but in some cases the production is slightly larger than the trailers can transport in the same time period. In that case the safety stock is consumed and transported by other trailers that shuttle between the warehouse of H&B and the brewery to supply the total amount of bottles needed.

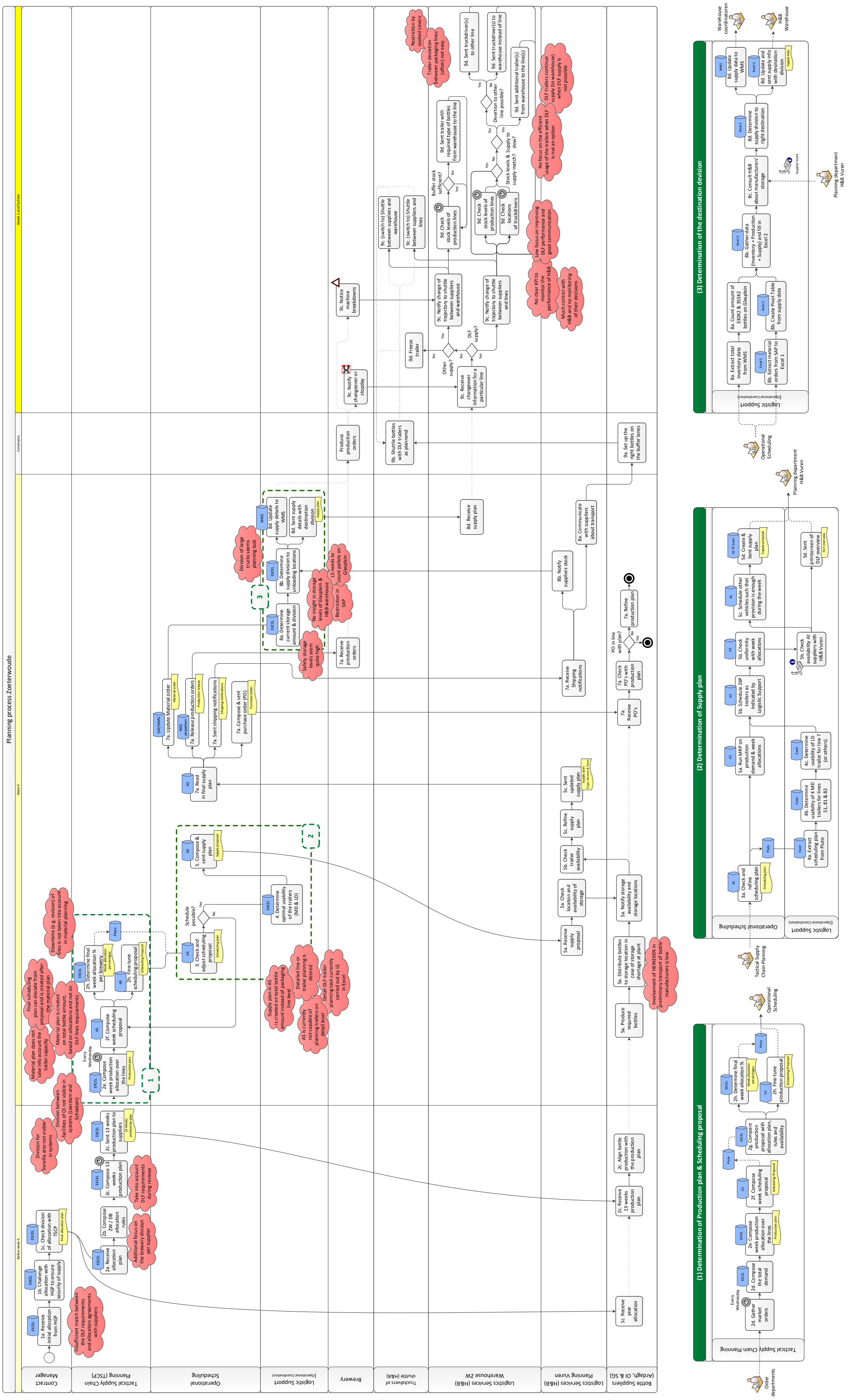
Limitations related to the supply of cans

Can supply via DLF is not plausible for line 6, only DD could be employed, because of two reasons:

- The distances of the can manufacturers is too far away from the brewery in Zoeterwoude. Just one manufacturer is located in the Netherlands, while the others are located in other countries of Europe and even the United States. A DLF process requires an (almost) constant supply of empty bottles that complements the buffer conveyor before all cans are used. Unpredictable delay at the can manufacturers (e.g., during loading) or during transport (e.g., traffic jams) will result in the fact that the supply takes longer than expected and that the supply of the lines is no longer carried out alternately. The further away the facilities are located, the bigger the risk that the required constant supply is completely out of balance, which makes the supply of cans via DLF impossible.
- The other reason requires a better understanding of one key difference between bottles and cans related to the diversification a product using the packaging material. HEINEKEN produces many different types of products if we would only distinguish on the obvious differences like the brands, flavours and primary packaging (e.g., bottles or cans). The number of different SKU's at Heineken is however even higher, since there are also differences in secondary packaging sizes, labels and languages. An interesting remark is the difference between bottles and cans for this matter. Every can SKU has his own primary package type in terms of different type of brand, flavour and language. This means that every changeover on the packaging line (i.e., every moment that a slightly different product is produced) requires that the inbound material needs to change as well. The same distinction for bottles on the other hand is made by the different labels, which allows HEINEKEN to work with just a few type of bottles and use the labels and secondary packaging material to diversity the products to serve all markets. In other words the number of different bottles that are needed is much lower than the number of different cans. This distinction between bottles and cans has a clear impact on the supply chain, since it facilitates that the required number of switches in primary packing material is much lower for bottles than for cans.

  Understanding this key difference between cans and bottles, we can explain the second reason why cans in Den Bosch are not supplied via DLF. The variety in different type of products, and thus the variety in different types of cans, is so large that there is often not enough cans of one specific type to fill a complete trailer. This results in the fact that different types of cans need be transported together in one truck and, in case of DLF or DD, these cans need to be placed in the truck in the exact correct order as they will be needed in the particular order on the production line. This makes it (almost) impossible to use DLF (instead of DD). First of all because sorting the cans would be an additional and difficult activity for the manufacturer, but more importantly the products that are produced in consecutive order on the packaging lines of HEINEKEN are often manufactured in different facilities.

Appendix A.5: DLF process with waste tags (section 5.3)



Appendix B: Background information related to the literature study

This appendix discusses some background information related to the literature studies conducted. In each title is indicated, which section it supports.

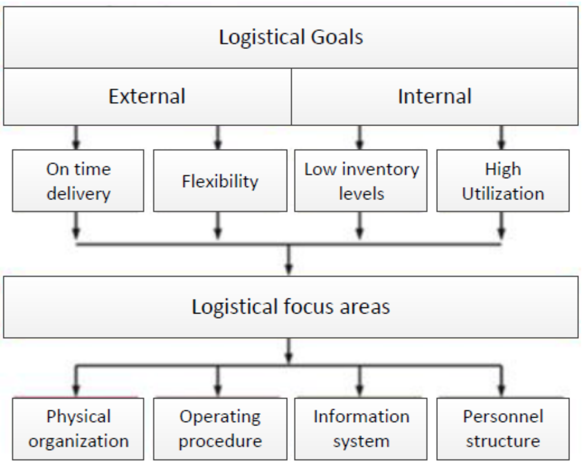
Appendix B.1: Integral Logistic Concept (section 1.5)

The logistical concept can be defined as the design of the desired layout for the logistic function in an organization, in which is described how the product, cash and information flows are aligned with each other (Visser & van Goor, 2011). According to these authors the development of such a logistical concept has 3 functions:

- To develop an integral vision on the coordination of the physical product flow.
- To provide a framework for a coordinated plan of action.
- To create a strong logistic awareness throughout the organization.

Based on this logistical concept the management can make substantiated decisions about the deployment of people and resources for the purpose of improved logistical performance (Visser & van Goor, 2011).

The figure below shows the structure of the logistical concept that is proposed by Visser & van Goor (2011), which differentiates between: (1) the logistical objectives of the logistical concept and (2) the focus areas where improvement measures would be possible. The logistical objectives concentrate on the internal logistical performance level that the organization wants to achieve for the benefit of the customer. They are divided in internal and external objectives with the aim to minimize the inventory levels and maximize the utilization on the one hand (the internal objectives) and the aim to maximize the on-time delivery and the flexibility on the other (the external objectives).



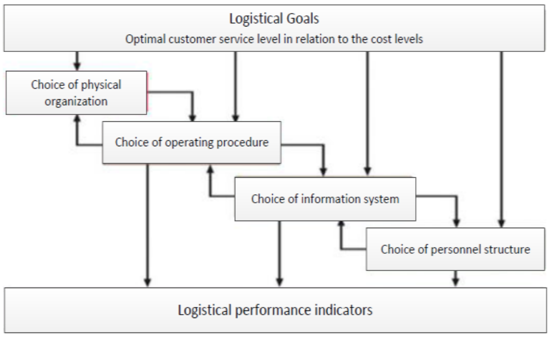
Structure of the logistic concept (Visser & van Goor, 2011) [A: Original; B: Translation]

To find the right balance of emphasis on these internal and external objectives Visser & van Goor (2011) differentiate between 4 focus areas where improvement measures would be possible.

- The *physical organization*: the physical features of the facility with direct impact on the way the products are processed, transported and stored (e.g., the factory lay-out).
- The *operating procedure*: the way the primary process is carried out, controlled and monitored (e.g., the planning activities).
- The *information system*: the way an adequate information system is involved in the process (e.g., the MRP calculations).

- The *personnel structure*: the realization of an effective coordination between the departments and functions in an organization (e.g., responsibilities).The four areas lie in line with each other, which means that they should be handled in the same consecutive order. The way these focus areas are organized determines the logistical performance and the extent to which the internal and external objectives are realized (Visser & van Goor, 2011).

The figure below shows the integral logistical concept as is should be used according to Visser & van Goor (2011). It starts with determination of the logistical objectives, followed by the implementation of the four areas in the consecutive order and considers the logistical performance indicators as the end point.



Integral logistic concept (Visser & van Goor, 2011) [modified]

Appendix B.2: Third Party Logistics (3PL) (section 2.2.3)

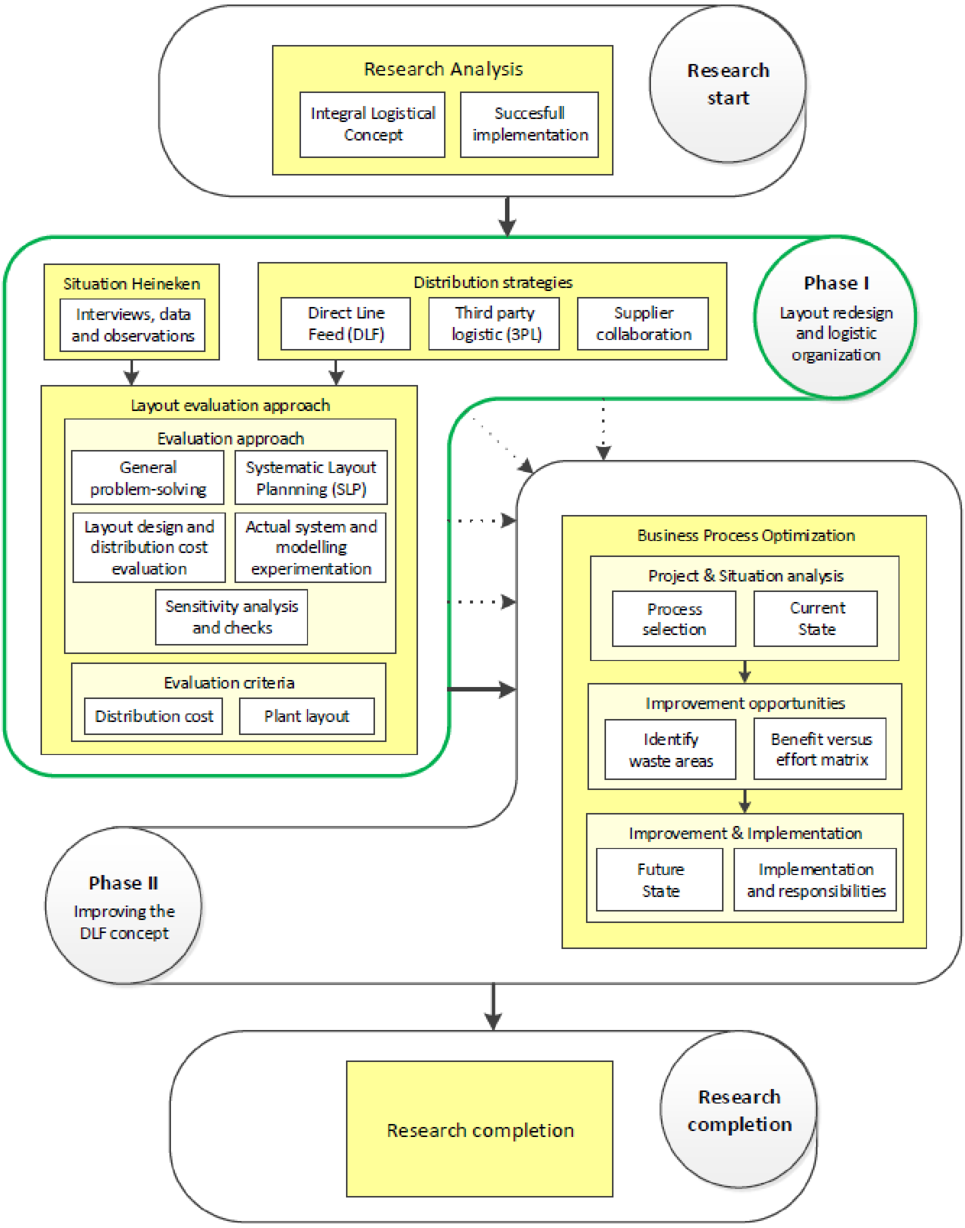
Till the 1980s outsourcing logistic activities did not exist, since organizations performed the logistical activities by themselves (1PL). In the years that followed this principle changed as organizations started to outsource the execution of logistic processes and the logistic assets (2PL). Later on also supply chain control and the control of the logistic processes turned out to be suitable for outsourcing, which resulted in the development of logistic service providers (3PL). Currently we see a development in this process where all logistic activities are outsourced to an external party, which includes the organization, tendering and evaluation of these processes (Visser & van Goor, 2011).

Outsourcing the distribution logistics has many potential benefits. According to Visser & van Goor (2011) the most important reasons are (1) concentration on the core business, (2) reduction of concerns, (3) financial benefits (e.g., shift from fixed to variable costs and thus lower investments) (4) higher quality in supply and (5) lower operational risks. The most obvious disadvantages of the use of 3PL is according to Simchi-Levi et al. (2008) the loss of control, which is inherent to outsourcing a particular function.

Cheong (2003) suggests that there are two main trends in logistic outsourcing: (1) an increase in the number of organizations that use logistic services and (2) an increase in the extent of the usage of these logistic services. As the idea of outsourcing logistics has been growing, the role of the 3PL organization within the supply chained changed along with it. Initially is was about offering transportation services, while 3PL nowadays offer a broad and integrated set of services including warehousing, inventory management, packaging, cross docking and technology management (Zacharia et al., 2011). The extent of usage increases in terms of the number of activities, the geographical coverage, the nature and length of the contract, the level of commitment and the percentage of total logistics budget allocated to 3PL organizations (Cheong, 2003).

Appendix B.3: Literature overview (Chapter 2 and 4)

This figure shows the theoretical process model, which is a visualization of the theories that we employ during the different phases of our research and shows the cohesiveness of these theories.



Appendix B.4: Supply Chain Collaboration theories (section 2.2)

Supply chain processes cope with the huge dilemma between efficient production, which requires stability, certainty and standardization, and the demand wishes of the customers, which show a dynamic, uncertain and diverse behaviour. To ensure that a manufacturer can fulfil an efficient supply of his customers the organization can keep large inventory levels. By doing so the manufacturer will be able to fulfil the demand of the customer at all times. The obvious downside however is that he will also face unnecessary high inventory levels and high production, logistic and inventory costs (van Amstel & van Goor, 2006).

In the early 1990s a collaborative initiative called Efficient Consumer Response (ECR) emerged in the Fast Moving Consumer Goods (FMCG) industries. The theory encourages organizations to shift from holding information internally to sharing it with others, developing meaningful relationships and searching for efficiency improvements that would deliver enhanced customer value (Whipple & Russel, 2007). The objective of ECR can be defined as working together to fulfil consumer wishes better, faster and at less costs (van Amstel & van Goor, 2006). Over the years the theory of ECR expanded and served as the fundament for additional collaborative approaches, which all share a common focus: enhancing supply chain integration through better information sharing. Collaborative supply chain initiatives gain attention based on the assumption that closer relationships and enhanced information sharing will improve the quality of decision making, reduce demand uncertainty and improve the overall supply chain performance. Here, improved supply chain performance includes increased sales, improved forecasts, increased accuracy of information, reduced costs, reduced inventory levels and improved customer service (Whipple & Russel, 2007).

While this research does not primary focus on the optimal way to organize the collaboration with the suppliers, understanding the bigger picture about supplier collaboration seems relevant for good decision making in this research. Therefore we briefly discuss some significant theories as Collaborative Planning, Forecasting and Replenishment (CPFR), Vendor Managed Inventory (VMI), synchronized production and Continuous Replenishment (CR).

Collaborative Planning, Forecasting and Replenishment (CPFR)

CPFR has the goal to increase the transparency of the supply chain by collaboration and exchange logistic information which enables organizations to align their logistic processes (van Amstel & van Goor, 2006). It has a focus on collaboration in the demand processes (e.g., demand forecasts and new product introductions) to enhance supply chain effectiveness as well as in the supply processes (e.g., production scheduling and truckload utilization) to increase supply chain efficiency. (Whipple & Russel, 2007). The CPFR approach consists of three components (van Amstel & van Goor, 2006; Whipple & Russel, 2007):

- Planning: consists of the processes and activities prior to the operational activities like the development of joint agreements and business plans for the coming year. A front-end planning document drives the process over a specific timeframe.
- Forecasting: consists of the process of demand and order forecast collaboration. The organizations may each create their own individual forecast or just one of the participants may develop the initial forecast. The forecast is reviewed jointly by each organization and any discrepancies are discussed and reconciled.
- Replenishment: involves the coordination, i.e.,, the collective generation of production orders and delivery schedules by exchanging significant information (e.g., stock details). Collective coordination on replenishment orders in accordance with the sales and order forecasts facilitates that a manufacturer knows in advance if orders cannot be filled and therefore future orders need to be reduced.

In general the manufacturer is provided with performance data and an activity report, which is reviewed daily as well as week-to-week, which makes it possible to analyses performance, look for exceptions and develop a plan for corrective action (Whipple & Russel, 2007). While CPFR support the complete logistic system, it is rarely implemented in full extent. Most of the time CPFR is only used for the planning and demand forecast processes (van Amstel & van Goor, 2006). Instead of implementing the CPFR across the entire business, organizations focus only on the areas that caused problems (Whipple & Russel, 2007).

Benefits from CPFR are reducing the out-of-stock risk, the inventory levels and the delivery times, increase the revenue, the forecast accuracy and the visibility in the supply chain, ease the control system and improve the relationships (van Amstel & van Goor, 2006; Whipple & Russel, 2007). An important barrier that is mentioned by Whipple & Russel (2007) is the difficulty of cross-functional integration. Another challenge they mention is the match (or mismatch) between the actual replenishment orders and the jointly determined sales forecast, since the sales forecast (triggered by demand planning) and the order forecast that generate supply replenishment (triggered via order placement) are two separate types of forecasts.

Vendor Managed Inventory (VMI)

In Vendor Managed Inventory systems the manufacturer controls the supply of the supply chain that follows (Hopp & Spearman, 2008), which means that the supplier is responsible for the inventory levels of the customer and therefore determines which products are supplied to the customer at what point in time (van Amstel & van Goor, 2006). A typical VMI relationship involves manufacturers and customers (e.g., retailer) who share demand and replenishment data via electronic exchange, which enables manufacturers to use this information to determine replenishment quantities and to generate purchase orders that are sent to these customers (Whipple & Russel, 2007).

The most important benefit of using this VMI technique is that in enables the organisations to pool inventory across levels which facilitates them to operate with substantially less inventory than is needed in uncoordinated supply chains (Hopp & Spearman, 2008). The manufacturer is giving more information than traditionally exchanged providing greater supply chain visibility. This enables each organization to eliminate problems, leading to cost reductions and improved in-stock performance. A drawback is that it is time consuming to set up and maintain the system due to the level of detail and the amount of data involved. There is a trade-off between data-intensive analysis and information that produces better decisions (Whipple & Russel, 2007).

Differences between VMI and CPFR (van Amstel & van Goor, 2006) *[modified]*

Differences between VMI and CPFR	
Vendor Managed Inventory (VMI)	Collaborative Planning, Forecasting and Replenishment
Plans of suppliers and manufactures are created and maintained separately, which means that all parts in the supply chain react in subsequent order	Plans of suppliers and manufactures are created and maintained jointly, which means that all parts in the supply chain react beforehand
Different demand and order forecasts for supplier and manufacturer	Different demand and order forecasts for supplier and manufacturer, which are shared to enhance collaboration between parts of the supply chain
Theory is limited to inventory control	Theory contains inventory control, logistic, sales, marketing and planning

Synchronized production and Continuous Replenishment (CR)

Besides CPFR and VMI there are more theories that support the idea of a more effective supply Chain. Two of the concepts are that are giving by van Amstel & van Goor (2006) are:

- Synchronized production: This concept is based on the idea that a production line that is perfectly synchronized, will produce exactly the amount that is needed to fulfil the need of the final customer. The manufacturer should create a production schedule which is based on the demand of the final (or an intermediate) customer. Traditional concept of production planning and control focuses on efficient production with maximization of the utilization of the own production process. While these goals seem logical, the concept of synchronized production suggests a focus on reactivity, flexibility and integration. The production processes should be organized in such a way that waste like waiting times, quality failure, wrong production layout and inefficient supply are minimized. An important benefit of this approach is that shorter cycle times can be obtained, which means that the manufacturer is less vulnerable for long term demand forecasts.
- Continuous Replenishment: In the concept of continuous replenishment the supply to customers occurs in small orders and as much as possible. The most important benefit of this concept is that the customer needs less inventory space while maintaining the own production or service level. An important requirement for this approach is that operations of the participating organizations should fit perfectly. Close communication needs to provide shorter cycle times and enhanced responsiveness.

Appendix B.5: Explanation of costs criteria remained unused (section 2.3)

In section 2.3.2 we mention the costs evaluation criteria mentioned by the literature. In this section we briefly explain which costs elements have not been taken into account in our research.

Inventory holding and warehousing costs

Storage is the physical stocking of goods while it is awaiting for demand (Kivinen & Lukka, 2004). According to Voordijk (2010) inventory costs are related to the number and locations of stock facilities and the safety stock kept, while warehousing costs are associated with the land and buildings. We address these subjects together, where inventory and warehousing costs comprise the storage space needed, costs of risk, the interest and opportunity costs, cost of obsoletes and the out of stock costs.

The storage space needed refers to the square meters used to store the materials or semi-finished products. These storage costs can include rent, depreciation and maintenance of the building (or other storage location) and storage shelves, electricity and heating. They vary largely with the number of different products (Wagner & Silveira-Camargos, 2011), the type of product, the type and location of the building and the storage location in the building (Visser & van Goor, 2011). These inventory costs could be calculated based on an average quantity of stock held per year expressed in euros per unit stock (Voordijk, 2010). The interest and opportunity costs refer to the benefit that the organization could have received by putting the money in the bank or investing it in the organization. Instead of holding inventory, the organization could free up these resources to the earn profit or interest (Visser & van Goor, 2011). Costs of obsoletes refers to the costs of products that cannot be sold anymore for a particular reason. An estimate of the obsolete costs can be done on the basis of historical data and experience (Voordijk, 2010). The out of stock costs refer to the costs that occur when an organization is not able to deliver (Visser & van Goor, 2011). In our project we could relate this to the consequences and costs that occur when the supply and the inventory, including safety stock, is not able to fulfil the replenishment of the production line.

While we found this in the literature we only took into account the costs of risk and damage into account in our research. We briefly explain why:

- Storage space needed: HEINEKEN wants a particular amount of bottles as safety stock closely to the premises of the brewery. This can either be on the Glasplein or in the H&B warehouse. While the new packaging line will result in more production during the weekdays (see Figure 3-2), we do not think that this will considerably increase the required safety stock. Furthermore we assume that the ratio between the safety stock kept in the warehouse and on the Glasplein will not differ much based on the chosen alternative. As explained in chapter 5 we do wonder if the safety stock of empty bottles currently held on both storage locations isn't quite high, but this should be investigated in another research. Obviously the inventory costs do exists, but in this research we assume that the inventory costs will not differ significantly between the alternatives. The only inventory costs that we do take into account are the costs for pallets that are transported via the warehouse in case of DLF supply, see Table 3-5. The reason for this is that these pallets are stored in the warehouse additionally during that week and are compensated with the next week (see chapter 5). Therefore we add storage costs of one week to all these pallets that are transported undesirably to the warehouse during the week.
- Interest and opportunity costs: Since HEINEKEN uses a general amount of empty bottles as safety stock in any case, these costs will not differ over the alternatives.
- Cost of obsoletes: The situation that bottles cannot be used anymore in the sense of obsoletes will not occur with universal packaging material like empty bottles.
- Out of stock costs: The safety stock used by HEINEKEN tries to prevent the situation (and costs) in which not enough bottles are available to supply the packaging lines. When this safety stock is kept high enough, the out of stock costs will not occur. When it does occur it would require some extra effort and/or transportation between the storage points or from somewhere else. Either way we assume that these costs do not differ significantly with the alternatives.

Others logistic cost elements

Prior to the processes of transportation, material handling and storing inventory the literature includes procurement, order processing and transaction and production planning and control to the distribution logistic process. Consequently the costs associated with these processes belong to the distribution logistic costs. While this is the case, we did not take these costs into account in phase I of our research. First of all because it does not seems likely that these costs differ (largely) between our alternatives and secondly because there is some time pressure on the decision making of phase I, resulting in the fact that these activities are not included in the scope of phase I. Below we explain these costs separately and in little more detail.

Transaction and order processing costs

These costs are related to procedures of data gathering and data processing and the administrative tasks associated with the processes of preparing, tracking, transporting, receiving, inspecting, storing and paying an order (Kivinen & Lukka, 2004; Visser & van Goor, 2011). While is seems reasonable to assume that these costs could differ slightly for the different scenarios, it does not seem plausible that these costs will differ significantly. Because we assume that these costs would not influence our final decision making and because it seems quite complicated to include all the little differences during the process in the OPEX calculations, we did not take the transaction and order processing cost into account.

Procurement and production planning and control costs

The procurement costs are related to the activities that ensure that de right quantities of products are made available at the right prices and for the right customer (Visser & van Goor, 2011). The cost of production planning and control are related to the activities required for the regulation and control of the production process. Thus the activities before the start of the production process itself (Visser & van Goor, 2011). This consists of all activities like capacity planning, resource planning, routing, production and supply scheduling and has the objective is to ensure that the products are at the production line at the agreed moment in time (Kivinen & Lukka, 2004). The process that comprises the planning and control activities at HEINEKEN is quite complex and needs to take into account a lot of aspects, where optimal DLF supply for the concerning DLF lines is just one of them (Stevens, 2016). In case of DLF supply for line 52, the planning process would have an additional line that should be supplied from the DLF locations as much as possible. Although it could lead to slightly more effort during the procurement and planning activities and thus lead to slightly higher costs, we do not expect substantial changes in the activities and thus assume that these cost differences are too small to influence the decision making process in phase I.

An interesting remark with regard to the procurement and production planning and control activities is that we expect quite some influence the other way around, when we would employ the DLF methodology. The way we arrange the activities, allocations and agreements in the procurement and planning process is very important for the performance of the DLF process. These activities determine which type of bottles are bought from which manufacturer in what quantity and brought to which brewery and which production line. Significant differences can be made here, since not every manufacturer is able to support the DLF process and not all production lines are supplied via the DLF process (Bos, 2016; Stevens, 2016).

Appendix C: Additional information related to the OPEX calculation model for line 52 and the associated input variables and parameters

This appendix discusses the calculation model and the input variables and parameters of the calculations model in further detail. In the title is indicated which section it supports.

Appendix C.1: Estimation of the bottle division (section 3.1.1)

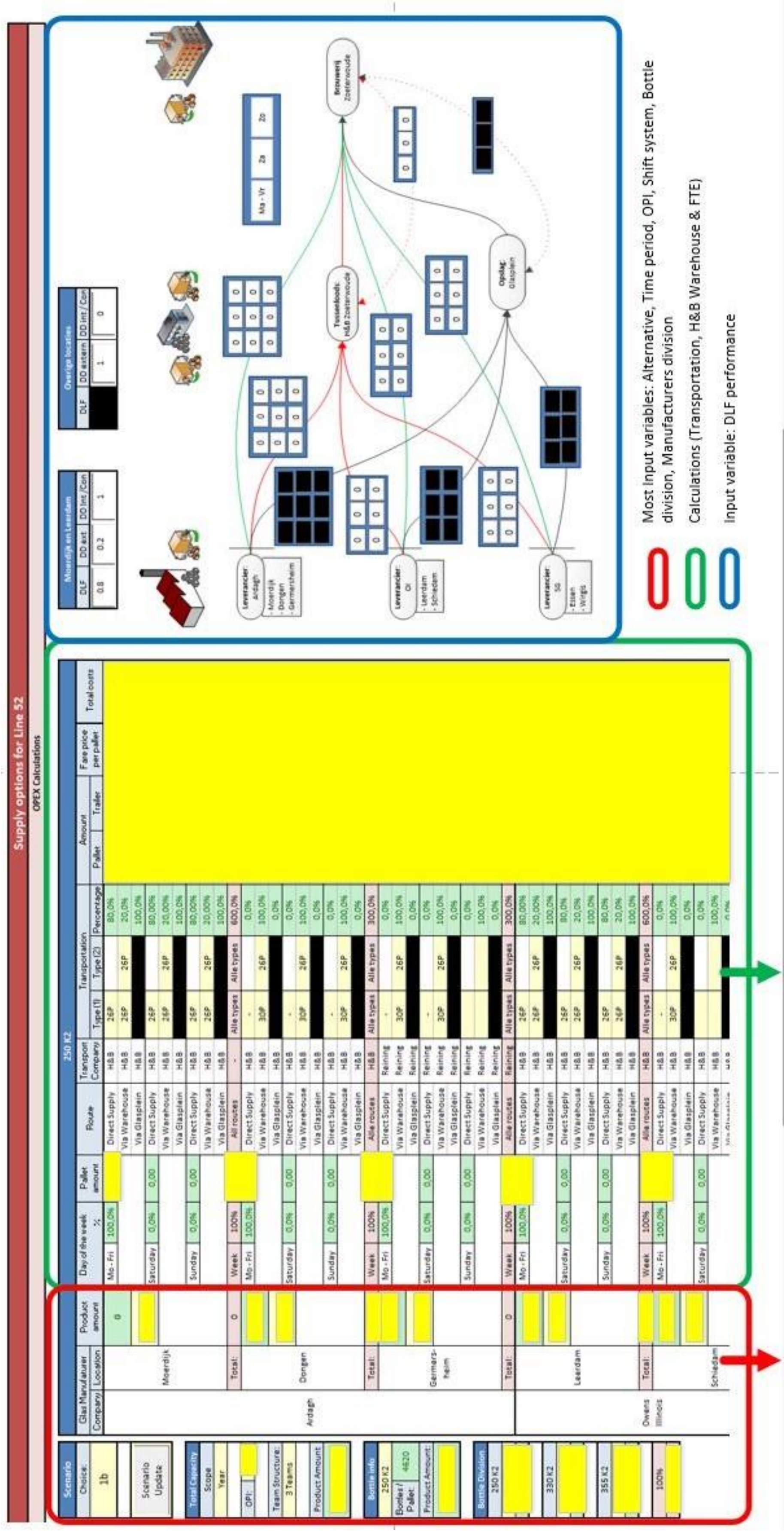
The packaging line will produce three types of bottles, 250K2, 330K2 and 355K2, with an estimation of the production ratio of respectively X%, X% and X%. Furthermore we assume that the bottle allocations of 2015 and 2016 are quite representative for the situation in 2017, but that the allocation for the bottles could be done little more efficiently than in the division of 2015, because of the addition of Leerdam in 2016. During the allocation negotiations for 2016 the addition of Leerdam was already known at HEINEKEN, so we assume that this has been taken into account in the allocation agreements already. With this knowledge, we have created and reviewed several production data and allocation overviews of 2015 and 2016 and created an expected bottle division for production line 52 in 2017. The overview of the estimation for 2017 is shown in Table 3-4A. The created and reviewed data overviews to support this estimation are shown below.

- Bottle manufacturing allocation for 2016: An overview of the production allocation agreements with the bottle manufacturers for 2016. This is an overview of the bottle allocation made in 2015 for Heineken Netherlands, which means that is consists of the agreements for the complete bottles manufacturing allocation for all one-way bottle lines of Zoeterwoude and Den Bosch.
- The bottles manufacturing division in 2015: An overview of the real data from 2015 concerning the bottles volume of the four one-way bottles lines at HEINEKEN that has been manufactured by the different production facilities.
- The bottle division between the breweries in 2015: An overview of the real data from 2015 concerning the total bottle division between the breweries of Den Bosch and Zoeterwoude for the bottle types 250K2, 330K2 and 355K2.

Manufacturers facilities		Bottle division of all one-way	Bottle allocation for all one-way
355 K2			
Ardagh	Moerdijk		
	Dongen		
Owens Illinois	Leerdam		
330 K2			
Ardagh	Moerdijk		
	Dongen		
Owens Illinois	Leerdam		
	Schiedam		
Saint Gobain	Essen		
	Wirgis	Confidential	
250 K2			
Ardagh	Moerdijk		
	Dongen		
	Germersheim		
Owens Illinois	Leerdam		
	Wingles		
	Essen		
Saint Gobain	Wirgis		

Production division over the breweries (Data 2015)			
From location to Den Bosch	355K2	330K2	250K2
Moerdijk (115075)			
Leerdam/Schiedam (115071)			
From location to Zoeterwoude	355K2	Confidential 330K2	250K2
Moerdijk (115075)			
Leerdam/Schiedam (115071)			

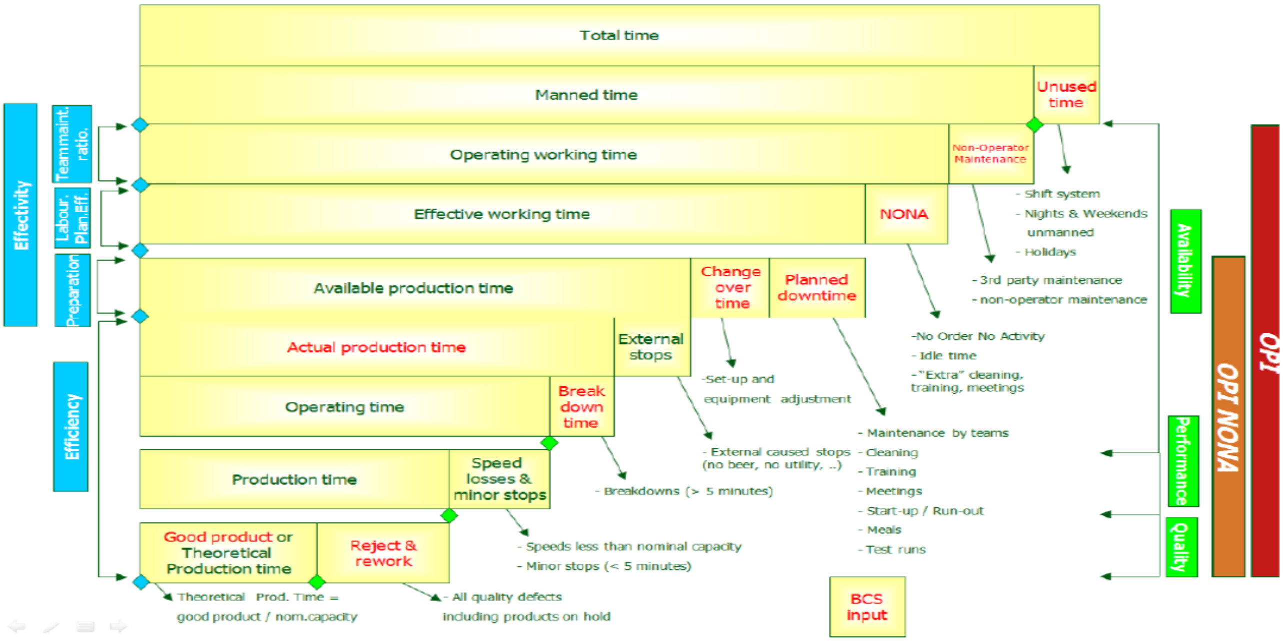
Appendix C.2: Overview of the calculation model used for line 52 (section 3.3.2)



Appendix C.3: OPI explanations (section 3.3.2)

In the following figure the different OPI, OPI NONA and efficiency calculations used at HEINEKEN are visualized. At HEINEKEN most of the time the OPI NONA is used. The reason for this is that perception prevails at HEINEKEN that it facilitates better insight in the performance of the line. The time periods where the production line is unused because of revision or because there are no orders planned, does not say much about the real performance of the packaging lines and the teams responsible for it.

For our research however, we want an as accurate as possible estimation of the 'normal' OPI, since we want insight in the real amount of bottles that will need to be transported. We know the ideal production volume of the line and want to derive an estimation of the real production volume, so that we can calculate and estimate the logistic costs of the different alternative scenarios in phase I.



One of the methods to calculate the OPI is:

OPI = Availability * Performance * Quality

Another method is via the formula below, which is the formula that we use.

OPI = Efficiency * Effectivity

X % * X % = X %

In this calculation the efficiency is based on data obtained via R. van Oost (2016). The effectivity is partly based on the same data and partly on estimations of R. van Oost (2016). The X% is based on the obtained data, whereas the X% is based on estimations. The estimation is that X week will get lost by revision (i.e., non operator maintenance) and X week because of exceptional stopping days that fall into the NONA category according to R. van Oost (2016).

Effectivity = X % * X % = X %

Efficiency = X %

The estimations and calculations on the data of R. van Oost (2016) give us the following OPI NONA, which is almost the same as the expectation done by I. Schrama (2016).

OPI NONA = Efficiency * Preparation ratio

= X % * X % = X %

Appendix C.4: Variables and parameters of the calculation model (section 3.3.2)

In this appendix we explain the different user input variables and parameters that are incorporated in the calculation model.

User input variables of calculation model

The logistic system related to the bottle supply of the packaging line 52 consists of many different (costs) elements, with several underlying input variables. We briefly discuss the relevant input variables, which we incorporated in our calculation model.

1) Alternative and transport modes:
   The first selection in the model is obviously the alternative that we want to evaluate. Which alternative we select will automatically change the transport modes related to the different scenarios. These transport modes can be changed manually as well when that is desired.
2) Time period of production (X_o):
   The model offers the option to select 'Week' or 'Year", which calculates with respectively 1 and X weeks. The estimation of X weeks is based upon X week that will get lost by revision and X week because of exceptional stopping days. These downtimes are not included in the OPI NONA used at HEINEKEN and are therefore added separately.
3) Estimated OPI of line 52 (G):
   The model offers the option to select a particular OPI percentage ranges from 0% - 100%. Since we already incorporated the X weeks of downtime above, we should select the OPI NONA estimation of X%. A more comprehensive explanation in given in appendix B.
4) Shift system (S_e and D_w):
   As explained in section 3.1.3 HEINEKEN uses multiple shift systems. The model offers the option to select the 3 shift (i.e., 5 days production) and 5 shift (i.e., 7 days production) system. This respectively corresponds with 120 and 168 working hours per week (S_e). It also responds to the spreading over the days of the week (D_w), since it implies when the supply is carried out.
5) Bottle division (B_x):
   The model offers the option of selecting the expected bottles division between the three bottles types 250K2, 330K2 and 355K2. As explained in section 3.1.3 we used the given estimation of respectively X%, X% and X%.
6) Manufacturers facility division (F_y):
   As explained in section 3.1.3 the bottles are manufactured by different manufacturers' facilities. We used the estimation of the facility division as shown in Table 3-4A, which is based on the overviews shown in appendix C.
7) DLF performance in percentage (T):
   As explained earlier the DLF performance indicates the percentage of supply volume that have been supplied via the DLF method, i.e., which has been transported directly and did not need to use the intermediate warehouse, relative to the total supply of empty bottles to that packaging line. This is only relevant for the DLF alternative. The models offers the option to insert separate DLF percentages from the different DLF locations or to use a universal percentage for all DLF locations. As explained in section 3.4.2, the estimation of the DLF percentage for line 52 is very difficult to estimate, which is the reason that we analysed the whole range from 0% - 100% DLF supply (i.e., 100% - 0% via DD and thus via the warehouse).

Parameters of calculation model

The input parameters that are incorporated in the model is the data that is currently used at HEINEKEN. We briefly discuss the parameters related to:

1) Production Capacity (L):

The production line will be equipped with two filler than both can fill approximately X bottles per hour in optimal circumstances. Since the fillers are supplied such that they are the bottle neck, the maximum capacity of lines 52 is X bottles an hour.

2) Transport prices:
   a. Transport prices ($R_{jyw)}$):
      Hartog & Bikker and Reining, two 3PL organisations for HEINEKEN, use different prices for the transport from different locations, with the different transport modes on the different days of the week. The prices used are shown in appendix E. Whether the pallets need to be transported to the warehouse or to the brewery does not matter, the prices are the same.
   b. H&B price (H):
      When the use of the warehouse of H&B is required, because direct supply is impossible, H&B charges a universal price as shown in Table 3-5.
3) Bottle and pallet amount:
   a. Pallets amount per transport mode (Q_j):
      The amount of pallets that fit in a vehicle differs per transport mode. A DLF trailer contains 26 pallets, a Combi truck contains 30 pallets and a LZV truck contains 42 pallets. As shown in the calculations of Figure 3-13 as well, the conventional transport is done by Combi and LZV trucks. In consultation with HEINEKEN we estimated the division between these two transported modes to be respectively 25% and 75%.
   b. Bottles per pallet (N_x):
      The amount of bottles per pallet differ for each bottle type. The pallets with the bottle types 250K2, 330K2 and 355K2 consist respectively of 4620, 3800 and 3610 bottles per pallet.
4) Material handling (see also appendix F):
   a. Activity durations (S_a and K_a)
      As suggested in 3.3.1 already and shown in Figure 3-14, the activities, the duration of these activities (S_a) and the amount of pallets per activity (K_a) differ between the alternatives. In appendix F an overview is given.
   b. FTE costs (C):
      HEINEKEN uses €X per year as the FTE cost per logistic employee, concerned with the material handling.
   c. Effective hours (E):
      HEINEKEN uses X hours as effective hour estimation per shift (of 8 hours) per logistic employee. A year contains X effective hours.
   d. Inefficiency ratio (M_u and Z):
      Besides the effective hours HEINEKEN uses two more inefficiencies in the workflow calculations. First it uses an inefficiency factor in the material handling proceedings of the employees (M_u), which is set on X. Second it uses a TARA (N), which is an inefficiency factor with regard to the presence of employees (e.g., illness) and for which the value X is used.

Appendix C.5: Transport prices used in the calculation model (section 3.3.2)

Transport prices										
Transport Company	Glas manufacturer Name	Location	Day of the week	From Location to Zoeterwoude DLF (26P)		Combi / LZV	Combi (30P)		LZV (42P)	
Hartog & Bikker	Ardagh	Moerdijk	Mon - Fri							
			Sat							
			Sun							
		Dongen	Mon - Fri							
			Sat							
			Sun							
	Owens Illinois	Leerdam	Mon - Fri							
			Sat							
			Sun							
		Wingles	Mon - Fri							
			Sat							
			Sun							
		Schiedam	Mon - Fri							
			Sat							
			Sun							
	Hartog & Bikker	Warehouse Zoeterwoude	Mon - Fri							
			Sat				Confidential			
			Sun							
Reining	Ardagh	Obernkirchen	Mon - Fri							
			Sat							
			Sun							
		Germersheim	Mon - Fri							
			Sat							
			Sun							
	Verallia	Essen	Mon - Fri							
			Sat							
			Sun							
		Wirges	Mon - Fri							
			Sat							
			Sun							
		Bad Wurzenbach	Mon - Fri							
			Sat							
			Sun							

Appendix C.6: Material handling data used in the calculations (section 3.3.2)

Pallet handeling activities					
Product type	Handling (activity) From (Start)	To (Finish)	# Pallets per activity	Time spend Duration	Unit
Bottles	Unload pallet from truck	To Glasplein			Minutes
	Place pallet from Glasplein	On buiscar			Minutes
	Load pallet from buiscar	To production line	Confidential		Minutes
	Shuttle buiscar between Glasplein and production line				Minutes
Cans	Unload pallet from truck	To in buffer storage			Minutes
	Load pallet from storage	To production line			Minutes

Related values	
FTE costs (loan) per year	
FTE costs (loan) per week	
Effective working hours per FTE per shift	
Effective working hours per FTE per week (5 days)	Confidential
Effective working hours per FTE per year	
Expected inefficiency (based on other 4 lines)	
Tara (Extra FTE needed: e.g. illness)	