2015

Designing a storage capacity plan for Roerink Food family

<u>Confidential</u>

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Roerink Food Famliy

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Preface

Before you lies the report of my master thesis project at Roerink Food family. This project was conducted from April 2015 until November 2015. The aim of this project was designing a storage capacity plan for Roerink Food Family under different future growth scenarios. Finishing this project means that I receive my master's degree in Industrial Engineering and Management at the University of Twente.

I thank Koen de Haan, my external supervisor, for giving me the opportunity to do this project at Roerink Food Family. The fact that my recommendations will be used for future strategic decisions regarding the decision for a warehouse location, makes me proud.

I also thank Peter Schuur my first supervisor, from the University of Twente, for giving me valuable feedback for writing this thesis. For his involvement I also thank Henk Kroon, my second supervisor, from the University of Twente.

And finally of course I want to thank my family and friends for their support and encouragement during my study and graduation.

- Daniëlle Kootstra, Hengelo, November 2015

Management summary

This report is the end result of the research which was performed to complete the author's master study Industrial Engineering and Management at the University of Twente. The research was conducted at Roerink Food Family. The performed research gives an answer on

"What should be the storage capacity plan for the Roerink Food family for different scenarios of future growth?"

Problem statement

The Roerink food family started their business as a small farm store under the name of Zuivelhoeve in 1981 in Enschede, where they sold self-made desserts, and other dairy products. From this small farm store the company has grown to a medium-sized family business with five subsidiaries: Zuivelhoeve Vers, Van der Poel Desserts, Heks'nKaas, Happy Goat and Zuivelhoeve retail chain. In all those years of growth, increasing and optimizing the production had priority. But to keep handling this growth also warehousing & logistics should have priority.

What raises questions to the company are the multiple locations where products for Zuivelhoeve Vers are stored and the corresponding internal inventory movements. Also the complete separation of Van der Poel Desserts' logistics and warehousing from the other subsidiaries is undesirable.

Therefore for these two subsidiaries we looked at what the possible alternative scenarios for the warehousing and associated logistics are and how well they do compared to the current situation. This has be done for the current stock levels and under different future growth scenarios.

We compared the alternative scenarios with the current situation based on the operational costs per year, these are the total costs for storage and (internal) transport in a year.

Current stock levels

The scenarios that were investigated are, a warehouse for Van der Poel Desserts in Raalte (scenario 1), a warehouse for Van der Poel Desserts in Hengelo (scenario 2) and a warehouse for Zuivelhoeve Vers in Twekkelo (scenario 3). Next two these scenarios, also for both subsidiaries we determined what the optimal location for the warehouse would be based on the transport streams , by applying the successive approximation method for Euclidean distances and the exact method for Manhattan distances. Surprisingly for Van der Poel Desserts, the optimal locations found using these two methods are the same as the locations in scenario 2 (Hengelo) and for Zuivelhoeve Vers this was the same location as the location in scenario 3(Twekkelo).

When comparing the operational costs per year for the alternative scenarios with the current situation under the current stock levels, we saw that Raalte is the most profitable location for both subsidiaries. Van der Poel Desserts has operational costs of €552,696.44 in this situation versus € 824,902.09 in the current situation. For Zuivelhoeve Vers this means that the warehouse of the current situation (€1,919,117.70) is better than the alternative scenario in Twekkelo (€ 2,051,213.79). But in the current situation there was also storage in Oldenzaal, which is undesirable, therefore storage of Zuivelhoeve Vers in Oldenzaal should move also to Raalte in this situation.

Future stock levels

Next to what the optimal location for a warehouse would be under the current stock levels, Roerink Food family also wanted to know what the best option would be in the future (3-years from now). The stock levels of Van der Poel Desserts and Zuivelhoeve Vers have therefore been forecasted, using the long-term forecasting model " forecasting by decomposition".

These stock levels have been forecasted for three different future growth scenarios, 10%, 30% and 50% growth with compared with the stock levels of 2014.

To determine the optimal location for a warehouse under these different future growth ratios, we formulated an ILP-model both for Zuivelhoeve Vers and Van der Poel Desserts. In this integer linear programming model the future stock levels, transport costs to each group of customers, internal transport costs and storage costs can be inserted. The output of the LP-model gives the operational costs as objective and indicates where the goods should be stored every week of the year. In the integer linear programming model we also inserted renting storage space as an extra storage option, This is done in case that if in just a few weeks of the year the capacity level of a warehouse is exceeded. By using this model, we came to the following conclusions regarding the optimal location for a warehouse under the different future growth scenarios:

Van der Poel Desserts:

- **10% growth ratio**: Expand the warehouse in Raalte (scenario 2), so that goods of Van der Poel Desserts can be stored here. Operational costs per year are: €533,616.59
- **30% growth ratio**: the optimal location for a warehouse under this growth ratio is also in Raalte. In the (few) weeks that the capacity is exceeded, extra storage space should be rented. Operational costs per year are: €610,294.75.

Zuivelhoeve Vers

- **10% growth ratio:** Optimal location for the warehouse is in Raalte. When the capacity level is exceeded, part of the expansion of the warehous in Raalte that is actually to be used by Van der Poel Desserts can also be used by Zuivelhoeve Vers. This is only possible if the expected growth ratio of Van der Poel Desserts is not more than 30 %. Operational costs per year are: €2,273,034.86
- **30 % growth ratio:** Optimal location for the warehouse is in Raalte. When the capacity level is exceeded, part of the expansion of the warehous in Raalte that is actually to be used by Van der Poel Desserts can also be used by

Zuivelhoeve Vers. This is only possible if the expected growth ratio of Van der Poel Desserts is not more than 30 %. In the weeks that the capacity is still exceeded, extra storage space should be rented. Operational costs per year are: € 2,734,068.12

50% growth ratio: When for one of the subsidiaries it is expected that the stock levels will grow with 50% with respect to the stock levels of 2014, only one subsidiary can stay using he warehouse in Raalte. For the other subsidiary the second best location should be used. This means there are two options:

1. Zuivelhoeve Vers will stay using the warehouse in Raalte and gets the storage space that was dedicated to Van der Poel Desserts, this leads to €2,727,435.08 as operational costs for Zuivelhoeve Vers in this option. For Van der Poel desserts the most profitable alternative location has to be used, this is building a warehouse in Hengelo, this leads to €1,011,659.18 as operational costs for Van der Poel Desserts in this option. Together for both subsidiaries the total operational costs are: € 3,739,094.26.
2. Van der Poel Desserts will stay using the warehouse in Raalte and gets the storage space that was dedicated to Zuivelhoeve Vers, this leads to € 707,601.54 as operational costs for Van der Poel Desserts in this option. For Zuivelhoeve Vers the most profitable alternative location has to be used, this is building a warehouse in Twekkelo, this lead to € 2,985,351.22 as operational costs for Zuivelhoeve Vers in this option.Together for both subsidiaries the total operational costs are: € 3,692,952.76.

Option 2 is cheaper, but involves more changes for Roerink Food Family with respect to the current situation. Therefore a trade-off has to be made by the management between the amount of changes and the costs involved.

<u>Recommendations</u>
We recommend to the company, in the coming year, to expand the warehouse in Raalte. In this way both companies can use this location for their warehouse.
The warehouse of Zuivelhoeve Vers was already located in Raalte, only the raw materials/packaging that were stored in Oldenzaal have to be moved to Raalte . This has to be done as soon as possible.
The warehouse of Van der Poel Desserts is now located in Holten, to move all storage at once to Raalte would be unwise. First the raw materials/ packaging should be moved to the warehouse in Raalte. This is also to gain insight in how well the warehouse in Raalte works out for Van der Poel Desserts.
When the company is positive about using the warehouse in Raalte for raw materials/ packaging also storage of the end products can be moved to Raalte. During this period it is necessary to monitor the stock levels and to make new future predictions for both subsidiaries. When the stock levels are expected to grow not

more than 30% (compared with stock levels of 2014) in 3 years from that moment, the warehouse in Raalte can still be used for both subsidiaries.
But when the stock levels are expected to grow more than 30% in 3 years from that moment, it has to be decided, for which subsidiary the storage has to move to another location, since the capacity in Raalte will become too small to store goods for both subsidiaries.
My advice is to stay using the warehouse in Raalte for Van der Poel Desserts and build a warehouse in Twekkelo to store the goods for Zuivelhoeve Vers. When looking at the costs this is not only the better option, also when looking at the changes involved there is no longer a preference for keeping the warehouse of Zuivelhoeve Vers in Raalte. This is because both subsidiaries were already located in Raalte and the storage of Van der Poel Desserts has already moved once to another location (from Holten to Raalte). When moving this again for Van der Poel Desserts, it involves again more changes for Van der Poel Desserts.

Contents

List of Abbreviations

BE	Belgium
CE	Contained element
DE	Germany
GMEA	Geometric mean absolute deviation
GMRAE	Geometric mean relative absolute error
HE	Holder element
HK	Heks'nKaas
HG	Happy Goat
ILP	Integer Linear Programming
MAD	Mean absolute deviation
MAPE	Mean absolute percentage error
MASE	Mean absolute squared error
MdRAE	Median relative absolute error
MSE	Mean squared error
MFFF	Muller Fresh Food Logistics
NL	The Netherlands
OC	Operational costs
PP	Pallet places
VDP Desserts	Van der Poel Desserts
ZVH Vers	Zuivelhoeve Vers

1 Introduction

In the framework of completing my Master Industrial Engineering and Management at University of Twente, I perform a research at Roerink Food Family. The goal of this research is defining a reliable storage capacity plan for Roerink Food Family.
Storage capacity planning is a part of supply chain management. The supply chain plays an important role in a company's cost structure and profitability. Compared to other business parts, a supply chains may look simple, even though they are not. In supply chains it often is the case; we can improve by keep digging further in the data. In nowadays competitive market, supply chain practice has even become more complex. There is an increasing number of products, more suppliers/buyers, an increasing capacity for production is needed, and an increasing capacity for storage capacity is needed. All these aspects lead to companies constantly having to improve their supply chain to stay up with the constantly changing market demand and their competitors.
Supply chain excellence aims at maximizing customer value at the most effective & efficient ways possible. Having a sound storage capacity plan can contribute in gaining supply chain excellence. Storage capacity planning is the activity of planning how much storage capacity is needed and where stock keeping units (SKUs) should be stored. Finding such a storage capacity plan, is not a simple process. A lot of variables and aspects have to be carefully taken into account.

2 Research Background and Design

This chapter introduces the purpose of the research. This means that a short introduction to the Roerink food family is given in section 2.1. In section 2.2 the description of the problem follows and in sections 2.3-2.6 an explanation of the research design is given, which includes, the goal of the research, the research question and the deliverables. At last in paragraph 2.7 an outline of this report will be given including the approach for the research.

2.1 Company background

The company background description is split into two parts. The first part contains general information about the Roerink Food Family. The second part is about the context in which the research will take place.

2.1.1 Roerink Food Family

The Roerink food family started their business as a small farm store in 1981 in Enschede, where they sold self-made desserts, and other dairy products. The products were such a success that by 1995, under the name of the Zuivelhoeve, the products that were sold in this small farm store, could also be found in the shelves of all retailers and the small farm store had grown to a retail chain of 35 stores.
Nowadays the Roerink Food Family has grown to a medium-sized family business with approximately 200 employees and an average turnover of 55 million euros per year. Thereby the family business has expanded, and now consists of five subsidiaries:

- **Zuivelhoeve Vers, located in Twekkelo**
  - Producer of Fresh yoghurt and Custard
  - Also sold in Belgium, Germany and England
- Zuivelhoeve Retail chain
  - 35 stores where cheese, nuts, meat, convenience and dairy products are sold
- Heks'nKaas – owner since 2011, located in Oldenzaal
  - Producer of spread, based on cream cheese
- **Van der Poel Desserts – owner since 2014, located in Hengelo**
  - Producer of exclusive ice products
- Happy Goat – since 2014, located in Oldenzaal
  - Producer of fresh biological goat cheese products
  - Production of goat cheese products has not started yet.

Besides these locations in Oldenzaal, Twekkelo and Hengelo for production of the five subsidiaries. The Zuivelhoeve has an external location for storage in Raalte.
An overview of all the locations is given in figure 2.1. As can be seen all production and

warehouse sites are located in the East of the Netherlands.

Figure 2-1 overview Locations Roerink Food Family

Through all those expansions, the company's passion remained the same; to make your daily eating moment, payable and special, with an eye for the well-being of humans, animals and the environment.

Quality and service management are of paramount importance for the company. To show the company's commitment to those two aspects, the Roerink Food Family has obtained several certificates (IFS, GMP+ and SKAL) for among others food quality and safety.

2.1.2 Warehousing & Internal Logistic streams at the Roerink Food family

As was mentioned in the general information about the Roerink Food Family, the company has grown a lot and expanded into having five subsidiaries. These five subsidiaries are still making a progressive growth in demand. In all those years of growth, the focus at all locations was on production. Logistics and warehousing were subordinate. But to be able to keep handling the growth in demand, warehousing and (internal) logistics itself should also be optimized.

In this section an overview is given of all production sites, starting with the subsidiary the Roerink Food family began with, the Zuivelhoeve, followed by Heks'nKaas & Lingehof and Van der Poel. For every site the related problems are explained and at last the research motivation will be given.

Zuivelhoeve Vers (Twekkelo)

In Twekkelo dairy products, like custard and yoghurt for the subsidiary Zuivelhoeve Vers are produced.

Since the beginning the production of Zuivelhoeve Vers has remained in Twekkelo, which means that the facility is operative for almost 30 years. Still Zuivelhoeve Vers produces its dairy products at this location, but when the company started to grow, the storage capacity at this site became too small. So over the years the company decided to expand and have an external location for storage capacity in Raalte.

In Raalte the end-products of the Zuivelhoeve, a small amount of packaging as well as bavarois and end-products for the Zuivelhoeve Retail Chain are stored. Which means that there is ambient (dry, 10-20°C), cold(-18°C)and refrigerated(0-6°C) storage at this warehouse.

Besides this location in Raalte for extra storage capacity, the location in Oldenzaal is also for ¾ in use by the Zuivelhoeve for storing packaging and raw materials. The result of this construction is that every day internal inventory movements take place between the locations.

Because of the still ongoing growth and the undesirable internal inventory movements, the company is planning to build extra storage capacity next to this production site in Twekkelo.

Planning

Rough production schedules are planned for several weeks ahead, based on historical demand data, intuition and common sense. Usually at the beginning of a week the production schedule for that week is adjusted to the latest changes in demand. Based on the week planning, raw materials and packaging can be ordered and scheduled for internal transport from the storage locations in Oldenzaal or Raalte. Also milk can be ordered, which must be delivered fresh every day.

A planner starts his/her day by checking the stock and actual sales of the previous day, this will be updated in excel. All changes in stock at a certain location at any point in time must be entered in the MRP system, so that the stock level can be easily checked. After updating Excel, the planning for the next day will be checked and work orders will be made in the MRP system. During the day the planner checks also if the work orders for that day are still going according to plan and adjusts them as necessary. So even on a daily basis the production schedule still can change. This can for example be due to a lack of certain raw materials, or a break down in the machine.

Production

Production starts at the milk receipt, where every day fresh milk is delivered. Then it goes to the (for-)factory where the products (custard, yogurt et.) are produced. When production is finished it goes to packing (see also Appendix A for overview of the location). Once the products are packed, the finished products are stored in the stockroom in Twekkelo. The distribution from the stockroom in Twekkelo to the warehouse in Raalte takes place multiple times a day. Custard can be transported directly after production, Yoghurt must

stay 24 hours in the stockroom to cool down before it can be transported to the warehouse in Raalte.
When there is an incoming sales order, the order is picked by the first expired first out dispatching rule in Raalte. After picking, the products can be delivered to the customer.
The distribution of the products between, Raalte- Twekkelo and Raalte- Customer is outsourced to a company called Nagel.

External Location Raalte, warehouse
As already explained in this section, in Raalte there is an external location for storage. Here the end products and packaging of the Zuivelhoeve Vers are stored as well as the products for the Zuivelhoeve retail chain and bavarois (produced and delivered by external suppliers). So there is cold, refrigerated and ambient storage. In Raalte there is also space for repacking desserts. Repacking desserts is the activity of combining different flavors of desserts in one carton(for example for Lidl). For an overview of this location, a rough picture of the floor plan can be seen in appendix A.
The warehouse in Raalte is located very close to the distributor, the distributor is located 100m behind the warehouse. Which is beneficial, because the distributor can transport the products directly from the warehouse in Raalte to the customer.

Heks'nKaas (Oldenzaal)
In 2011 the recipe for Heks'nkaas was bought, this is a recipe for spread, based on cream cheese. Since the production of Heks'nkaas started in 2012 in Oldenzaal, it has been and still is a success.
Production planning for all subsidiaries is decentralized, which means that every subsidiary has its own planner. However production planning at Heks'nKaas is done in the same manner as the production planning for Zuivelhoeve Vers, so rough production schedules are planned for several weeks ahead. And in the week of the production itself planners often adjust the production schedule based on latest demand information. In the planning process both subsidiaries use the same MRP system.
All raw materials, packaging and end products for Heks'nkaas are stored in Oldenzaal.
Once production is finished and there is an incoming order, the orders are picked, and transported via the distributor (Nagel Raalte) to the customer. The distribution of the end-products to the customer is outsourced to the same company as the company that does the distribution for Zuivelhoeve products.

Happy Goat (Oldenzaal)
The production of Happy Goat(producer of fresh goat cheese products) still has to start in Oldenzaal, but has to be taken into account when looking at the storage capacity available for every subsidiary. Now ¾ of the storage capacity in Oldenzaal is occupied by the Zuivelhoeve. Once the production of Happy Goat starts also all raw materials and end-products for Happy Goat have to be stored in Oldenzaal, so packaging and raw materials of Zuivelhoeve Vers cannot be stored there anymore.

Van der Poel Desserts (Hengelo)

Added as latest subsidiary to the Roerink Food Family is van der Poel desserts. Van der Poel is since the end of 2014 part of the Roerink Food Family, but it has existed since 1925 and it is known for its ice and desserts. Over the years Van der Poel Desserts has become an international organization.

Because of the fact that Van der Poel Desserts was an already existing organization, it has its own MRP system, different from the MRP system that is used for Heks'nKaas and the Zuivelhoeve. Also van der Poel has its own logistics partner (Müller Fresh Food Logistics (MFFF), located in Holten). In addition, storage space is rented from Müller in Holten, because in Hengelo the storage capacity is very limited.

External Location Holten

As already pointed out in this part, external storage space for Van der Poel Desserts is rented in Holten. At this location all end products, raw materials and packaging of Van der Poel Desserts are stored.

When raw materials and packaging are ordered, these are first delivered in Holten. If the raw materials and packaging are needed for production in Hengelo, these have to be transported from Holten to Hengelo. And vice versa once production is finished in Hengelo, end products have to be transported from Hengelo to Holten. From there the end products can be delivered to the customer.

Stock levels in Holten have been investigated last year, after the investigation it was concluded that there was a lot of unnecessary stock and stock levels have been reduced greatly.

Summary of the locations and the (internal) movement

To give a quick overview of what happens at which location, in figure 2-2 an overview is given of the different locations and the movements that take place.

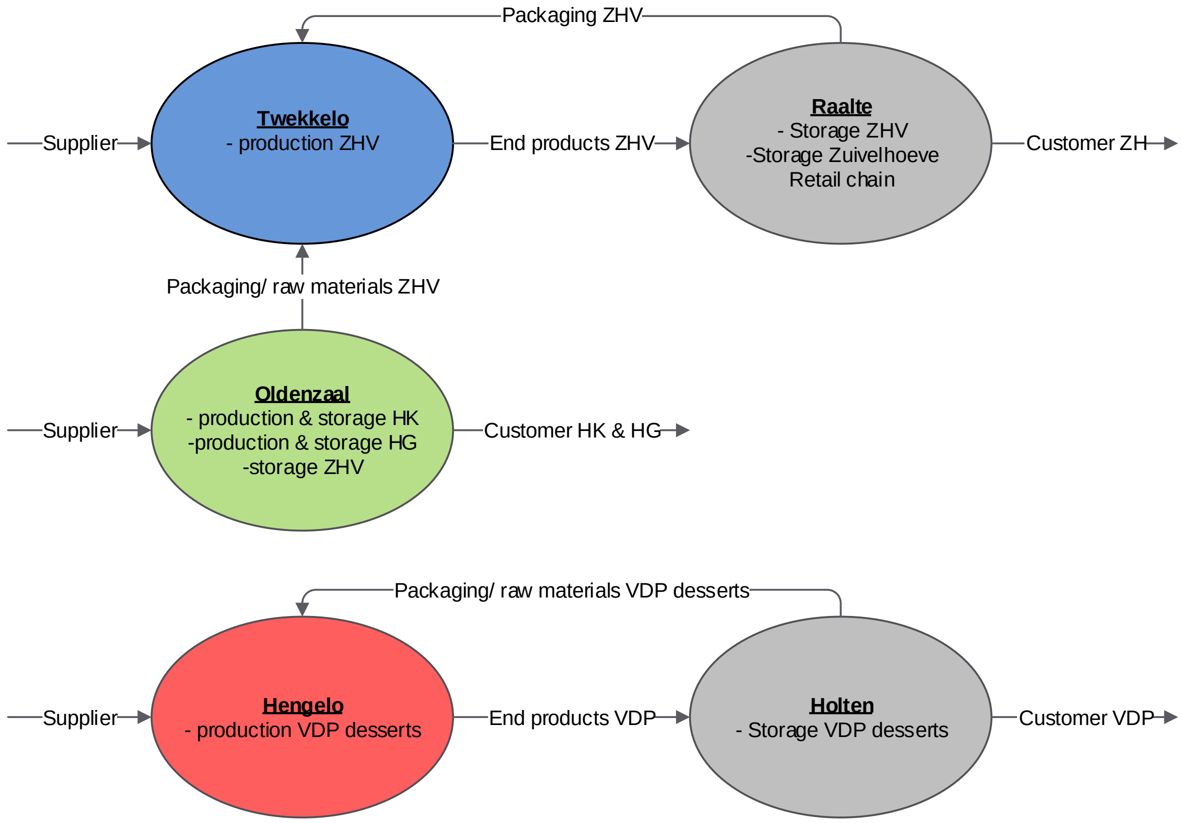


Figure 2-2 overview locations Roerink Food Family

2.1.3 External Logistics – Suppliers & Customers

In figure 2-2, two logistical streams are drawn that have not been discussed yet. These are movements from the supplier to subsidiaries of Roerink Food Family and movements from the subsidiaries to the customer. In this section first the "supplier stream" is explained and then the "customer stream".

Suppliers

The three production subsidiaries (Zuivelhoeve Vers, Heks'nKaas and Van der Poel), have suppliers for all their raw materials and packaging.
Zuivelhoeve Vers and Van der Poel Desserts also have suppliers for some of their end products, like for example the bavarois for Zuivelhoeve Vers.
Next to these, products for Zuivelhoeve Retail Chain, like nuts and cheese also come from a supplier.
Since all those goods have to be transported from the location of the supplier to the to the location of the subsidiary where it should be stored, costs are involved for the distribution. These costs are usually included in the costs price of the goods.

Customers

Customers of Zuivelhoeve Vers and Heks'nkaas are generally supplied with refrigerated transport, customers of Van der Poel Desserts are supplied with cold transport. Customers of Van der Poel Desserts are located all over Europe, customers of Heks'nkaas and Zuivelhoeve Vers in just a few countries in Europe. Since each subsidiary has different customers it is easier to look at the customer streams for each production subsidiary separately.

Zuivelhoeve Vers

Customers of Zuivelhoeve Vers are mainly located in Germany and the Netherlands. In the Netherlands, Zuivelhoeve Vers supplies its products to the Out-of-Home market, retail chains and the Zuivelhoeve Vers Retail chain. In Germany and Belgium Zuivelhoeve Vers supplies its products just to retail chains. In figure 2-3 an overview is given of the customers across Europe and how much their share is in the sales of the subsidiary and in figure 2-4 an overview is given of how many pallet places are shipped to each part of the Netherlands and Germany, since most of the pallets are shipped to those countries. In the figure customers in Germany are clustered based on their postal code and customers in the Netherlands based on their location and proximity to other customers in the Netherlands.

All these customers (except for REWE FL retail chain in Germany) are supplied from Raalte directly by the distributor (Nagel) to the customer. The distribution to the REWE FL retail chain starts in Raalte, from Raalte Nagel transports the end products to one of their distribution centers in Germany (Borgholzhausen). From Borgholzhausen the goods are transported at a cheaper rate to the REWE FL retail chain, which has several sites in Germany.

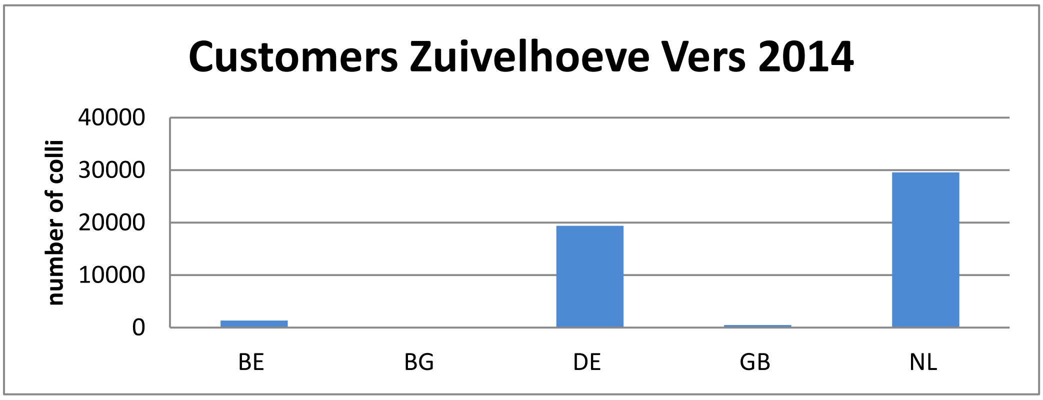


Figure 2-3 Overview sales distribution Zuivelhoeve Vers

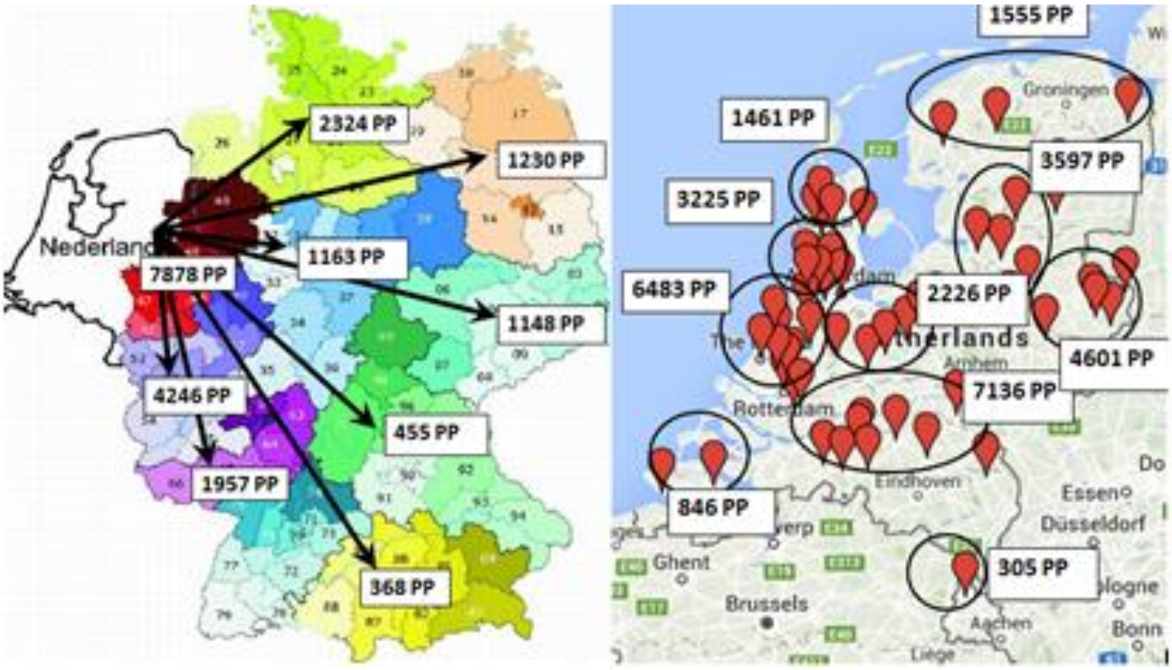


Figure 2-4 Overview transport to customers of Zuivelhoeve in Germany and the Netherlands (in number of pallet places)

Heks'nKaas

Customers of Heks'nKaas are mainly located in the Netherlands, only a small part of the sales goes to customers in Belgium and Germany, as can be seen in figure 2-5.

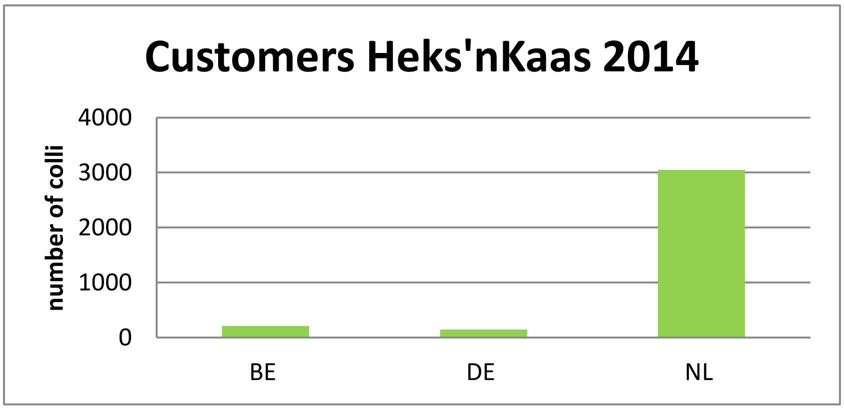


Figure 2-5 Overview sales distribution Heks'nKaas

Since the production began only in 2011, it is for now still mainly located in the Netherlands. To see if there is growth potential in the number of items sold between 2014 and 2015 in Germany and Belgium, the sales in the first quarter of both years are compared (figure 2-6). In the figure we can see that in 2015 the sales rose in the Netherlands as well as in Germany and Belgium compared to 2014. Which indicates that there might be growth potential for the Netherlands as well as for Belgium and for Germany.

All the customers in Belgium, the Netherlands and Germany are supplied from the location of Heks'nKaas in Oldenzaal to the customer by the distributor (Nagel). In figure 2-7 an overview is given of how many pallet places are transported to locations of customers in the Netherlands in 2014. In the figure customers in the Netherlands are clustered based on their location and proximity to other customers in the Netherlands.

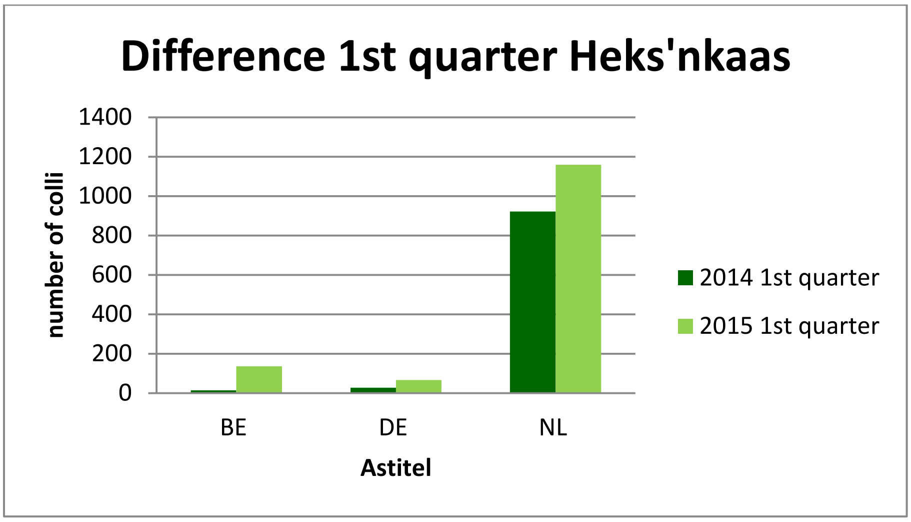


Figure 2-6 Overview difference sales 2014 and 2015''

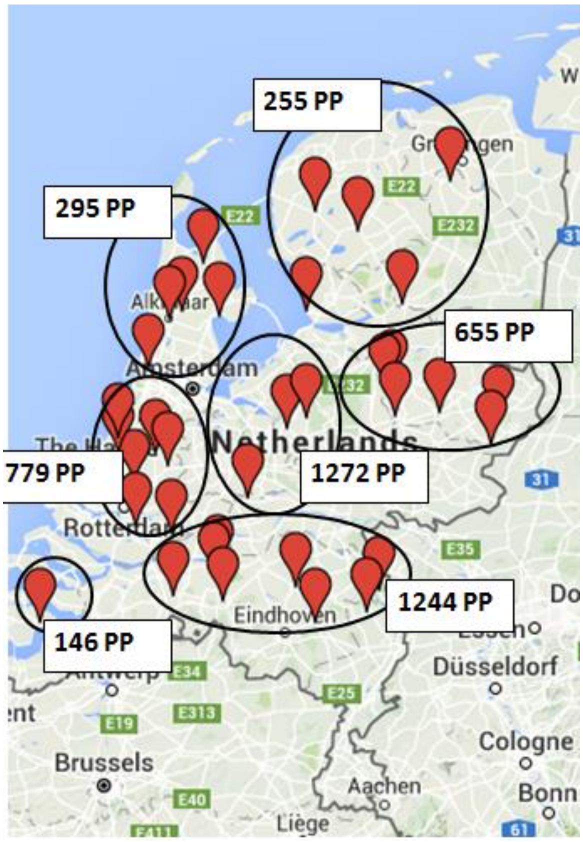


Figure 2-7 Overview transport to customers of Heks'nKaas in the Netherlands (in number of palletplaces)

Van der Poel Desserts

Customers of van der Poel dessert are located all over Europe. Customers are supplied from

Holten mainly by two different distributors, Muller Fresh Food Logistics (MFFL) and Overnight. About ten different retail chains in Germany are supplied by Overnight. Other customers in Germany, Belgium and the Netherlands are supplied by Muller Fresh Food Logistics.
Products to customers in other countries in Europe are delivered from a distribution center in Gross Gerau in Germany. From Holten goods are transported to Gross Gerau by Muller Fresh Food Logistics, and from Gross Gerau these products are distributed to the customer. The distribution costs from Gross Gerau to the customers in other countries in Europe are reflected to the customer in the cost price of the goods. In Figure 2-8 there is an overview of the sales distribution over the countries and the distributors and in figure 2-9 it can be seen how many pallet places are shipped to each location in the Netherlands and Germany. In this figure customers in Germany are clustered based on their postal code and customers in the Netherlands based on their location and proximity to other customers in the Netherlands.

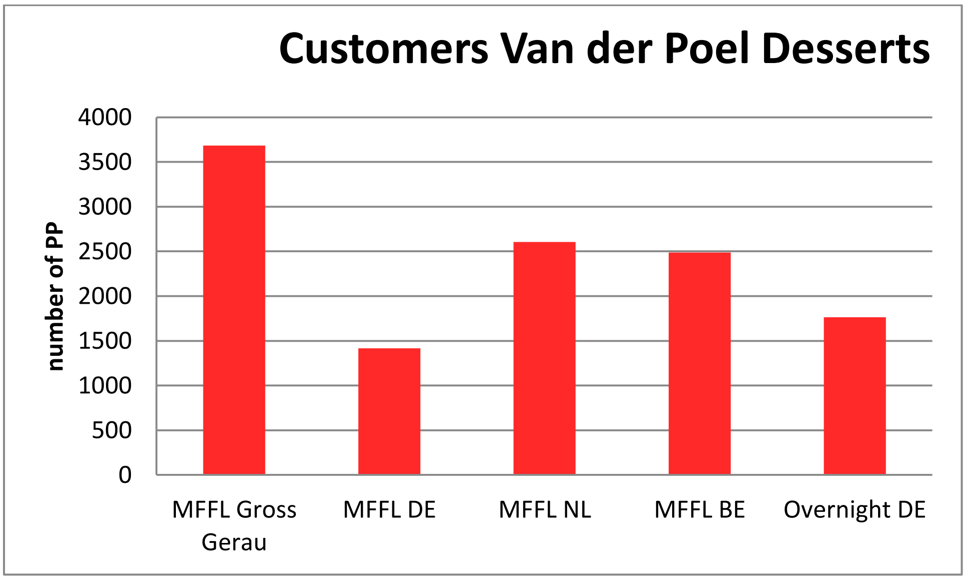


Figure 2-8 Overview sales distribution coutries/ distibutors

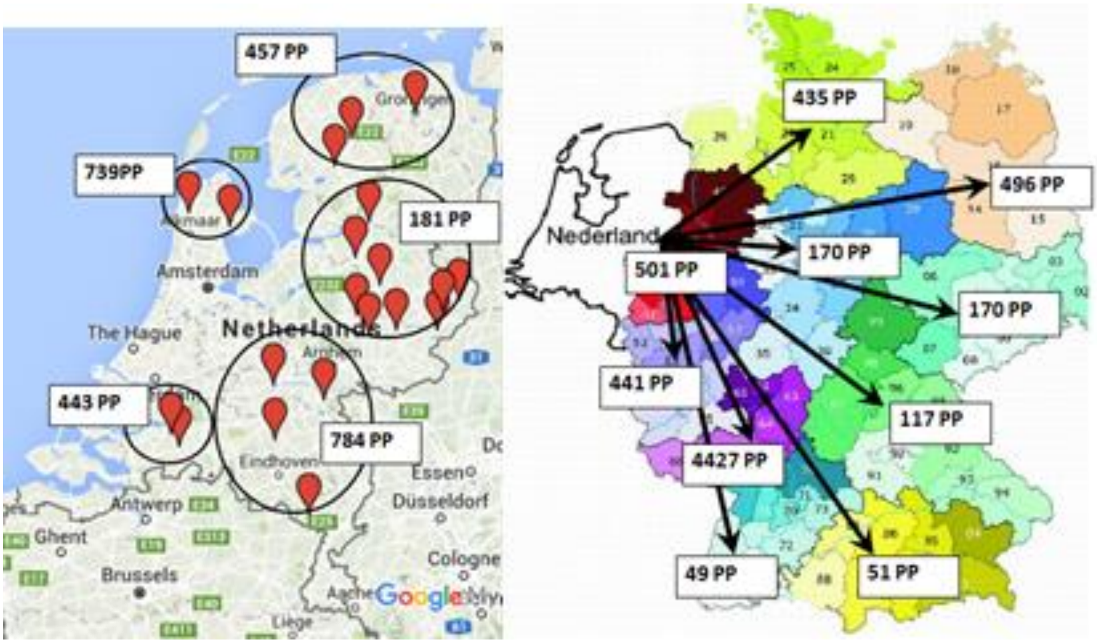


Figure 2-9 Overview transport to customer of VDP Desserts in the Netherland and Germany (in number of palletplaces)

2.2 Research Motivation

To handle the growth and promising market development, not just production but also warehousing & logistics should have priority.
What raises questions to the company are the multiple locations where products for one subsidiary are stored and the corresponding internal inventory movements. Also the complete separation of Van der Poel Desserts' logistics and warehousing from the other subsidiaries is undesirable.
Therefore Management of Roerink Food Family wants to gain insight into alternative solutions for the storage capacity plan.
For storage capacity planning and allocation of products across the warehouses/ stockrooms, a lot of variables have to be considered related to the three manufacturing companies. This makes storage capacity planning and allocation based on rationalization and experience, what has been done in the past, more difficult.
Storage capacity planning and allocation is important for the Roerink food family because it decreases the operational costs of the warehouses needed to match the available capacity.

2.3 Research Scope

The Roerink Food family wants to have a new storage capacity plan and allocation of products across their (new) warehouses/ stockrooms. In the past these activities have been done on rationalization and experience. Now the company wants to know when looking at the warehouses/stockrooms from a scientific approach, what will the storage capacity plan than be?
First of all, the scope of this research is limited due to time constraints. There are only six months available to complete this research. Tradeoffs have to be made about the breadth and depth of the study (Cooper & Schindler, 2014).

For this case study the focus is mainly on the warehousing and (internal) logistics activities of the subsidiaries Zuivelhoeve Vers and Van der Poel desserts. This tradeoff is made because Zuivelhoeve Vers and Van der Poel desserts both have a lack of storage capacity at their production site, so for these subsidiaries there is an external storage location respectively in Raalte and in Holten. Because of the external storage location there are a lot of internal inventory movements, which are interesting to investigate for the research. Also for these subsidiaries it is interesting to look at where the perfect location for external storage should be regarding to the location of the customers and the production site.

The focus of the research will not be on Heks'nKaas and Happy Goat (producer of goat cheese products, production still has to start), because production and storage of both subsidiaries are located at the same site in Oldenzaal, which means that there are no internal inventory movements at this site. This makes Heks'nKaas and Happy Goat less interesting for this research.

2.4 Research Objective

The aim of this research is to help Roerink Food Family in designing a reliable and sound storage capacity plan and product allocation across the warehouses, with a view to the future growth of the company. Since growth can be unpredictable, the research objective is:

"To come up with a storage capacity plan and product allocation for the different warehouses/ stockrooms of the Roerink Food Family for several future growth scenarios"

2.5 Research Questions & Research Design

To give a solution to this research objective the following main research question has been formulated:

"What should be the storage capacity plan for the Roerink Food family for different scenarios of future growth?"

To divide this research question into manageable pieces, the following sub-research questions guide the research; per sub-research questions also the way in which the questions are answered is given:

1. *What is the current situation and current performance of Roerink Food Family?*
   Before going into detail on the new storage capacity plan, first the current situation and performance of Roerink Food Family should be examined. The current situation will give us inside into the product assortment and the flow of the products at the locations.
   The current performance is about cost-effectiveness. The cost-effectiveness of a storage capacity plan is specified as minimizing the total operation costs of the warehouses/ stockrooms and minimizing distribution costs.

To guide answering the first research question and to give a clear overview of what will be examined, questions a-d are formulated:

a. Which products are parts of the assortment of Roerink Food Family?
    - Check databases/ interviews
    - Graphical overview of the assortment to show historic demand and stock levels of the products.
    - Explanation flow of products
b. What is the current capacity of all existing locations? Dry, cold and refrigerated storage?
    - Check database
    - Meeting decision maker
    - Storage space expressed in number of pallet places
c. What are the current operational costs per year for the warehousing &logistics activities?
    - Check database
    - Meeting with decision maker

2. *What are alternative storage location scenarios and what is the performance of these alternative location capacity scenarios under current conditions?*
   Besides the current locations for warehousing, Roerink family also thought of a few alternative locations where stock for Van der Poel Desserts and Zuivelhoeve Vers could be kept instead of the current locations. Roerink Food Family wants to have these alternative scenarios to be investigated. To compare it with the current situation, costs for logistics and warehousing for these scenarios should be calculated. Besides the given alternatives to be investigated, there are maybe more interesting alternatives to have a look at.
    a. What are the alternative scenarios Roerink Food Family wants to have investigated?
        - Meeting with decision maker
    b. What are other interesting scenarios to be investigated
        - Applying location-allocation models

3. *How can long-term forecasts be made for Roerink Food Family?*
   Since the company wants to know how they should store their products in 3 years a long-term forecast should be executed to know what the future stock levels will be. The most-suitable long-term forecast model will be chosen based on literature
    a. Which data is required to make long-term forecasts?
        - Forecast quality is always based on accuracy of (historical) input data. Therefore it is essential to specify which data is useful.

4. *What is the storage capacity needed for the subsidiaries under different future growth rates?*
   This is necessary to know because the company wants to know, how they should manage their stock in the future.
   a. What are the future stock levels that can be expected?
      - Use forecast models to estimate future stock levels

5. *How should Roerink Food Family allocate its products across the different possible locations under the different future growth rates?*
   Allocation of products across locations is necessary to know, because it gives an insight in what the most cost beneficial storage capacity option would be in case of future growth
   a. Which model is appropriate to support Roerink Food Family in this decision making?
      - Use ILP Model

2.6 Deliverables

The deliverables of this research exists of:

- Overview of the performance of the current situation regarding cost-effectiveness of warehousing and logistics
- Comparison between operational costs of the current situation and the alternative scenarios for current stock levels
- Finding the optimal location for a warehouse based on minimizing transport costs, using the successive approximation method for Euclidian distances and the exact method for Manhattan distances
- Forecasting model for predicting future stock levels
- Applying an ILP model to know what the best scenario is for storing products under future stock levels

2.7 Structure of the Thesis

In this section the structure of the thesis will be explained. The structure will follow the sequence of the research questions and the research design. The structure is outlined in figure 2-10. First, an introduction to the thesis is given in chapter 1. In chapter 2 the research background, research questions and research design are given. This chapter gives an overview of the company and the motivation for the research. The current practices along the supply chain of Zuivelhoeve Vers and Van der Poel desserts are explained in chapter 3. The alternative scenarios for warehousing and logistics of Zuivelhoeve Vers and Van der Poel desserts are explained in chapter 4. In chapter 5 two new alternative scenarios are introduced using the center of gravity method.

From the main research question it follows that it is necessary to know what the future growth of the stock levels will be. So in chapter 6 it will be explained which forecast model is most suitable to use to predict these future stock levels. Subsequently in chapter 7, future stock levels will be calculated.

In chapter 8 an ILP- model is developed to help in the decision which scenario is most economically beneficial in the future.

The conclusion and recommendations that result from the research are presented respectively in chapter 9 and suggestions for future research are made in chapter 10

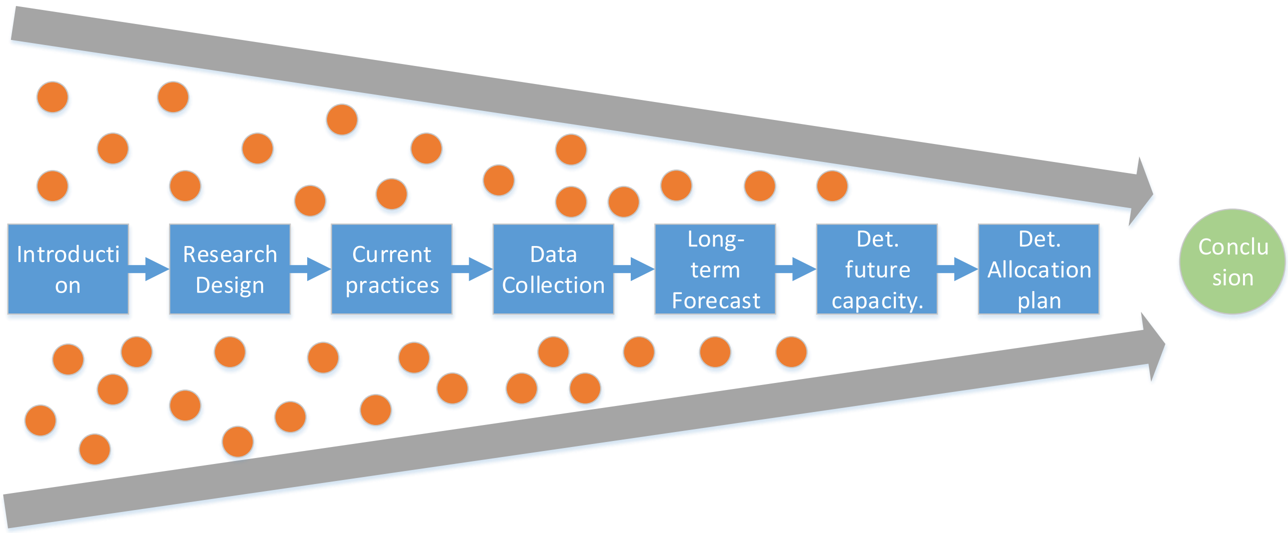


Figure 2-10 Thesis structure

3 Current situation & performance

In this chapter an answer is provided to the first research question: “*What is the current situation at Roerink Food Family?”*. The current situation is investigated with a focus on the flow of products at/between the different locations and to the customers. The purpose of looking at the flow of products across the supply chain is that, when this is understood, the data required for the following chapters can be defined. Also it can be used as a benchmark to compare the solution that is found in this research.

In section 3.1 an introduction is given to the products that are produced at the different subsidiaries. In section 3.2 and 3.3, respectively warehousing at the different locations is explained and the current distribution and storage costs are calculated.

Finally in section 3.4 an answer is given to the first research question, using the main points that follow from this chapter.

3.1 Product assortment production subsidiaries Roerink Food Family

Roerink Food Family develops and produces most of its products itself. The assortment of products has changed over time, new flavors are take into the assortment, flavors that do not sell well are taken out of the assortment, different sizes are introduced. But the head divisions of the products remained the same for the subsidiaries, see figure 3-1.

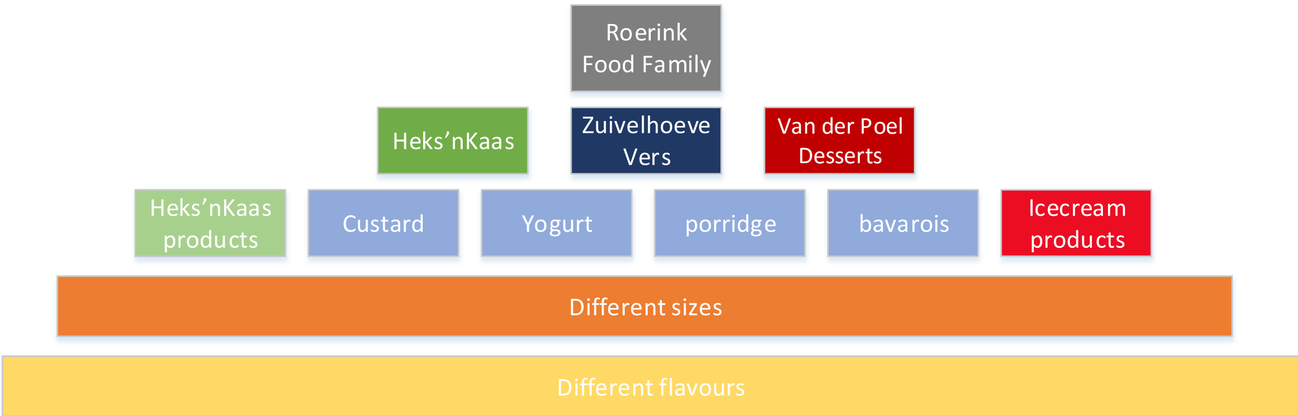


Figure 3-1 Product assortment overview

The products of Zuivelhoeve Vers and Heks’nKaas have a limited shelf life, products of Van der Poel Dessert have a longer shelf life since these are frozen products.

Next to these products in the future Roerink Food Family will also be producing goat cheese products and Zuivelhoeve retail chain sells products like cheese and nuts.

3.1.1 Make-to-order Products

In production planning a distinction can be made between make-to-order and make-to-stock products. In the make-to-order strategy, end-products are only manufactured once the customer places the order.
Most of the production is planned based on historical demand, but when an unexpected order comes in or when there is a promotion in a customer's store, these products have to be planned according to a make-to-order strategy. A retail chain like Albert Heijn for example can place an order one day before they need it. So flexibility is necessary.

3.1.2 Make-to-stock products

Make-to-stock, also known as push production literally means manufacturing products for stock based on demand forecasts. Make-to-stock is used to prevent stock-out and thereby opportunity losses, also it is used to minimize excessive inventory.
Roerink Food family plans almost all production of its products based on the make-to-stock policy. Using historical demand, intuition and forecasts.
The make-to-stock policy is especially important for seasonal products. For example for Van der Poel the demand around Christmas and Easter is so high, that production already starts a few months ahead to meet the demand that is expected in these months.

3.1.3 Historical demand products

Historical demand can be defined as the sales orders that have been put into the MRP-system. Historical demand is used to monitor the service level, but can also be used for capacity planning. In case of capacity planning the historical demand is expressed in number of cartons sold (colli). Figure 3-2 shows the historical demand of Heks'nKaas, Zuivelhoeve and Van der Poel desserts. What can be seen is that the historical demand is still rising for Heks'nKaas and Zuivelhoeve Vers. In figure 3-2 the historical demand for Van der Poel is shown for the last two years, what can be seen here is that the demand has remained relatively stable and that there are fluctuations in demand around the same time of the year, this is due to seasonal factors (Christmas, Easter, Summer).
When looking at the total demand and growth for Heks'nKaas, Zuivelhoeve and Van der Poel Desserts in the last years (see table 3-1), the demand for Heks'nKaas rose a lot from 2012 to 2015. The demand for Zuivelhoeve Vers rose from to 2012-2013 a little, but from 2013-2014 there was a larger increase. The demand for Van der Poel decreased a little in the years 2013-2014.

	Demand 2012	Demand 2013	Demand 2014	Growth 2012-2013	Growth 2013-2014
ZH	6797704	6941594	7407252	2%	7%
VDP		1860151	1580445		-15%
HK	245260	811280	1167560	231%	44%

Table 3-1 Total demand Zuivelhoeve, Heks'nKaas & Van der Poel

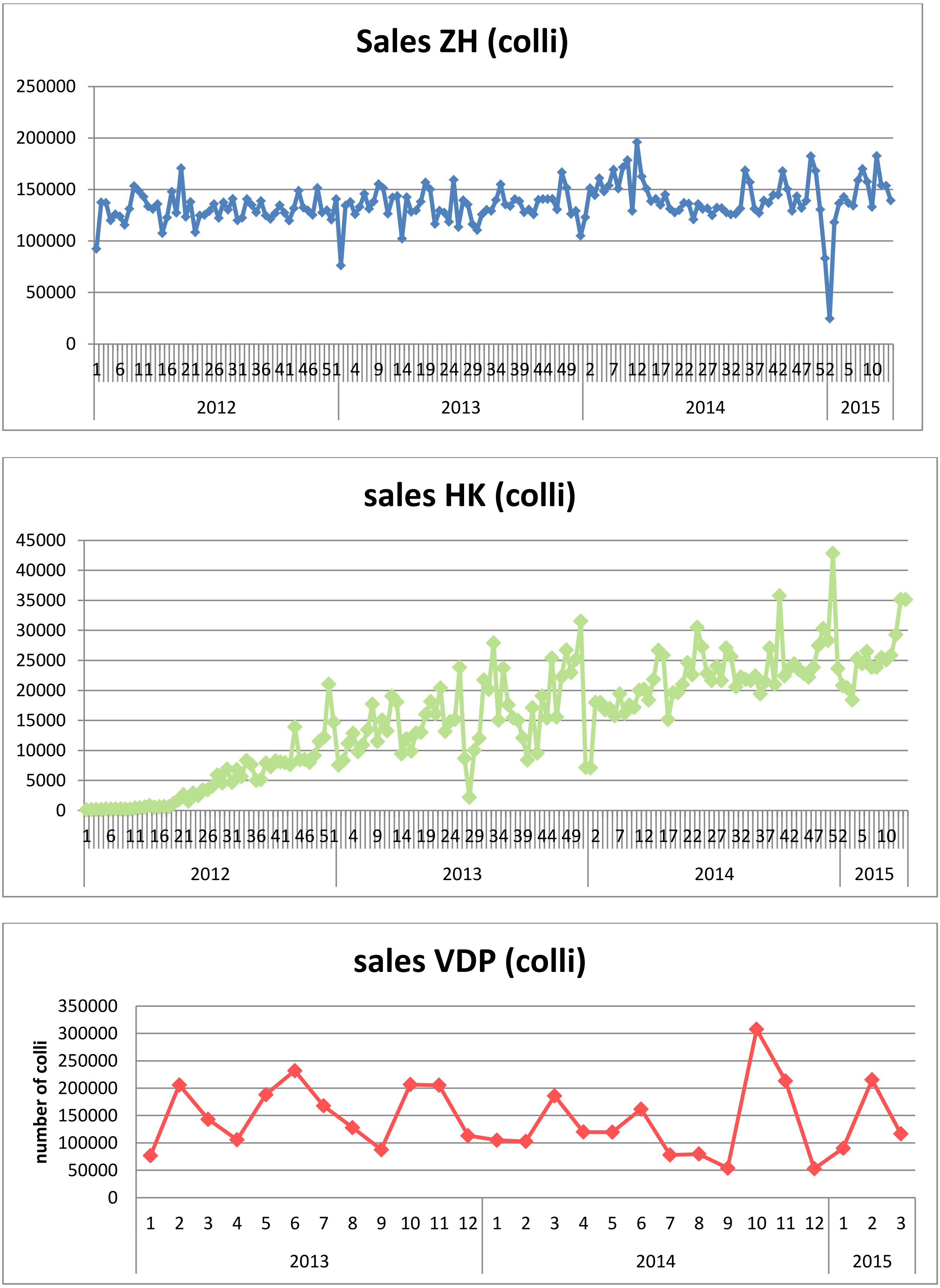


Figure 3-2 Sales Zuivelhoeve Vers, Heks'nKaas & Van der Poel in number of colli

3.2 Current situation warehousing

In this part several aspects of warehousing are examined. We look at the incoming goods, the way in which goods are packed, transported and stored. Also an overview is given of the storage capacity available at all the locations and what the fill rates are of the different warehouses/ stockrooms. This gives us inside in the current practices and might already provide data that can be used for the new storage capacity plan.

3.2.1 Incoming goods

Incoming goods are all the goods that arrive from an external location at a certain site. It can be that raw materials and packaging arrive in Raalte, Oldenzaal or Holten from the supplier. Or that the raw materials and packaging arrive at the production location(Hengelo, Twekkelo), transported from the storage locations (Raalte, Oldenzaal, Holten). Also it can be that end products arrive at the storage locations transported from the production locations. For all these incoming goods, certain activities have to be performed, to know for example where the goods are stored and how many goods are stored at a certain location.

Zuivelhoeve Vers

When raw materials and packaging for Zuivelhoeve Vers arrive in Raalte or Oldenzaal from the supplier, the number of goods must be entered in the MRP-system under division 200 for Raalte and division 400 for Oldenzaal. Also the truck must be unloaded and the goods must be placed at their dedicated storage location.
When raw materials/packaging are needed in Twekkelo for production, an internal inventory movement must take place from Raalte or from Oldenzaal to Twekkelo. But before transport can take place, first the order for Twekkelo must be processed in the shuttle list and there must be made a delivery note. When the goods are picked and loaded in the truck, transport to Twekkelo can take place. When the goods arrive in Twekkelo, this must be entered in the MRP system and the truck must be unloaded.
When end products from Twekkelo arrive in Raalte, again this must be entered in the MRP system and the goods can be stored in the warehouse at dedicated places until they are needed for transport to the customer.

Van der Poel desserts

At Van der Poel Desserts, raw materials and packaging are first stored in Holten (MFFL), which means that suppliers transport the raw materials and packaging from their location to Holten. In Holten the truck must be unloaded and the goods must be moved to their storage place. When the raw materials and packaging are needed in Holten for production, an internal inventory movement must take place from Holten to Hengelo. Sometimes in case of cold transport this can be combined with transporting end products from Hengelo to Holten, because end products of Van der Poel are stored in Holten. All those inventory changes must be entered in the MRP system, so it can easily be checked how many goods are stored at which location.

3.2.2 Transport

All subsidiaries of Roerink Food Family use so called standardized wooden EURO pallets (figure 3-3) to store and transport their products. The EURO pallet has dimensions 80 X 120 cm and can carry a weight of 2000 kg maximum (Bartholdi & Hackman, 2011). In the warehouses a reach truck is used for transporting these pallets to their locations.
At MFFL in Holten where products for Van der Poel Desserts are stored, also a small amount of block pallets (figure 3-4) are used for storage. These pallets usually have dimension 100 X 120 cm and is besides the standardized wooden EURO pallet the most commonly used pallet.

Figure 3-3 Euro pallet

Figure 3-4 Block pallet

For internal transport between locations a truck is used, in which approximately 32 pallets can be stored. Between Twekkelo and Oldenzaal, there is just ambient (dry) transport. Between Twekkelo and Raalte there is ambient and refrigerated transport and between Hengelo and Holten there is ambient and cold transport.
For internal transport for Van der Poel Desserts (Hengelo-Holten), the trucks are usually stored around 80 percent of their total capacity.

3.2.3 Packaging

According to Hellström and Saghir (2007), the functions that packaging must perform are manifold and complex: it has to protect, contain, preserve and communicate the product. They argue that packaging can be classified in three different levels: 1) primary packaging, the material that is in direct contact with the product; 2) secondary packaging, this is designed to contain several primary packages; and 3) tertiary packaging, an assembly of a number of primary or secondary packages. At all Roerink Food Family subsidiaries there is a maximum of three layers of packaging.
First of all, the contained element (CE) is comparable with primary packaging. It's in direct contact with the product and is packed in a way such that it's commercially presentable, such as bowls, cubes and cups in several sizes. It refers to the units purchased by the customer in the stores. To increase the stability and speed of handling the sales unit is bundled into a holder element (HE/colli). For example, if a retail order consists of ten CEs, the picking can be done ten times as fast. Consequently, stores are only allowed by Roerink Food Family to order HEs. HEs are for example trays or boxes in which the CEs can be stored.

These HEs can consist of two layers at a maximum. For example two trays which can hold 6 desserts can be put in another tray, so that customers must at once buy 12 CE instead of 6 CE.

3.2.4 Storage capacity warehouses/ stockrooms

As we want to define a storage capacity plan for Roerink Food Family, the current storage capacity of all locations must be known. In table 3-2 the total storage capacity for all locations in terms of ambient, refrigerated and cold storage are given. In Holten the storage space is indicated as infinity capacity, because storage capacity in Holten is rented from MFFL and if extra storage space is needed, it is possible to rent extra storage space.

	Ambient (PP)	Refrigerated (PP)	Cold (PP)
Oldenzaal	600	216	0
Twekkelo	146	142	0
Raalte	196	1285	318
Holten	∞	0	∞
Hengelo	250	0	115

Table 3-2 Total storage capacity at all locations

The storage spaces can all be filled up to 100 % of their capacity.

3.3 Current Distribution/Storage Costs

To find out if alternative storage capacity solutions are better than the current situation, all operational costs of the current situation have to be known to compare it with the costs of the alternative solutions. In the beginning of the report our operational costs were defined as the (internal) distribution costs and storage costs. In figure 3-5, a schematic overview is given of all locations and how many pallet places are transported on average per week to and from each location (indicated by T, T2,..T7), storage locations are indicated as S1,S2, S3 or S4. In the following sections, where the current distribution and storage costs are calculated for Zuivelhoeve Vers and Van der Poel Desserts, these abbreviations are used to refer to a storage location or movement stream.

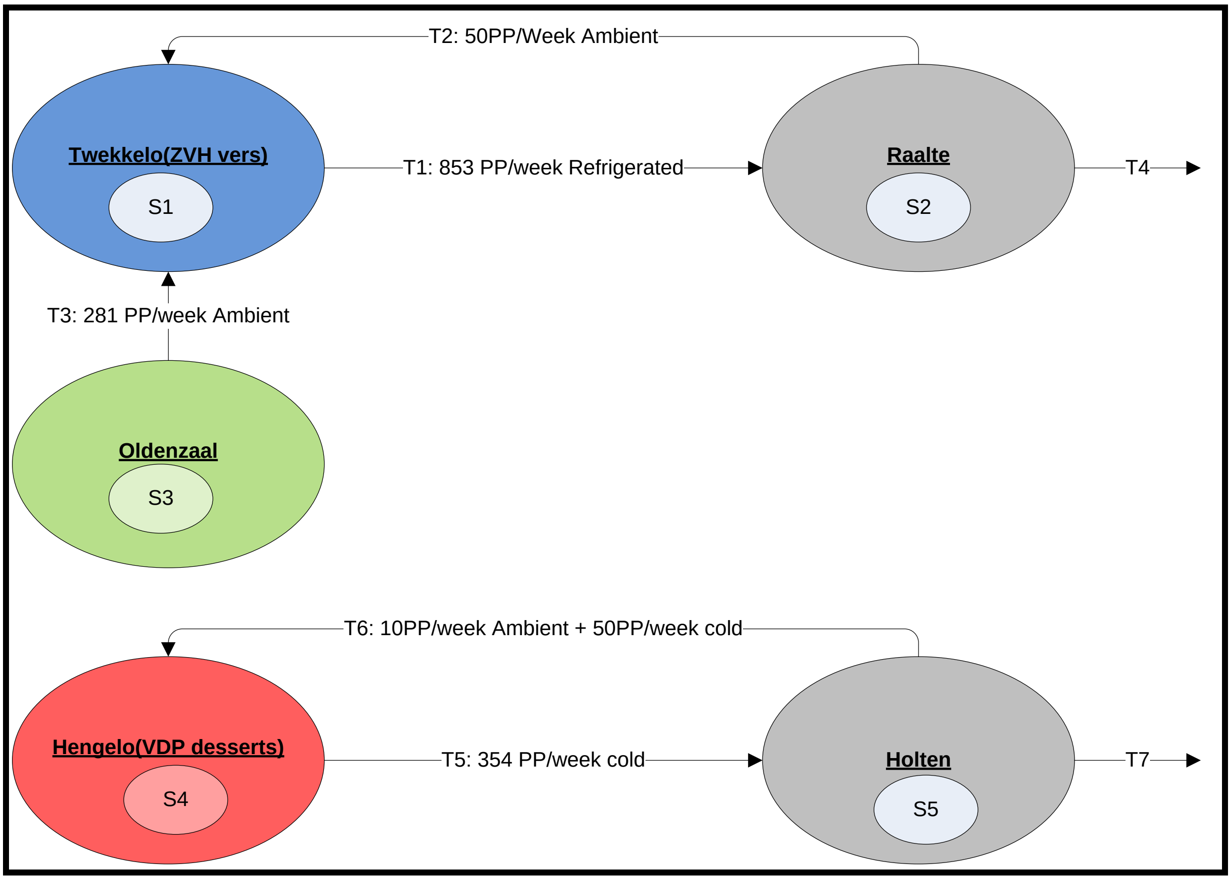


Figure 3-5 overview storage locations and internal movements Roerink Food Family

3.3.1 Current distribution/storage costs Zuivelhoeve Vers

To calculate the storage and distribution costs of Zuivelhoeve Vers, the focus is just on the top half of figure 3-5, which is also shown in figure 3-6. These are all (internal) movements and storage locations for the subsidiary Zuivelhoeve Vers. In words these streams and storage locations are:

- S1: Storage in Twekkelo
- S2: Storage in Raalte
- S3: Storage in Oldenzaal
- T1: Internal inventory movements Twekkelo→ Raalte
- T2: Internal inventory movements Raalte → Twekkelo
- T3: Internal inventory movements Oldenzaal → Twekkelo
- T4: Transport Raalte → customer (BE,DE,NL)

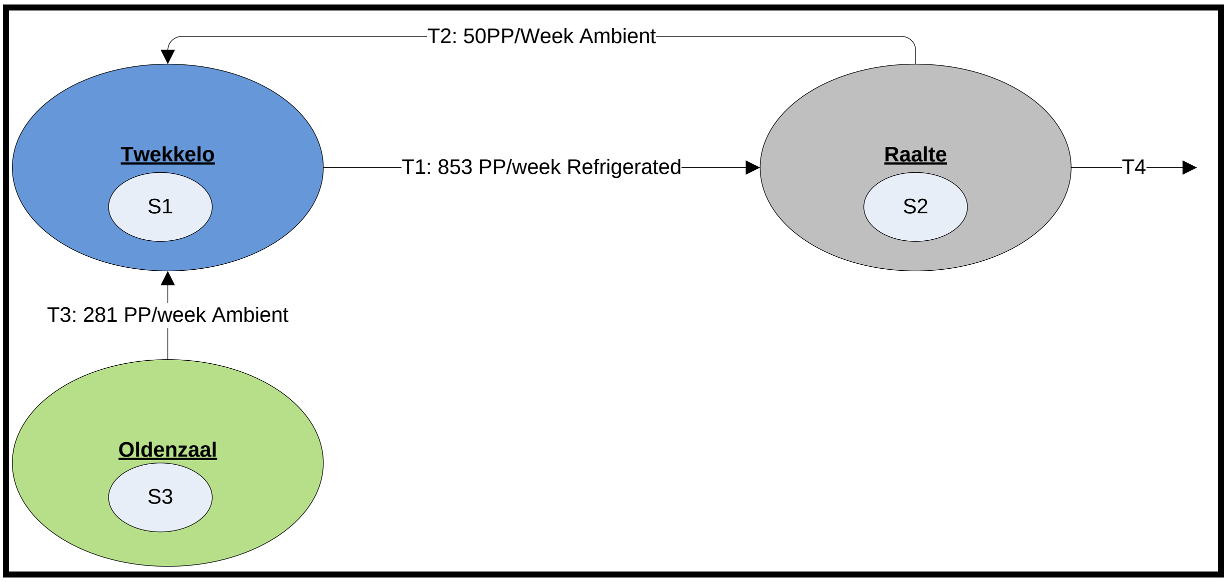


Figure 3-6 overview storage locations and internal movements Zuivelhoeve Vers

S1, S2, S3: Storage costs in Oldenzaal, Twekkelo, Raalte

The storage costs for the locations in Oldenzaal, Twekkelo and Raalte are all the same, these are €0,07 per PP/day for ambient storage and refrigerated storage and €0,20 per PP/day for cold storage (Hannink, 2015). When a storage location is owned by Roerink Food Family, storage costs are always €0.07 per PP/day for ambient and refrigerated storage and €0.20 per PP/day for cold storage. In figure 3-3 an overview is given of the total storage costs per year for all locations.

Calculations for the average number of pallet places in stock for every location can be found in appendix B.

	What has to be stored?	Costs per PP/day	# of PP on average in stock	Costs per year
S1: Twekkelo	End product	€ 0.07	92	€ 3,113.45
S1: Twekkelo	Raw material/ packaging	€ 0.07	95	€ 2,409.68
S2: Raalte	End product	€ 0.07	853	€ 21,794.15
S2: Raalte	Raw material/ packaging	€ 0.07	100	€ 2,555.00
S3: Oldenzaal	Raw material/ packaging	€ 0.07	500	€ 12,775.00
Total storage costs per year				**€ 42,647.28**

Table 3-3 Storage costs Zuivelhoeve Vers

T1: Internal inventory movements Twekkelo → Raalte

Every week 853 pallet places (see appendix B) of end products are transported from Twekkelo to Raalte at a cost of €4.03 per pallet place. So per year these internal movements cost: € 178,708.55.

T2: Internal inventory movement Raalte → Twekkelo

Every week 50 PP (see appendix B) of raw materials are transported from Raalte to Twekkelo, but these internal movements do not cost the Roerink Food Family anything, because it is combined with picking up end products in Twekkelo (Hannink, 2015).

T3: Internal inventory movements Oldenzaal → Twekkelo

Every week 281 PP (see appendix B) of raw materials and packaging are moved from Oldenzaal to Twekkelo, because these are needed in Twekkelo for production. The transport from Oldenzaal to Twekkelo costs €2.43 per pallet place. So the total costs per year for this internal transport movement is €35,458.45.

T4: Transport Raalte → Customer

Zuivelhoeve Vers has customers in Belgium, the Netherlands and Germany.
For transport to the customers in Belgium, the transport costs per pallet place depend on how many pallets are transported at once to a customer.
For transport to customers in the Netherlands the costs per pallet place are always €13.50 , regardless of how many pallets are transported at once. But in the Netherlands every stop also costs €13.50.
For transport to customers Germany (except for the customer REWE FL), the costs per pallet place depend on the postal code of the customer and how many pallets are transported at the same time.
For transport to several locations of REWE FL in Germany, first end products are transported from Raalte to Borgholzhausen (distribution center of the distributor Nagel in Germany) at a cost of €13.85 per pallet place with a maximum of €387,65 per ride. From Borgholzhausen the end products are transported to the different locations of REWE FL in Germany. The costs per pallet place to the several locations of REWE FL depend on the locations itself and the number of pallets that are transported at the same time.
For calculating the transport costs per year to the customers of Zuivelhoeve Vers, an overview of 2014 is used in which all the customers and the corresponding number of pallet places that are transported to each customer are given.
The total costs per year for transport to customers are given in table 3-4(see appendix B for calculations):

	Total costs per year
REWE FL	€ 154,806.16
Germany (except REWE)	€ 871,762.35
Netherlands	€ 604,219.42
Belgium	€ 46,302.65
Total Costs	**€ 1,677,090.59**

Table 3-4 overview distribution costs to the customer Zuivelhoeve Vers

<u>Total operational costs per year for Zuivelhoeve Vers</u>

The costs for all operational activities for Zuivelhoeve Vers have now been calculated. So the costs for these activities can now be summed up to know what the total operational cost per year are for the current situation at Zuivelhoeve Vers (see table 3-5).

	Costs
Total storage costs	€ 42,647.28
Transport from the production location to the warehouse	€ 178,708.55
Transport from the warehouse to the distribution center(s)	-
Transport from the warehouse to the production location	€35,458.45
Transport from the distribution center(s) to the customer(s)	€ 1,677,090.59
Total operational costs ZVH Vers	**€ 1,933,904.87**

Table 3-5 overview total operational costs Zuivelhoeve Vers current situation

3.3.2 Current distribution/storage costs Van der Poel Desserts

To calculate the storage and distribution costs for Van der Poel Desserts, the focus is just on the bottom half of figure 3-5, which is also shown in figure 3-7. These are all (internal) movements and storage locations for the subsidiary Van der Poel Desserts. In words these streams and storage locations are:

- S4: Storage in Hengelo
- S5: Storage in Holten
- T5: Internal inventory movements Holten → Hengelo
- T6: Internal inventory movements Hengelo →Holten
- T7: Transport Holten → customer

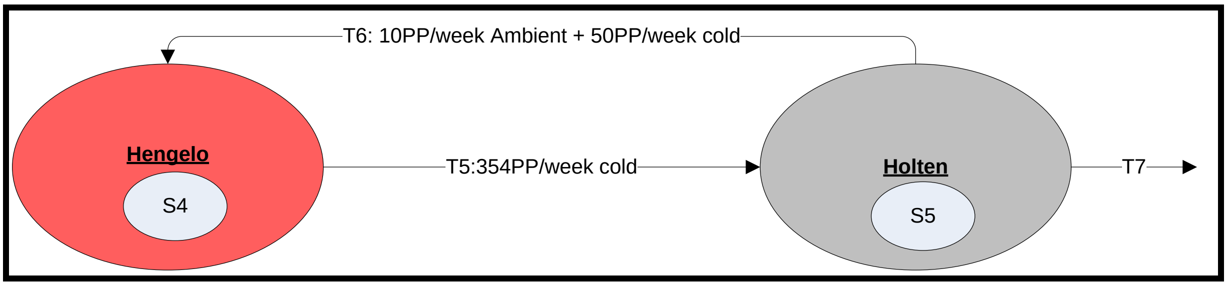


Figure 3-7 overview storage locations and internal movementsVan der Poel desserts

S4, S5: storage costs in Hengelo and Holten

In Holten and Hengelo , raw materials/ packaging and end products are stored, the costs for storing all these products are given in table 3-6.

In Hengelo raw/materials and packaging are stored so that they can be used for production, end products are stored in Hengelo, because they have to cool down and/or have to wait to be transported to the warehouse in Holten.

For the location in Hengelo the average number of pallet places on stock (raw materials/ packaging and end products) were given (Bom, 2015), since no historical stock levels were available. The average number of pallet places on stock for Holten (S5) have been calculated using the weekly stock levels of 2014, both for raw materials/ packaging and the end products.

	What has to be stored?	Costs per PP/ day	# of PP on average in stock	Costs per year
S4: Hengelo	End products	€0.20	115	€ 6,387.50
S4: Hengelo	Raw materials/ packaging	€0.07	250	€ 8,395.00
S5: Holten	End Products	€ 0.32	2680	€ 312,166.40
S5: Holten	Raw materials/ packaging	€ 0.11	922	€ 36,080.00
Total storage cost VDP Desserts				€ 363,028.90

Table 3-6 overview storage costs Van der Poel desserts

T5: Transport from Holten to Hengelo

In case of transport from the warehouse Holten to the production location in Hengelo a distinction can be made between cold and ambient transport.

Every week 50 pallet places (see appendix B)are transport via cold transport at a cost of €6.50 PP. Total costs per year for cold transport are € 16,900.00.

Also every week 100 pallet places of ambient products (raw materials/ packaging) are transport at a cost of €5 per PP. Total costs per year for transporting raw materials/ packaging are € 26,000.00.

T6: Transport costs from Hengelo to Holten

On average 354 pallet places are transported per week from Hengelo to Holten at a cost of €3.79 per pallet place. The total costs per year for transport from Hengelo to Holten is € 69,727.27.

T7: Transport from Holten to Customer

When goods are transported from the warehouse in Holten to the customer a distinction can be made between, transport via Muller and transport via Overnight.

- <u>Transport via Muller (T7.1)</u>
  Muller directly distributes goods from Holten to the customer. The costs per pallet place to customers in the Netherlands and Germany (expect for the places Gross-Beeren and Gross-Gerau) depend on the number of pallets distributed at the same time.
  The costs for transport to a customer in Gross-Gerau , Gross-Beeren or Belgium is based on a full truck load and the location. From Gross-Gerau goods are distributed to customers in other countries in Europe for which the transport costs from Gross-Gerau are included in the cost price of the goods, therefore just the distribution costs to Gross Gerau are included now for calculating the distribution costs to those customers.
  In appendix B the calculations are given that were needed to calculate the total costs per year for transport via Muller (see table 3-7).

	Costs per year
Netherlands	€ 66,655.81
Germany	€ 121,925.66
Belgium	€ 68,547.22
Total costs per year	**€ 257,128.74**

Table 3-7 overview transport costs to customer via Muller

- <u>Transport via overnight(T7.2)</u>
  In case of transport via Overnight, goods are first distributed from Holten to Osnabruck. From Osnabruck goods are transported to several customers in Germany. The costs of transport from Holten to Osnabruck are based on the number of pallets that are distributed at the same time. The costs of transport from Osnabruck to the customer is based on the number of pallets transported at the same time and the location of the customer.
  In appendix B the calculations are given that were needed to calculate the total costs per year for transport via Overnight (see table 3-8).

	Costs per year
Holten → Osnabruck	€ 27,390.40
Qsnabruck → customer	€ 64,726.78
Total costs per year	**€ 92,117.18**

Table 3-8 overview transport costs to customer via overnight

Total operational costs per year

All costs for the operational activities of Van der Poel Desserts have been calculated, see table 3-9 for an overview of all costs. The total operational costs for Van der Poel Desserts are:

	Costs
Total storage costs VDP desserts (S4+S5)	€ 363,028.90
Transport from the production location to the warehouse (T5)	€ 69,727.27
Transport from the warehouse to the distribution center(s)	-
Transport from the warehouse to the production location (T6)	€ 42,900.00
Transport from the distribution center(s) to the customer (T7)	€ 349,245.92
Total Operational costs VDP Desserts	€ 824,902.09

Table 3-9 Overview total operational costs Van der Poel Desserts current situation

3.4 Conclusion

The product assortment of the Roerink Food Family, consists of several dairy products made in different sizes and flavors. The refrigerated dairy products have a limited shelf time and the frozen dairy products (like ice-cream of Van der Poel Desserts) have a long shelf time. The products are produced either according to a make-to-order or a make-to-stock policy and picked using the first expired first out dispatching rule.
Suppliers deliver goods by truck and it is assumed that all products arrive on a pallet. When goods arrive at a location, the quantity and the location must be entered in the MRP-system. Also when products leave a location (for example for transport to the customer) it must be entered in the MRP-system, in this way it is always possible to check the stock level at each location. All the goods, after production, are packed using a maximum of three packaging layers: 1) the contained element (CE) and a maximum of two extra layers which make it easier and more efficient to handle at the warehouses (HE).
Since goods arriving from the supplier, goods that are stored in a warehouse or transported to the customer are all placed on pallets, we use the number of pallet places in this thesis to express the stock level.
The total number of pallet places that can be stored at each location for ambient, cold and refrigerated are known and can be used for future calculations.
To know what the current operational costs per year are, all costs for the operational

activities of the Zuivelhoeve Vers and Van der Poel Desserts have been calculated.
The operational activities of Zuivelhoeve Vers included to calculate its operational costs are: Storage in Twekkelo, Oldenzaal and Raalte, internal inventory movements between Twekkelo and Raalte and vice versa, internal inventory movement between Oldenzaal and Twekkelo and transport from Raalte to the customer. The total costs per year for these activities are : €1,919,117.70
The operational activities of Van der Poel Desserts included in the calculation of the operational costs are: storage in Holten and Hengelo, internal inventory movements between Hengelo and Holten and vice versa and transport from Holten to the customer. The total costs for these activities are: € 824,902.09
These current operational costs can be used to compare with the operational costs of alternative scenarios, which are investigated in the next two chapters.

4 Alternative scenarios

For the research different alternative storage capacity solutions have to be investigated, the management has given three possible scenarios. In this part we look at what those possible scenarios are and what the operational costs of such a scenario are for current conditions. Besides these three given scenarios, also the optimal location for a warehouse for Zuivelhoeve Vers and Van der Poel Desserts have been calculated using location-allocation models, this will be explained in the next chapter.
The scenarios are explained for van der Poel Desserts and Zuivelhoeve Vers separately, so one scenario describes only a different situation for one subsidiary. The following three possible scenarios will be discussed in this chapter:

- Scenario 1: Holten closes → VDP Desserts storage location in Raalte
- Scenario 2: Holten closes → VDP Desserts storage location in Hengelo (Westermaat)
- Scenario 3: Expansion Twekkelo → Zuivelhoeve Vers storage in Twekkelo

4.1 Scenario Holten closes → VDP Desserts storage location in Raalte

Management of Roerink Food Family thinks it is undesirable that all logistics and warehousing of Van der Poel are separate from that of the rest of Roerink Food Family. A scenario that Roerink Food Family wants to investigate is when the external storage location in Holten closes and that all end products, raw materials and packaging of Van der Poel Desserts that were stored in Holten are now stored in Raalte. In this case the external storage location in Raalte must be expanded. The expansion will imply that there will be 3000 extra pallet places of cold storage and 1500 extra pallet places of ambient storage, that can only be used by Van der Poel Desserts. In figure 4-2 an overview is given of what the new situation in scenario 1 will look like. As can be seen for Zuivelhoeve Vers (green and blue location) there are no changes, but for VDP Desserts the operational activities that are marked with a star in the following list are changes in operational activities with respect to the current situation of Van der Poel Desserts (as a reminder given in figure 4-1):

- S4: Storage of end products and raw materials/packaging of VDP desserts in Hengelo
- S5*: Storage of end products and raw materials/ packaging of VDP desserts in Raalte
- T5*: Internal inventory movements Hengelo → Raalte
- T6*: Internal inventory movements Raalte → Hengelo
- T7.1*:Transport to the customer that first went via Muller to the customer, now goes via Nagel to the customer.
- T7.2*:Transport to the customer that first went via overnight, now goes via Nagel.
  OR
- T7.2*: Transport to the customer that first went via overnight, stays going via overnight. The only change is that now first goods have to be transported from Raalte to Osnabruck instead of Holten to Osnabruck.
- B1: Building the expansion in Raalte

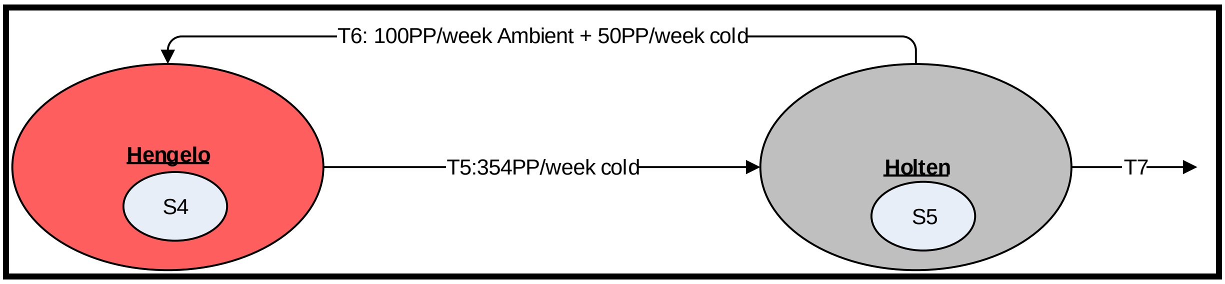


Figure 4-1 Overview of the current situation of Van der Poel desserts.

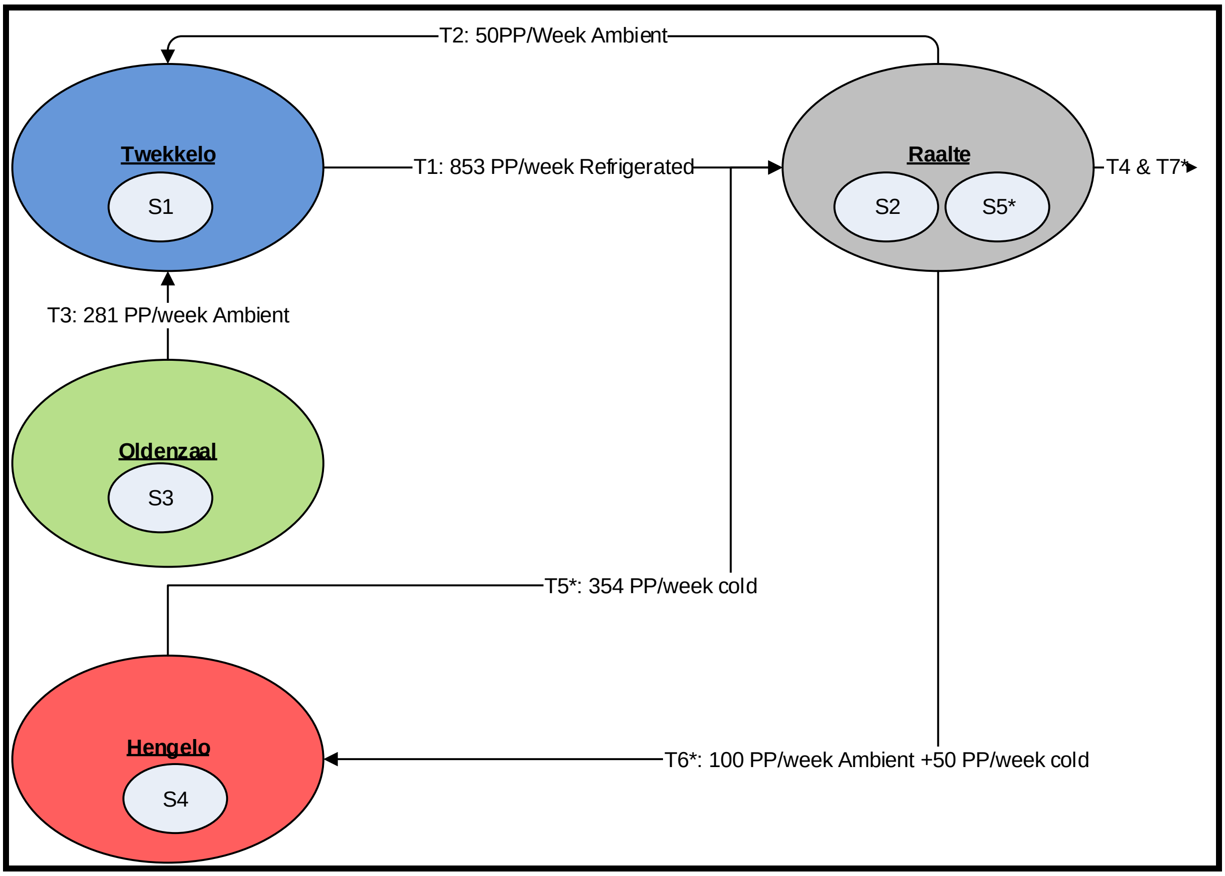


Figure 4-2 overview scenario 1: Holten closes → VDP storage location in Raalte

S4: Storage of end products and raw materials/packaging of VDP desserts in Hengelo

We assume that this alternative scenario does not change the amount of stock kept in Hengelo at the production location, because still raw materials and packaging are needed for production and end products have to cool down and have to be kept in stock before they can be transported. So the amount of pallets on stock will be the same as in the current situation, see table 4-1.

	What has to be stored?	Costs per PP/ day	# of PP on average in stock	Costs per year
S4: Hengelo	End products	€0.20	115	€ 6,387.50
S4: Hengelo	Raw materials/ packaging	€0.07	250	€ 8,395.00
Total storage cost VDP Desserts				**€ 14,782.50**

Table 4-1 Overview storage costs in Hengelo, scenario 1

S5*: Storage of end products and raw materials/ packaging in Raalte

In Raalte the average stock levels will be the same as the average stock levels were in Holten both for the end products and for the raw materials/packaging. In table 4-1 an overview is given of what the storage costs will be in Raalte for Van der Poel Desserts.

	What has to be stored?	Costs per PP/ day	Average # of PP in stock	Costs per year
S5*: Raalte	Raw materials/ packaging	€0.07	922	€ 23,557.10
S5*: Raalte	End products	€0.20	2680	€ 195,640.00
Total storage costs VDP desserts				**€ 219,197.10**

Table 4-2 overview storage costs in Raalte, scenario 1

T5*: Internal inventory movements Hengelo → Raalte

Van der Poel Desserts transported on average 354 PP of end products per week to Holten. This will now go to Raalte at a cost of €4.03 per PP, this is the same cost rate as the transport stream between Twekkelo and Raalte for Zuivelhoeve Vers. The same transport cost rate as Zuivelhoeve Vers can be used because there is no difference in costs between cold and refrigerated transport (see appendix C) and the distance is about the same. So the total internal transport costs per year between Hengelo and Raalte are then € 74,184.24.

T6*: Internal inventory movements Raalte → Hengelo

It is assumed that the transport from Raalte to Hengelo will cost van der Poel nothing, because it can be combined with picking up end products in Hengelo, which is also the case for transport of Zuivelhoeve Vers from Raalte to Twekkelo in the current situation.

T7.1*Transport Muller, now Nagel

Transport to customers of Van der Poel Desserts that in the current situation went via Muller to the customer, will in scenario 1 go via Nagel. Since the transport cost rates from Nagel in Raalte are already known for customers of Zuivelhoeve Vers in the Netherlands, Belgium and Germany , these cost rates can now also be used to calculate the transport costs to customers of Van der Poel Desserts in these countries. Calculations for the transport costs from Raalte to customers of Van der Poel Desserts can be found in Appendix C. The results of those calculations can be found in table 4-3, these are the yearly transport costs for customers that in the current situation of Van der Poel Desserts were supplied by Muller from Holten and now are supplied by Nagel from Raalte.

	Costs
Costs transport NL	€ 41,249.52
costs transport DE	€ 29,046.29
costs transport BE	€ 42,792.72
costs transport Gross Gerau	€ 50,974.48
Total costs per year	**€ 164,063.01**

Table 4-3 overview transport costs to customers of Van der Poel Desserts first supplied by Muller now via Nagel

<u>T7.2* transport that first went via Overnight</u>

For transport to customers that in the current situation went via Overnight, there are to options for how it can go in this scenario:

T7.2 Transport Overnight, now Nagel*

Transport to customers of Van der Poel Desserts that in the current situation went via Overnight will now go via Nagel in Raalte, which means that just as for customers that were first supplied via Muller(T7.1*) ,also the transport costs to these customer can be calculated by using the transport cost rates of Nagel to customers of Zuivelhoeve Vers (see appendix C for calculations).
Transport costs to those customers will now be € 80,469.59.

T 7.2 Transport Overnight, stays via Overnight*

Transport to the customer that first went via overnight, stays going via overnight. The only change is that now first goods have to be transported from Raalte to Osnabruck instead of Holten to Osnabruck.
Transport costs from Raalte to Osnabruck are (see appendix C for calculations): € 29,313.37.
The transport costs from Osnabruck to the customer were already calculated in the current situation of Van der Poel Desserts, those were: € 64,726.78.
So the total transport costs to the customer for this option are : € 94,040.15

From those two options of transport overnight, is transport via Nagel the best/ cheapest option.

<u>B1: Building the expansion</u>

There are costs involved for expanding the warehouse in Raalte, these are €30000 for furnishing the warehouse and €40000 per year for rent. (Hannink, 2015)

Conclusion

The costs for all operation activities have now been calculated. In table 4-4 an overview is given of those costs and the total operational costs per year.

Operational activity	Costs
Storage in Hengelo	€ 14,782.50
Storage in Raalte	€ 219,197.10
Total storage costs	**€ 233,979.60**
Transport from the production location to the warehouse	€ 74,184.24
Transport from the warehouse to the distribution center(s)	-
Transport from the warehouse to the production location	-
Transport from the distribution center(s) to the customer	€ 244,532.60
Total operational costs	**€ 552,696.44**
One-off costs buying land	€ -
One-off costs Building warehouse	€ 30,000
Rent (yearly)	€ 40,000

Table 4-4 Overview costs for operational activities scenario 1

4.2 Holten closes → VDP desserts storage location in Hengelo (Westermaat)

Another Scenario that Roerink Food Family had in mind for storage of Van der Poel Desserts is building a new storage location of 3000m^2 in Hengelo (Westermaat). Which means that the storage location will just be 10 kilometers away from Van der Poel Desserts production location in Hengelo, this scenario is shown in figure 4-4. In the following list the operational activities for scenario 2 are shown, activities marked with a star are changes with respect to the current situation of Van der Poel desserts:

- S4: storage of end products and raw materials/packaging of Van der Poel Desserts in Hengelo (production location)
- S5*: storage of end products and raw materials/packaging of Van der Poel Desserts in Hengelo (Westermaat)
- T5*: internal inventory movements Hengelo production location → Hengelo storage location
- T6*: internal inventory movements Hengelo storage location → Hengelo production location
- T5.1*: transport from the warehouse in Hengelo to the distribution center of Nagel in Raalte
- T5.2*: transport from the warehouse in Hengelo to the distribution center of Nagel in Borgholzhausen

- T7.1*: transport to customers in the Netherlands and Belgium that first went via Muller to the customer will in this scenario go via Nagel in Raalte to the customer
- T7.2 *: Transport to customers in Germany that first went via Muller and Overnight will in this option both go via the distribution center of Nagel in Borgholzhausen to the customer
- B1: building the warehouse in Hengelo

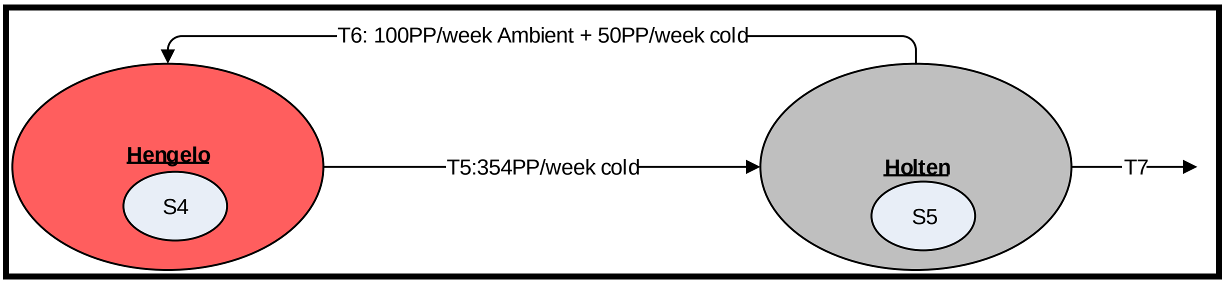


Figure 4-3 Overview of the current situation of Van der Poel Desserts

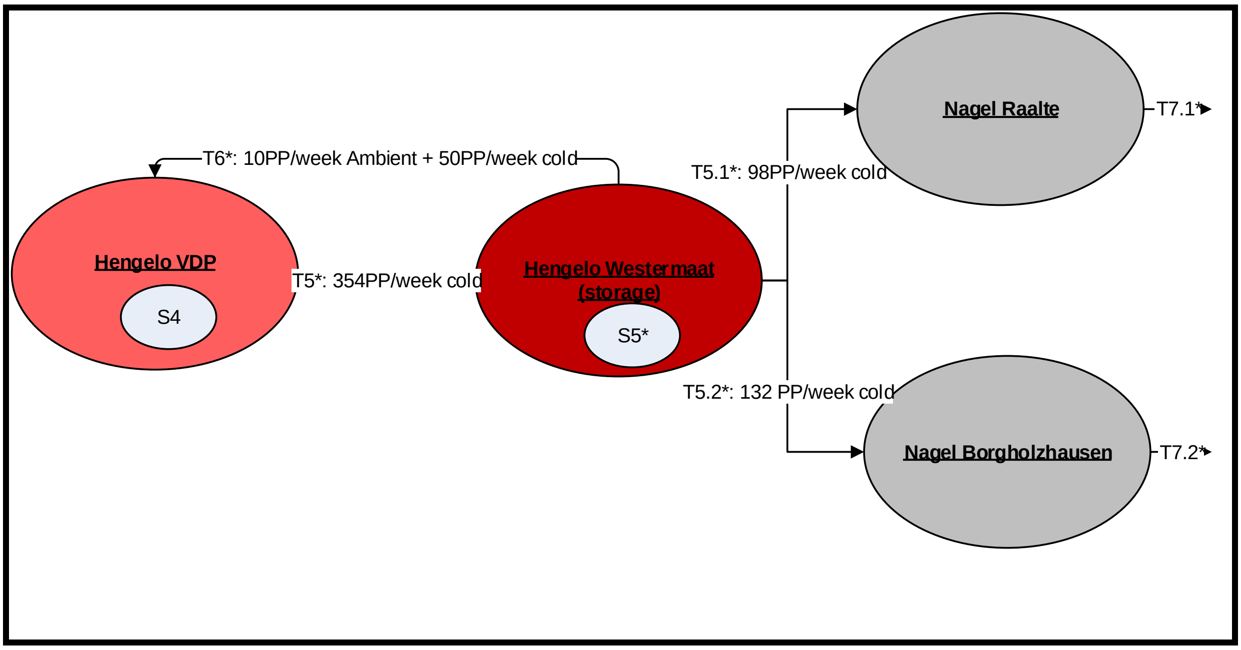


Figure 4-4 Overview scenario 2: Holten closes → VDP desserts storage location in Hengelo (Westermaat)

S4: Storage of end products and raw materials/packaging of VDP desserts in Hengelo

We assume that also for this alternative scenario the amount of stock kept in Hengelo at the production location does not change, because still raw materials and packaging are needed for production and end products have to cool down and have to be kept in stock before they can be transported. So the amount of pallets on stock will be the same as in the current situation, see table 4-5.

	What has to be stored?	Costs per PP/ day	# of PP on average in stock	Costs per year
S4: Hengelo	End products	€0.20	115	€ 6,387.50
S4: Hengelo	Raw materials/ packaging	€0.07	250	€ 8,395.00
Total storage cost VDP Desserts				**€ 14,782.50**

Table 4-5 Overview storage costs at production location in Hengelo for scenario 2

S5*: Storage of end products, raw materials and packaging in Hengelo (Westermaat)

In Hengelo (Westermaat) the average stock levels will be the same as the average stock levels of Van der Poel Desserts were in Holten. When a storage location is owned by Roerink Food Family, storage costs are always €0.07 per PP/day for ambient and refrigerated storage and €0.20 per PP/day for cold storage. In table 4-6 an overview is given of what the storage costs will be at the warehouse in Hengelo for Van der Poel desserts.

	What has to be stored?	Costs per PP/ day	Average # of PP in stock	Costs per year
S5*: Hengelo (warehouse)	Raw materials/ packaging	€0.07	922	€ 23,557.10
S5*: Hengelo (warehouse)	End products	€0.20	2680	€ 195,640.00
Total storage costs VDP desserts				**€ 219,197.10**

Table 4-6 Overview storage costs at the warehouse in Hengelo for scenario 2

T5*: Internal inventory movements Hengelo production location → Hengelo storage location

Van der Poel Desserts transported on average 354 pallet places of end products per week to Holten. This will now go to Hengelo at a cost of €0.09 per PP/kilometer (see appendix D for calculations). Since the distance is about 10 kilometer, the total internal transport costs per year to the storage location are then: €17,306.40.

T6*: internal inventory movements Hengelo storage location → Hengelo production location

Every week 100 PP of packaging (ambient transport) and 50 PP of raw materials (cold transport) are transport from Holten to Hengelo in the current situation. In the new scenario these internal inventory movements take place between the storage location in Hengelo and the production location in Hengelo. The cost rate per pallet per kilometer for internal transport was €0.09 (see appendix D,T5*) and the distance to be covered is about 10 kilometer. So the transport costs for these internal inventory movements are:€ 7,333.22

T5.1*: Transport from the warehouse in Hengelo to the distribution center of Nagel in Raalte

Transport to customers in the Netherlands and Belgium that first went via Muller will now go via Nagel in Raalte to the customer. So first the goods must be transported from Hengelo to the distribution center of Nagel in Raalte. Since in the current situation the cost rate from Hengelo to Raalte was already known to be € 4.03 per pallet place and there is no difference in costs for refrigerated and cold transport, this rate can also be used in this situation.
All we have to know now to calculate the transport costs between the warehouse in Hengelo and the distribution center of Nagel in Raalte are the average number of pallets transported per week to those customers in the Netherlands and Belgium. In appendix D this average number per week is calculated to be 98 pallet places. This will have as a result that the transport costs per year between the warehouse and the distribution center of Nagel in Raalte will be €20,516.73.

T5.2*: Transport from the warehouse in Hengelo to the distribution center of Nagel in Borgholzhausen

Transport to customers in Germany that first went from Holten via Muller and Overnight, will now go both from the warehouse in Hengelo to the distribution center of Nagel in Borgholzhausen and from there to the customer. Which means for T5.2* that all the pallets transported in a year to those customers in Germany first have to be transported from the warehouse in Hengelo to the distribution center of Nagel in Borgholzhausen.
The transport cost rate for internal transport is €0.09 per pallet per kilometer, this also used for T5* and T6*. What we need to know now for calculating the total transport costs to Borgholzhausen are the distance to be covered and the average number of pallets transported per week between Hengelo and Borgholzhausen The distance between the warehouse in Hengelo is and the distribution center in Borgholzhausen has been looked up in Google Maps and is 125 kilometer.
The average number of pallet places transported per week is calculated in appendix D and is 132 pallet places per week.
This will have as a result that the transport costs per year between the warehouse and the distribution center of Nagel in Borgholzhausen will be € 80,641.92.

T7.1*: Transport to customers in the Netherlands and Belgium that first went via Muller to the customer will now go via Nagel in Raalte to the customer

This transport stream means that transport to every customer of Van der Poel Desserts in the Netherlands and Belgium will now go via the distribution center Nagel in Raalte to the customer. The transport costs from Raalte to customers of Van der Poel desserts in Belgium and the Netherlands were already calculated in scenario 1, and since there are no changes in the amount of pallet places transport to those customers, these costs can also be used for this scenario, see table 4-7.

	costs
Transport costs Customers NL	€ 41,249.52
Transport costs customers BE	€ 42,792.72
Total transport costs per year	**€ 84,042.24**

Table 4-7 Overview transport costs to customer in Belgium and the Netherlands for scenario 2

T7.2 Transport to customers in Germany

Transport to customers in Germany that first went from Holten via Muller and Overnight, will now go both from the distribution center of Nagel in Borgholzhausen to the customer. Transport cost rates from Borgholzhausen to customers in Germany can be calculated by using the transport cost rates of Zuivelhoeve Vers to their customers and the distances to their customers. In appendix D these calculations are executed and explained and the following transport costs are the result of those calculations:

	Costs
Transport costs, customers first via Muller	€ 63,971.95
Transport costs, customers first via Overnight	€ 94,261.08
Total transport costs per year T7.2*	**€ 158,233.03**

Table 4-8 transport coststo customer in Germany T7.2 , scenario 2

B1: Building a warehouse in Hengelo

Building the warehouse can be separated into two expenses, costs for buying the land and cost for building the warehouse.

Buying the land: Costs for buying the land are in Hengelo €150 per m^2 (de Haan, 2015) For the warehouse 2 hectare of land is necessary. So costs for buying the land are: €3,000,000.00.

Building the warehouse: The costs per m^2 for building the warehouse are €1000 per m^2 (de Haan, 2015) and the warehouse should be 3000m^2. So total costs for building the warehouse are: € 3,000,000.00.

Conclusion

All operation costs for scenario 2 have been calculated, in table 4-9 an overview is given of those costs.

Operational activity	costs
Storage Hengelo (production location)	€ 14,782.50
Storage Hengelo (Westermaat)	€ 219,197.10
Total storage costs	€ 233,979.60
Transport from the production location to the warehouse	€17,306.40
Transport from the warehouse to the distribution center(s)	€ 101,158.65
Transport from the warehouse to the production location	€ 7,333.22
Transport from the distribution center(s) to the customer	€ 242,275.27
Total operational costs	€ 602,053.14
One-off costs buying land	€3,000,000.00
One-off costs Building warehouse	€3,000,000.00

Table 4-9 Overview total costs for all operational activities of scenario 2

4.3 Expansion Twekkelo →Zuivelhoeve Vers storage in Twekkelo

Roerink Food Family is thinking of building extra storage capacity next to its production location in Twekkelo. The result of this expansion is that there will be 900 PP of extra ambient storage, 530 PP of cold storage and 2250 PP of refrigerated storage. This implies that all storage of Zuivelhoeve in Raalte and Oldenzaal, as it was in the current situation(figure 4-5), has to move to Twekkelo. In figure 4-6 an overview is given of the new situation for Zuivelhoeve Vers.

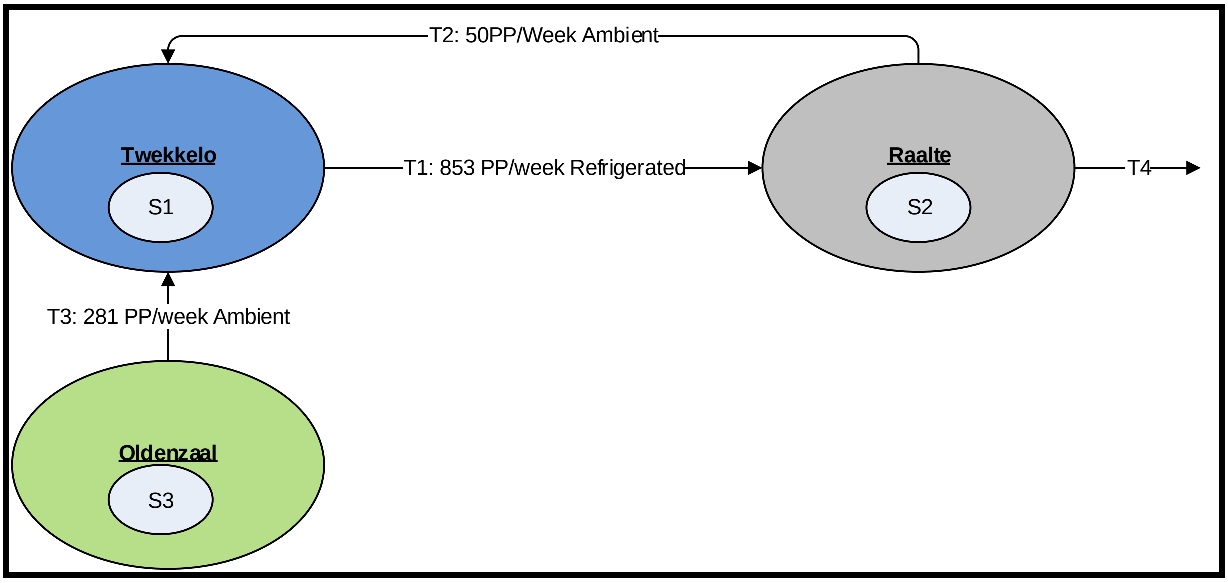


Figure 4-5 Overview current situation Zuivelhoeve Vers

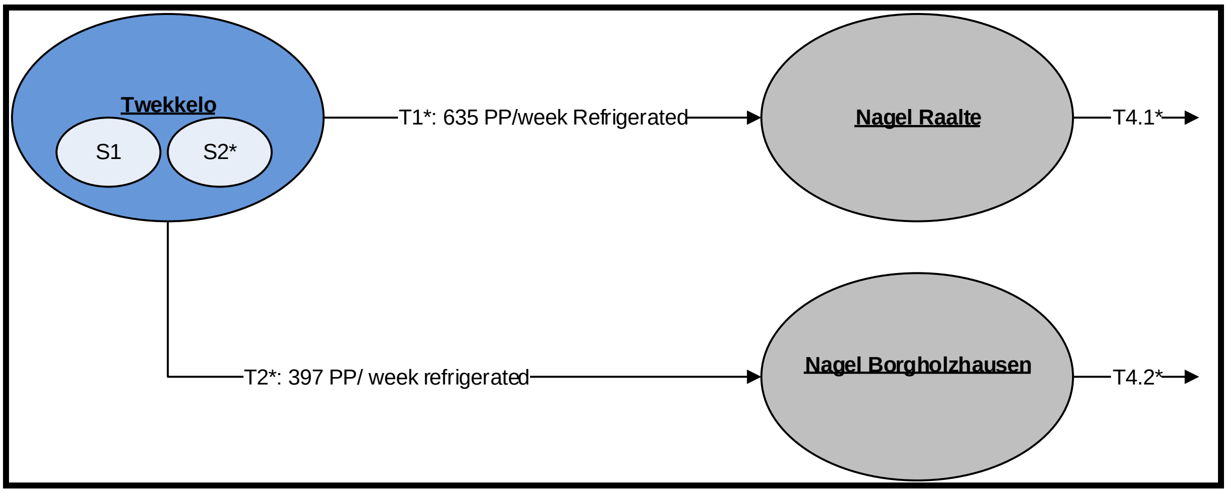


Figure 4-6 Overview Scenario 3: Expansion Twekkelo

For Zuivelhoeve Vers the operational activities are as follows in scenario 3:

- S1: storage of end products and raw materials/ packaging of Zuivelhoeve Vers at the production location in Twekkelo
- S2*: Storage of end products and raw materials/ packaging of Zuivelhoeve Vers at the warehouse in Twekkelo
- T1*: Internal transport between the warehouse and Twekkelo and the distribution center of Nagel in Raalte
- T2*: Internal transport between the warehouse and Twekkelo and the distribution center of Nagel in Borgholzhausen
- T4.1*: From Nagel in Raalte the end products are transported to the customers in the Netherlands and Belgium
- T4.2*: From Nagel in Borgholzhausen the end products are transported to the customers in Germany
- B1: Building the warehouse in Twekkelo

S1: storage of end products and raw materials/packaging of Zuivelhoeve Vers at the production location in Twekkelo

In the current situation, see section 3.3, raw materials/ packaging were stored at the production location in small amounts, so that they were immediately available to be used in the production process. Also end products were stored at the production location, because they first had to cool down before they could be moved (in case of yoghurt) or they had to wait to be transported to the warehouse. It is assumed that this will not change for the new situation, so storage costs per year at the production location is the same as it was for the current situation (see table 4-10).

	What has to be stored?	Costs per PP/ day	Average # of PP in stock	Costs per year
S4: Twekkelo	Raw materials/ packaging	€0.07	95	€ 3113.45
S4: Twekkelo	End products	€0.20	92	€ 2409.68
Total storage costs Twekkelo				**€ 5,523.13**

Table 4-10 Overview storage costs Twekkelo, scenario 3

S2*: Storage of end products and raw materials/packaging of Zuivelhoeve Vers in Twekkelo

In the new warehouse in Twekkelo the average stock levels will be the same as the average stock levels of Zuivelhoeve Vers were in Raalte for the current situation. In table 4-11 an overview is given of what the storage costs will be in Twekkelo for Zuivelhoeve Vers

	What has to be stored?	Costs per PP/day	# of PP on average in stock	Costs per year
S2*: Twekkelo(expansion)	End product	€ 0.07	853	€ 21794.15
S2*: Twekkelo (expansion)	Raw material/ packaging	€ 0.07	600	€ 15330.00
Total storage costs Twekkelo (warehouse)				**€ 37,124.15**

Table 4-11 Overview storage costs Twekkelo (expansion), scenario 3

T1*: Internal transport between the warehouse in Twekkelo and the distribution center of Nagel in Raalte

In this new situation, transport cannot go directly from the warehouse to the customer. From the warehouse the end products first have to be transported to distribution center of Nagel (the distributor) in Raalte or in Borgholzhausen in Germany. Transport to customers in Belgium and the Netherlands will go via the distribution center in Raalte and transport to customers in Germany will go via the distribution center in Borgholzhausen. To calculate the yearly transport costs for the internal transport between Twekkelo and Raalte, the average number of pallet places transported per week to the customers in the Netherlands and Belgium must be known. This can be done by summing up all pallets that are transported in a year to these customers and dividing it by 52 weeks (see also appendix E for this calculations). This will come to an average of 635 PP per week. It is assumed that the transport costs between Twekkelo and Raalte are the same as in the current situation, namely €4.03 per pallet. So the yearly transport costs for transport between the ware and the distribution center in Raalte are: €133,070.60.

T2*: Internal transport between the warehouse and Twekkelo and the distribution center of Nagel in Borgholzhausen

As already explained in the previous section about transport stream T1*, transport to customers in Germany goes via the distribution center of Nagel in Borgholzhausen to the customer. Just as for calculating the transport costs between the warehouse in Twekkelo and the distribution center in Raalte, the average number of pallets transported to customers in Belgium and in the Netherland had to be known, also for transport between the warehouse in Twekkelo and the distribution center in Borgholzhausen, the average number of pallet places transported per week to the customers Germany must be known. This can be done by summing up all pallets that are transported in a year to these customers and dividing it by 52 weeks (see appendix E for this calculation). This will come to an average of 397 PP per week. Transport costs from Twekkelo to Borgholzhausen are based on known transport cost rates for internal transport and their distances (for example Twekkelo-Raalte and Oldenzaal-Raalte), see appendix E for calculations. The transport costs between Twekkelo and Borgholzhausen are €0.09 per PP per kilometer and the distance to be covered is 128 kilometer. So the yearly transport costs for transport between the ware and the distribution center in Borgholzhausen are: €248,429.95.

T4.1*: From Nagel in Raalte the end products are transported to the customers in the Netherlands, Belgium

In the current situation the end products for customers in the Netherlands and Belgium were also transported from Raalte (by Nagel) to the customer. So the total transport costs per year to these customers do not change for this scenario, compared to the current situation. The yearly transport to customer in Belgium and the Netherlands were:

	Costs per year
Netherlands	€ 604,219.42
Belgium	€ 46,302.65
Total Costs	**€ 650,522.07**

Table 4-12 Overview yearly transport costs to customers in the Netherlands and Belgium, scenario 3

T4.2*: From Nagel in Borgholzhausen the end products are transported to the customers in Germany

Transport from the distribution center in Borgholzhausen to the customer, can be separated into two parts; transport to locations of REWE FL(retail chain) in Germany and transport to other customer in Germany. Recall from the current situation that transport to locations of the retail chain REWE FL could be done at more beneficial transport cost rates from the distribution center in Borgholzhausen to the customer. Assumed is that these rates will hold for the new situation and that therefore the yearly transport costs to these customer are the same as in the current situation.

For calculating the transport costs to other customer in Germany, the known transport costs rates of Raalte to the customers in Germany were used. The transport cost rates and distances of Nagel in Raalte to customers in Germany were looked up and the costs per kilometer were applied to the distances of Borgholzhausen to the customers in Germany (see appendix for calculations). The following transport costs have been calculated:

	Costs per year
Transport costs customers DE	€ 821,737.73
Transport costs customer REWE FL	€ 154,806.16
Total Costs	**€ 976,543.89**

Table 4-13 overview yearly transport costs to customers in Germany, scenario 3

B1: Building the warehouse in Twekkelo

Building the warehouse can be separated into two expenses, costs for buying the land and cost for building the warehouse.

Buying the land: The land is already owned by Roerink Food Family so there are no costs involved for buying the land.

Building the warehouse: We assume that building the warehouse will cost just like the expansion of Van der Poel Desserts (scenario 2), €1000 per m^2. Since the warehouse will be 2500m^2, the total costs for building this warehouse are: €2,500,000.00.

Conclusion

All operational costs for scenario 3 have been calculated, these can all be added up and then the total operational costs for this scenario can be given. In table 4-14 an overview is given of the costs for the different operational activities and the total operational costs.

Operational activity	Costs
storage in Twekkelo (production location)	€ 5,523.13
storage in Twekkelo (warehouse)	€ 37,124.15
Total storage costs	**€ 42,647.28**
Transport from production location to warehouse	-
Transport from warehouse to distribution center(s)	€ 381,500.55
Transport from the warehouse to the production location	-
Transport from the distribution center(s) to the customers	€ 1,627,065.96
Total Operational Costs	**€ 2,051,213.79**
One-off Costs buying land	-
One-off costs Building the warehouse	€ 2,500,000

Table 4-14 Overview operation costs per year, scenario 3

4.4 Conclusion

In this chapter the operational costs per year for three alternative scenarios, regarding the location for the warehouse of Van der Poel Desserts and Zuivelhoeve Vers have been calculated.

In scenario 1, Raalte was investigated as alternative location for the warehouse of Van der Poel Desserts. In scenario 2 we investigated Hengelo (Westermaat) as an alternative location for the warehouse of Van der Poel Desserts and at last in scenario 3, Twekkelo was investigated as alternative location for the warehouse of Zuivelhoeve Vers .

The transport costs between the alternative locations of the warehouse and the production site and to the customer have been based on transport cost rates of the distributor of Zuivelhoeve Vers (Nagel).

To see if another location for a warehouse, proposed in these scenarios, is better than the location of the warehouses in the current, we compared the yearly operational costs of these three alternative scenarios with the operational costs of the current situation (chapter 3).

In table 4-15 the operational costs for Zuivelhoeve Vers are given. We can see in this table that the current situation in which the warehouse is located in Raalte is more profitable than the alternative scenario (scenario 3) in which the warehouse is located in Twekkelo (operational costs of € 1,933,904.87 versus € 2,051,213.79 per year). It is not surprising that the warehouse in Raalte is a more profitable option than the warehouse in Twekkelo, because the distribution center of Nagel in Raalte is located very close to the warehouse. Which has as a result that because of this small distance, transport costs from the warehouse to the distribution center can be neglected.

Operational activity	scenario 3: Expansion Twekkelo	current situation Zuivelhoeve Vers
storage in Twekkelo (production location)	€ 5,523.13	€ 5,523.13
Storage warehouse	€ 37,124.15	€ 37,124.15
Total storage costs	**€ 42,647.28**	**€ 42,647.28**
Transport from production location to warehouse	-	178,708.55
Transport from warehouse to distribution center(s)	€ 381,500.55	-
Transport from the warehouse to the production location	-	35,458.45
Transport from the distribution center(s) to the customers	€ 1,627,065.96	€ 1,677,090.59
Total Operational Costs	**€ 2,051,213.79**	**€ 1,933,904.87**
One-off Costs buying land	-	-
One-off costs Building the warehouse	€ 2,500,000	-

Table 4-15 Overview operational costs of scenario 3 versus operational costs of the current situation

In table 4-16 the operational costs of Van der Poel Desserts are given. We can see in this table that the scenario in which the warehouse for Van der Poel Desserts is located in Raalte (scenario 1), is also the most profitable scenario. The operational costs per year for this scenario are € 552,696.44 versus € 602,053.14 of scenario 2 and € 824,902.09 of the current situation. Even when we look at the one off costs and the rent of scenario 1, this is still the most profitable option compared to the other locations. Which is also not surprising, because of the fact that costs between the warehouse and the distribution center can be neglected when the warehouse is located in Raalte. This is due to the close proximity between the warehouse and the distribution center in this scenario.

Operational activity	scenario 1: Expansion Raalte	Scenario 2: Building warehouse in Hengelo	Current situation VDP Desserts
Storage Hengelo (production location)	€ 14,782.50	€ 14,782.50	€ 14,782.50
Storage warehouse	€ 219,197.10	€ 219,197.10	€ 348,246.40
Total storage costs	€ 233,979.60	€ 233,979.60	€ 363,028.90
Transport from the production location to the warehouse	€ 74,184.24	€ 17,306.40	€ 69,727.27
Transport from the warehouse to the distribution center(s)	-	€ 101,158.65	-
Transport from the warehouse to the production location	-	€ 7,333.22	€ 42,900.00
Transport from the distribution center(s) to the customer	€ 244,532.60	€ 242,275.27	€ 349,245.92
Total operational costs	**€ 552,696.44**	**€ 602,053.14**	**€ 824,902.09**
One-off costs buying land	€ -	€ 3,000,000.00	-
One-off costs Building warehouse	€ 30,000.00	€ 3,000,000.00	-
Rent	€ 40,000.00		

Table 4-16 Overview operational costs of scenario 1 and 2 versus operational costs of the current situation

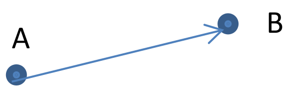
5 Alternative Scenarios: Location-allocation model

The following two scenarios that are explained in the next sections, are based on the outcomes of the location-allocation model. These are scenarios 4 & 5:

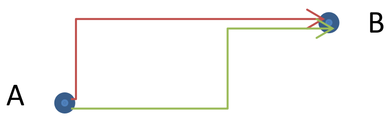
- Scenario 4: The location-allocation model: VDP Desserts
- Scenario 5: The location-allocation model: Zuivelhoeve Vers

Location-allocation models are used for calculating an optimal location on the basis of minimizing the transport costs (Van Goor & Visser). For Zuivelhoeve Vers and Van der Poel Desserts we want to know what the most ideal location is for a warehouse based on the existing transportation costs to the customers and the production locations. There are different models to calculate the optimal location. In this research we used two models to see if they have the same optimal location as an outcome:

- Using Euclidean (straight line) distances, using this manner there is only one way to get from point A to point B.



- Or using Manhattan distances, using this manner there are multiple ways to get from point A to point



A drawback of these location- allocation models are that they only focus on the transportation costs per unit or quantity per km that is transported and it should be kept in mind that there are many more factors that play a role in the choice of a location, like the infrastructure, the possibilities of the distributor and the wishes of the personnel.
That is why these location-allocation model for this research can only take into account the transportation costs from the production location to the warehouse and the costs from the warehouse to the customer. But in real-life, since transportation is outsourced, transport from the warehouse does not go directly to the customer, but via a distribution center of the distributor and costs are involved for this extra stop. That is why for scenarios 4 and 5 in the next two sections the ideal and the realistic situation will be given.
As already said for the location-allocation models, the cost per unit (in this case per pallet place) per kilometer must be known from the production location to the warehouse and from the warehouse to the customers , in appendix F the calculations here for can be found .
The customers are clustered together in different groups, in Germany customers are clustered based on their postal code, in the Netherlands based on their location, and in Belgium all customers are clustered together. The costs per pallet per kilometer are calculated by taking the average costs per pallet per kilometer of all customers in a cluster.

The clusters are placed on a land map that is covered by a coordinate system with boxes of 1 by 1 cm, where 1 cm is equal to 58.8 kilometers. Once this is done the costs per pallet per km to a cluster of customers are known.
What we need to know now is the location for which the total transport cost are minimalized. This can be done in two ways, the successive approximation method for Euclidean distances and the exact method for Manhattan distances.
Both this manners are used the calculate the optimal location for the warehouse and their associated transport costs. In the next sections, first the Euclidean distances are explained and then the Manhattan distances are explained.

Euclidean Distances
For calculating the coordinated of the optimal location using Euclidean distances, the successive approximation method is used. This is an exact method to calculate the optimal coordinates for the warehouse.
First some equations used for this method are explained and then the method itself will be explained in steps.

The total transport costs per year using Euclidean distances can be calculated using the following equation. In this equation X,Y are the coordinated of the optimal warehouse and X_i and Y_i are the coordinates of the clusters and the production location

$$Z(X,Y) = \sum_{i=1}^{n} D_i * R_i * d(X_i, Y_i; X, Y) = \sum_{i=1}^{n} W_i * d(X_i, Y_i; X, Y) \qquad \textbf{5.1}$$

In equation 5.1 the distances from the warehouse to a cluster of customers or to the production location are given as $d(X_i, Y_i; X, Y)$. Using the Euclidean distances this part stands for the following equation:

$$d(X_i, Y_i; X, Y) = \sqrt{((X_i - X) * \ (X_i - X) + (Y_i - Y) * (Y_i - Y))} \qquad \textbf{5.2}$$

The minimum of the costs function Z(X,Y) can be found by taking the partial derivative to both coordinates of the optimal location (X and Y) and set the found equations equal to zero

$$\sum_{i=1}^{n} \frac{w_i * (Xi - X)}{d(X_i, Y_i; X, Y)} = 0 \qquad \textbf{5.3}$$

$$\sum_{i=1}^{n} \frac{w_i * (Xi - X)}{d(X_i, Y_i; X, Y)} = 0 \qquad \textbf{5.4}$$

These equations can be circumscribed to the following equations:

$$X = \frac{\left(\sum_{i=1}^{n} \frac{w_i * Xi}{d(X_i, Y_i; X, Y)}\right)}{\left(\sum_{i=1}^{n} \frac{w_i}{d(X_i, Y_i; X, Y)}\right)} \qquad \textbf{5.5}$$

$$Y = \frac{\left(\sum_{i=1}^{n} \frac{w_i * Yi}{d(X_i, Y_i; X, Y)}\right)}{\left(\sum_{i=1}^{n} \frac{w_i}{d(X_i, Y_i; X, Y)}\right)} \qquad \textbf{5.6}$$

Now that all equations have been given, the successive approximation method to find the optimal location of the warehouse can be explained as follows:

1. Choose a starting location P^0. This location is chosen using the approximation method for Euclidean distances, it involves the following equations:

$$X = \frac{\sum_{i=1}^{n} D_i * R_i * X_i}{\sum_{i=1}^{n} D_i * R_i} \quad \textbf{5.7}$$

$$Y = \frac{\sum_{i=1}^{n} D_i * R_i * Y_i}{\sum_{i=1}^{n} D_i * R_i} \quad \textbf{5.8}$$

2. Substitute the found coordinates of step one for X and Y in the right hand of equations 5.5 and 5.6. From this, in the left-hand side of the equations there are new values for the coordinates of the warehouse, P^1.
3. Repeat this step as many times until the coordinates P^k are almost unchanged from the previous coordinates P^{k-1}. This is the optimal location for the warehouse.

For calculating the transport costs for the optimal location, the cost function Z(X,Y) can be filled in and this has to be multiplied by 58.8. This must be done since 1 cm of the coordinate system is equal to 58.8 kilometers.

Manhattan distances
Straight line distances can strongly underestimate the real distances, this can have an effect on the found optimal location. Therefor also Manhattan distances are often used as distance measures.
Manhattan distances from the warehouse to the clusters of customers and to the production location, can be calculated using the following formula:

$$d(X_i, Y_i; X, Y) = |X - X_i| + |Y - Y_i| \quad \textbf{5.9}$$

The total transport costs per year are defined as:

$$Z(X,Y) = Z_1(X) + Z_2(Y) = \sum_{i=1}^{n} w_i * |X - X_i| + \sum_{i=1}^{n} w_i * |Y - Y_i| \quad \textbf{5.10}$$

This cost function Z(X,Y) can be divided into two separate parts , of which the first part is depends only on X and the second part only on Y. These two parts can be minimized exactly, independently of each other. The optimal X- coordinate can be found using $Z_1(X)$ and the optimal Y-coordinate can be found using $Z_2(X)$. The cost functions can be set out in a graph and the optimal coordinates can be read from the graph.

For calculating the transport costs for the optimal location, the cost function Z(X,Y) can be filled in and this has to be multiplied by 58.8. This must be done since 1 cm of the coordinate system is equal to 58.8 kilometers.

5.1 Location –allocation model: Van der Poel Desserts

In this section the different location-allocation models are applied to find the optimal warehouse location for Van der Poel Desserts. As already explained in the previous section, these model do not take into account the preferences of the distributor, therefore two situations are explained: first the ideal situation were the distributor can directly transport goods from the warehouse to the customer is evaluated and in the next section the realistic situation is explained where the distributor first has to transport the goods from the warehouse to the distribution center and from there to the customer, which involves additional costs.

5.1.1 Ideal situation location-allocation model: Van der Poel Desserts

For both methods(Euclidean and Manhattan distance), we start with calculating the transport costs per pallet per km for the production location and each customer, these calculations can be found in appendix F. When this is done, the customers are clustered in groups and placed on a land map covered by a coordinate system, see figure 5-1.

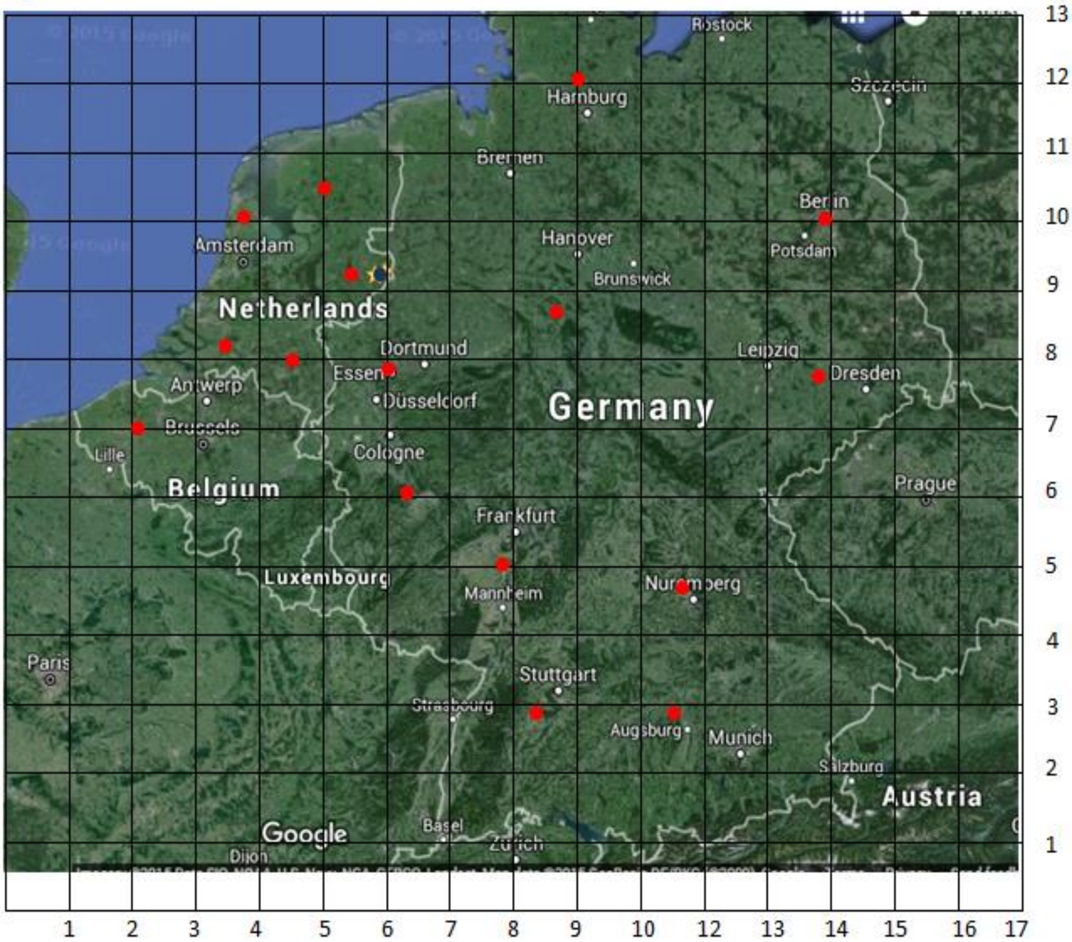


Figure 5-1 Coordinate system for Center of gravity method Van der Poel Desserts

In figure 5-1 the customers are indicated with a red dot and the production location is indicated with a blue dot. For each cluster of customers and the production location the costs per pallet per km, the total number of pallets transported in a year and the X and Y coordinate are given.

When all necessary data is found or calculated, we can start by finding our optimal location for the warehouse and the associated costs using the two different methods. First we will use the method for Euclidian distances and after that the method for Manhattan distances, calculations can be found in appendix F.

Euclidian Distances
The successive approximation method, we use to find an optimal location for the Euclidian distances, begins by calculating a starting location P^0. This can be done by using equation 5.7 and 5.8. By filling in these equations we get the following starting location:

- X = 5.99
- Y = 8.43

These coordinates can be substituted for X and Y at the right hand side of equations 5.5 and 5.6. When doing this we get at the left hand side of the equation new coordinates for the optimal location, this is P^1. The X and Y of P^1 are respectively 5.85 and 8.96. We can continuously substitute these new coordinates P^k into the right hand side of equation 5.5 and 5.6. The optimal coordinates are found when the new coordinates do not differ much from the previous coordinates P^{k-1}, this is in case of Van der Poel Desserts, when X= 5.9 and Y=9.3.
These coordinates are equal to the coordinates of the production location of Van der Poel Desserts in Hengelo. This makes it that Hengelo is the optimal location for a warehouse for Van der Poel Desserts.

The corresponding transport costs per year for a warehouse at this location can be calculated by filling in equation 5.1 and multiplying this number by the real distance of 58.8 kilometer that corresponds to 1 cm in the grid model. We then get costs of € 352,625.91 per year for transport.

Manhattan Distances
The total transport costs for the Manhattan distances can be calculated using equation 5.10, as a reminder also given below:

$$Z(X,Y) = Z_1(X) + Z_2(Y) = \sum_{i=1}^{n} w_i * |X - X_i| + \sum_{i=1}^{n} w_i * |Y - Y_i|$$

Using this equation, the optimal X-coordinate can be determined by setting Z1(X) out in a graph and the optimal Y- coordinate can be determined by setting Z2(X) out in a graph, see figure 5-2.
What we can see in this graph, is that the Z1(X) and Z2(Y) are minimalized at respectively X= 5.9 and Y= 9.3. Which means that just as for the Euclidian distances also for the Manhattan

distances the optimal coordinates for the warehouse are equal to the coordinates of the production location of Van der Poel Desserts.

The corresponding transport costs per year for this a warehouse at this location can be calculated by filling in equation 5.10 and multiplying this number by the real distance of 58.8 kilometer that corresponds to 1 cm in the grid model. We then get the costs of € 460,693.30 per year for transport.

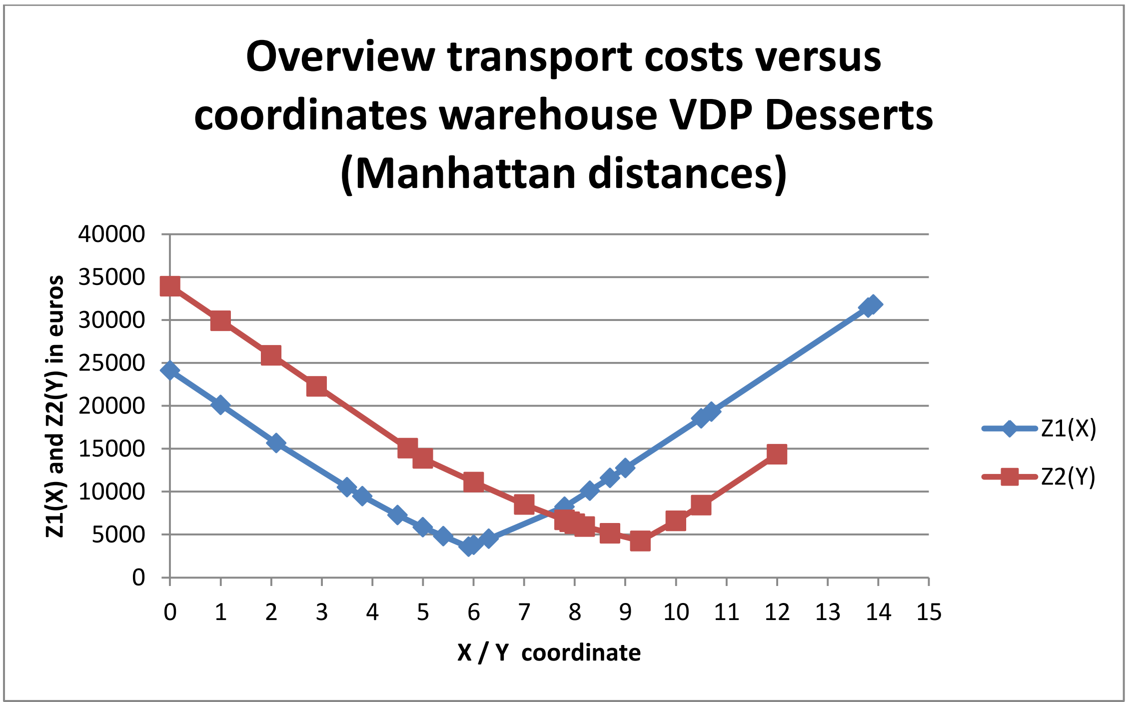


Figure 5-2 Graph used to determine what the optimal X and Y coordinates for warehouse of VDP Desserts are

Since these two methods only calculate the transport costs, we also need to calculate the costs for building the warehouse and the storage costs, for a complete picture of the operational costs per year.

<u>Cost for building a warehouse in Hengelo</u>

Building the warehouse can be separated into two expenses, costs for buying the land and cost for building the warehouse. Since also in scenario 2, the case of building a warehouse in Hengelo for Van der Poel Desserts was treated, we can use the same costs for this situation.

Buying the land: Costs for buying the land are in Hengelo €150 per m^2 (de Haan, 2015)
For the warehouse 2 hectare of land is necessary. So costs for buying the land are: €3,000,000.00.

Building the warehouse: The costs per m^2 for building the warehouse are €1000 per m^2 (de Haan, 2015) and the warehouse should be $3000m^2$. So total costs for building the warehouse are: € 3,000,000.00.

Storage Costs

When a storage location is owned by Roerink Food Family costs for storing ambient or refrigerated goods are €0.07 per pallet per day, costs for storing cold goods are €0,20 per pallet per day.

Production location - Hengelo

Just as in the current situation 115 pallet places of end products (cold) and 250 pallet places of raw materials/ packaging are stored at this site in Coesfeld (refrigerated/ ambient). The costs for storing the products are:

	What has to be stored?	Costs per PP/ day	Average # of PP in stock	Costs per year
Production location	Raw materials/ packaging	€0.07	250	€ 6,387.50
Production location	End products	€0.20	115	€ 8,395
Total storage costs production location				€ 14,782.50

Table 5-1 Overview storage costs production location, ideal situation scenario 4

Warehouse-Hengelo

In the current situation the average stock in Holten of 2680 pallets of end products and of 922 pallet places of raw materials/ packaging, will now be stored in Hengelo at a cost of €0.20 and €0.07 respectively. So the costs per year for storing these products in Hengelo are:

	What has to be stored?	Costs per PP/ day	Average # of PP in stock	Costs per year
Warehouse	Raw materials/ packaging	€0.07	922	€ 23,557.10
Warehouse	End products	€0.20	2680	€ 195,640.00
Total storage costs Warehouse				€ 219,197.10

Table 5-2 Overview storage costs warehouse, ideal situation scenario 4

Conclusion

Now that all operational costs have been calculated, we can look at what the total costs for the operational activities are, this is shown in table 5-3:

Operational activity	Euclidian distances	Manhattan distances
Storage in Hengelo	€ 14,782.50	€ 14,782.50
Storage in Coesfeld	€ 219,197.10	€ 219,197.10
Total storage costs	€ 233,979.60	€ 233,979.60
Transport customers & production location	€ 352,625.91	€ 460,693.30
Total operational costs	**€ 586,605.51**	**€ 694,672.90**
One-off costs buying land	€ 3,000,000.00	€ 3,000,000.00
One-off costs Building warehouse	€ 3,000,000.00	€ 3,000,000.00

Table 5-3 Overview operational costs, ideal situation scenario 4

5.1.2 Realistic situation location-allocation model: Van der Poel Desserts

In the realistic situation the distributor cannot transport goods directly from the warehouse to the customer, but first has to go via a distribution center and then to the customer. Also in the ideal situation for Van der Poel Desserts the model assumes that it is possible to build a warehouse next to the production location in Hengelo, so that transport costs between production location and the warehouse can be neglected. In the realistic situation this is not possible, because there is not enough space to build a warehouse next to the production location. Which means that the warehouse has to be built somewhere else in Hengelo close to the production location.

In scenario 2, the case of building a scenario in Hengelo (Westermaat) was explained, this is a realistic alternative location in Hengelo to build a warehouse for Van der Poel Desserts. Choosing scenario 2 as the realistic situation of scenario 4 has a result that the operational costs per year for the realistic situation of scenario 4 are equal to those of scenario 2:

Operational activity	costs
Storage Hengelo (production location)	€ 14,782.50
Storage Hengelo (Westermaat)	€ 219,197.10
Total storage costs	€ 233,979.60
Transport from the production location to the warehouse	€17,306.40
Transport from the warehouse to the distribution center(s)	€ 101,158.65
Transport from the warehouse to the production location	€ 7,333.22
Transport from the distribution center(s) to the customer	€ 242,275.27
Total operational costs	€ 602,053.14
One-off costs buying land	€3,000,000.00
One-off costs Building warehouse	€3,000,000.00

Table 5-4 Overview operational costs realistic situation scenario 4

5.2 Location-allocation model: Zuivelhoeve Vers

In this section two different location-allocation model are applied to find to optimal warehouse location for Zuivelhoeve Vers. Just like in the previous section, these models do not take into account the preferences of the distributor, therefore also for Zuivelhoeve Vers two situations are explained: first the ideal situation were the distributor can directly transport goods from the warehouse to the customer is evaluated and in the next section the realistic situation is explained where the distributor first has to transport the goods from the warehouse to the distribution center and from there to the customer, which involves additional costs.

5.2.1 Ideal situation location-allocation model: Zuivelhoeve Vers

For both method (Euclidean distances and Manhattan distances), we start with calculating the transportation costs per pallet per km for the production location and each customer, these calculations can be found in appendix F. After that the customers are clustered in groups and placed on a land map, covered by a coordinate system, see figure 5-3. In figure 5-3 the customers are indicated with a red dot and the production location is indicated with a blue dot.

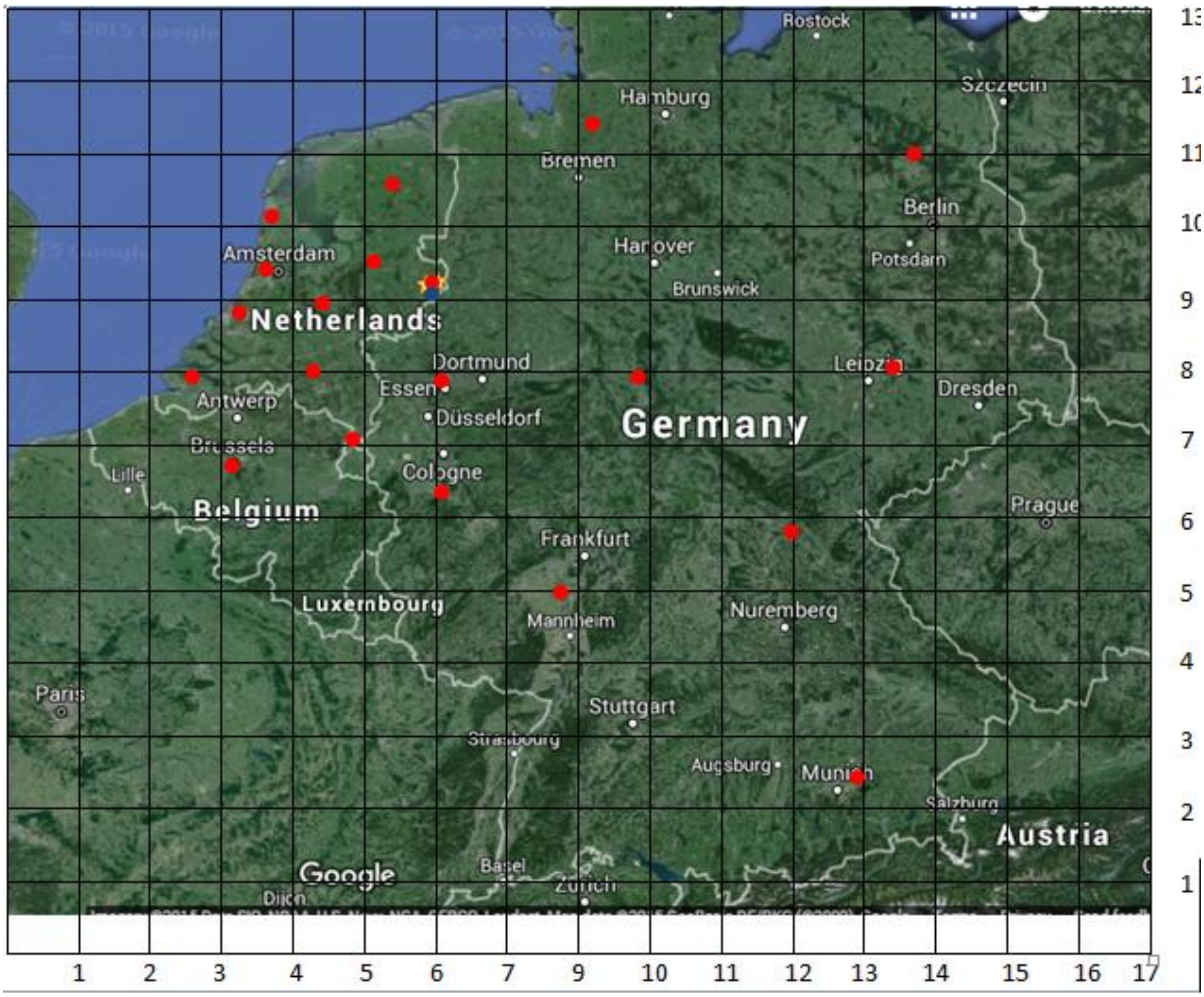


Figure 5-3 Coordinate system for Center of gravity method Zuivelhoeve Vers

For each cluster of customers and the production location the costs per pallet per km, the total number of pallets transported in a year and the X and Y coordinate are given.
When all necessary data is found or calculated, we can start by finding our optimal location for the warehouse and the associated costs using the two different methods. First we will use the method for Euclidian distances and after that the method for Manhattan distances, calculations can be found in appendix F.

Euclidian Distances
The successive approximation method, use to find an optimal location for the Euclidian distances begins by calculating a starting location P^0. This can be done by using equation 5.7 and 5.8. By filling in these equations we get the following starting location:

- X=5.73
- Y=8.8

When we substitute X and Y at the right hand side of equations 5.5 and 5.6 with the coordinates of this starting location, we get at the left hand side of the equation new coordinates for the optimal location(P^1). The X and Y coordinate of P^1 are respectively 5.79 and 9.11. We can continuously substitute these new coordinates P^k into the right hand side of equation 5.5 and 5.6 and get new (better) coordinates The optimal coordinates are found when the new coordinates do not differ much from the previous coordinates, this is in case of Zuivelhoeve Vers, when X= 5.9 and Y=9.2.
These coordinates are equal to the coordinates of the production location of Zuivelhoeve Vers in Twekkelo.

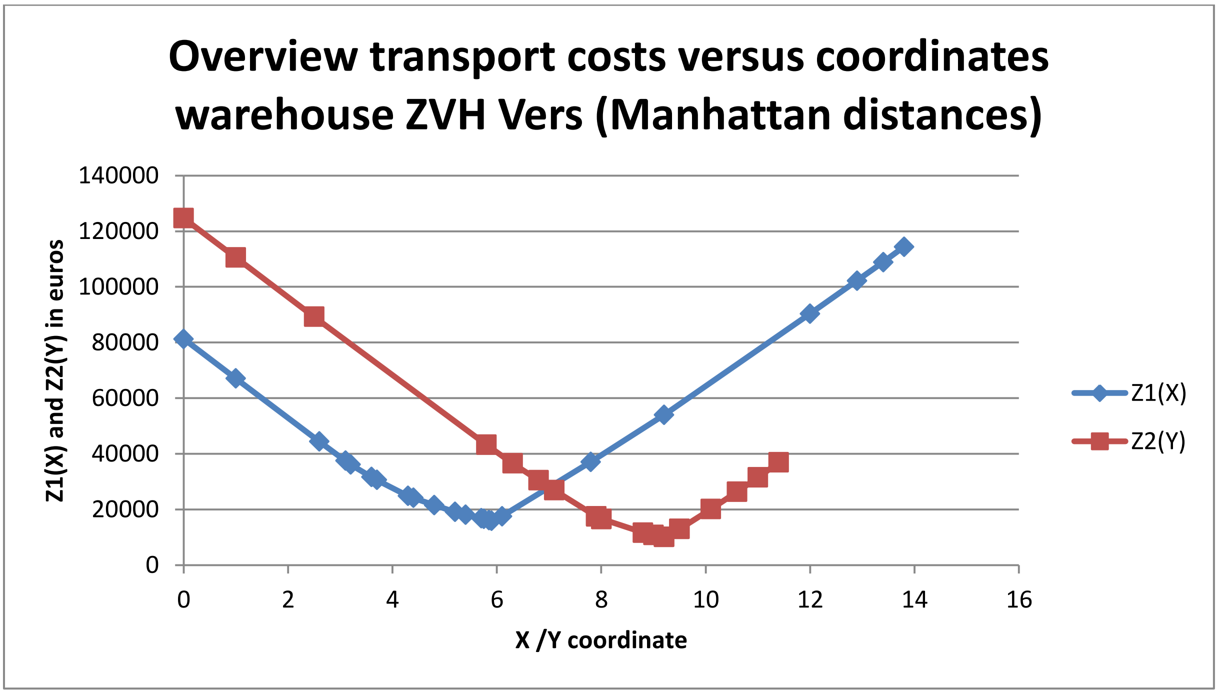
The corresponding transport costs per year for this a warehouse in Twekkelo, can be calculated by filling in equation 5.1 and multiplying this number by the real distance of 58.8 kilometer that corresponds to 1 cm in the grid model. We then get costs of € 1,242,147.74 per year for transport.

Manhattan distances
The total transport costs for the Manhattan distances can be calculated using equation 5.10, as a reminder also given below:

$$Z(X,Y) = Z_1(X) + Z_2(Y) = \sum_{i=1}^{n} w_i * |X - X_i| + \sum_{i=1}^{n} w_i * |Y - Y_i|$$

Using this equation, the optimal X-coordinate can be determined by setting Z1(X) out in a graph and the optimal Y- coordinate can be determined by setting Z2(X) out in a graph, see figure 5-4.
What we can see in this graph, is that the Z1(X) and Z2(Y) are minimalized at respectively X= 5.9 and Y= 9.2. Which means that just as for the Euclidian distances also for the Manhattan distances the optimal coordinates for the warehouse are equal to the coordinates of the production location of Zuivelhoeve Vers.

The corresponding transport costs per year for a warehouse at this location can be calculated by filling in equation 5.10 and multiplying this number by the real distance of 58.8 kilometer that corresponds to 1 cm in the grid model. We then get the costs of €1,535,590.87 per year for transport.



These two methods only calculate the transport costs for the new warehouse location of Zuivelhoeve Vers . For a complete picture of the operational costs per year we also need to calculate the costs for building the warehouse and the storage costs at the production location and the warehouse.

<u>Building a warehouse in Twekkelo</u>

Since also in scenario 3, a warehouse was built next to the production location in Twekkelo, we can use these costs also for this situation
Building the warehouse can be separated into two expenses, costs for buying the land and cost for building the warehouse.

Buying the land: The land is already owned by the director of Roerink Food Family, so there are less costs involved probably then buying land somewhere else. What exactly those costs are, are not known.

Building the warehouse: We assume that building the warehouse will cost just like the expansion of Van der Poel Desserts (scenario 2), €1000 per m^2. Since the warehouse will be $2500m^2$, the total costs for building this warehouse are: €2,500,000.00.

<u>Storage Costs</u>

There is storage of end products and raw materials & packaging at the production of Zuivelhoeve Vers in Twekkelo and at the new warehouse in Twekkelo. When a storage location is owned by Roerink Food Family costs for storing ambient or refrigerated goods are €0.07 per pallet per day, costs for storing cold goods are €0,20 per pallet per day.

Production location - Twekkelo

Just as in the current situation 92 pallet places of end products (refrigerated) and 95 pallet places of raw materials/ packaging are stored at this site in Twekkelo (refrigerated/ ambient). The costs for storing the products are:

	What has to be stored?	Costs per PP/ day	Average # of PP in stock	Costs per year
Production location	Raw materials/ packaging	€0.07	95	€ 3113.45
Production location	End products	€0.20	92	€ 2409.68
Total storage costs Production location				**€ 5,523.13**

Table 5-5 Overview storage costs Twekkelo, ideal situation scenario 5

Warehouse- Twekkelo

In the current situation the average stock of 853 pallet of end products and 600 pallet places of raw materials/ packaging that was stored in Raalte will now be stored in Twekkelo at a cost of €0.20 and €0.07 respectively. So the costs per year for storing these products in Twekkelo are:

	What has to be stored?	Costs per PP/ day	Average # of PP in stock	Costs per year
Warehouse	Raw materials/ packaging	€0.07	600	€ 15,330.00
Warehouse	End products	€0.07	853	€ 21794.15
Total storage costs Warehouse				**€ 37,124.15**

Table 5-6 Overview storage costs Ahaus, ideal situation scenario 5

Conclusion

Now that all operational costs have been calculated, we can look at what the total costs for the operational activities are, this is shown in table 5-7:

Operational activity	Euclidian Distances	Manhattan Distances
Storage in Twekkelo	€ 5,523.13	€ 5,523.13
Storage in Ahaus	€ 37,124.15	€ 37,124.15
Total storage costs	€ 42,647.28	€ 42,647.28
Transport customers & production location	€ 1,242,147.74	€1,535,590.87
Total operational costs	**€ 1,284,795.02**	**€ 1,578,238.15**
One-off costs buying land	-	-
One-off costs Building warehouse	€ 2,500,000.00	€ 2,500,000.00

Table 5-7 Overview operational costs, ideal situation scenario 5

5.2.2 Realistic situation center of gravity method Zuivelhoeve Vers.

In scenario 3 the same situation as the realistic situation of scenario 5 was already explained. In scenario 3 also a warehouse was built next to the production location in Twekkelo. The difference between the ideal situation and realistic situation of scenario 5/ the situation in scenario 3 is that in the ideal situation, goods can be transport directly from the warehouse to the customers. In the realistic situation goods have to be transported from the warehouse to a distribution center and from there goods can be transported to the customer. Which makes the realistic situation of scenario 5 the same as scenario 3. The operation costs involved for the realistic situation of scenario 5 are thus the same as the operational costs of scenario 3:

Operational activity	Costs
storage in Twekkelo (production location)	€ 5,523.13
storage in Twekkelo (warehouse)	€ 37,124.15
Total storage costs	**€ 42,647.28**
Transport from production location to warehouse	-
Transport from warehouse to distribution center(s)	€ 381,500.55
Transport from the warehouse to the production location	-
Transport from the distribution center(s) to the customers	€ 1,627,065.96
Total Operational Costs	**€ 2,051,213.79**
One-off Costs buying land	-
One-off costs Building the warehouse	€ 2,500,000

Table 5-8 Overview operational costs realistic situation scenario 5

5.3 Conclusion

In this chapter for Van der Poel Desserts and Zuivelhoeve Vers the center of gravity method was executed. The center of gravity method pictures an ideal situation for transport between the different locations, it does for example not take into account preferences of customers and distributors. Therefor for both subsidiaries the ideal situation and the realistic situation is explained.

Ideal Situation

Using two different methods, the method for Euclidian distances and the method for Manhattan distances, the optimal location for a warehouse for these subsidiaries are determined. For Van der Poel Desserts and Zuivelhoeve Vers, both methods resulted in the same optimal location for the subsidiaries. For Van der Poel Desserts the ideal optimal location would be next its production site in Hengelo and for Zuivelhoeve Vers the ideal optimal location would be next to its production site in Twekkelo.

The Euclidian distances and Manhattan distances do not result in the same transport costs per year, in most cases transport costs for Euclidian distances are lower than the real transport costs. Therefor the total operational costs differ for both methods:

	Euclidian Distances	Manhattan distances
Operational costs VDP Desserts	€ 586,605.51	€ 694,672.90
Operational costs ZVH Vers	€ 1,284,795.02	€ 1,578,238.15

Table 5-9 Operational costs ideal situation scenario 4 & 5

Before using the center of gravity method it was already expected for both subsidiaries that the optimal warehouse location would be located relatively close to the production location, because all finished products have to be transported to the warehouse. But transport costs from the production location to the warehouse are cheaper and from the warehouse to the customer, therefor it was not expected that the optimal coordinates would be exactly the same as those of the production location.

Realistic Situation

For Van der Poel Desserts in the realistic situation it is not possible to build a warehouse next to the production location because there is not enough space. Also there is not direct transport from warehouse to the customer, goods first have to be transported from the warehouse to a distribution center. From the distribution center goods can be transported to the customer. For Zuivelhoeve Vers it is possible to build a warehouse next to its production location in Twekkelo, only in this situation also costs to the distribution center and from the distribution center to the customer should be included. These realistic adaptions to the ideal situations of scenarios 4 and 5, have as a result that the realistic situation for Van der Poel desserts is the same a scenario 2, explained in the previous chapter. And that the realistic situation for Zuivelhoeve Vers is the same as scenario 3, explained in the previous chapter.

Therefor the operational costs for the realistic situation of scenario 4 and 5 are the same as those of scenarios 2 and 3 respectively.

	Van der Poel Desserts	**Zuivelhoeve Vers**
Operational costs	€ 602,053.14	€ 2,051,213.79
One-off costs buying land	€ 3,000,000.00	-
One-off costs building the warehouse	€ 3,000,000.00	€2,500,000.00

Table 5-10 Overview operationcal costs realistic situation scenario 4 &5

Since the realistic situation of scenarios 4 and 5 are the same as earlier explained scenarios 2 and 3, we decided that in further chapters, scenarios 4 and 5 are omitted.
To know which of the given scenarios should be used in case of future growth, in the next chapter an introduction is given to forecasting stock levels.

6 Forecasting

The design of a new storage capacity plan for Roerink Food Family is based on future stock levels. Which means that these future stock levels must be forecasted for the coming three years.

Forecasting is not unique to capacity/ inventory management. Every business plan becomes effective in some point in the future, which means that such a plan must not be based on current circumstances, but on prevailing circumstances at the time the plan becomes active. Often it is not possible to conclude with certainty what is going to happen in the future, but by using the right way of forecasting, the outcomes are close to expected conditions and plans can be made using this right forecasting information. If forecasts are not accurate, the plans are based on faulty assumptions, which leads to poor results.

Forecasting can give us important information for our storage capacity plan, but in forecasting also information is needed from other sources, see figure 6-1 for an outline of the information flow.

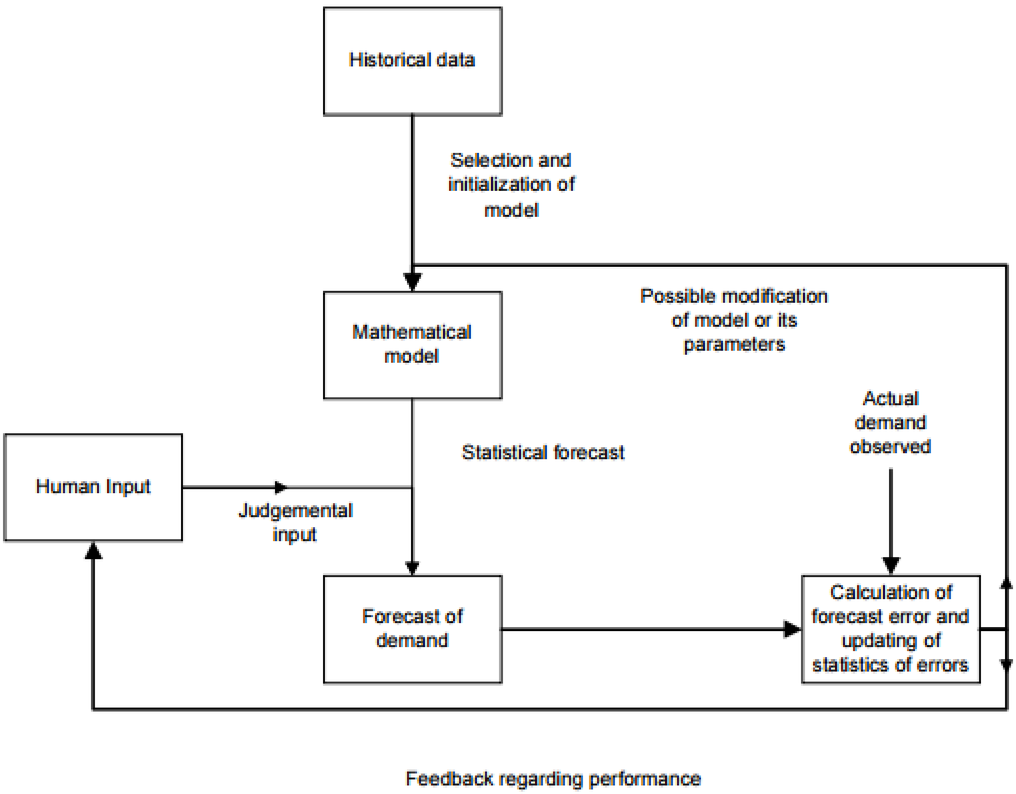


Figure 6-1 Forecasting framework (Silver, Pyke and Peterson)

The first step in forecasting is the collection of historical data and the mathematical model, quality measures and human input will be the next steps. In this chapter the head subject is historical data and thereby the data collection needed for forecasting. Since the historical data is the basis for forecasting it is important to select this in an appropriate way. In the chapter that follows the choice for a mathematical model, quality measures and human input is made.

6.1 Time Series

Forecasts are often based on time series. Time series data are useful in case of forecasting something that is changing over time. A time series is a sequence of observations at regular intervals of time (daily, weekly, monthly) (Yaffee & McGee, 2000). Often patterns can be found in these time series, like trend, seasonal, cyclical and/or irregular patterns. The forecasting model should be able to capture these variations.
For a forecasting model to capture these variations, the time series must be decomposed into separate components and recombined to get the final forecast (Walters, 2003). Each component will be analyzed so that it can be projected into the future. For time series with a regular interval of less than a year, each original value is the multiplicative of the four possible patterns (Hanke & Reitsch, 1998):

$$Y = TSCI \qquad \textbf{6.1}$$

In this equation Y is the original value, T is the trend pattern, S is the seasonal pattern, C is the cyclical pattern and I is the irregular pattern. In the following sections the selection of the historical data is explained and the four patterns are discussed. Also it is explained how the time series can be decomposed regarding to the different patterns.

6.2 Time series: Selecting historical data

To make accurate forecasts for the coming three years the right historical data must be selected. Also there can be some complexities in the historical data that might obstruct the accuracy of the forecast.

6.2.1 Historical Data Zuivelhoeve Vers

Zuivelhoeve Vers has stock of end products and packaging & raw materials in Twekkelo, Oldenzaal and Raalte. So for all these locations ideally future stock levels (in number of pallet places) for Zuivelhoeve are forecasted with weekly measured stock levels of at least the past three years. Unfortunately these data are not directly available for the end products and also not for packaging & raw materials at all locations.
But for the end products due to the short expiration date of almost all Zuivelhoeve Vers end products, the end products that are produced in a week are also sold in a week. Which means that weekly sales numbers are also approximately what was in stock for that week in Raalte (Hannink, 2015).
So weekly sales numbers of the past three years are used to calculate future stock levels of the end products in Raalte. The weekly sales numbers are given in number of CE sold per product in a certain week (See figure 6-2) .

Aantal (CE) als waarden	201401	201402	201403	201404
Appelmoes 5 kg	0	0	0	0
Basis Vla 5kg	0	0	0	0
Bav Aardbei 12x140	624	612	1.008	936
Bav Bitterkoekjes 12x140	816	720	1.272	1.008
Bav Chipolata 12x140	396	1.608	2.352	576
Bav Chocolade 12x140	1.104	840	972	1.200
Boer'n Vla Choco (room) 5 KG	0	0	0	0

figure 6-2

For forecasting future stock levels in number of pallet places, we need to convert the number of CE to the number of pallet places. This can be done using the average number of CE per pallet place in Raalte, which is 1336(see appendix A: "average number of CE per pallet place" for calculations).
The aggregation level (product level used for forecasting) used for forecasting the stock level of the end products, is forecasting all different products together as one product.
Information about the weekly stock levels of packaging & raw materials for all locations are not available and cannot be derived from other data, only an average number of what is in stock is available. We therefore assume that these future stock levels will rise (or fall) with the same percentage as the future stock levels of the end products of Zuivelhoeve Vers in Raalte.

6.2.2 Historical Data Van der Poel Desserts

Van der Poel desserts has stock of end products and raw materials & packaging in Holten and Hengelo. Ideally for forecasting future stock levels, weekly stock levels in number of pallet places of the past three years should be used.
Van der Poel Desserts has only been measuring its stock levels in Holten (for end products and packaging & raw materials separately) since June 2013. So the weekly historical stock levels since June 2013 are used for forecasting the stock level of end products and raw materials & packaging in Holten. Stock levels before June 2013 cannot be derived from for example sales data, because end products have a long expiration date and stock is build up for peak periods like Christmas or Easter.
Stock levels in Hengelo are not measured by Van der Poel Desserts, only an average number of what is in stock is available. Therefore we assume that the future stock levels will rise (or fall) respectively with the same percentage as the future stock levels of the end products and raw materials & packaging in Holten.

6.3 Time Series: Trend Pattern

Trend exists when there is a long-term growth movement of a time series (Hoshmand, 2009). Trend may be increasing, decreasing or steady. It can be drawn as a smooth linear or as a nonlinear trend, like logarithmic or exponential, through a series of data points. Because of its ease and widespread use, the linear trend will only be used. The equation for the linear trend is:

$$\hat{Y} = aX + b \qquad \textbf{6.2}$$

In this equation, a is the slope of the trend, b is the Y intercept (so the value when X=0), $\hat{Y}$ is the predicted trend value for Y and as we are dealing with a time series, X is the time.
To calculate the parameters of this equation linear regression is used and the least squares method is applied. In the least squares method the squared errors are calculated, so by using this method the optimal values for the parameters can be found by minimizing the squared errors.
The squared errors can be calculated by the following formula:

$$R^2 = 1 - \frac{SSe}{SSt} = 1 - \frac{(Y_t - \hat{Y}_t)^2}{(Y_t - \bar{Y})^2} \qquad \textbf{6.3}$$

In this equation R^2(also called the coefficient of determination) is the percentage of the variations that can be explained by trend , Y_t is the actual value, $\hat{Y}_t$ is the trend value, $\bar{Y}$ is the mean of the actual values and t is the period 1,2,3,…,t.
R^2 is a number between 0 and 1, when the value of R^2 is 1, the trend line perfectly fits the data. There is no value of R^2 that indicates a suitable trend line from an unsuitable trend line (Ozer, 1985). The value of R^2 that separates “good” from “bad” depends on the research and on the choice of the researcher.

6.4 Time Series: Seasonal pattern

Seasonality is a regular cyclical pattern, where each cycle repeats the same pattern (Walters, 2003). Two examples in which seasonality is present is when there are certain discount promotions in the same period every year, or when luxury desserts are sold more around Christmas and Easter each year.
Seasonality indexes can be estimated by calculating the moving average method. The moving average can be calculated over n periods, the formula here for is:

$$\bar{Y}_n = \frac{1}{n} * (Y_t + Y_{t-1} + .. + Y_{t-n+1}) \qquad \textbf{6.4}$$

In this equation $\bar{Y}_n$ is the moving average over n periods, n is the number of periods, Y_t are the actual values at time t.

To estimate the seasonal factor according to Hyndman (2015)the most common procedure is the 2 x n- moving average. This means that first the n- period moving average is calculated, and then from these results a 2-period moving average is calculated. This is done to make even order moving average symmetric. As in this research weekly sales/stock levels are used as historical data, a 2 x 52 (yearly) , a 2x 26 (half-yearly), a 2 x 13 (quarterly) or a 2 x 4(monthly) – moving average can be applied.

6.5 Time Series: Cyclical pattern

Cyclical variations are recurrent upward or downward movements with a period greater than a year. These variations are not regular as in seasonality. Cyclical patterns can be calculated using the residual method. This method is based on the multiplicative model of time series (Y=TSCI).

In the residual method al other components need to be removed and what is left is the cyclical pattern. This means that the trend and seasonal components need to be removed according to the methods described in the previous section. So the trend component according to least squares method and linear regression and the seasonal components according to the 2 x 52- moving average method.

The irregular component is in practice impossible to separate from the cyclic pattern, so this component can be omitted (Singh & Singhal, 2009).

This means that the cyclical pattern (including irregular component) can be calculated by the following formula:

$$CI = \frac{Y}{TS} \qquad \textbf{6.5}$$

The seasonal component in this equation can be removed by applying the 2x n moving average method. The trend component in the equation can be removed by rebuilding the equation just for the trend component. So the equation becomes:

$$CI = \frac{2\ x\ n{-}MA}{T} \qquad \textbf{6.6}$$

6.6 Time Series: Irregular Pattern

Irregular variations are variations that are short in duration and follow no regular pattern. These variations are also called residual variations, because these variations are not accounted for by cyclic, trend or seasonal variations. So they refer to what is left out in a time series after cyclical, trend and seasonal variation. As mentioned in the last section, in practice it is not possible to calculate this component, so this component is not considered for further analysis.

6.7 Conclusion

Future stock levels for Zuivelhoeve Vers are determined by forecasting the stock levels for future circumstances. This is done using the forecasting framework (figure 6-1), in this model it can be seen that for an accurate forecast, the right historical data, mathematical model and quality measures must be selected and human judgement is needed. For the historical data it is important to use a time series, this is a sequence of observations at regular intervals of time. Time series must be used, because often in these series patterns (trend,

seasonal, cyclical and irregular) can be found that can be extrapolated into the future. For Zuivelhoeve Vers, historical weekly sales data of 2012 until 2015 are used as a time series to predict future stock levels. For forecasting the stock levels of Van der Poel desserts historical weekly stock levels of the end products and the raw materials & packaging since June 2013 until now are used.
In the following chapter human judgement, the mathematical model and the quality measures for accurate forecasting are explained. When all these necessary factors for forecasting are explained, the mathematical model is applied to the time series.

7 Long-term Forecasting model

In this chapter, the remaining steps of the forecasting framework are explained. These are the choice of the mathematical model, the quality measures and the input of human judgement.

In forecasting no single forecasting technique is always the best, there are many ways of forecasting, many things to forecast and many circumstances in which the forecast will take place. So a method that best suits our needs has to be chosen. This choice can depend on many factors, for example: availability of historical data, type of product, money and time available for forecasting, time period for which the forecasting must take place etcetera. Selecting a forecasting method for a large extend depends on the time period for forecasting (Walters, 2003):

- Short-term forecasts cover a few weeks, most of the time used for scheduling operations and demand.
- Medium-term forecasts cover a period between three months and a year, this is for example used for production planning
- Long-term forecast cover a period of several years, often used to make important managerial decisions a building a new factory.

Since in this research a 3-year period is covered, a long-term forecasting model should be applied.

Forecasting models can be distinguished between quantitative, qualitative and unpredictable forecasting according to Makridakis, Wheelwright and Hyndman (1998). Qualitative forecasting is forecasting based on judgment and accumulated knowledge. It is often used for medium- and long-term forecasting and in combination with a quantitative forecasting method.

Quantitative forecasting methods can be divided into two groups, causal model and time series models. Causal models look for a cause and effect relationship. Time series models use past values to discover a pattern in these historical values and extrapolate this pattern into the future. In this research times series models are used, because we want to find a pattern in the past stock levels and extrapolate this into future stock levels.

The last category in forecasting models, unpredictable forecasting, is when little or no information is available, which is not the case for this research.

To predict the future in the most secure way we make use of a combination of qualitative and quantitative forecasting methods.

7.1 Selecting a forecasting model

A quantitative technique that is often used for forecasting is standard exponential smoothing. It is a very easy and fast technique that can be applied to time series. Although autoregressive integrated moving average (ARIMA) models have been thought of as a more sophisticated method for forecasting, it was showed that these models are just a subset of exponential smoothing methods even though they are more complicated. ARIMA models can be seen as models that try to separate a pattern from the noise and extrapolate this

pattern into the future to obtain a forecast (Duke).
Another method that is used in practice for forecasting is artificial neural networks (ANN). Artificial neural networks are self-adaptive data driven methods that learn from examples and find patterns and underlying relationships (Zhang, Patuwo, & Hu, 1998). The implementation of artificial neural networks is not very easy and in a research of benchmarking forecasting methods(M3-Competition) it showed that artificial neural networks do not outperform standard exponential smoothing techniques (Makridakis & Hibon, 2000).
The artificial neural network method is an advanced forecasting method, other advanced forecasting methods are: Dynamic regression models and vector auto regressions (Hyndman R. J., 2015).
What all methods above have in common is that they are very useful for forecasts up to 12 periods ahead. But in the long-term they do not give very good predictions.
Therefore according to Hanke and Reitsch (1998), long-term forecasts should simply be made by the decomposition of the time series and examining the trend and cyclical component. The trend can exactly be calculated but for the cyclical component a qualitative forecasting method, like applying management judgement is needed to make the most accurate forecast.
In the following sections first the method of decomposition is explained more fully. After that the quality measures for forecast accuracy are explained in section 7.3. And then the historical trend and cyclical effect are calculated using the decomposition of the time series technique. This is done for Zuivelhoeve Vers (end products) and Van der poel Desserts (end products and raw materials/ packaging) separately, respectively in section 7.4, 7.5 and 7.6.

7.2 Chosen Forecast technique: forecasting by decomposition

Forecasting by decomposition is a mixture of a quantitative and qualitative forecasting technique. The forecasting method starts by calculating the moving averages by the four different options (2x52-, 2x26-, 13- or 2x4-MA), using equation 6.4. Using the moving averages the seasonal component can be calculated and the data can be deseasonalized. These deseasonalized data can be used for defining our trend line with a certain linear trend equation (see equation 6.2). For every moving average option there is a different linear trend equation. To evaluate each trend line and to see what percentage of the variations of the historical data can be explained by trend, the coefficient of determination is calculated (see equation 6.3). These scores contribute in choosing the most accurate moving average option for forecasting.
When this is all done, the cyclical component for the historical data can be calculated. This can be done by applying equation 6.6, in this equation the actual historical data is divided by the trend. For future predictions this cyclical component is dependent on managerial decisions and other long-term changes that affect the stock level. For example when management decides to lower safety stocks, this affects the stock level over a long period of time, this change can be seen in the cyclical variation.

When all components are known (seasonal, trend and cyclical), forecasts can be made using equation 6.1. All components can be extrapolated into the future.
But first the most accurate moving average option for the forecast has to be chosen. This can be done by calculating the forecasts until the point in time there is no historical data anymore. Using quality measures (explained in the next section), it can be calculated how well each forecast option describes the historical data, and therefore how well each forecast option will predict the future.

7.3 Quality measures for forecast accuracy

The quality of a forecasting model is measured by applying error-metrics. In error-metrics the model that has the smallest error values is the most suitable in explaining the pattern in the dataset. There are four types of forecast-error metrics (Hyndmand, 2006) :

1. Scale-dependent metrics
2. Percentage-error metrics
3. Relative-error metrics
4. Scale-free error metrics

In section 7.3.1 scale- dependent metrics is discussed. Respectively in section 7.3.2, 7.3.3 and 7.3.4 the other three types of error metrics are explained. The most appropriate model for measuring the forecast accuracy is selected in section 7.3.5.

7.3.1 Scale-dependent error metrics

Scale dependent metrics are the oldest error-metrics method. This method is useful for assessing a model's accuracy on a single time series, since the measures are on the same scale as the data. The forecast error is measured by Y_t-F_t, where Y_t is the observed value and F_t is the forecasted value.
The most commonly used error metrics in this category are:

- MAD (mean absolute deviation) = $\frac{\sum |Y_t - F_t|}{n}$ **7.1**
- GMAE (geometric mean absolute deviation)= geometric mean | $Y_t - F_t$| **7.2**
- MSE (mean squared error)=$\left(\frac{1}{n}\right) * \sum | Y_t - F_t|^2$ **7.3**

Often the MAD is the preferred method in this category of error metrics, because of its simplicity, it is easy to compute and to understand. However it must be kept in mind that these error metrics cannot be compared between series, because they are dependent on the scale. The GMAE is often used in case of intermittent data.

7.3.2 Percentage-error metrics

Percentage error-metrics have the advantage that they are scale independent, but have the disadvantage that they are undefined in case of intermittent data (zero values in the time series). Being scale independent makes these error metrics useful for comparing the quality

of forecasting between data series.
The forecast error for percentage-error metrics is measured by 100*(Y_t-F_t/ Y_t).
The most often used technique in this category is the mean absolute percentage error (MAPE), calculated by

$$\text{MAPE} = \frac{\sum 100\%*(|\, Y_t - F_t / Y_t|)}{n} \qquad \textbf{7.4}$$

A drawback of this method, besides the general drawback of percentage error metrics that they are not useful in case of intermittent data is, that it puts a heavier penalty on positive errors compared to negative errors.
This drawback can slightly be undone by using the symmetric MAPE (sMAPE), but there might still not be correct. Though sMAPE may be a little more secure than MAPE, often MAPE is preferred because it is easier to calculate.

7.3.3 Relative-error metrics

Relative-error metrics is an alternative to percentage- metrics for measuring scale independent metrics. The forecast error is calculated by dividing each error (Y_t-F_t) by the error obtained using a benchmarking method for forecasting. For the benchmark method often a naïve method is used. The naïve benchmark uses the last observation as the new forecast.
Different error metrics used in this category are:

- MdRAE (Median relative absolute error)= median |error/ benchmark error| **7.5**
- GMRAE (Geometric mean relative absolute error)= geometric mean |error/ benchmark error| **7.6**

A drawback of relative-error metrics is that these metrics can also not be used in case of intermittent data. When the naïve benchmark is used, you would be dividing by zero.

7.3.4 Scale-free error metrics

The scale-free error metrics were proposed to be disposed of the drawbacks of the other three categories of error metrics. Scale-free error metrics are thus generally applicable , even for intermittent datasets and between different scales.
The scaled forecast error is calculated by using the naïve method:

$$Q_t = \left(\frac{Y_t - F_t}{\frac{1}{n-1} * \sum |Y_t - Y_{t-1}|} \right) , \qquad \textbf{7.7}$$

Where the nominator is the observed value minus the forecasted value and in the denominator the naïve method is used: Observed value in period t minus observed value in period t-1.
Error metrics used in this category are:

- MASE (mean absolute scaled error) = $\frac{\sum|Q_t|}{n}$ **7.8**

  When MASE is below 1, quality of the forecast is better than when MASE scores above 1
- MAD/ MEAN ratio: this method scales the errors by using the mean instead of the absolute mean error
  - MAD/MEAN= $\frac{\sum|Y_t - F_t|}{\frac{\sum Y_t}{n}}$ **7.9**

Of these two metrics the MASE method is preferred, because it is more widely applicable. The MAD/MEAN assumes that the mean is stable over time, so it for example does not account for seasonality and trends

7.3.5 Selecting error metrics method

Not in every error metric the same forecasting option will be the best and there is no quality measure that is best in every situation (Makridakis & Hibon, 2000). Therefore to be sure that the right forecasting model is chosen for this research, three error metrics are selected. The MAD (see equation 6.1) is used because of its simplicity, besides the MAD also the MAPE and MASE are chosen as error metric. MAPE is used because the metric is scale independent and MASE is used because for multistep forecasts it gives good comparisons.

7.4 Long-term forecast Zuivelhoeve Vers – End products

As already said in the beginning of this chapter, for making a long-term forecast the time series should be decomposed and the trend and cyclical component need to be examined. In the next sections for Zuivelhoeve Vers (end products) , the best option for forecasting is chosen (2 x 52, 2x26, 13 or 2x4- MA) and the trend and cyclical pattern of the best option are examined.

7.4.1 Choosing most accurate forecast option

The moving average options will provide four different forecasts, therefore the forecasts must be evaluated on how well these options could predict historical forecasts and therefor how well they will predict the future. As explained in section 6.3, the coefficient of determination (R^2) can be used to evaluate the trend line. For the forecast itself three different quality measure are used: MAD, MAPE and MASE. In table 7-1 an overview is given on how well each moving average scores on the forecast and the trend line applying the quality measures (see appendix C for calculations).

	Trendline	Forecast		
	R^2	MAD	MAPE	MASE
MA(52)	0.0503486	36.19898	4.43%	0.332845
MA(26)	0.0428667	47.8941	5.96%	0.326955
MA(13)	0.0386709	49.10933	7.11%	0.299169
MA(4)	0.0469516	46.50673	6.34%	0.273691

Table 7-1 quality measures Zuivelhoeve Vers

As can be seen in the table the 2x52- MA scores best on almost all quality measures. So the 2x 52- MA is used for forecasting the stock level of end products for Zuivelhoeve Vers. Figure 7-1 shows how well the 2x52- MA has predicted the historical data.

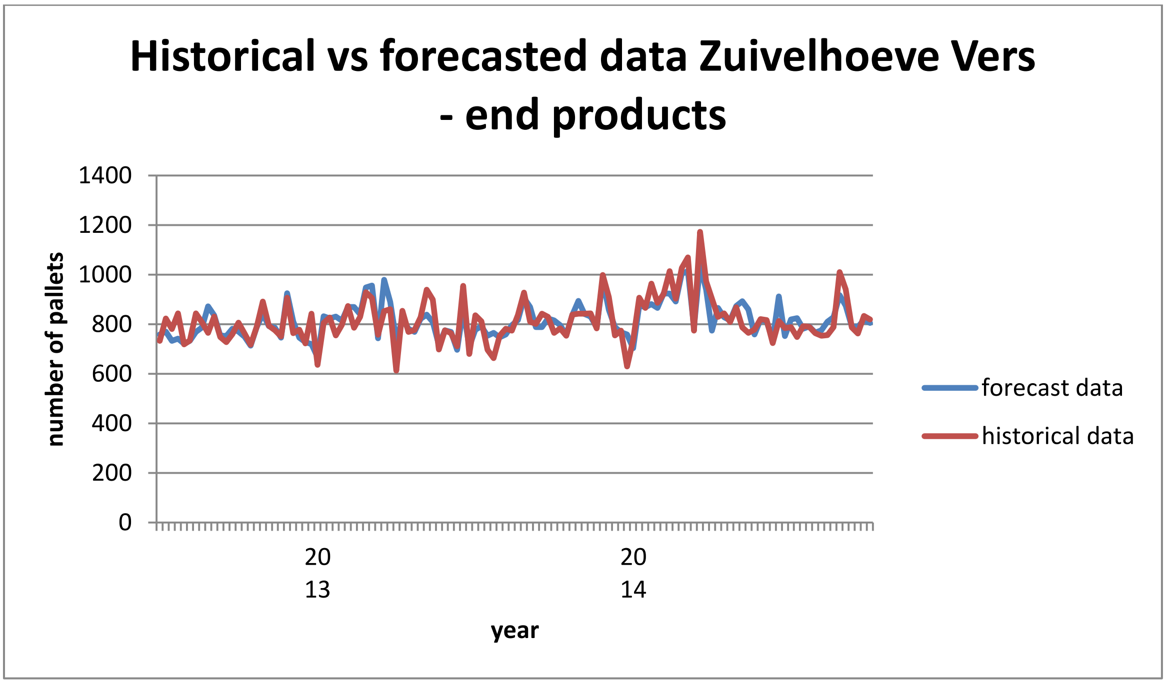


Figure 7-1 overview historical and forecasted stock levels of Zuivelhoeve Vers – end products

7.4.2 Trend Estimation Zuivelhoeve Vers - end products

An estimation of the trend is made using the historic stock levels from 2012 -2015. In figure 7-2 the historic stock levels are pictured (blue line) and the trend line is shown (green line). The trend line is calculated by using the “2 x 52-MA” method(see equation 6.4) and performing a regression analysis, for calculations see appendix C.

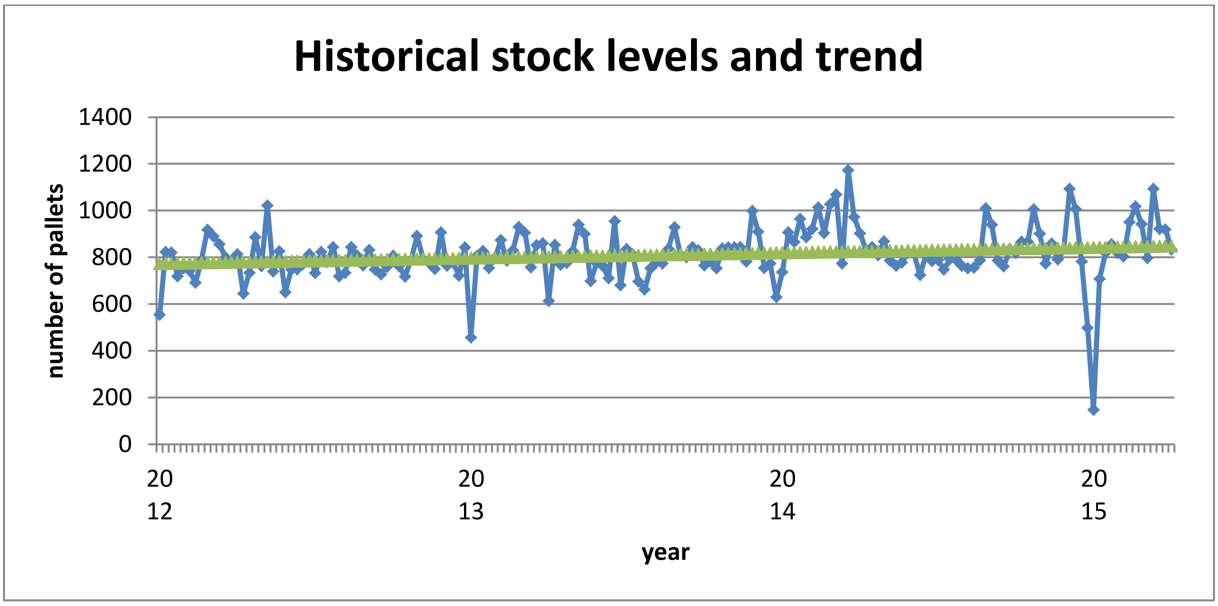


Figure 7-2 Overview historical stock levels and trend Zuivelhoeve Vers

The equation for this trend line, derived from equation 6.2 is:

$$\hat{Y} = 0.44X + 772.38$$

As discussed in Section 6.3, we need to calculate the coefficient of determination to assess the percentage of variations in the historic data that is explained by the trend. The residual sum of squares is 1504440.55 and the total sum of squares is 1584203.02. Subsequently, equation 6.3 gives the following:

$$R^2 = 1 - \frac{1504440.55}{1584203.02} = 0.05035$$

This is a very low score for the coefficient of determination, which means that a lot of the variations in the historical data are due to the cyclic pattern or the irregular pattern. In cases like this where the coefficient of variation is very low it is hard to make a reliable forecast, because irregular patterns cannot be measured and cyclical patterns for future predictions are mostly based on human judgement.

7.4.3 Cyclical Estimation Zuivelhoeve Vers- end products

For the cyclical estimation the stock level data is first deseasonalized by using the "2 x 52-MA" procedure (equation 6.4). When the seasonal component is removed, equation 6.6 can be applied to calculate the cyclical component every week. In this equation the "2 x 52 –MA" data is divided by the weekly estimated trend level (see appendix F for calculations). Figure 7-3 shows the weekly cyclical estimations, the trend line is the base line in the graph and is expressed as 1.

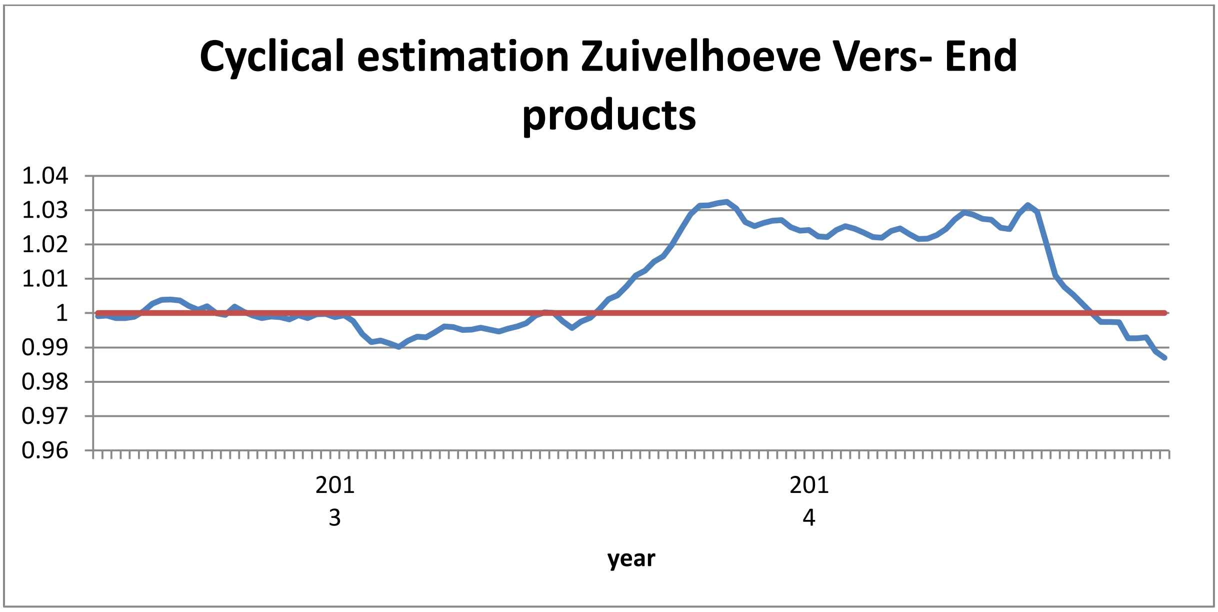


Figure 7-3 cyclical estimation Zuivelhoeve Vers

Cyclical variations as already mentioned in section 6.5 cannot be seen apart from irregular variations. Cyclical variations are recurrent upward or downward movements with a period greater than a year, as can be seen in figure 7-3 the cyclical component was constant in 2013. Then there is an upward movement in 2014. The cyclical component varies between 0.98 and 1.03.

7.5 Long-term forecast Van der Poel desserts – End Products

In the next sections the best option for forecasting is chosen (2 x 52, 2x26, 13 or 2x4- MA) for the end products of Van der Poel Desserts. When the most accurate forecast option is chosen, the trend and cyclical pattern of this option are examined.

7.5.1 Choosing most accurate forecast option

The four moving average options give us four different forecasts, these forecasts must be evaluated on how well the different options can predict historical forecasts and therefor how well they can predict the future. As explained in section 6.2, the coefficient of determination (R^2) can be used to evaluate the trend line. For the forecast itself three different quality measure are used: MAD, MAPE and MASE. In table 7-2 an overview is given on how well each moving average scores on the forecast and the trend line applying the quality measures (see appendix C for calculations). The 2 x 52- MA cannot be applied because there is too little data for applying this moving average option.

	trendline	forecast		
	R^2	MAD	MAPE	MASE
MA(52)	-	-	-	-
MA(26)	0.45482	111.427	4.92%	0.468059
MA(13)	0.354832	97.34907	4.20%	0.343636
MA(4)	0.267522	51.52687	2.21%	0.171978

Table 7-2 overview quality measures Van der Poel Desserts – end products

As can be seen in the table the 2x4- MA scores best on all three measure best for the forecast, but has compared to the other moving average options a very low R^2 score on the trend line. When the trend line has a higher score on R^2 more accurate forecasts can be mad, because data depends less on human (managerial) judgement. So now a consideration has to be made between the score on the trend line and the sores for the forecast. For the MASE score counts that a score below 1 gives better predictions than a score above 1. The MAPE score counts what percentage of the forecast is off, this score has to be as low as possible, but there is no standard cut-off value. Since all MASE scores are below 1 and the score for the MAD and MAPE do not differ much for MA(13) and MA(26), the MA (26) will be used for forecasting the stock level on end products. In figure 7-4 a graph is given to show how the 2 x 26- MA method forecasts the historical data.

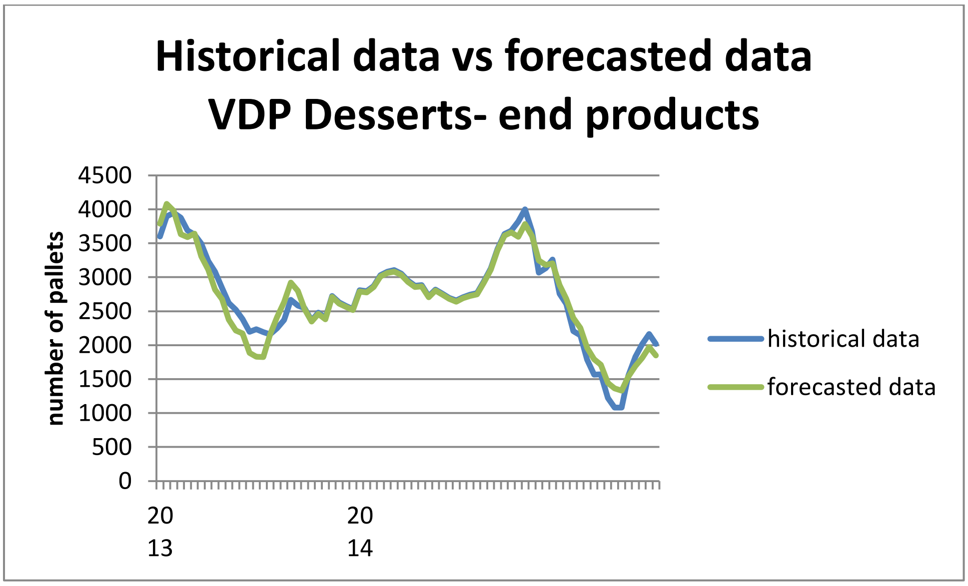


Figure 7-4 Historical stock levels vs forecast stock levels Van der poel desserts – end products

7.5.2 Trend Estimation Van der Poel Desserts- end products

An estimation of the trend is made using the historic stock levels from 2013 -2015. In figure 7-5 the historic stock levels is pictured (blue line) and the trend line is shown (green line). The trend line is calculated by using the "2 x 26-MA" method(see equation 4.4) and performing a regression analysis, for calculations see appendix C.

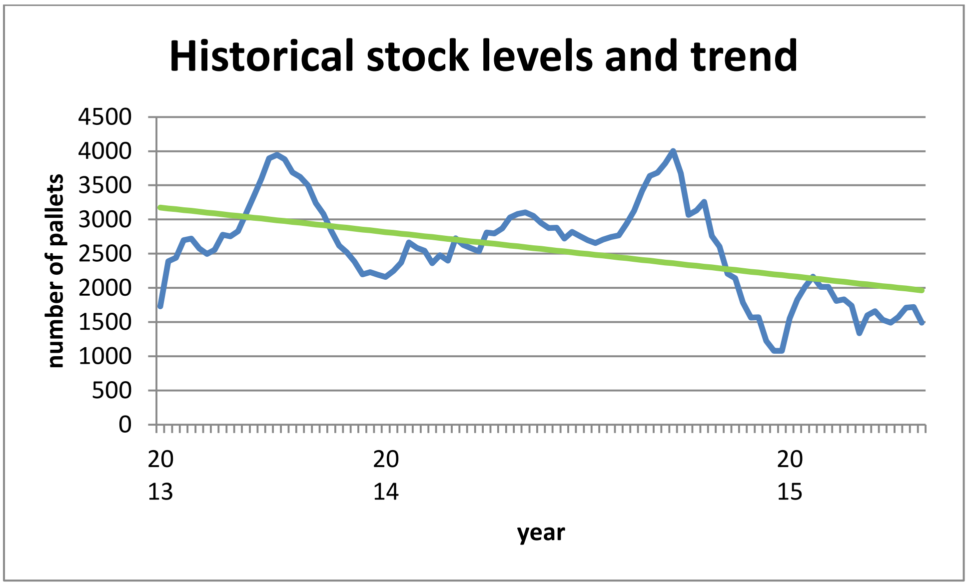


Figure 7-5 overview historical stock levels and trend Van der Poel desserts- end products

The equation for this trend line, derived from equation 5.2 is:

$$Y = -12.35X + 3187.54$$

As discussed in section 6.3, we need to calculate the coefficient of determination to assess the percentage of variations in the historic data that is explained by the trend. The residual sum of squares is 14785701 and the total sum of squares is 27120789. Subsequently, equation 6.3 gives the following:

$$R^2 = 1 - \frac{14785701}{27120789} = 0.4548$$

This is a reasonably good score for the coefficient of determination, it means that 45% of the historical data can be explained by the trend.

7.5.3 Cyclical Estimation Van der Poel Desserts – end products

For the cyclical estimation the stock level data is first deseasonalized by using the “2 x 26-MA” procedure (equation 6.4). When the seasonal component is removed, equation 6.6 can be applied to calculate the cyclical component every week. In this equation the ”2 x 26 –MA” data is divided by the weekly estimated trend level (see appendix F for calculations). Figure 6-6 shows the weekly cyclical estimations, the trend line is the base line in the graph and is expressed as 1.

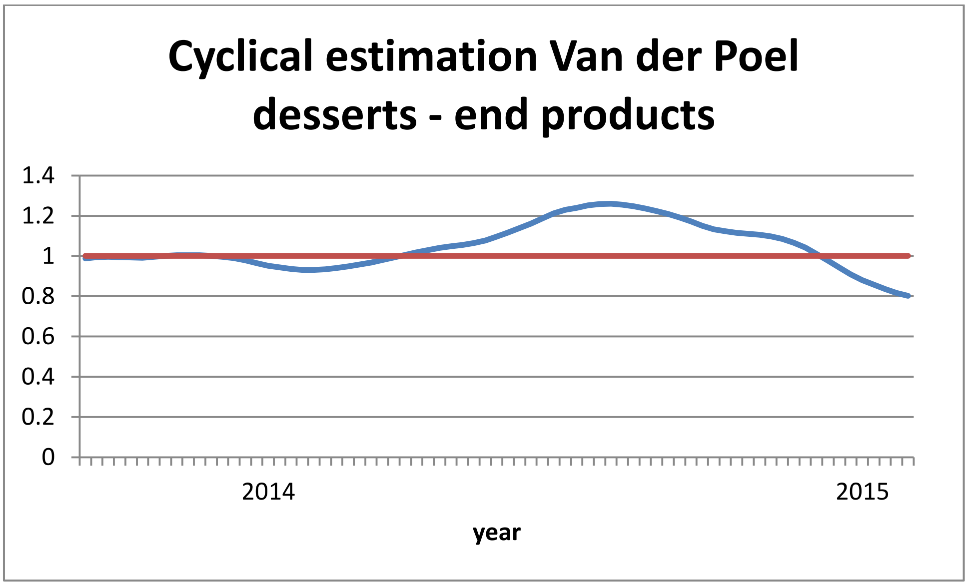


Figure 7-6 cyclical estimation given as a fraction of the trend for Van der Poel desserts – end products

As can be seen in figure 7-6 the cyclical component has remained relatively stable. Since the middle of 2014 the cyclical component is decreasing, which is due to changes/improvements in the stock levels in Holten.

7.6 Long-term forecast Van der Poel desserts – Raw materials & packaging

In the next sections the best option for forecasting is chosen (2 x 52, 2x26, 13 or 2x4- MA) for the raw materials/ packaging of Van der Poel Desserts. When the most accurate forecast option is chosen, the trend and cyclical pattern of this option are examined.

7.6.1 Choosing most accurate forecast option

The four moving average options gives us four different forecasts, these forecasts must be evaluated on how well the different options can predict historical forecasts and therefor how well they can predict the future. As explained in section 6.2, the coefficient of determination (R^2) can be used to evaluate the trend line. For the forecast itself three different quality measure are used: MAD, MAPE and MASE. In table 7-3 an overview is given on how well each moving average scores on the forecast and the trend line applying the quality measures (see appendix C for calculations). The 2 x 52- MA cannot be applied because there is too little data for applying this moving average option.

	trendline	forecast		
	R^2	MAD	MAPE	MASE
MA(52)	-	-	-	-
MA(26)	0.652574	28.81576	3.39%	0.66729
MA(13)	0.55583	25.88137	3.08%	0.403104
MA(4)	0.510836	15.24968	1.80%	0.232641

Table 7-3 overview quality measures Van der Poel Desserts- Raw materials/ packaging

As can be seen in the table the 2x4- MA scores best on all three measure best for the forecast, but has compared to the other moving average options the lowest R^2 score on the trend line. When the trend line has a higher score on R^2 more accurate forecasts can be mad, because data depends less on human (managerial) judgement. So now a consideration has to be made between the score on the trend line and the sores for the forecast. The “MA(26)-option” has the best R^2 score (0.65) but scores worst on all forecast quality measures. Since R^2 score of the “MA(4)-option” is the lowest R^2 score of all options, it is a reasonably good score (0.51) to make a forecast. So although it has the lowest R^2, the MA(4)- option is chosen for forecasting. In figure 7-7 a graph is given to show how the 2 x 4- MA method forecasts the historical data.

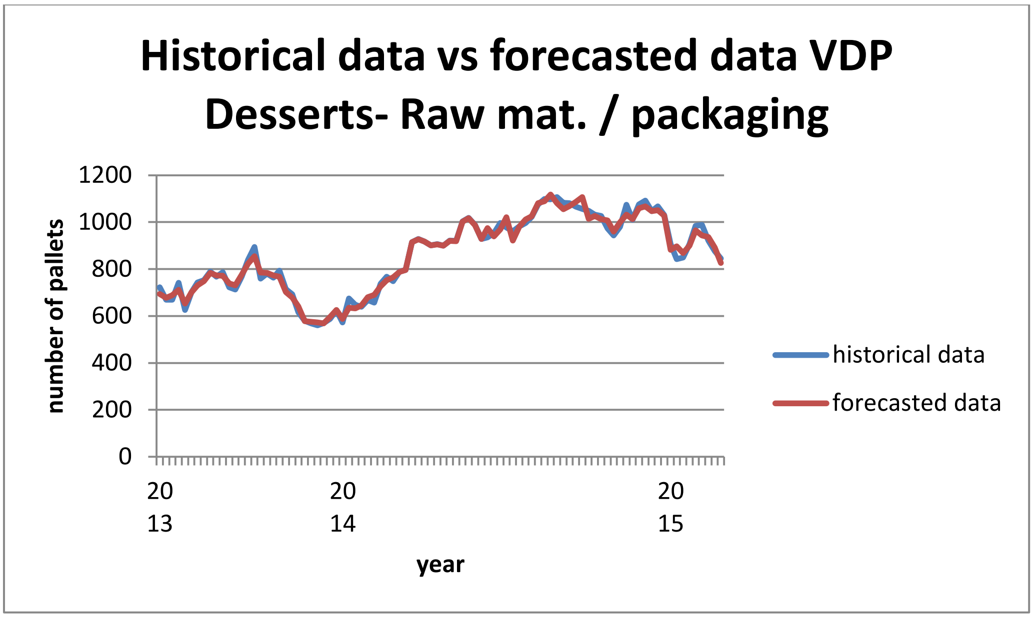


Figure 7-7 Historical stock levels vs forecasted stock levels VDP Desserts- end products

7.6.2 Trend Estimation Van der Poel desserts- Raw materials/ packaging

An estimation of the trend is made using the historic stock levels from 2013 -2015. In figure 7-8 the historic stock levels is pictured (blue line) and the trend line is shown (green line). The trend line is calculated by using the “2 x 4-MA” method(see equation 6.4) and performing a regression analysis, for calculations see appendix F.

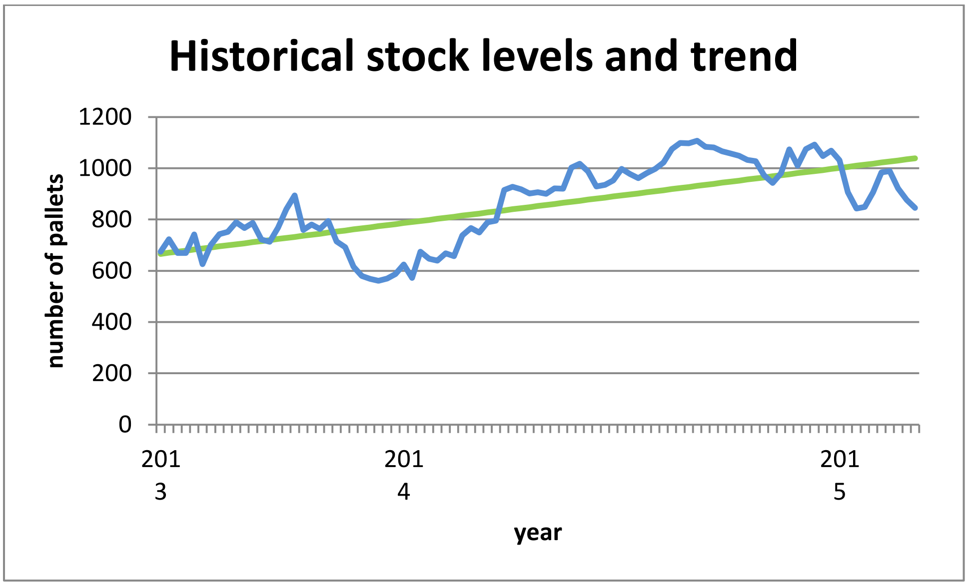


Figure 7-8 Overview historical stock level and trend VDP Desserts- raw materials/ packaging

The equation for this trend line, derived from equation 6.2 is:

$$Y = 4.14X + 657.84$$

As discussed in section 6.3, we need to calculate the coefficient of determination to assess the percentage of variations in the historic data that is explained by the trend. The residual sum of squares is 1135427 and the total sum of squares is 2321157. Subsequently, equation 6.3 gives the following:

$$R^2 = 1 - \frac{1135427}{2321157} = 0.5108$$

This is a reasonably good score for the coefficient of determination, it means that 51% of the historical data can be explained by the trend.

7.6.3 Cyclical Estimation Van der Poel Desserts – Raw materials/ packaging

For the cyclical estimation the stock level data is first deseasonalized by using the “2 x 4-MA” procedure (equation 6.4). When the seasonal component is removed, equation 6.6 can be applied to calculate the cyclical component every week. In this equation the ”2 x 4 –MA” data is divided by the weekly estimated trend level (see appendix F for calculations). Figure 7-9 shows the weekly cyclical estimations, the trend line is the base line in the graph and is expressed as 1.

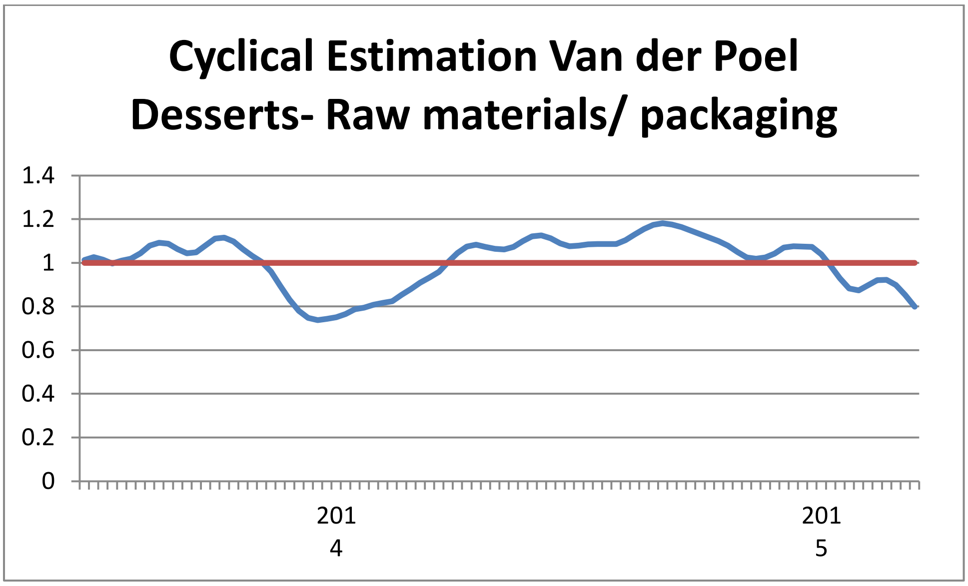


Figure 7-9 Overview Cyclical estimation (given as a fraction of the trend)

In figure 7-9 it can be seen that there are ups and downs in the cyclical component and like the end products of VDP Desserts also the cyclical component for the raw materials/packaging is decreasing since the middle of 2014. Which is probably also due to improvements in the stock levels in Holten.

7.7 Conclusion

Since the forecasting in this thesis must cover a 3-year period, we are dealing with a long-term forecast and therefore the mathematical model should fit with a long-term period. According to Hanke and Reitsch (1998), long-term forecasts should simply be made by the decomposition of the time series and examining the trend and cyclical component. The trend component can be calculated and can directly be extrapolated into the future, for the cyclical component to be extrapolated into the future, human judgement is necessary.
For the time series to be decomposed, a moving average option should be chosen that is necessary for decomposing the time series. In this thesis four different moving average options (2x52-MA,2x26-MA, 13-MA and 2x4-MA) are used to forecast the stock levels of Zuivelhoeve Vers and Van der Poel desserts. Using quality measures one of the four moving average options is most accurate in forecasting the stock levels for Zuivelhoeve Vers and Van der Poel Desserts. The quality measures that are chosen to evaluate the accuracy of a forecast are the R^2 (coefficient of determination), MAD (mean absolute deviation), MAPE(mean absolute percentage error) and MASE(mean absolute squared error). The R^2 measures the variations in the historical stock levels that can be explained by the trend. The other three measures (MAD, MAPE and MASE) evaluate the accuracy of the forecast. Based on the scores for those measures, the following forecast options are best for forecasting the stock levels of the end products of Zuivelhoeve Vers and for the end products and raw materials & packaging of Van der Poel Dessert, respectively the 2x52-MA, 2x26-MA and 2x4-MA. Using these moving average options, the time series are decomposed and the trend and cyclical component are calculated for Zuivelhoeve Vers and Van der Poel desserts. These

components are used in the following chapter to calculate the future stock levels and there by the capacity needed.

8 Determining capacity needed

In this chapter the future stock levels will be determined using the forecast model chosen in chapter 6 and using the components for the forecasting determined in chapter 7. In consultation with the management of Roerink Food family three future growth scenarios are examined: (small) growth ratio of about 10%, (medium) growth ratio of about 30% and a (large) growth ratio of about 50%. First the future stock levels are calculated under these growth scenarios, after that an ILP-model is formulated, to help determine which scenario for warehousing is most profitable under which future growth scenario

8.1 Future stock levels

Future stock levels can be determined by using the decomposition of the time series, which is explained in chapter 7 for Zuivelhoeve Vers and Van der Poel Desserts. The seasonal and trend factor can be extrapolated into the future directly, how the cyclical component is extrapolated into the future depends om human judgement. Since management wants to know what the future stock levels are under small, medium and large growth ratios, the cyclical component must be adapted such that the total number of pallets in storage in 2017 are respectively about 10% ,30% and 50% larger than the total number of pallets stored in 2014 for Zuivelhoeve Vers and for Van der Poel Desserts.
For Van der Poel Desserts several improvements have been made in the stock levels of end products in 2014, therefor 2014 is not the ideal base year to compare our future stock levels with. So for the stock levels of Van der Poel Desserts the end of 2014 / the beginning 2015 will be used to compare the forecast with.
The future stock levels of Zuivelhoeve Vers and Van der Poel Desserts will be discussed in the following sections separately

8.1.1 Future stock levels Zuivelhoeve Vers

Future stock levels for Zuivelhoeve Vers can be divided into four parts, stock levels of raw materials/packaging at the production location, stock levels of end products at the production location, stock levels of raw materials/packaging at the warehouse and stock levels of end products at the warehouse. Only the future stock levels for the end products of Zuivelhoeve Vers at the warehouse can be calculated using historical stock levels, the other stock levels are based only on an average number. These four different stock levels are explained separately.

Future stock levels end products - Warehouse
For determining future stock levels at the warehouse for the three growth ratios (10%, 30% and 50%) ,the trend and seasonal component are extrapolated into the future, this is to give stock levels the right fluctuations every week. Which has a result, that the basis for calculating stock levels for all three ratios is the same.
In chapter 7 the cyclical component and trend component were investigated, the cyclical component of Zuivelhoeve Vers fluctuated around one and in the trend just a slight increase

in the stock levels could be seen, which means that the stock levels for the end products of Zuivelhoeve Vers were around the same level the last three years. This makes it very easy to choose a factor for the cyclical component for all three ratios.
For the 10% growth, 30% and 50% growth with respect to the base, the following cyclical factors have been chosen: 1.1, 1.3 and 1.5 respectively. Note that these cyclical factors do not have as a result that every week the stock levels just grow with 10, 30 or 50%, this also depends on the trend and seasonal component that are extrapolated into the future. In figure 8-1, a graph can be seen in which the future stock levels for 2017 are given for all three ratios. Also two straight lines have been drawn which indicate the capacity levels for the warehouse in the current situation and the alternative scenario. We see that for the 10% and 30% growth ratio the warehouse of the current situation is sufficient to handle this growth. For the 50% growth ratio we see that the capacity of the current situation is too low almost every week , but that the capacity of the warehouse of scenario 3 is sufficient to handle this growth.

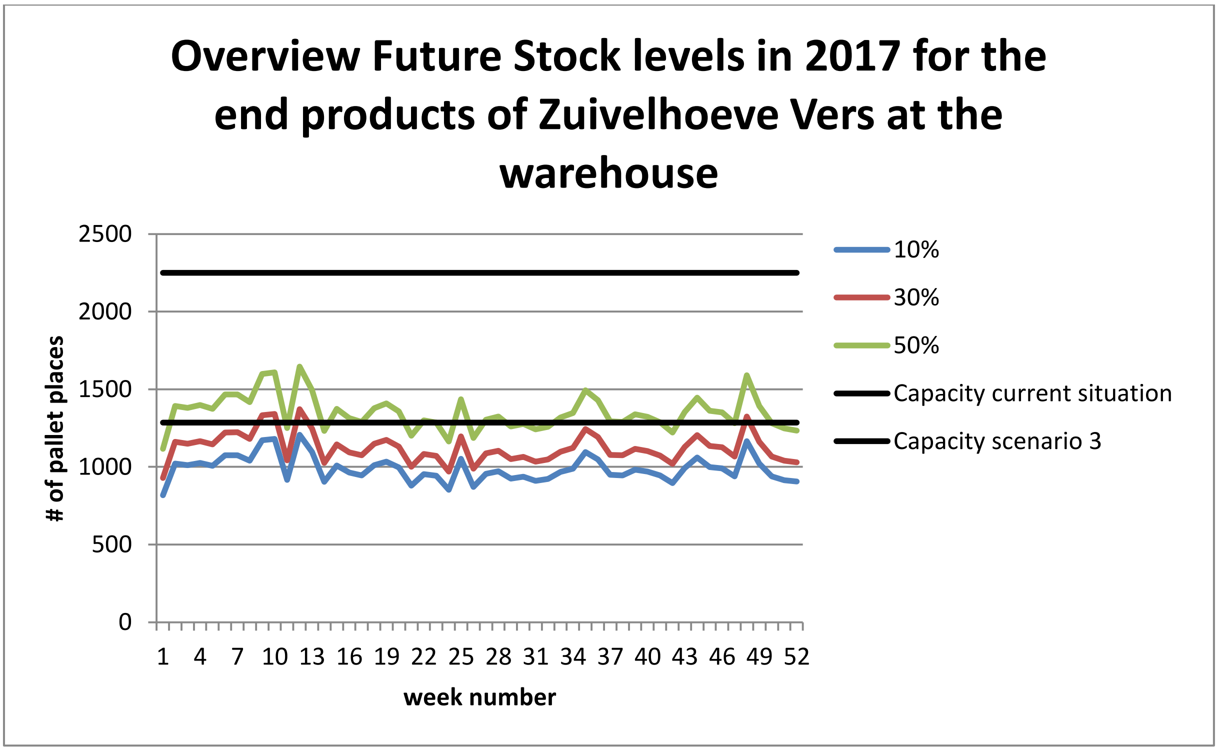


Figure 8-1 Overview future stock levels of end products at the warehouse Zuivelhoeve Vers

Future stock levels Raw materials/packaging – Warehouse
In chapter 3, the average stock levels of raw materials/packaging at the warehouse were given as 100 pallet places in stock at the warehouse in Raalte and 500 pallet places in stock at the warehouse in Oldenzaal. To calculate the future stock levels for the raw materials/packaging, we assume that if for in the future 10%, 30 % or 50% extra end products are in stock at the warehouse, also 10%, 30 or 50% extra raw materials/ packaging are needed to produce these end products. This means that we get the following future stock levels for the raw materials/ packaging at the warehouse:

	# pallets current stock level	Growth rate	# pallets future stock level	Total #pallets future stock level	Capacity current situation	Capacity scenario 3
10% growth rate	500	10%	550	660	196	900
	100	10%	110			
30% growth rate	500	30%	650	780	196	900
	100	30%	130			
50% growth rate	500	50%	750	900	196	900
	100	50%	150			

Table 8-1 Overview future stock levels raw materials/ packaging at the warehouse, Zuivelhoeve Vers

In the problem description it was told that in the future holding stock for Zuivelhoeve Vers in Oldenzaal is undesirable. The reason for this decisions was that for the production of Happy Goat that will start in December 2015 in Oldenzaal, also storage capacity is needed. Therefore we do not take the capacity in Oldenzaal into account for the current situation. In the table 8-1,we see that no growth rate the current capacity in Raalte is sufficient. But that the capacity of the warehouse of scenario 3 is sufficient for all three growth scenarios.

Future stock levels end products- production location

When stock levels at the warehouse for end products grow and therefore also the sales level grow, (because the stock almost equals the sales), the production has to increase also. This means that more end products are produced and more products have to stay in Twekkelo to cool down or have to wait to be transported to the warehouse. In chapter 3, for the current situation we said that 75% of all end products produced on a day are stored in Twekkelo before they can be transported.

We can say that the average number of products that is produced in a week, is equal to the average weekly stock level of end products at the warehouse. Because of this we can use the average future stock levels of the end products at the warehouse to calculate the average future stock levels of the end products at the production location.

Growth rate	Average stock level-warehouse	Average number of PP of products produced on a day	Average stock level of end products at production location	Capacity current situation	Capacity scenario 3
10%	989	141	106	142	142
30%	1123	160	120	142	142
50%	1348	193	144	142	142

Table 8-2 Overview future stock levels end products at the production location, Zuivelhoeve Vers

As can be seen in table 8-2 the capacity for end products at the production location is the same for the current situations and for the alternative scenario. This is because there is only a change at the warehouses and not at the production location between the current situation and scenario 3. For all three growth scenarios, the capacity at the production location for the end products is about enough to handle these growth rates in the future stock levels.

Future stock levels raw materials/packaging -production location

The stock levels for raw materials and packaging at the production location depend on the number of pallets transported every week from the warehouse to the production location. In the current situation in total 331 pallets of raw materials /packaging were transported every week from the warehouses (from the 600 PP of average stock) in Oldenzaal and Raalte to the production location and these pallets stayed on average 2 days on stock in Twekkelo. Which meant that the average stock level in this situation was 95 pallet places. To calculate the average future stock levels for the three growth scenarios, we use the proportions between the pallets transported in a week to the production location in the current situation and the average stock of the current situation to calculate the average future stock level at the production location, see tableb-3

Growth rate	Proportions transported/ stored at warehouses Current situation	Stock level raw materials at warehouse	Pallets transported future stock levels	Average stock level of raw materials/ packaging at production location
10 %	0.55	660	364	104
30 %	0.55	780	430	123
50%	0.55	900	497	142

Table 8-3 future stock levels raw materials/packaging at the production location, Zuivelhoeve Vers

8.1.2 Future stock level Van der Poel Desserts

Future stock levels for Van der Poel Desserts can also be divided into four parts, stock levels of raw materials/packaging at the production location, stock levels of end products at the production location, stock levels of raw materials/packaging at the warehouse and stock levels of end products at the warehouse. Only the future stock levels for the end products and raw materials/packaging at the warehouse of Van der Poel Desserts can be calculated using historical stock levels, the other two stock levels at the production location are based only on an average stock level. These four different stock levels are explained separately.

Future stock levels end products-warehouse

For determining future stock levels of end products at the warehouse for the three growth ratios (10%, 30% and 50%) ,the trend and seasonal component are(just like they were for

calculating the stock levels of Zuivelhoeve Vers), extrapolated into the future to give the stock levels the right fluctuations every week.
In chapter 7 the cyclical component and trend component were investigated. The cyclical component decreased from the middle of the year 2014 to the beginning of 2015 from 1.2 to 0.8.
Also the trend component was decreasing, which means that if the trend component is extrapolated into the future, the future stock levels will just stay decreasing. Since it is clear the stock levels cannot be decreasing forever, this has to be corrected, this is done by "freezing" the trend for the last known stock level in 2015.
To realize 10% growth, 30% and 50% growth with respect to the base year, the cyclical component has to increase again. Therefore for the cyclical component factors respectively 1, 1.15 and 1.35 have been chosen.
In figure 8-2, a graph can be seen in which the future stock levels for 2017 are given for all three ratios. Also a straight line has been drawn which indicates the capacity level for the warehouses build in scenarios 1 and 2. There has no line been drawn which indicates the capacity of the warehouse in the current situation, because storage space is rented from MFFF in Holten and when extra capacity is needed it is possible to rent extra storage space. Therefor we assume that for all three growth scenarios the storage capacity at the warehouse of the current situation is sufficient. We see that for the other scenarios, for the 10% and 30% growth rate the capacity is sufficient. But for the 50% growth scenario, in particular around Christmas there is not enough storage space.

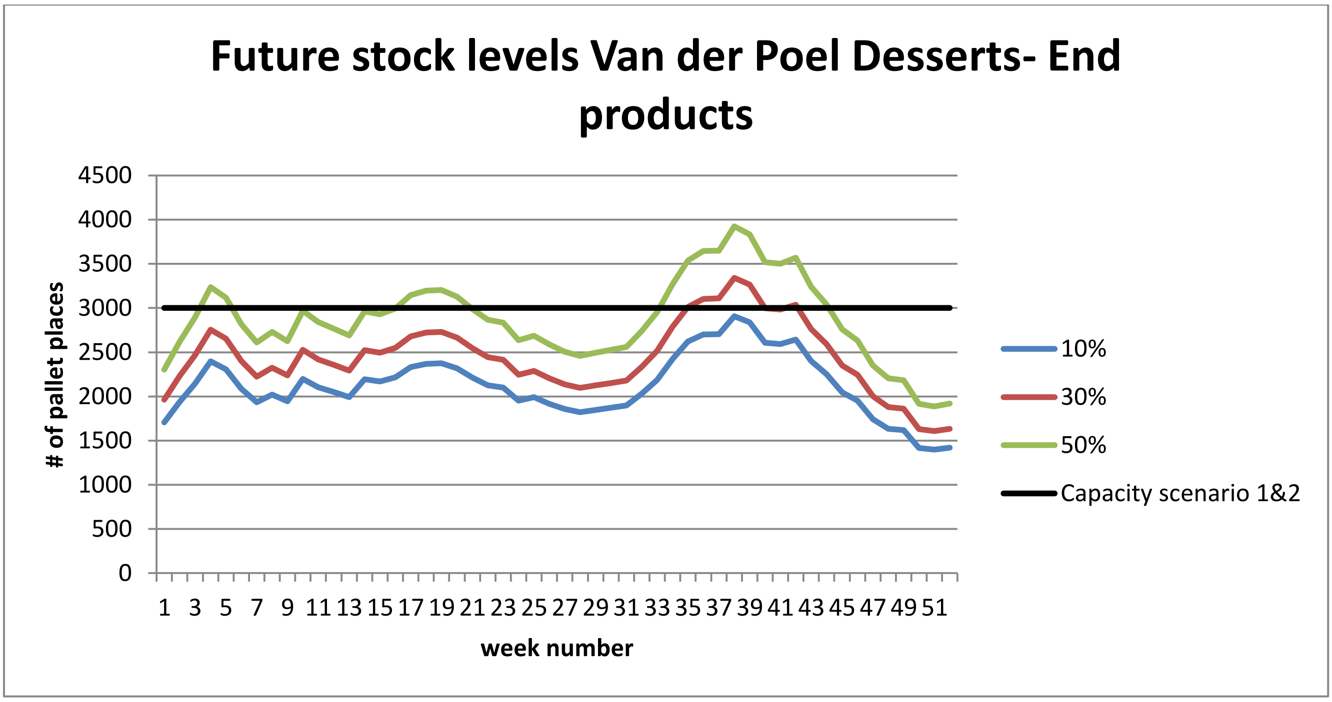


Figure 8-2 Overview future stock levels end products at the warehouse, Van der Poel Desserts

Future stock levels raw materials/packaging –warehouse

For determining future stock levels of raw materials/packaging at the warehouse for the three growth ratios (10%, 30% and 50%) ,the trend and seasonal component of this time series are also extrapolated into the future to give these stock levels the right fluctuations every week.

In chapter 7 the cyclical component and trend component were investigated. The cyclical component was just like it was for the end products decreasing since the middle of 2014 to the beginning of 2015 from 1.2 to 0.8, but the trend line showed despite this decrease at the end of 2014 an increasing trend.

For accomplishing the 10% growth, 30% and 50% growth with respect to the base year, the following cyclical factors have been chosen: 0.65, 0.8 and 0.9 respectively.

In figure 8-3, a graph can be seen in which the future stock levels for 2017 are given for all three growth ratios. Also a straight line has been drawn which indicates the capacity level for the warehouses build in scenarios 1 and 2. There has no line been drawn which indicates the capacity of the warehouse in the current situation, because storage space is rented from MFFF in Holten and when extra capacity is needed it is possible to rent extra storage space. So we assume that for all three growth scenarios the storage capacity of the current situation is sufficient. We see that for the other scenarios also for all three growth rate the capacity is sufficient.

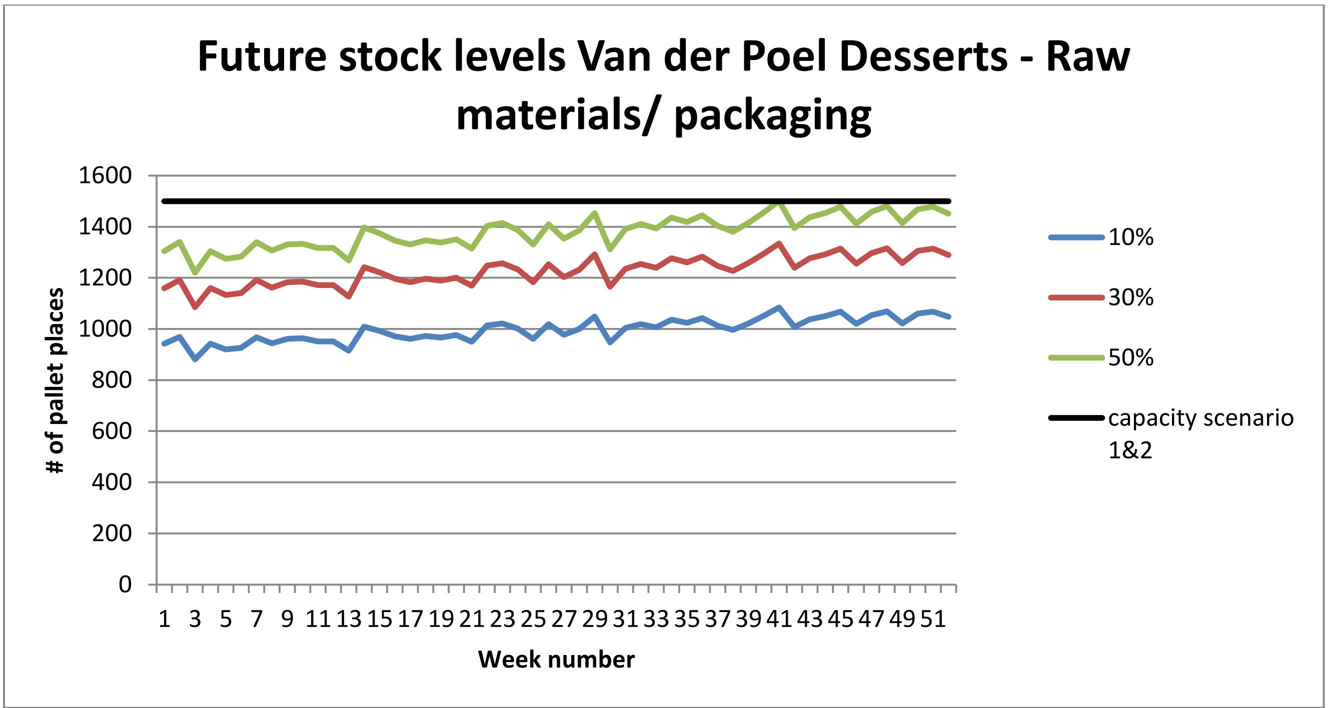


Figure 8-3 Overview stock levels raw materials/packaging at the warehouse, Van der Poel Desserts

Future stock levels end products and raw materials/packaging- production location

In an interview it was said, that the capacity in Hengelo is already used at its full capacity.

Which means that no more stock can be hold here at this location. This has a result that there must be more often transport between the warehouse and the production to resolve the capacity issue here for future stock levels.

8.2 Storage model

To support Roerink Food Family in making the right decision for a storage location under the future stock levels of Zuivelhoeve Vers and Van der Poel Desserts, we introduce a simple storage model. This storage model is programmed in the OMST LP solver as an integer linear programming (ILP) model. The ILP models for Zuivelhoeve Vers and Van der Poel Desserts will be explained separately in the following sections.

8.2.1 LP-model Zuivelhoeve Vers

By setting up and using an ILP-model for future stock levels of Zuivelhoeve Vers, we want to determine which storage location (from the already explained scenarios) is most profitable under the three future growth scenarios.
The ILP-model is only based on the stock levels and transport of end products, because the end products result in the largest expense, with regard to the storage costs and transport costs. And besides this, the ILP-model cannot be made for both raw materials/packaging and end products together. So a consideration between the end products and raw materials/packaging had to be made.
For the future stock levels it can possible that in just a few weeks of the year extra storage space is needed. In this case it would probably not be profitable to build a whole new warehouse for just these few weeks of surplus. Therefore we also include the option renting extra storage space from a refrigerated/cold store in our model. We use Muller Fresh Food logistics in Holten as s possible option for renting storage space since the costs for storing goods in Holten are already known. Transport costs to and from this location are based on the transport costs rates of Nagel.
By taking all this into account for our model, the ILP-model for Zuivelhoeve Vers should include the following factors:

- Transport costs from the production location to the warehouse and from the warehouse to the customer for each scenario.
- Storage costs of the end products at the warehouse for each scenario
- Costs for building the warehouse per year for each scenario (20 year amortization)
- Costs for renting extra storage space
- Transport costs from and to the rented storage location

We define the ILP-model in the following standard form:

Indices:

d	d={1…3} which represent the warehouses of the 2 scenarios and the possibility of renting extra storage space

s	s={1..4} which represent the customers in the Netherlands, Belgium, Germany and of REWE concern
t	t={1..52} which represent the 52 weeks in a year

Parameters:

$Transportcost_{s,d}$	transport costs per pallet for transport from warehouse d to customer s
$TransCostToWareh_{d}$	transport costs per pallet for transport from the production location to the warehouse d
$Demand_{s,t}$	Demand of customer s is in week t
Bulkfactor	factor that makes up for the difference in number of products on a pallet when it is on stock and when it is transported to the customer
BigM	Indicates largest demand
$MaxInventory_{d}$	Maximum stock level in number of pallets of warehouse d
$CostBuildwareH_{d}$	Amortization costs per year for building warehouse d
$StorageCost_{d}$	Costs per pallet per week for storing in warehouse d

Variables:

$Sales_{s,d,t}$	Number of pallets delivered/sold to customer s from warehouse d in week t
$EndproductsInv_{d,t}$	Number of pallets in inventory in warehouse d in week t
X_{d}	Warehouse d opened or not

Objective:

$$min(\sum_{s}^{4}\sum_{d}^{4}\sum_{t}^{52} sales_{s,d,t} * Bulkfactor * transportcost_{s,d} \\ + \sum_{d}^{4}\sum_{t}^{52} EndproductsInv_{d,t} \\ * TransCosttoWareh_{d} \\ + \sum_{d}^{4} CostBuildWareh_{d} * X_{d} \\ + \sum_{d}^{4}\sum_{t}^{52} EndProductsInv_{d,t} * Storagecost_{d})$$

Subject to:

$Sales_{s,d,t} \leq BigM * X_d$ $\forall s,d,t$

$\sum_d^4 sales_{s,d,t} \geq Demand_{s,t}$ $\forall s,t$

$EndproductsInv_{d,t} = \sum_s^4 sales_{s.d.t}$ $\forall d,t$

$EndproductsInv_{d,t} \leq Maxinventory_d$ $\forall d,t$

$Sales_{s,d,t} \geq 0$, integer ` $\forall s,d,t$

$EndproductsInv_{d,t} \geq 0$ $\forall d,t$

$X_d \in \{0,1\}$ $\forall d$

In this model the calculated future stock levels of Zuivelhoeve for all three growth ratios are processed in the model as the demand per week per customer group. This means that the future stock levels are divided as sales demand over the four customer groups (Belgium, the Netherlands,REWE FL and Germany) according to division of pallets sold to the four groups in the current situation. Since what is sold in a week is also produced and kept in stock in a week, we can say that the demand/sales is equal to the number of pallets in stock.
When we apply this model to the three growth scenarios we get the following results(in Appendix H an example of more elaborate results is given)

Growth ratio of 10 %:
When we optimize the ILP-model for the future stock levels in case of 10% growth, in the OMST LP Solver with LP_SOLVE we get the solution in 0.484 seconds. The output of the model indicates that all end products should be stored at the current warehouse in Raalte, the objective function gives € 2,000,200.34 as total operational costs. Which means that capacity of this warehouse is, just like indicated in figure 8-1, not exceeded for the future stock levels of the end products is case of 10% growth. But for the raw materials/ packaging (which are not included in the LP-model) the number of pallet places in Raalte dedicated to store these materials is exceeded. In table 8-1 it can be seen that the average stock level for raw materials and packaging is 660PP and the capacity is just 196PP. In this case there are two options for storing the raw materials/ packaging. Which option to choose depends on where the optimal location for the warehouse of Van der Poel Desserts will be.

- Optimal location for a warehouse for Van der Poel Desserts also in Raalte (scenario 1): In this case the warehouse in Raalte would be expanded to store the end products and Raw materials of Van der Poel Desserts also in Raalte. In figure 8-3 it can be seen that the capacity for ambient storage for Van der Poel Desserts is 1500 but for the 10 % and 30% growth ratio this capacity is by far not exceeded. Which means that you can make use of a part of the storage capacity in Raalte that would be dedicated to store raw materials/packaging of Van der Poel Desserts in Raalte. If

still the capacity is exceeded in some weeks, then extra storage space should be rented.
Only when the growth of the future stock levels for Van der Poel desserts is expected to be more than 30 %, this option is not possible any more. Then it must be chosen to let the warehouse in Raalte be fully dedicated to Van der Poel Desserts or fully dedicated to Zuivelhoeve Vers.
- Optimal location warehouse Van der Poel Desserts not in Raalte:
  In this case it is possible to expand the warehouse in Raalte for Zuivelhoeve Vers, so that no extra storage space has to be rented from an external location.

Growth ratio of 30%:
When we optimize the ILP-model for the future stock levels in case of 30% growth, we get the solution in 0.437 seconds with LP_SOLVE in the OMST LP Solver. The output of the model indicates that all end products should be stored at the current warehouse in Raalte, except for the four weeks in which the stock levels of the end products exceed the maximum capacity of the warehouse. In those weeks the surplus should be extra storage space should be rented in Holten (or from another external warehouse). The objective function in this case gives € 2,273,034.86 as total operational costs.
When we look at the raw materials/ packaging for this growth ratio we see that just like for the 10 % growth ratio the capacity is exceeded by a lot, the average stock level is 780 and the capacity is 196. In this case there are the same two options for storing the raw materials/ packaging as for the 10 % growth ratio. Which option to choose depends on where the optimal location for the warehouse of Van der Poel Desserts will be.

Growth ratio of 50%:
When we optimize the ILP-model for the future stock levels in case of 30% growth, we get the solution in 0.469 seconds with LP_SOLVE in the OMST LP Solver. The output of the model indicates that all end products should be stored at the current warehouse in Raalte, only for the in which weeks the stock level exceeds the maximum capacity. The stock level of the end products exceeds the capacity in a lot of week but the average amount that exceeds the maximum capacity per week is relatively small (78 pallet places per week). The ILP-model advices in those weeks to rent extra storage capacity. The objective function gives € 2,734,068.12 as the total operational costs.
When looking at the raw materials/ packaging for this growth ratio we see that just like for the 10 % and 30% growth ratio the capacity is exceeded by a lot, the average stock level is 900 and the capacity is 196.
To the company it is probably undesirable that the capacity of the end products and for the raw materials/ packaging in the warehouse is exceeded in a lot of weeks. In this In this case there are three options for storing the raw materials/ packaging.
Which option to choose depends on where the optimal location for the warehouse of Van der Poel Desserts will be and the operational costs per year of the options.

- Optimal location for a warehouse for Van der Poel Desserts also in Raalte (scenario 1): In the parts about the 10% and 30% growth ratio we already said that when the 50 % growth ratio of Van der Poel is expected it must be chosen to let the warehouse in Raalte be fully dedicated to Van der Poel Desserts or to let it be fully dedicated to Zuivelhoeve Vers. Now also when the 50 % growth ratio for Zuivelhoeve Vers is expected, this rule counts. So under this option there are two suboptions:
    - The warehouse in Raalte will be fully dedicated to Zuivelhoeve Vers (end products and raw materials/packaging) stays in Raalte), so Zuivelhoeve Vers gets the storage space that was dedicated to Van der Poel Desserts. By increasing the capacity of the warehouse in Raalte in the LP-model and let it run just for this warehouse we get operational costs € 2,727,435.08 per year. For Van der Poel desserts the most profitable alternative location has to be chosen.
    - Storage for Van der Poel Desserts (end products and raw materials/packaging) stays in Raalte and gets the storage space that was dedicated to Zuivelhoeve Vers. For Zuivelhoeve Vers the most profitable alternative has to be chosen. Since there is only one alternative location (Twekkelo, scenario 3). We let the LP-model run for just this warehouse and we get total operational costs of € 2,985,351.22 per year.
- Optimal location warehouse Van der Poel Desserts not in Raalte:
  In this case it is always possible to expand the warehouse in Raalte for Zuivelhoeve Vers, so that no extra storage space has to be rented from an external location. Operational costs will be € 2,727,435.08 per year.

For Zuivelhoeve Vers the optimal location for a warehouse for all three future growth scenarios has been determined. In weeks where the stock levels exceed the capacity of the warehouse, still has a choice to be made where the surplus should be stored. Since this choice depends on where the optimal location for a warehouse for Van der Poel Desserts will be, we first determine this in the next section. And after that a conclusion is given both for Van der Poel Desserts and Zuivelhoeve Vers.

8.2.2 LP-Model Van der Poel Desserts

By setting up and using an ILP-model for future stock levels of Zuivelhoeve Vers,, we want to know which storage location (from the already explained scenarios) is most profitable under the three future growth scenarios.

The ILP-model for Van der Poel Desserts is, just like the ILP-model for Zuivelhoeve Vers only based on the stock levels and transport of end products.

If those stock levels might exceed the storage capacity in just a few weeks in a year it would probably not be profitable to build an extra warehouse, that is why we include the option renting extra storage space in Holten also in this model.

The model used for Van der Poel Desserts is therefore almost the same as the model used for Zuivelhoeve Vers, except that for Van der Poel desserts there are three customer groups (Belgium, the Netherlands and Germany) and there are three possible scenarios plus the renting space option (d=1,..,4). Also the objective function for Van der Poel Desserts is different than that from Zuivelhoeve Vers, Van der Poel desserts has the following objective function:

$$
\begin{aligned}
min(\sum_{s}^{3}\sum_{d}^{5}\sum_{t}^{52} sales_{s,d,t}/Bulkfactor * transportcost_{s,d} \\
+ \sum_{s}^{3}\sum_{d}^{5}\sum_{t}^{52} \frac{Sales_{s,d,t}}{bulkfactor2} \\
* TransCosttoWareh_{d} \\
+ \sum_{d}^{5} CostBuildWareh_{d} * X_{d} \\
+ \sum_{d}^{5}\sum_{t}^{52} EndProductsInv_{d,t} * Storagecost_{d})
\end{aligned}
$$

In this model the calculated future stock levels of Van der Poel Desserts are inserted in the model as the demand per customer group per week . This means that the future stock levels are divided over the three customer groups (Belgium, the Netherlands and Germany), according to division of pallets sold to the three groups in the current situation. Since stock is build up for Van der Poel Desserts for peak periods, sales demand per week is not equal to the stock level per week. The reason why we inserted the stock levels nevertheless as the demand per customer group per week, is because otherwise the future stock levels cannot be modeled. The stock levels depend on the starting inventory, the demand of the customers and the number of products produced. When working with multiple possible warehouses, the starting inventory and the pallets transported from the production location to a warehouse cannot be modeled.
But when inserting the stock levels as weekly demand we have the right stock levels per week (This is done in the ILP-model) and we can easily calculate the transport costs from the warehouse to the customer and transport costs from the production location to the warehouse by using bulk factors (see objective function).
When applying the future stock levels to this model we get the following results:

Growth ratio of 10%:
When we optimize this model in the OMST LP Solver with LP_SOLVE we get the solution in 0.422 seconds. The output shows that all end products should be stored at the warehouse in Raalte (scenario 1) at total operational costs of €533,616.59 per year. This means that the stock levels for the end products do not exceed the capacity, see also figure 8-2. When looking at the stock levels for raw materials and packaging (figure 8-3), we see that these

stock levels also do not exceed the capacity. The average stock level is around 1000 PP, while the storage capacity is 1500 PP.

Growth ratio of 30%:
When we optimize this model in the OMST LP Solver with LP_SOLVE we get the solution in 0.437 seconds. The output shows that all end products should be stored at the warehouse in Raalte (scenario 1) , but that around Christmas the capacity of the warehouse is exceeded. In these weeks the ILP-model indicates that extra storage space should be rented. This can be done at total operational costs of €610,294.75.
When looking at the stock levels for raw materials and packaging (figure 8-3), we see that these stock levels also do not exceed the capacity. The average stock level is around 1200 PP, while the storage capacity is 1500 PP.

Growth ratio of 50 %:
When we optimize this model in the OMST LP Solver with LP_SOLVE we get the solution in 0.437 seconds. The output shows that all end products should be stored at the warehouse in Raalte(scenario 1), but that in the weeks around Easter and Christmas the capacity of the warehouse is exceeded with a large amount of pallets. For those weeks theI LP-model indicated that it is most profitable to rent extra storage in Holten. This can be done at total operational costs of €713,180.56 per year.
When looking at the stock levels of the raw materials and packaging, see figure 8-3, we see that the capacity is just enough to handle this growth ratio.
To the company it is probably undesirable to rent extra storage space in all these weeks around Christmas and Easter. There are two options that can undo this:

- The warehouse in Raalte will be fully dedicated to Van der Poel Desserts. Which means that for Zuivelhoeve Vers the second most profitable alternative location must be used, because the optimal location for storing end products and raw materials/packaging for Zuivelhoeve Vers was also in Raalte. For Van der Poel Dessert this means that the total operational costs for this option will be: € 707,601.54.
- Since the building in Raalte cannot be expanded further, build the warehouse at the external location in Hengelo (this is the only possible alternative location) and make sure that it has enough capacity to handle this growth. The total operational costs for a warehouse at this location will be: €1,011,659.18.

8.3 Conclusion

This chapter began by calculating the future stock levels and thereby the capacity needed under the future growth scenarios of 10%, 30% and 50% with respect to the base year, 2014. The future stock levels have been compared with the storage capacity of the warehouses of the possible scenarios. Since the capacity at the production location does not change for all three scenarios and therefore does not have influence on the storage location decision, in the following tables only an overview is given of whether the warehouse of a certain scenario can handle the future stock levels. When the stock levels do not exceed the capacity of a warehouse this is indicated with OK and when the stock levels do exceed the capacity of a warehouse this is indicated with NOT OK.

Zuivelhoeve Vers		capacity	10% growth	30% growth	50% growth
Current situation-Raalte	End products-warehouse	1285	OK	NOT OK	NOT OK
	Raw materials/ packaging - warehouse	196	NOT OK	NOT OK	NOT OK
Scenario 3 (warehouse in Twekkelo)	End products-warehouse	2250	OK	OK	OK
	Raw materials/packaging -warehouse	900	OK	OK	OK

Table 8-4 Overview capabality of warehouses to handle to future growth of stock levels, Zuivelhoeve Vers

Van der Poel Desserts		capacity	10% growth	30% growth	50% growth
Current Situation - Holten	End products-warehouse	-	Undesirable	Undesirable	Undesirable
	Raw materials/ packaging - warehouse	-	Undesirable	Undesirable	Undesirable
Scenario 1 (warehouse in Raalte)	End products-warehouse	3000	OK	NOT OK	NOT OK
	Raw materials/ packaging - warehouse	1500	OK	OK	OK
Scenario 2 (warehouse in Hengelo)	End products-warehouse	3000	OK	NOT OK	NOT OK
	Raw materials/ packaging - warehouse	1500	OK	OK	OK

Table 8-5 Overview capabality of warehouses to handle to future growth of stock levels, Van der Poel Desserts

After the future stock levels were calculated an LP-model was made. This model was used to help determine what scenario is most profitable to use under which future growth ratio. The ILP-model was only based on the stock levels of end products and transport of end products, because the end products result in the largest expense with regard to the storage costs and transport costs. And above that the ILP-model could not be made for both raw materials/packaging and end products together, so a consideration had to be made which of those two to use in the ILP-model.

When the ILP- model was applied to all future stock levels, the output of this model indicated that the most profitable location for a warehouse both for Zuivelhoeve Vers and Van der Poel Desserts would be in Raalte(next to the distribution center of Nagel). In the weeks in which the stock levels would exceed the capacity level of this warehouse, the output of the LP-model indicated that extra storage space should be rented in Holten. In figure 8-4, this is drawn for the 10 % and 30% growth ratios, including the operational costs. For the 50% growth ratio the stock levels exceeded the capacity levels for both subsidiaries in a lot of weeks, which may be undesirable to the company. Therefore for the 50 % we thought of two alternative solutions to this dilemma, see figure 8-5. For option 1 the operational costs for both subsidiaries together are: € 3,739,094.26 and for option 2 the operational costs for both subsidiaries together are: € 3,692,952.76. When looking at the operational costs option 2 should be chosen for the 50 % growth ratio, but taking the amount of changes with regard to the current situation into account, scenario 1 is the better option. In the current situation the warehouse of Zuivelhoeve Vers was already located in Raalte and in option 1 nothing changes for Zuivelhoeve Vers except that the warehouse is expanded. For Van der Poel Dessert, changes have to take place anyway, because the current situation in which storage space is rented from MFFF in Holten is undesirable. Therefore a trade-off has to be made by the management between the amount of changes and the costs involved.

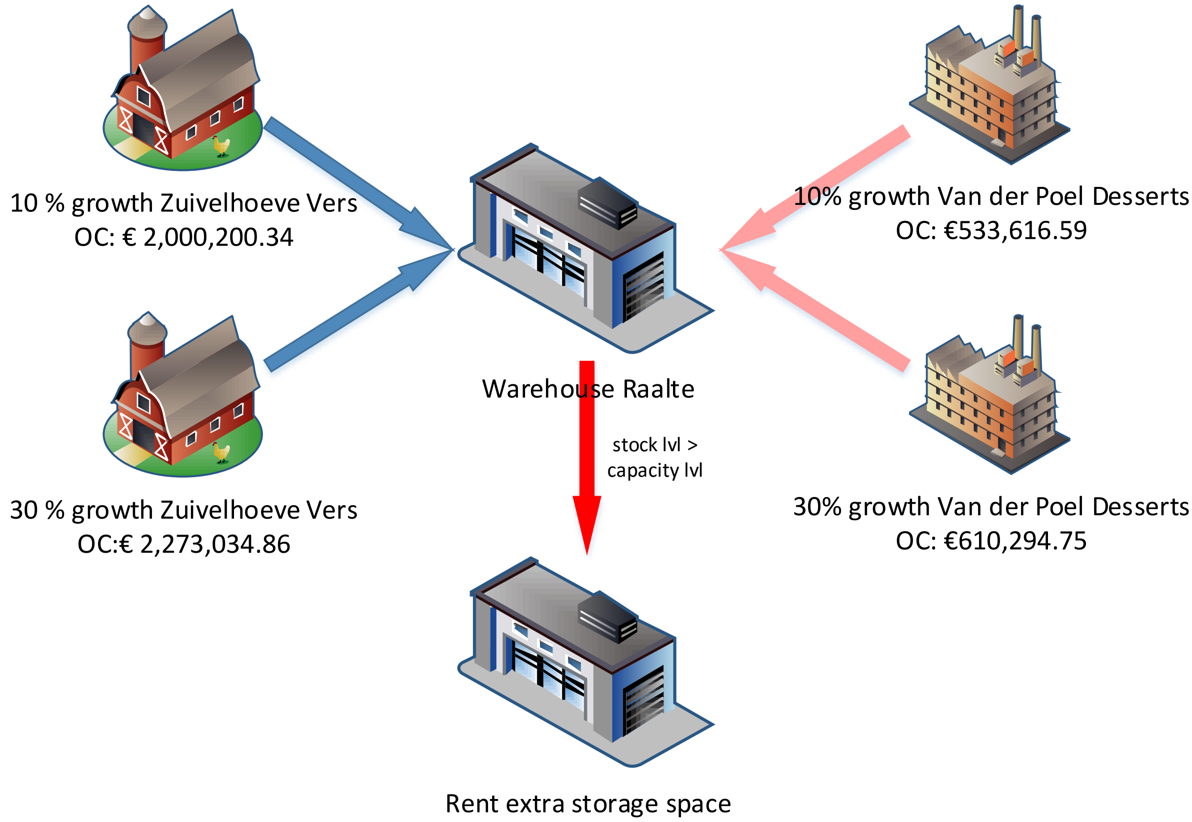


Figure 8-4 Overview optimal warehouse location 10 % and 30% growth ratio Zuivelhoeve Vers and Van der Poel Desserts

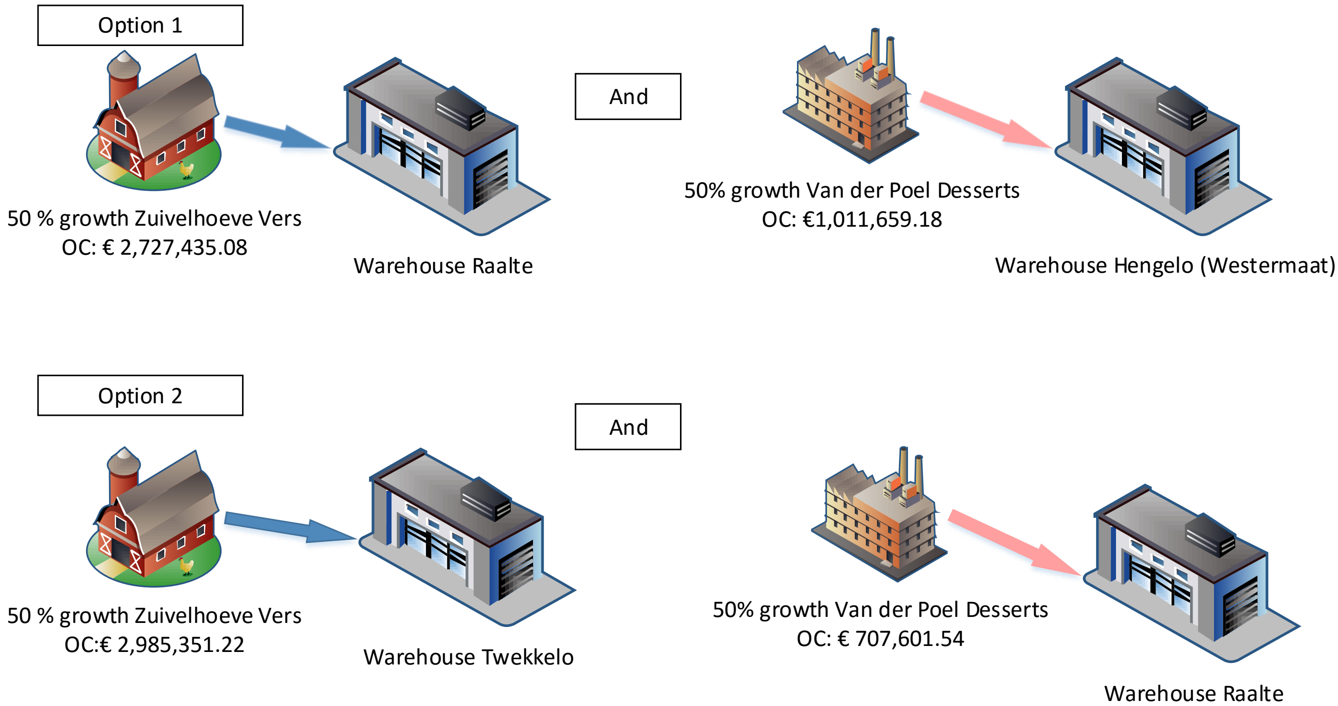


Figure 8-5 Overview optimal warehouse location 50% growth ratio Zuivelhoeve Vers and Van der Poel Desserts

9 Conclusions & recommendations

The aim of this research (as stated also in Section 2.4) is to help Roerink Food Family in designing a reliable and sound storage capacity plan and product allocation across the warehouses, with a view to the future growth of the company. The main research question we tried to answer in this thesis was therefore:

"What should be the storage capacity plan for the Roerink Food family for different scenarios of future growth?"

In Section 9.1 we recapitulate the previous chapters and present the research conclusions based on the sub research questions. Subsequently, in Section 9.2 we give the recommendations for Roerink Food Family relating to the research aim.

9.1 Conclusions

In this part we answer the sub research questions , which were developed in section 2.4, to help answer the main research question. The answers to these sub research questions recapitulate conclusions of previous chapters.

2. *What is the current situation and current performance of Roerink Food Family?*
   For this research we only investigated the warehousing and associated transport streams for two subsidiaries of Roerink Food Family, Zuivelhoeve Vers and Van der Poel Desserts. We investigated what the total operational costs per year are for both subsidiaries, this includes storage costs, transport costs to the customer and internal transport costs.
   In the current situation, the warehouse for Zuivelhoeve Vers is located in Raalte (and part of the raw materials/packaging are stored in Oldenzaal), the total operational costs associatied with a warehouse at this location are: €1,919,117.70.
   For Van der Poel Desserts, in the current situation storage space is rented in Holten from MFFF. But renting storage space in Holten from is undesirable for Roerink Food Family, so this option for storing goods of Van der Poel Desserts is unlikely to be used in the future. But it is useful to compare alternative scenarios for the location of the warehouse with the operational costs of this situation. The total operational costs for Van der Poel Desserts in the current situation are: € 824,902.09

3. *What are alternative storage location scenarios and what is the performance of these alternative location capacity scenarios under current conditions?*
   For the current stock levels we investigated three given alternative scenarios for the location of the warehouse. Also we calculated what the optimal location for a warehouse would be for Zuivelhoeve Vers and Van der Poel Desserts using the successive approximation method for Euclidian distances and the exact method for Manhattan distances.
   Another location for the warehouse, leads to different transport streams and thereby

also to different operational costs per year. We compared the total operational costs of these alternative scenarios with the operational costs of the current situation.
For Zuivelhoeve Vers there is only one given alternative scenario (scenario 3). In this scenario the warehouse is located in Twekkelo next to the production location. The operational costs per year for this scenario are € 2,051,213.79, but above that also costs are associated with building the warehouse, these costs are €2,500,000.00.
So for Zuivelhoeve Vers we can conclude that the warehouse location of the current situation in Raalte is more profitable than scenario 3, where the warehouse is located in Twekkelo (operational costs of €1,919,117.70 versus € 2,051,213.79).
For Van der Poel Desserts, there are two alternative scenarios. In scenario 1, the warehouse is located in Raalte (same location as for the current situation of Zuivelhoeve Vers) and in scenario 2 the warehouse is located in Hengelo (Westermaat). The operational costs for these scenarios are respectively €552,696.44 and € 602,053.14. Which means that by comparing these operational costs to the operational costs of the current situation € 824,902.09. We can conclude that under the current stock levels, the best location for the warehouse is in Raalte.
Next to these given scenarios, by the two different location-allocation models (for Euclidian distances and manhattan distances), the optimal location for a warehouse is determined based on the transport costs to customers and the production location. We found that for Zuivelhoeve Vers the optimal location according these models isin Twekkelo and for Van der Poel Desserts in Hengelo. Which are the same as the locations of scenario 3 and 2 respectively.

4. *How can long-term forecasts be made for Roerink Food Family?*
Besides finding the optimal location for a warehouse under the current stock levels, our main research question also indicates that the optimal location for a warehouse under different future growth scenarios should be found. Since Roerink Food family wants a 3 year period to be covered, we were dealing with a long-term forecast period. In the literature we found that forecasting by decomposition of the time series (historical stock levels of Zuivelhoeve Vers and Van der Poel Desserts) can be used as mathematical model to forecast the stock levels.
For Van der Poel Desserts and Zuivelhoeve Vers the historical stock levels were decomposed in three different components, the seasonal component, the trend component and the cyclical component. By extrapolating the seasonal and trend component into the future, we gave the stock levels the right fluctuations. The cyclical factor could be adapted such that the future stock levels would be (about) equal to the growth scenarios, Roerink Food Family wanted to have investigated. These were a 10%, 30% and 50% growth rate compared to the total stock levels of 2014.

5. *What is the storage capacity needed for all companies under different future growth rates?*
   In chapter 8 the future stock levels for Zuivelhoeve Vers and Van der Poel Desserts were calculated and compared to the capacities of the current warehouse location and the warehouses of the alternative scenarios.
   For Zuivelhoeve Vers we saw that for refrigerated storage (end products) the capacity of the current warehouse in Raalte is enough to handle the stock levels under the 10% and 30% growth rate. For the 50 % growth rate capacity is exceeded in almost every week. For the ambient storage of Zuivelhoeve Vers the capacity in Raalte is exceeded every week. When we looked at the capacity of the warehouse in Twekkelo (scenario 1), we saw that the capacity were never exceeded both for ambient and refrigerated storage.
   For Van der Poel Desserts , we only look at the capacities of the alternative scenarios, since renting storage space from MFFF (the current warehouse) is undesirable in the future. The future stock levels indicate that the capacity of both warehouses (Raalte and Hengelo) are enough for ambient storage under all future growth ratios. For refrigerated storage, the capacity of both warehouses are not exceeded under the 10% and 30 % growth ratio (except for weeks around Christmas), but for the 50% growth ratios the capacity is exceeded also around Easter by a large amount of pallets.

6. *How should Roerink Food Family allocate its products across the different possible locations under the different future growth rates?*
   To determine the optimal location for a warehouse under the different future growth ratios, we formulated an ILP-model both for Zuivelhoeve Vers and Van der Poel Desserts. In this ILP-model the future stock levels, transport costs to each group of customers, transport costs and storage costs can be inserted. The output of the ILP-model gives the operational costs as objective and indicates where the goods should be stored every week of the year. In theILP-model we also inserted renting storage space as option if just in a few weeks of the year the capacity level of a warehouse is exceeded. So by using this model, we came to the following with regard to the optimal location for a warehouse under the different future growth scenarios:

   <u>Van der Poel Desserts:</u>

   - **10% growth ratio**: Expand the warehouse in Raalte (scenario 2), so that goods of Van der Poel Desserts can be stored here. Operational costs per year are: €533,616.59
   - **30% growth ratio**: the optimal location for a warehouse under this growth ratio is also in Raalte. In the (few) weeks that the capacity is exceeded, extra storage space should be rented. Operational costs per year are: €610,294.75.

Zuivelhoeve Vers:

- **10% growth ratio:** Optimal location for the warehouse is in Raalte. When the capacity level is exceeded, part of the expansion that is actually to be used by Van der Poel Desserts can also be used by Zuivelhoeve Vers, if the expected growth ratio of Van der Poel Desserts is not more than 30 %. Operational costs per year are: €2,273,034.86
- **30 % growth ratio:** Optimal location for the warehouse is in Raalte. When the capacity level in this warehouse dedicated to Zuivelhoeve Vers is exceeded, part of the expansion that is actually to be used by Van der Poel Desserts can also be used by Zuivelhoeve Vers, if the expected growth ratio of Van der Poel Desserts is not more than 30 %. In the weeks that the capacity is still exceeded, extra storage space should be rented. Operational costs per year are: € 2,734,068.12

50% growth ratio: When for one of the subsidiaries it is expected that the stock levels will grow with 50% with respect to the stock levels of 2014, only one subsidiary can use the warehouse in Raalte. For the other subsidiary the second best location should be used. This means there are two options:

1. Zuivelhoeve Vers will stay using the warehouse in Raalte and gets the storage space that was dedicated to Van der Poel Desserts, this leads to €2,727,435.08 as operational costs for Zuivelhoeve Vers in this option.
   For Van der Poel desserts the most profitable alternative location has to be used, this is building a warehouse in Hengelo, this leads to €1,011,659.18 as operational costs for Van der Poel Desserts in this option. Together for both subsidiaries the total operational costs are: € 3,739,094.26.
2. Van der Poel Desserts will stay using the warehouse in Raalte and gets the storage space that was dedicated to Zuivelhoeve Vers, this leads to € 707,601.54 as operational costs for Van der Poel Desserts in this option. For Zuivelhoeve Vers the most profitable alternative location has to be used, this is building a warehouse in Twekkelo, this lead to € 2,985,351.22 as operational costs for Zuivelhoeve Vers in this option.Together for both subsidiaries the total operational costs are: € 3,692,952.76.

Option 2 is cheaper, but involves more changes for Roerink Food Family with respect to the current situation. Therefore a trade-off has to be made by the management between the amount of changes and the costs involved.

9.2 Recommendations

We recommend to the company, in the coming year, to expand the warehouse in Raalte. In this way both companies can use this location for their warehouse.
The warehouse of Zuivelhoeve Vers was already located in Raalte, only the raw materials/packaging that were stored in Oldenzaal have to be moved to Raalte. This has to be done as soon as possible.
The warehouse of Van der Poel Desserts is now located in Holten, to move all storage at once to Raalte would be unwise. First the raw materials/ packaging should be moved to the warehouse in Raalte. This is also to gain insight in, how well the warehouse in Raalte works out for Van der Poel Desserts.
When the company is positive about using the warehouse in Raalte for raw materials/ packaging also storage of the end products can be moved to Raalte.
During this period it is necessary to monitor the stock levels and to make new future predictions. When the stock levels are expected to grow not more than 30% (compared with stock levels of 2014) in 3 years from that moment, nothing has to change and the warehouse in Raalte can still be used for both subsidiaries.
But when the stock levels are expected to grow more than 30% in 3 years from that moment, it has to be decided, for which subsidiary the storage has to move to another location, since the capacity in Raalte will become too small to store goods for both subsidiaries.
My advice is to stay using the warehouse in Raalte for Van der Poel Desserts and build a warehouse in Twekkelo to store the goods for Zuivelhoeve Vers. When looking at the costs this is not only the better option, also when looking at the changes involved there is no longer a preference for keeping the warehouse of Zuivelhoeve Vers in Raalte. This both subsidiaries were already located in Raalte, but the storage of Van der Poel Desserts already moved once to another location (from Holten to Raalte). When moving this again for Van der Poel Desserts, it involves again more changes for Van der Poel Desserts.

10 Future research

In this chapter suggestions for future research are given:

- What is interesting to look at for future research is the possibility of not outsourcing transport anymore. The ideal situation of the center of gravity method, gives already an indication of what the transport costs will be then.
  But by not outsourcing transport anymore of course costs are involved for buying trucks, hiring people and extra tasks for management.
- In this research we worked just with the given stock levels, what is interesting to know if those stock levels are the most optimal stock levels. By doing an inventory policy research the stock levels may even be decreased.
- In this research we only looked at two subsidiaries, further research can also be conducted including the other subsidiaries. For all subsidiaries together it can for example be investigated if a central warehouse is an economically beneficial option.

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11 Appendices

11.1 Appendix A: Floorplan locations Zuivelhoeve vers

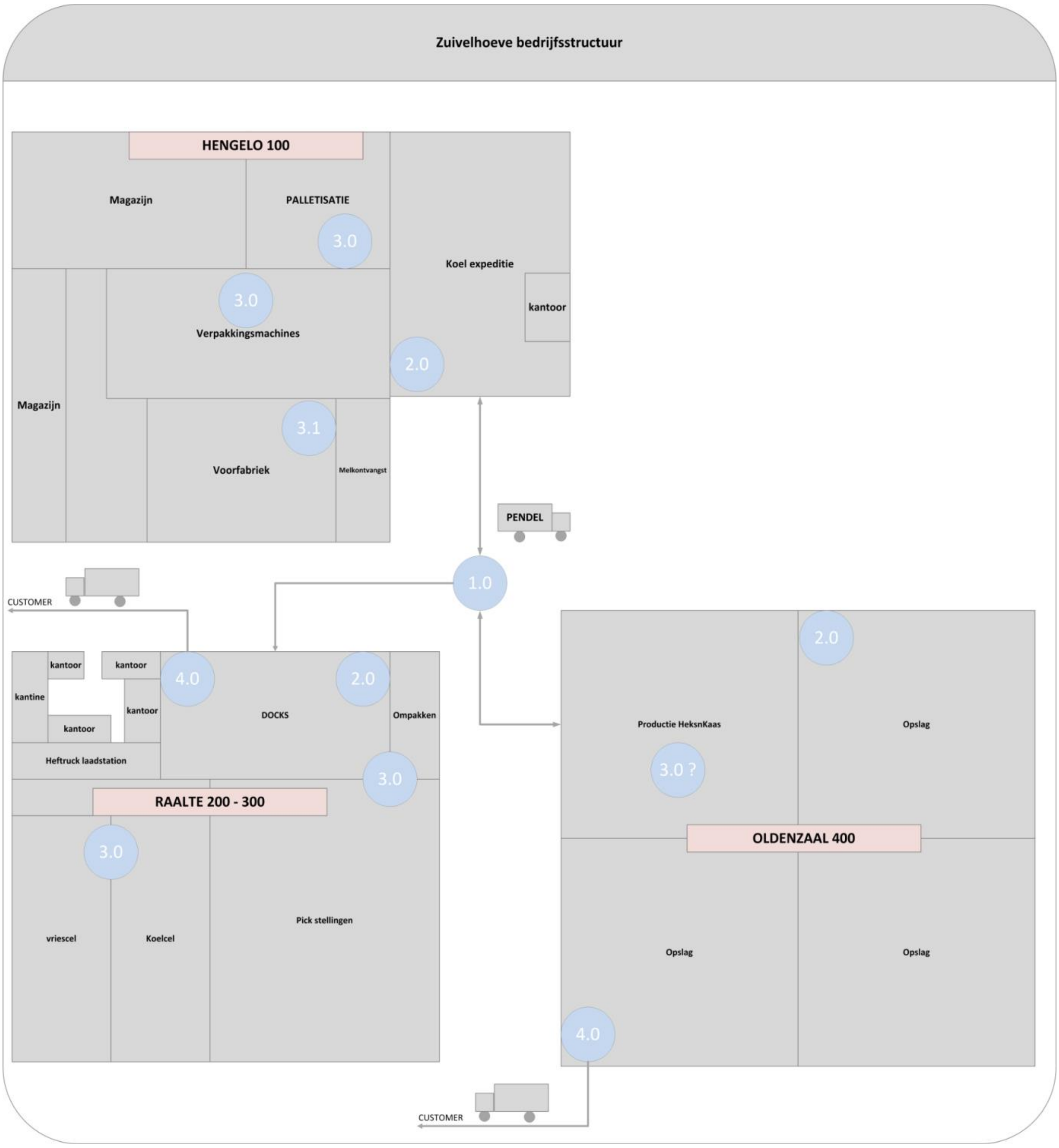

Figure 11-1 Overview locations current situation

11.2 Appendix B: Calculations current storage/distribution costs per year

In this appendix the necessary calculations for evaluating the current situation at Roerink Food Family are explained.

11.2.1 Storage costs Zuivelhoeve Vers

For calculating the current storage costs, the average number of pallet places in stock at each location must be known.

In an interview with the logistics manager it emerged that the average number of end products produced in one week is also the average number of sales in one week. So since there is no historical stock data of the end products, the sales numbers are used as stock levels. For analyzing the current situation it is best to used recent data, therefore we use sales numbers of 2014. These sales numbers are given in numbers of CE sold per product per week(see figure 2) and must be converted into number of pallet places. This can be done by calculating the average number of CE per pallet place.

Aantal (CE) als waarden	201401	201402	201403
WCBav Chipolata 12x150	1,788	2,376	2,772
WCBav Chocolade 12x150	1,692	1,320	1,632
WCBav Sinaasappel Perzik12x150	912	684	2,556
WCBav Tiramisu 12x150	792	2,976	1,644
WK Coupe	0	0	0
Yoghurt Naturel 5KG	0	0	0
ZH CupMuesli+löff naturel 2011	0	0	0
ZH CupMuesli+löff naturel 2013	0	0	0
ZVH Rolcontainer	0	0	0
Artikelen	414,663	1,234,108	1,198,011

Table 11-1 Overview part of weekly sales numbers Zuivelhoeve Vers in number of CE sold in 2014

<u>Average number of CE per pallet place</u>

The average number of colli per pallet place are known to be 167 (Hannink, 2015). So if the average number of CE per colli are known, our sales numbers can be easily converted into number of pallet places instead of number of CE. So what has to be known in steps:

- Average number of CE per palletplace = ?
- Average number of colli per palletplace = 167
- Average number of CE per colli =?

First we focus on the **number of CE per colli.** To calculate the average number of CE per colli, the service level overview and sales numbers of 2013 are used. This is because in 2013 the sales overview also included the sales of Heks'nkaas and the service level overview (table 11-2) is always given for Heks'nkaas and Zuivelhoeve Vers together. The sales overviews of

Zuivelhoeve Vers of 2014 and 2015 do not include sales numbers of Heks'nKaas anymore.

Week nummer	Aantal colli	Gemist		Service.grd	
		aantal	%	aantal	%
201301	114793	1113	1.0	113680	99.0
201302	145535	769	0.5	144766	99.5
201303	153600	1295	0.8	152305	99.2
201304	135261	1306	1.0	133955	99.0
201305	140889	585	0.4	140304	99.6
201306	157513	810	0.5	156703	99.5
201307	144803	55	0.0	144748	100.0
201308	164086	679	0.4	163407	99.6
201309	177812	469	0.3	177343	99.7
201310	154468	779	0.5	153689	99.5
201311	138265	106	0.1	138159	99.9
201312	157983	114	0.1	157869	99.9
201313	151922	1428	0.9	150494	99.1
201314	127253	1215	1.0	126038	99.0
201315	146589	1761	1.2	144828	98.8
201316	133991	695	0.5	133296	99.5
201317	134698	863	0.6	133835	99.4
201318	155286	783	0.5	154503	99.5
201319	183861	2740	1.5	181121	98.5
201320	163620	1774	1.1	161846	98.9
201321	130465	394	0.3	130071	99.7
201322	145528	357	0.2	145171	99.8

Table 11-2 service level overview Heks'nKaas and Zuivelhoeve Vers

Using the sales overview of 2013 the average number of CE per colli for Heks'nKaas can easily be calculated (table 11-3). For example Heks'nKaas 6x150g means that there are 6 CE per colli. So all we have to do is calculate for every Heks'nKaas product the fraction of number of CE sold divided by the total number of CE sold for Heks'nKaas and multiply this fraction by the number of CE per colli for that product. For example for the first week:

$$\frac{(840 * 12) + (1212 * 4) + (41022 * 6) + (564 * 1)}{840 + 1212 + 41022 + 564} = 5.995325175$$

By averaging this number for all weeks for which the sales of Heks'nKaas is included in 2013 we get an average of 5,77 CE per colli for Heks'nKaas.

Havermoutpap verrijkt 12 x 150	0	0	0	0	0	0
HEKS'NKAAS Tomaat Bas 6 x 200g	0	0	0	0	0	0
HEKS'NKAAS® 12 x 35 gr	840	600	600	600	600	804
HEKS'NKAAS® 4 x 1 kg	1,212	1,364	1,528	1,532	2,000	1,812
HEKS'NKAAS® 6 x 150g	0	0	0	0	0	0
HEKS'NKAAS® 6 x 200g	41,022	44,886	61,464	71,190	52,890	59,382
HEKS'NKAAS® basis 3kg	564	1,085	689	758	908	934
HEKS'NKAAS® Gr. Olijf 4x1kg	0	0	0	0	0	0
HEKS'NKAAS® Gr. Olijf 6x80g	0	0	0	0	0	0

Table 11-11-3 Overview part of the sales numbers Heks'nKaas

Now the weekly numbers of colli sold for Heks'nkaas in 2013 can be calculated and can be deducted from the total number of colli sold from the service level overview (these weekly numbers were given for Heks'nKaas and Zuivelhoeve Vers together). The number of colli that remains are the weekly numbers of colli sold for Zuivelhoeve Vers in 2013. Example for week 1 of 2013.

- Number of colli sold for Heks'nkaas in week 1 of 2013

$$\frac{840 + 1212 + 41022 + 564}{5{,}77} = 7562.911612$$

- Number of colli sold for Zuivelhoeve Vers in week 1 of 2013

$$113680 - 7563 = 106117$$

So now we can also calculate the average number of CE per colli for Zuivelhoeve Vers, this can be done by dividing the weekly sales numbers in CE of Zuivelhoeve Vers (from the sales overview) by the weekly sales number in colli of Zuivelhoeve Vers (calculated from service level overview) and average this number for all weeks. This comes to an average **of 8 CE per colli for Zuivelhoeve Vers**.

Now for all years (2012, 2013 ,2014, 2015) the weekly number of pallet places in stock can be calculated by using the average number of CE per pallet place:

$$\#\ of\ Colli\ \ per\ PP * \#\ of\ CE\ per\ colli = 167 * 8 = 1336$$

Calculating the average # of pallet places in stock for storage locations ZVH Vers

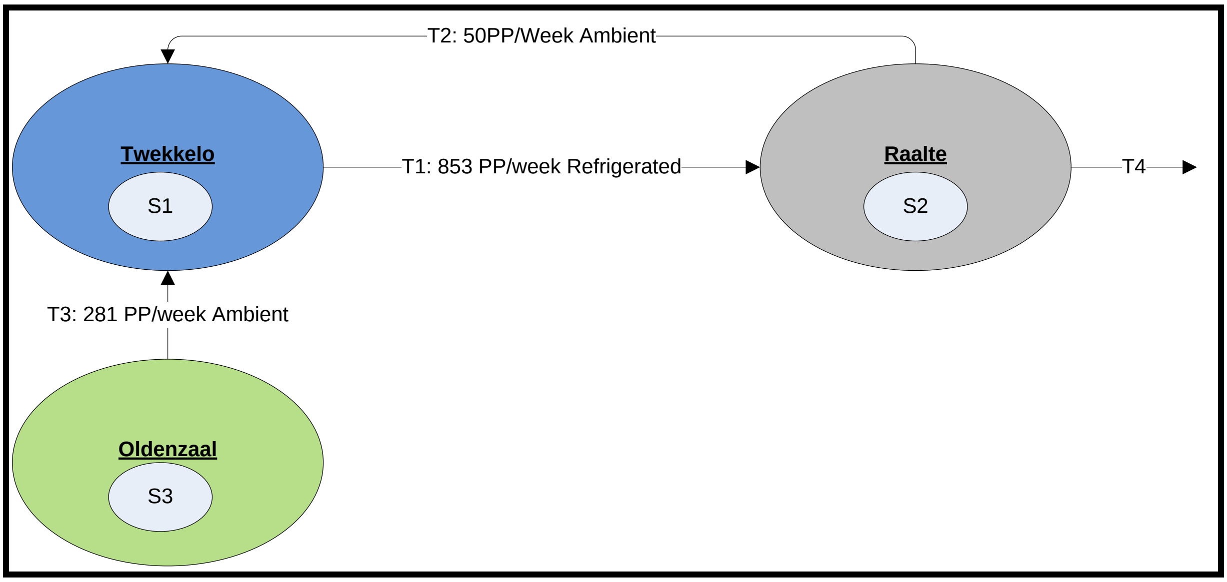

Figure 11-2 Overview current situation logistics & warehousing Zuivelhoeve Vers

In figure 11-2 the average amount that is transported in a week for streams T2 and T3 are given (Hannink, 2015). The stream T1 is calculated by taking the average of the weekly stock levels of 2014 in Raalte which is 853. The average of the weekly stock levels is equal to T1, because the end products on average remain one week 1 stock, so weekly stock levels in Raalte are equal to the amount of pallet places that is transported every week from Twekkelo to Raalte.

In **Twekkelo** (S1) raw materials, packaging and end products are stored. On average 75% of the total amount of end products (853, see figure 11-2) that are produced in a week can be directly transported to Raalte, but yoghurt (25% of the total end products) must stay in storage for 24 hours in Twekkelo to cool down before it can be transported. That 75% of the end products can directly be transported does not mean that they can be loaded into a truck immediately after production, when this is not possible a part of the end products must also be stored in Twekkelo before they can be loaded into a truck for transport. We assume therefore that on average 75% (including yoghurt) of all end products produced must be stored in Twekkelo before they can be transported. Which means that on average:

$$\frac{853}{7} * 0{,}75 = 91.39285714$$

pallet places of end products are stored in Twekkelo on a day.

In Twekkelo 281+50= 331 pallet places of raw materials and packaging arrive every week from the storage locations in Oldenzaal and Raalte. These raw materials and packaging stay on stock for about 2 days in Twekkelo (Hannink, 2015). Which means that on average:

$$\frac{331}{7} * 2\ days = 94.57$$

pallet places of raw material and end products are stored in Twekkelo on a day.

In **Raalte** the end products on average remain one week in stock. So the average amount of end products that is transported from Twekkelo to Raalte in one week, is also the average amount of end products in stock in Raalte (853 PP).

In **Raalte** and **Oldenzaal** also raw/materials and packaging are stored, respectively 100 PP and 500 PP on average (Hannink, 2015).

11.2.2 Distribution Costs Zuivelhoeve Vers

Zuivelhoeve Vers has customers in the Netherlands, Belgium and Germany. For all those countries the distribution costs have to be calculated in a different way. So per country the calculations are explained.

Distribution costs customers in The Netherlands

For customers in the Netherlands the distribution costs consist of a starting fee and a standard cost per pallet.

What we want to know for determining our distribution costs are the average number of pallets transported at once to a customer and the total number of pallets transported to a customer in a year, see table 11-4. Once this is known the total distribution costs per year to a customer can be calculated. For example for Apetito BV:

$$Distribution\ costs\ apetito = \frac{total\ \#\ PP}{\#\ PP\ at\ once} * starting\ fee + costs\ per\ PP * total\ \#\ PP$$

$$= \frac{57}{1} * 13.50 + 13.50 * 57 = 1539.00$$

klant	totaal aantal PP	aantal PP /keer	starttarief	kosten/PP	totaal kosten (excl diesel)	totaal kosten (incl diesel 4%)
Apetito BV	57	1	€ 13.50	€ 13.50	€ 1,539.00	€ 1,600.56
CHEFS Culinair West GmbH & CO.KG	38	1	€ 13.50	€ 13.50	€ 1,026.00	€ 1,067.04
HAVI Logistics BV Nederland	80	1	€ 13.50	€ 13.50	€ 2,146.50	€ 2,232.36
Hoogesteger BV	19	2	€ 13.50	€ 13.50	€ 378.00	€ 393.12
Horesca Lieferink B.V.	6	1	€ 13.50	€ 13.50	€ 162.00	€ 168.48
Jansen Foodservice Lochem	22	1	€ 13.50	€ 13.50	€ 594.00	€ 617.76
Maxivers Kaas & Zuivel	94	1	€ 13.50	€ 13.50	€ 2,470.50	€ 2,569.32
Van Marle de Culinaire Groenteman	56	1	€ 13.50	€ 13.50	€ 1,512.00	€ 1,572.48

Table 11-4 Overview table used for calculation distribution costs to customers in het Netherland

The total distribution costs for customers in the Netherlands is the sum of the total distribution costs to all customers.

Distribution costs customers in Belgium

The distribution costs to customers in Belgium consist of variable costs per pallet. These variable costs per pallet depend on the average number of pallets that are transported at once. What we want to know for determining our distribution costs in Belgium are the average number of pallets transported at once to a customer and the total number of pallets transported to a customer in a year, see table 11-5 .

klant	postcode	aantal pp/keer	totaal aantal PP	prijs/PP	totaal kosten	totaal kosten incl dieseltoeslag (4%)
Frabelec		2	764	€ 33.13	€ 25,310.87	€ 26,323.30
N.V. Etn Franz Colruyt 06	1500	2	371	€ 33.13	€ 12,291.01	€ 12,782.65
						€ -
proefleveringen		1	10	€ 39.34	€ 393.41	€ 409.15
Retail Partners Colruyt gr NV	1740	1	9	€ 39.34	€ 354.07	€ 368.23
Spar Retail NV Belgie	1740	1	151	€ 39.34	€ 5,940.52	€ 6,178.14
Superlog		2	7	€ 33.13	€ 231.91	€ 241.18

Table 11-5 overview table used for calculating distribution costs for customers in Belgium

The average number of pallets transported at once is used to find the cost per pallet, if more pallets are transported at the same time, the cost per pallet is less.
The total costs to a customer can be calculated by multiplying the costs per pallet by the total number of pallets supplied to a customer in a year. For example for Frabelec:

$$Total\ costs\ Frabelec = 33.13 * 764 = 26{,}323.30$$

The total distribution costs for customers in Belgium is the sum of the total distribution costs to all customers.

<u>Distribution costs customers in Germany</u>

Distribution costs in Germany can be divided into distribution costs to several locations of REWE FL and distribution costs to other customers in Germany. First calculations for REWE FL are explained and then calculations for the other customers in Germany are given.

Distribution costs several locations of REWE FL

Goods to several locations of REWE FL are transported from Raalte to Borgholzhausen (place in Germany) and from Borgholzhausen the goods are transported to the customer.
From Raalte to Borgholzhausen the distribution costs consist of a standard costs per pallet (€13.85). From Borgholzhausen the distribution costs are variable per pallet. These variable costs depend on the location of the customer and the number of pallets transported at once to a location (see table 11-6). Every location of REWE FL has its own cost prices per pallet.
What we have to know for calculating the distribution costs are the average number of pallets transported at once to a location of REWE FL and the total number of pallets supplied to a location of REWE FL.

Klant	prijs 1 PP / postode	gem aantal PP/ keer	totaal aantal PP	Prijs/ PP (aantal PP per keer)	prijs/PP incl diese	Totaal prijs
Rewe FL 011 Rosbach v.d. H.	€ 13.85	3	313	€ 27.57	€ 43.08	€ 13,483.04
Rewe FL 018 Russeina Ketzerbachtal	€ 13.85	2	263	€ 37.78	€ 53.70	€ 14,121.84
Rewe FL 025 Koblenz	€ 13.85	3	328	€ 24.50	€ 39.88	€ 13,081.95
Rewe FL 039 Koln Langel	€ 13.85	6	752	€ 27.57	€ 43.08	€ 32,393.75
Rewe FL 044 Eitting	€ 13.85	2	223	€ 37.78	€ 53.70	€ 11,974.03
Rewe FL 061 Wiesloch	€ 13.85	3	304	€ 29.61	€ 45.20	€ 13,740.31
Rewe FL 073 Lehrte	€ 13.85	3	298	€ 27.57	€ 43.08	€ 12,836.89
Rewe FL 163 Breuna	€ 13.85	2	190	€ 26.55	€ 42.02	€ 7,983.04
Rewe FL 173 Buttenheim	€ 13.85	1	161	€ 33.69	€ 49.44	€ 7,960.10
Rewe FL 193 Neudietendorf	€ 13.85	2	202	€ 31.65	€ 47.32	€ 9,558.64
Rewe Frischelager Stelle	€ 13.85	3	391	€ 29.61	€ 45.20	€ 17,672.57

Table 11-6 Overview table used for calculating distribution costs for locations of Rewe FL

The total distribution costs for each location can be calculated by the following equation:

$$\begin{aligned} &Total\ costs\ location\ REWE\ FL \\ &\quad = (cost\ per\ PP\ Raalte\ Borgholzhausen * total\ \#PP \\ &\quad + cost\ per\ PP\ Borgholzhausen\ Location\ REWE\ FL * total\ \#\ PP) \\ &\quad * fuel\ surcharge \end{aligned}$$

For example for REWE FL in Wiesloch this means

$$Total\ costs\ Wiesloch = (13.85 * 304 + 29.61 * 304) * 1{,}04 = 13{,}740.31$$

The total distribution costs to REWE FL is the sum of the total distribution costs to all locations.

Distribution costs customers in Germany

The distribution costs to customers in Germany consist of variable prices per pallet. These variable prices per pallet depend on the zip code of the customer and the number of pallet places transported at once to a customer.

What we have to know for calculating the distribution costs are the average number of pallets transported at once, the total number of pallets supplied to a location of REWE FL and the zip codes of all customers (see table 5).

Klant	postcode	gem aantal PP/ keer	totaal aantal PP	Prijs/ PP (aantal PP per keer)
Aldi Datteln GmbH & Co KG	D-45711	2	253	€ 41.83
Aldi GmbH & Co KG Dormagen	D-41542	1	316	€ 43.69
Aldi GmbH & Co KG Eschweiler	D-52231	2	376	€ 41.83
Aldi GmbH & Co KG Kerpen	D-50171	1	276	€ 43.69
Aldi GmbH & Co KG Langenfeld	D-40736	2	377	€ 41.83
Aldi GmbH & Co KG Mönchengladbach	D-41010	2	349	€ 41.83
Aldi GmbH & Co KG Montabaur	D-56410	2	66	€ 60.88
Aldi GmbH & Co KG Mühlheim	D-45476	1	340	€ 43.69
Aldi GmbH & Co KG Rheinberg	D-47495	2	349	€ 41.83

Table 11-7 overview table used for calculating distribution costs for customers in Germany

The total distribution costs can be calculated by multiplying the total number of pallets with the costs per pallet. For Aldi Datteln this is for example:

$$253 * 41.83 = 10{,}582.99$$

The total distribution costs for customers in Germany is the sum of the total distribution costs to all customers.

11.2.3 Storage costs Van der Poel desserts

For calculating the current storage costs, the average number of pallet places in stock at the locations S4 and S5 must be known (see figure 11-3). Therefore these will be calculated, using the stock level data of Van der Poel. For location S4 the average stock levels were given for end products and raw materials and packaging (Bom, 2015). For location S5 the average stock levels for end products and raw materials/ packaging are calculated by taking the average of the weekly stock levels of 2014, since these are the most recent stock level of a complete year.

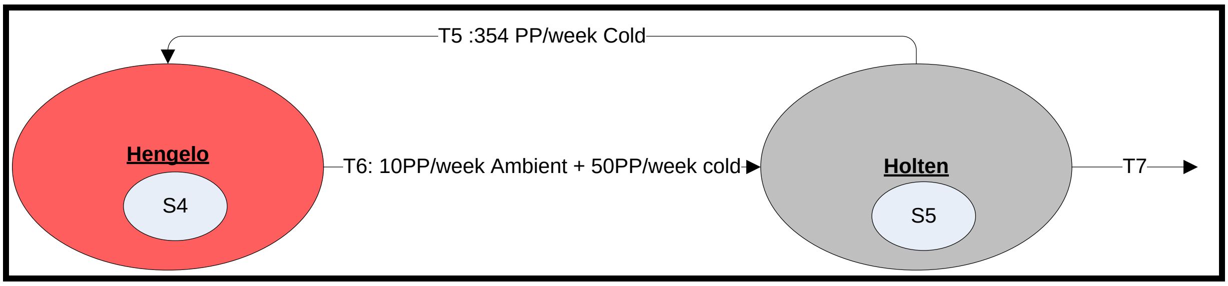

Figure 11-3 Overview current situation Van der Poel Desserts

The streams T5 and T6 were also given by the supply chain manager of Van der Poel desserts.

11.2.4 Distribution costs Van der Poel Desserts

In case of transport to the customer a distinction can be made between transport via Muller and transport via Overnight. First the calculations for Muller are explained, then the calculations for Overnight are given.

Distribution costs to customers via Muller

Part of Van der Poel Desserts customers is supplied from Holten by Muller to the customer. For customers in Belgium and the Netherlands the cost price per pallet depends on the number of pallets transported at once, see table 11-8 for an overview of the data for Muller. The total costs per customer in Belgium and the Netherlands can be calculated by multiplying the total number of pallets per customer by the cost price per pallet.

Laden	Lossen	Klant	Plaatsnaam	pallets	pp	kosten /PP	kosten volle pendel (excl, die	Wachturen	kosten totaal
10-6-2014	11-6-2014	Lidl	Groß Gerau	32			625		662.5
11-6-2014	12-6-2014	Lidl	Groß Gerau	28			625		662.5
12-6-2014	13-6-2014	Lidl	Groß Gerau	33			625		662.5
17-6-2014	18-6-2014	Lidl	Groß Gerau	19			625		662.5
18-6-2014	19-6-2014	Lidl	Groß Gerau	33			625		662.5
24-6-2014	25-6-2014	Lidl	Groß Gerau	22			625		662.5
25-6-2014	26-6-2014	Lidl	Groß Gerau	33			625		662.5
26-6-2014	27-6-2014	Lidl	Heerenveen	3		36.67			116.6106
1-7-2014	2-7-2014	Lidl	Groß Gerau	22			625		662.5
2-7-2014	3-7-2014	Lidl	Heppenheim	19		26.84			540.5576
9-7-2014	10-7-2014	Lidl	Groß Gerau	11			625		662.5
9-7-2014	10-7-2014	Lidl	Heppenheim	22		26.67			621.9444

Table 11-8 Overview data Muller used for calculating distribution costs Van der Poel Desserts

For customers in Germany the distribution costs are given per ride (full truck). As can be seen in table 11-8, there are mainly rides to Germany with full truck loads (33 pallets).

<u>Distribution costs to customers via overnight</u>

To several customers of van der Poel desserts the distribution goes via Overnight. This means that first goods are transported from Holten to Osnabruck and from Osnabruck goods are transported to the customer. What we want to know are the distribution costs from Holten to Osnabruck and the distribution costs from Osnabruck .

The distribution costs from Holten to Osnabruck can be calculated by using the number of pallets transported at once and the corresponding cost price per ride (depends on number of pallets (see table 11-9).

	# of pallets transported at once	costs
Rate 1	1-10	€120
Rate 2	11-20	€200
Rate 3	21-33	€280

Table 11-9 transport cost rates from Holten to Osnabruck (Overnight)

In table 11-10 a snapshot is given of what the data for Overnight looks like. The number of pallets transported at once to Osnabruck can be calculated by summing the number of pallets that are loaded on the same day (Bom, 2015).
So the costs per ride to Osnabruck can be derived from table 11-9, using the number of pallets of that ride to find the corresponding price.
The total costs from Holten to Osnabruck can be calculate by summing the prices for every ride.

Laden	Lossen	Klant	Plaatsnaam	pallets	aantal PP Holten-->Osnabruck	kosten Holten-->Osnabruck	kosten Raalte-->Osnabruck
7-5-2014	9-5-2014	Agro	Hann Munden	4	9	120	128
7-5-2014	9-5-2014	Rewe	Stelle	3			
7-5-2014	9-5-2014	Rewe	Wiesloch	2			
8-5-2014	12-5-2014	Rewe	Eitting	12	17	200	215
8-5-2014	12-5-2014	Edeka	Gochsheim	5			
9-5-2014	13-5-2014	Rewe	Koln-Langel	2	5	120	128
9-5-2014	13-5-2014	Rewe	Lehrte	3			
12-5-2014	14-5-2014	Rewe	Bondorf	1	3	120	128
13-5-2014	15-5-2014	Rewe	Koln-Langel	2			
15-5-2014	19-5-2014	Rewe	Dortmund	14	20	200	215
16-5-2014	20-5-2014	Edeka	Hamm	3			
16-5-2014	20-5-2014	Edeka	Meckenheim	2			
16-5-2014	20-5-2014	Rewe	Raunheim	1			
19-5-2014	21-5-2014	Rewe	Bondorf	1	8	120	128
19-5-2014	21-5-2014	Rewe	Lehrte	3			

Table 11-10 snapshot data Overnight used to calculate transport costs of Van der Poel Desserts

Distribution costs for transportation between Osnabruck depend on the location of the customer and the number of pallets transported at once. Every location has different cost prices (see table 11-10 & 11-11). The costs are calculated for every activity apart, so for every activity the cost price per pallet is found using the number of pallets supplies in that activity. And the total costs for that activity are calculated by multiplying the number of pallets by the cost price per pallet.

	kosten/PP Osnabruck -->klant	totale kosten Osnabruck --> klant	totale kosten incl.diesel
8	€ 35.00	€ 140.00	148.4
	€ 41.50	€ 124.50	131.97
	€ 51.00	€ 102.00	108.12
5	€ 37.00	€ 444.00	470.64
	€ 39.00	€ 195.00	206.7
8	€ 46.00	€ 92.00	97.52
	€ 40.50	€ 121.50	128.79
8	€ 61.00	€ 61.00	64.66
	€ 46.00	€ 92.00	97.52
5	€ 20.50	€ 287.00	304.22

Table 11-11 Overview transport costs to a few customers (Overnight)

The total distributions costs per year for transporting goods from Osnabruck to the customer are calculated by summing the costs for all activities.

11.3 Appendix C: Calculations operational costs Scenario 1

Scenario 1 implies several changes in the logistics and warehousing for Van der Poel desserts (see figure 11-4). The calculations that are needed to calculate the costs for these changes are given in this appendix.

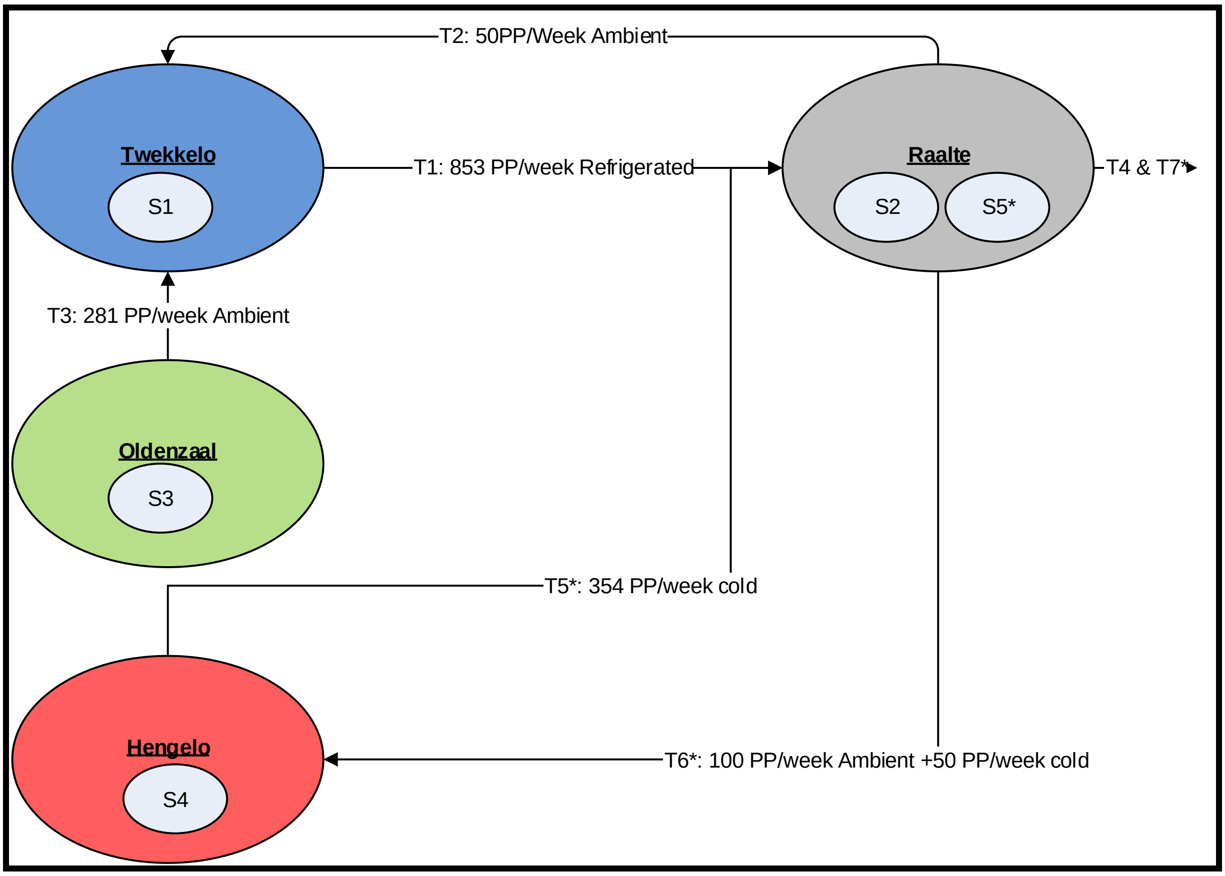

Figure 11-4 Overview Scenario 1 Van der Poel Desserts

11.3.1 Difference costs Cold and Refrigerated transport

To calculate the transport costs for scenario 1, we want to use the transport costs rates of Zuivelhoeve Vers, since the transport for Van der Poel dessert will now be executed by the same distributor as Zuivelhoeve Vers (Nagel). The only difference is that the transport costs rates for Zuivelhoeve Vers are based on refrigerated transport and for Van der Poel Desserts there is only cold transport. To see if there is also a difference in the transport costs for cold and refrigerated transport several distributors that both can transport cold an refrigerated goods have been emailed.
The following answers were given:

- Distributor A: The difference in cost is negligible, the cooling system will run just a little bit more because the temperature difference with the outside air is larger. We are talking about approximately 0.75 cents per km with 24 hours and 650 km. A cooler will be working for about 3 hours in 24 hours .A trailer has sufficient capacity for the temperature to get quickly on the right level, on condition that the goods are loaded on the correct temperature.

- Distributor B: At our company, the rates for refrigerated & frozen transport at least are equal. Only rates for dry cargo (unconditioned) be at least 10% lower. This applies to the Netherlands, Belgium and Germany.
- Distributor C: No difference in costs between cold and refrigerated.

What can be concluded from these e-mails is that there is no difference in costs between cold and refrigerated transport. So the transport cost rates of Zuivelhoeve Vers can be used to calculate the new transport cost rates for Van der Poel desserts.

11.3.2 Calculations T7.1 Muller → Nagel

Transport to the customer that first went via Muller from Holten to the customer, now goes via Nagel from Raalte to the customer. So what we have to know is what the transport costs are from Raalte to the customers of Van der Poel desserts.
Since the transport cost rates of Nagel from Raalte to locations in the Netherlands, Germany and Belgium are known for Zuivelhoeve Vers. We can also use these transport cost rates from Raalte to customers of Van der Poel Desserts.

Transport costs customers Belgium and the Netherlands

For locations in Belgium and the Netherlands the transport cost rates depended on the number of pallets that were transported at the same time and the starting fee.
In order to calculate the transportation costs to customers of Van der Poel Desserts in Belgium and the Netherlands we have calculated for every customer what the price is per pallet for the average number of pallets that is transported at once. See table 11-12 for a snapshot of the data of Van der Poel desserts that is transported via Muller. As can be seen in table 11-12(last column), the number of pallets transported at once to a customer are given. To calculate the average number of pallets transported at once to a customer, we take the average of the pallets transported at all dates at which a customer has been supplied.
For example for the Lidl in Tiel we find that the average number of pallets transported at once is 11(see table 11-13) and that in total for 2014, 371 pallets have been transported.

Datum Laden	Datum Lossen	Klant	Plaatsnaam	Aantal pallets
4-9-2014	5-9-2014	Lidl	Tiel	2
8-9-2014	9-9-2014	Lidl	Groß Gerau	33
8-9-2014	9-9-2014	Lidl	Heerenveen	2
8-9-2014	9-9-2014	Lidl	Zwaag	4
9-9-2014	10-9-2014	Lidl	Heppenheim	12
10-9-2014	11-9-2014	Lidl	Tiel	2
12-9-2014	15-9-2014	Lidl	Londerzeel	1
15-9-2014	16-9-2014	Lidl	Tiel	2
16-9-2014	17-9-2014	Lidl	Etten Leur	5
16-9-2014	17-9-2014	Lidl	Groß Gerau	13
16-9-2014	17-9-2014	Lidl	Heppenheim	20
16-9-2014	17-9-2014	Lidl	Sint Niklaas	3
18-9-2014	19-9-2014	Lidl	Heerenveen	4
19-9-2014	22-9-2014	Lidl	Londerzeel	1
22-9-2014	23-9-2014	Lidl	Tiel	3

Table 11-12 overview data customers Van der Poel desserts

Plaatsnaam	totaal aantal PP	gemiddeld aantal PP	postcode (alleen Duitse)	kosten/PP	kosten totaal excl. Diesel
Sint Niklaas	247	11		19.93	€ 4,922.71
Tiel	371	11		13.5	€ 5,454.00
Tuitjenhorn	391	9		13.5	€ 5,845.50

Table 11-13 snapshot transportation costs Van der Poel desserts

To calculate the total costs per year to each customer the following equations can be used rescpectively for customers in the Netherlands and Belgium:

$$Yearly\ transport\ costs\ to\ customer\ in\ the\ Netherlands = \frac{total\ \#\ PP}{\#\ PP\ at\ once} * starting\ fee + costs\ per\ PP * total\ \#\ PP$$

The starting fee in the Netherlands was €13.50 and the standard costs per pallet were also €13.50.

$$Yearly\ transport\ costs\ to\ customer\ in\ Belgium = Costs\ per\ PP * total\ \#PP$$

In this equation the costs per pallet depend on the number of pallet places transported at the same time. When more pallet places are transported at the same time, the costs per pallet are less.
When for all customers in the Netherlands and Belgium the yearly transport costs are known, the total yearly transport costs to those countries can be calculated by summing up the total yearly transport costs to each customer in that country.

Transport costs customer Germany

For calculating the transport costs to customers in Germany that in the current situation were supplied by Muller and now by Nagel in Raalte , we have to look at the zip codes of the customers, because transport cost rates of Zuivelhoeve Vers to Germany depended on the zip code and the number of pallets transported at once (see table 11-14).
To know what the transport costs are for customers of Van der Poel Desserts in Germany the zip codes of every customer and the average number of pallets transported at once have been looked up. These numbers have been used to find the corresponding price per pallet, see figure 8 for a snapshot of the transport cost rates to Germany.
Once the costs per pallet place are known the following equation can be used to calculate the transport costs per customer:

$$Yearly\ transport\ costs\ to\ customers\ in\ Germany = costs\ per\ PP * total\ \#\ PP$$

When for all customers in Germany the yearly transport costs are known, the total yearly transport costs to those countries can be calculated by summing up the total yearly transport costs to each customer in Germany

Duitsland							
Starttarief	€ -						
Aantal pallets	Tarief per postcode						
	D-01	D-02	D-03	D-04	D-05	D-06	D-07
1	€ 63.15	€ 65.02	€ 58.96	€ 59.63		€ 61.60	€ 64.60
2	€ 62.43	€ 63.67	€ 57.98	€ 58.91		€ 60.25	€ 60.25
3	€ 59.84	€ 60.88	€ 56.27	€ 56.32		€ 57.36	€ 57.36
4	€ 58.39	€ 59.22	€ 56.27	€ 54.87		€ 55.80	€ 55.80
5	€ 54.87	€ 55.80	€ 55.80	€ 51.56		€ 52.39	€ 52.39
6	€ 52.39	€ 53.21	€ 50.78	€ 49.07		€ 49.90	€ 49.90
7	€ 50.00	€ 50.83	€ 50.78	€ 46.80		€ 47.52	€ 47.52

Table 11-14 overview transport cost rates Nagel Germany

11.3.3 Calculations T7.2 Overnight → Nagel

Transport to customers in Germany that in the current situation went via Overnight to several customers of Van der Poel Desserts will in this option for T7.2* go via Nagel to customers of Van der Poel Desserts. So transport cost rates of Nagel used for Zuivelhoeve to customers in Germany can also be used for these customers of Van der Poel Desserts.
For transport via Overnight, in the current situation end products were first transported from Holten to Osnabruck and then from Osnabruck the goods weretransported to the customer. In this option for transport stream T7.2,* the end products will directly be transported from Raalte to the customers in Germany.
What we have to know for the new situation are the zip codes of the customers and the average number of pallets transported at once to a customer. So for every customer the zip codes have been looked up and the total number of pallets transported to a customer together with the average number transported to a customer at once have been calculated (see table 11-16) using the data for Overnight (see table 11-15).

Datum Laden	Datum Lossen	Klant	Plaatsnaam	Aantal pallets	aantal PP Holten-->Osnabruck	kosten Holten-->Osnabruck	kosten Raalte-->Osnabruck
7-5-2014	9-5-2014	Agro	Hann Munden	4	9	120	128
7-5-2014	9-5-2014	Rewe	Stelle	3			
7-5-2014	9-5-2014	Rewe	Wiesloch	2			
8-5-2014	12-5-2014	Rewe	Eitting	12	17	200	215
8-5-2014	12-5-2014	Edeka	Gochsheim	5			
9-5-2014	13-5-2014	Rewe	Koln-Langel	2	5	120	128
9-5-2014	13-5-2014	Rewe	Lehrte	3			
12-5-2014	14-5-2014	Rewe	Bondorf	1	3	120	128
13-5-2014	15-5-2014	Rewe	Koln-Langel	2			
15-5-2014	19-5-2014	Rewe	Dortmund	14	20	200	215
16-5-2014	20-5-2014	Edeka	Hamm	3			
16-5-2014	20-5-2014	Edeka	Meckenheim	2			
16-5-2014	20-5-2014	Rewe	Raunheim	1			
19-5-2014	21-5-2014	Rewe	Bondorf	1	8	120	128
19-5-2014	21-5-2014	Rewe	Lehrte	3			

Table 11-15 Overview data Overnight

Once the zip codes and the average number of pallets transported at once are known the cost price per pallet can be derived from the cost rates overview (see table 11-14). And then for every customer we can calculate the distribution costs per year (see table 11-16)

Plaatsnaam	totaal aantal PP	gemiddeld aantal PP	postcode	kosten/PP	kosten totaal excl diesel	kosten totaal incl. diesel
Bad Wünnenberg	10	10	33	€ 28.26	€ 282.60	€ 293.90
Berlin	12	12	10		€ 468.99	€ 487.75
Bingen	157	5	55	€ 46.07	€ 7,232.99	€ 7,522.31
Bondorf	30	2	71	€ 66.26	€ 1,987.80	€ 2,067.31
Borna	71	3	4	€ 56.32	€ 3,998.72	€ 4,158.67
Bottrop	12	4	46	€ 44.72	€ 536.64	€ 558.11
Buttenheim	7	7	96	€ 48.35	€ 338.45	€ 351.99
Coswig	12	12	6		€ 446.21	€ 464.06
Dortmund	201	6	44	€ 32.72	€ 6,576.72	€ 6,839.79

Table 11-16 snapshot of calculating the transport costs for stream T7.2 scenario 1

11.3.4 Calculations T7.2 Overnight via Holten → Overnight via Raalte

Transport that first went from Holten via Osnabruck to several customers of Van der Poel Desserts in Germany, will in this option for transport stream T7.2 go from Raalte via Osnabruck to customers in Germany. Since the costs from Onsabruck to the customers will not change with respects to the current situation, the only thing we have to calculate for this option are the transport costs from Raalte to Osnabruck. Therefore the distance from Holten to Osnabruck and the distance from Raalte to Osnabruck must be known and the costs from Raalte to Osnabruck can be derived from these distances. As can be seen in appendix C, there are three cost rates for transport from Holten to Osnabruck, so we must also calculate three cost rates for transport from Raalte to Osnabruck.
For the first rate, the following calculations have been made:

$$Rate\ 1\ Raalte\ Osnabruck\ = \frac{Distance\ Raalte\ Osnabruck * Rate\ 1\ Holten\ Osnabruck}{Distance\ Holten\ Osnabruck}$$

$$= \frac{133 * 120}{124} = 128$$

The other transport rates are presented in the table below (table 1):

	# of pallets transported at once	costs
Rate 1	1-10	€ 128
Rate 2	11-20	€ 215
Rate 3	21-33	€ 300

Table 11-17 transport cost rates Raalte- Osnabruck scenario 1

Now we have to know the number of pallets transported at once from Raalte to Osnabruck. These are the same as the number of pallets transported at once from Holten to Osnabruck, see table 11-15, sixth column. The costs from Raalte to Osnabruck can be derived from the number of pallets transported at once from Raalte to Osnabruck and using the cost rates in table 11-17. In the last column of figure 11-15 for the transport costs for a few rides from Raalte to Osnabruck have been given. When the costs for all rides in a year are known, these costs can be summed up to calculate the total transport costs per year from Raalte to Osnabruck.

11.4 Appendix D: Calculations operational costs scenario 2

Scenario 2 implies several changes in the logistics and warehousing for Van der Poel desserts (see figure 11-5). The calculations that are needed to calculate the costs for these changes are given in this appendix

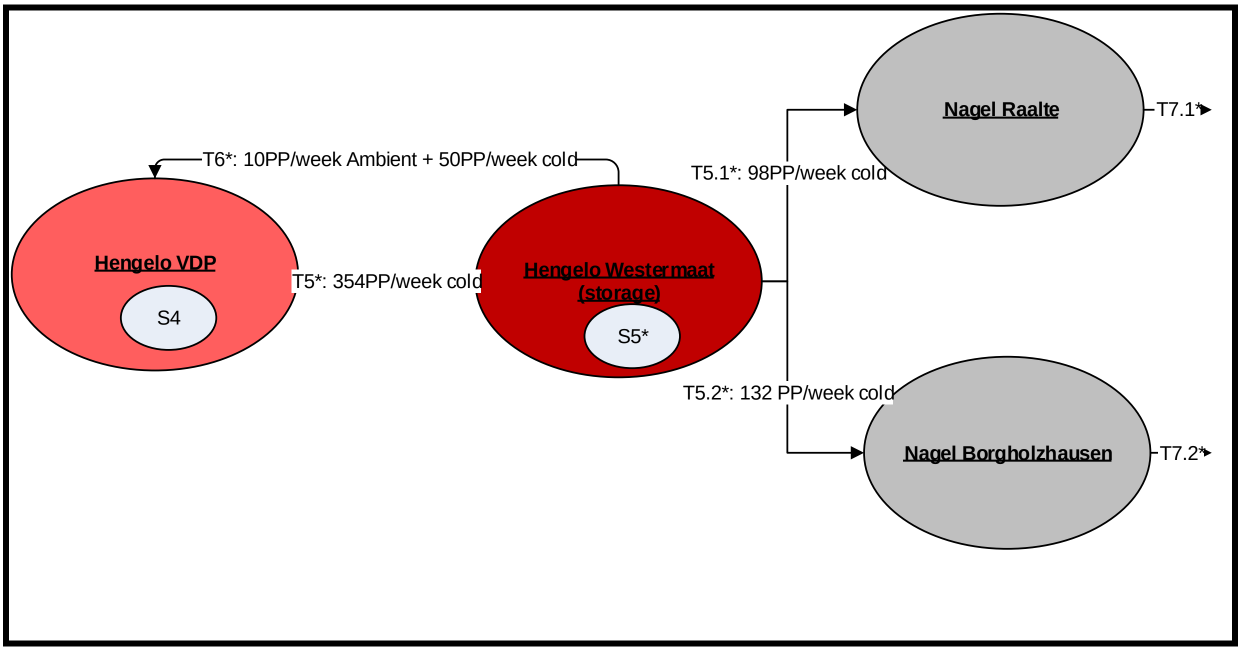

Figure 11-5 Overview logistics and warehousing in Scenario 2

11.4.1 Calculations T5: Internal inventory movements between the production location in Hengelo and the warehouse in Hengelo

What we need to calculate to know the transport costs for transport between the production location of Van der Poel Desserts in Hengelo and the warehouse in Hengelo is the transport cost rate.
For calculating the transport cost rate between the production location and the warehouse, several known transport costs rates between two internal location are used and their distances have been looked up, see table

Internal transport	km	costs	costs/PP/km
Oldenzaal-Raalte	49.5	117.82	0.074381313
Holten-Raalte	19.4	101.95	0.164223582
Twekkelo-Raalte	45.9	116.22	0.079125817
Ede-Raalte	71	132.53	0.058331866
Average			**0.094015645**

Table 11-18 Overview known cost rates for several internal transport options

Based on a truckload of 32 PP, the costs per PP per kilometer have been calculated for each internal transport option (see last column, table 11-18). By taking the average of this number over all known internal transport options, we have the transport cost rate that can

be used to calculate the transport costs between Twekkelo and Borgholzhausen. The average is : €0.094 per pallet per kilometer.
This number can be used to calculate transport costs for all internal transports.

11.4.2 Calculations T5.1 & T5.2*:

For calculating the transport costs for T5.1* & T5.2, the average number of pallets per week transported from the warehouse in Hengelo to the distribution center of Nagel in Raalte and Borgholzhausen must be known.

Average number of pallets per week to the distribution center in Raalte
Since only customers of Van der Poel Desserts in Belgium and the Netherlands will be supplied from the distribution center in Raalte, we have to add together all pallets transported in a year to customers in those countries and divide this by 52 weeks.
In table 11-19 a few locations of customers(first column) and the number of pallets transported(second column) in a year to those locations have been given. So by summing up these number of pallets and dividing it by 52 week, you will have the average number of pallets per week that have to be transported to the distribution center in Raalte. This average number is 98 pallet places per week.

Plaatsnaam	totaal aantal PP
Groningen	12
Gullegem	404
Haaksbergen	3
Heerenveen	438
Hengelo	1
Kortrijk	157
Lochem	8
Londerzeel	231
Meppel	1
Merelbeke	1
Nijmegen	22
Oldenzaal	2
Oostkamp	1164

Table 11-19 snapshot number of pallets transported per year to a customer of Van der Poel Desserts

Average number of pallets per week to the distribution center in Borgholzhausen
Customers of Van der Poel Desserts in Germany will be supplied from the distribution center in Borgholzhausen. So we have to add together all pallets transported in a year to the customers in Germany and divide this number by 52 weeks, then the average number of pallets that have to be transported each week to the distribution center in Borgholzhausen are known. This average number is 132 pallet places per week.

11.4.3 Calculations T7.2*: Transport to customers in Germany

For calculating the transport costs between Borgholzhausen and the customers of Van der Poel Desserts in Germany the transport cost rates to be used must be known. These are calculated using the transport cost rates of Zuivelhoeve Vers to their customers in Germany and the distances from Raalte to those customers in Germany. The calculations for the transport cost rate are further explained in appendix D(calculation T4.2*). The result of those calulcations were that the following equation can be used to calculate the transport costs to each customer of Van der Poel Desserts in Germany:

$$“y = -5E\text{-}05x^2 + 0.0803x + 33.05”$$

In this equation y is the costs per pallet to a customer and x is the distance to a customer.
So all we have to know now are the distances from the distribution center to each customer of Van der Poel Desserts in Germany and use this number in the equation for each customer.
The distances to each customer have been looked up using Google Maps. Once the costs per pallet to each customer are known. The total costs per year to each customer can be calculated by using the following equation:

$$Yearly\ costs\ to\ a\ customer\ in\ Germany = costs\ per\ PP * Total\ \#\ of\ PP/year$$

The total transport costs for T7.2 per year is equal to the sum of the yearly transport costs to all those customers.

11.5 Appendix E: Calculations operational costs scenario 3

Scenario 3 implies several changes in the logistics and warehousing of Zuivelhoeve Vers, see figure. The calculations that are needed to calculate the costs for these changes are given in this appendix.

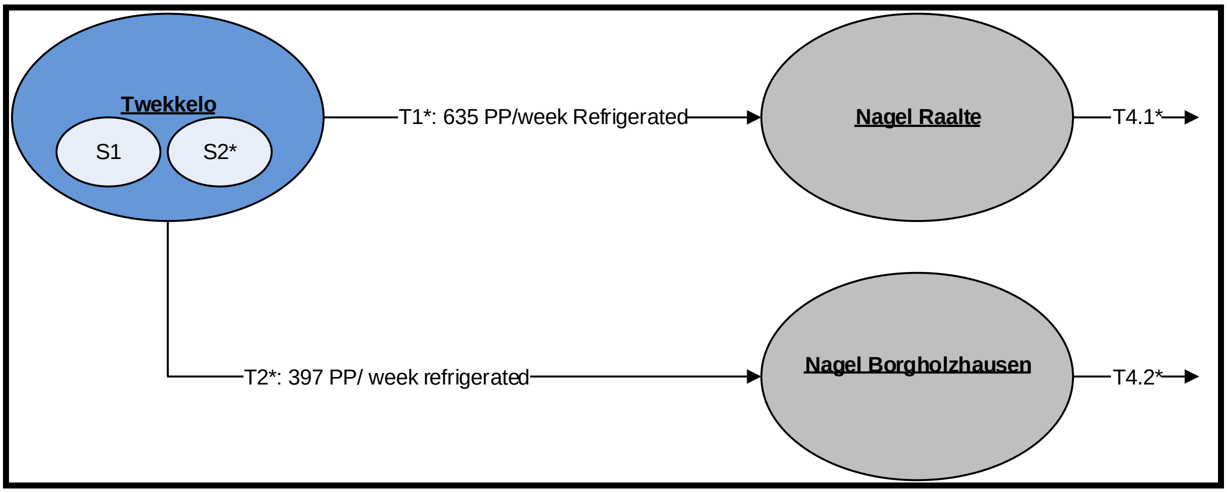

Figure 11-6 Overview warehousing & logistics scenario 3

11.5.1 Calculations T1*: Internal transport Twekkelo - Raalte

What we need to calculate to know the transport costs for transport between the warehouse in Twekkelo and the distribution center in Raalte, are only the number of pallets transported every week between Twekkelo and Raalte, since the costs per pallet are already known from the current situation.

The number of pallets transported per week between Twekkelo and Raalte we assume are equal to the total number of pallets transported per week to customers in the Netherlands and Belgium. In table 11-20 an overview is given of the number of pallets transported to a few customers in the Netherlands. By summing up all the number of pallet places in the third columns for the Netherlands and for Belgium, the total number of pallet places transported in a year between Twekkelo and Raalte are known. By dividing this number by 52 weeks, you will have the average number of pallets transported between Twekkelo and Raalte per week, this is 635 PP/week.

klant	plaats	totaal aantal PP
Apetito BV	denekamp	57
CHEFS Culinair West GmbH & CO.KG	nijmegen	38
HAVI Logistics BV Nederland	amersfoort	80
Hoogesteger BV	zwanenburg	19
Horesca Lieferink B.V.	twello	6
Jansen Foodservice Lochem	lochem	22
Maxivers Kaas & Zuivel	amsterdam	94
Van Marle de Culinaire Groenteman	kampen	56
Sligro Barendrecht	barendrecht	165
Sligro Bezorgcentrum Venray	venray	233
Sligro Bezorgservice Amsterdam	amsterdam	653

Table 11-20 Overview of the number of pallets transported per year to a few customers in the Netherlands

11.5.2 Calculations T2*: Internal transport Twekkelo - Borgholzhausen

What we need to calculate to know the transport costs for transport between the warehouse in Twekkelo and the distribution center in Borgholzhausen, are the number of pallets transported every week between Twekkelo and Borgholzhausen and the transport cost rate for transport between these two cities.

Number of pallets transported

First we begin with calculating the average number of pallets transported per week between Twekkelo and Borgholzhausen. we assume that the total number of pallets transported per week to customers in Germany. In table 11-21 an overview is given of the number of pallets transported to a few customers in Germany. By summing up the number of pallets to all customers in Germany, the total number of pallet places transported in a year between Twekkelo and Raalte are known. By dividing this number by 52 weeks, you will have the average number of pallets transported between Twekkelo and Borgholzhausen per week, this is 397.

Klant	totaal aantal PP
Aldi Datteln GmbH & Co KG	253
Aldi GmbH & Co KG Dormagen	316
Aldi GmbH & Co KG Eschweiler	376
Aldi GmbH & Co KG Kerpen	276
Aldi GmbH & Co KG Langenfeld	377
Aldi GmbH & Co KG Mönchengladbach	349
Aldi GmbH & Co KG Montabaur	66
Aldi GmbH & Co KG Mühlheim	340
Aldi GmbH & Co KG Rheinberg	349
Aldi GmbH & Co KG St. Augustin	293
Aldi GmbH & Co. KG	366
Aldi GmbH & Co. KG Scharbeutz	108
Aldi Herten GmbH & Co KG	219
Aldi Jarmen GmbH & Co KG	103

Table 11-21 overview of the number of pallets transported per year to a few customers in Germany

Transport cost rate Twekkelo – Borgholzhausen

For calculating the transport cost rate between Twekkelo and Borgholzhausen, several known transport costs rates between two internal location are used and their distances have been looked up (this is also calculated in Appendix D), see table 11-22.

Internal transport	km	costs	costs/PP/km
Oldenzaal-Raalte	49.5	117.82	0.074381313
Holten-Raalte	19.4	101.95	0.164223582
Twekkelo-Raalte	45.9	116.22	0.079125817

Ede-Raalte	71	132.53	0.058331866
Average			**0.094015645**

Table 11-22 Overview known cost rates for several internal transport options

Based on a truckload of 32 PP, the costs per PP per kilometer have been calculated for each customer(see last column, table). By taking the average of this number over all known internal transport options, we have the transport cost rate that can be used to calculate the transport costs between Twekkelo and Borgholzhausen. The average is : €0.094 per pallet per kilometer.

This number can be used to calculate transport costs for all internal transports.

11.5.3 Calculations T4.2*: Transport Borgholzhausen – Customers Germany

For calculating the transport costs between Borgholzhausen and the customers in Germany (except REWE FL) the transport cost rates must be known. These are calculated using the transport cost rates from Raalte to the customers in Germany and the distances from Raalte and Borgholzhausen to the customers in Germany.

First the distances from Raalte to the customers in Germany have been looked up using Google Maps (see third column, table 11-23.). The transport cost per pallet, based on the average number of pallets transport at once to a customer, are already known for each customer supplied from Raalte (see seventh column, table 11-23).

Klant	postcode	afstand vana	afstand borg	gem aantal PP/	totaal aantal	Prijs/ PP (aantal	prijs/PP borgho	totaal prijs bo
Aldi Datteln GmbH & Co KG	D-45711	174	124	2	253	€ 41.83	€ 42.07	€ 10,642.45
Aldi GmbH & Co KG Dormagen	D-41542	216	196	1	316	€ 43.69	€ 46.47	€ 14,684.96
Aldi GmbH & Co KG Eschweiler	D-52231	238	248	2	376	€ 41.83	€ 49.33	€ 18,548.61
Aldi GmbH & Co KG Kerpen	D-50171	231	215	1	276	€ 43.69	€ 47.55	€ 13,123.18
Aldi GmbH & Co KG Langenfeld	D-40736	200	180	2	377	€ 41.83	€ 45.54	€ 17,167.45
Aldi GmbH & Co KG	D-41010	190	210	2	349	€ 41.83	€ 47.27	€ 16,496.53
Aldi GmbH & Co KG Montabaur	D-56410	308	283	2	66	€ 60.88	€ 51.10	€ 3,372.87
Aldi GmbH & Co KG Mühlheim	D-45476	165	160	1	340	€ 43.69	€ 44.33	€ 15,073.22
Aldi GmbH & Co KG Rheinberg	D-47495	144	182	2	349	€ 41.83	€ 45.66	€ 15,933.66
Aldi GmbH & Co KG St. Augustin	D-53757	244	219	1	293	€ 63.77	€ 47.77	€ 13,996.54
Aldi GmbH & Co. KG	D-49811	105	101	2	366	€ 48.97	€ 40.55	€ 14,840.62
Aldi GmbH & Co. KG Scharbeutz	D-23684	433	349	1	108	€ 68.95	€ 54.11	€ 5,844.29
Aldi Herten GmbH & Co KG	D-45699	148	145	2	219	€ 41.83	€ 43.40	€ 9,505.42
Aldi Jarmen GmbH & Co KG	D-17126	624	542	1	103	€ 67.81	€ 60.42	€ 6,222.77

Table 11-23 Overview table used to calculate transport cost rate for transport between Borgholzhausen and customers in Germany

Using these costs and the distances to each customer, the graph in figure 11-7 has been made. In the graph a polynomial trend line was added, because this type of trend line fitted best the data based on the coefficient of determination (R^2). R^2 is the percentage of the variations that can be explained by the trend. R^2 is a number between 0 and 1, when the value of R^2 is 1, the trend line perfectly fits the data. There is no value of R^2 that indicates a suitable trend line from an unsuitable trend line (Ozer, 1985). The value of R^2 that separates “good” from “bad” depends on the research and on the choice of the researcher, for this graph we assume that an R^2 of 0.55 is a suitable score for the trend line. In the graph it can be seen that the score of R^2 is 0.6222, which is above our threshold of 0.55 and it means that

62 percent of the variations can be explained by the trend. The equation in the graph "y = -5E-05x^2 + 0.0803x + 33.05" is the equation of the trend line and shows the relationship between the costs per pallet and the distance. This equation will be used to calculate the costs per pallet from Borgholzhausen to the customers in Germany. On the place of the "x" in the equation the distance (in kilometers) from Borgholzhausen can be filled in, in this way the costs per pallet to each customer in Germany can be calculated (see column 8, table 11-23). By multiplying the costs per pallet by the total number of pallets transported to each customer the total transport costs to each customer can be calculated (see last column, table). By adding together the total transport costs to each customer, the total yearly transport customer to all customers in Germany supplied from Borgholzhausen are known.

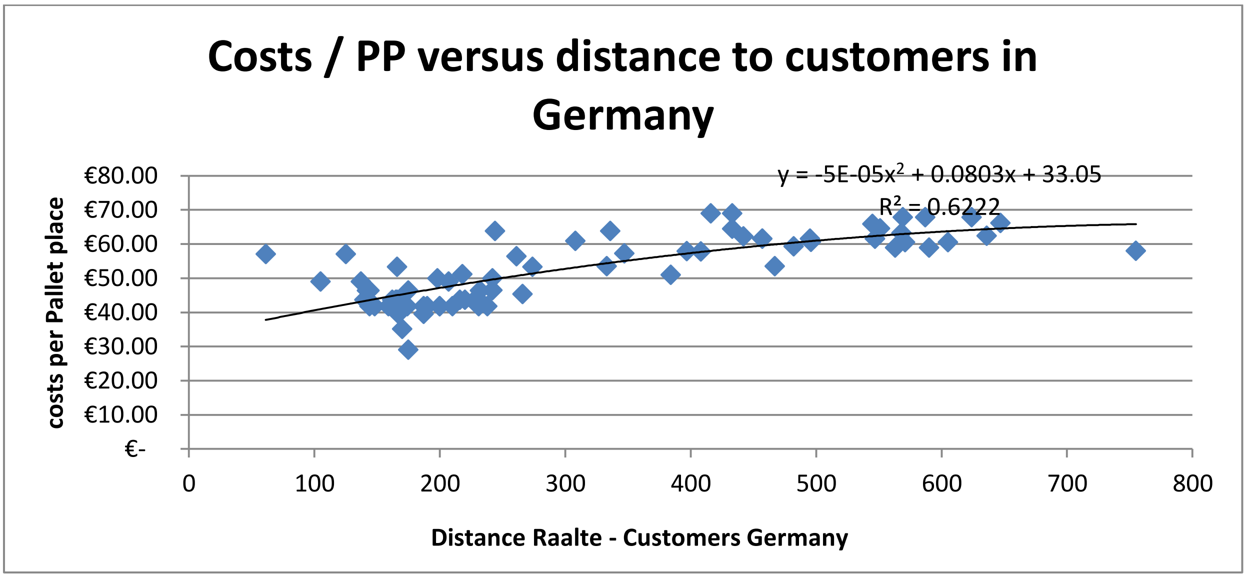

Figure 11-7 Costs per pallet versus the distance to the customers in Germany (current situation Zuivelhoeve Vers)

11.6 Appendix F: Calculations scenario 4&5 Center of gravity method

In this appendix it is explained how the costs per pallet per kilometer for each customer and production location are calculated. When this is done the calculations for the center of gravity method are further explained.

11.6.1 Calculations transport cost of customers and production location

As basis for calculating the transport costs per pallet per km, we use the already known transport cost rates of the current distributor (Nagel). These transport costs are based on transport cost rates from the production location to the distribution center in Raalte and from the distribution center in Raalte to the customer. For each country the transport costs per pallet per km will be calculated separately, since the transport cost rates used by Nagel are calculated different for each country. The calculations are applicable to both Zuivelhoeve Vers and Van der Poel desserts.

Netherlands

For the Netherlands the transport costs rates have a fixed price per pallet (€13,50) and a fixed price per stop €13,50, so it does not matter where the location the customer of the customer in the Netherlands is, the price does not depend on the distance, only on the number of pallets transported at the same time. To convert these cost rates into costs per pallet per km for each cluster of customers, first for each customer the costs per pallet have been calculated by using the following equation:

$$costs\ per\ pallet = \frac{Total\ costs\ excl.diesel}{Total\ number\ of\ pallet\ places}$$

When the costs per pallet are known for each customer, the costs per pallet per km can be calculated. Since it does not matter where the location of the customer is in the Netherlands the costs per pallet per kilometer for each customer are calculated as follows:

$$Cost\ per\ pallet\ per\ km = \frac{Cost\ per\ pallet}{average\ distance\ to\ all\ customers\ in\ the\ Netherlands}$$

In table 11-24 the costs per pallet for a few customers can be seen.

aantal km (echt)	totaal aantal PP	aantal PP /keer	starttarief	kosten/PP	totaal kosten (excl diesel)	totaal kosten (incl diesel 4%)	cost per pallet	cost per pallet /km
58.6	57	1	€ 13.50	€ 13.50	€ 1,539.00	€ 1,600.56	€ 27.00	€ 0.23
98.7	38	1	€ 13.50	€ 13.50	€ 1,026.00	€ 1,067.04	€ 27.00	€ 0.23
84.3	80	1	€ 13.50	€ 13.50	€ 2,146.50	€ 2,232.36	€ 26.83	€ 0.23
144	19	2	€ 13.50	€ 13.50	€ 378.00	€ 393.12	€ 19.89	€ 0.17
25.1	6	1	€ 13.50	€ 13.50	€ 162.00	€ 168.48	€ 27.00	€ 0.23
33.6	22	1	€ 13.50	€ 13.50	€ 594.00	€ 617.76	€ 27.00	€ 0.23
127	94	1	€ 13.50	€ 13.50	€ 2,470.50	€ 2,569.32	€ 26.28	€ 0.22
44.8	56	1	€ 13.50	€ 13.50	€ 1,512.00	€ 1,572.48	€ 27.00	€ 0.23
170	165	35	€ 13.50	€ 13.50	€ 2,291.14	€ 2,382.79	€ 13.89	€ 0.12

Table 11-24 Overview data customers of Zuivelhoeve Vers in the Netherlands

Since it is not clear if every customer is shown on the coordinate system for the center of gravity method, customer will be clustered. In the Netherlands customers will be cluster on their location in the Netherlands. In table 11-24 you can already see that several customers have been clustered together, indicated by the colours in the first columns (purple, red, green, etcetera). For these clusters the price per pallet per kilometer are calculated as follows:

$$\text{Cost per pallet per km (Cluster)} = \frac{\sum_{i=1}^{n} \text{cost per pallet per km for each customer in the same cluster}}{\text{total number of customers in a cluster}}$$

Besides the cost per pallet per kilometer, also the total number of pallets transported in a year to a cluster must be known. This can be done by summing up the total number of pallets transported to each customer in a cluster.

<u>*Germany*</u>

For customers in Germany the transport cost rates of Nagel are based on the postal code of the customer and the number of pallets transported at the same time. To convert these costs rates into costs per pallet per km for each cluster of customers, first for each customer the costs per pallet per kilometer must be calculated. This can be done by using the following equation:

$$\text{Costs per pallet per km} = \frac{\text{costs per pallet (corrected for \# of pallets shipped at same time)}}{\text{average distance from Nagel to all customers in Germany}}$$

The costs per pallet per kilometer for a few customers are shown in table 11-25.

Klant	postcode	afstand Nagel (km)	totaal aantal PP	Prijs/ PP (aantal PP per keer)	prijs/PP incl dies	Totaal prijs	prijs per pallet /km
Rewe FL 018 Russeina Ketzerbachtal	D-01683	593	263	€ 37.78	€ 53.70	€ 14,121.84	€ 0.11
EDEKA HG Borna	D-04552	563	2	€ 58.91	€ 61.26	€ 122.53	€ 0.17
EDEKA HG Hof/Staucha	D-04758	590	2	€ 58.91	€ 61.26	€ 122.53	€ 0.17
EDEKA HG Landsberg	D-06188	495	178	€ 61.60	€ 64.06	€ 11,403.39	€ 0.18
Aldi Konnern GmbH & Co KG	D-06420	457	89	€ 61.60	€ 64.06	€ 5,701.70	€ 0.18
Aldi Nortorf GmbH & Co KG	D-06420	457	199	€ 61.60	€ 64.06	€ 12,748.74	€ 0.18
Kaufland Verteilzentrum Osterfeld	D-06721	547	161	€ 61.60	€ 64.06	€ 10,314.30	€ 0.18
Kaufland Zentrallager Groß Klessow	D-06721	547	155	€ 61.60	€ 64.06	€ 9,929.92	€ 0.18

Table 11-25 Overview data customers of Zuivelhoeve Vers in Germany

When the costs per pallet per kilometer for each customer in Germany are known, the costs per cluster of customers can be calculated. Customers in Germany are clustered based on their postal code, so customers with a postal code starting with 0 are clustered together, customer with a postal code starting with 1 are clustered together, etcetera. The costs eper cluster can be calculated using the following formula:

$$\text{Cost per pallet per km (Cluster)} = \frac{\sum_{i=1}^{n} \text{cost per pallet per km for each customer in the same cluster}}{\text{total number of customers in a cluster}}$$

Besides the cost per pallet per kilometer, also the total number of pallets transported in a year to a cluster must be known. This can be done by summing up the total number of pallets transported to each customer in a cluster.

Belgium

For customers in Belgium the transport cost rates of Nagel depend on the number of pallets transported at the same time, so the location of the customer in Belgium does not have influence on the cost rate. Since there are just a few customer in Belgium, they are directly grouped together. The costs per pallet per kilometer for the cluster a calculated by taking the average costs per pallet and dividing this number by the average distance to the customers.

The total number of pallets transported to the cluster in Belgium are calculated by summing up the total number of pallets transported to each customer in a year.

11.6.2 Calculations center of gravity method

When all costs and the quantity of pallets transported to a cluster of customers in a year are known, the clusters of customers can be put on a land map with a coordinate system. Which means that each cluster has its own coordinates on the map. The coordinate system has boxes of 1 by 1 cm, where 1 cm is equal to 58,8 kilometer. See figure 11-8 for the land map with coordinate system

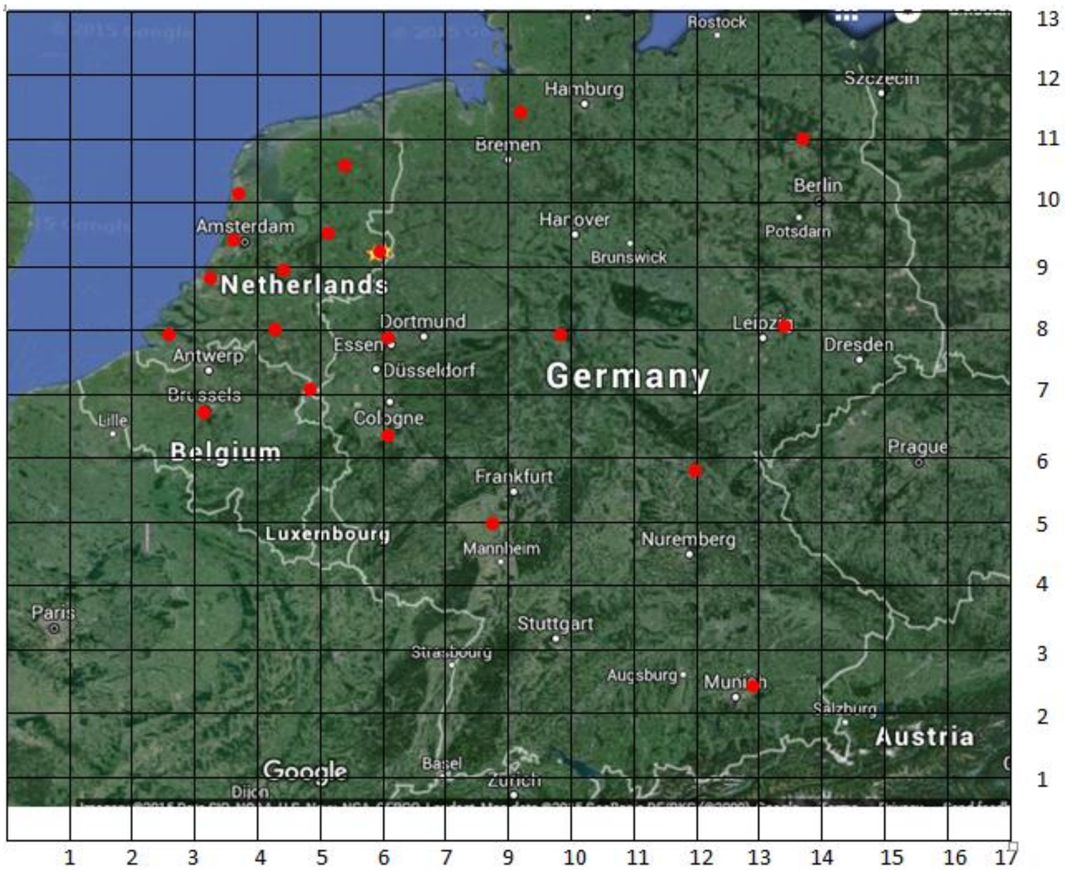

Figure 11-8 Overview land map with coordinate system Zuivelhoeve Vers

The optimal location for a warehouse and its associated transport costs are determined in two different ways, using Euclidian distances and using Manhattan distances.

Euclidian distances

The steps of the successive approximation method to determine the optimal location were:

1. Choose a starting location P^0. This location is chosen using the approximation method for Euclidean distances, it involves the following equations (data of Zuivelhoeve Vers used as example):

$$X = \frac{\sum_{i=1}^{n} D_i * R_i * X_i}{\sum_{i=1}^{n} D_i * R_i} = \frac{81272.08}{14178.13} = 5.73 \qquad \textbf{5.7}$$

$$Y = \frac{\sum_{i=1}^{n} D_i * R_i * Y_i}{\sum_{i=1}^{n} D_i * R_i} = \frac{124725.5}{14178.13} = 8.8 \qquad \textbf{5.8}$$

2. Substitute the found coordinates of step one for X and Y in the right hand of equations 5.5 and 5.6. From this, in the left-hand side of the equations there are new values for the coordinates of the warehouse, P^1.

$$X = \frac{\left(\sum_{i=1}^{n} \frac{w_i * Xi}{d(X_i, Y_i; X, Y)}\right)}{\left(\sum_{i=1}^{n} \frac{w_i}{d(X_i, Y_i; X, Y)}\right)} = 5.79 = P^1(x) \qquad \textbf{5.5}$$

$$Y = \frac{\left(\sum_{i=1}^{n} \frac{w_i * Yi}{d(X_i, Y_i; X, Y)}\right)}{\left(\sum_{i=1}^{n} \frac{w_i}{d(X_i, Y_i; X, Y)}\right)} = 9.11 = p^1(y) \qquad \textbf{5.6}$$

3. Repeat this step as many times until the coordinates P^k are almost unchanged from the previous coordinates P^{k-1}. This is the optimal location for the warehouse, see table 11-26. The optimal X-coordinate is 5.9 and optimal Y-coordinate 9.2 for Zuivelhoeve Vers

p0(x)	5.7	p0(y)	8.8
p1(x)	5.79	p1(y)	9.11
p2(x)	5.83	p2(y)	9.15
p3(x)	5.86	p3(y)	9.17
p4(x)	5.88	p4(y)	9.18
p5(x)	5.89	p5(y)	9.19
p6(x)	5.89	p6(y)	9.2
p7(x)	5.9	p7(y)	9.2

Table 11-26 overview coordinates calculated using successive approximation method

Manhattan Distances

For calculating the optimal location using Manhattan distances the following formula was used:

$$Z(X,Y) = Z_1(X) + Z_2(Y) = \sum_{i=1}^{n} w_i * |X - X_i| + \sum_{i=1}^{n} w_i * |Y - Y_i|$$

The equation can be split up in two independent parts, $Z_1(X)$ and $Z_2(Y)$. The optimal X- and Y-coordinate can be calculated by setting $Z_1(X)$ and $Z_2(Y)$ out in a graph. We used the X and Y coordinates of the existing locations for clusters of customers and the production location as input for the graph, see table

X	Z1(X)	Kolom1	Y	Z2(Y)
0	81272.08		0	124725.8
1	67093.95		1	110547.6
2.6	44408.94		2.5	89280.45
3.1	37480.61		5.8	43271.03
3.2	36131.69		6.3	36575.71
3.6	31617.66		6.8	30474.84
3.7	30605.25		7.1	26924.52
4.3	24863.92		7.9	17564.37
4.4	24149.65		7.9	17564.37
4.8	21595.33		8	16631.32
5.2	19094.68		8	16631.32
5.4	18103.35		8	16631.32
5.9	15904.9		8.8	11662.13
5.9	15904.9		9	10860.68
6.1	17554.84		9.2	10210.59
6.1	17554.84		9.2	10210.59
7.8	37082.48		9.5	13029.44
9.2	53931.22		9.5	13029.44
12	90345.99		10.1	20140.68
12.9	102241.6		10.6	26344.3
13.4	108901.8		11	31531.12
13.8	114386.1		11.4	36904.9

Table 11-27 Overview input graph Z1(X) and Z2(Y) Zuivelhoeve Vers

When setting these numbers out in a graph it can easily be seen where the lowest point for $Z_1(X)$ and $Z_2(Y)$ are.

11.7 Appendix G: Calculations forecasting

In this appendix the necessary calculations for evaluating the moving average options are explained. For these calculations historical data of Zuivelhoeve Vers- end products are used, but the calculation also be applied to data of Van der Poel desserts - end products and Van der Poel desserts - raw materials & packaging. Evaluating the moving average options consists of multiple steps:

1. Calculating the 2 x n- MA
2. Calculating the seasonal component
3. Deseasonalizing the data
4. Calculating the trend component
5. Calculating the cyclical component
6. Calculating the forecast
7. Calculating quality measures

1. Calculating the 2 x n-MA

The calculation starts with calculating a 52-period MA (52-MA)over the historical data and then over the 52-MA a 2-period MA is calculated (2-MA).
Week 26 of 2012 is the first point in time for which the 52-MA is calculated. This first point is the average stock level from week 1 to week 52 of 2012. The second point is in week 27 and is calculated by taking the average stock level from week 2 of 2012 to week 1 in 2013 , the third point is the average stock level from week 3 of 2012 to week 2 in 2013 and so on. Since the actual average of a 52-period falls between weeks (see table 11-28) indicated with an arrow for week 26 and week 27), the 52 period moving average is not symmetric. Therefore over the 52 period moving average a 2 period moving average is calculated. Week 27 of 2012 is the first period of time for which this is calculated by taking the average of week 26 and week 27.

=GEMIDDELDE(E3:E54)

B	C	E	F	G
jaar	week	voorraad zuivelhoeve per weel	MA (52)	MA(2)
2012	1	553		
	2	823		
	3	821		
	4	718		
	5	754		
	6	742		
	7	692		
	8	786		
	9	918		
	10	890		
	11	856		
	12	799		
	13	784		
	14	813		
	15	644		
	16	734		
	17	885		
	18	762		
	19	1021		
	20	739		
	21	826		
	22	650		
	23	747		
	24	749		
	25	773		
	26	813	=GEMIDD	
	27	732	780,9	781,9
	28	823	780,6	780,7
	29	780	780,7	780,6
	30	844	781,4	781,0
	31	719	782,2	781,8

Table 11-28 applying the 2xn-MA method

2. Calculating the seasonal component

This calculation starts by dividing the actual weekly historic stock levels by the weekly 2-period moving averages. What is calculated now are the seasonal(S_t) and the irregular(I_t) component together. But what has to be calculated is the seasonal component on its own, see table 11-30.

This seasonal component S_t is calculated by taking the average "St, It" of a certain week for all the years of historical data. So for week X the average of week X over 2012, 2013, 2014, 2015 is calculated. When S_t is calculated for all 52 weeks , these numbers have to be adjusted by dividing it by the average for all weeks together, see table 11-29.

week	St	adjusted St
1	0.727344	0.726916
2	1.049129	1.048511
3	1.038485	1.037874
4	1.052112	1.051493
5	1.032407	1.031799
6	1.101587	1.100939
7	1.101766	1.101117

=V19/GEMIDDELDE(V19:V70)

Table 11-29 Calculations adjusted seasonal component

These adjusted seasonal components are the seasonal factors that are used for further calculations and can be filled in for every week, which means that every year has the same cycle of seasonal factors, for week 1 0.7269, week 2 1.0485, week 3 1.0367 and so on.

=D29/F29

S_t, I_t	S_t	deseasonalize	T_t
	0.70	787.53	774.18
	1.01	814.24	774.57
	1.00	822.50	774.96
	1.01	713.14	775.36
	0.99	761.35	775.75
	1.06	701.37	776.15
	1.05	655.71	776.54
	1.02	770.65	776.94
	1.16	793.22	777.33
	1.18	756.69	777.73
	0.92	929.75	778.12
	1.21	663.09	778.51
	1.10	714.41	778.91
1.0373	0.95	858.27	779.30
0.8183	0.94	683.42	779.70
0.9334	0.95	770.76	780.09
1.1230	1.01	878.38	780.49
0.9647	1.00	760.02	780.88
1.2939	1.13	903.05	781.27
0.9327	0.99	744.07	781.67
1.0390	0.95	868.27	782.06
0.8196	0.93	700.81	782.46

Table 11-30 overview seasonal and trend component

3. Deseasonalizing the data

The historical stock levels can be deseasonalized by dividing the actual weekly stock levels by the weekly seasonal factors. Deseasonalized data are the stock levels as they would be if there were no seasonal influences, see table 11-30.

4. Calculating the trend component

For calculating the trend component a regression analysis must be performed, this can be done in excel. A regression analysis must be performed with period t as X values and with the weekly deseasonalized values as Y values. The output of the regression analysis can be found in table 11-31.From this output we can derive the linear trend equation, for calculating the weekly trend levels. The linear trend equation is as follows:

$$Y = 0.4414\,X + 772.379$$

Also from the graph the coefficient of determination (R^2) can be derived, this is 0.0503

SAMENVATTING UITVOER	
Gegevens voor de regressie	
Meervoudige correlatie	0.224385027
R-kwadraat	0.05034864
Aangepaste kleinste k	0.044695954
Standaardfout	94.6308792
Waarnemingen	170
Variantie-analyse	
	Vrijheidsgraden
Regressie	1
Storing	168
Totaal	169
	Coëfficiënten
Snijpunt	772.3794035
t	0.441391583

Table 11-31 output regression analysis

5. Calculating the cyclical component

The cyclical component can be calculated by dividing the weekly deseasonalized data by the weekly trend data (see equation 6.6).

6. Calculating the forecast

The forecast can be calculated by using equation 6.1:

$$Y = TSCI$$

Since the irregular pattern cannot be seen apart from the cyclical pattern. The forecast can be calculated as follows:

$$Y = C * T * S$$

The cyclical component, seasonal and the trend component can be extrapolated into the future. The trend component and seasonal component can as already said be calculated exactly. For the cyclical component to be extrapolated in to the future, it is necessary to consider managerial judgement.

7. Calculating quality measures

As last step in the calculations for forecasting is calculating the quality measures, which is needed to see which moving average option is most accurate in forecasting the stock level for the subsidiaries.

The quality measure chosen are MAD, MAPE and MASE and these can be calculated by applying equation 7.1, 7.4 and 7.8 respectively.

11.8 Appendix H: Output LP-model

Example of the output of the LP model (Zuivelhoeve Vers 10% growth ratio):

week	Current warehouse(Raalte)	scenario 1 (Twekkelo)	scenario 5 (Ahaus)	Renting extra storage space
1	0	818	0	0
2	0	1022	0	0
3	0	1013	0	0
4	0	1025	0	0
5	0	1007	0	0
6	0	1075	0	0
7	0	1076	0	0
8	0	1039	0	0
9	0	1173	0	0
10	0	1180	0	0
11	0	917	0	0
12	0	1208	0	0
13	0	1096	0	0
14	0	904	0	0
15	0	1009	0	0
16	0	963	0	0
17	0	946	0	0
18	0	1012	0	0
19	0	1034	0	0
20	0	996	0	0
21	0	880	0	0
22	0	953	0	0
23	0	942	0	0
24	0	853	0	0
25	0	1053	0	0
26	0	870	0	0
27	0	956	0	0
28	0	972	0	0
29	0	925	0	0
30	0	937	0	0
31	0	910	0	0
32	0	924	0	0
33	0	967	0	0
34	0	988	0	0
35	0	1095	0	0
36	0	1050	0	0
37	0	949	0	0
38	0	946	0	0

39	0	982	0	0
40	0	971	0	0
41	0	944	0	0
42	0	897	0	0
43	0	993	0	0
44	0	1060	0	0
45	0	999	0	0
46	0	990	0	0
47	0	939	0	0
48	0	1166	0	0
49	0	1022	0	0
50	0	939	0	0
51	0	915	0	0
52	0	906	0	0