

Evaluation of the Production Planning at Rexam Beverage Can

The Production Plant in Fosie, Sweden

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Abstract

- Title:** Evaluation of the Production Planning at Rexam Beverage Can
-The Production Plant in Fosie, Sweden
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- Problem definition:** An increased demand of beverage cans has caused problems with deliveries to several of Rexam's customers. Rexam need to improve their delivery performance in order to maintain customer confidence.
- Purpose:** The purpose with this master thesis is to map, describe and analyses the production plant in Fosie's production planning; regarding forecasting, material planning, safety stock, an optimal production batch and capacity planning. This is performed both on a central level as well as on an operational level. Secondly, guidelines and suggestions are presented for a more effective production planning.
- Methodology:** The thesis is a qualitative based case study with constituent of quantity based information.
- Conclusions:** Rexam's production planning can be improved by some easy changes. More accurate forecasts are decreasing the uncertainties. With a previously released line load, follow-ups can be done earlier and actions can be taken for possible deviations.
- The size of the order quantities are decreasing and expect to further be reduced. Nevertheless, an increased flexibility in the production makes it possible. The demand expects to increase in the future and a growing market as for the can industry, it is important to keep and improve customer's confidence.
- Key Word:** Capacity, Forecasting, Material Planning, Order Quantities, Production Planning, Safety Stock

Preface

This master thesis has been conducted during the autumn 2006 and is the last step of my degree in Master of Science in Mechanical Engineering with major in Industrial Management and Logistics. It has been performed at the department of Sales Administration at Rexam Beverage Can in Fosite, Sweden and at the division of Production Management at Lund Institute of Technology. This thesis has been very interesting and has given me a great deal of valuable knowledge about production planning, as well as the can industry. I really hope this thesis will contribute with valuable information to Rexam in the future.

I am very thankful for Rexam who has given me this exciting task and all people who have helped me. I especially want to thank Christian Nilsson, my tutor at Rexam and all people at the sales department for valuable information and support in my work. I also want to thank Ingela Elofsson, my academic tutor for helpful ideas and criticism of my work. Further, I want to give a great thank you to all people who have taken time for my questions and ponder.

Lund, December 2006

Cecilia Danneke

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1 Introduction

This introduction chapter contains a description of the background, problem discussion, objectives, delimitations and target group to the thesis. A short disposition of the thesis follows.

1.1 Background, problem discussion & delimitations

Rexam PLC is one of the world's leading companies for consumer packaging and the world's dominant company for beverage cans. They work within the markets of beverage, beauty, pharmaceuticals and food, with a worldwide operation in more than 20 countries and more than 100 manufacturing plants.

Rexam PLC is divided into smaller businesses units, where Rexam Beverage Can Europe & Asia is a part of the group. Furthermore, Rexam Beverage Can Europe & Asia is divided into smaller sales areas. Europe has several production plants in different countries; each plant has its own structural challenges. This master thesis will deal with the production plant in Fosie of Rexam Beverage Can Europe & Asia.

To enable the control of this organisation, there is a central planning function for the production plants in Europe. Central planning issues monthly a line load, outlining sales for each market area, expected production and inter company support. This line load constitutes the base for decisions of the individual plants on production planning and the inter company support.

Each production plant has their own sales area, e.g. the production plant in Fosie, Sweden, primarily delivers cans for the Nordic and Baltic States. Sweden altered its recycling legislation in 2006, making the end-seller of the filled can responsibly to verify payment of deposit. This has led to a reduction of import of 'illegal cans' for which deposit has not been paid, an increase in domestic demand, on top of an already strong market growth in the Nordic countries. Sales are also expected to increase in the forthcoming years.

Sales of cans carry a strong seasonality effect; the peak is during the summer and winter; is the period for building stock. Products are customer linked so that no production to stock occurs without an explicit manufacturing authority from customers. However, capacity during the summer is tight for many productions plants and for some units not enough capacity to meet the demand. For exposed units, production has been characterised by small production batches and plentiful label changes, making it more difficult to meet the original production budget. Capacity shortages and the difficulty of timing the inter company support could be possible and likely explanations for the recent delay to customers.

An increased demand of beverage cans has caused problems with deliveries to several of Rexam's customers. Rexam need to improve their delivery performance in order to maintain customer confidence.

In the beginning of 2006, the production plant in Fosie had their lowest inventory level ever. Daily call offs from customers resulted in several label changes which decreased the production efficiency. The internal support had in many situations long lead time and cannot be utilised as the production plants own more reliable production.

The production planning function within the company needs to be evaluated. This evaluation will include forecasting, material planning, safety stock, ordering quantities, capacity planning and other company specific features. Different plants have different conditions and for an equitable evaluation of the production planning, these features need to be identified and be taken in consideration.

The safety stock and capacity has experienced to be too low the year of 2005 and 2006 which has caused several problems. Neither the stock nor the capacity can be regarded as sufficient. These had implied small ordering quantities which brought problems for the production, stock level etc. The system for material planning has an important role for these problems and can be interesting to evaluate.

These inconveniences can be considered on a central level as well as on an operational level, but also with different time perspectives. Figure 1.1 shows the relation between production planning's different parameters; forecasting, material planning, safety stock, capacity and order quantities.

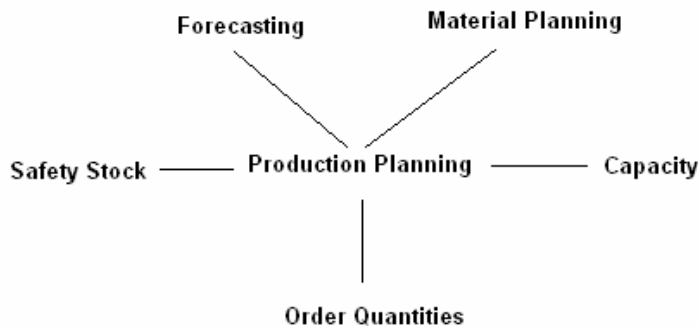


Figure 1.1 The production planning's parameters

1.2 Objectives

The objective with this master thesis is to map, describe and analyse the production plant of beverage cans in Fosie's way of; production planning, regarding forecasting, material planning, safety stock, ordering quantities and capacity planning. This is performed both on a central and operational level. Secondly, guidelines and recommendations are presented for a more effective production planning.

1.3 Target group

This master thesis has two target groups, firstly, students in the end of their education and secondly, professionals and employees at the company.

1.4 Disposition

Chapter 1 Introduction

The introduction chapter describes the background, purpose, problem discussion and target groups to the thesis.

Chapter 2 Methodology

This chapter describes which methods are used to perform the thesis, validity and reliability of the results. The author's way of performing the thesis is described in connection to the theories.

Chapter 3 Presentation of Rexam PLC

The presentation of Rexam contains a background description, the overall strategy, customers and other valuable information about the company. The different divisions and the market segments are presented to provide an overall overview of the company's structure.

Chapter 4 Theory

Theories and models are presented as a framework for the thesis. This framework is used for analysing the empirics.

Chapter 5 Empirics

This chapter contains a description of the present situation in Rexam Beverage Can Europe & Asia, especially the production plant in Fosie. This information together with theories and models is the base for the analysis.

Chapter 6 Analysis & Conclusions

This chapter is the main and most important part of the thesis. It presents the evaluation of the empirics according to theories and models.

Chapter 7 Suggestions & Improvements

This chapter presents suggestions of improvements.

References

Appendix

2 Methodology

This chapter aims to describe the method and the procedure to achieve the thesis purpose. Moreover, method criticism and sources of errors are considered.

2.1 Research methods

To conduct a research it is important to identify necessary information, the extent of the research, sources to use and gathering methods. Analysing the main interest is an appropriate way to choose research method. It can take appearance of three different approaches;¹

- Case study of a specific problem/case.
- Cross section approach, a group of cases/situations are compared.
- Time series approach, where the research is bound to time development for one or several occasions.

Awareness of ambition and expected result is important when choosing an appropriate research method. Firstly, a research can be distinguished between being experimental and non experimental. Foremost, an experimental research is aimed to uses for explanations of a specific case and a non experimental research method is characterised by surveys and case studies. Secondly, different research methods can be divided into explorative, describing, explaining, diagnostic, evaluating and predictable research.

2.1.1 Explorative research²

An explorative research is used for problem specifications, problem discussions, subject knowledge, specifications of research plans etc. This method is foremost used to collect an appropriate amount of information to commence a research. Collected data is a base for continued researches. Interviews, literature studies and case studies are typical methods for an explorative research.

2.1.2 Describing research³

Fields of application for a describing research method can differ. However, the method aims to describe a specific situation. A describing research method requires an appropriate amount of accessible knowledge from the beginning, therefore, total available data is important to consider before starting a research. This method intends to give a description of occasions, historical and existing situations. However, a describing research gives a report of the actual situation, but not the reason why it looks like it does.

2.1.3 Explaining research⁴

An explaining research aims to clarify what has caused a specific problem and why. This research method is an extension of the describing research method. However, this method

¹ Lundahl, Ulf &Skärvad, Per-Hugo. (1982) *Utredningsmetodik för samhällsvetare och ekonomer*

² Lundahl, Ulf &Skärvad, Per-Hugo. (1982) *Utredningsmetodik för samhällsvetare och ekonomer*

³ Lundahl, Ulf &Skärvad, Per-Hugo. (1982) *Utredningsmetodik för samhällsvetare och ekonomer*

⁴ Lundahl, Ulf &Skärvad, Per-Hugo. (1982) *Utredningsmetodik för samhällsvetare och ekonomer*

intends to find relations between different factors. This research method is based on statistical testes with specific hypotheses, where the relation between cause- and effect variables is tested. An explaining research aims to give a description why a situation looks like it does.

2.1.4 Diagnostician research⁵

The diagnostician research intends to find the cause to a specific phenomenon and is often based on historical occasions. However, this research method is useful when finding solutions to practical and concrete problems. The method concentrates on the “right” problem and to find the “right” threatening method. A diagnostician research shall also give guidelines to how a problem can be solved.

2.1.5 Evaluating research⁶

An evaluating research intends to measure effects of made actions. It evaluates if the solution fulfil the expected result. An evaluating research aims to establish result, effects and consequences of a measuring.

2.1.6 Predictable research⁷

This method aims to give a predictable outcome, what is going to ensue according to some conditions. The predictable development of an occurrence is of interest in this approach.

Level of ambition increases through different research methods. However, the available information also increases for each research stage. Knowledge about previous steps is required to continuing a research. To plan and perform a describing research, it is necessary with knowledge about what is going to be described.

2.1.7 The thesis’s research method

The thesis is a non experimental case study regarding Rexam Beverage Can Europe & Asia’s production planning and foremost the production plant in Fosie, Sweden. The can industry has special features which results in a case study of the production plant in Fosie. To perform the thesis, the describing and the explaining research methods is used. They are chosen due to the author’s ambition and the thesis purpose.

⁵ Lundahl, Ulf &Skärvad, Per-Hugo. (1982) *Utredningsmetodik för samhällsvetare och ekonomer*

⁶ Lundahl, Ulf &Skärvad, Per-Hugo. (1982) *Utredningsmetodik för samhällsvetare och ekonomer*

⁷ Lekvall, Per & Wahlbin, Clas. (1993) *Information för marknadsföringsbeslut*

2.2 Gathering of data

According to British people, data can be gathered from “paper and people” (secondary and primary data).⁸ Example of paper can be documents as books, newspapers, letters, tape-recording, radio, TV-programs, research reports, annual reports etc. On the other hand, information from people is mostly gathered by interviews, questionnaires and observations.⁹ Primary and secondary data is another designation for this data which can be gathered from quantitative and qualitative research methods.

2.2.1 Quantitative and qualitative research

A research can be divided into be a qualitative or a quantitative approach. The qualitative and quantitative research methods are not mutually exclusive. The main difference is more the manner of analysing the data than the gathering method.

2.2.1.1 Qualitative research

A qualitative research is performed by gathering data, for analysing and interpreting. However, this data cannot be expressed numerical.¹⁰ Case studies and surveys with small samples are example of qualitative researches. A qualitative research aims to gather a deeper knowledge than the quantitative research. Though, it characterises by the author.¹¹

2.2.1.2 Quantitative research

A quantitative research characterises by numerical expressed information. This method is often associated by using a large sample, with a specific focus. Questionnaires, experiments, tests, time series analyses are approaches which can be analysed by quantitative methods.¹²

2.2.2 Primary data

Primary data is foremost gathered from personal interviews, questionnaires and observations. A fully explanation of each method follows.

2.2.2.1 Personal interviews

This method possesses gathered data from personal interviews. Data is collected when an interviewer asks the interviewed person (the respondent) relevant questions or has a dialogue with him or her. Thus, the respondents answer is used as raw data. If the respondent experiences the interview interesting, the interviewer has unlimited possibilities for an extensive and deep interview.

⁸ Lundahl, Ulf &Skärvad, Per-Hugo. (1982) *Utredningsmetodik för samhällsvetare och ekonomer*

⁹ Lundahl, Ulf &Skärvad, Per-Hugo. (1982) *Utredningsmetodik för samhällsvetare och ekonomer*

¹⁰ Lundahl, Ulf &Skärvad, Per-Hugo. (1982) *Utredningsmetodik för samhällsvetare och ekonomer*

¹¹ Runa, Patel & Davidson, Bo. (1994) *Forskningsmetodikens grunder –att planera, genomföra och rapportera en undersökning*

¹² Lekvall, Per & Wahlbin, Clas. (1993) *Information för marknadsföringsbeslut*

An interview is especially good for specific questions and test methods. Interviews are best to use for extensive and detailed questions. However, the cost for an interview is high and time demanding which require a small sample of interviewed persons to limiting the costs. Registration of interview results can be performed both in writing and on tape.¹³ The access problem is one significant problem with interviews, especially interviews with representatives from companies.

Interviews can be divided into structured, semi structured and unstructured¹⁴. The different methods are presented below.

2.2.2.1.1 Structured interviews

It is a type of interview where the interviewer uses a preset questionnaire. All respondents experience the same contents of the interview as formulations, environment, order etc. With this performance, the respondent's answers can be regarded more reliable¹⁵. The enquiries in the questionnaires are made for specific answers and therefore can be used for quantitative analyses. The method is information oriented, where the interviewer, from the beginning, knows the objectives and the expected results.

2.2.2.1.2 Semi structured interviews

A semi structured interview encloses a guide for particular subjects that have to be considered during the interview. The questions do not have to be asked in a specific order and the interviewer decides how to perform. The interviewer may also have the opportunity to ask additional questions.¹⁶

2.2.2.1.3 Unstructured interviews

It is a form of interview where the respondent can get extensive questions. The order of the questions does not need to be the same for all respondents and the formulation can be chosen by the interviewer. However, the interview must cover intended information. An unstructured interview results in a more flexible and adjusted situation both for the interviewer and the respondent. The unstructured interviews mainly give qualitative data where the result is difficult to quantify. Thus, the method is both information and person oriented and is suitable for social science, psychology, organisation research, recruiting etc. Deep interview is another name for this method.¹⁷

As an interviewer it is important to be aware of data gathered from interview's objectiveness. The interviewed person can answer in own interest or does not communicate all information.

2.2.2.2 Questionnaires¹⁸

This method is foremost suitable for a large sample of participants. This method is especially cost effective and questionnaires as research method main advantageous. However, this

¹³ Lekvall, Per & Wahlbin, Clas. (1993) *Information för marknadsföringsbeslut*

¹⁴ Lundahl, Ulf & Skärvad, Per-Hugo. (1982) *Utredningsmetodik för samhällsvetare och ekonomer*

¹⁵ Bryman, Alan & Bell, Emma. (2003) *Företagsekonomiska forskningmetoder*

¹⁶ Bryman, Alan & Bell, Emma. (2003) *Företagsekonomiska forskningmetoder*

¹⁷ Lundahl, Ulf & Skärvad, Per-Hugo. (1982) *Utredningsmetodik för samhällsvetare och ekonomer*

¹⁸ Lundahl, Ulf & Skärvad, Per-Hugo. (1982) *Utredningsmetodik för samhällsvetare och ekonomer*

method is time consuming regarding sending the questionnaires and receiving them. The decline of answer is often large. Further, it is difficult to know if the questionnaire has been performed seriously or not.

2.2.2.3 Observations¹⁹

Observations can be performed in different ways. For example, behaviours can be observed, where the observer observes a person's behaviour. However, it is possible to believe that an observed would act different from their normal behaviour during an observation. Therefore, it is important to accomplish the observation without knowledge from the observed person.²⁰

2.2.3 Secondary data

Secondary data defines as already composed data. For example, it can be existing statistics or previous performed surveys. Secondary data can be useful in many situations but it is not adjusted to each specific case. It can be difficult to project the quality and application of gathered data. Secondary data does not show sorted information and gives no exact definition of a searched problem. However, it is important to collect as much information as possible regarding secondary data before using it for own purpose.²¹

Regarding secondary data, it is important to be aware of its actuality, source, type of media and the original purpose with the information. For example, data from old articles or not updated homepages can give wrong or distorted information.

2.2.4 The thesis's method for gathering of data

This thesis is foremost based on qualitative data which has both primary and secondary shaping. The primary information is composed by personal interviews with several employees at the company. The respondents is selected none randomly. They are chosen due to their area of knowledge. Information from interviews is firstly used for qualitative analyses. Therefore, semi and unstructured interviews are the best interviewing method. The author's interview technique is changed over time when knowing employees better at the company. From the beginning the interviews were more structured with prepared and specified questions. However, further in the interviewing process the interviews were more unstructured with some topics for discussion. At the mean time, it is important for the author to be critic during the interviews and sort data in an objective manner.

Quantitative data is mainly secondary data, gathered for basic calculations. It takes form of production and sales statistics. Nevertheless, a qualitative research method is primary utilised for the work with this thesis. Secondary data as annual reports and other internal reports are also a base for the thesis. Sales and production statistics are changed due to the secrecy. The statistics show relations between actual value and forecasted value instead of the actual sales and production rates. Further, some costs are adjusted and fictive, also due to the secrecy.

¹⁹ Lundahl, Ulf & Skärvad, Per-Hugo. (1982) *Utredningsmetodik för samhällsvetare och ekonomer*

²⁰ Lundahl, Ulf & Skärvad, Per-Hugo. (1982) *Utredningsmetodik för samhällsvetare och ekonomer*

²¹ Lekvall, Per & Wahlbin, Clas. (1993) *Information för marknadsföringsbeslut*

2.3 Method criticism

It is important to be aware of gathered information's validity and reliability. Even so, objectiveness is another important factor to consider when gathering information to a research.

2.3.1 Validity

Validity indicates to what extent the research data and the gathering methods are exact and accurate.²² However, the difficulty with validity is to measure if a method is applicable or not.

Validity can be divided into internal and external validity;²³

- Internal validity is when a question measures what it is intended to measure. If it does, it is a superior agreement between the theoretical and the operational definition.
- External validity is when people answer questions dissimilar from their behaviour. People can lie, remember erroneous etc.

2.3.2 Reliability

Reliability is another concept for measure uncertainties for different researches. The reliability is measuring the method's capability to resist random variations. Assume that an interview is performed with the same person several times. If the interviewed person gives the same answers over and over again, the interview has high reliability.²⁴

Low reliability can be caused by several factors:²⁵

- Differences in changeable features for the interviewed persons as; health, stress, fatigue, motivation etc.
- Dependence on the situation, e.g., contact with the interviewer, distraction surroundings etc.
- Variation of the way of asking a question between different interviewers.
- "Lay-out" factors, as a large handwriting where the whole answer does not fit the paper.
- Inconveniences for measuring instruments. For example, difficulties to understand a question, or different interpretations.
- Randomly, the interviewed person only guesses.

Reliability is a necessary condition for validity. A perfect tool can be used in a wrong way or careless. Standardisation of the performance of a research increases the reliability.

²² Lekvall, Per & Wahlbin, Clas. (1993) *Information för marknadsföringsbeslut*

²³ Lundahl, Ulf & Skärvad, Per-Hugo. (1982) *Utredningsmetodik för samhällsvetare och ekonomer*

²⁴ Lekvall, Per & Wahlbin, Clas. (1993) *Information för marknadsföringsbeslut*

²⁵ Lekvall, Per & Wahlbin, Clas. (1993) *Information för marknadsföringsbeslut*

2.3.3 Objectivity

Objectiveness is important when performing a research. The credibility is affected if the research is not objective. Sometimes objectiveness means to separate facts from valuations, impartial, unbiased, versatility, inter objectiveness and completeness²⁶.

2.3.4 The thesis's criticisms of method

To make sure the validity and the reliability the author performed the interviews with the same topics in different situations and instants. Comparison between the answers increased both the validity and the reliability.

²⁶ Lundahl, Ulf &Skärvad, Per-Hugo. (1982) *Utredningsmetodik för samhällsvetare och ekonomer*

2.4 Source of errors

There are some usual sources of error, the respondent, the instruments and the interviewer. For example, an error can occur as a cause by the manner of asking questions.

2.4.1 The respondent

Uncertainty regarding the respondent's attitude to a question can affect the answer and it can be varying for different situations. In this case, information from the interview has bad capability to resist random variations and the determination has unpredictable reliability. In some cases, the respondent can be affected to give a specific answer even though the person does not have an option about it.

Cases when the respondent is guessing instead of knowing can bring randomly influences to the information which brings uncertainties to the research. However, the respondent can adjust the answer to an acceptable or social accepted level. This phenomenon affects the validity of a research.

A tired and stressed respondent can circuitously bring sources of errors to the research. There is a risk that the respondent answers the question without consideration to his or her real opinion.

2.4.2 The instrument

The question's formulation can significantly affect the research. An indistinct language, sensitive or leading questions are factors that can influence the result. These factors are regarded as instrument errors. Tests of the questionnaire and having test interviews are superior ways to establish an interview's validity.

The emplacement of questions in a questionnaire also affect the result; especially in the middle part of the questionnaire where the respondent can be tired and "just" pick answers without consideration or reading the question.

Numbers of answering alternatives can be another instrumental effect. The reliability can be suffering if there are too few answering alternatives whereas too many alternatives can be tiring for the respondent.

2.4.3 The interviewer

The interviewer effect is a well known mistake when performing interviews. The respondent can be affected by the interviewer's clothes, way of acting, age, gender etc. Further, the interviewer can interpret the respondent's answer wrong. For example, if the interviewer has a positive picture of the respondent, answers can be interpreted benevolent.

The choice of an interview sample can be additional one type of interviewer mistake. If the interviewer decides the sample by him/herself, it is a risk for choosing a special kind of respondents. However, it is important that the interviewer is objective in the choice of sample.

2.4.4 The thesis's sources of errors

Presented source of errors are well considered by the author when performing the interviews. The interviews have been held with the same respondent several times, therefore, the risk of variation in attitude and randomly influences is minimised.

Used instrument when the author held the interviews has changed. In the end of the interviewing process, some topics were discussed. For this reason, the errors were minimised.

The interview sample was chosen due to their area of knowledge, hence, the source of errors were minimised. The respondent can answer for own interest in a subject which require attention and objectiveness from the interviewer when performing the interviews. Even so, during the interviews, the respondents have confessed own strengths and weaknesses in their job, therefore, the risk with misleading information is minimised.

3 Presentation of Rexam PLC

This chapter contains a short presentation of Rexam PLC and its history. The main propose is to give the reader knowledge about the company.

3.1 Background

Rexam PLC consists of many acquired companies. Following chapter presents a brief outline of the origin and the company's history. PLM is of significance interest for the thesis; therefore, its history is presented separate.

3.1.1 PLM

In 1919, PLM was founded by Oscar Laurin. From the beginning PLM produced enamelled containers, stainless sinks, saucepans and tin cans.²⁷ The company was also called "Plåtmanufakturen" which means working in metal.²⁸ 1st of October 1955, the beer can was introduced on the Swedish market and PLM produce their first can for Stockholm's Bryggerier, with the brand name Three Towers. PLM also started to deliver cans to Carlsberg and Tuborg and in 1979 half of all beers were sold in cans.²⁹

From the beginning the can had standard tin ends and special equipment was required to open it. However, in the United States an easy-open can was launched which also was introduced on the Swedish market in the mid of the 1960. Nevertheless, 1967, all cans were opened by ring pull ends and the can became easy to open. In the same year, the medium-strong beer was launched in cans which became a big success in Sweden. The can market increased and most breweries offered beer in cans.

In 1970, all breweries offered beer in cans and the market increased. Approximately 25% of all sold beers were in cans. The success continued and some new brands were launched. The year of 1979, the half amount of sold beers in Sweden was in cans.³⁰ The success of beer in cans resulted in launching soft drinks in cans.

The can has had the same look since the development. However, in 1978, it changed. The can was produced with smaller bottom and with necked-in. These changes lead to changed raw materials, space etc. PLM started to use this technique in 1979 and in 1981 they began to build a new production plant in Fosie with the innovative technology.

Furthermore, in 1995 the coloured tab was launched and in 1997, shaped and debossed cans were introduced on the market. A new type of end was also introduced which had wider opening (large pour opening) and was the first of its type in Europe. The under tab printing was another developed feature in 1999 which allowed symbols and text printed under the tab.

²⁷ Borg, Henrik, *Den Skånska Livsmedelsindustrin*, 2005

²⁸ Borg, Henrik, *Den Skånska Livsmedelsindustrin*, 2005

²⁹ Plančim, Sören, Ericsson, Hans-Christer, Nylin Göte, *Burkens Historia* 1980

³⁰ Plančim, Sören, Ericsson, Hans-Christer, Nylin Göte, *Burkens Historia* 1980

3.1.2 The origin of Rexam PLC

In London 1881, William Vansittart Bowater established a firm of paper agents and in 1920 they started its specialisation in newsprints. However, in 1923 the company changed strategy, from selling to making paper as well as they changed name to Bowater's Paper Mills. This old company is a direct predecessor of today's Rexam. Rexam characterises of a great deal of acquisitions during its history with some strategy changes and diversifications.

3.1.3 1999, PLM became a part of Rexam

In 1999 PLM was acquired by Rexam and a structural change became a fact for PLM. During the year 2000 thermo sensitiveness and UV inks that react to temperature were developed as new can innovations.

2003 was an immense year for Rexam; it became the world's leading beverage can manufacturer. Concurrently, Latasa was acquired by Rexam and they became the leading producer and supplier of aluminium beverage cans in Brazil, Argentina and Chile. It was also the year when Rexam changed its portfolio to value-added instead of the plastic portfolio³¹.

During 2006, Rexam entered the Middle East market, where they have acquired the Egypt based beverage can maker Ecanco.

³¹ Homepage, www.rexam.com

3.2 General presentation

Rexam PLC is the world's fifth largest consumer packaging company with a turnover of £3.4 billion.³² They supply packaging within beverage, beauty, pharmaceuticals and food markets and for a range of other specialist markets including medical, industrial and automotive. Rexam has roughly 100 manufacturing plants in more than 20 countries worldwide. They work within Europe, the Americas and Asia with ca 25.500 employees. Figure 3.1 shows Rexam's plants and offices and Figure 3.2 show which market segments they are operating on.



Figure 3.1 Rexam PLC's plants and offices

Markets	Rexam's Business					
	Beverage Packaging		Plastic Packaging			
	Beverage Can	Glass	Beauty	Pharmaceutical	Plastic Containers	Closures & Containers
Beverage	•	•			•	•
Beauty			•			•
Pharma		•		•		•
Food		•			•	•

Figure 3.2 Market segments

Rexam provides packaging solutions for many of the world's most famous brands. They provide their customers with solutions for future needs and knowledge about brand strategies³³. All markets they are operating on are further presented in this chapter.

³² Packaging for the world, Annual report 2005

³³ Packaging for the world, Annual report 2005

3.2.1 Vision³⁴

Rexam's vision is to "become the leading global consumer packaging company". Recent years, they have concentrated on operations, consolidate presence in niche markets and building positions on fast growing markets. Rexam aspire to be large enough to meet customer's requirements, as well as be regarded as an interesting packaging company.

3.2.2 The Rexam Way³⁵

The Rexam Way affects the whole company; from the manufacturing, marketing, IT, human resource etc and it is a framework for all strategic initiatives. "Trust, Teamwork, Continuous Improvements and Recognition" are the four principles for The Rexam Way which aims to give Rexam competitive advantage and a frame to realise their vision.

3.2.3 Strategy³⁶

Rexam's strategy for the last five years has been to transform into a highly focused and leading consumer packaging group. Nowadays, they regard that strategy to be fulfilled. However, now they want to strengthen this position on their markets and to achieve this Rexam wants to:

- Use innovations to develop new products and service to enhance their offer to exciting customers.
- Being in position in emerging markets such as Brazil, Russia and China.
- Winning new business from new customers.

They aim to continue with product innovations to enhance the service and provide new products to existing and new customers. Rexam also intends to grow by acquisition of growing markets and product segments.

3.2.4 Customers³⁷

Rexam's main customers are large consumer packaging companies, e.g., L'Oreal, Heineken, Pepsi, Proctor & Gamble and Unilever. Mutual trust and respect for customers brings loyalty to Rexam which gain competitive advantages³⁸. In 2005, twenty of their customers corresponded for 68 % of sales and the top ten customers corresponded to 60 % of sales.

³⁴ Packaging for the world, Annual report 2005

³⁵ Homepage, www.rexam.com

³⁶ Homepage, www.rexam.com

³⁷ Packaging for the world, Annual report 2005

³⁸ Homepage, www.rexam.com

3.3 Organisation

Rexam can be divided into two business segments, plastic and beverage packages. Each of them is shared into smaller divisions and the connections are shown in Figure 3.3.

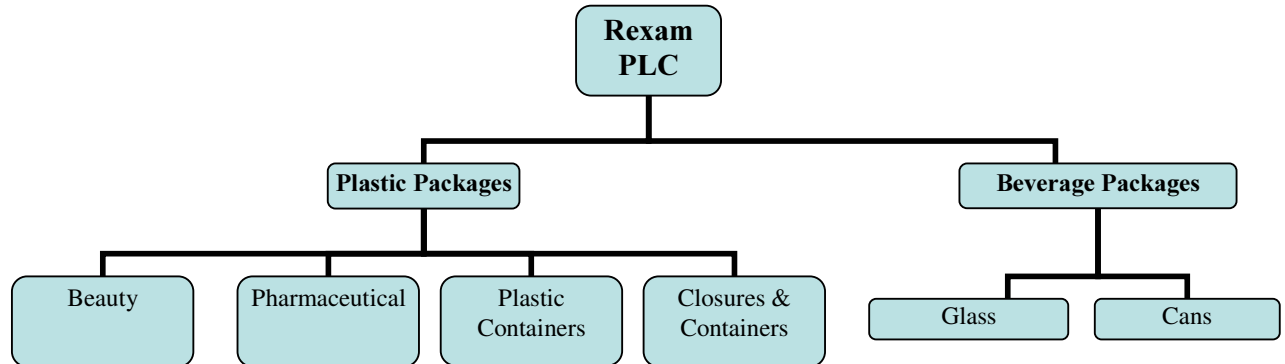


Figure 3.3 Rexam PLC

3.3.1 Plastic packages

Rexam provides standard and customised products for beverage, beauty, pharmaceutical and food markets and they are a well known retailer of these products. These market segments are grouped together because of common technology as well as having the same customers across the business. This brings the capability for synergies in the business³⁹.

The market for plastic packages is a fast increasing market segment within the packaging business, with a growth of approximately 6-7% annually.⁴⁰ The main strategy for this segment is to find attractive niches with high entry cost for competitors, where Rexam can develop their customer contacts. Rexam's main purpose is an expansion of profitable segments which contain of value added applications, technology and good growth opportunities and potential for profits⁴¹. In 2005, 35 % of Rexam's sale came from the packaging plastic business.

3.3.1.1 Beauty⁴²

Rexam are supplier for many leading beauty brands. They provide the beauty industry with packages for fragrances, personal care and make-up, lipsticks, compacts, diapering systems for perfumes and lotions etc. Production plants in France, the United States, Brazil, China and Indonesia gives a unique position for providing demanded products worldwide. In total they have 14 manufacturing plants for beauty products they supplies worldwide.

The beauty plastic packaging market is expected to grow roughly 4-5 % annually of a business worth around £4,1 billions. However, the market is still fragmented and the top three

³⁹ Packaging for the world, Annual report 2005

⁴⁰ Packaging for the world, Annual report 2005

⁴¹ Homepage, www.rexam.com

⁴² Homepage, www.rexam.com

providers only correspond to 25 % of the market share. Rexam is the fourth leading company in this business, with 6 % of the market share.

3.3.1.2 Pharmaceutical⁴³

For the pharmaceutical market segment, Rexam has their main niche in plastic injections and high speed automated assembly. They foremost produce drug and medical devices, metering pumps and valves, pharmaceutical primary packaging and diagnostic disposables.⁴⁴ Rexam operates both in Europe as well as in the United States and provide their products worldwide. Seven production plants produce products as advanced asthma inhalers, pumps and valves for pharmaceutical applications, eye droppers, nasal sprays, pill jars, tablet dispensers, indictable, diagnostic disposables, medical device components and assemblies to mention some of their products.

The pharmaceutical market is worth 5% of the whole pharmaceutical market which approximately is worth US \$410 billions. Market drivers are mostly healthcare coverage in developing countries. The pharmaceutical packaging market is as the beauty market fragmented However, it is expected to consolidate. Today, Rexam is the top three actors on this market.

3.3.1.3 Plastic containers⁴⁵

PET and PEN beverage packaging are examples of plastics containers that Rexam produces. Theses products can be tailored after customer's requirements. Rexam offers a wide rang of products, e.g. plastics bottles for carbonated soft drinks, mineral water, beer and fruit drinks. Rexam has leaded the development of refillable bottles (RefPET). They are still the leading producer of these in Europe, where they supply all major soft drink brands.

Rexam has a strong position on the refillable PET bottle market in Northern Europe and their new innovations bringing more market shares, especially in Denmark and Norway. They are as well the first PET bottle maker for beers. The market of plastic containers regards as a niche for Rexam, where they aim to bring innovations for future growing opportunities.

3.3.1.4 Closures and containers⁴⁶

Closures and containers is another market segment for Rexam. They develop and manufacture rigid containers for ambient shelf stable foods across Europe and the United States. Rexam provides a broad assortment of products e.g. packages for baby food, ready meals, fruits and vegetables, soups, sauces, snacks and pet foods. These packages often contains two packages (inner and outer) to ensure the foods quality. Most of their packaging is customised; therefore, Rexam constantly develops and improves their packaging solutions.

⁴³ Homepage, www.rexam.com

⁴⁴ Homepage, www.rexam.com

⁴⁵ Homepage, www.rexam.com

⁴⁶ Homepage, www.rexam.com

3.3.2 Beverage packages

Rexam provides the market with beverage packages as cans, glass and plastics bottles, pouches and cartons. The packages contain all from vodka to milk, as well as carbonated soft drinks.

In average, the usage of beverage packages increases with 4 % annually. Today, beverage packages correspond to 15 % of the global usage of packages and the market is worth around \$45 billions. The increasing usage of beverage packaging is a result of the general trend for refillable and recyclable packages and the on-the-go consumption. In 2005, 65 % of the company's sales came from beverage packages.⁴⁷ Figure 3.4 shows how the division for beverage packages is organised.

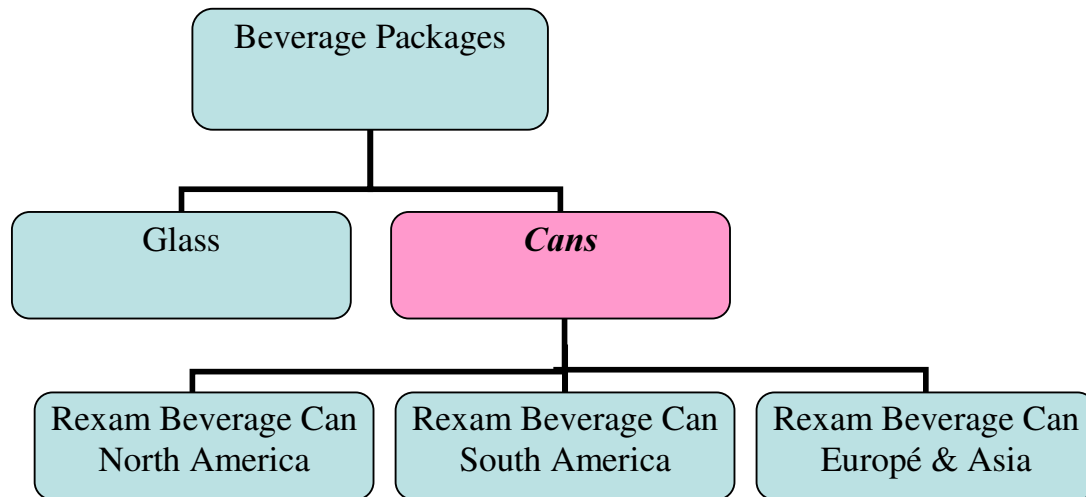


Figure 3.4 Beverage packages

3.3.2.1 Glass

In Northern Europe, Rexam has 13 glassworks located in Denmark, Germany, the Netherlands, Poland and Sweden. They are market leaders in application of new decorative technologies. Rexam customises their products for customer's special requirements. Glass is an important packaging material because of its features to naturally protect and preserve beverage. However, it is also an environmentally friendly material.⁴⁸

Rexam has their strength in Northern Europe, with 27% of the market share, where they are the second largest glass producer in Northern Europe. During 2005, the sales growth with 4%, with total sales of £405 millions (if UK should be excluded; the growth should be 7%).

Rexam's strategy for the Northern European glass market is to be a part of the consolidation of the European glass market. Rexam intends to achieve this strategy by synergies and operational excellence.⁴⁹

⁴⁷ Homepage, www.rexam.com

⁴⁸ Packaging for the world, Annual report 2005

⁴⁹ Homepage, www.rexam.com

3.3.2.2 Beverage Can

Rexam is the world's leading company of beverage cans and the largest producer with more than 23 % of the total market share. Rexam is the largest beverage can maker in Europe with 43 % of the market share, in North America; Rexam is the number three producer with 33 % of the market shares. Moreover, in South America Rexam is the market leader with more than 60 % of the market. In the Far East in China and Korea, Rexam has a small part of the market share which they aspire to increase in the future.

Beverage cans gets more and more popular among consumers. They are lightweight, easy to chill and keep the carbonate⁵⁰. Cans are easy to transport and to storage regarding usage of space.⁵¹ The beverage can market expects to grow with ca 4% annually, where countries as Denmark, Spain, Portugal, Russia and the Eastern Europe are expected to grow mostly. Particularly, energy drinks are strong market drivers.

Producing cans is a capital intensive industry, where the profit is depending on a high utilisation of available capacity. Closures of plants in US and Brazil, line rationalisation for Europe are measures to maintain high capacity utilisation.⁵²

Rexam Beverage Can is divided into three divisions, North America and South America and Europe & Asia which further are presented. The organisation of Rexam Beverage Can is shown in Figure 3.5.

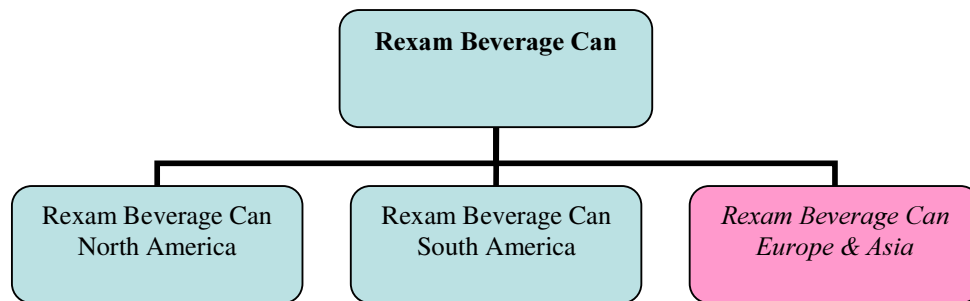


Figure 3.5 Rexam Beverage Can

3.3.2.2.1 Beverage Can North America⁵³

In the United States, Rexam is the third largest beverage can maker with an annual sold volume of 110 billion cans. Rexam has 19 production plants, where two of them are end plants. They also have one plant in Mexico. Rexam has 23% of the market share in the US and 15 % of Mexico's market share.

The US mature market characterises by a low growth rate which lead to their specific strategy. Rexam will achieve top-line growth by operational excellence and further become a more customer focused organisation. However, new technologies, as changes are in shape,

⁵⁰ Packaging for the world, Annual report 2005

⁵¹ Global Packaging Trends, facts & Insight, Consumer Packaging Report 2003

⁵² Packaging for the world, Annual report 2005

⁵³ Homepage, www.rexam.com

colours and sizes has led to innovations and improved profits.⁵⁴ Nevertheless, Rexam is the main supplier to Coca Cola in the US.

3.3.2.2 Beverage Can South America⁵⁵

In South America, Rexam is the leading producer of beverage cans. They offer aluminium cans in three different sizes, for various contain. Their location across the continent is statically to meet their customer's requirements. They have seven production plants (one end plant) which are located in Brazil, Chile and Argentina.

From 1997 to 2001 the beverage can market has grown with 12% in Brazil. However, in 2002 and 2003 they had a return of sales. Sales expect to grow based on the consumption rates of cans. In average, Europe used 76 cans per capita, the US 360 and in comparison to South America, where they uses 60 cans per capita, Rexam expects an increased sale in South America. Nevertheless, if Europe follows the US lifestyle, the demand of cans significant will increase in the future.

The main strategy for the South American market is to adjust the capacity to meet demand. Rexam want to achieve a constant market growth where their acquisition of Latasa expects to give synergies in the end of 2006.

3.3.2.3 Beverage Can Europe & Asia⁵⁶

Rexam Beverage Can Europe & Asia is the largest supplier of beverage cans in Europe. With their 15 can plants and four end plants, they cover a wide part of Europe, from the UK to Turkey. Moreover, they have one production plant in Egypt, one in China and partnership with both South Korea and India.⁵⁷ Figure 3.6 show a map of Rexam's production and end plants in Europe.



Figure 3.6 Rexam's production and end plants in Europe

⁵⁴ Packaging for the world, Annual report 2005

⁵⁵ Homepage, www.rexam.com

⁵⁶ Homepage, www.rexam.com

⁵⁷ Intranet, www.rexam.com

Rexam produces both aluminium and steel cans, in 13 different sizes. They provide both small stubby cans, slim models to large pint size; they offer the broadest assortment in the industry. Beer, fizzy drinks, juices, sports and energy drinks, water, wine, spirit mixes and iced coffees are examples of beverages that cans are used for.

The European market has grown approximately 5% during 2004 which includes Germany. The German market has been affected by the legal situation of the deposit system in 2003 which has had a negative impact on the sales. If Germany is excluded, the market growth should be around 7 %. The highest growth was in Denmark, Austria, Spain, Portugal, Eastern Europe, Russia and Turkey.

Rexam Beverages Can Europe & Asia's main strategy is to maintain the dynamic growth in the market with at least 5 % (excluding Germany). To achieve this, they going to offer brand driven innovations as well as new applications in growing markets as health and functional beverages.

On the Asian market, the presence in South Korea, China and India will ensure a future growth and participating on this market. Nevertheless, the Asian market is developing by a good pace.

Organisation of Rexam Beverage Can Europe & Asia

Rexam Beverage Can Europe & Asia's executive committee has the overall responsibility for the organisation. Figure 3.7 shows the organisation of Rexam Beverage Can Europe & Asia's executive committee.

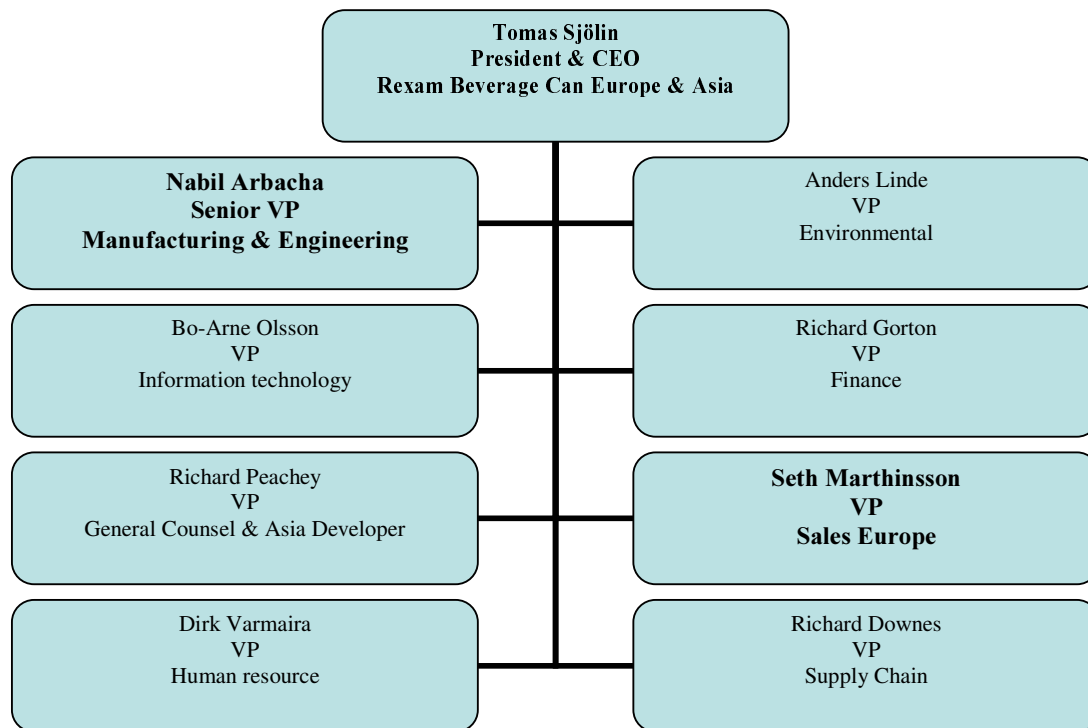


Figure 3.7 Rexam Beverage Can's executive committee

The sales department in Rexam Beverage Can Europe & Asia is divided, into different sales regions. The vice president for sales, Seth Marthinsson has the overall responsibility for the sales organisation. Nevertheless, each sales director is responsibly for its sales area.

Figure 3.8 shows how the sales function is organised. Rexam Beverage Can Europe & Asia has sixteen different sales divisions; United Kingdom, Benelux, Spain, France, Berlin, Recklinghausen, Gelsenkirchen, Sweden, Austria, Italy, Ejpovice, Russia, Turkey, Egypt, China and India.

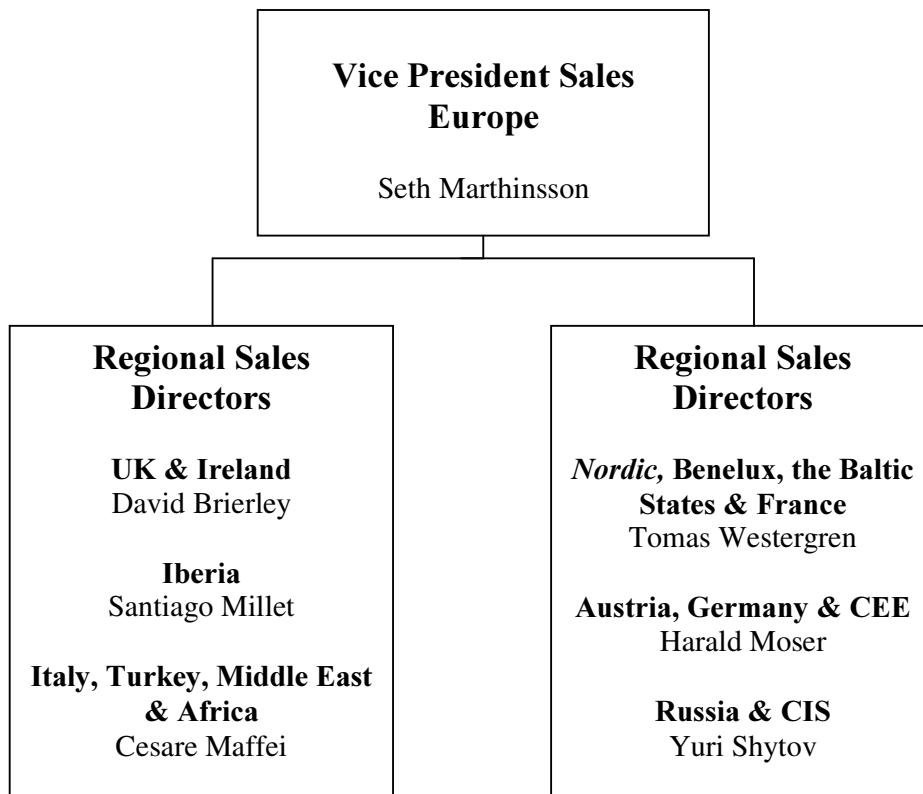


Figure 3.8 Rexam Beverage Can Europe & Asia's sales function

The organisation of Rexam Beverage Can Europe & Asia is built upon the idea where all production plants are independent departments from their sale areas. However, each production plant has their main sales area, e.g. the production plant in Fosie, Sweden, primarily delivers cans for the Nordic and Baltic States. The production plant sells produced cans to its main sales department (LRD, limited risk distributor) due to their customer's demand. Conversely, all LRD buys from different plants to cover all customer demand when their major supplier has lack of capacity.

The production department has the same organisation as the sales department. The vice president for manufacturing and engineering, Nabil Arbacha is responsible for the organisation. Further, each general manager is responsible for its plant. Rexam Beverage Can Europe & Asia has seventeen production plants in Europe and Asia. There are Wakefield, Milton Keynes, Chieti, Norgara, Dunkeraque, Fosie, Vademorillo, La Selva, Naro Fominsk, Manisa, Ejpovice, Enzesfeld, Recklinghausen, Gelsenkirchen, Berlin, Egypt and in China, Zhao Qing. The organisation of the production departments shows in Figure 3.9.

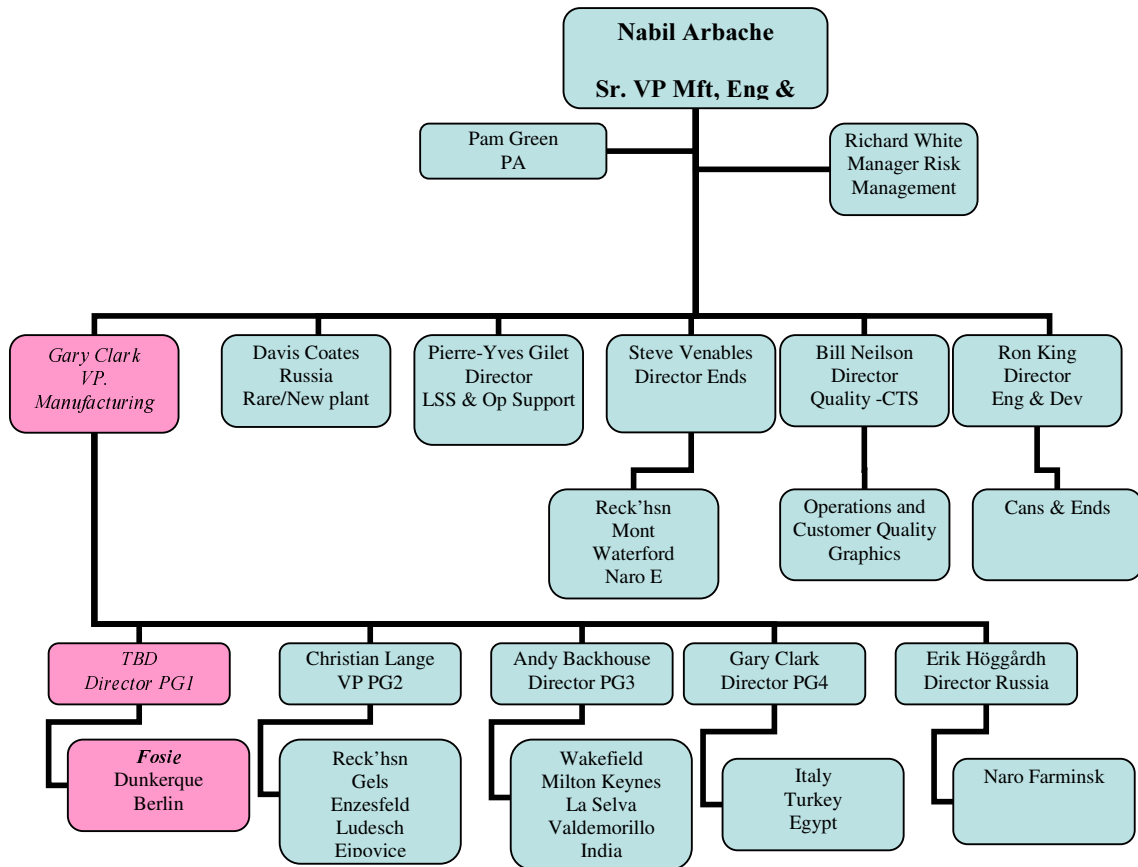


Figure 3.9 Rexam Beverage Can Europe & Asia's operations organisation

Central planning, a part of the supply chain, is responsible to coordinate the sales departments and the production plants. Central planning's main task is to synchronise all plants, maintain relations between them and support them in their undertakings.

4 Literature study

This chapter describes theories and models which are used for analysing the empirics. Framework for this thesis's analyse chapter are theories and models for forecasting, material planning, safety stock, optimal ordering quantities and capacity planning.

4.1 Planning & managing within a company

Long and short term planning are required in all type of companies. The planning is done with different time horizons and detail levels. Adaptability to new trends is one significant factor that effect future planning. High flexibility to changes increases the ability to long term planning. However, uncertainties increase for long term planning. Likewise, frequently changes bring a shorter planning horizon. The relation between different planning horizons and detail levels is shown in Figure 4.1.⁵⁸

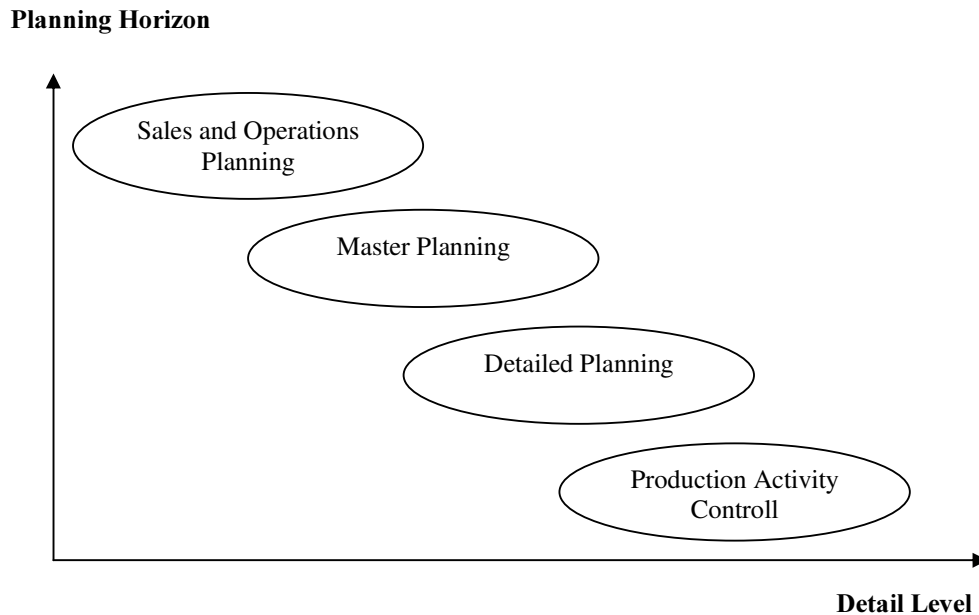


Figure 4.1 Planning horizons vs. detailed level

4.1.1 Sales and operations planning⁵⁹

The sales and operations planning is long term planning, for one year or more. However, the planning is not as detailed as for short term planning. Available production capacity, raw material and resource allocation are examples of issues on this planning level. Authorities for sales and operations planning are set by the company's business plan and the sales forecasts constitutes as a frame for this planning level.

The sales and operation planning aim to find a balance between available resources/capacity and demand. If the demand is larger than available resources; it results in lost sales, decline delivery capability, higher costs etc. In the opposite, more free capacity than demand, results

⁵⁸ Mattsson, Stig-Arne & Jonson, Patrik. (2003) *Produktionslogistik*

⁵⁹ Mattsson, Stig-Arne & Jonson, Patrik. (2003) *Produktionslogistik*

in higher stock levels, unnecessary tie up capital and stock holding costs. Low utilisation of capacity increases the production cost which entails price reductions or discounts to increase the demand.

4.1.2 Master planning⁶⁰

The master planning's main responsibility is to translate the sales and operation planning's purpose into a production plan for individual products. The master planning specifies number of single products which need to be produced during a time period. However, the master planning requires more detailed information than the sales and operations planning. It also has a shorter planning horizon.

Master planning can be divided into four steps⁶¹:

1. Forecasting of future demand.
2. Generate preliminary delivery schedule, based on forecasts and orders on hand.
3. Generate a preliminary production plan based on the delivery schedule, stock on hand and the size of orders.
4. Evaluate created plans against existing conditions to realise them.
5. Realise the achieved plans.

Production and delivery plans are based on forecasted quantities and available stock on hand. The master planning is representing the expected production and not the expected demand. It shall be regarded as a production plan, not a forecast for expected sales.

4.1.3 Detailed scheduling⁶²

Detailed scheduling aims to decide when an order shall be produced, within the frame of the master planning. Times and quantities are determined for each product to minimise tied up capital and increase delivery reliability to customer, as well as optimising the utilisation of inter company resources.

4.1.4 Production activity control⁶³

The detailed scheduling is a frame for production activity control and placed orders on the detailed scheduling level is followed up on this level. The production performance is set concurrent as different operations are planned for each production order. Realisation of production orders is the main task for this planning level. According to Mattsson and Jonson, main responsibilities for the production activity control are:

1. Realise orders in consideration to capacity conditions and throughput.
2. Guarantee available raw material when a production will start.
3. According to delivery times and suitable operations, production orders are released.

⁶⁰ Mattsson, Stig-Arne & Jonson, Patrik. (2003) *Produktionslogistik*

⁶¹ Mattsson, Stig-Arne & Jonson, Patrik. (2003) *Produktionslogistik*

⁶² Mattsson, Stig-Arne & Jonson, Patrik. (2003) *Produktionslogistik*

⁶³ Mattsson, Stig-Arne & Jonson, Patrik. (2003) *Produktionslogistik*

4.2 Forecasting

Forecasting is a method to estimate expected demand in the future. Products with longer total production time than expected delivery time needs to be forecasted. Forecasts are built upon estimations which general never agree with actual demand. However, it is important to minimise the forecasting errors. Forecasts can be created in two manners; estimations and calculations. Nevertheless, it is often necessary to work with both of these methods to get a fair estimation of expected sales.

A good forecasting model needs to fulfil following criteria⁶⁴:

- Stable against random variations in demand.
- React promptly within systematically changes.
- Foresee systematically changes.

4.2.1 Manuel forecasts⁶⁵

Manual forecasts can be helpful to utilise of several reasons. Though, a manual forecast is used when known changes going to affect the demand. Changes in price, advertising campaigns and new legislation are examples of factor which can bring unexpected changes in demand. These unpredicted variations are often difficult to discover for a computer based forecasting program. In the case with a computer based forecasting, the forecast needs to be manually adjusted. Three different methods for manual forecasting are presented; management group, grass roots and pyramid forecasting.

4.2.1.1 Management group⁶⁶

When performing a management group forecast, employees on leading positions are together creating a forecast. Depending on a company's size; different people contributes within the creating process. A forecast is often based on gathered sales statistics and other necessary information. Advantageously, a management group forecast can be created relatively fast. This method is favourable suitable for long run and overall planning. When employees in a leading position create the forecast, it brings a significant risk for influences from them, instead of employees who work close to the market. Furthermore, all forecasts tend to be more wishes than reality.

4.2.1.2 Grass roots level⁶⁷

When accomplish a grass root forecast, sales employees and other who are working close to the market do their own forecasts, for one sales area or total expected sales. These assessments are collected for a common forecast for expected. Conversely, this method brings a great time for work within the forecasting process. However, the person who have most contact to the market, also gather the most correct information. Further, they are responsible

⁶⁴ Mattsson, Stig-Arne & Jonson, Patrik. (2003) *Produktionslogistik*

⁶⁵ Axsäter, Sven. (2001) *Lagerstyrning*

⁶⁶ Mattsson, Stig-Arne & Jonson, Patrik. (2003) *Produktionslogistik*

⁶⁷ Mattsson, Stig-Arne & Jonson, Patrik. (2003) *Produktionslogistik*

for the implementation of the forecast. The close cooperation with the market is an advantageous for the method.

4.2.1.3 Pyramid forecast⁶⁸

A pyramid forecasting model is a combination of the management group and the grass root forecast. Forecast created with the management group method is often regarded as the most reliable and is the base for a pyramid forecast. If the grass roots level's forecasts diverge from the managements group's, all individual forecasts are adjusted to the more reliable forecast (the management group). The executive group has better understanding for a markets development and conjuncture. Therefore, they have better conditions to estimate sales. Nevertheless, sales and product managers who create the forecast are not bounded to the forecast.

4.2.2 Methods for calculation of forecasts

There are several methods for calculation of forecasts which are more or less complicated. These methods can be divided into depending and not depending methods. Generally, depending methods require more data and work with forecasts than the not depending methods.

4.2.2.1 Moving average⁶⁹

The moving average forecasting method is based on historical consumption. The calculated average value is used as a forecast for following periods. When a new forecast is created, the oldest demand data is replaced with the most recent value of the demand. Though, numbers of periods decisive how well the method works. If several periods are used, the forecast is stable against randomly variations. However, it also gives inferior conformity to trends and season variations.

Forecasted demand can be calculated from:

$$P(t+1) = \frac{D(t) + D(t+1) + \dots + D(t-n+1)}{n}$$

Where;

P(t+1)= forecasted demand, period t+1

D(t)= actual demand, period t

n= number of periods

⁶⁸ Mattsson, Stig-Arne & Jonson, Patrik. (2003) *Produktionslogistik*

⁶⁹ Mattsson, Stig-Arne & Jonson, Patrik. (2003) *Produktionslogistik*

4.2.2.2 Exponential smoothing⁷⁰

This method works likely as the moving average method. The main dissimilarity is the way of measuring historical data. This method weights the demand data according to the smoothing constant; α . The choice of α is important as the number of chosen periods for the moving average method regarding randomly variations and consideration to systematic changes. α is adjusted to historical data to obtain best suitability. A higher value of α gives better flexibility to systematic changes, although it is unstable for random changes.

Expected demand is calculated from following expression:

$$P(t+1) = \alpha \cdot D(t) + (1 - \alpha) \cdot P(t)$$

Where;

α = smoothing constant ($0 < \alpha < 1$)

4.2.2.3 Focus forecasting

A focused forecast is updated when a recent value of demand is received. Simulations are done to consider the best appropriate forecasting method for creating a forecast. Nevertheless, this method requires a huge availability of data capacity. Two theses summarise the focus forecasting method⁷¹:

- An easy method works well as an advanced
- If a method works satisfied one period, the probability it does it the next coming period is large.

4.2.2.4 Trend correction⁷²

It is easy to consider trends with manual forecasts. However, with mathematical and computer based systems, awareness of trends is important when finding a reliable forecast. A forecast with trend correction can be calculated from following expression:

$$P(t+1) = PG(t+1) + \frac{1-\alpha}{\alpha} \cdot T$$

Where;

$P(t+1)$ = trend corrected forecasted demand, period t+1

$PG(t+1)$ = general forecast for the demand, period t+1 without consideration to trends

α = smoothing constant

$\frac{1-\alpha}{\alpha}$ = correction factor

T = estimated trend according to comparison between forecasts for different periods

⁷⁰ Mattsson, Stig-Arne & Jonson, Patrik. (2003) *Produktionslogistik*

⁷¹ Mattsson, Stig-Arne & Jonson, Patrik. (2003) *Produktionslogistik*

⁷² Mattsson, Stig-Arne & Jonson, Patrik. (2003) *Produktionslogistik*

In real, the demand is not linear which brings a risk for random variations which can give distinctions in the forecast.

4.2.2.5 Season variations⁷³

Seasonal variation is another usual type of systematically changes in demand. Index for seasons can be calculated according to following formula:

$$S(t) = \frac{D(t)}{D(m)}$$

S(t)= season index, period t

D(t)= actual demand, period t

D(m)= mean demand over a year

4.2.3 Forecasting errors

As mentioned before, forecasting is just an estimation of the demand. The purpose with a forecast control is to identify occasional random errors, but also systematically errors. A forecast error can be defined as the different between a period's forecast and the same period's actual demand. A positive forecast error indicates a too high forecast and a negative difference indicates a too low estimated forecast. The forecast error use calls Mean Absolute Deviation (MAD). MAD is a measure of the forecasts spread in relation to actual demand. Calculations of MAD are favourable done by following expression:

$$MAD(t) = \alpha \cdot |P(t) - D(t)| + (1 - \alpha) \cdot MAD(t - 1)$$

Where;

MAD(t) = MAD, period t

P(t)= forecasted demand, period t

D(t)= actual demand, period t

α = smoothing constant

If the demand is normal distributed, the standard deviation of the demand can be calculated as:

$$s = 1,25 \cdot MAD$$

Furthermore, the lead time's standard deviation can be useful for calculations of a safety stock.

⁷³ Mattsson, Stig-Arne & Jonson, Patrik. (2003) *Produktionslogistik*

4.3 Material planning

The material planning's main purpose is to find an efficient way to establish deliveries for specific quantities and time periods. An effective material planning includes the flow from receiving an order to the delivery. Different material planning methods give guidelines for purchasing, manufacturing and inventory levels. Moreover, products kept in stock gives the possibility to balance the need against availability products in flow. Material planning is about answering following four questions⁷⁴:

1. Which articles should be planned into the production?
2. Which quantity for each article?
3. When shall the order be delivered? Directly to customer or to the warehouse?
4. When shall the article be delivered and when shall it be manufactured?

This chapter contains descriptions of different material planning methods and which answering or give support to these four questions. Furthermore, their appropriateness for different situations and field of application is discussed for each method.

Each method field of application depends on several factors⁷⁵;

- Type of demand
- Demand distribution
- Product or component orientating
- Character of demand
- Order principles
- Principles for material planning
- Priority rules
- Reorganisation capability
- Type of material plan
- Time interval between orders

Following material planning methods going to describes in this chapter; reordering level system, consumption based replacing system, planning with cover time, material requirement planning and cyclical production planning.

4.3.1 Reordering level system⁷⁶

Reordering level systems is a common name for one type of material planning's method. This type of planning system regards as an easy method to understand and one of the most commonly used in the industry.

The available quantity in stock compares to a reference point, called reordering level. A new production is initiated if the stock falls below the reordering level. Time for delivery is set as today's date plus the article's lead time. The reordering level corresponds to expected demand during the lead time. Figure 4.2 shows the design of a reordering level system.

⁷⁴ Mattsson, Stig-Arne & Jonson, Patrik. (2003) *Produktionslogistik*

⁷⁵ Mattsson, Stig-Arne & Jonson, Patrik. (2003) *Produktionslogistik*

⁷⁶ Mattsson, Stig-Arne & Jonson, Patrik. (2003) *Produktionslogistik*

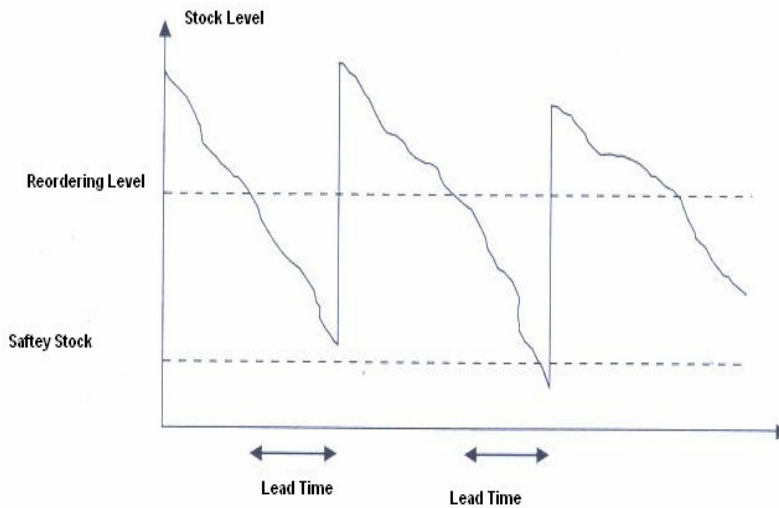


Figure 4.2 Reordering level system

A reordering level system is favourable used for products with independent demand without underlying dependent components.

Managing finished products and spare parts, is this system's main field of application. However, it is also suitable for highly frequent cheap articles, as screws and nuts, where the reordering time is short. The reordering level system is a good planning method for customised production and for difficult forecasted articles.

The reordering level decides according to the summation of safety stock and expected demand during the lead time. Demand with trend and seasons variations, brings changes within the system and the reordering level needs to be adjusted for these variations. In cases with significant variations in demand this method needs to be considered. Therefore, another material planning method can be favourable used. Capacity limitation is another factor that needs to be concerned when using this material planning system. This method does not take capacity into consideration and enough capacity is required when using this method.

Decision rule: A new order is placed when the stock plus possible planned arrivals has followed below the reordering level. Time for delivery is today's date plus the article's lead time.

Following formula is used for calculation of the reordering level:

$$RL = SS + D \cdot L$$

Where;

- RL= reordering level
- SS=safety stock
- D=demand per period
- L=lead time

4.3.2 Consumption based replacing system⁷⁷

Consumption based replacing system works in the opposite way to a reordering system. This system reorders with specific time intervals and with varying order quantities. The delivery time of an order is in the end of next refilling period. However, changes in demand carry modifications in the system. To meet the expected service level, the system must be updated with modifications for adjustment to changes. Figure 4.3 shows a consumption based replacing system.

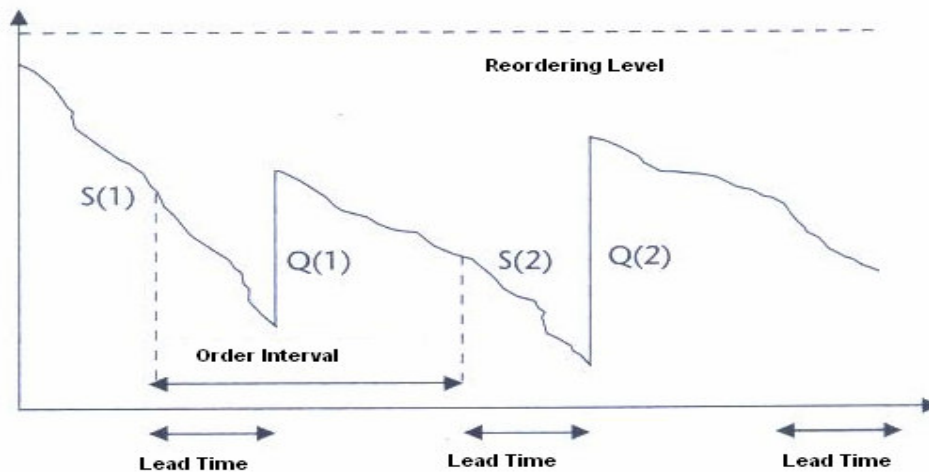


Figure 4.3 Consumption based replacing system

For calculating the replacing level, following formula is used:

$$RL = D \cdot (O + L) + SS$$

Where;

RL= reordering level

D=demand

O= ordering interval

L= lead time

SS= safety stock

S=stock level

The ordering quantity (Q) is calculated from;

$$Q = RL - S$$

Decision rule: The difference between the reordering level and actual physical stock corresponds to the reordered quantity. Time for delivery time is in the end of next stock cycle.

This system is advantageous used for companies with independent needs and articles made immediately sales. However, either this method takes capacity in consideration and the

⁷⁷ Mattsson, Stig-Arne & Jonson, Patrik. (2003) *Produktionslogistik*

method works best in cases when capacity is no obstruction. The method's main advantageous is its capability to coordinate deliveries and sequences.

4.3.3 Planning with covering time⁷⁸

A cover time planning system reminds about a standard reordering system. The prominent different is they way of measuring a product's demand. The system is built upon comparisons of time instead of quantities which often gives better understanding of the demand and time for reordering.

A new order is initiated when the cover time minus the safety time is less than required cover time. Conversely, this system does not take existing order reservations into consideration. Nevertheless, these orders regards as a part of the demand during the lead time. This system has the same benefits and difficulties as the reordering system. Calculations of a cover time show when the stock needs to be refilled. This system regards as a proactive system.

Advance production planning can be performed by generating new orders even if the cover time are longer than the sum of reordering time and safety time. This method can easily be used for priorities; the article with shortest cover time shall be produced first. Calculation of cover time is an alternative to material requirement planning, where the articles have a deduced require, instead of here, independent require. This method is foremost favourable for articles with unknown demand, continuous need of material, small batches and short flow.

Decision rule: A new order is initiated when the cover time minus the safety time is less than the replacement time. The delivery time is set as today's date plus the articles lead time.

4.3.4 Material requirements planning (MRP)⁷⁹

Material requirement planning is regarded as a more complex material planning method than other methods. However, it is the most correct method for articles with derived need and for standard products. This method renders the possibility to trace need of material within different structural relations.

In the opposite too other methods, this method plan the production and deliveries as late as possible. It is a market and product oriented method, where new orders are generated from customer needs or production plans. Capacity limitation is not taken into consideration when planning an order. The purpose is to reach an optimal material flow. When using this system, the delivery times, is a base for priorities.

This method is favourable used in planning environments with derived needs. Material for final products, as raw materials, purchased components and own produced details and semi-manufactured articles are typical item for a MRP system. It is also good to use for products with high refining value and its advantageous increases with higher product complexity.

This method can be an alternative to a reordering level systems, the consumption based system and the cover time planning system. It is also advantageous to use for reserved orders

⁷⁸ Mattsson, Stig-Arne & Jonson, Patrik. (2003) *Produktionslogistik*

⁷⁹ Mattsson, Stig-Arne & Jonson, Patrik. (2003) *Produktionslogistik*

and seasonal variation demand. However, this method's advantageous decreases with more unexpected demand and special orders.

4.3.5 Cyclical production planning⁸⁰

Cyclical production planning is the only method which considers capacity limitations. Articles for planned production are placed into a cyclical schedule. The method is appropriate for articles with high value and with high manufacturing frequency, where the production schedule is repeatable with cyclical patterns.

The length of a period need to be chosen to a calendar year divided by 1, 2, 4, 8, 16 etc, where each production area needs its own cyclical period. These periods needs to be coordinated, depending on geometrical series. For example, if the demand depends upon seasonality, the production is injured to full capacity even during low season. However, there cannot be need of high flexibility when using this system.

To create an effective production pattern, there are some steps to follow:

1. Expected yearly demand (D) for each article needs to be calculated. Together, the added quantity brings full capacity for a production group.
2. According to Wilson's formula for an optimal order quantity (q), q is calculated for each article.
3. Calculate manufacturing frequency (D/q) series per year.
4. Chose the closest higher number of the manufacturing frequency for each article from the series 2^n series/year.
5. Establish some alternative production schedules. One period needs to cover at least the time for changeovers and the operation time. These different timetable needs to be evaluated and compared to the total cost for different situations.

When a cyclical production order is established it is easy and rational to use. On the other hand, it has a strong need of support systems. Nevertheless, the capacity consideration is the main advantage with this method.

⁸⁰ Mattsson, Stig-Arne & Jonson, Patrik. (2003) *Produktionslogistik*

4.3.6 Comparison between different material planning methods

Different methods can be useful in different situations. Figure 4.4 describes which method that is useful in different situations.

Material planning system / Features	Reordering level system	Consumption based replacing system	Time period coverage	Material requiring system (MRP)	Cyclical production planning
Type of demand	Forecasts and historical based consumption	Forecasts and historical based consumption	Forecasts and historical based consumption	Reservations and forecasts	Forecasts
Demand distribution	Total summation	Total summation	Total summation	Time distributed	Total summation
Product or component oriented	Component	Component	Component	Product	Component
Character of demand	Independent	Independent	Independent	Derived	Independent
Order principles	Consumption based	Plan initiated	Consumption based	Need initiated	Cyclical pattern
Principles for order planning	From surveillance	Planned time	From surveillance	Needed time	Planned time
Priority rules	No	No	Yes	Yes	No
Reorganisation capability	No	No	Yes	Yes	No
Type of material plan	Individual order and call off	Individual order and call off	Individual order and call off	Delivery plan and orders	Delivery plan and orders
Time between orders	Vary	Fixed	Vary	Vary	Fix

Figure 4.4 Material planning method's field of application⁸¹

⁸¹ Mattsson, Stig-Arne & Jonson, Patrik. (2003) *Produktionslogistik*

4.4 Ordering quantities

Ordering quantities are important to consider of several reasons. Only producing an actual need is in several cases not optimal and it is often not suitable or possible to produce a single need for each period. Historical, many different methods to design an optimal ordering quantity have been developed. Some of these methods are presented in this chapter. Minimisation of the ordering costs and tied up costs is the fundamental idea within these methods. Nevertheless, some essential differences separate these methods from each other. They can be classified according to fix or varying order quantity, but also with consideration to fix or varying time intervals.

4.4.1 According to requirement⁸²

The order quantity corresponds to a unique call of and the ordered quantity only corresponds to a required quantity for one single period. Usage of this method brings no tied up capital and no stock holding costs. However, this ordering procedure often brings small order quantities, where the articles are reordered fairly often. This method can best be utilised for expensive goods and for just-in-time deliveries.

4.4.2 Estimated order quantity⁸³

This method is based on a fixed ordering quantity evaluated from experienced based knowledge. For every reordering instance a new quantity is estimated. Theoretical, it is impossible to estimate a correct balance between the ordering costs and the tied up capital cost for each reordering period. Primarily, this method is useful for uncomplicated circumstances, for example, when system support is missing, undeveloped, or when information for calculations is missing. However, a new update process for each reordering period brings a lot of work which can lead to mistakes.

4.4.3 Economical order quantity (EOQ)⁸⁴

Wilson's formula for an optimal economical order quantity is the most common and used method to calculate a fix and optimal order quantity. This method aims to obtain a total minimal cost for the stock holding and the ordering cost. The model is based on following assumptions:

- The demand per unit time (D) is constant and known.
- The lead time for inventory replenishment is constant and known. The storage is filled instantaneous with the whole order quantity during arrivals to storage.
- The ordering cost (S) or the setup cost is constant, known and independent of the order quantity.
- The stock holding cost per unit and unit time is constant, known and independent of the order quantity ($I \cdot C$).
- No shortages are allowed.

⁸² Mattsson, Stig-Arne & Jonson, Patrik. (2003) *Produktionslogistik*

⁸³ Mattsson, Stig-Arne & Jonson, Patrik. (2003) *Produktionslogistik*

⁸⁴ Mattsson, Stig-Arne & Jonson, Patrik. (2003) *Produktionslogistik*

- The price or cost for each unit is constant, known and independent of order quantity and place of purchase.

Moreover, there is no need of having a safety stock when the order quantities, the demand and the lead time are known and constant. This entails the maximum order quantity (Q) and a mean stock level of ($Q/2$). Figure 4.5 shows a typical pattern of the stock cycle. Demand per unit time (D) brings consumption of one ordering quantity during one time period (Q/D) which corresponds to a stock cycle. A yearly ordering cost is the mean stock level multiplied by yearly stock keeping cost ($I \cdot C$).

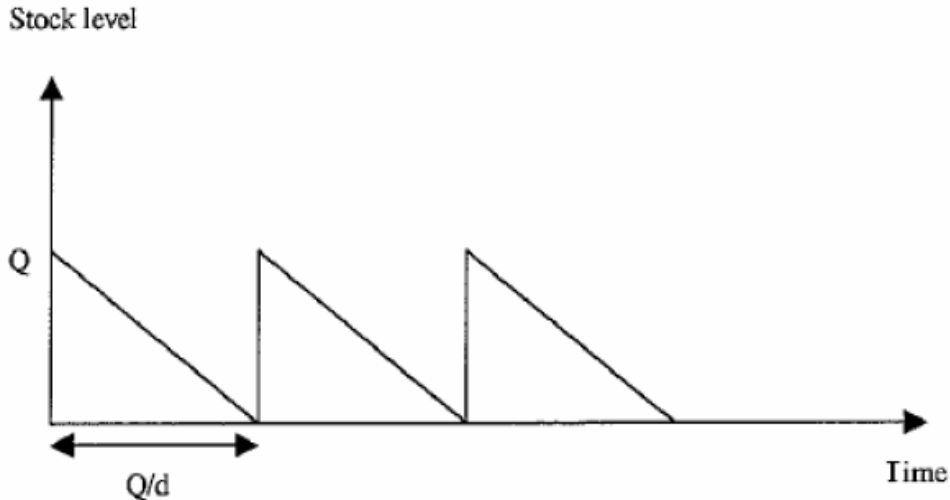


Figure 4.5 Stock cycle (saw tooth curve)

The total yearly ordering cost is expressed by:

$$TC = \frac{Q}{2} \cdot I \cdot C + \frac{D}{Q} \cdot S$$

D = demand per unit time

S = cost per ordering occasion

I = cost for articles kept in stock

C = value of an article per stock unit

The total cost function is minimised to receive an optimal ordering quantity:

$$Q_{opt} = \sqrt{\frac{2 \cdot D \cdot S}{I \cdot C}}$$

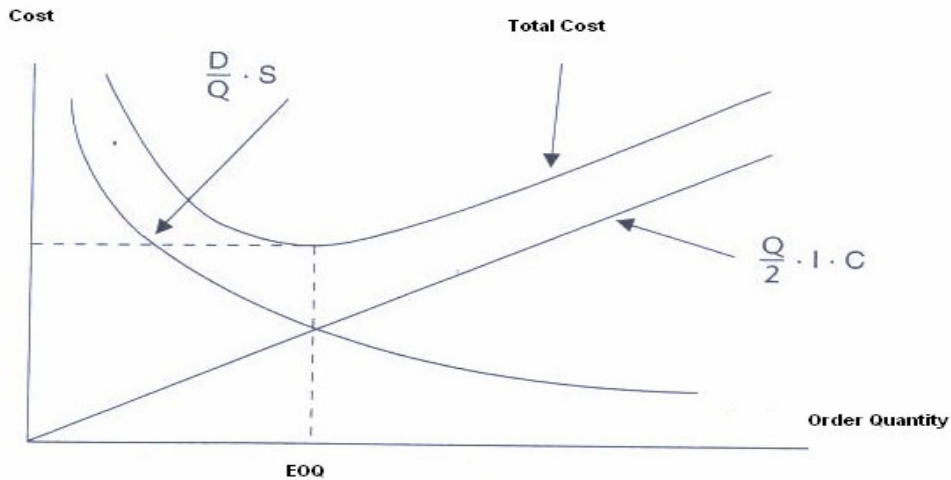


Figure 4.6 The total cost, ordering cost and stock keeping cost

Figure 4.6 shows the total cost, the ordering cost and the stock keeping cost. Close to the optimum of the total cost the curve it is very flat which means that the total cost does not changes significant for small differs in the order quantity. As a result, the model is not sensitive for variations.

4.4.4 Estimated required covering time⁸⁵

This method is based on covering time planning. Time intervals are chosen according to the time interval a specific need shall be covered. It corresponds to intact planning periods, for example weeks or days. Number of periods is chosen with consideration to experienced based knowledge. These estimations are foremost based on expected sales, price and available recourses. An order quantity is calculated with consideration to numbers of periods and expected need during each period. Each article or classification group gets a set covering time. The reordering quantity varies and changes from time to times, to cover exposed covering time.

4.4.5 Economical required covering time⁸⁶

The main different between estimated and economical required covering time, is the way of settle the cover time. The economical required covering time is calculated according to the optimal order quantity and subsequently be transformed into a time perspective. Firstly, an optimal order quantity (EOQ) is calculated. Further, the economical required covering time (ERCT) is obtained from:

$$ERCT = \frac{EOQ}{D}$$

Where;

D= mean demand per period

⁸⁵ Mattsson, Stig-Arne & Jonson, Patrik. (2003) *Produktionslogistik*

⁸⁶ Mattsson, Stig-Arne & Jonson, Patrik. (2003) *Produktionslogistik*

Theoretical, this method is more correct than an estimated method for deciding the covering time.

4.4.6 Silver-Meal's algorithm

Silver-Meal's algorithm is one of the most used methods for calculating dynamical order quantities. The EOQ models assume constant demand. However, there are different models to use for variation in demand over different periods. Fixed quantity, time intervals and discrete distributions are characterises of the Silver-Meal algorithm, but also other dynamical methods. By using this method, the ordering quantity varies and the total cost is calculated for each period. This algorithm can be solved by dynamic programming.⁸⁷

As the other methods, Silver-Meal's algorithm is built upon a balance between the sum of the ordering and the stock keeping cost. When a new order is placed, considerations needs to be made between producing a small batch without stock keeping cost, or a larger batch with stock keeping costs.

Decision rule: to get an optimal order quantity it needs to cover a whole time period. There are two alternatives for each period, to order needed demand plus future periods, or using products kept in stock from a previous period⁸⁸.

$$\frac{A + h \sum_{j=2}^k (j-1) \cdot d_j}{k} \leq \frac{A + h \sum_{j=2}^{k-1} (j-1) \cdot d_j}{k-1} \quad \text{For } 2 \leq k \leq n$$

A= ordering cost

d_i=demand for period i=1,2,....

h= stock keeping cost per unit and period

⁸⁷ Mattsson, Stig-Arne & Jonson, Patrik. (2003) *Produktionslogistik*

⁸⁸ Axsäter, Sven. (2001) *Lagerstyrning*

4.5 Safety stock

Safety stock and safety time are different ways to assure a company from uncertainties. The safety stock assures a company from fluctuations in demand during the lead time. Material planning is often associated with uncertainties as changed demand, order quantities, confidence to suppliers, deliveries on time etc. These uncertainties can be divided into two groups; time or quantity dependent. When an optimal order quantity is calculated, a proper safety stock can be established. The demand is assumed to be normally distributed and deterministic, even if actual demand is stochastic.

4.5.1 Manuel estimated safety stock⁸⁹

The easiest way to dimension a safety stock is by manual estimations based on experience. These estimations consider cost of tied up capital and stock keeping costs as well as consequences for shortages.

4.5.2 Safety stock based on SERV1

SERV1 defines as the percentages of demand that can be satisfied immediately from stock during a time period⁹⁰. The expression for SERV1 corresponds to the probability that a delivery is on time. However, SERV1 has some disadvantages; it takes no consideration to the size of an order quantity. If the order quantity is large, it covers the demand for a long time period and it does not matter if the service level is low, because the deliveries are so infrequently.⁹¹

The size of the safety stock can be calculated from the standard deviation of the demand during the lead time multiplied by a safety factor. This factor corresponds to the accepted probability for a shortage during a period.

Following expression can be used to measuring a safety stock⁹²:

$$SS = k \cdot \sigma_{DL}$$

Where:

SS = safety stock

k = safety factor

σ = the demand's standard deviation during the lead time

⁸⁹ Mattsson, Stig-Arne & Jonson, Patrik. (2003) *Produktionslogistik*

⁹⁰ Mattsson, Stig-Arne & Jonson, Patrik. (2003) *Produktionslogistik*

⁹¹ Axsäter, Sven. (2001) *Lagerstyrning*

⁹² Mattsson, Stig-Arne & Jonson, Patrik. (2003) *Produktionslogistik*

With an already high service level, to reach a higher, results in increased tied up capital. Table 4.1 show the relation between different service level and safety factors.

Service %	Safety Factor
50	0
75	0,67
80	0,84
85	1,04
90	1,28
95	1,65
98	2,05
99	2,33
99,5	2,57
99,99	4

Table 4.1 Relation between the service level and the safety factor

4.5.3 Safety stock based on SERV2

SERV2 defines as the probability that a customer does not has to wait, part of the demand that can be meet direct from stock⁹³. In the opposite of SERV1, this method takes consideration to numbers of periods per year. However, the method is also more mathematical advanced than SERV1.

$\sigma_{DL} \cdot E(z)$, express the expected number of shortages per storages cycles, where σ_{DL} is the demand's standard deviation during the lead time and $E(z)$ an expression for the service level. SERV2 can be calculated from following expression:⁹⁴

$$SERV2 = 1 - \frac{\frac{D}{Q} \cdot \sigma_{DL} \cdot E(z)}{D} = 1 - \frac{\sigma_{DL} \cdot E(z)}{Q}$$

Where;

D=demand per year

σ_{DL} = the demand's standard deviation during lead time

Q= mean order quantity

To solve $E(z)$, following expression can be used:

$$E(z) = \frac{(1 - SERV2) \cdot Q}{\sigma_{DL}}$$

The safety stock is decided with the same expression as for SERV1,

$$SL = \sigma_{DL} \cdot Z$$

⁹³ Axsäter, Sven. (2001) *Lagerstyrning*

⁹⁴ Mattsson, Stig-Arne & Jonson, Patrik. (2003) *Produktionslogistik*

4.5.4 Safety stock based on cost optimisation⁹⁵

A high safety stock decreases the shortage cost, but increase the tied up capital costs. From these costs, an optimisation can be done according to find the lowest total cost. Mattsson and Jonson had defined a formula for the probability that a shortage will not occur during a period

(a shortage leads to lost demand):
$$\phi(k) = \frac{SC}{SC + CA \cdot \frac{Q}{D}}$$

Where:

SC= shortage cost per unit

CA= tied up capital

D=demand per unit time

k= safety factor

Q=order quantity

If a shortage occurs it leads to a rest order, following expression can be used:

$$\phi(k) = 1 - \frac{CA \cdot Q}{D \cdot SC}$$

This expression can be used for all demand distributions.

4.5.5 Comparison between different SS methods⁹⁶

Figure 4.7 shows a comparison between different safety stock methods.

Demand Variables/Features	Estimated Quantity	SERV1	SERV2	Cost Optimisation
Consideration to demand variations	Institutive	Yes	Yes	Yes
Consideration to number of shortages	No	No	Yes	Institutive
Consideration to service level	No	Yes	Yes	No
Consideration to actual incremental cost	Institutive	No	No	Yes

Figure 4.7 Comparison between different safety stock methods

⁹⁵ Mattsson, Stig-Arne & Jonson, Patrik. (2003) *Produktionslogistik*

⁹⁶ Mattsson, Stig-Arne & Jonson, Patrik. (2003) *Produktionslogistik*

4.5.6 Seasonality and stock levels

With a seasonal demand, the demand and stock level curve look different from a normal demand and stock cycle curve.⁹⁷ The seasonal demand and the stock level curve are shown in Figure 4.8 and Figure 4.9.

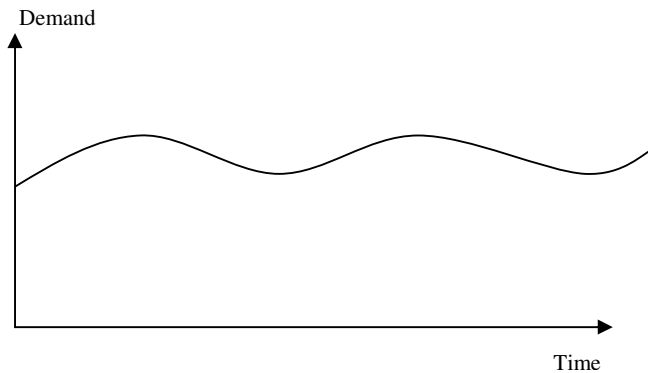


Figure 4.8 Cyclical demand curve

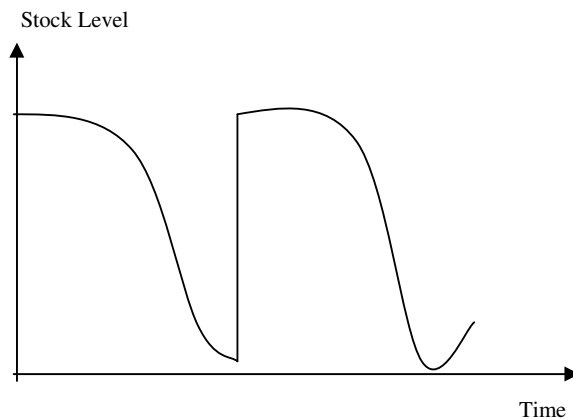


Figure 4.9 Stock level curve for cyclical demand

Companies that meet seasonal demand often have a more complex production situation than companies with uniform demand. Often, companies that meet seasonal demand have insufficient capacity to meet all demand during the peak season. These companies need to produce to stock during the off peak season in anticipation of high demand during the peak season.⁹⁸ Academic literature gives no appropriate models for calculations of safety stocks when meeting seasonal demand and it is a general lack of guidelines for making appropriate decisions. To optimise the stock building and the safety stock three questions need to be answered:

1. When shall the stock building start?

Time for start the stock building is a critical factor when producing to stock. A too early start of the stock building process results in a risk for exceed of the inventory that might be held to the peak season. However, if the production to stock process

⁹⁷ Aronsson, Håkan. Ekdahl, Bengt. Oskarsson, Björn. (2003) *Modern Logistik - för ökad lönsamhet*

⁹⁸ Krane, S.D & Braun, S.N., (1991) *Production smoothing evidence from physical demands subject to seasonal variations*

starts to late, lost sales might be a risk.⁹⁹ The trade off between the lost sales cost and one period's stock holding cost indicates that at the peak season, a stock level close to the traditional is appropriate.¹⁰⁰

2. Which production mix?

To reduce the cost of stock outs and markdowns, products with relatively predictable demand should be made in advance to make sure available manufacturing capacity for unpredictable manufacturing during the peak season.¹⁰¹ The product mix in stock is important to consider, when it is not unusual that some companies have a large stock of one material and can be a significant backlog for other materials.¹⁰²

3. Priorities when shortages of capacity?

When the plan fails, produce the money makers and demanded products.

⁹⁹ Metters, R (1998) *General rules for production planning with seasonal demand*

¹⁰⁰ Metters, R (1998) *General rules for production planning with seasonal demand*

¹⁰¹ M.L.Fischer, J.H. Hammond, W.R. Obermeyer, A.Raman, (1994) *Making supply meet demand in an uncertain world*

¹⁰² Berry, W, L., Vollman, T.E., Whybark, D.C., (1979), *Master Production Scheduling; Principles and Practises*

4.5.7 Measuring of service¹⁰³

SERV1 and SERV2 can easily be evaluated by mathematical methods. However, these methods take no consideration to soft factors as customisation, information and flexibility. These factors are not easy to measure, but they are important as other factor that measures the service level.

4.5.7.1 Delivery reliability

Delivery reliability is measured from the number of deliveries on time divided by total number of deliveries. However, the definition “on time” varies between different companies; it depends on different products and how time critic they are. Delays can be accepted for some companies, nevertheless in cases it is only accepted in the right hour.

$$\text{Delivery reliability (\%)} = \frac{\text{number of deliveries on time}}{\text{total number of deliveries}} \cdot 100$$

4.5.7.2 Delivery dependability

Expected time for deliveries is essential to consider. It is important to deliver right things and with right quality. Delivery dependability is a way of measuring that.

$$\text{Delivery dependability (\%)} = \frac{\text{number of complet deliveries}}{\text{total number of deliveries}} \cdot 100$$

The definition of a “complete order” can vary also for this measuring method.

Common for these methods is to measure the performance and how well the company is satisfying the demand from customers.

4.5.8 Shortage cost¹⁰⁴

Different costs can arise when the customers require a product and it is not kept in stock. These costs are very difficult to measure. If there are no disadvantageous for a customer to wait, they order can be delivered later. However, if a customer cancels the order, the profit contribution is lost, but also goodwill is lost for the company. However, lost of goodwill is especially difficult to measure. In some cases, the shortage cost can be measured. For example, when a company needs to buy the component or the product from a competitor or inter company, the shortage cost is the difference between the prices.

¹⁰³ Aronsson, Håkan. Ekdahl, Bengt. Oskarsson, Björn. (2003) Modern Logistik - för ökad lönsamhet

¹⁰⁴ Axsäter, Sven. (2001) *Lagerstyrning*

4.6 Capacity planning¹⁰⁵

Capacity planning aims to balance available capacity against need. Decisions concerning capacity regard both size of volumes and when they have to be produced. It is important to balance the capacity to meet expected demand. Higher capacity than demand results in lost sale and a lower demand results in stock keeping costs. Comparison between available capacity and the need of capacity is the starting point for capacity planning.

4.6.1 Capacity planning on different planning levels

The procedure for capacity planning often starts with a calculation of needed capacity, in comparison to existing capacity. This calculation results in an ideal capacity need which is important to reach for the sales and operation planning. If the production planning is done due to maximal capacity, decisions regarding expansion of capacity cannot be based on actual orders from customers and deliveries. It would not give enough information for a cost optimisation of increasing or decreasing the capacity, respective increasing the stock or to produce less than the market demands.

4.6.1.1 Sales and operation planning

Capacity planning on this level is based on needs and deliveries in the future. Expected demand and deliveries are normally based on forecasts. Long time planning for one year or more carries an opportunity to change available capacity. Decisions on this level mostly regard investment of new production plants or discontinuation.

4.6.1.2 Master planning

As on the sales and operation planning level, the master planning is based on forecasts. It is a half to one years planning horizon and the ability to adjust the capacity is more limited than for the sales and operating planning. Decisions regarding capacity are limited to some product groups to combat bottle necks.

4.6.1.3 Detailed planning

A decision of capacity is bound to released or planned production orders. Typical planning horizon for this level is one or two months and the ability to adjust the capacity are even more limited on this level.

¹⁰⁵ Mattsson, Stig-Arne & Jonson, Patrik. (2003) *Produktionslogistik*

4.6.2 Strategies for capacity adjustment

All companies experience variations in the demand, sometimes it increases and sometimes it decreases. The unbalance between capacity and demand can in some cases be handled by increasing or decreasing the stock. If these actions are impossible capacity adjustments have to be done. Some different strategies can be used; leading- or following strategy. These strategies are shown in Figure 4.10.

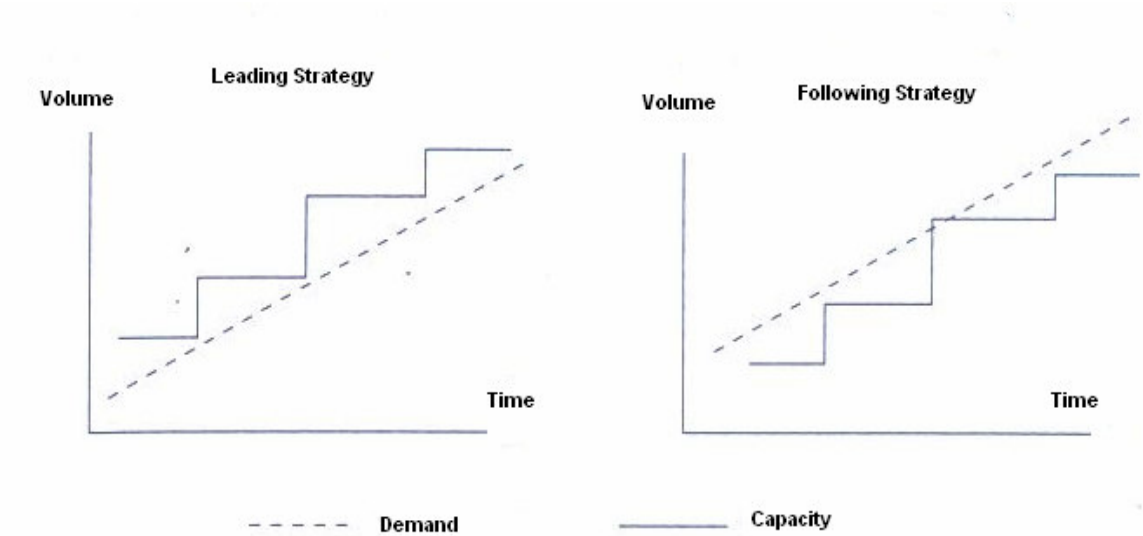


Figure 4.10 Leading and following strategy

4.6.2.1 Leading strategy

This is a proactive strategy, where the capacity is higher (lower) before the demand will increase (decrease). When the demand is increasing, this method brings flexibility in volume which bring possibilities to gain market shares and the business can grow. However, this method carries a lot of risks regarding free capacity.

4.6.2.2 Following strategy

This is a reactive strategy. New investments are planned firstly when a change in demand is reality. It has low volume flexibility when the demand increasing, a high stock level is required to not lose market shares. This method results in a general higher average stock level. However, this method decreases the risk of costs for abound of capacity.

4.6.3 Adjustments for capacity utilisation

There are strategies for capacity adjustments. Mattsson and Jonson have described two strategies; compensation- and adjustment strategy.

4.6.3.1 Compensation strategy

The compensation strategy aims to maximise the usage of storage and time for deliveries, to reach a uniform capacity utilisation. However, the capacity is not adjusted to the demand. The production volume can be calculated from following formula:

$$\text{Production volume per period} = \frac{\text{outgoingstock} - \text{ingoingstock} + \text{delivery volume}}{\text{number of planning periods}}$$

It is important to control the stock and keep away from a negative stock level during the peak periods. Avoiding costs for capacity adjustments is an advantage with this method. Nevertheless, the major disadvantage is the stock building during low seasons and the tied up of capital. The characteristics of the compensation strategy are shown in Figure 4.11.

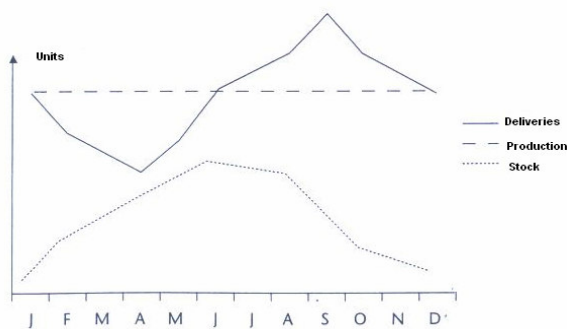


Figure 4.11 The compensation capacity strategy

4.6.3.2 Adjusted strategy

When using this strategy the capacity utilisation is adjusted to the demand from time to time. The strategy's characteristics are shown in Figure 4.12.

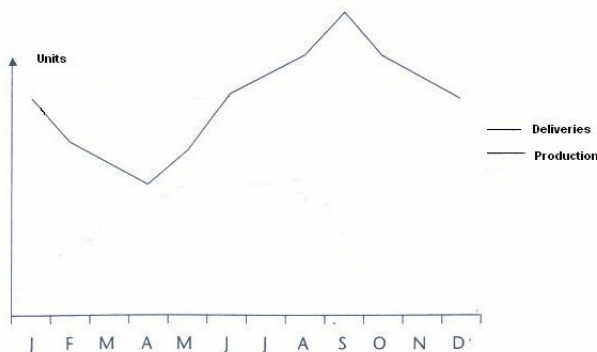


Figure 4.12 Adjusted capacity strategy

5 Empirics

This chapter present gathered data from the research at Rexam Beverage Can Europe & Asia, foremost the production plant in Fosie. It aims to present the different functions of production planning within the company and how they work.

5.1 Planning & managing the organisation

The Rexam Beverage Can Europe & Asia is a large organisation, where central planning (a part of the supply chain division) aims to coordinate the organisation, foremost the sales and the production department. Figure 5.1 shows the relation between central planning, LRDs and production plants.

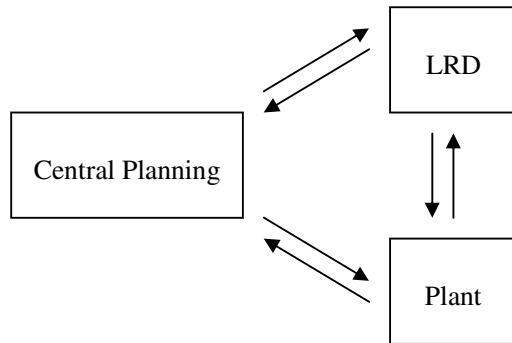


Figure 5.1 Relation between central planning, LRDs and plants ¹⁰⁶

5.1.1 Sales and operation planning

Rexam's executive committee in Luton, England (introduced in chapter 3.3.2.2.3) is performing the sales and operations planning.

5.1.2 Master planning

The master planning is a tactical managing level within the company and is performed at each production plant and LRD. The regional sales manager and the general manager are responsible for performing the master planning for its area. Central planning's role is to coordinate all the LRDs and the production plants, where the line load is a tool for communication between the master planning and detailed planning.

5.1.2.1 Central planning's role

Rexam Beverage Can Europe & Asia is organised so central planning coordinating all LRDs and production plants. Central planning main task is to synchronise all plants and maintain relations as well as support them in their undertakings.

¹⁰⁶ Interview, Leif Nilsson

Central planning's ambition is to surpass customer demand, optimise/minimise the stock level, ease manufacturing issues and eliminate surprises. To achieve these ambitions teamwork, communication, clear responsibilities, clear procedures and discipline are issues to reach these goals.¹⁰⁷

Central planning has the responsibility to manage all sixteen independent LRDs. However, eleven of them are connected to each other. Figure 5.2 shows the complexity of the relations between the LRDs. Therefore, central planning is important in order to maintain command within the organisation.

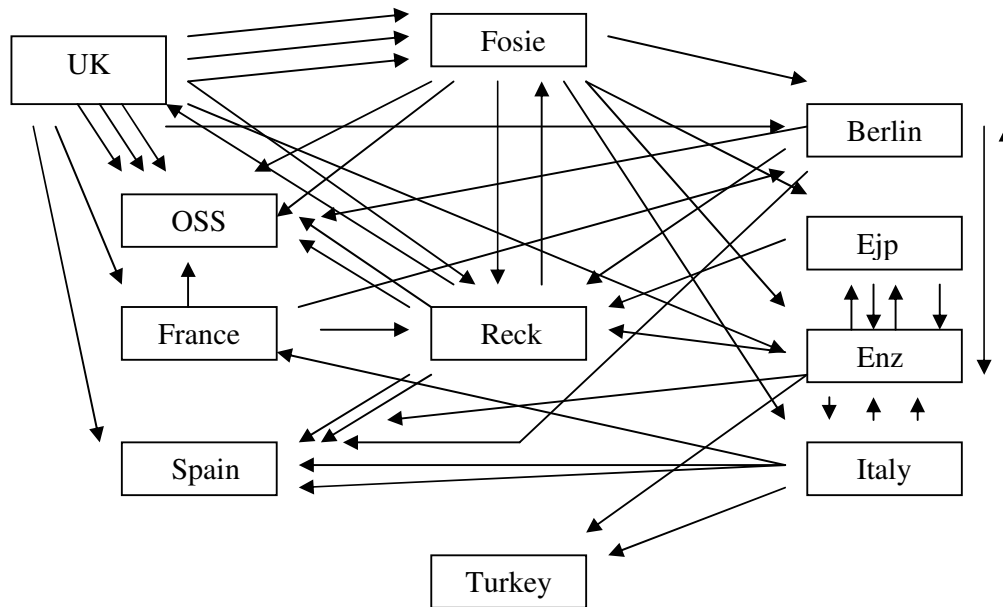


Figure 5.2 Inter company connections

Central planning gather each production plant's and LRD's information regarding expected production, sales etc each month. Collected information is compiled into a line load which is the foundation for the planning in the sector. However, central planning has no possibilities to control the reliability of collected information.¹⁰⁸

5.1.2.2 The line load

The line load contains information about forecasts of production, sales and support for coming months but also historical data from past months. Inter company support is important; especially due to the capacity distribution since all plants do not produce all can sizes. For example, Fosie only produces 330 and 500 ml cans and therefore need support of 250, 440 ml cans.

¹⁰⁷ Interview, Leif Nilsson

¹⁰⁸ Interview, Leif Nilsson

5.1.2.3 Information exchange

The organisation is built upon an idea where each production plant and LRD gives information to central planning regarding the macro environment. Central planning collects and sort information which later is sent out as a line load. From the outlined line load, each plant and LRD translates the information into a micro environment.¹⁰⁹ Possible problems for the LRDs and the production plants are discussed with central planning. The procedure for performing the line load and the interaction between central planning, LRDs and production plant is shown in Figure 5.3.

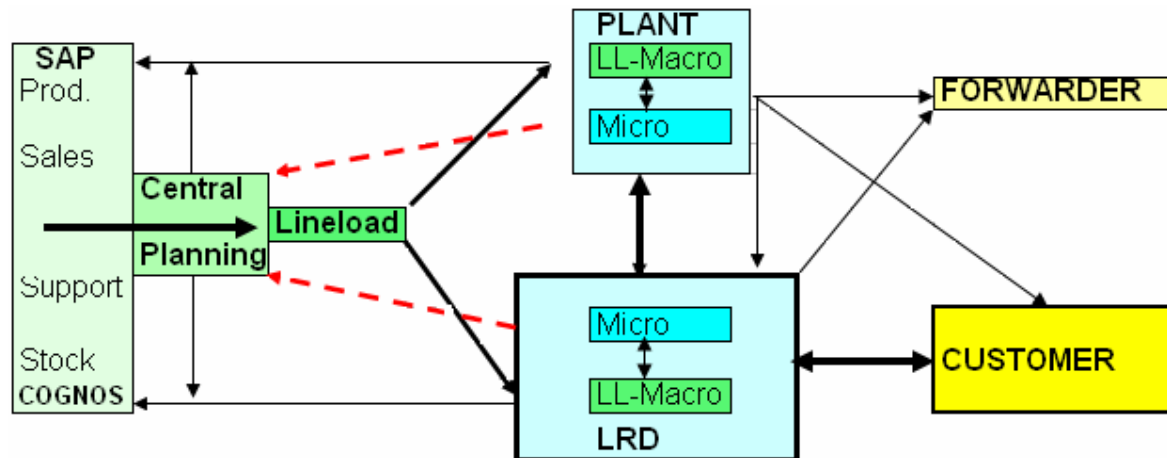


Figure 5.3 Central planning's interaction with LRDs and plants

Each production plant has own responsibility for production planning, regarding time for production and batch sizes. Every production plant needs to assure deliveries in time to customers with consideration to available capacity.

5.1.3 Detailed scheduling

The detailed scheduling is achieved in Fosite, Sweden, where the department for sales administration is an important performer on this managing level.

5.1.3.1 Sales administration

The sales administrators are the customer's first contact and they take care of most of all customer contact on an operational level. In Fosite, each sale administrator has own customers to provide with desired information and assure their need of assist regarding placing orders, delivery information etc.

All customers have their own procedure for order releasing. When a production order is sent to Rexam, the sales administrator registers it in the SAP system. Therefore, it is a released order. In most cases, the call off is compared to available balance and when shortages occur, the design is placed into the production plan. However, during the off peak season, Rexam mostly produces to stock to meet future demand.

¹⁰⁹ Interview, Leif Nilsson

5.1.4 Production activity control

At the production plant in Fosie, the production planner is responsible for the production activity control. This responsibility includes priority control according to call offs, shortages, capacity conditions and available production orders.

5.2 Forecasting

A forecast is an expectation of the future and does often not give exact values. However, it can be a useful guideline for all companies. Rexam does forecast both for expected sales and production, due to the need of settle an appropriate capacity distribution.

5.2.1 Forecasting sales

Sales in the can industry are depending on seasonal demand. Naturally, sales of beverages are higher when the weather is good. However, length of the summer period can be another factor that affects sales, for example, a long summer period results in higher sales and vice versa.

Figure 5.4, Figure 5.5 and Figure 5.6 show external sales, i.e. sales to the Nordic customers, except inter company sales. As the figures show, the demand varies with seasonality. Statistics of sales show trends of increased sales during the recent years and the peak season tends to reach longer into the autumn. According to the statistics, the statistical highest sales use to be in June.

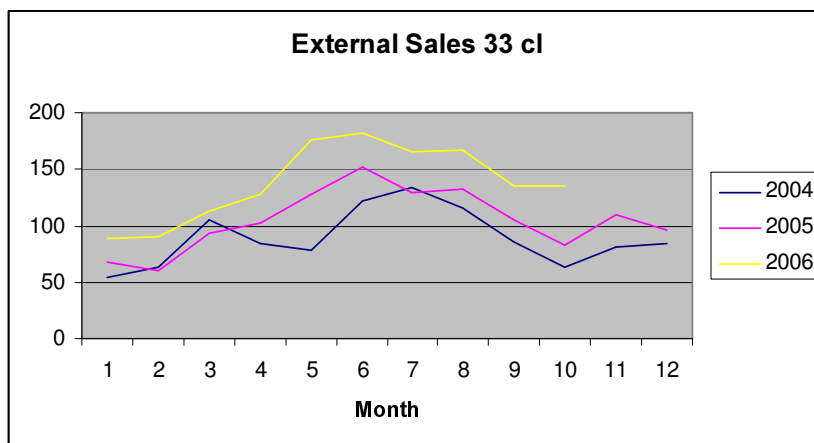


Figure 5.4 Sales year 2004 to 2006 of 33 centilitre

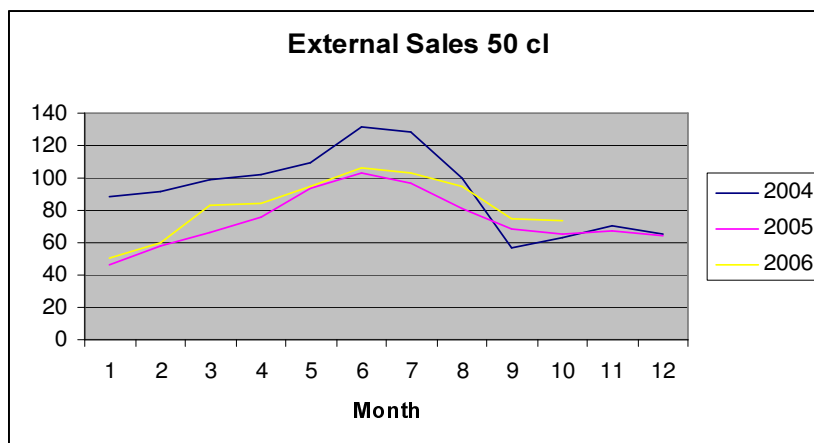


Figure 5.5 Sales year 2004 to 2006 of 50 centilitre

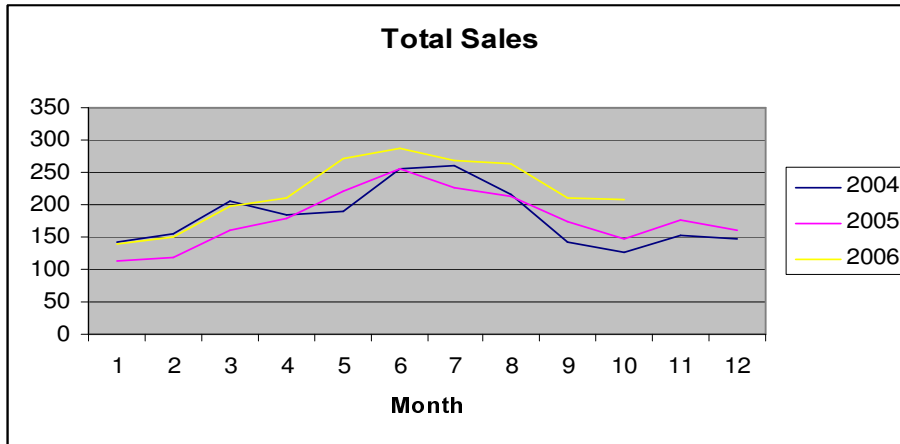


Figure 5.6 Total sales year 2004 to 2006

The boarder shop in Germany and the new legislation in Sweden concerning deposit of cans have together with other factors brought and large increased sales 2006. The new legislation supposes to correspond to additional 100 millions cans sold sales during this year.¹¹⁰ Further, the boarder shop has for long time been uncertain. However, sales on the boarder shops correspond to approximately 800-900 million cans of the total expected sales of 2,6 billions cans.¹¹¹ Nevertheless, the boarder shops have increased sales significant and are expected to even increase the forthcoming years.

5.2.2 Description of Rexam's forecasting system

For the monthly outlined line load, the sales & customer service manager projects expected sales with the Antvision's forecasting function. An expected sale is reported to central planning, where the sales forecast together with other gathered information result in the line load. The line load is also updated with actual values of opening stock, production, support of cans, customer sales, inter company sales, and closing stock for the last month.

5.2.2.1 Antvision's forecasting method¹¹²

Sales statistics are acquired from the SAP system monthly. The last year's sale is the base for the forecasts. In order to bring seasonal adjustments into consideration, the expected sale during the peak season, January to August, are estimated by a percentage rate. This rate is the expected value of how much out of total sales that are expected to occur in January to August. The percentage rate differs for different customers, depending on the customer's sales curve but also market they are operating at.¹¹³ However, the forecast is as well experience based and is often adjusted manual.¹¹⁴ If the deviation between two months is large, the system adjusts the expected sale for the upcoming months. The calculated forecast is also compared to the customer's forecasts. However, a customer often overestimates their forecasts in the beginning of the year to ensure availability of cans during the rest of the year.¹¹⁵ Antvision's

¹¹⁰ Interview, Leif Nilsson

¹¹¹ Interview, Christian Nilsson

¹¹² Interview, Gunilla Linde

¹¹³ Interview, Christian Nilsson

¹¹⁴ Interview, Anders Borgström

¹¹⁵ Interview, Christian Nilsson

forecasting model consider seasonality, however, adjustments for trends is missing.¹¹⁶ A further explanation of the Antvision system is presented in chapter 5.2.2.1.

5.2.2.2 Forecast errors

Forecast errors are evaluated month by month and possible deviations are analysed for each LRD. The deviations are normally small for the LRD in Sweden.¹¹⁷ However, estimations for longer time periods often have reasonably larger deviations, but it is nothing Rexam is measuring. For example, Rexam does not evaluate the forecast from January to June. However, it is especially difficult to forecast sales on an increasing market. Extracts from the budgets and the forecasts (line loads) from 2006 are shown in Table 5.1. The table show several line loads, e.g. 2+10, is the forecast for March to December, made in the beginning of March. Further, the line load for 5+7 is the forecasted values for June to December, when the actual value for January to May is known. The table show the overestimated share in comparison to actual value. However, actual sales for October, November and December is not considered.

Budget	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Opening Stock	167,2	124,4	116,3	118,1	133,7	168,4	139,9	153,7	140,7	105,7	83,0	59,0
Production	98,7	112,9	114,1	113,4	105,7	106,5	111,0	106,1	105,3	97,7	88,3	85,2
Support Cans	12,5	5,0	24,1	103,3	97,8	45,0	83,4	37,8	38,7	15,2	16,4	25,9
Customer Sales	89,1	86,9	84,1	89,8	76,4	81,5	88,8	80,3	82,4	76,8	85,5	79,9
Inter-Company Sales	152,1	175,1	167,6	296,2	420,4	789,3	723,5	745,4	351,5	175,5	177,1	136,2
Closing Stock	124,4	116,3	118,1	133,7	168,4	139,9	153,7	140,7	105,7	83,0	59,0	52,6
2+10	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Opening Stock	100,0	100,0	99,8	106,3	96,5	125,7	96,5	126,9	162,1	116,4	107,1	85,1
Production	100,0	100,0	104,8	105,7	104,5	105,1	114,5	106,2	107,0	103,5	95,9	95,7
Support Cans	100,0	100,0	64,8	91,7	80,1	35,3	72,0	43,7	14,3	16,6	13,5	18,4
Customer Sales	100,0	100,0	87,3	116,9	86,3	91,6	89,0	76,9	82,3	77,0	92,5	94,3
Inter-Company Sales	100,0	100,0	103,6	94,8	37,9	222,0	175,4	188,4	198,6	81,0	78,2	109,5
Closing Stock	100,0	100,0	106,3	96,5	125,7	96,5	126,9	162,1	116,4	107,1	85,1	73,2
5+7	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Opening Stock	100,0	100,0	100,0	100,0	100,0	100,0	100,3	140,3	154,3	108,3	102,7	78,3
Production	100,0	100,0	100,0	100,0	100,0	97,6	107,1	98,4	93,8	92,7	89,7	85,7
Support Cans	100,0	100,0	100,0	100,0	100,0	111,7	147,6	61,0	42,8	37,6	46,6	72,6
Customer Sales	100,0	100,0	100,0	100,0	100,0	101,6	99,3	85,0	87,3	76,9	105,3	94,9
Inter-Company Sales	100,0	100,0	100,0	100,0	100,0	164,0	149,1	168,4	98,0	45,7	44,1	52,4
Closing Stock	100,0	100,0	100,0	100,0	100,0	100,3	140,3	154,3	108,3	102,7	78,3	71,0

Table 5.1 Extract of the budget and the sales forecasts

¹¹⁶ Interview, Christian Nilsson

¹¹⁷ Interview, Christian Nilsson

5.2.3 Forecasting of production

The line load contains a forecast of expected production level each month. The forecast is performed according to following parameters; rated speed, efficiency, hourly running speed, daily output, potential monthly output, monthly output, line OEE and idle time. Figure 5.7 shows total production for year 2004 to 2006.

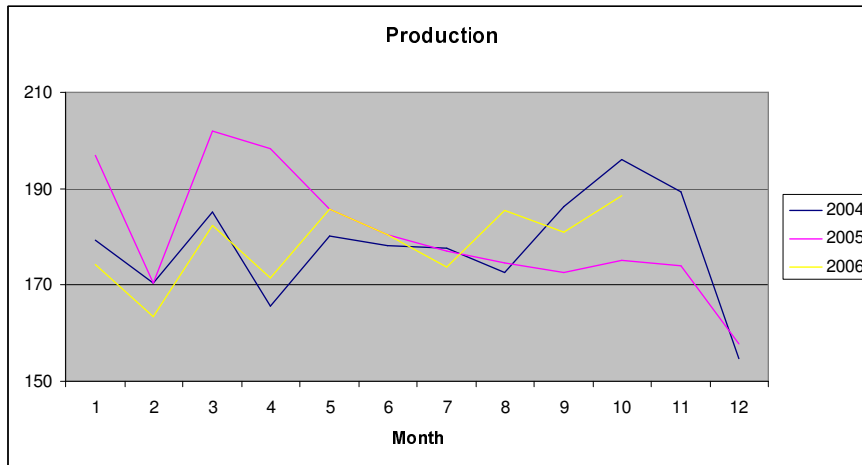


Figure 5.7 Total production year 2004 to 2006

The production is forecasted with consideration to maintenance, production mix and historical data but also with concern to season. The production manager together with the general manager set a reachable production level. However, this production level is often be adjusted to a higher level than firstly set.¹¹⁸ In many cases, the production does not meet these expectations. The production forecast is sent to central planning.

5.2.3.1 Expectations of production

In the beginning of the year, the production manager strives for a higher production level than the last year. The wished production level is often obtained before the peak season. However, the production level often decreases again through the peak season. To meet production decline, the production department must come beyond the expectations of production in the end of the year.¹¹⁹ Figure 5.8 shows expectations of production.

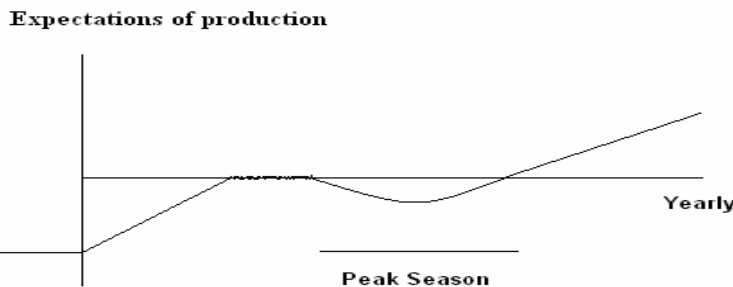


Figure 5.8 Expectations of production

¹¹⁸ Interview, Henrik Lidman

¹¹⁹ Interview, Henrik Lidman

5.2.3.2 Forecasting factors

The production forecast is difficult to foresee. The production equipment has different maximal speed for various types of cans. Production of debossed cans takes more time than standard cans. Unreliable forecasts of expected sales for special designed cans as debossed can results in changes for the total production output.¹²⁰

Size	Standard (%)	Debossing
Line 1 (50 cl)	100	-
Line 2 (50 cl)	100	74
Line 3 (33 cl)	100	71
Line 4 (33 cl)	100	-

Table 5.2 Normal production rate

The forecast of production starts by estimations from optimal production rates in Table 5.2, where debossed cans only have 74 % and 71% of the maximal production speed. A normal label change takes roughly 20 minutes. Nevertheless, line one have a double printer which decreases a label change to roughly five minutes.

Every upstart of the production lead to around 1050 discard cans and additionally 1100 cans are rejected when changing pallets. When performing a forecast it is especially difficult to foresee numbers of label changes and therefore also the production speed, as well as other production related factors. Number of label changes is difficult to predict, but can favourable be estimated based on season.

The varnish of the cans is additional one important factor to consider when creating a production forecast. Cans with white base coat is favourable produced together. The production of these cans is more complicated and requires more attention than production of standard cans.¹²¹ Further, cans with matt varnish are slightly more complex to produce than cans with standard varnish. Expected sales and production of matt varnish and white base coat is important to estimate when performing a production forecast. The production quantity of matt varnish cans is foremost calculated from historical data. The cost for matt varnish leads to a higher total cost for varnish and increased waste, although it does not significant decrease the production rate. Production of cans with white base coat, often results in lower production speed and approximately an increases waste with 0,5%. Moreover, a label change to white base coat takes additional 20 minutes to perform than a standard label change.¹²²

Rexam offers two types of neck sizes 202 and 206 millimetres; however most of their customers use neck size 202. Changing between neck size 202 and 206, only regards line 2 and 3. Nevertheless, these changes are not critical since the rebuilding equipment has been installed. Today, a rebuilding from 202 to 206 takes less time than a normal label change.¹²³

A label change for debossed cans takes approximately four hours. Debossed cans need thicker material than standard cans and a label change to debossed cans require a change of aluminium coli. Therefore production of debossed can be critical concerning the time aspect, especially during the peak season.¹²⁴

¹²⁰ Interview, Henrik Lidman

¹²¹ Interview, Thomas Jönsson

¹²² Interview, Henrik Lidman

¹²³ Interview, Henrik Lidman

¹²⁴ Interview, Henrik Lidman

An additional process that entails more awareness than standard cans is the requirement of pasteurisation. Cans with prerequisite of pasteurisation are preferable to produce after one other. Colours and type of pallets are two other conditions that need to be considered when performing priority control and creating production forecasts. If cans with similar colours are produced after one other, time for label change can be decreased with approximately eight minutes. On the other hand, a label change from blue to white varnish results in more cleaning and can cause additional mistakes, than a label changes between similar colours.

Waste in the production can be deduced to be 33% depending on label change, 33% on the human factor and 33% of breakdowns.¹²⁵ Rexam is actively working with Lean and Six Sigma to improve their production performance, where SMED is a tool for more efficiency performed label changes.

Extract of the production forecast is shown in Table 5.3 and Table 5.4. Line one and four is chosen to show, because these lines mostly produce standard cans. The table show the overestimated production rate in comparison to actual value. However, actual sales for October, November and December is not considered.

Budget	Jan	Feb	Mar	Apr	Mag	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rated Speed cpm	100	100	100	100	100	100	100	100	100	100	100	100
Efficiency %	106,2	105,1	106,9	116,9	121,6	116,7	119,7	114,4	104,6	103,8	97,6	97,6
Hourly Running Speed cph	106,2	105,1	106,9	116,9	121,6	116,7	119,7	114,4	104,6	103,8	97,6	97,6
Daily Output	106,2	105,1	106,9	116,9	121,6	116,7	119,7	114,4	104,6	103,8	97,6	97,6
Monthly Output	106,8	106,5	109,9	128,4	108,7	110,9	118,4	107,0	102,8	101,4	82,4	82,2
Line OEE	107,8	105,8	108,4	136,3	120,6	115,7	119,1	113,4	105,5	103,0	80,4	85,7
2+10	Jan	Feb	Mar	Apr	Mag	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rated Speed cpm	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
Efficiency %	100,0	100,0	101,8	112,8	117,4	112,6	118,2	114,4	105,9	106,4	100,0	100,0
Hourly Running Speed cph	100,0	100,0	101,8	112,8	117,4	112,6	118,2	114,4	105,9	106,4	100,0	100,0
Daily Output	100,0	100,0	101,8	112,8	117,4	112,6	118,2	114,4	105,9	106,4	100,0	100,0
Monthly Output	100,0	100,0	104,7	106,2	101,1	110,7	125,2	105,1	105,9	107,5	101,7	94,5
Line OEE	100,0	100,0	103,3	108,0	116,3	110,7	116,7	113,4	105,9	104,7	99,2	98,1
5+7	Jan	Feb	Mar	Apr	Mag	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rated Speed cpm	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
Efficiency %	100,0	100,0	100,0	100,0	100,0	105,8	108,1	104,3	99,4	102,6	100,0	100,0
Hourly Running Speed cph	100,0	100,0	100,0	100,0	100,0	105,8	108,1	104,3	99,4	102,6	100,0	100,0
Daily Output	100,0	100,0	100,0	100,0	100,0	105,8	108,1	104,3	99,4	102,6	100,0	100,0
Monthly Output	100,0	100,0	100,0	100,0	100,0	101,1	108,9	95,9	97,7	101,9	101,7	94,5
Line OEE	100,0	100,0	100,0	100,0	100,0	105,8	108,5	103,4	100,3	101,7	99,2	98,1

Table 5.3 Extract of production forecast 33 cl (line four)

¹²⁵ Interview, Henrik Lidman

Budget	Jan	Feb	Mar	Apr	Mag	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rated Speed cpm	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
Efficiency %	105,0	98,1	101,2	106,9	105,5	108,7	115,4	106,3	112,7	102,6	100,0	100,0
Hourly Running Speed cph	105,0	98,1	101,2	106,9	105,5	108,7	115,4	106,3	112,7	102,6	100,0	100,0
Daily Output	105,0	98,1	101,2	106,9	105,5	108,7	115,4	106,3	112,7	102,6	100,0	100,0
Monthly Output	53,6	105,1	111,0	103,3	102,7	106,9	113,5	104,6	110,8	101,0	65,0	78,4
Line OEE	110,2	105,1	111,0	105,1	105,4	106,9	113,5	104,6	110,8	101,0	78,0	93,5
2+10	Jan	Feb	Mar	Apr	Mag	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rated Speed cpm	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
Efficiency %	100,0	100,0	99,9	102,9	102,9	106,0	115,4	106,3	114,1	102,6	101,3	100,0
Hourly Running Speed cph	100,0	100,0	99,9	102,9	102,9	106,0	115,4	106,3	114,1	102,6	101,3	100,0
Daily Output	100,0	100,0	99,9	102,9	102,9	106,0	115,4	106,3	114,1	102,6	101,3	100,0
Monthly Output	100,0	100,0	109,6	99,5	100,2	104,2	113,5	104,6	112,2	101,0	62,7	96,3
Line OEE	100,0	100,0	109,6	101,2	102,8	104,2	113,5	104,6	112,2	101,0	62,7	93,9
5+7	Jan	Feb	Mar	Apr	Mag	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rated Speed cpm	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
Efficiency %	100,0	100,0	100,0	100,0	100,0	103,3	112,4	100,8	109,7	101,3	100,0	100,0
Hourly Running Speed cph	100,0	100,0	100,0	100,0	100,0	103,3	112,4	100,8	109,7	101,3	100,0	100,0
Daily Output	100,0	100,0	100,0	100,0	100,0	103,3	112,4	100,8	109,7	101,3	100,0	100,0
Monthly Output	100,0	100,0	100,0	100,0	100,0	98,7	112,4	99,2	71,3	67,0	65,0	58,3
Line OEE	100,0	100,0	100,0	100,0	100,0	103,3	112,4	99,2	107,0	93,9	97,5	93,7

Table 5.4 Extract of production forecast 50 cl (line one)

5.3 Material planning

The production plant in Fosie uses the SAP system as their main material planning system. Nevertheless, they are using some support systems, for example, Antvision and Cognus. All articles are classified into seven value classes, A-G, depending on actual sale statistic in order to facilitate the material planning. A further explanation of these systems is presented in this chapter.

5.3.1 Rexam's material planning system

Rexam in Fosie use the number of days an article is kept in stock together with experience based knowledge as their main way for performing material planning. The SAP system gives no information regarding the number of days an article is kept in stock. However, the support system Antvision contributes with information concerning stock relevance, sales history and production orders to facilitate the material planning. Antvision is used to ease decisions regarding number of days an article is kept in stock, forecasting, but also customer information as stock reports. The optimal number of days an article is kept in stock is not set in Fosie. However, the number days an article is kept in stock gives a lucid view of the situation when performing material planning. Conversely, Rexam's material planning system works different in the peak and the off peak season.

5.3.1.1 The off peak season

Production to stock is the main task during the off peak season and consideration to the stock building strategy needs is needed when performing the material planning. (the stock building strategy is presented in 5.5.1). During the off peak season, the number of days an article is kept in stock together with experience based knowledge are used for obtain an effective production planning. Normally, no decision regarding priority needs to be done during this period. However, the off peak season is experienced by the staff as a more manageable period than the peak period.

5.3.1.2 The peak season

Production planning during the peak seasons is characterised by requirement based production. However, in the beginning of the peak season, the production batch covers one call off and some additional call offs. Nevertheless, in the end of the peak period, the production batch shall only cover the call off. Therefore, a minimised tied up capital cost. The stock building strategy is further described in chapter 5.5.1.

When a call off is received, production is planned if needed. However, in some cases, the entire called off quantity cannot be produced in one batch. During the most intensive periods, an order of 500 000 cans, with deliveries the two following days has to be divided into two production batches of 250 000 cans each in order to not occupy the production capacity with a too long batch. However, normally 500 000 cans is not a large production batch. Today, a batch of 100 000 cans is the minimum size of production batch. Nevertheless, the minimum batch size has decreased during the last couple of years. Therefore, priority control is important for Rexam, especially due to the tight production capacity during peak season.

5.3.1.2.1 Priorities

As mentioned earlier, low production capacity results in problems for the production planning. Priorities between articles that need to be produced are commonly during the peak season. The number of days an article is kept in stock indicates the priority between different articles. However, there are several other important factors in each priority case. Priorities of articles can also be done based on special designs and their features, such as debossing and white base coat. As mentioned earlier, special designs decrease the production efficiency and are produced separately. Priorities are described more in the chapter 5.5.3.

5.3.2 System and system support

To enforce and get an understandable view of the large organisation a working and foreseeable business system as well as a system support are required. Therefore, Rexam Beverage Can Europe & Asia uses SAP for all their production plants.

5.3.2.1 Classification of articles

Rexam in Fosie has divided their articles into seven classes which corresponds to actual sales statistics: A: > 10 M, B: 5-10 M, C: 2-5 M, D: 0, 5-2, E: 0, 25 – 0, 5, F: 0-0, 25 and G: <= 0.¹²⁶ This classification system facilitates decisions regarding stock building, production batches etc. However, this information is only available in their support system Antvision. The design of the classification system is shown in Table 5.5.

Vol. Value Class	No of Articles	Acc %
A:>10 M	54	2
B:5-10	79	5
C: 2-5	225	13
D:0.5-2	548	33
E:0.25-0.5	377	47
F:0-0.25	755	74
G:<=0	721	100
Total:	2 759	100

Table 5.5 Classification of articles

5.3.2.2 The SAP system

The SAP system is a leading business system which facilitates a common system for all Rexam's production plants and LRDs. The SAP system is based on the material requirement planning method (MRP) and the system intends to be a correct method for articles with derived needs in an environment with standard products. The system is used in order to have a uniform usage area and an easy clear overview of all production plants.

¹²⁶ Interview, Thomas Jönsson

5.3.2.3 The Antvision system

The Antvision system is used as a support system to SAP. For example, it contains information about numbers of deliveries, produced cans, purchased cans, available stock, remaining production and days an article is kept in stock. This system shows much of missing or indistinct information from the SAP system and is a frequently used system in Fosie.¹²⁷

The Antvision system acquire information from SAP daily and updates numbers of sales, stock, production orders etc. The daily update results in correct information, for example, daily decision as setting production batches and safety stock. The system is also useful for the customer contact. Every Monday, all customers receive current information regarding stock level, production orders etc. This information facilitates placing of production orders and other important decisions for customers.

¹²⁷ Interview, Thomas Jönsson

5.4 Order quantities

The production planner is responsible for deciding the order quantity when performing priority control. The order quantity is in a normal case based on experience, forecasts and information from the Antvision system.¹²⁸ However, the size of an order quantity is also set with consideration to actual season. Figure 5.9 shows production order sizes over the years 2003 to 2006.

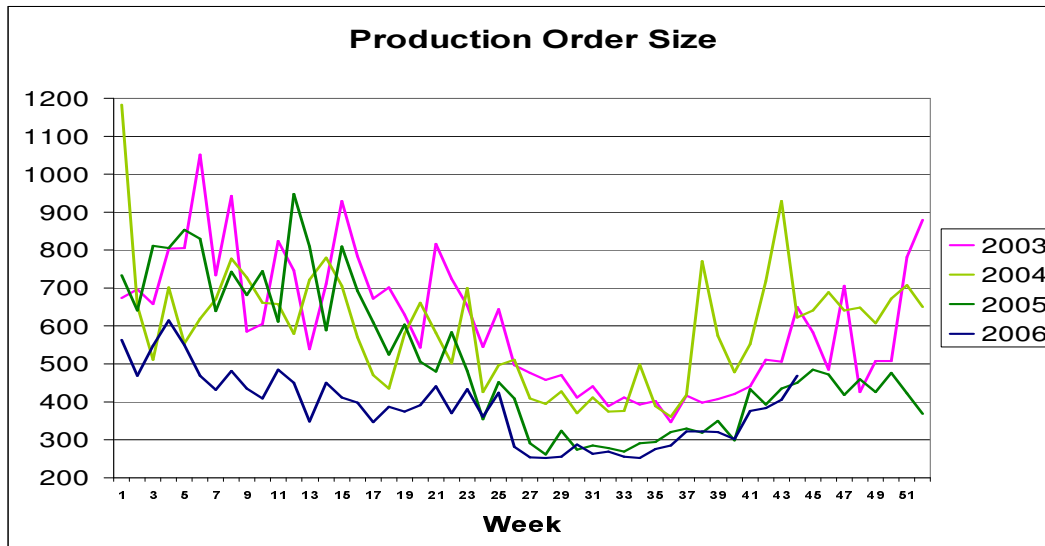


Figure 5.9 Production order size

During the off peak season the average sales, experience and forecasts are dominating the decision regarding order quantities. However, during the peak season, the planning conditions are different. There are often no possibilities for consideration to forecasts. The order quantity does in generally cases correspond to the exact requirement which lead to many label changes. Several label changes results in much down time which affect the production efficiency.¹²⁹ Statistics for the average order quantity during they year 2004 to 2006 and how the order quantity vary for different season can be found in Table 5.6 and Table 5.7.

Year	Average rder Quantity
2004	623 191
2005	462 531
2006	365 631

Table 5.6 Average ordering quantity independent of season

Season	Average Produced uantity
Off Peak 2005/2005	687 602
Peak 2005	409 238
Off Peak 2005/2006	444 292
Peak 2006	326 488
Off Peak 2006	343 147

Table 5.7 Average production batch depend on season

¹²⁸ Interview, Thomas Jönsson

¹²⁹ Interview, Thomas Jönsson

The average call off quantity differs for various classified articles. However, the called off quantity has changed during the last years but no so significant as the produced order quantity. Table 5.8 shows statistics for the average call off quantity.

Year	Average Call Off Quantity
2004	196 299
2005	198 700
2006	178 618

Table 5.8 Average call off quantity

Another factor to consider, the A-D classified articles are called off more often than the E-G classified articles. Even if the average called off value is low, the articles are called of with different frequencies. Table 5.9 shows examples of how the called off quantity and demand varies within different classification classes.

Vol. Value Class	No of Articles	No of Deliveries past 12 months	Delivered (pcs) past 12 months	Called of per year	Average Call off	Mean demand per article
A:>10 M	54	8 067	860 783 893	149	106 704	15 940 442
B:5-10	79	5 963	539 899 457	75	90 542	6 834 170
C: 2-5	225	8 657	696 313 384	38	80 434	3 094 726
D:0.5-2	548	8 315	563 347 600	15	67 751	1 028 007
E:0.25-0.5	377	2 436	131 750 704	6	54 085	349 471
F:0-0.25	755	2 008	81 323 874	3	40 500	107 714
G:<=0	721	11	0	0	0	0
Total:						

Table 5.9 Called of quantities and demand

5.4.1 Stock keeping costs

When an article is kept in stock, the capital cost corresponds to approximately 8 % of the cans value.¹³⁰ With a product value of roughly 0,5 SEK per can, the yearly capital cost corresponds to 0,04 SEK per can and a monthly cost of 0,0033 SEK.

Rexam has several warehouses. However, one example of a warehouse is used as a standard example for the thesis (the costs are fictitious). The total cost for the warehouse is roughly 100 000 SEK a month which is independence of number of pallets in stock. Nevertheless, there is an additional cost of 1200 SEK a month for book keeping. The warehouse can keep maximal 5000 pallets and is covered with approximately 60% over the year. However, it is assumed that 50% of the cans kept in stock are 50 centilitre cans and 50 % of the pallets with 33 centilitre which leads to in average 7234 cans per pallet. Therefore, the monthly fix stock keeping cost correspond to a monthly cost of 0,0046 SEK per month and can.

Further, there are separate handling costs; 25 SEK per pallet in storage for each month. Therefore, the monthly stock keeping cost is 0,0035 SEK per month and can.

¹³⁰ Interview, Stefan Malmros

Moreover, there is a handling cost of 40 SEK, for transportation in and out from the warehouse. Therefore an additional stock handling cost of 0,0057 SEK.

Summation of the different stock keeping costs gives the total cost of 0,017 SEK per month and can, or 0,20 SEK per year and can.

5.4.2 Ordering costs

The ordering cost corresponds to an order's cost from it is received to it is sent to the customer. The department for sales administration and design correspond to a cost of roughly 240 000 SEK a month. These department works with approximately 35 500 orders a year. Therefore a handling cost of 80 SEK per order.

A label change in the production is valued to cost approximately 3300 SEK. It is therefore it is added to the ordering cost. Hence, the total order handling cost is 3380 SEK.

5.4.3 Label changes

As mentioned in chapter 5.2.3.2, a label change takes approximately 20 minutes and results in a production decline. Figure 5.10 shows number of label changes from year 2003 to 2006. Many label changes leads to a great deal of unused production time, hence lower production efficiency. With fewer label changes, more production time could be utilised. Regarding the time aspect, a reduction of number of label changes would increases the utilisation. However, larger batches occupy more capacity from other articles which need to be produced.

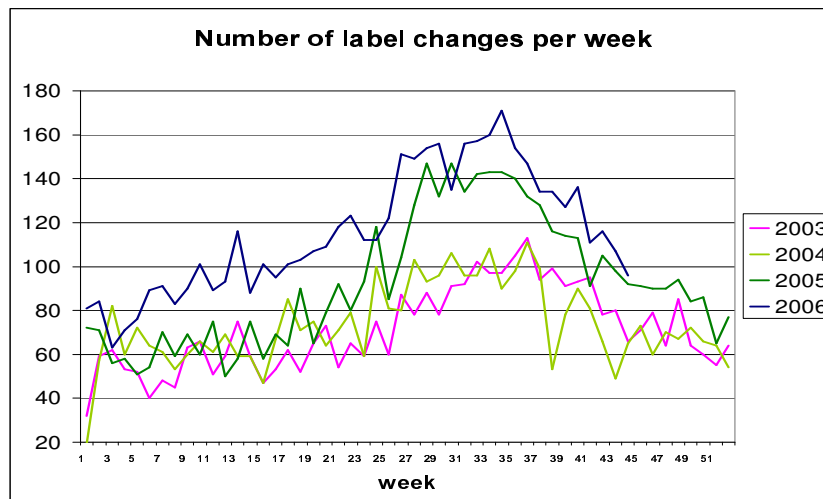


Figure 5.10 Number of label changes

Figure 5.11 shows how the production efficiency varies within different seasons and its indirect connection to the number of label changes. As the statistics shows, the production efficiency is often lower during the peak seasons when there are several label changes. However, the production efficiency does not only depend on number of label changes. Figure 5.11 also shows high production effectiveness during the peak season. For example, one week in August, the efficiency was the highest ever at the mean time as they achieved a new record of number of label changes.

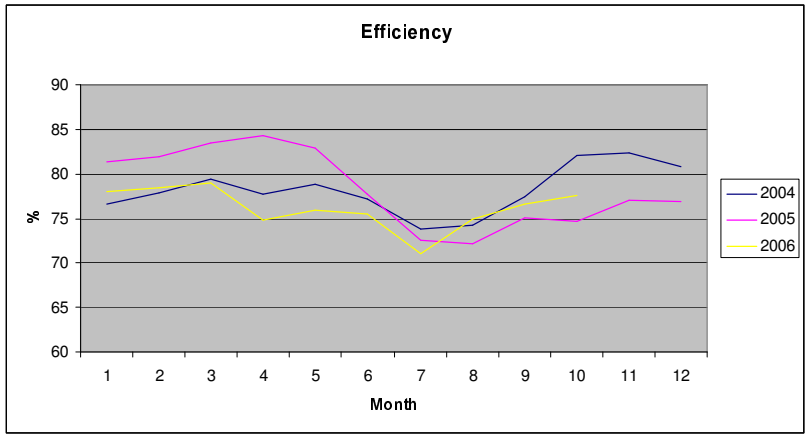


Figure 5.11 Production efficiency

5.4.4 Production staff's bonus system¹³¹

The bonus system for the production staff at Rexam in Fosie is based on the number of waste cans. However, this bonus system is inequitable in comparison to the other plants staff where they produce longer production batches, with less waste cans. This system gives no incitement for a greater effort from the staff when performing label changes.

¹³¹ Interview, Henrik Lidman

5.5 Safety stock

The seasonal demand in the can industry leads to production in order to build stock during the off peak season.¹³² Statistical, the highest stock level occurs in the third week of March and usually the lowest inventory level occurs in the third week in August. Figure 5.12 shows how the stock level varies over a year.

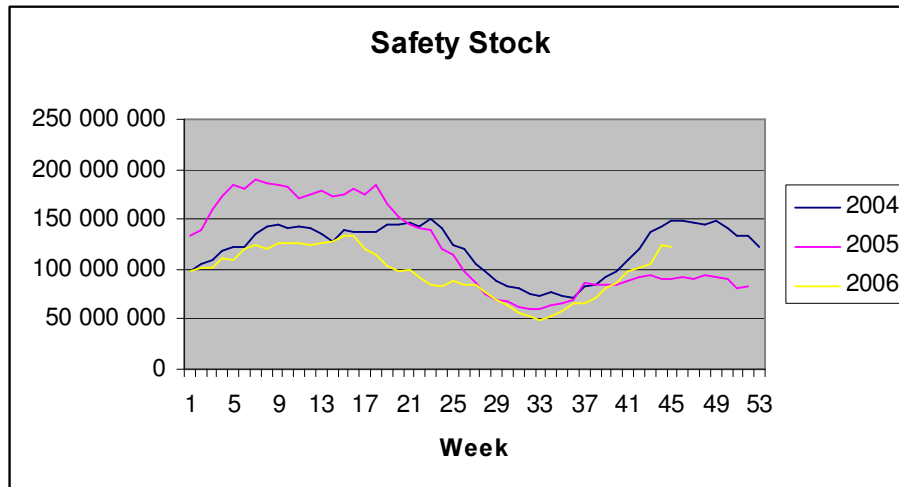


Figure 5.12 Safety stock year 2004 to 2006

5.5.1 Stock building strategy

Rexam applies a specific stock building strategy, where A and B classified (high frequently) articles foremost are used for stock building. This strategy results in production of small batches with low frequent articles during the peak season.¹³³ To follow this strategy, the production must be flexible and several label changes are required during the peak season. Stock of low frequently articles take capacity from high frequently articles. However, the small brands are not called off as often as highly frequented.

Changes in an articles design is an important factor to consider when producing to stock. Most customers change the design of their cans regular which leads to difficulties when producing to stock.¹³⁴ A produced order of one design can in the end be lost stock if the design is changed. However, the customer is responsibility to purchase the produced stock, although, the LRD miss an important share to the stock building process. Instead the customer requests more cans of the new label. This results in a lower stock level of applicable and useful designs for all customers.¹³⁵

In many situations, customers do not want to release large production orders during the autumn. This causes problem for Rexam's stock building process. Customers often have limits for possible highest stock level and do not often release production orders when the

¹³² Interview, Thomas Jönsson

¹³³ Interview, Christian Nilsson

¹³⁴ Interview, Leif Nilsson

¹³⁵ Interview, Leif Nilsson

stock has reach 8-10 weeks of sales.¹³⁶ However, this stock level differs from one customer to next, some can place production orders for few more weeks of sales and some customers for fewer weeks. Usually the amount of released production orders bound the possible high stock level for Rexam.

When producing to stock, many factors need to be considered. The order of producing available production orders is important. A uniform stock composition is important, where all articles has the same level of stock, e.g. not having a huge amount of one article and nothing of another.¹³⁷

The lead time to customers varies depending on the distance, the contract and available production capacity.

The weeks in the end of the year are often critical concerning the stock building. Rexam produces maximal; however, the customer demand is often especially low. Availability of packaging material and production orders are important to ensure before the period of Christmas and the turn of the year. Lack of either packaging material or production orders would interrupt the important stock building process.¹³⁸

5.5.2 Measuring of service

Rexam Beverage Can Europe & Asia is measuring their service level with “On Time In Full” (OTIF). Rexam in Fosie has an OTIF value close to 99%.¹³⁹ However, the OTIF measurement takes no consideration to if the order can be delivered on time with demanded content. In other words, what is delivered might not be what was ordered.

5.5.3 Shortage costs

Generally, Rexam does not measure shortage costs. However, when the sales administrator cannot negotiate as solution with the customer, a shortage has occurred. Nevertheless, negotiations are a part of the sales administrator’s job and it cannot be regarded as a shortage until the inconvenience reaches a higher level in either the customer’s or in the internal organisation.¹⁴⁰

Measurable shortage costs could be when a design is moved for production on a sister plant. Costs regarding sending design information, films for manufacturing and plates can be measured in these situations. Additional costs as transportations, also needs to be considered when moving an article for production.¹⁴¹

Changeover for one line is another type of measurable shortage costs. The plant can does an easy label change, neck size change, or change from 330 to 500 ml which can be measured in terms of money.

¹³⁶ Interview, Leif Nilsson

¹³⁷ Interview, Thomas Jönsson

¹³⁸ Interview, Leif Nilsson

¹³⁹ Interview, Christian Nilsson

¹⁴⁰ Interview, Leif Nilsson

¹⁴¹ Interview, Thomas Jönsson

Decision concerning measurements when a shortage occurs requires quick response and because of the time aspect, it is impossible to calculate a shortage cost for a single case. However, a calculation for a specific case either not give the right perspective of other consequences.¹⁴²

It is possible to calculate shortages cost. However, if the shortage cost is calculated for one design with low margins the shortage cost is small. Nevertheless, this calculation takes no consideration to the “bad will” that occurs, margins on the customer’s other cans.¹⁴³

The size of a customer is another dimension when regarding shortage cost. A large customer has better possibilities to handle an absent of delivery where a small customer’s business can be depending on just one delivery. A non measurable shortage cost can be absent deliveries. It is extremely difficult to measure the affects and loss of income, if the customer does not sets a price on the claim.¹⁴⁴

¹⁴² Interview, Leif Nilsson

¹⁴³ Interview, Leif Nilsson

¹⁴⁴ Interview, Leif Nilsson

5.6 Capacity planning

Central planning is responsible for the capacity distribution for all production plants around Europe and Asia. However, some of the production plants have more available capacity than others.

5.6.1 Existing capacity strategy

First of all, each production plants provide their customer with required demand. However, all production plants do not produce all variations of 25, 33, 44 and 50 centilitres cans. Therefore, different production plants have to support various LRDs with demanded cans.

The support of cans is an important issue for Rexam, where possible free capacity in one production plant is utilised for LRD's with shortage of capacity. However, controlling different plant's requirement of support is in many situations difficult, especially due to required administration.

Lack of capacity during the peak season requires stock building during the off peak season¹⁴⁵. All production plants produce cans with consideration to season. The stock building process is important to consider for all production plants. Nevertheless, all production plants are maximal utilised as long as there are available production orders. However, lack of own production orders in e.g. Berlin's production plant results in additional support for its sister plants. When lack of production orders arise, some lines in a production plants risks be closed.¹⁴⁶

5.6.2 Capacity planning on an operational level¹⁴⁷

The capacity planning on an operational level is more limited than on a central level, due to the time aspect. However, capacity is often limited during the peak season, where risk for shortages occurs and priorities of orders have to be done.

Features as white base coat, debossing etc. for various cans are other important when distribute the capacity utilisation. Usage of coats and special effects as debossing requires more production time and are favourable produces together as mentioned before. In a tight production situation, these special designs often have to be delayed and sometimes result in absent deliveries to the customers.

5.6.3 Inter company support¹⁴⁸

The difference of capacity allocation for different plants leads to inter company support. To uniform the capacity distribution, the inter company support is an important issue for Rexam Beverage Can Europe & Asia. During the peak season of year 2005 and 2006 the available capacity in Fosie was tight and the LRD had a great need of support. With a great need of support and complex inter company situation, some orders were delayed to the customers.

¹⁴⁵ Interview, Tomas Jönsson

¹⁴⁶ Interview, Leif Nilsson

¹⁴⁷ Interview, Tomas Jönsson

¹⁴⁸ Interview, Leif Nilsson

However, with a great need of support the situation becomes more complicated and complex. Figure 5.13 show the complexity for coordinating the inter company support.

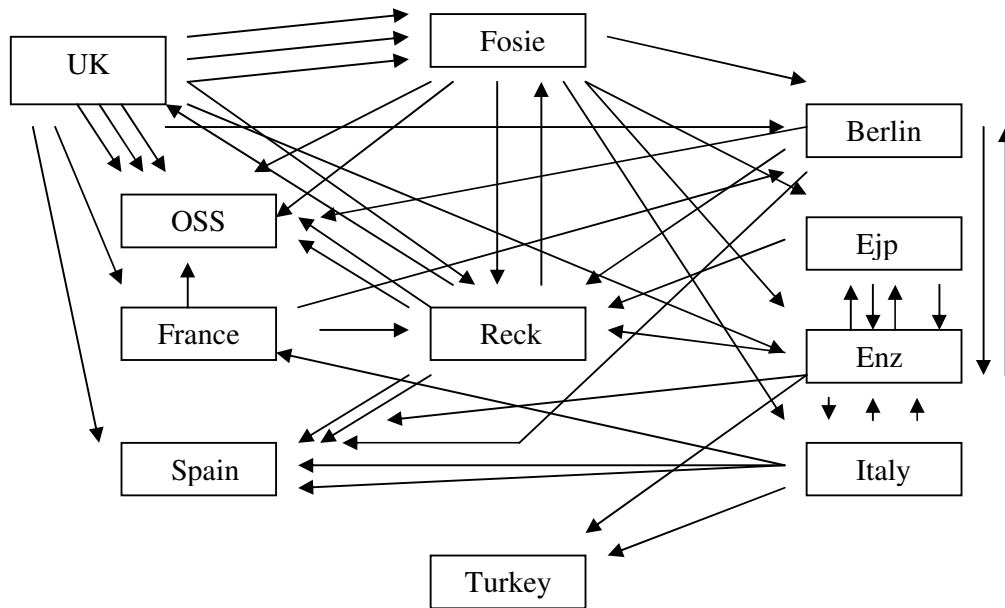


Figure 5.13 Complexity for inter company support

The monthly outlined line load delineates which amount of support each production plant can claim. However, each production plant is responsible to make sure deliveries of these quantities. On the other hand, the line load is updated regularly during an actual month which can results in uncertainties regarding claimable amount of support.

Transportations have been a bottle neck during the peak season 2006, where the transportations expected arrival time could not be confirmed. To ensure deliveries to customers, the production plant in Fosie sometimes had to produce the expected support cans by themselves. However, that resulted in less capacity for other customers demanded articles.¹⁴⁹

The inter company support mostly includes the high volume sales articles (A and B classified articles) which are produced in large batches. A high demand of these articles results in a more or less continuous demand. To ensure meeting the customer's demand, the supporting plant must work according to the "make and ship" policy.

A customer's location is another important factor to consider when distributing the support among a LRD's customers. However, in some situations, to ensure deliveries to customers, long transportations and a high transportation cost is needed. The transportation cost has increased the last years and is predicted to additional increase the forthcoming year which make in less profitable with inter company support.

¹⁴⁹ Interview, Leif Nilsson

6 Analysis

In this chapter, empiric is compared to theories and models to understand the current situation. The chapter also contains conclusions to fulfil the thesis purpose.

6.1 Planning and managing the organisation

A large company as Rexam needs strong managing and require extensive planning. Planning on different levels in the company entail a framework for how each division and department shall work. When PLM became a part of Rexam, it became fare more difficult to manage this large organisation.

6.1.1 Sales and operations planning

The executive committee, who are performing the sales and operation planning, has the overall responsibly for the organisation. However, they are not principal involved in all tactical and operational problems.

6.1.2 Master planning

The regional sales manager and the general manager are responsible to perform the master planning for its LRD and production plant. Nevertheless, central planning is responsible for coordinating the organisation. However, it is important for central planning to understand different LRD's and production plant's various features and conditions for a superior coordination.

6.1.2.1 The line load

The line load is a useful tool for managing this large organisation, but it has some deficiencies. The line load is performed in the beginning of each month and released to the LRDs and the production plants in the mid of the month. However, the LRDs and the production plants are short of information from the line load within the first two weeks of each month. The current model for performing and releasing the line load is shown in Figure 6.1.

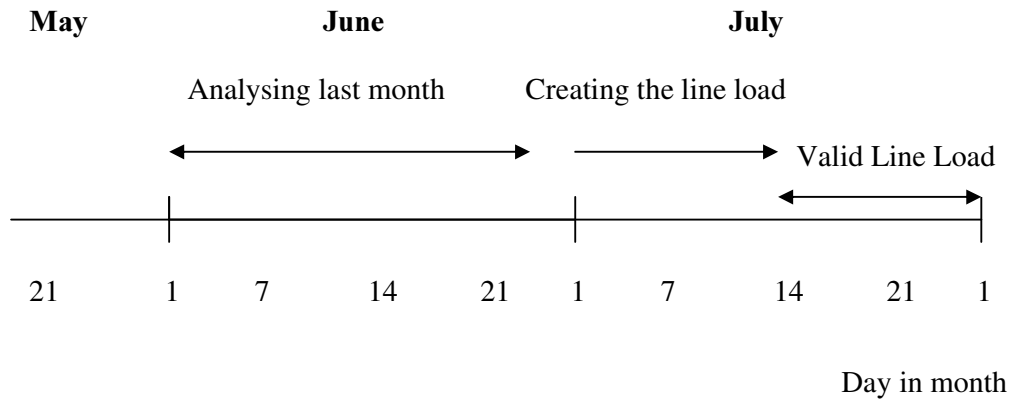


Figure 6.1 Current model for releasing the line load

A change in sales or production is not discovered until four to six weeks after its occasion. Therefore, it can be difficult or too late to measure the deviations.

The line load is sometimes updated during the month which brings inconvenience regarding what is relevant information or not. To have a more working line load, the interaction between central planning, LRDs and plants need to be deeper and characterises by trust.

A more suitable model for releasing the line load should be where it is released in the beginning of the month e.g. each first workday every month. To create the line load information from past month is used; however, time for creating the line load is replaced by the previous week's last sales. The line load will still be based on one month's sales but instead be build upon sales statistics e.g. from the 21st to the 21st last month. The line load has the same base, but can catch changes earlier and measuring can be taken in action. An appropriate model is shown in Figure 6.2. This model makes it possible to follow up problems and changes earlier in the process but also give necessary information to the LRDs and the production plants in an early stage.

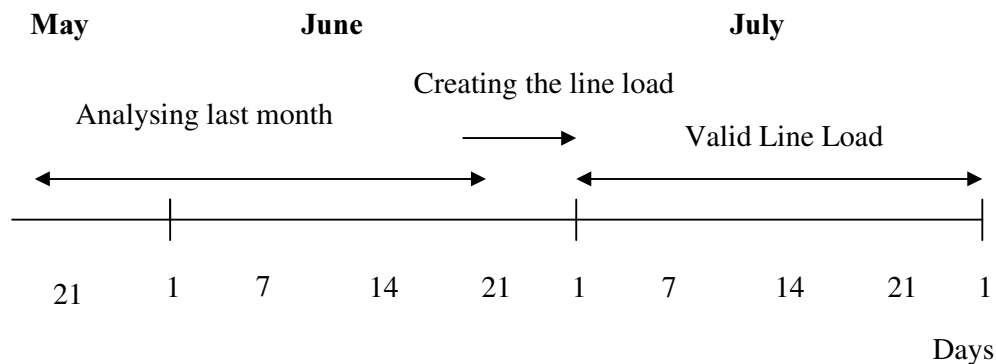


Figure 6.2 Suggestion of an appropriate model for releasing the line load

The extent of the line load is another significant deficient. The first budget shows the expected sales etc. for the whole year. However, for each past month, there is no overlapping to the next coming year. For example, in October and November, the forecast only covers expected sales and the production during November and December and does not overlap with expected sales in January and February.

6.1.3 Detailed scheduling

The line load needs to be followed by different production plants and LRDs for an appropriate overall managing. However, a late released line load results in less conformity with decision on the tactical level and necessary measurements risks to be delayed. The detailed scheduling is suffering because of deficient and indistinct managing on the master planning level.

The outlined line load must contain reliable and updated information. For example, for a working support function, each LRD needs reliable information regarding possible size of claimable support from different plants.

The main idea, where all LRDs buy cans from their production plants, makes them far from the end consumers. They often miss understanding for the market's demand, trends etc. When buying cans from sister plants, the LRD shall be regarded in the same way as their own external customer. To maintain the main idea the company's culture and "The Rexam Way" has to be settled and followed by all production plants and LRDs.

6.1.4 Production activity control

When performing production activity control it is important with reliable decisions from above described managing level. When having a deficient decision base, this managing level is as well suffering.

6.2 Forecasting

Companies working on a mature market often have a more stable demand and therefore can create more reliable forecasts. Nevertheless, the can industry is a fast increasing market. As a result, it is a more difficult to forecast expected sales for Rexam. General, historical sales statistics and forecasts show an increased demand of 33 centilitres cans and a decrease demand of 50 centilitres. This trend is important to consider for forthcoming long term forecasts.

6.2.1 Forecasting of sales

Difference between one month's forecasted sales and actual sales is normally small. On the other hand, a deviation of only 2 % of 100 million sold cans results in a difference of 2 million cans.

Long term forecasting can in some situations differ significant from forecasted to actual sales. To measure Rexam's long term forecasting, the comparison between expected sales in the budget, the line load 2+10, the line load 5+7 and the actual sales for January to August is shown in Table 6.1 (the figure shows fictitious sales) where large deviations are shown. In many situations, the long term forecasts have low reliability in comparison to the superior monthly forecasting with only some percentages in deviation.

Budget and real result	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Extra million cans	15,2	20,1	31,8	21,8	65,2	53,8	30,5	52,1
2+10 and real result	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Extra million cans	0	0	25,4	-36	37,7	24,4	29,8	61,1
5+7 and real result	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Extra million cans	0	0	0	0	0	-4,7	1,9	39,7

Table 6.1 Deviations in sales forecasts

Unreliable long term forecasts can cause problems with stock levels, required support etc. An already low stock level can be critical low even with small changes in the forecast. Long term forecast is difficult to estimate. Therefore, it is important with a plan B when deviations occur. An increased sale of e.g. 20 million cans must be meet by inter company support, if there is no safety stock to meet the extra demand. However, that require available capacity in one of the sister plants. Nevertheless, 20 million cans affect the rest of the organisation.

6.2.2 Production

The normal rated speed for a production forecast is constant; however, the efficiency varies monthly. To measure the reliability in Rexam's production forecasts, expected and actual production is compared. Table 6.2 and Table 6.3 show actual production in comparison to forecasted value (the figure shows fictitious production rates). Worth consideration, the forecasts are taken from, in comparison; unproblematic lines to forecast where only standard cans are produced (line one and line four).

Budget & actual value	<u>Jan</u>	<u>Feb</u>	<u>Mar</u>	<u>Apr</u>	<u>May</u>	<u>Jun</u>	<u>Jul</u>	<u>Aug</u>
Deviations in million cans	-3,2	-3,1	-4,9	-11,7	-4,3	-5,3	-8,2	-3,4
2+10 & actual value	<u>Jan</u>	<u>Feb</u>	<u>Mar</u>	<u>Apr</u>	<u>May</u>	<u>Jun</u>	<u>Jul</u>	<u>Aug</u>
Deviations in million cans	0	0	-2,3	-2,5	-0,5	-5,2	-11,2	-2,5
5+7 & actual value	<u>Jan</u>	<u>Feb</u>	<u>Mar</u>	<u>Apr</u>	<u>May</u>	<u>Jun</u>	<u>Jul</u>	<u>Aug</u>
Deviations in million cans	0	0	0	0	0	-0,5	-4,0	2,0

Table 6.2 Line 4 (33cl) Actual value in comparison to forecasted value

Budget & actual value	<u>Jan</u>	<u>Feb</u>	<u>Mar</u>	<u>Apr</u>	<u>May</u>	<u>Jun</u>	<u>Jul</u>	<u>Aug</u>
Deviations in million cans	18,09	-1,99	-4,59	-1,48	-1,23	-2,95	-5,45	-2,01
2+10 & actual value	<u>Jan</u>	<u>Feb</u>	<u>Mar</u>	<u>Apr</u>	<u>May</u>	<u>Jun</u>	<u>Jul</u>	<u>Aug</u>
Deviations in million cans	0	0	-4	0,22	-0,08	-1,81	-5,45	-2,01
5+7 & actual value	<u>Jan</u>	<u>Feb</u>	<u>Mar</u>	<u>Apr</u>	<u>May</u>	<u>Jun</u>	<u>Jul</u>	<u>Aug</u>
Deviations in million cans	0	0	0	0	0	0,57	-4,99	0,37

Table 6.3 Line 1 (50cl) Actual values in comparison to forecasted value

The difference between expected value and actual value can make significant variation when creating the line load and estimate required support. With consideration to special designs (on line two and three), the difference can be considerable greater each month. The way of setting the efficiency affects the whole production situation for the production plant. On the other hand, the production needs goals to work for; otherwise they have nothing to strive for. However, it has to be achievable goal.

When performing a production forecast, the efficiency in the production must be set in relation to expected batch sizes. With smaller batch sizes, the waste in the production increases at the mean time as decreased production efficiency. It requires awareness from the production managers of using a lower efficiency when creating forecasts.

6.2.3 Forecasting errors

Monthly, the forecast errors are normally small. However, as mentioned before, long term forecasting is the main problem where several factors affect the forecast.

Follow-up of forecast are achieved due to the last month's sales/production in comparison to expected sales/production. Conversely, this forecast's follow-up of gives no information of its reliability for long term planning. With the improved model for creating the line load, follow-up could be performed in advance and required actions could be done earlier.

A too low sales forecasts and a too high production forecast results in problems with deliveries. When creating the line load, the difference between sales and production capacity corresponds to the amount of required support. However, problems arise when the demand increases. Therefore, the planned support amount is too low. Table 6.4 show how sales, the stock level and support affect each other.

Deviation Budget Actual value	May	Jun	Jul	Aug
Opening Stock	-69,8	-106,6	-58	-55,2
Production	-10,6	-11,8	-19,1	-11,4
Support	1,3	60,1	10,3	49,4
Customer Sales	65,2	53,8	30,5	52,1
Inter-Company Sales	-42,3	-55,9	-42,7	-38,7
Closing Stock	-106,6	-58	-55,2	-37

Table 6.4 Deviations between budget and actual values

For example, underestimated sales of 40 million cans correspond to 450 optimal production hours in one line (roughly 17 optimal production days). With an already tight production situation, these forecasting errors result in a significant different situation for the production and for their customers. From another point of view, increased sales with 40 million cans decreases the stock level, with the same amount as the production cannot meet. With an already low stock level, the inventory level cannot decrease under minimum stock level.

Long term forecasting is difficult to carry out and alternative plans can be useful. The alternative plans can consist of "the best case" with increased sales and "the worst case" with lower demand than forecasted. "The best case" includes an action plan to meet increased sales and "the worst case" consists of a plan for how to meet a lower demand than expected. Nevertheless, these plans shall be easy to use when deviations occur.

6.3 Material planning

The can industry is a fast increasing market which does it difficult with material planning in many situations. Fast decisions, short planning horizon, insufficient capacity and increasing transportation cost bring complexity to the material planning.

6.3.1 Material planning with SAP

The SAP system requires fairly long planning horizon for achieving an appropriate material planning. However, the can industry requires possibilities for fast decisions for short planning horizons which the SAP system does not support. The SAP system works best for long planning horizons without changes. However, production of cans is component based in comparison to the SAP system which is a product based system. This is another main difference between the systems. The Antvision system is a special designed support system for Rexam in Fosie. It is a cover time based planning system which shows number of days an article is kept in stock for each design to facilitate material planning. However, there is not set cover time for each article.

A covering time based material planning system can favourable be used for Rexam in Fosie, with consideration to the industry's characteristics. It facilitates decisions for material planning in many situations, e.g. priorities of design, ordering principles etc. However, need of fast decision is important when performing material planning. It is also the main reason why other material planning system is not useful for Rexam.

The value classification of articles is good working and as in most industries the 20/80 rule can be applied. For Rexam in Fosie, 20% of the A-C classified articles correspond to 80% of the total sales. The classification also gives valuable information for facilitating decisions regarding order sizes, stock levels etc.

6.3.1.1 The peak season

During the peak season, Rexam in Fosie is more or less using a requirement based ordering system, where the produced quantity corresponds to an exact called off quantity. In some situations, call offs and deliveries need to be cancelled or delayed as a consequence of shortage of capacity/stock.

Material planning is in many situations critical, regarding ordering quantity and time for deliveries. In many situations, only the called off quantity is produced, with minimum of 100 000 cans. However, in some circumstances either the production of small batches guaranty delivers on time.

An improved material planning during the peak season can be carried out by increased capacity, higher stock levels as well as a better planning function. When it is insufficient capacity and a low stock level, the material planning is complicated to perform. However, if the material planning should be without concerns, the stock should be too high or having too much free capacity. The balance between stock level and capacity is important to be aware off.

6.3.1.2 The off peak season

During the off peak season, Rexam in Fosie and the other production plants are mostly producing to stock. Nevertheless, the off peak season enable material planning with consideration to covering time.

The classification of articles in the Antvision system is useful information when planning the stock building of foremost A and B classified articles. Consideration to the stock building strategy is important as producing the right mix of designs; favourable A and B classified articles. A, B and C classified articles corresponds to 80% of total sales and many of these designs can be regarded as more predictable designs.

Material planning during the off peak season regards as easier to perform than during the peak season, where all demand can be meet and safety margins can be used.

6.3.2 The support system

To support both customer and inter company decisions, it is important to have a good material planning system which shows reliable and correct information as available stock, remaining production etc. However, these functions are not supported by the way the SAP system is used today. Nevertheless, today the Antvision system gives customer accurate information concerning remaining production, available stock etc once a week. This information is very important for the customers, the inter company support, as well as for the material planning.

6.4 Order quantities

The size of the order quantities has decreased the over past years and is expected to further decrease in the future. Changed market conditions, increased production flexibility are reasons why it necessary and possible to produce smaller production batches.

6.4.1 Optimal production batch

When having a too low stock level and shortage of capacity, the size of the order quantities has been affected. It has resulted in several label changes to meet customer demand. The minimum ordering sizes has the last year been a batch sizes of roughly 100 000 cans. However, in the future this quantity is expected to decrease further.

Rexam and the can industry's special conditions result in difficulties to use presented models for calculating of an optimal production batch size. However, due to the classification system, different articles should be produced in different batch sizes and therefore have different optimal production batches.

6.4.1.1 Optimal order quantity based on EOQ

Using Wilson's formula for calculate an optimal order quantity is the most general manner for these type of calculations. However, it takes no consideration to seasonal demand. Table 6.5, Table 6.6 and Table 6.7 show how the order quantities vary with different ordering costs and stock keeping costs.

Demand (yearly)	Ordering Cost (SEK)	Stock keeping cost (SEK)	EOQ
100 000	3380	0,2	58 138
250 000			91 924
500 000			130 000
2 000 000			260 000
5 000 000			411 096
10 000 000			581 378

Table 6.5 EOQ, S=3380 SEK and $I \cdot C = 0,20$ SEK a year

Demand (yearly)	Ordering Cost (SEK)	Stock keeping cost (SEK)	EOQ
100 000	10 000	0,2	100 000
250 000			158 114
500 000			223 607
2 000 000			447 214
5 000 000			707 107
10 000 000			1 000 000

Table 6.6 EOQ, S=10 000 SEK and $I \cdot C = 0,20$ SEK a year

Demand (yearly)	Ordering Cost (SEK)	Stock keeping cost (SEK)	EOQ
100 000	3 380	0,04	130 000
250 000			205 548
500 000			290 689
2 000 000			581 378
5 000 000			919 239
10 000 000			1 300 000

Table 6.7 EOQ, $S=3380$ SEK and $I \cdot C = 0,04$ SEK a year

As the figures show the ordering cost does not affect the result in the same manner as the stock keeping cost. Therefore, an accurate stock keeping cost is needed for more reliable calculations. However, awareness of these calculations limitations is important.

6.4.1.2 Optimal order quantity based on Silver Meal's algorithm

The Silver Meal algorithm considers seasonal variations in demand when calculating an optimal order quantity. It is difficult to estimate in which period a demand occurs which leads to inconveniences when it is time to order.

With a stock keeping cost of 0,017 SEK a month and with an ordering cost of 3380 SEK following situation occur when using the Silver Meal algorithm. The demand is assumed to occur in April and August.

	Demand	Production of one batch
Jan		
Feb		
Mar		
Apr	50 000	
May		
Jun		
Jul		
Aug	50 000	2 250
Sep		
Oct		
Nov		
Dec		

Table 6.8 The Silver Meal algorithm

The stock keeping cost should be 2 250 SEK, shown in Table 6.8. Therefore, it is more profitable to produce the demand of 100 000 can in one batch. Nevertheless, the ordering cost and stock keeping cost are relatively uncertain.

If the demand occurs in April and September, the situation should be changed. The stock keeping cost correspond to 3 400 SEK and therefore it is still more profitable to produce two batches of 50 000 cans in each. The relation is shown in Table 6.9.

	Demand	Production of one batch
Jan		
Feb		
Mar		
Apr	50 000	
May		
Jun		
Jul		
Aug		
Sep	50 000	3 400
Oct		
Nov		
Dec		

Table 6.9 The Silver Meal algorithm

According to these two calculations, it is profitable to produce the whole demand in one batch if it is called off within four months. However, the small difference between producing a whole batch and keep it in stock or two batches, when the demand occur within fifth months is very little. Therefore, it can be recommended within shortages of capacity, to divide the total order into two batches for more free production capacity when the demand expects to occur within four months. However, the little difference in producing one batch or two separate does not results in any conclusions regarding optimal batch sizes can be done according to these calculations.

6.4.2 Production

Comparison between number of label changes 2005 and 2006 and the productivity 2005 and 2006 shows several remarkable facts. More label changes were performed during 2006 than 2005; however, the production efficiency was equal or higher during 2006. Therefore, the connection between number of label changes and production efficiency has another dimension. The production has been more flexible and can handle label changes in a better manner than the years before. Several label changes has improved the production staff's ability and knowledge for performing label changes. Nevertheless, in the future, the production expects to be more and more flexible as well as better developed routines when performing label changes. Rexam works actively with SMED and has tools and incitement for improving their performance of label changes.

On the other hand, the bonus system for the production staff is depending upon waste in the production. Several label changes brings more waste which has a negative impact on the production staff's bonus. The bonus system obstructs more flexible production with several label changes. Therefore, the bonus system needs to be changed to increase the production staff's willingness to perform several label changes, as well as finding better routines for them.

Many of the A and B classified articles is produced at Fosie's sister plants which results in requirement for flexible production of C-G articles in the production plant in Fosie. The called off quantity tends to be smaller in the future and a more flexible production is required. The peak season tend to be extended in the future, especially with consideration to the sales curve. The change in demand of 33 and 50 centilitre cans needs to be a considered factor. A strong increased demand of 33 centilitre cans requires more capacity for production of this can size.

6.5 Safety stock

A high safety stock is important for companies with limited production capacity. However, the relation between the safety stock and available capacity needs to be balanced. Rexam meet seasonal demand and is producing to stock during the off peak season. This performance result in a high stock level during the off peak season to meet all demand during the peak season. Figure 6.3 shows how the stock level varies.

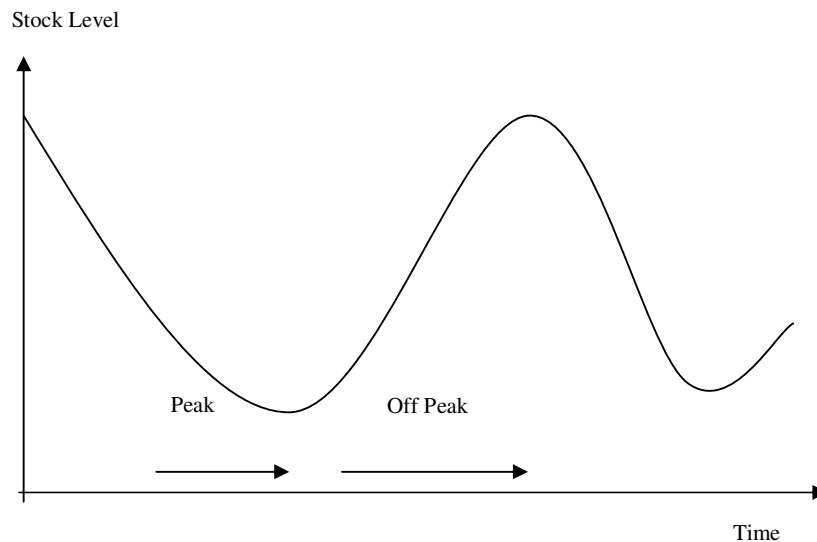


Figure 6.3 Stock level depending on season

Rexam's safety stock strategy is optimal concerning tied up capital. Nevertheless, the composition of the safety stock is as well important to consider. A and B classified articles are foremost kept in stock. Rexam's performance concerning safety stock follows the stated conditions for an optimal safety stock level.

To measure an optimal stock level, reliable forecasts for sales and production are required. Difficulties with estimating correct forecasts for sales and production complicates the decision of required stock level. Nevertheless, the available capacity and released production orders can restrict the possibility to achieve an optimal stock level.

The stock level can be too low, e.g. the line load shows, if sales should increase with only 1% with an already low stock level, the stock level should reach a lower stock level of approximately 2 ½ week of sales.

Measuring of SERV1 or SERV2 is favourable used for companies with uniform distributed demand. However, an equal stock level over the year is not optimal for Rexam. Materials kept in stock in the end of the peak season are unnecessary tied up capital. According to the theory, the trade off between the cost of lost sales and one period's stock holding cost indicates that at the peak season, a stock level close to the traditional is appropriate. Table 6.10 show the optimal safety stock level with starting point from short term forecast's deviations. This level should be achieved in the beginning of the peak period. However, as mentioned earlier, the lead time vary for Rexam's customers. The Swedish customers only have one day (if

available capacity) and some more distant customers have a lead time up to seven days. Nevertheless, the lead time is assumed to be constant for these calculations.

Service %	Safety Stock (1 day lead time)	Safety Stock (7 days lead time)
50	-	-
75	75 349 931	3 692 146 611
80	94 468 570	4 628 959 930
85	116 961 087	5 731 093 247
90	143 952 107	7 053 653 227
95	185 563 263	9 092 599 863
98	230 548 296	11 296 866 496
99	262 037 819	12 839 853 139
99,5	289 028 839	14 162 413 119
99,99	449 850 333	22 042 666 333

Table 6.10 Safety stocks based on short term forecasts

Table 6.10 show an unrealistic high stock level when seven days lead time is assumed. However, even if it should be an optimal stock level, available production orders are limiting the highest stock level. Worth consideration, this calculation of a safety stock level is based on the short term forecasts which are much more reliable than the long term forecasts.

Calculations of a safety stock with starting point from long term forecasts result in a significant higher safety stock level, shown in Table 6.11.

Service %	Safety Stock (Budget)	Safety Stock (2+10)	Safety Stock (5+7)
50	-	-	-
75	296 007 396	291 286 222	172 271 889
80	371 113 750	365 194 667	215 982 667
85	459 474 167	452 145 778	267 407 111
90	565 506 667	556 487 111	329 116 444
95	728 973 438	717 346 667	424 251 667
98	905 694 271	891 248 889	527 100 556
99	1 029 398 854	1 012 980 444	599 094 778
99,5	1 135 431 354	1 117 321 778	660 804 111
99,99	1 767 208 333	1 739 022 222	1 028 488 889

Table 6.11 Safety stock for long term forecast and with one day in lead time

These calculations show a high safety stock level in comparison to Rexam's actual safety stock. All customers have different lead time; however, it is between one and seven days. Nevertheless, this method has some deficiencies when measuring the safety stock which are important to be aware off.

With tight capacity conditions, the safety stock needs to compensate the extra demand that occur during the peak season. However, in Rexam's case with shortage of capacity, the safety stock needs cover the abundance of capacity during the peak season. Customer's released production orders can be a definition of wished available stock level. However, when deciding a level of the safety stock, the available production orders are a limiting factor. Therefore, it should be optimal to produce all available production orders for stock building during the off peak season.

Time for start the stock building process is an important factor to consider. A too early start brings tied up costs, although a too late start, can result in shortage during the peak season. However, Rexam only produce cans with released production orders. To have the possibility to meet unexpected demand during the peak season and late released production orders, the stock building process shall start early as possible. The production to stock shall foremost endure of A-B classified articles, but also C classified articles. These designs can be regarded as more reliable than the D-G classified articles. When the production orders of these designs are lacking, production of the other designs is recommended, instead of closing the line. However, a uniform distribution of articles kept in stock is important.

When producing to stock, Rexam has two choices;

1. Producing all available production orders when having free capacity and keep them in storage with high tied up costs. Nevertheless, it results in a risk of lack of production orders and a closed line.
2. Waiting with the production of all available production orders which results in lower tied up capital costs, but also a risk for difficulties to meet all demand during the peak season.

Rexam is acting on a growing market and according to the last year's delivery problems, strategy one is recommended. In comparison to an optimal safety stock, producing all available production orders is recommended in earlier stated manner. However, the size of available production orders limits the stock level.

6.5.1 Measuring of service

Rexam in Fosie measure their customer service with OTIF (On Time In Full). However, calculations of OTIF do not measure if Rexam deliver customer's requirement and if the order actually is on time. Rexam in Fosie's high value of service does show customer's satisfaction.

OTIF is a measure for both the delivery reliability and the delivery dependability. However, as the theory state "on time" and "a complete order" can be defined unlike in different companies. "On time" for Rexam is when the order is on time to their customer, but agreement of later delivery takes not into consideration and the order is still measured as an order on time. "A complete order" is defined as an order with correct amount of cans, but it says nothing if it is the required design. OTIF is more a measure of what Rexam's transportation company (DFDS) can deliver than if it is a complete order on time.

6.5.2 Shortage costs

Shortages cost is difficult to assess, both for a single case and overall situations. Calculations of shortage costs require both a lot of time and money. Rexam's need of quick decisions do these calculations untenable. However, Rexam in Fosie does not measure shortage cost for a specific order in terms of costs because of these aspects.

Decisions regarding moving designs to other plants often have been taken far before the actual occasion of a specific shortage cost and time for placing a new design in another plant

often require more time than the lead time for a specific order. Therefore, moving designs to other plants cannot be regarded as an action for a shortage.

The size of a shortage cost is depending on if the market is sold out or not. If the market is sold out, Rexam's competitors either do not have available capacity and the customers do not have any other supplier. However, if their competitors have available capacity and can deliver right quantity on time, Rexam risk losing them as customers currently and in the future, therefore also market shares. The summer 2006, the can market has been sold out and it has been difficult for breweries to get cans.

Priorities of customers need to be done, from one case to another. However, margins on a specific can are not an appropriate way to measure a shortage cost. Even if the order should not be profitable in a specific case, it needs to be set in an overall view.

6.6 Capacity planning

The demand of cans has the last year increased dramatically and the unexpected growth has resulted in insufficient capacity for the whole industry, even Rexam. It is difficult to foresee sales on a growing market and especially major changes.

6.6.1 Capacity strategy

Rexam Beverage Can has taken a following capacity strategy, where they have less or exact available capacity than customer's requirements. Historically, the stock level has been too little in comparison to available capacity and demand. This strategy has low volume flexibility and requires a high stock level. Nevertheless, when having this strategy, awareness of high tied up capital cost and a high stock level is necessary and required to meet customer demand during the peak season.

The can industry is capital intensive, where the production equipments are very costly. However, on the other hand, a large stock level binds tied up capital which brings huge costs. For example, new printer which should decrease the time for a label change on one line to 5 minutes, costs around 10 million SEK.

6.6.2 Capacity utilisation

Shortage of capacity during the peak season results in production to stock during the off peak season to meet customer's demand. However, that entails a compensation strategy for capacity utilisation. The production produces maximum amount during the whole year or as long as there are available production orders.

6.6.3 Inter company support

Shortage of capacity for one LRD aims to be met by inter company support from another production plant. However, the complex inter company situation sometimes results in using the own production plant's more reliable production, where deliveries can be confirmed to customers.

Transportations across Europe has resulted in increasing transportation costs which tend to additionally increase the forthcoming years. In the future, increased transportation cost can make it impossible with inter company support across Europe. Perhaps inter company support can be forbidden or impossible to use in the future with consideration to the environmental and the cost situation.

Rexam in Fosie has a huge need of support from their sister plants, especially during the peak season. However, more needed support results in a more complex situation. Together with a late released line load with outlined amount of inter company support; can bring difficulties to get an appropriate level of support on time and uniform distributed. If the line load was outlined in the beginning of the month and all plants should stick to it, the support function should be facilitated. However, trust between plants needs to be improved to maintain a good relation.

6.6.4 Operational capacity

With lack of capacity during peak season, the production planning for the plant results in a complicated situation. As mentioned before, missing support will in some cases result in production of the design in the own production plant. The unexpected production causes problems for production of other designs which affects deliveries to customers. The size of a shortage cost is as mentioned in an earlier chapter up to each specific situation.

To have a working situation during the peak season the stock level needs to increase significant, alternatively an increased capacity and more reliable long term forecasting.

7 Result & Recommendations

The chapter is a summary of the master thesis. It contains results and recommendations to Rexam, as well as companies in similar situations. Further, a discussion for additional researches is presented.

7.1 The Rexam Way

Today, many of the existing problems are organisational based. Working according to “The Rexam Way” is central where trust and respect between plants and LRDs are important for a working organisation. Information from the line load needs to be accurate and all production plants and LRDs should stick to it. A late outlined line load results in problems for the LRDs and the production plants.

When using the inter company support, it is important for the selling production plant and its LRD to regard the purchasing LRD in the same manner as an external customer; i.e. working according to “The Rexam Way”.

The line load needs to be released earlier every month. Today, the delay where a half month has past before it is released, results in inconvenience according to actual month’s production, sales and support. Nevertheless, there is also a delay when catching deviations. Figure 7.1 shows an appropriate model for creating and releasing the line load. It is released in the beginning of the month and deviations can be picked up at an early stage.

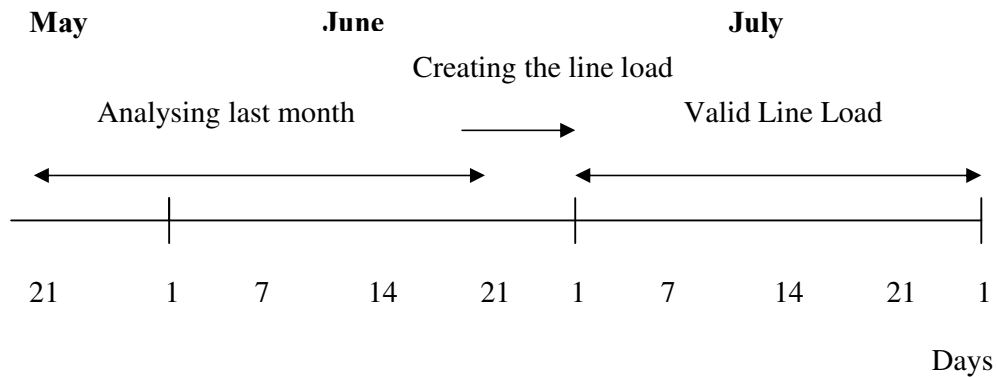


Figure 7.1 Suggestion of an appropriate model for releasing the line load

7.2 Forecasting

It is often difficult to perform a reliable forecast for an expanding market. Nevertheless, Rexam in Fosie has very good short term forecasts in comparison to the other LRDs. The long term forecasts often have large deviations for all LRDs, including Fosie. To have a more reliable long term forecast, accurate researches is important. Awareness of an unreliable forecast’s impact on the stock level and the capacity utilisation is important. Especially, how it can affect future decisions. The inter company support is based on sales and production

forecasts and with a higher sales and lower production than expected; the size of the support is insufficient. With more reliable forecasts, both for sales and production, the inter company support should be easier to manage. Reachable production rates and well estimated forecast should facilitate the production planning.

Long term forecasting is difficult, where an over estimated forecast brings tied up cost and an under estimated forecasts brings shortage costs. However, when performing a long term forecast it is favourable to create an alternative plan, if deviations occur. The alternative plan could be created with consideration to the “best case” with increased sales and the “worst case” with decreased sales. For each of these there should be a handling plan. This together with an earlier released line load, there should be better possibilities to meet unexpected situations.

7.3 Material planning

The Antvision system is a good working support system which facilitates the material planning and customer support. Especially because the system can be tailored to their specific need. The possibility with extension of additional needed functions is an advantage with the system.

Awareness of the SAP systems limitations with consideration to the can industry is important, however, it is a good system for material planning within a large organisation as Rexam Beverage Can Europe & Asia.

Existing problems with material planning could easily be eliminated with extended capacity, higher stock levels or improved planning.

7.4 Ordering quantities

The size of the ordering quantities has for a long time been a twisted question between the production and sales department. The production department advocates long production batches with high production efficiency, in contrast to the sales department which want to meet the markets demands with low tide up capital cost, through short production batches.

Nevertheless, the production conditions during the summer 2005 and 2006 have decreased the ordering quantities. On the other hand, the production staffs have improved their capability for label changes which can further be improved.

The bonus system for the production staffs need to be changed, to be a profitable based system as the other employees have. An increased number of label changes increases the waste in the production which is not profitable for their bonus. Therefore, the production staffs are not motivated for performing label changes. With a profitable based bonus system the production staff should be more motivated to label changes and therefore also give a potential higher profit for the company.

Process thinking instead of operation or department based thinking should facilitate the production situations and the incitement for different departments for shorter vs. longer ordering quantities should decrease. The calculations of an optimal ordering quantity gives guidelines for order quantities, however, there are many uncertain factor in the calculations.

Therefore, a conclusion regarding an optimal order quantity is difficult to state. Nevertheless, it has to be considered and perhaps analysed further.

7.5 Capacity vs. Safety stock

With seasonal demand, producing to stock is required to meet all demand during the peak season. Therefore it is important to have a sufficient stock building strategy which Rexam in Fosie has from a tied up capital view. However, the stock level has changed during the year and tends to be smaller for each year. The low stock level has caused problems with deliveries and customer confidence has been affected.

Rexam is acting on a growing market and with consideration to the last year's delivery problems; an optimal safety stock should be production of all available production orders. However, the size and numbers of available production orders limit the possible stock level. Nevertheless, the production mix is important to consider. A uniform distribution of A and B classified articles is recommended. When having shortages of these production orders, C-F classified articles can be produced to stock.

With a strong market growth as in the can industry, the capacity needs to be increased in the forthcoming years. However, too much free capacity results in high costs for unused production capacity, but on the other hand, shortage and stock building is also cost demanding. Still, with a higher stock level follow enhanced delivery performance with in deemed crucial major customers.

7.6 Summary of recommendations to Rexam

With consideration to the actual consumption of cans in Europe to the US, Rexam expects a strong market growth in the future. To meet the increased demand, higher stock levels or more capacity is required. Nevertheless, with more reliable forecasts, the entire production planning can be improved. Better forecasts and a previous released line load results in earlier follow-up and deviations can be measured in a previously stage.

The order quantities have decreased the last year and further tend to decrease in the future. Therefore, an increased flexibility in the production is important to meet the new production conditions, as well as the markets shifting requirements.

7.7 General recommendations

Awareness of how an unreliable forecast affects the stock level and the production is important to consider for all companies. Though, more accurate forecasts can decrease the uncertainties, nevertheless, it is difficult to create exact forecasts. Therefore, alternative handling plans can be a good measurement when possible deviations occur. By earlier measurements, many problems can be extenuating circumstances instead of measuring a problem when it occurs.

7.8 Discussion and suggestions for further research

As mentioned earlier, the order quantities tend to decrease in the future. Even so, calculation of an optimal order quantity is of interest. If today's shortest production batch of 100 000 cans should be decreased to merely produce a batch of 50 000 cans. The effect on the production and other consequences to a decreased production quantity should be of interest to evaluate. Further, how much should the deliver reliability be improved and should the measurement be profitable are considerable condition.

Evaluation of the possible market growth is another interesting issue to consider in a further research. Today, in the US, 360 can per capita and year is consumed in comparison to Europe's consumption of 76 cans per capita and year. Is the European market going to increase to the same level as in the US and if so, how the increased demand could be met is interesting to assess.

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Appendix

Appendix 1: Interview Guide Antvision

1. Can you tell me about the Antvision system?
2. Which method does the Antvision forecasting system uses?
3. Does it consider trends and seasonality?
4. Can the Antvision system consider forecasting errors?

Appendix 2: Interview Guide Production

1. How can you forecast the production? Which factors do you consider?
2. How does this forecast differ between peak season and off peak season?
3. Do you consider season when performing a forecast?
4. Who do you report the forecast to?
5. How long is an average label change?
6. How long time does it take to start up the production after a label change?
7. Is it an advantageous with similar colours? Is it significant differing, changing from blue to white etc?
8. How much does a label change cost?
9. How much does the production waste in a label change?
10. Is the efficiency proportional against label changes?
11. Is it more complicated to produce new designs? Is it often problems with these?
12. Debossed, Illustration Impact, Matt Varnish and base coat, how is the production affected by these special designs?

Appendix 3: Interview Guide Production Planner

1. Would you please describe your main responsibilities? (Capacity, line load, released production orders, raw material etc.)
2. Can you tell me about the classification of articles? Does this system help you?
3. Can you work with starting point from forecasts? (Both internal and external)
4. Do they help you in you work?
5. Do you think they are reliable?
6. How does the material planning function works within SAP?
7. Does SAP give any support for priorities?
8. Do you know which production planning system that is used? (MRP / Cover time etc.)
9. How does Antvision help you regarding production planning?
10. Do you have different approaches regarding production planning for different seasons?
11. Do you always have enough production orders to have a smooth production flow during the whole year?
12. Can you produce according to forecasts?
13. Does the classification system help you within the production planning?
14. How do you decide the size of an order? Special methods?
15. Is the size of an order quantity depending on season? How do you take seasonality in consideration?
16. How does the order quantity affect the production efficiency?
17. What is you strategy for stock building? According to the classification system etc.
18. Do you strive for a special mix of safety stock?
19. Do you know something about future need?
20. Does a low safety stock affect the production efficiency?
21. Do you have any help of SAP or Antvision for capacity planning?
22. To what extent can you do priorities?
23. How can you see realised orders in SAP?
24. Which information do these orders give you?
25. Which role has the sales administrator in this job?
26. How do you perform a priority control?
27. How often do you change it?
28. Can the production changes order for orders?
29. How often does the production change it?